Investigation of the Hydrodynamics of Fixed Bed Reactor: Co-current Upflow

by

Syamsina Rashid

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Chemical Engineering Programme
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Approved by,

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

SYAMSINA RASHID

ABSTRACT

The main objective of this project is to investigate the hydrodynamic characteristics of co-current upflow of gas and liquid in a fixed bed reactor. This is an experimental based project utilizing the packed bed reactor for residence time distribution (RTD) studies. In this project, the RTD of a bench-scale multiphase was studied using air as a gaseous phase and water as a liquid phase. The ranges of air and water velocities are kept at such levels as to simulate the hydrogen/oil ratios of typical bench-scale hydroprocessing units. The experiments are conducted in upflow mode of operation in the reactor, with increasing gas/liquid ratio. The effects of gas and liquid velocities on different hydrodynamic parameters such as pressure drop and operating liquid holdup are investigated. Operating the fixed bed reactor in upflow mode showed increase in pressure drop, and decrease in operating liquid holdup. Three moments analysis, which are mean residence time, variance, and skewness, are evaluated in order to characterize the RTD. These three moments analysis revealed an increase in mean residence time, and also increases in variance and skewness with increasing gas/liquid ratio. Other parameters such as bed Peclet number of liquid and stagnant zone volume were also investigated with variation of gas and liquid velocities as to measure the efficiency of the reactor. Decreasing Peclet number and stagnant zone volume suggested the decreasing efficiency of the reactor, with increasing gas/liquid ratio. The discrepancies in experimental results suggested that there are conditions to be altered in order to eliminate the inconsistency.

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ABBREVIATIONS AND NOMENCLATURES

LPM	Liter per minute
d_c	Column diameter
d_p	Particle diameter
ΔP	Pressure drop
H_o	Operating liquid holdup
L_c	Height of column
ε	Fractional void volume
μ_g	Absolute viscosity of gas
μ_l	Absolute viscosity of liquid
U_g	Superficial gas velocity
U_l	Superficial liquid velocity
D_p	Effective particle diameter
G_g	Mass flow rate of gas
G_l	Mass flow rate of liquid
ρ_g	Density of gas
ρ_l	Density of liquid
g	Gravitational acceleration
Re	Reynolds number
D	Axial dispersion coefficient
L	Distance between the tracer injection point and conductivity measurement probe
u	Mean real liquid velocity
t_m	Mean residence time
σ^2	Variance of the E curve

s^3	Skewness of the E curve
σ_θ^2	Variance of the E curve for dimensionless time units
C	Concentration
C_i	Concentration at time t_i
HRT	Hydraulic retention time
T_d	Theoretical mean residence time
Q	Volumetric flow rate of liquid
V	Volume of column

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

Simultaneous gas-liquid flow through packed beds is frequently encountered in chemical process equipment and is practiced as countercurrent flow, co-current downflow (trickle bed) or co-current upflow. Countercurrent flow is preferred for mass transfer operations, while the co-current flow of gas and liquid phases is frequently adopted in multiphase reactors, since the throughput is not limited by flooding.

Multiphase packed-bed reactor with two-phase upflow is used in gas-liquid and gas-liquid-solid processes that require a high ratio between the liquid and gas flow rates. It is also used for processes with relatively large liquid residence time in order to achieve the necessary degree of conversion. It is also used when the heat of reaction is high, due to the large liquid holdup and their improved radial liquid mixing and radial heat transfer. The upflow operation is also advantageous in cases where the ratio of column diameter over particle diameter, d_c / d_p is relatively small, because then the liquid-solid contact is more effective than in trickle-bed operation. A ratio of the column to the catalyst diameter smaller than 15 inch the other types of fixed-bed reactor such as trickle beds, cause unsatisfactory liquid distribution due to wall bypassing. One of the drawbacks of the upflow fixed-bed reactors is that the flow behavior of the liquid is non ideal and that backmixing is considered to be more important than in trickle beds. This may give better heat transfer, but larger axial mixing would give poorer conversion.

Considerable work has been reported in literature on co-current downflow of phases; very little however has been reported on co-current upflow in spite of the specific advantages of the downflow model; i) the liquid distribution is radially uniform; this promote efficient distribution of heat and its transfer to and from the wall when desired and prevents the formation of dry spots, ii) the larger liquid holdup gives higher production rate for a given size of reactor, and iii) liquid-side mass transfer coefficients are higher.

Few reports are available comparing the hydrodynamics of the two modes of operation. It is concluded that the superiority of any mode of operation depends on whether the reaction is liquid- or gas-limited, i.e. the performance of trickle bed reactor is superior for a gas-limited reaction, whereas upflow fixed bed reactor gave advantages for liquid-limited reaction.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

Hydrodynamics study in a fixed bed reactor is vital in obtaining relevant data for reactor scale up as well as investigating the performance of the reactor. Co-current upflow arrangement received considerable interest due to the fact that almost complete catalyst particle wetting is achieved which enhance the reaction rate of the process. However, the continuous liquid phase and dispersed gas phase will probably result to non-ideal flow and possibility of stagnant zone in the reactor, thus resulted poor reactor performance.

1.2.2 Significant of Project

The RTD of a bench-scale multiphase reactor has been investigated mainly for industrial scale-up purposes. The successful design of commercial reactors involved generation of reliable data in laboratory-scale reactors and scaling up of these data for larger units. The study of effects of gas and liquid flow rates on various hydrodynamics parameters utilizing the RTD technique using tracer is important for the performance of the reactor. Future work may be based on the development of this study.

1.3 OBJECTIVE AND SCOPE OF STUDY

1.3.1 Objectives

- To investigate the effect of gas/liquid ratio on pressure drop and operating liquid holdup.
- To characterize residence time distribution (RTD) of reactor by three moments analysis (mean residence time, variance, and skewness).
- To perform the residence time study (tracer study) in order to analyze the effect of gas/liquid ratio on the axial dispersion and stagnant zone volume.

1.3.2 Scope of Study

The scope of this project is to utilize the existing laboratory experiment on RTD study in packed bed reactor, at the Reaction Teaching Lab. However, few modifications are done in order to study the hydrodynamics of the packed bed reactor. The modifications are mainly on the variation of the gas and liquid flow rates, to suit the scaled down of commercial reactors. These variations are analyzed based on the response of hydrodynamics parameters.

1.3.3 Feasibility of the Project within the Scope and Time frame

This experiment is conducted as nearly similar to the existing procedures. Due to time constraint, the RTD study may not be extended to the effect of different catalyst particle and diluent size, or effect of different packing.

The experiments emphasized mainly on the investigation of the hydrodynamic characteristics of co-current upflow of gas-liquid reactor. With the available equipment, the RTD study can be conducted to evaluate the three moments analysis, to evaluate the effects of gas/liquid ratio on axial dispersion and stagnant zone volume. Consecutively, the effect of gas/liquid ratio on operating liquid holdup and pressure drop are also investigated.

CHAPTER 2

LITERATURE REVIEW / THEORY

2.1 PRESSURE DROP AND OPERATING LIQUID HOLDUP IN PACKED BED REACTOR

2.1.1 Pressure Drop Correlation

The pressure loss accompanying the flow of gas through packed columns has been the subject of many theoretical analysis and experiment investigations to try to find a suitable mathematical expression to predict the pressure drop caused by both kinetic and viscous energy losses.

A very successful attempt is that of Ergun [1] which is included in the Perry's Handbook. The Ergun equation is;

$$\frac{\Delta P}{L_c} g = 150 \frac{(1-\varepsilon)^2}{\varepsilon^3} \frac{\mu U_g}{D_p^2} + 1.75 \frac{1-\varepsilon}{\varepsilon^3} \frac{G_g U_g}{D_p} \qquad (1)$$

The Ergun equation gave very good results in the whole range of Reynolds numbers from 1 to 100,000. Also, it should be noted that the effective diameter is equal to real diameter only when the particles are spherical; for all other shapes the D_p is define as $D_p = 6V_p/A_p$, where V_p is the volume of particles and A_p is the external surface of particle. Ergun equation assumed equivalent pressure drop regardless of any type of flow regimes.

Turpin and Huntington [2] also gave a single relation for pressure drop valid for all the regimes, in terms of a dimensionless parameter, $Z = \mathrm{Re}_g^{1.167} / \mathrm{Re}_l^{0.767}$. On the other hand, Varma et al. [3] developed an empirical equation for predicting the transition from one flow regime to another. It presented typical variation of frictional pressure drop with liquid and gas flow rates respectively for bubble flow, pulse flow and spray flow. It is seen that though the pressure drop increases with the gas and liquid rates in all the regimes, its variation differs for the different flow regimes. For example, the pressure drop increases rapidly with the gas rate in the spray flow as compared to its increase in pulse flow and in bubble flow.

However, it is noted that the transition between the flow regimes is not sharp and occurred over a small range in gas and liquid flow rates. Thus, all flow regimes in co-current upflow can be assumed equivalent in this experiment, as in Ergun [1] principle, which has been used widely in several researches.

In experiment, pressure drop is directly obtained from the differential pressure reading at control panel or via the Data Acquisition System (DAS). The pressure drop reading is taken at time interval of one minute, and readings are averaged for one value of pressure drop for every variation of gas and liquid flow rates.

2.1.2 Operating Liquid Holdup

Liquid holdup may well be considered as the basic liquid-side dependent variable in packed tower operation. Holdup has a direct influence on factors such as liquid-phase mass transfer, loading behavior, and gas-phase pressure gradient. Researchers measured holdup, with or without gas flow, and have produced empirical description of their results. Only the correlation of Buchanan [4] is in dimensionless form and can claim any generality over a wide range of Reynolds numbers (from 0.01 to 1000). This correlation is appropriate for experimental research. It applied to ring packing operating below the load point and correlated all literature data to about ±20%. The Buchanan equation is consisted of two dimensionless terms, the 'Film number' and 'Froude number';

$$H_o = 2.2\left(\frac{\mu_l U_l}{g\rho_l D_p^{\ 2}}\right)^{1/3} + 1.8\left(\frac{U_l^2}{gD_p}\right)^{1/2} \qquad (2)$$

Experimentally, the operating liquid holdup of liquid is the portion of liquid that is drained out of the catalyst bed when both gas and liquid flows are stopped. The operating liquid holdup is an important parameter influencing the rate of reaction in a gas-liquid-solid multiphase reactor. The operating liquid holdup of liquid is defined as the ratio of the volume of the free-drained water to the total volume of the packed bed.

Chander et al. [5] determined the effect of liquid space velocity on holdup and proved that the operating liquid holdup increased with liquid space velocity. Thus, higher liquid flow rate could increase the reaction rate. Also, the studies also showed that liquid holdup for the upflow mode of operation was reduced when smaller size of particles was used. Stiegel and Shah [6] also have reported the decrease of liquid holdup with the decrease in particle size for the upflow mode of operation. It is also observed that studies by Chander et al. [5] showed that when catalyst bed was diluted with smaller size of particles, the effect of space velocity on operating liquid holdup was very small or negligible.

Chander et al. [5] also studied the effect of gas/liquid ratio on operating liquid holdup, which resulted that the liquid holdup decreased with increasing gas flow rate for the upflow mode when the bed was packed with a larger size of diluent.

2.2 RESIDENCE TIME DISTRIBUTION (RTD) STUDY IN REACTOR

The RTD of a reactor is a characteristic of the mixing that occurs in the chemical reactor. There is no axial mixing in a plug-flow reactor (PFR), and this omission is reflected in RTD which is exhibited by this class of reactors. The CSTR (constant stirred type reactor) is thoroughly mixed and possesses a far different kind of RTD than the plug-flow reactor. The RTD exhibited by a given reactor yields distinctive clues to the type of mixing occurring within it and is one of most informative characterizations of the reactor.

2.2.1 Measurement of the RTD

The RTD is determined experimentally by injection of an inert chemical, molecule, or atom, called a tracer, into the reactor at some time, $t = 0$ and then measuring the tracer concentration, C, in the effluent stream as a function of time. In addition to being a non-reactive species that is easily detectable, the tracer should have physical properties similar to those of the reacting mixture and be completely soluble in the mixture. The latter requirements are needed so that the behavior of tracer will honestly reflect that of the material flowing through the reactor. The two most used methods of injection are pulse input and step input;

2.2.1.1 Pulse Input

In a pulse input, an amount of tracer N_o is suddenly injected in one shot into the feedstream entering the reactor in as short a time as possible. The outlet concentration is then measured as a function of time. Typical concentration-time curves at the inlet and outlet of an arbitrary reactor are shown in ***Figure 2.1***. The effluent concentration-time curve is referred to as the C curve in RTD analysis. The injection of a tracer pulse shall be analyzed for a single-input and single-output system in which only flow (i.e. no dispersion) carries the tracer material across system boundaries. First, an increment of time Δt is chose to be sufficiently small that the concentration of tracer, $C(t)$, exiting between time t and $t + \Delta t$ is essentially constant. The amount of tracer material, ΔN, leaving the reactor between time t and $t + \Delta t$ is then

$$\Delta N = C(t)v\Delta t \tag{3}$$

where v is the effluent volumetric flow rate. In other words, ΔN is the amount of material that has spent time between time t and $t + \Delta t$ in the reactor. If the term is divided by the total amount of material that was injected into reactor, N_o, then

$$\frac{\Delta N}{N_o} = \frac{vC(t)}{N_o}\Delta t \tag{4}$$

which represents the fraction of material that has a residence time in the reactor between time t and $t + \Delta t$.

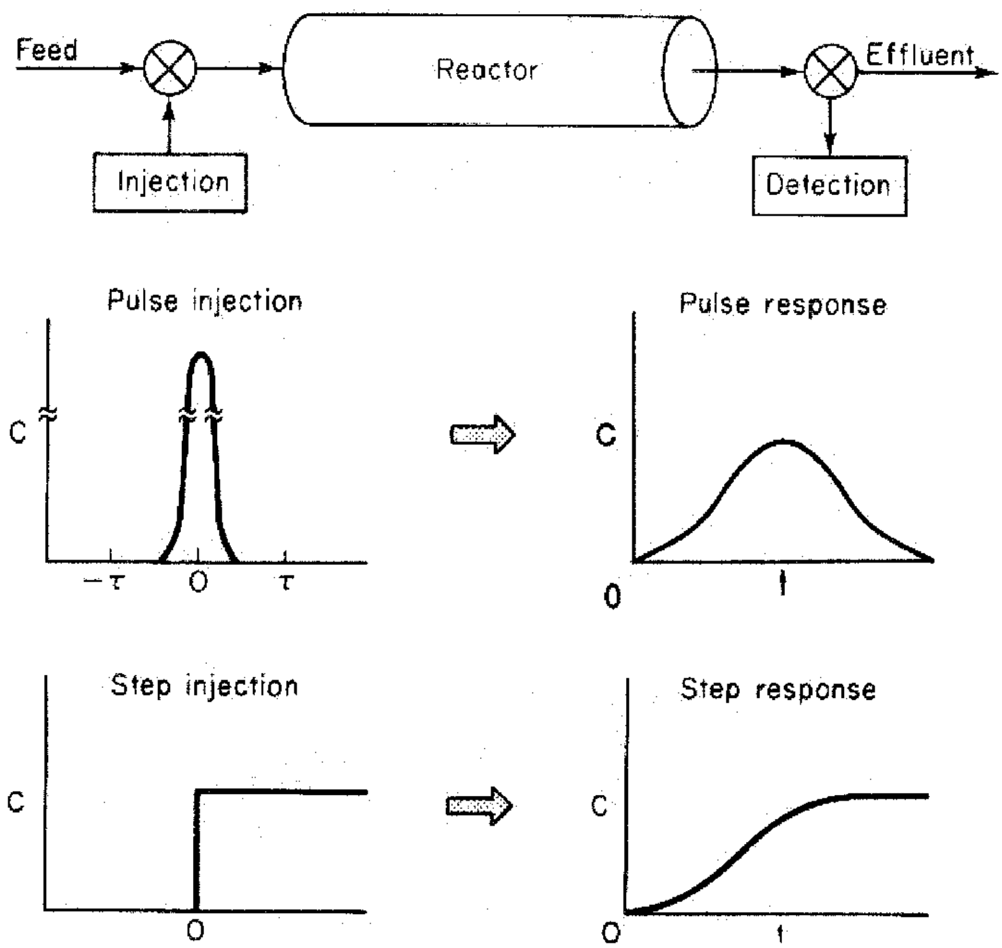

Figure 2.1 RTD measurements.

For pulse injection, it is defined

$$E(t) = \frac{vC(t)}{N_o} \tag{5}$$

so that

$$\frac{\Delta N}{N_o} = E(t)\Delta t \tag{6}$$

The quantity $E(t)$ is called the residence-time distribution function. It is the function that describes in a quantitative manner how much time different fluid elements have spent in the reactor.

If N_o is not known directly, it can be obtained from the outlet concentration measurements by summing up all the amounts of materials, ΔN, between time equal to zero and infinity. Writing equation (3) in differential form yields,

$$dN = vC(t)dt \tag{7}$$

and then integrating,

$$N_o = \int_0^\infty vC(t)dt \tag{8}$$

The volumetric flow rate is usually constant, so $E(t)$ can be defined as

$$E(t) = \frac{C(t)}{\int_0^\infty C(t)dt} \tag{9}$$

The integral in the denominator is the area under the C curve.

An alternative way of interpreting the residence-time function is in its integral form:

$$\left[\begin{array}{l}\text{Fraction of material leaving the}\\ \text{reactor that has resided in the}\\ \text{reactor for time between } t_1 \text{ and } t_2\end{array}\right] = \int_{t_1}^{t_2} E(t)dt \tag{10}$$

It is known that the fraction of all the material that has resided for a time t in the reactor between $t = 0$ and $t = \infty$ is 1; therefore,

$$\int_0^\infty E(t)dt = 1 \tag{11}$$

The principal potential difficulties with the pulse technique lie in the problems connected with obtaining a reasonable pulse at a reactor's entrance. The injection must take place over a period which is very short compared with residence times in various segments of the reactor or reactor system, and there must be a negligible amount of dispersion between the point of injection and the entrance to the reactor system. If these conditions can be fulfilled, this technique represents a simple and direct way of obtaining the RTD.

There are problems when the concentration-time curve has a long tail because the analysis can be subject to large inaccuracies. This problem principally affects the denominator of the right-hand side of equation (9), i.e. the integration of the $C(t)$ curve. It is desirable to extrapolate the tail and analytically continue the calculation. The tail of the curve may sometimes be approximated as an exponential decay. The inaccuracies introduced by this assumption are very likely to be much less than those resulting from either truncation or numerical imprecision in this region.

2.2.1.2 Step Tracer Experiment

The meaning of the RTD curve is previously discussed, now a more general relationship between a time varying tracer injection and the corresponding concentration in the effluent will be formulated. It should be stated without development that the output concentration from a vessel is related to the input concentration by the convolution integral [7].

$$C_{out}(t) = \int_0^t C_{in}(t - t')E(t')dt' \tag{12}$$

The inlet concentration most often takes the form of either perfect pulse input (Dirac delta function), imperfect pulse injection (see ***Figure 2.1***), or step input.

Step input in the tracer concentration will be analyzed for a system with a constant volumetric flow rate. Consider a constant rate of tracer addition to a feed which is initiated at time $t = 0$. Before this time, no tracer was added to the feed. Stated symbolically,

$$C_o(t) = 0 \qquad t < 0$$

$$C_o(t) = \text{constant} \qquad t \geq 0$$

The concentration of the tracer in the feed to the reactor is kept at this level until the concentration in the effluent is indistinguishable from that in the feed; the test may then be discontinued. A typical outlet concentration curve for this type of input is shown in ***Figure 2.2***.

Because the inlet concentration is constant with time, C_o, the integral is taken outside the integral sign, i.e.,

$$C_{out} = C_o \int_0^t E(t')dt'$$

Dividing by C_o

$$\left[\frac{C_{out}}{C_o}\right]_{step} = \int_0^t E(t')dt' = F(t) \qquad (13)$$

This expression is differentiated to obtain the RTD function $E(t)$:

$$E(t) = \frac{d}{dt}\left[\frac{C_{out}}{C_o}\right]_{step} \qquad (14)$$

The positive step is usually easier to carry out experimentally that the pulse test, and it has the additional advantage that the total amount of tracer in the feed over the period of the test does not have to be known as it does in the pulse test. One possible drawback in this technique is that it is sometimes difficult to maintain a constant tracer concentration in the feed. Obtaining the RTD from this test also involves differentiation of the data and presents an additional and probably more serious drawback to the technique, because differentiation of data can, on occasion, lead to large errors. A third problem lies with the large amount of tracer required for this test. If the tracer is very expensive, a pulse test is almost always used to minimize the cost.

2.2.2 Characteristics of the RTD

Sometimes $E(t)$ is called the exit-age distribution function. If the 'age' of an atom is regarded as the time it has resided in the reaction environment, the $E(t)$ concerns the age distribution of the effluent stream. It is the most used of the distribution functions connected with reactor analysis because it characterizes the lengths of time various atoms spend at reaction conditions.

Figure 2.2 illustrates typical RTDs resulting from different reactor situations. ***Figure 2.2 (a)*** and ***(b)*** correspond to nearly ideal PFRs and CSTRs respectively. In ***Figure 2.2 (c)***, it is observed that a principal peak occurs at a time smaller than the space-time, $\tau = V/v$ (i.e. early exit of fluid) and also that fluid exits at a time greater than space time τ . This curve is representative of the RTD for a packed-bed reactor with channeling and dead zones. One scenario by which this situation might occur is shown in ***Figure 2.2 (d)***. ***Figure 2.2 (e)*** shows the RTD for the CSTR in ***Figure 2.2 (f)*** which has dead zones and bypassing. The dead zone serves to reduce the effective reactor volume indicating that the active reactor volume is smaller than expected.

2.2.2.1 Integral Relationships

The fraction of the exit stream that has resided in the reactor for a period of time shorter than a given value t is equal to the sum over all times less than t of $E(t)\Delta t$, or expressed continuously,

$$\int_0^t E(t)dt = \boxed{\begin{array}{l}\text{Fraction of effluent}\\ \text{which has been in reactor}\\ \text{for less than time } t\end{array}} = F(t) \qquad (15)$$

Analogously,

$$\int_t^\infty E(t)dt = \boxed{\begin{array}{l}\text{Fraction of effluent}\\ \text{which has been in reactor}\\ \text{for longer than time } t\end{array}} \quad 1 - F(t) \qquad (16)$$

Because t appears in the integration limits of these two expressions, equation (15) and (16) are both functions of time. Danckwerts [8] defined expression (15) as a cumulative distribution function and called it $F(t)$. $F(t)$ can be calculated at various times t from area under the curve of $E(t)$ versus t plot. The typical shape of the $F(t)$ curve is shown for a tracer response to a step input in ***Figure 2.3***.

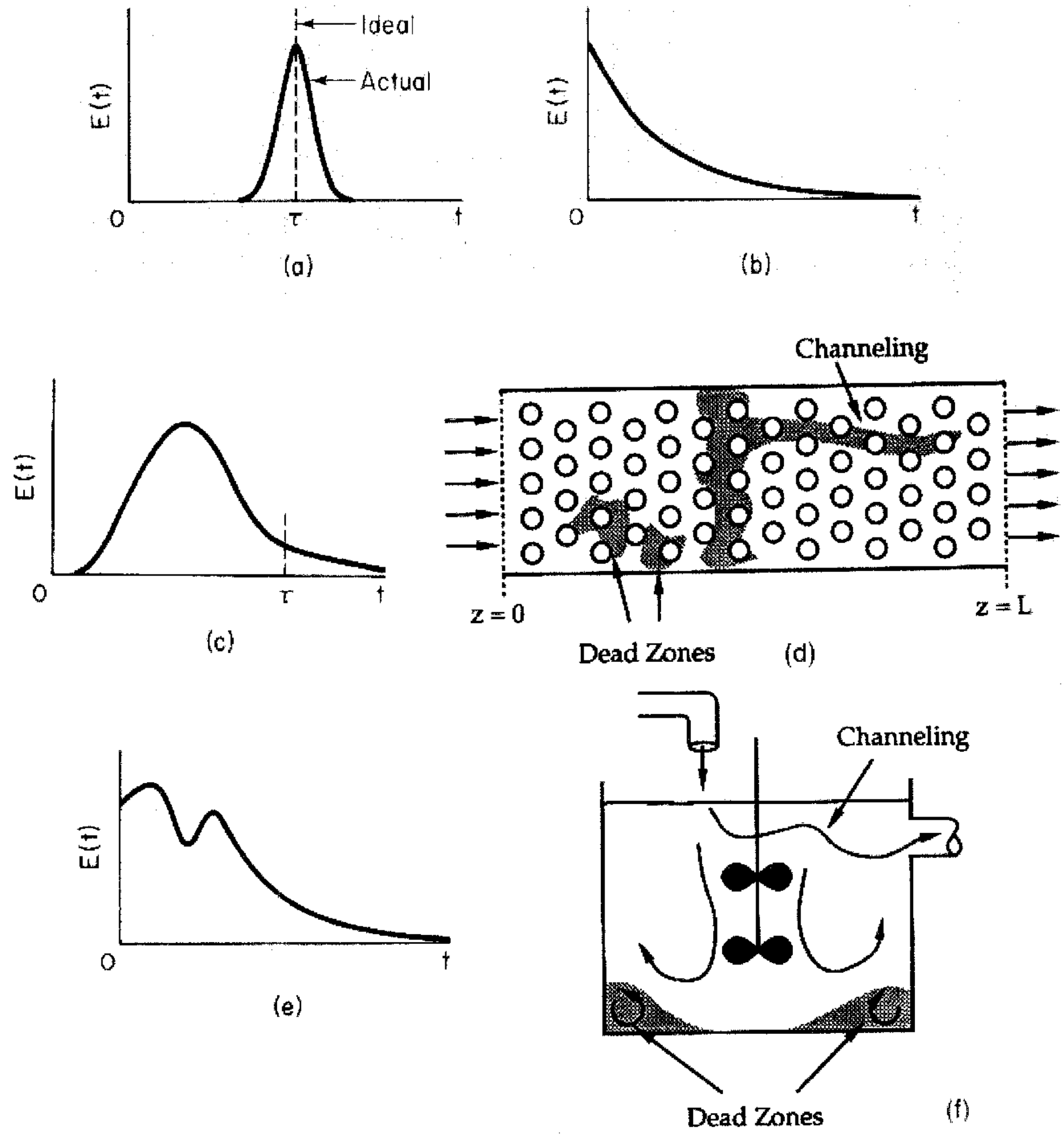

Figure 2.2 (a) RTD for near plug flow reactor; (b) RTD for near perfectly mixed CSTR; (c) RTD for packed-bed reactor with dead zones and channeling; (d) packed-bed reactor; (e) tank reactor with short-circuiting flow (bypass); (f) CSTR with dead zone.

The F curve is another function that has been defined as the normalized response to a particular input. Alternatively, equation (15) has been used as a definition of $F(t)$, and it has been stated that as a result it can be obtained as the response to a positive-step tracer test. Sometimes the F curve is used in the same manner as the RTD in the modeling of chemical reactors.

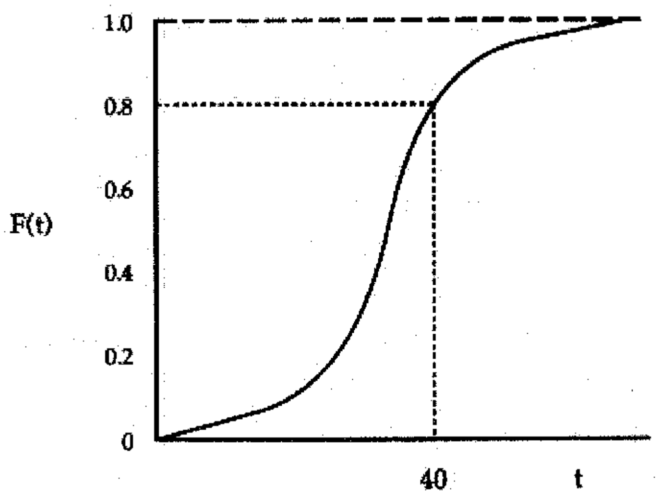

Figure 2.3 The Cumulative Distribution Curve, $F(t)$.

2.2.2.2 Mean Residence Time

A parameter frequently used in analysis of ideal reactors is the space-time or average residence time τ, which is defined as being equal to V/v. It can be shown that no matter what RTD exists for a particular reactor, ideal or non-ideal, this nominal holding time τ, is equal to the mean residence time, t_m.

As is the case with other variables described by its distribution functions, the mean value of the variable is equal to the first moment of the RTD function, $E(t)$. Thus, the first moment is the mean residence time,

$$t_m = \frac{\int_0^\infty tE(t)dt}{\int_0^\infty E(t)dt} = \int_0^\infty tE(t)dt = \frac{\int_0^\infty tC(t)dt}{\int_0^\infty C(t)dt} = \frac{\sum t_i C_i \Delta t_i}{\sum C_i \Delta t_i} \qquad (17)$$

Chander et al. [5] determined the effect of liquid hourly space velocity on mean residence time of the liquid. It is reported that the mean residence time of the liquid decreased with increase in liquid space velocity. However, the mean residence time was a stronger function of space velocity for the upflow mode of operation. The higher mean residence time in the upflow mode could definitely provide a better utilization of catalyst. At the same time, the liquid would also spend undesired longer residence time when not in contact with the catalyst. As a result, a number of undesirable thermal reactions would take place during this period.

Chander et al. [5] also studied the variation of liquid mean residence time with gas velocity at constant liquid hourly space velocity. The study showed that when a larger size of diluent was used, the mean residence time increased with gas/liquid ratio for the upflow mode of operation. The increased gas flow rate in the upflow mode perhaps induced circulatory motion of liquid inside the catalyst bed so that the liquid spent more time in the reactor.

2.2.2.3 Other Moments of the RTD

It is very common to compare RTDs by using their moments instead of trying to compare their entire distributions.

The second moment commonly used is taken about the mean and is called the variance, or square of the standard deviation. It is defined by

$$\sigma^2 = \int (t - t_m)^2 E(t) dt \tag{18}$$

alternatively,

$$\sigma^2 = \frac{\int_0^\infty (t - t_m)^2 C(t) dt}{\int_0^\infty C(t) dt} = \frac{\sum (t_i - t_m)^2 C_i \Delta t_i}{\sum C_i \Delta t_i} \tag{19}$$

The magnitude of this moment is an indication of the 'spread' of the distribution as it passes the vessel exit and has units of $(\text{time})^2$; the greater the value of this moment, the greater a distribution's spread.

It is particularly useful for matching experimental curves to one of a family of theoretical curves. ***Figure 2.4*** illustrates these terms.

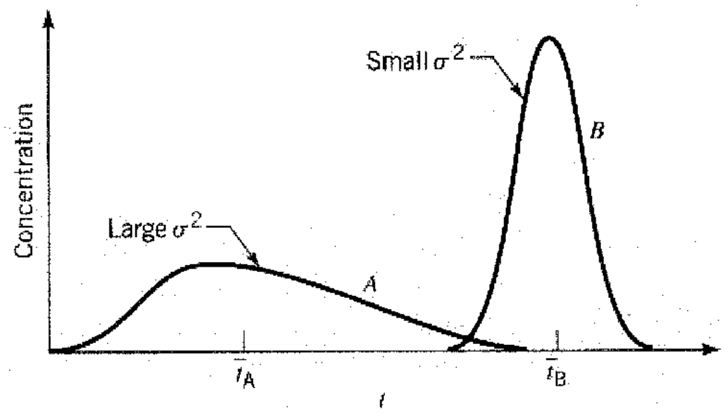

Figure 2.4 Variance for matching theoretical curves.

The third moment is also taken about the mean and is related to the skewness. The skewness is defined by

$$s^3 = \frac{1}{\sigma^{3/2}} \int_0^\infty (t - t_m)^3 E(t) dt \qquad (20)$$

The magnitude of this moment measures the extent that a distribution is skewed in one direction or another in reference to the mean.

Rigorously, for complete description of a distribution, all moments must be determined. Practically, these three (t_m , σ^2 , s^3) are usually sufficient for a reasonable characterization of an RTD.

2.3 RTD ANALYSIS ON AXIAL DISPERSION AND STAGNANT ZONE VOLUME

2.3.1 Axial Dispersion

Suppose an ideal pulse of tracer is introduced into the fluid entering a reactor. The pulse spreads as it passes through the vessel, and to characterize the spreading according to dispersion model (***Figure 2.5***), it is assumed a diffusion-like process superimposed on plug flow. This is called dispersion or longitudinal dispersion to distinguish it from molecular diffusion. The dispersion coefficient D (m^2/s) represents this spreading process. Thus

- large D means rapid spreading of the tracer curve
- small D means slow spreading
- $D = 0$ means no spreading, hence plug flow

Also, $\left(\frac{D}{uL}\right)$ is the dimensionless group characterizing the spread in the whole vessel.

D or D/uL is evaluated by recording the shape of the tracer curve as it passes the exit of the vessel. In particular, t_m (mean time of passage, or when the curve passes by the exit) and σ^2 (variance, or a measure of the spread of the curve) are measured.

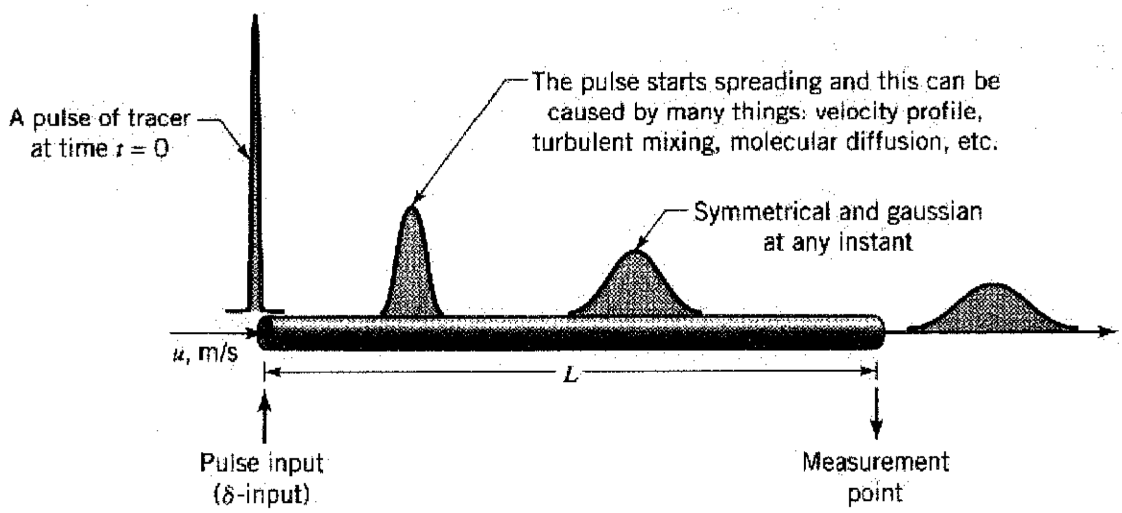

Figure 2.5 The spreading of tracer according to the dispersion model.

These measures, t_m and σ^2, which are earlier mentioned, are directly linked by theory to D and D/uL.

Consider plug flow of a fluid, on top of which is superimposed some degree of backmixing, the magnitude of which is independent of position within the vessel. This condition implies that there exist no stagnant pockets and no gross bypassing or short-circuiting of fluid in the vessel. This is called the dispersed plug flow model, or simply the dispersion model. ***Figure 2.6*** shows the conditions visualized. Note that with varying intensities of turbulence or intermixing the predictions of this model should range from plug flow at one extreme to mixed flow at the other. As a result, the reactor volume for this model will lie between those calculated for plug and mixed flow.

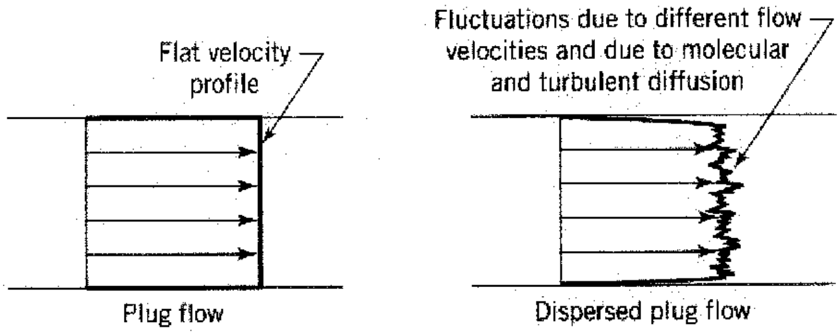

Figure 2.6 Representation of the dispersion (dispersed plug flow) model.

Since the mixing process involves a shuffling or redistribution of material either by slippage or eddies, and since this is repeated many, many times during the flow of fluid through the vessel, these disturbances are considered to be statistical in nature, somewhat as in molecular diffusion. For molecular diffusion in the x-direction, the governing differential equation is given by Fick's law;

$$\frac{\partial C}{\partial t} = \mathscr{D} \frac{\partial^2 C}{\partial x^2} \tag{21}$$

where $\mathscr{D}$, the coefficient of molecular diffusion, is a parameter which uniquely characterizes the process. In an analogous manner, it can be considered that all the contributions to intermixing of fluid flowing in the x-direction to be described by a similar form of expression, or

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} \tag{22}$$

where the parameter *D*, which is called the longitudinal or axial dispersion coefficient, uniquely characterizes the degree of backmixing during flow. The terms longitudinal and axial are used because it is to distinguish mixing in the direction of flow from mixing in the lateral or radial direction, which is not the primary concern. These two quantities may be quite different in magnitude. For example, in streamline flow of fluids through pipes, axial mixing is mainly due to fluid velocity gradients, whereas radial mixing is due to molecular diffusion alone.

In dimensionless form where $z = (ut + x)/L$ and $\theta = t/t_m = tu/L$, the basic differential equation representing this dispersion model becomes

$$\frac{\partial C}{\partial \theta} = \left(\frac{D}{uL}\right)\frac{\partial^2 C}{\partial z^2} - \frac{\partial C}{\partial z} \tag{23}$$

where the dimensionless group $\left(\frac{D}{uL}\right)$, called the vessel dispersion number, is the parameter that measures the extent of axial dispersion. Thus

$\left(\frac{D}{uL}\right) \to 0$ negligible dispersion, hence plug flow

$\left(\frac{D}{uL}\right) \to \infty$ large dispersion, hence mixed flow

The dispersion model usually represents quite satisfactory flow that deviates not too greatly from plug flow, thus real packed bed and tubes (not long ones if flow is streamline).

The bed Peclet number (henceforth only Peclet number) of liquid is the reciprocal of the dispersion number, $\left(\frac{D}{uL}\right)$, i.e.

$$\mathrm{Pe} = \frac{1}{D/uL} \tag{24}$$

which the dispersion number is also defined by introduce a tracer at the inlet or some point within the reactor. Then, at some point along the reactor or at an exit, the tracer is collected to measure the concentration subsequent time interval. In order to illustrate the RTD of the actual flow, the stimulus-response experiment can be conducted with an appropriate choice of tracer. The packed bed reactor presumably behaves as a plug flow reactor. However, deviation from the ideal plug flow can occur due to short-circuiting, channeling or an existence of dead zone (***Figure 2.7***). Arrangement of packing and adequate distribution of liquid can disrupt the ideal behavior of plug flow due to the channeling of liquid.

Sata et al. [10] considered an ideal plug flow behavior in which the tracer should emerge in the exit until $T_i = T_d$ at the same concentration of the entrance. The mean residence time, t_m is calculated from RTD analysis, previously mentioned.

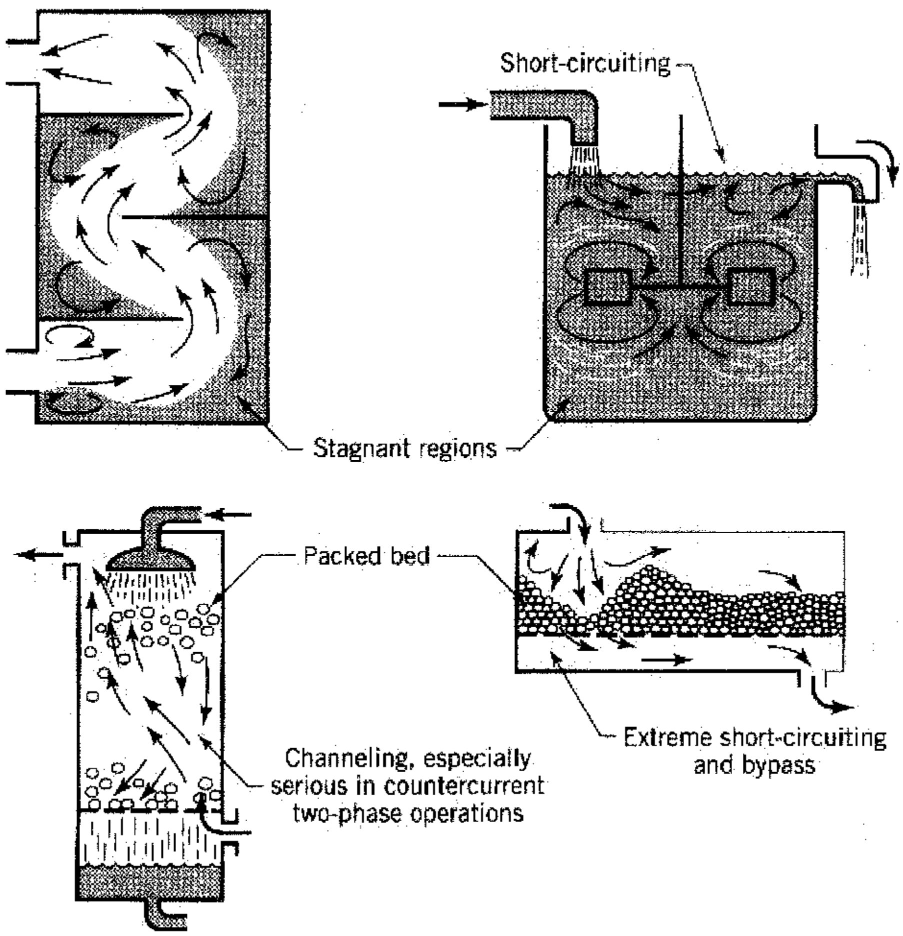

Figure 2.7 Non ideal flow patterns which may exist in process equipment

The mean residence time can be determined by the equation:

$$t_m = \frac{\sum (t_i C_i \Delta t_i)}{\sum C_i \Delta t_i} \tag{27}$$

The mean residence time can also be defined as the reactor volume-volumetric flow rate ratio:

$$T_d = \frac{V}{Q} \tag{28}$$

The stagnant zone volume can be estimated based on the ratio of actual, t_m and theoretical HRT, T_d:

$$V_{stagnant} = V\left(1 - \frac{t_m}{T_d}\right) \tag{29}$$

Study by Sata et al. [10] have reported that if the tracer peak emerged earlier than the predicted theoretical HRT, this meant that the effective volume of the reactor is reduced due to a form of channeling in the packing media, which will give low t_m/T_d ratio.

It is also observed that the peak of higher flow rate will appear first, which indicated the phenomenon of channeling. Another deviation is the tailing effect of the tracer toward longer time, which indicated recycling effect and tracer accumulation in the reactor.

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 GENERAL EXPERIMENTAL EQUIPMENT

The SOLTEQ RTD studies in Tubular Reactor (Model BP 112) is utilized for this experiment and is designed for experiment on residence time distribution (RTD) in a packed bed reactor. Process diagram of this experimental instrument is illustrated in ***Figure 3.1***. The unit consisted of a reactor, a system for feeding controlled and measured amounts of gas and liquid, tracer injection, and conductivity measurement instrument for detecting the concentration of the tracer. The liquid phase is de-ionized water and the gas phase is air.

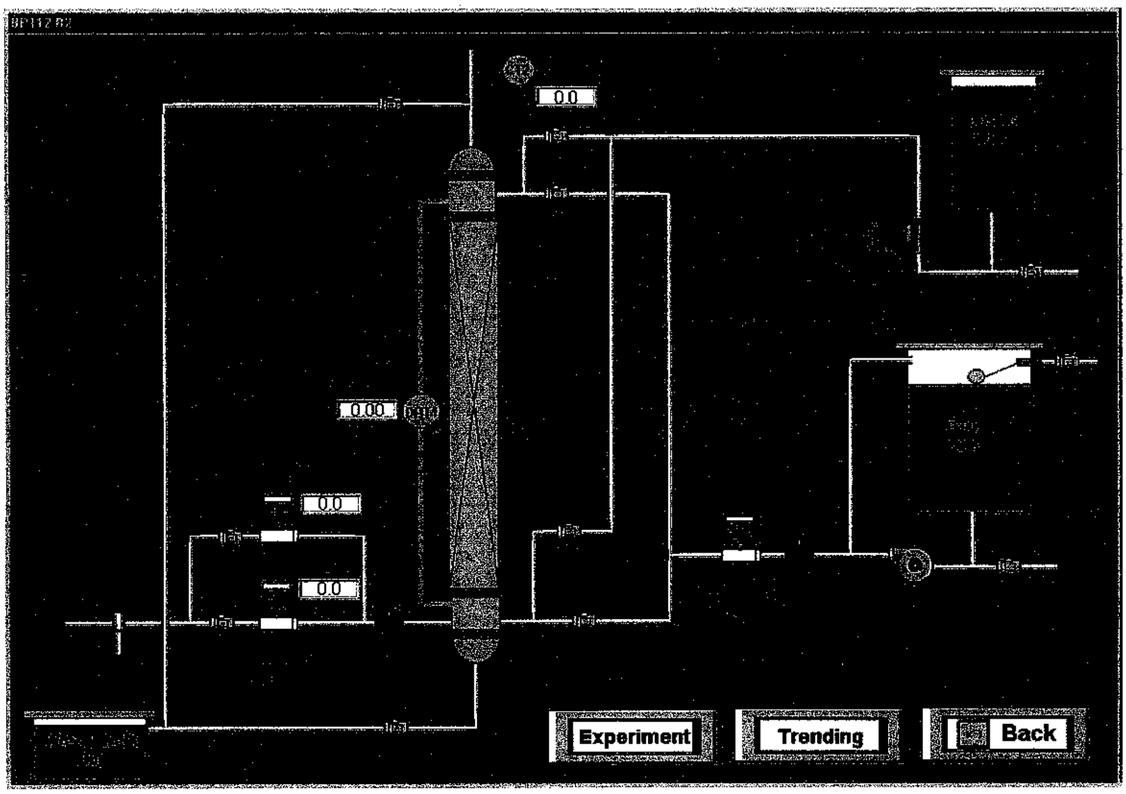

Figure 3.1 Process Diagram for RTD Studied in Tubular Reactor (BP 112).

a) *Reactor*

A column made of borosilicate glass packed with 8 x 8 mm Raschig rings. Column OD: 100 mm; ID: 82 mm; Height: 1500 mm. Top and bottom caps made of stainless steel fitted with appropriate inlet and outlet ports. A differential pressure tapping is also provided on both caps.

b) *Feed Tank*

20-L stainless steel cylindrical tank, equipped with circulation pump. The tank is fitted with a level switch to protect the pump from dry run.

c) *Dosing Tank*

20-L stainless steel cylindrical tank equipped with a metering pump.

d) *Waste Tank*

50-L rectangular tank made of stainless steel.

e) *Instrumentations*

Air Flowmeter;

Fluid	:	Compressed air (0.34 Mpa)
Range	:	0 to 50 LPM
Output	:	0 to 5 VDC
Display	:	LCD digital display

Liquid Flowmeter;

Fluid	:	De-ionized water
Range	:	0 to 5 LPM
Output	:	0 to 5 VDC
Display	:	LCD digital display

Conductivity Meter;

Sensor Range	:	0 to 200 mS/cm
Sensors	:	CT2 (Co-current Upflow)
Output	:	4 to 20 mA
Display	:	Conductivity controller with digital display

g) *Data Acquisition System (DAS)*

DAS is consisted of a personal computer, ADC modules and instrumentations for measuring the process parameters. A flowmeter with 0 to 5 VDC output signal is supplied for feed flowrate measurement. Conductivity sensors with controller are provided for monitoring the tracer concentration in each reactor. All analog signals from the sensors are then converted by the ADC modules into digital signals before being sent to the personal computer for display and manipulation.

3.2 EXPERIMENTAL GAS AND LIQUID FLOW RATES

The gas and liquid flow rates used in the experiment are maintained close to those typically used for testing different hydroprocessing catalysts in a bench-scale unit. The level of these flow rates depend on the type of catalyst to be tested.

For atmospheric gas oil hydrotreating catalyst, gas/liquid ratio (hydrogen/oil ratio) of approximately 150 – 250 (v/v) is required. The values of gas/liquid ratio are used in this experiment, which is summarized in ***Table 3.1***.

Gas/Liquid Ratio (LPM/LPM)	Gas Flow Rates (LPM)	Liquid Flow Rates (LPM)
150	7.5	0.05
	15.0	0.10
	22.5	0.15
200	10.0	0.05
	20.0	0.10
	30.0	0.15
250	12.5	0.05
	25.0	0.10
	37.5	0.15

Table 3.1 Experiment gas and liquid flow rates with specified gas/liquid ratio.

3.3 PROCEDURE IDENTIFICATION

3.3.1 General Start-up Procedure

1. A quick inspection is performed to ensure that the equipment is in proper working condition.
2. 10 liter of 0.2M NaCl solution is prepared for tracer solution.
3. The system is flushed with de-ionized water until no traces of salt is detected.
4. The equipment is ready to be run.

3.3.2 Determination of Experimental Pressure Drop and Liquid Holdup

1. General start-up procedure is performed.
2. Valves are set appropriately for co-current upflow mode.
3. Gas and liquid flow rates are adjusted to obtain desired gas/liquid ratio.
4. Conductivity reading is observed and stabilized at low value.
5. The system is maintained approximately 30 minutes to attain steady state, which the flow rates did not change after 30 minutes of operation.
6. The pressure drop is obtained from the differential pressure reading at control panel or via the DAS.
7. The liquid holdup is determined as follows;
    a. After attaining steady state, the gas and liquid flows are stopped simultaneously.
    b. The total free liquid in the reactor is drained in a liquid collector and measured.
    c. The liquid holdup is expressed as (Volume of Liquid) / (Volume of Column).
8. Gas and liquid flow rates are varied to obtain required gas/liquid ratio as per commercial reactors.
9. Data are recorded in Appendices.

3.3.3 Residence Time Distribution (RTD) Analysis

1. The general start-up procedure is performed.
2. The valves are set appropriately for co-current upflow mode.
3. Gas and liquid flow rates are adjusted to obtain desired gas/liquid ratio.
4. Conductivity reading is observed and stabilized at low value.
5. Tracer is introduced in the system for two minutes. The conductivity reading is recorded at 1 minute interval, until the reading is constant.
6. Experiment is stopped by closing the inlet and outlet valves simultaneously.
7. From the concentration-time data from experiment, E curve and F curve are constructed.
8. The values of hydrodynamics parameters are determined by utilizing the RTD analysis. Mean Residence Time (t_m), Variance (σ^2), Skewness (s^3), Axial Dispersion (expressed by Peclet number of liquid, Pe) and Stagnant Zone Volume ($V_{stagnant}$) are calculated as outlined in Chapter 2, and summarized in Chapter 4.
9. The experiment is repeated with different gas and liquid flow rates.
10. Data are recorded in Appendices.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 EFFECT OF GAS/LIQUID RATIO ON PRESSURE DROP AND OPERATING LIQUID HOLPUP

4.1.1 Effect of Gas/Liquid Ratio on Pressure Drop

Pressure drop analysis across the reactor is done by investigating the effect of gas/liquid ratio, as well as comparing the experimental value with Ergun [1] correlation. The pressure drop throughout the experiment is recorded and the result is shown in ***Figure 4.1***, ***Figure 4.2*** and ***Figure 4.3***. For all constant liquid flow rates, the pressure drop increases with increasing gas/liquid ratio, both experimentally and theoretically.

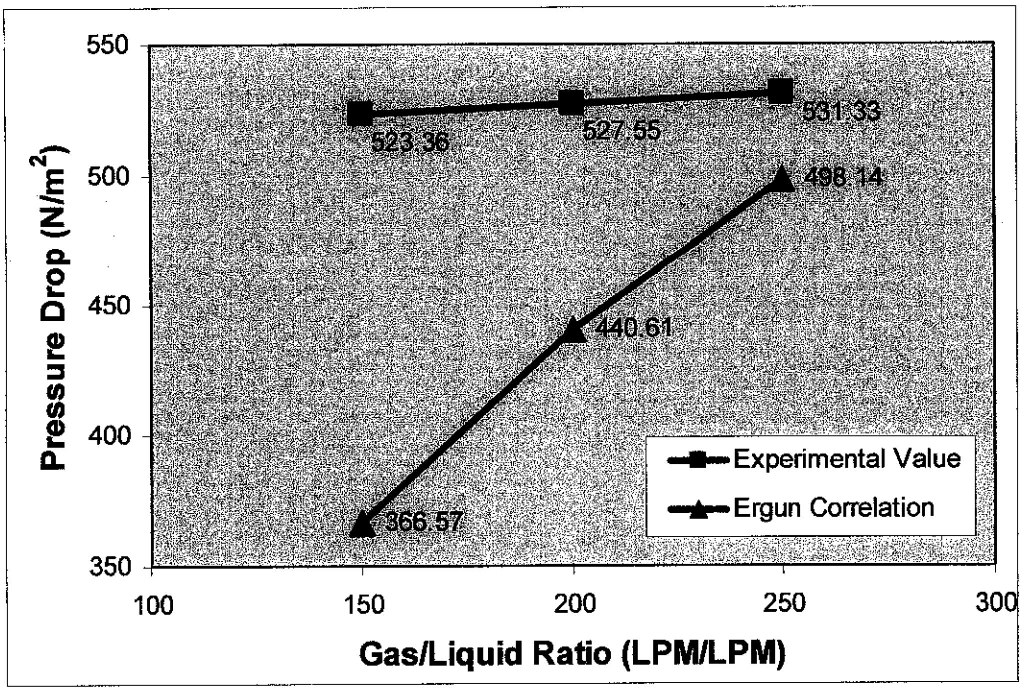

Figure 4.1 Effect of gas/liquid ratio on pressure drop at constant liquid flow rates of 0.05 LPM.

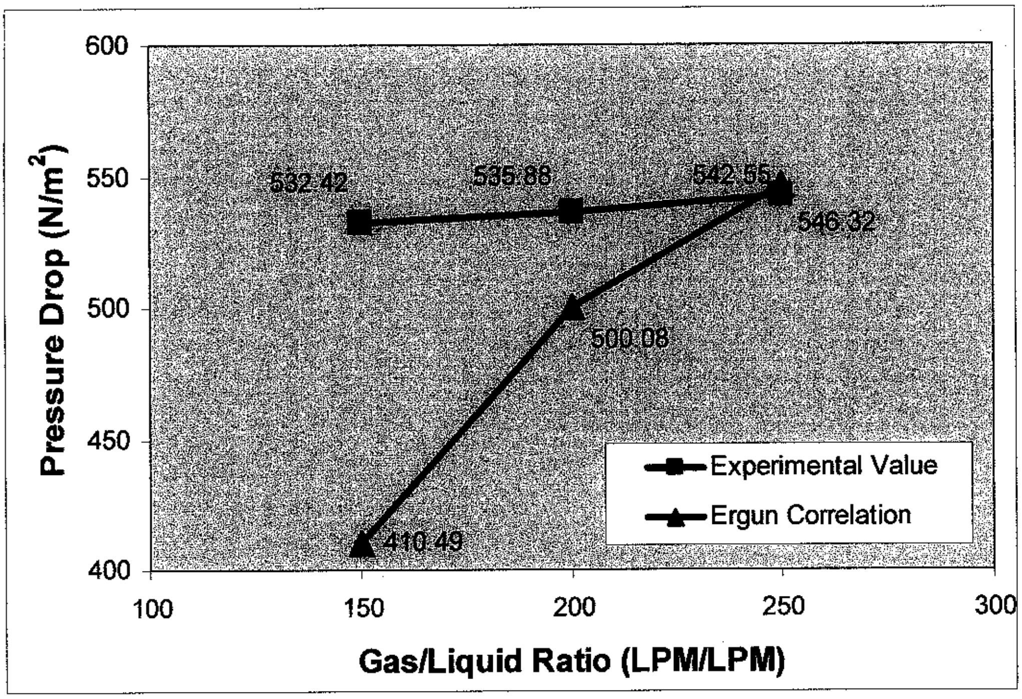

Figure 4.2 Effect of gas/liquid ratio on pressure drop at constant liquid flow rates of 0.10 LPM.

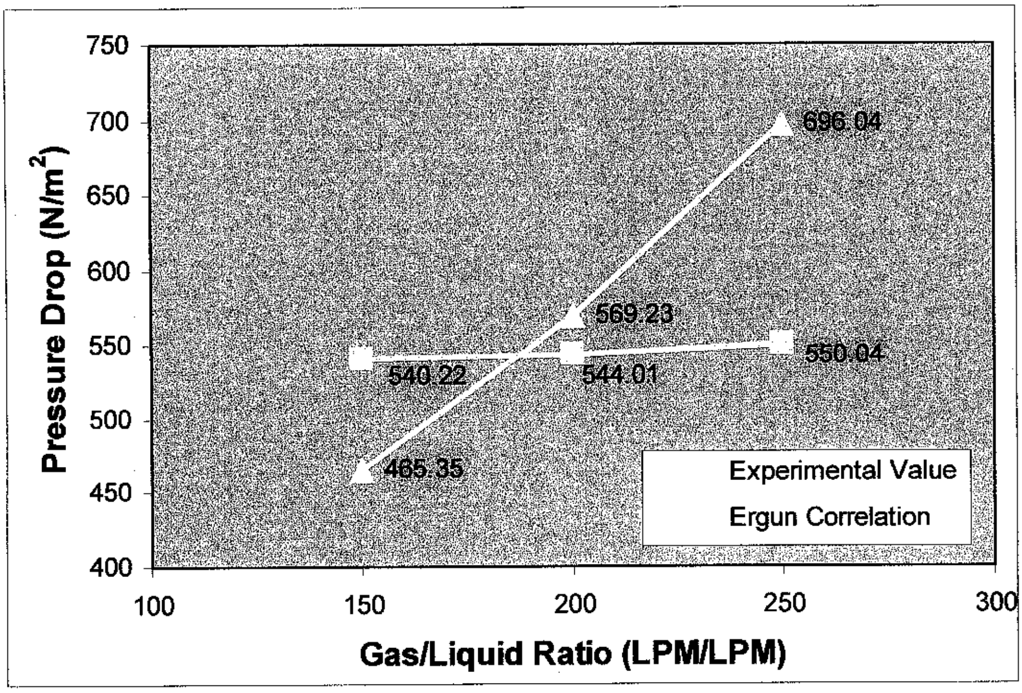

Figure 4.3 Effect of gas/liquid ratio on pressure drop at constant liquid flow rates of 0.10 LPM.

Observing the values of pressure drop for every constant liquid flow rates of 0.05, 0.10 and 0.15 LPM, the pressure increases with increasing variation of liquid flow rates, for both experimental value and Ergun [1] correlation.

However, there is a small deviation between experimental values and the values calculated from Ergun [1] correlation. This may be due to experimental error involved in data gathering. However, the results obtained in this experiment is in strong agreement with results obtained by Varma et al. [3], who shows that the pressure drop increased with the gas and liquid flow rates in all the regimes in upflow mode of operation.

4.1.2 Effect of Gas/Liquid Ratio on Operating Liquid Holdup

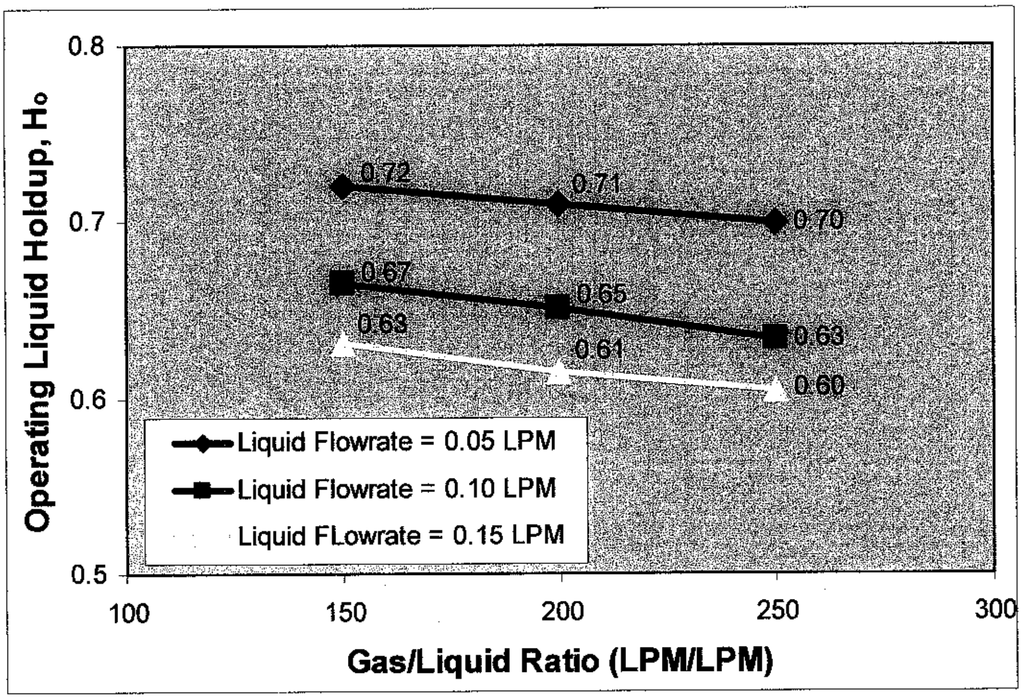

Figure 4.4 Effect of gas/liquid ratio on operating liquid holdup at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

Figure 4.4 shows that the operating liquid holdup decreases with increasing gas/liquid ratio. This is similar to the findings by Chander et al. [5]. Also, as the liquid flow rates increase, the operating liquid holdup decreases. Thus, higher liquid flow rates could increase the reaction rate.

However, Buchanan [4] correlation does not agree with the experimental results. From ***Figure 4.5***, it is observed that operating liquid holdup is increasing with increasing liquid flow rates, and it is rather constant for gas/liquid ratio. For liquid flow rate of 0.05 LPM, the operating liquid holdup is approximately 0.03, regardless of the gas flow rate. This can be due to the basis of this correlation which only emphasized on only liquid phase in equation (2), and not both gas and liquid phases. Also, it might be because the correlation has used different condition against the condition being used in this experiment during that time. This can also be true if the correlation agrees with Chander et al. [5], which proved that the effect of gas flow rate on liquid holdup in upflow mode could be removed, if the catalyst bed was diluted with a smaller size of diluent. However, Buchanan [4] correlation might not be appropriate in this experiment; thus, results would be only based on the experiment.

Thus, from the experimental results, operating the packed bed reactor at lower gas/liquid ratio (150) with higher gas and liquid flow rates (L = 0.15 LPM) is more desirable.

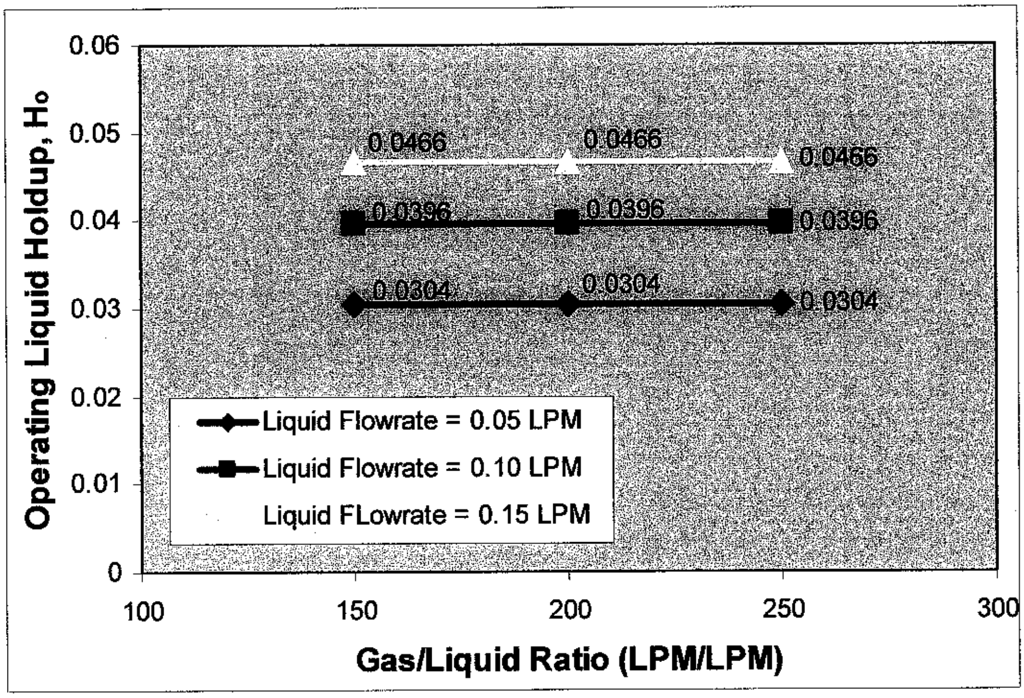

Figure 4.5 Buchanan correlation on effect of gas/liquid ratio on operating liquid holdup.

4.2 EFFECT OF GAS/LIQUID RATIO ON MOMENTS OF RTD

For this experiment, RTD experiment with pulse input is used. An amount of tracer (NaCl) is injected in one shot into the feedstream entering the reactor in as short time as possible. The outlet conductivity is then measured as a function of time. The effluent concentration-time curve is referred as *C* curve in RTD analysis. However, the consideration is more to the *E* curve, *F* curve and the three moments of RTD.

4.2.1 *E* Curve

All three *E* curves (***Figure 4.6***, ***Figure 4.7*** and ***Figure 4.8***) showed that at any gas/liquid ratio, with low liquid flow rate, which in this case is 0.05 LPM, the *E* curve exhibited deviation from ideal plug flow reactor and approached mixed flow behavior. However, as the liquid flow rates are increased, the *E* curves approach the behavior of a plug flow.

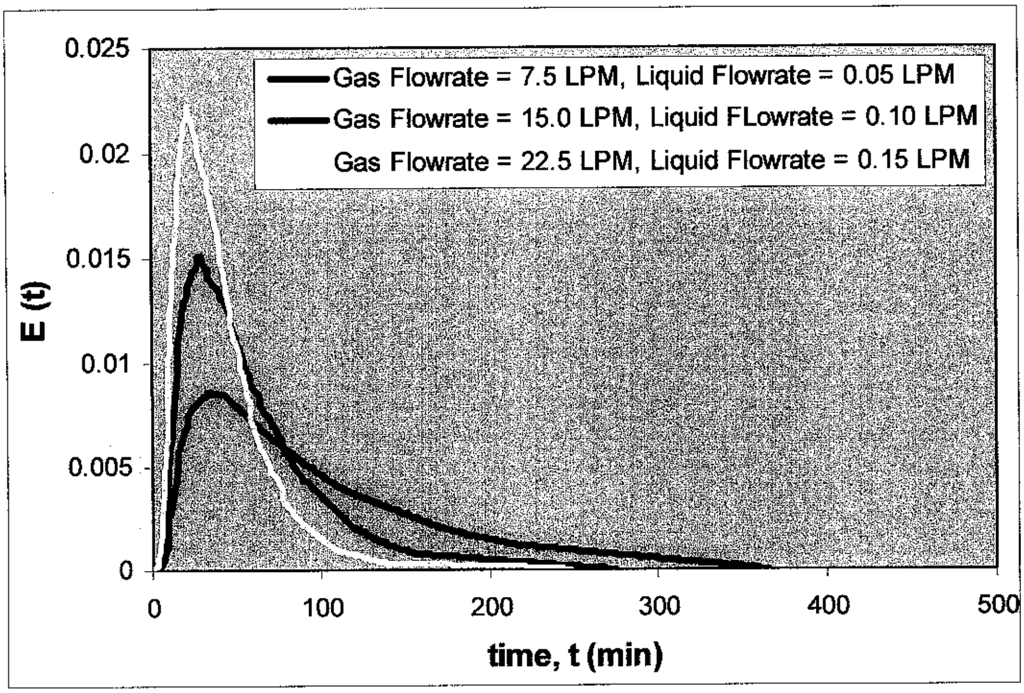

Figure 4.6 *E* curves for gas/liquid ratio of 150.

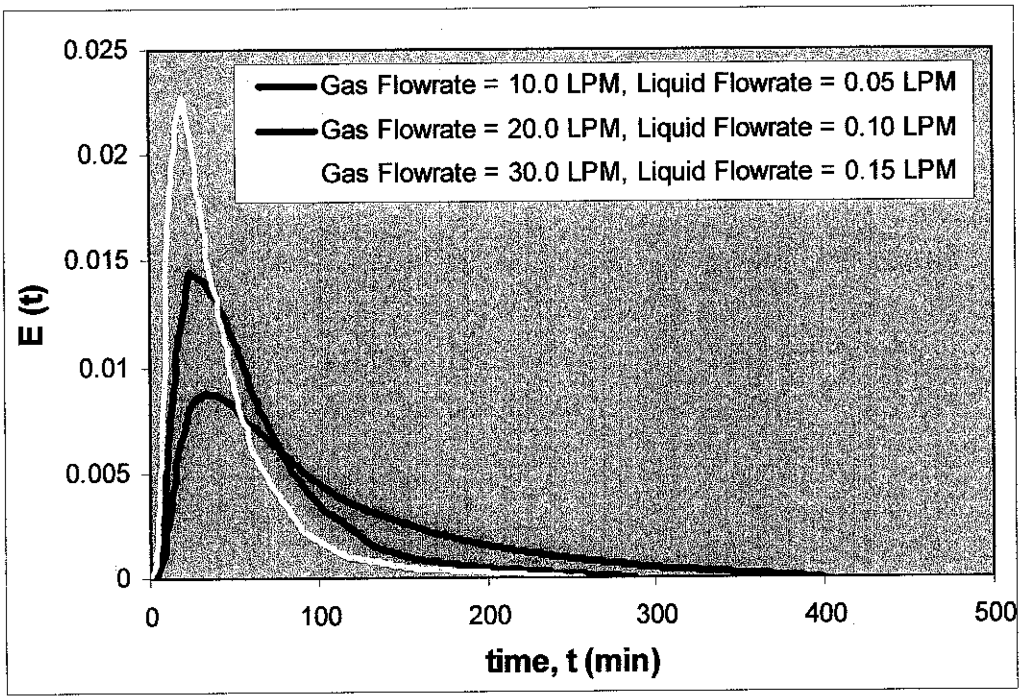

Figure 4.7 *E* curves for gas/liquid ratio of 200.

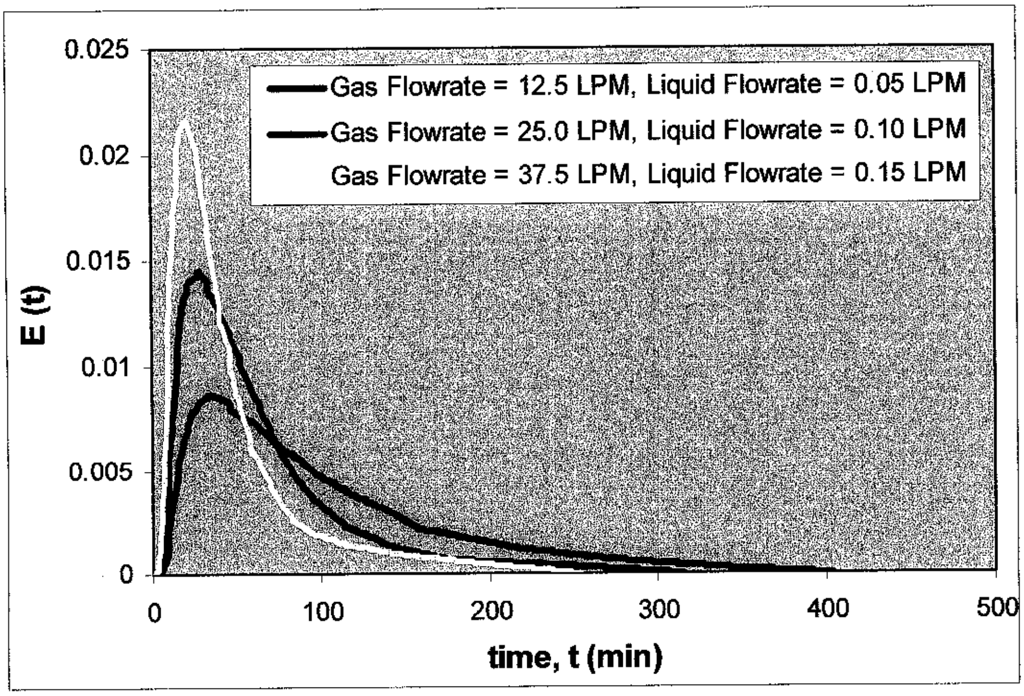

Figure 4.8 *E* curves for gas/liquid ratio of 250.

4.2.2 *F* Curve

F curve is used to determine the percentage of molecules spent at specific time or less in the reactor. For this experiment, comparison at constant liquid flow rate of 0.15 LPM for all gas/liquid ratios is investigated.

From ***Figure 4.9***, approximately 94.8% $[F(t)]$ of the molecules spend 100 minutes or less in the reactor and 5.2% of the molecules $[1 - F(t)]$ spend longer than 100 minutes in the reactor. As in ***Figure 4.10***, 92.7% of the molecules have spent 100 minutes or less and in ***Figure 4.11***, 89% of the molecules have spent 100 minutes or less in the reactor.

Thus, from the *F* curve interpretation, as gas/liquid ratio is increased, the longer the molecules would spend in the reactor. This is desirable as the molecules would have more contact with catalyst thus utilizing the catalyst. However, this statement is true for constant liquid flow rates of 0.10 and 0.15 LPM, and this is not the case for constant liquid flow rate of 0.05 LPM. This is an indication that the molecules would spent consistent time at any gas/liquid ratio, may be due to low liquid flow rate, which has no effect in the mixing rate of the molecule in the reactor.

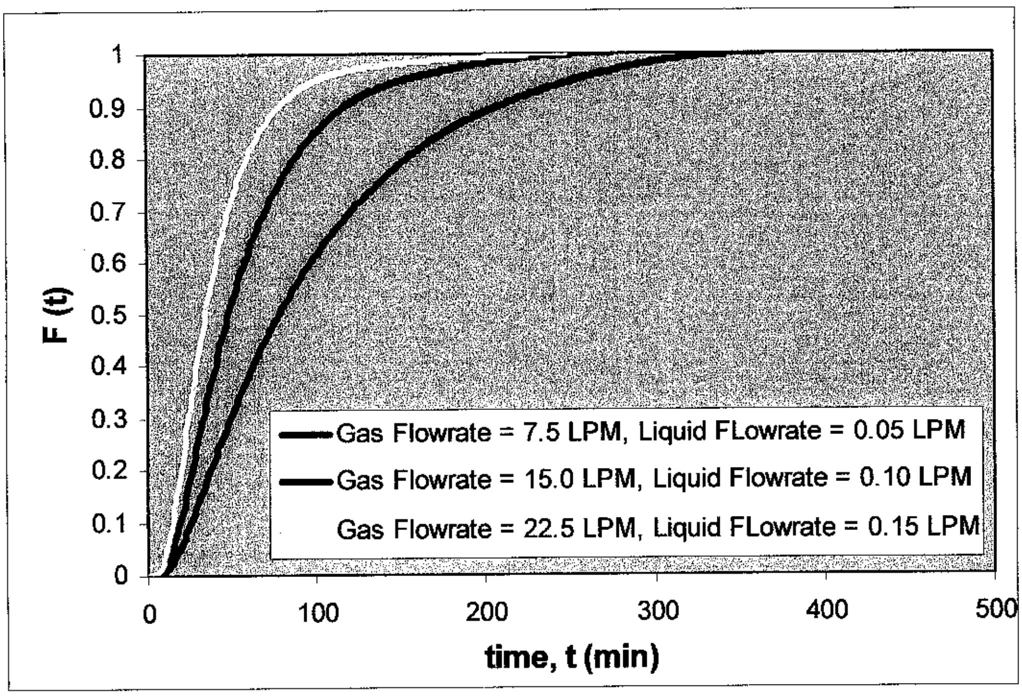

Figure 4.9 *F* curves for gas/liquid ratio of 150.

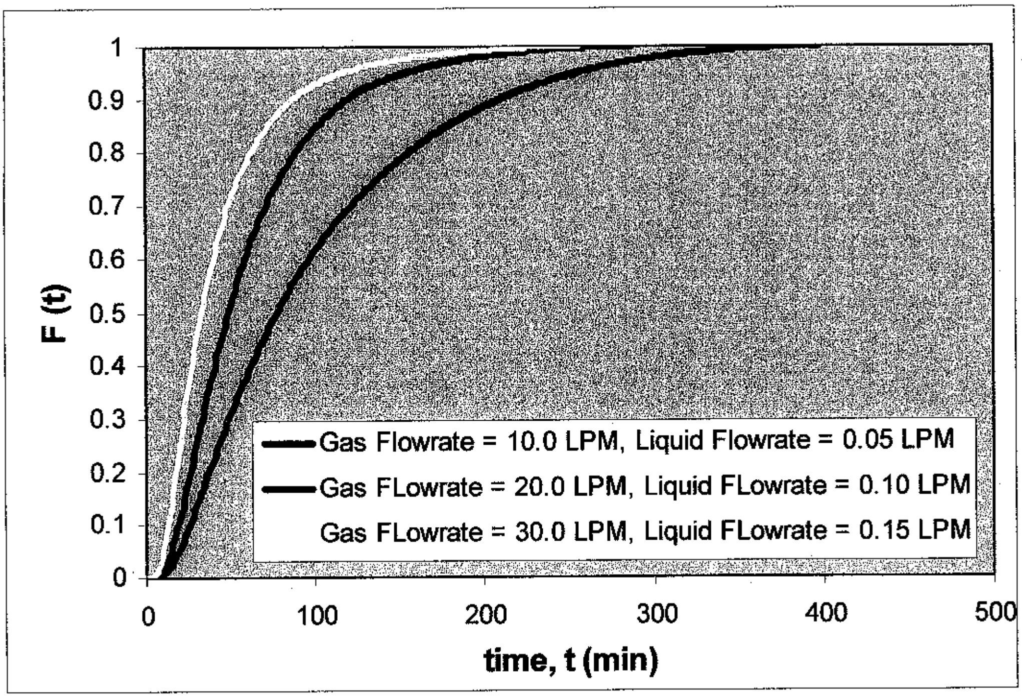

Figure 4.10 *F* curves for gas/liquid ratio of 200.

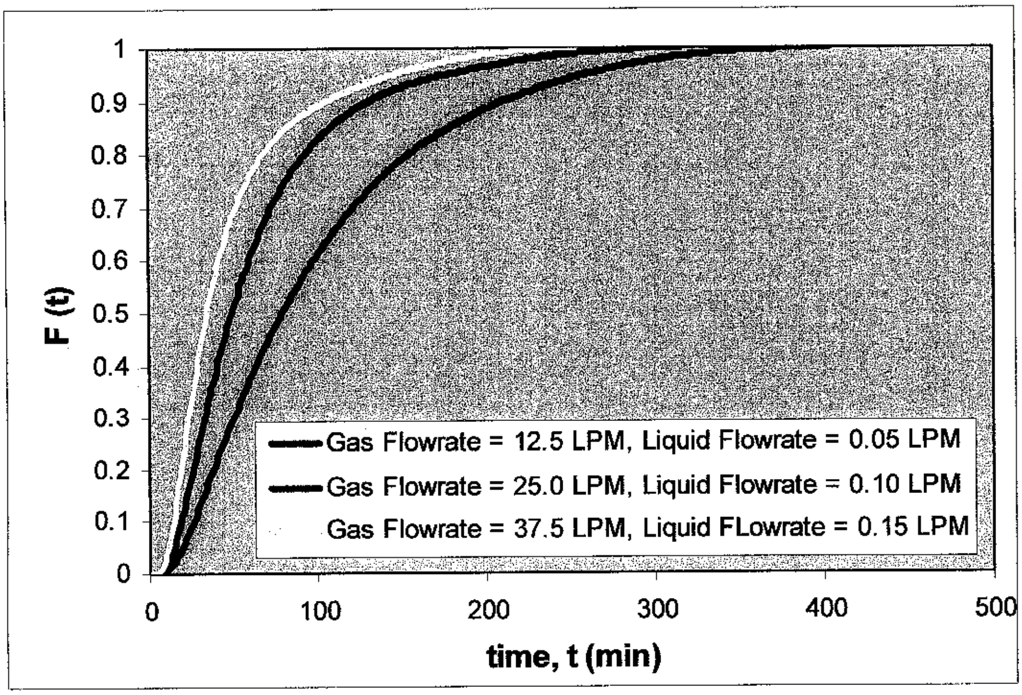

Figure 4.11 *F* curves for gas/liquid ratio of 250.

4.2.3 Three Moments Analysis of RTD

4.2.3.1 First Moment Analysis: Mean Residence Time, t_m

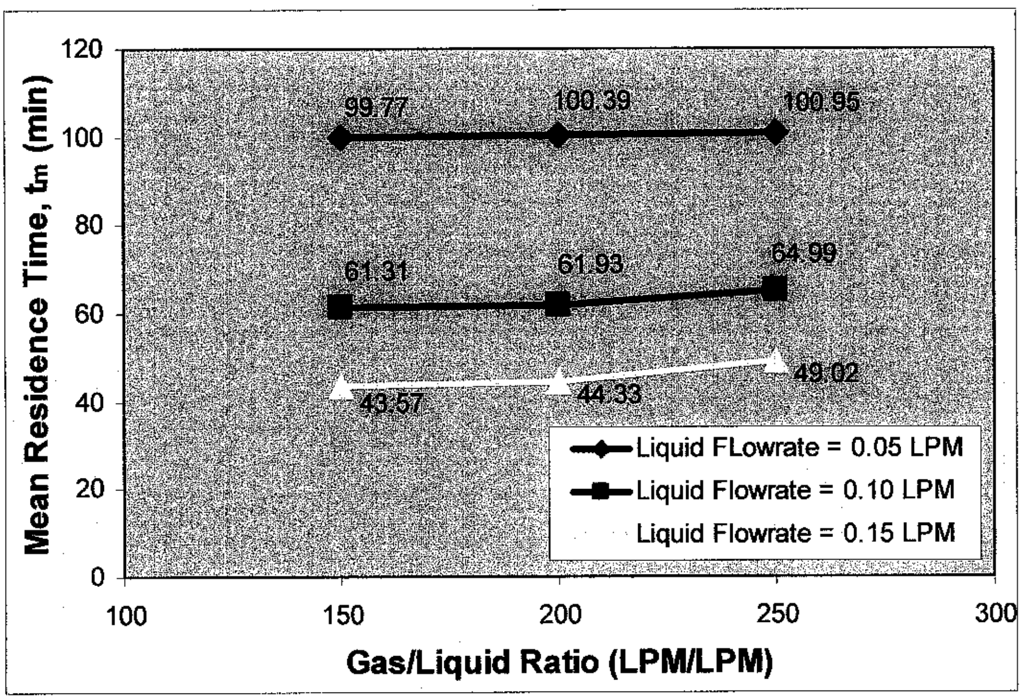

Figure 4.12 Effect of gas/liquid ratio on mean residence time of liquid at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

Experimentally, it is observed that there is a considerable increase in mean residence time as the gas/liquid ratio is increased, illustrated in ***Figure 4.12***. Also, the mean residences time is increased with decreasing variation of liquid flow rates. These results are also agreed with Chander et al. [5], which proved that the mean residence time is increased with gas/liquid ratio for upflow mode of operation. The increasing gas flow rate maybe induced circulatory motion of the liquid inside the bed so that the liquid would spend more time in the reactor.

The analysis shows that the mean residence time for this reaction is high. Furthermore, the peak of the *E* curves (***Figure 4.6***, ***Figure 4.7*** and ***Figure 4.8***) occurs earlier than the mean residence time. This is an indication of the possibility of stagnant zone in the reactor. This could be due to excessive liquid holdup inside the catalyst bed. According to Chander et al. [5], the higher mean residence time would provide a better utilization of catalyst or the liquid would also spend undesired longer residence time when not in contact with the catalyst. In this case, the emerging peak of E curves which is earlier than the mean residence time suggests that there would be insufficient contact with catalyst and also, excessive thermal reaction would not likely to occur.

4.2.3.2 Second Moment Analysis: Variance, σ^2

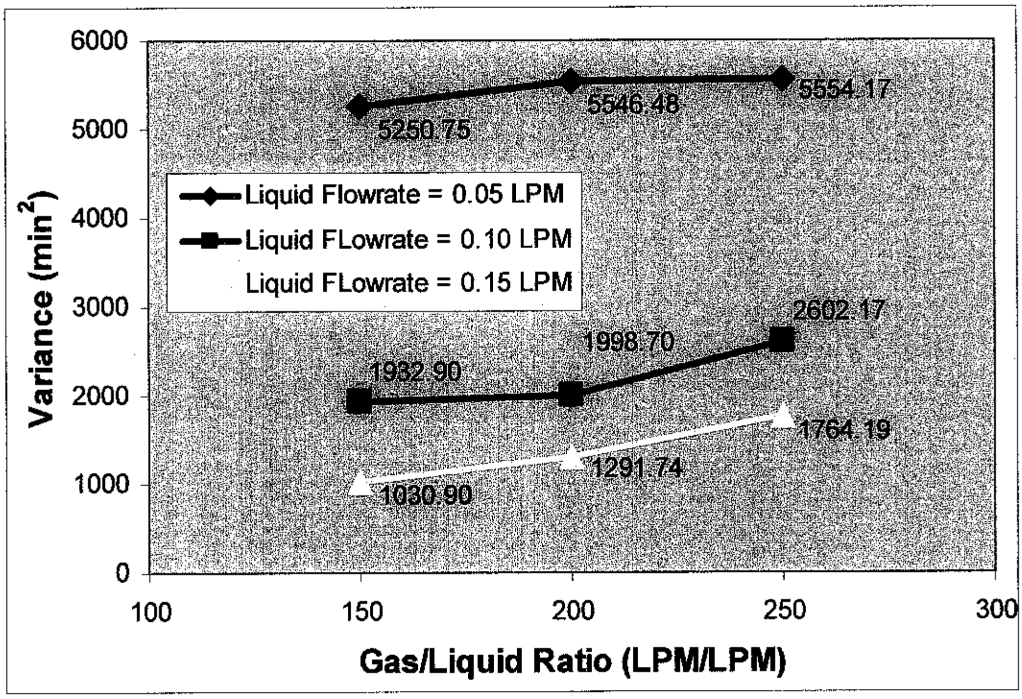

Figure 4.13 Effect of gas/liquid ratio on variance at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

Experimentally, from ***Figure 4.13***, the variance increases as the gas/liquid ratio increases. The variance is also increased with decreasing variation of liquid flow rates. These results are also consistent with the E curve in ***Figure 4.6***, ***Figure 4.7*** and ***Figure 4.8***; the E curve for highest constant liquid flow rate (0.15 LPM) has the highest peak among the other constant liquid flow rates for all gas/liquid ratio, which indicates smaller variance, and vice versa. Thus, it is proved that the smaller the variance, the smaller the distribution's spread.

In order to achieve plug flow characteristic, smaller variance is required. Thus, from this experiment, it is proved that operating packed bed reactor at high gas/liquid ratio (250) with lower gas and liquid flow rate (L = 0.05 LPM), would result smaller variance, with approaching plug flow behavior.

4.2.3.3 Third Moment Analysis: Skewness, s^3

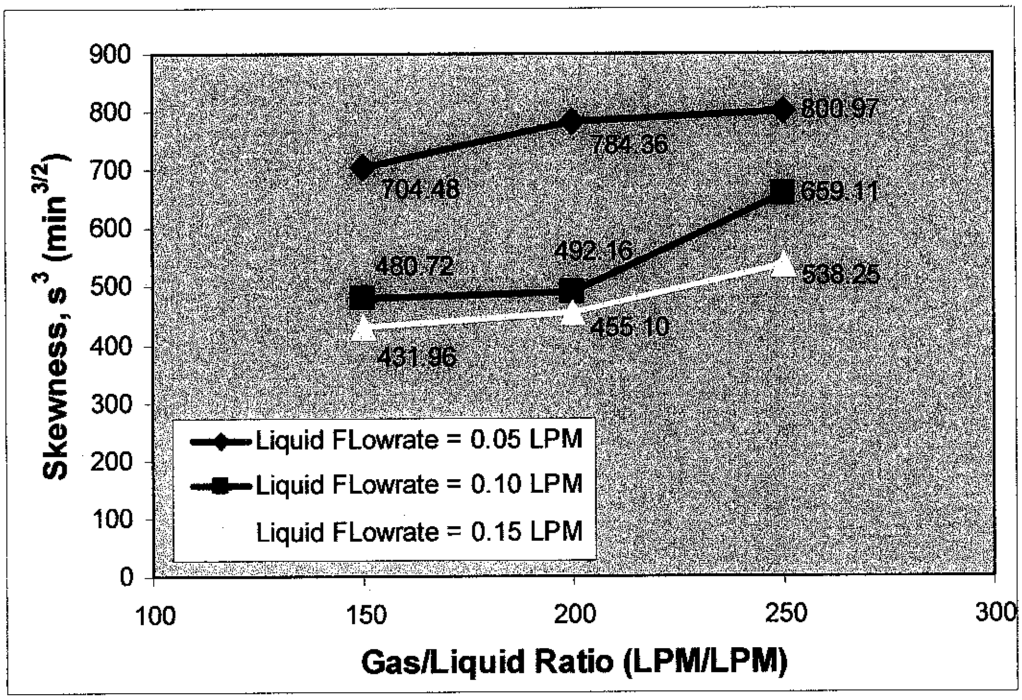

Figure 4.14 Effect of gas/liquid ratio on skewness at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

From ***Figure 4.14***, it is observed that the skewness increases as the gas/liquid ratio increases, and the skewness also increases as variation of liquid flow rates decreases. Again, these results are reflected by the *E* curve in ***Figure 4.6***, ***Figure 4.7*** and ***Figure 4.8***; the *E* curve for highest constant liquid flow rate (0.15 LPM) is not skewed far from the reference of mean compared to other constant liquid flow rates for all gas/liquid ratio, which indicates lowest skewness, and vice versa. Thus, it is proved that the lower the skewness, the less skewed the distribution is, from its mean.

In order to achieve plug flow behavior, it is desirable to have smaller value of skewness, which also meant that the distribution is not skewed much from the reference of the mean. Unlike *E* curve for lower flow rates which has high value of skewness and skewed more towards the left, it is preferred to operate packed bed reactor at higher gas/liquid ratio (250) with lower gas and liquid flow rates (L = 0.05), which will result lesser skewness and will approach the plug flow behavior.

4.3 EFFECT OF GAS/LIQUID RATIO ON AXIAL DISPERSION AND STAGNANT ZONE VOLUME BY RTD ANALYSIS

4.3.1 Effect of Gas/Liquid Ratio on Axial Dispersion

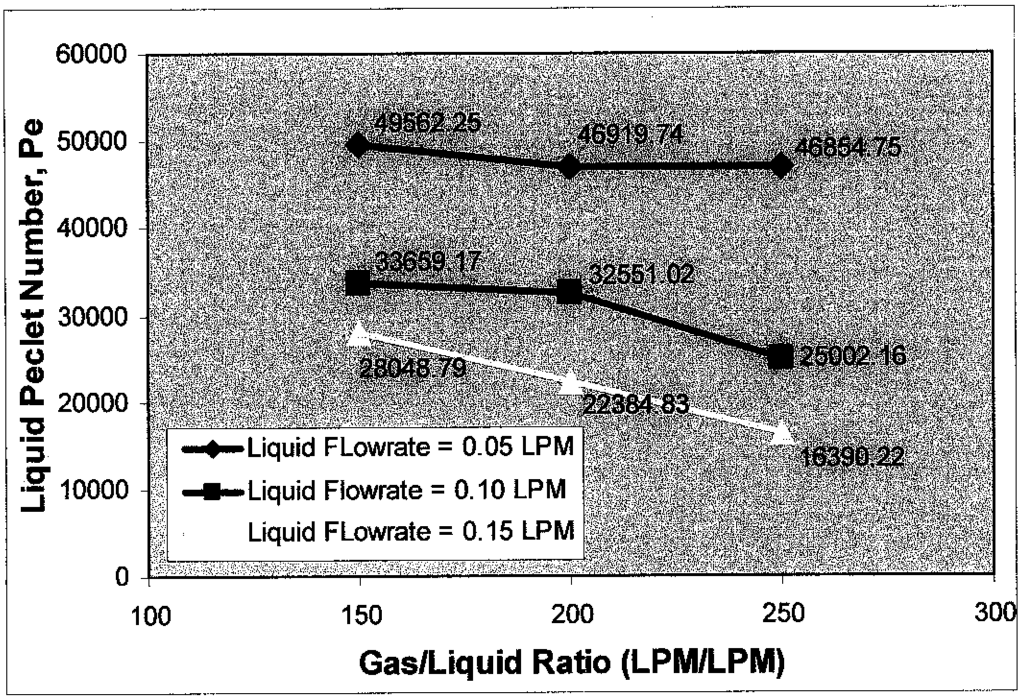

Figure 4.15 Effect of gas/liquid ratio on liquid Peclet number at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

Another analysis in RTD study is the degree (intensity) of liquid-phase axial dispersion. This axial dispersion is conveniently expressed as Peclet number in the analysis.

Experimentally, the Peclet number relatively decreases with increasing gas/liquid ratio, as well as increasing variation of liquid flow rates, as illustrated in ***Figure 4.15***. These results agrees with studies done by Chander et al. [5], who also reported that the Peclet number is a very strong decreasing function of gas/liquid ratio for upflow mode. This might due to the increase of circulatory motion of liquid causing backmixing with increasing gas flow rate. Study by Cassanello et al. [9] also agrees that the gas velocity affects the Peclet number value for upflow mode of operation. Thus, the reduction of backmixing can be achieved at low gas/liquid ratio (150) with lower gas and liquid flow rates (L = 0.05 LPM).

4.3.2 Effect of Gas/Liquid Ratio on Stagnant Zone Volume

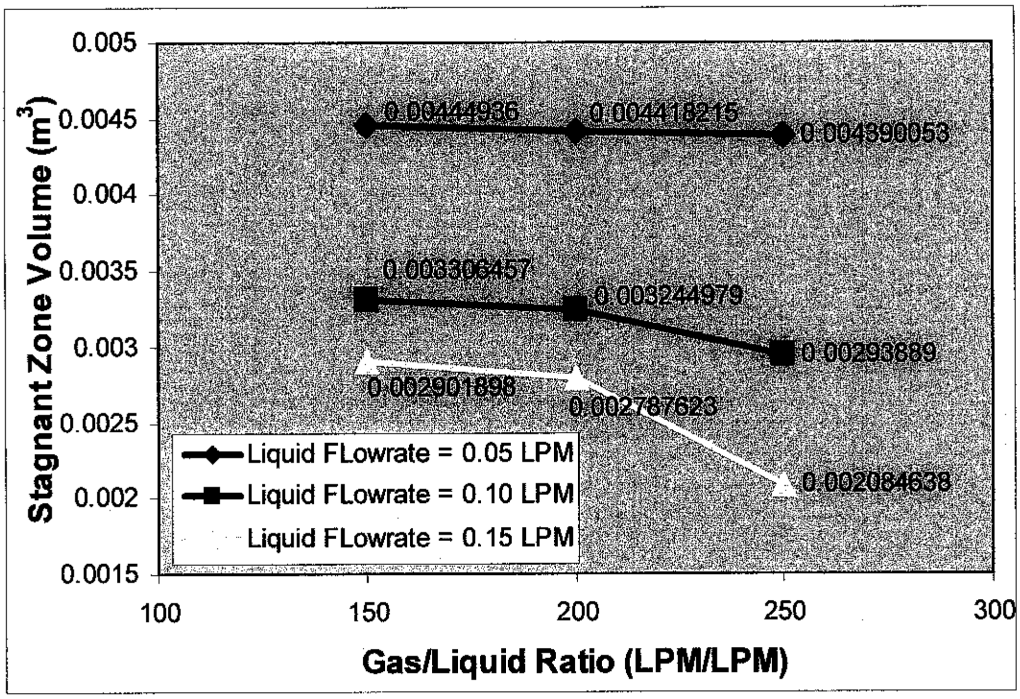

Figure 4.16 Effect of gas/liquid ratio on stagnant zone volume at constant liquid flow rates of 0.05, 0.10 and 0.15 LPM.

From experiment, it is observed that stagnant zone volume can be reduced if the gas/liquid ratio is increased, as illustrated by ***Figure 4.16***. Also, the stagnant zone volume reduces with increasing variation of liquid flow rates. This is with agreement with the theoretical HRT proposed by Sata et al. [10] in equation (28) and (29), which is only influenced by liquid flow rate.

At low gas/liquid ratio with low liquid flow rate, the mean residence time is lower than the predicted theoretical HRT, which means that the effective volume of the reactor is reduced due to a form of channeling in the packing media, which will give low t_m / T_d ratio. Another deviation is the tailing effect of the tracer towards longer time, which indicated recycling effect and tracer accumulation in the reactor.

Thus, to reduce stagnant zone volume effectively, the packed bed reactor must be operated at higher gas/liquid ratio (250) with higher gas and liquid flow rates (L = 0.15 LPM).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Experimentally, pressure drop, ΔP can be reduced with decreasing gas/liquid ratio. Thus, gas and liquid flow rates should be maintain low as to reduce pressure drop across the reactor. Also, the theories introduced in this project are considered parallel with the experimental results.

Operating liquid holdup, H_o , is decreasing with increasing gas/liquid ratio in experiment. Also, the liquid holdup is decreased with increasing liquid flow rates. Thus, for a desirable process, liquid holdup must be maximized, which can be achieved at low gas/liquid ratio (150) with low gas and liquid flow rates (L = 0.05 LPM). However, the theory neglected the effect of gas flow rate and thus constant for same liquid flow rate. Thus, the theory used in this project is considered inappropriate and required the need of other theories in future.

Mean residence time, t_m is increased with increasing gas/liquid ratio. This can be explained by the induced circulatory motion of liquid with higher flow rates. This is desirable for better utilization of catalyst. However, too high mean residence time would also result undesirable thermal reaction. Mean residence time is also increased with decreasing variation of liquid flow rates. Thus, the desirable operation can be done at high gas/liquid ratio (250) with lower gas and liquid flow rates (L = 0.05 LPM).

Variance, σ^2 is decreased if the gas/liquid ratio is decreased. Also, the variance is decreased with increasing variation of liquid flow rates. Variance reflects the spread of distribution. The more the distribution spread, the higher the value of variance, which also results more towards mixed flow behavior. Small variance is desired for a fixed bed reactor to behave more towards plug flow, which can be achieved at low gas/liquid ratio (150), but with higher gas and liquid flow rates (L = 0.15). This is also reflected in the E curves of all gas/liquid ratios.

Skewness, s^3 measured the extent that the distribution is skewed in one direction or another in reference to its mean. From the experiment, skewness can be decreased as the gas/liquid ratio is decreased and with increasing variation of liquid flow rates. Skewness is undesirable because the higher the value of skewness, the further the distribution is skewed from the mean, which will also deviate from plug flow characteristics. Thus, lower value of skewness is preferred to operate the packed bed reactor towards plug flow behavior. This can be done at lower gas/liquid ratio (150) with higher gas and liquid flow rates (L = 0.15 LPM).

Axial dispersion of liquid, expressed by Peclet number, Pe can be increased with decreasing gas/liquid ratio and decreasing variation of liquid flow rates. The increase of circulatory motion of liquid can cause backmixing which is due to the increasing gas flow rates. Thus, it is proved that backmixing can be reduced if this packed bed reactor is operated at low gas/liquid ratio (150) with lower gas and liquid flow rates (L = 0.05 LPM).

Stagnant zone volume, $V_{stagnant}$, can be reduced with higher gas/liquid ratio, as well as higher liquid flow rates. This is mainly because the mean residence time is lower than the predicted HRT. Thus, the effect of non ideal reactor, which is caused by channeling, dead zones, or short-circuiting, can be reduced at higher gas/liquid ratio (250) flow rates with higher gas and liquid flow rates (L = 0.15 LPM).

As overall conclusion, in order to be an ideal reactor, certain requirements must be fulfilled. From the experiment;

- Higher gas/liquid ratio (250) with higher gas and liquid flow rates (L = 0.15 LPM) is desired to reduce the stagnant zone volume.

- Lower gas/liquid ratio (150) with lower gas and liquid flow rates (L = 0.05 LPM) is desired to reduce pressure drop, to increase operating liquid holdup, and to increase the Peclet number (axial dispersion).
- However, there are cases where high gas/liquid ratio (250) is preferred but with lower gas and liquid flow rates (L = 0.05 LPM), in order to increase the mean residence time.
- There are also cases where low gas/liquid ratio (150) is required, but with higher gas and liquid flow rates (L = 0.15 LPM), to obtain lower variance and lower skewness.

5.2 RECOMMENDATIONS

Recommendations outlined here is based on studies that can be done or extended for future development of RTD analysis, or rather the investigation of hydrodynamic characteristics of fixed bed reactor or packed bed reactor.

5.2.1 Comparative Study between Co-current Upflow and Downflow Mode of Operation

Trickle bed reactors with co-current downflow of gas and liquid have found wide application in oil industries for the hydroprocessing of petroleum fractions. However, there are several drawbacks for scaling up and scaling down of commercial reactor. Owing to the differences in the hydrodynamics, a small-scale reactor cannot be treated as an exact replica of a commercial unit.

Two approaches can be recommended to overcome the drawbacks during the testing of commercial catalysts in small reactor. The first one is to use these catalyst particles in a downflow trickle bed reactor but diluted with non-porous inert fine diluent particles. The second approach is to operate the fixed bed catalytic reactor in the upflow mode where wetting of the catalyst is almost complete. However, these two approaches differ in their basic nature and performance; in the upflow mode of operation, liquid is in continuous phase and gas remains in the dispersed phase, whereas the situation is reversed in downflow operation. The upflow mode of operation, though it ensures almost complete wetting of catalyst, suffers from serious drawback of non-ideal flow of liquid and formation of a stagnant zone inside the catalyst bed.

Thus, there is a need to compare the hydrodynamic behavior of a fixed bed reactor in the upflow and downflow modes of operation. There are several theories regarding this comparative study. For example, the downflow mode provided much lower residence time to the liquid as compared to that for the upflow mode of operation, probably owing to channeling of liquid in the former case. On the other hand, the upflow mode of operation gave a much higher liquid holdup as compared to the downflow mode. It is predicted that higher liquid hourly space velocity reduced the channeling of liquid in downflow operation and reduced backmixing in upflow mode. Also, a higher liquid holdup at higher liquid hourly space velocity may be obtained in the downflow mode of operation.

5.2.2 Effect of Diluent Size

When the catalyst was loaded with smaller size of diluent, the values of mean residence time, Peclet number and liquid holdup is expected to increase for the downflow mode. As a result of this, the hydrodynamics behavior for both upflow and downflow modes of operation can be improved.

Since the project study did not discuss the effect of diluent size, future study can be made on investigating the change in the behavior of the upflow mode on using a smaller size of particle as diluent in the catalyst bed. The use of smaller size of diluent can increase the value of Peclet number and moderate the excessive liquid holdup, and thus eliminated the limitations of the upflow mode of operation. The differences in the nature of E curves for the two modes of operation under similar operating conditions of liquid and gas velocities can also be eliminated for the smaller size of diluent. The values of mean residence time, Peclet number and liquid holdup are predicted nearly the same for the two modes of operation. Thus, the use of a smaller size of diluent could remove the drawbacks of both upflow fixed bed and trickle bed reactors, which will provide suitable tools for generating reliable data for scale-up and scale-down activities.

The use of a smaller size of diluent can also decreased the porosity of the bed, which in turn reduced the excessive mean residence time of liquid in the upflow mode of operation. This could help in the reduction of undesirable non-catalytic reaction in the upflow mode.

5.2.3 Effect of Packing Types

The hydrodynamics comparison between different packing types can be done with same variation of gas and liquid flow rates. The effect of packing type can be investigated by RTD analysis to study the hydrodynamics of the reactor at different types of packing.

The comparison can also made by the estimation of stagnant zone volume or by investigation of the effect of packing types on nature of *E* curve. The *E* curve can be a direct indication whether there is non-ideal behavior in the reactor. It is seen if any peak of *E* curve emerges first compared to others, which can be attributed by to the channeling.

Moreover, different types of packing introduced different types of distribution in the reactor. As an example, Raschig rings and Pall rings have different shapes and sizes, which in turn affect the distribution. Also, the different packing types can be studied against pressure drop, which also an effect of the different distribution in the reactor.

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APPENDICES

G =	7.5

L =	0.05

t (min)	C (mS)	C-250	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2*C*\Delta t$	$(t-tm)^3*E*\Delta t$	F (t)	σ^2	s^3
0	250	0		0	0	0	0	0	0	#DIV/0!	0
1	255	5	2.5	4.08811E-05	5	5	48776.38046	-39.38960169	4.08811E-05	9755.276091	-0.063858006
2	260	10	7.5	8.17621E-05	20	10	95567.38489	-76.41051159	0.000122643	9558.738489	-0.123875913
3	265	15	12.5	0.000122643	45	15	140463.0133	-111.1346738	0.000245286	9364.200886	-0.180170357
4	270	20	17.5	0.000163524	80	20	183433.2657	-143.6330512	0.000408811	9171.663284	-0.232856383
5	275	25	22.5	0.000204405	125	25	224528.142	-173.9756255	0.000613216	8981.125682	-0.282047444
6	280	30	27.5	0.000245286	180	30	263777.6424	-202.2313976	0.000858502	8792.588079	-0.327855402
7	310	60	45	0.000490573	420	60	516363.0286	-391.6600915	0.001349075	8606.050477	-0.634955197
8	370	120	90	0.000981146	960	120	1010581.545	-756.260694	0.002330221	8421.512874	-1.229284539
9	400	150	135	0.001226432	1350	150	1235846.291	-917.1772954	0.003556653	8238.975272	-1.486918128
10	520	270	210	0.002207578	2700	270	2175778.171	-1596.953527	0.005764231	8058.43767	-2.588964163
11	580	330	300	0.002698151	3630	330	2600367.022	-1867.327388	0.008462381	7879.900067	-3.059715191
12	640	390	360	0.003188723	4680	390	3004311.361	-2155.943344	0.011651105	7703.362465	-3.49519254
13	700	450	420	0.003679296	5850	450	3387971.188	-2403.563182	0.015330401	7526.624862	-3.896631202
14	760	510	480	0.004169869	7140	510	3751706.503	-2630.936906	0.01950027	7358.28726	-4.265247077
15	850	600	555	0.004905726	9000	600	4311449.794	-2988.21342	0.024405998	7185.749657	-4.844459982
16	940	690	645	0.005641587	11040	690	4841676.316	-3316.257377	0.030047586	7017.212055	-5.376261375
17	970	720	705	0.005886874	12240	720	4932485.606	-3337.987675	0.035934459	6850.674453	-5.411510304
18	1030	780	750	0.006377447	14040	780	5215186.743	-3486.661064	0.042311906	6686.13685	-5.652538029
19	1060	810	795	0.006622733	15390	810	5264115.391	-3489.539688	0.048934639	6523.599248	-5.657205149
20	1090	840	825	0.00686802	16800	840	5344971.782	-3486.026761	0.055802659	6363.061645	-5.651509737
21	1120	870	855	0.007113306	18270	870	5397935.917	-3478.435671	0.062915965	6204.524043	-5.635960731
22	1150	900	885	0.007358592	19800	900	5443187.797	-3461.074597	0.070274557	6047.986441	-5.61105752
23	1180	930	915	0.007603879	21390	930	5480907.42	-3440.245712	0.077878436	5893.448838	-5.577289953
24	1210	960	945	0.007849165	23040	960	5511274.786	-3414.245284	0.085727601	5740.911236	-5.535138333
25	1220	970	965	0.007930927	24250	970	5422682.424	-3315.012909	0.093658529	5590.373633	-5.374263856
26	1230	980	975	0.008012689	25480	980	5332999.31	-3216.5958	0.101671218	5441.836031	-5.214711081
27	1240	990	985	0.008094452	26730	990	5242345.444	-3119.05543	0.10976567	5295.298429	-5.056579666
28	1250	1000	995	0.008176214	28000	1000	5150760.826	-3022.451309	0.117941883	5150.760826	-4.899966086
29	1260	1010	1005	0.008257976	29290	1010	5058305.456	-2926.840983	0.126199659	5008.223224	-4.744963637
30	1270	1020	1015	0.008339738	30600	1020	4965039.334	-2832.280037	0.134539597	4867.685621	-4.591682432
31	1280	1030	1025	0.0084215	31930	1030	4871022.46	-2738.822095	0.142961098	4729.148019	-4.440149405
32	1285	1035	1032.5	0.008462381	33120	1035	4753351.761	-2633.795169	0.151423479	4592.610417	-4.269880663
33	1290	1040	1037.5	0.008503262	34320	1040	4638395.727	-2531.082568	0.159926741	4458.072814	-4.103364282
34	1295	1045	1042.5	0.008544143	35530	1045	4520184.296	-2430.682697	0.168470885	4325.535212	-3.940597397
35	1300	1050	1047.5	0.008585024	36750	1050	4404747.49	-2332.593777	0.177055909	4194.997609	-3.781576354
36	1299	1049	1049.5	0.008576848	37764	1049	4265716.647	-2224.090646	0.185632757	4066.460007	-3.605872225
37	1298	1048	1048.5	0.008568672	38776	1048	4129038.68	-2119.088632	0.194201429	3939.922405	-3.435411647
38	1297	1047	1047.5	0.008560496	39786	1047	3994707.888	-2017.466988	0.202761925	3815.384802	-3.270696136
39	1296	1046	1046.5	0.00855232	40794	1046	3862716.171	-1919.225162	0.211314245	3692.8472	-3.111427528
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49	1236	986	990.5	0.008061747	48314	986	2541388.579	-1054.920854	0.294891502	2577.471176	-1.710226529
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51	1218	968	972.5	0.007914575	49368	968	2302287.3	-918.0235772	0.310794237	2378.395971	-1.486290111
52	1209	959	963.5	0.007840989	49868	959	2188302.175	-854.6806501	0.318635226	2281.858368	-1.385599228
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55	1182	932	936.5	0.007620231	51260	932	1867956.863	-683.7456009	0.341716678	2004.245561	-1.108481134
56	1173	923	927.5	0.007546645	51688	923	1768198.446	-632.7729324	0.349263323	1915.707959	-1.025844784
57	1164	914	918.5	0.007473059	52098	914	1671861.706	-584.6260717	0.356736383	1829.170356	-0.947792845
58	1155	905	909.5	0.007399473	52490	905	1578892.642	-539.208648	0.364135856	1744.632754	-0.874159356
59	1146	896	900.5	0.007325888	52864	896	1489237.256	-496.4140566	0.371461743	1662.095162	-0.804781217
60	1137	887	891.5	0.007252302	53220	887	1402841.546	-456.1454595	0.378714045	1581.557549	-0.739498193
61	1128	878	882.5	0.007178716	53558	878	1319651.513	-418.3057837	0.385892761	1503.019947	-0.678152911
62	1119	869	873.5	0.00710513	53878	869	1239613.157	-382.7997229	0.392997891	1426.482344	-0.620590681
63	1110	860	864.5	0.007031544	54180	860	1162872.478	-349.5337366	0.400029434	1351.944742	-0.566660396
64	1101	851	855.5	0.006957958	54464	851	1088775.476	-318.4160511	0.406987392	1279.40714	-0.516212733
65	1092	842	846.5	0.006884372	54730	842	1017868.15	-289.3568576	0.413871764	1208.869537	-0.469101952
66	1083	833	837.5	0.006810786	54976	833	949896.5016	-262.2673142	0.42068255	1140.331935	-0.425184996
67	1074	824	828.5	0.0067372	55208	824	884806.5298	-237.0615446	0.42741975	1073.794332	-0.384321668
68	1065	815	819.5	0.006663614	55420	815	822544.2349	-213.654639	0.434083365	1009.25673	-0.34637464

142	612	362	364	0.002959769	51404	362	645617.6429	222.9261608	0.766675388	1783.474152	0.361405533
143	608	358	360	0.002927085	51194	358	669079.2647	236.4977971	0.769602472	1868.936549	0.383407727
144	604	354	356	0.00289438	50976	354	692565.2272	250.4618763	0.772496852	1956.398947	0.406046144
145	600	350	352	0.002861675	50750	350	716051.4706	264.810119	0.775358527	2045.861345	0.429307363
146	596	346	348	0.00282897	50516	346	739514.0148	279.5334606	0.778187497	2137.323742	0.453176689
147	592	342	344	0.002796265	50274	342	762928.8598	294.6220516	0.780983762	2230.78614	0.477638153
148	588	338	340	0.00276356	50024	338	786272.0056	310.0652577	0.783747322	2326.248537	0.502674515
149	584	334	336	0.002730855	49766	334	809519.4523	325.8518596	0.786478178	2423.710935	0.528287263
150	580	330	332	0.002698151	49500	330	832647.1997	341.9690532	0.789176328	2523.173333	0.554396611
151	576	326	328	0.002665446	49226	326	855631.248	358.4044492	0.791841774	2624.63573	0.581041501
152	572	322	324	0.002632741	48944	322	878447.5971	375.1440737	0.794474515	2728.098128	0.608179603
153	568	318	320	0.002600036	48654	318	901072.247	392.1733677	0.797074551	2833.560525	0.635787315
154	564	314	316	0.002567331	48356	314	923481.1978	409.4789874	0.799641882	2941.022923	0.66383976
155	560	310	312	0.002534626	48050	310	945650.4494	427.038804	0.802176508	3050.48532	0.692310791
156	556	306	308	0.002501921	47736	306	967556.0017	444.8419036	0.80467643	3161.947718	0.721172988
157	552	302	304	0.002469217	47414	302	989173.8549	462.8885881	0.807147646	3275.410116	0.750397658
158	548	298	300	0.002436512	47084	298	1010480.009	481.1003735	0.809584156	3390.872513	0.779954836
159	544	294	296	0.002403807	46746	294	1031450.464	499.5179915	0.811987965	3508.334911	0.809813283
160	540	290	292	0.002371102	46400	290	1052061.219	518.1013868	0.814358067	3627.797308	0.83994049
161	536	286	288	0.002338397	46046	286	1072288.276	536.829727	0.816697454	3749.259706	0.870302674
162	532	282	284	0.002305692	45684	282	1092107.633	555.681383	0.819003158	3872.722104	0.900864779
163	528	278	280	0.002272987	45314	278	1111495.291	574.6339487	0.821276143	3998.184501	0.931590478
164	524	274	276	0.002240283	44936	274	1130427.25	593.664231	0.823516426	4125.646899	0.962442171
165	520	270	272	0.002207578	44550	270	1148679.51	612.748252	0.825724004	4255.109296	0.993380984
166	517	267	268.5	0.002183049	44322	267	1171214.642	634.2366671	0.827907053	4388.571694	1.026217775
167	514	264	265.5	0.00215852	44088	264	1193289	655.946989	0.830065573	4520.034092	1.063414287
168	511	261	262.5	0.002133992	43848	261	1215084.584	677.8627196	0.832199565	4655.496489	1.09894387
169	508	258	259.5	0.002109463	43602	258	1236583.393	699.968892	0.834309028	4792.958887	1.13477692
170	505	255	256.5	0.002084935	43350	255	1257767.428	722.2416707	0.836393963	4932.421284	1.17089088
171	502	252	253.5	0.002060406	43092	252	1278618.688	744.6694515	0.838454369	5073.883682	1.207250237
172	499	249	250.5	0.002035877	42828	249	1299119.174	767.2306415	0.840490248	5217.34608	1.243828523
173	496	246	247.5	0.002011349	42558	246	1319250.885	789.9086591	0.842501594	5362.808477	1.280588319
174	493	243	244.5	0.00198682	42282	243	1338995.823	812.676934	0.844488414	5510.270875	1.317503248
175	490	240	241.5	0.001962291	42000	240	1358335.985	835.5211073	0.846450706	5659.733272	1.35453798
176	487	237	238.5	0.001937763	41712	237	1377253.374	858.4180312	0.848388468	5811.19567	1.391658231
177	484	234	235.5	0.001913234	41418	234	1395729.988	881.3459696	0.850301702	5964.658068	1.428628762
178	481	231	232.5	0.001888705	41118	231	1413747.827	904.2825972	0.852190406	6120.120465	1.46601338
179	478	228	229.5	0.001864177	40812	228	1431288.693	927.2050005	0.854054584	6277.582863	1.503174937
180	475	225	226.5	0.001839648	40500	225	1448335.184	950.089677	0.855894232	6437.04526	1.540275333
181	472	222	223.5	0.001815119	40182	222	1464866.7	972.9125356	0.857709352	6598.507658	1.57727551
182	469	219	220.5	0.001790591	39858	219	1480871.442	995.6488966	0.859499943	6761.970056	1.614135458
183	466	216	217.5	0.001766062	39528	216	1496325.41	1018.273492	0.861266005	6927.432453	1.650814212
184	463	213	214.5	0.001741534	39192	213	1511212.603	1040.760463	0.863007538	7094.894851	1.687269852
185	460	210	211.5	0.001717005	38850	210	1525515.022	1063.083368	0.864724543	7264.357248	1.723459505
186	458	208	209	0.001700652	38686	208	1546650.486	1090.45775	0.866425196	7435.819646	1.767838568
187	456	206	207	0.0016843	38522	206	1567512.101	1117.982435	0.868109496	7609.282043	1.812461296
188	454	204	205	0.001667948	38352	204	1588087.866	1145.642047	0.869777443	7784.744441	1.857302766
189	452	202	203	0.001651595	38178	202	1608365.781	1173.42082	0.871429039	7962.206839	1.902337419
190	450	200	201	0.001635243	38000	200	1628333.847	1201.302594	0.873064281	8141.669236	1.947539056
191	448	198	199	0.00161889	37818	198	1647980.064	1229.270819	0.874683172	8323.131634	1.992880847
192	446	196	197	0.001602538	37632	196	1667292.43	1257.308551	0.87628571	8506.594031	2.03833532
193	444	194	195	0.001586185	37442	194	1686258.947	1285.398453	0.877871895	8692.056429	2.083874372
194	442	192	193	0.001569833	37248	192	1704867.615	1313.522796	0.879441728	8879.518827	2.129469261
195	440	190	191	0.001553481	37050	190	1723106.433	1341.663461	0.880995209	9068.981224	2.175090608
196	438	188	189	0.001537128	36848	188	1740963.401	1369.801932	0.882532337	9260.443622	2.220708401
197	436	186	187	0.001520776	36642	186	1758426.52	1397.919305	0.884053113	9453.906019	2.266291988
198	434	184	185	0.001504423	36432	184	1775483.789	1425.99628	0.885557536	9649.368417	2.311810083
199	432	182	183	0.001488071	36218	182	1792123.206	1454.013167	0.887045607	9846.830815	2.357230763
200	430	180	181	0.001471718	36000	180	1808332.778	1481.949881	0.888517325	10046.29321	2.402521469
201	428	178	179	0.001455366	35778	178	1824100.499	1509.785948	0.889972691	10247.75561	2.447649007
202	426	176	177	0.001439014	35552	176	1839414.369	1537.500499	0.891411705	10451.21801	2.492579543
203	424	174	175	0.001422661	35322	174	1854262.39	1565.072273	0.892834366	10656.6804	2.537278612
204	422	172	173	0.001406309	35088	172	1868632.562	1592.479617	0.894240675	10864.1428	2.581711108
205	420	170	171	0.001389956	34850	170	1882512.884	1619.700485	0.895630631	11073.6052	2.625841291
206	418	168	169	0.001373604	34606	168	1895891.358	1646.712439	0.897004235	11285.0676	2.669632765
207	416	166	167	0.001357251	34362	166	1908755.979	1673.492646	0.898361487	11498.53	2.713048577
208	414	164	165	0.001340899	34112	164	1921094.752	1700.01769	0.899702386	11713.99239	2.756051018
209	412	162	163	0.001324547	33858	162	1932895.676	1726.264548	0.901026932	11931.45479	2.798601823
210	410	160	161	0.001308194	33600	160	1944146.75	1752.208615	0.902335127	12150.91719	2.840662069
211	408	158	159	0.001291842	33338	158	1954835.975	1777.82569	0.903626968	12372.37959	2.882192201
212	406	156	157	0.001275489	33072	156	1964951.349	1803.090981	0.904902458	12595.84198	2.923152022
213	404	154	155	0.001259137	32802	154	1974480.675	1827.979301	0.906161595	12821.30438	2.963500704
214	402	152	153	0.001242784	32528	152	1983412.55	1852.465074	0.907404379	13048.76678	3.00319678

288	327	77	77.5	0.000629568	22176	77	2728185.763	4198.72844	0.976076399	35430.9842	6.806934126
289	326	76	76.5	0.000621392	21964	76	2721441.941	4210.600633	0.976697791	35808.4486	6.8261812
290	325	75	75.5	0.000613216	21750	75	2714093.175	4221.421686	0.977311007	36187.909	6.843724144
291	324	74	74.5	0.00060504	21534	74	2706133.483	4231.167319	0.977916047	36569.37139	6.859523693
292	323	73	73.5	0.000596864	21316	73	2697556.867	4239.813176	0.97851291	36952.83379	6.873540266
293	322	72	72.5	0.000588687	21096	72	2688357.326	4247.334626	0.979101598	37338.29619	6.885733961
294	321	71	71.5	0.000580511	20874	71	2678528.86	4253.706862	0.979682109	37725.75859	6.896064562
295	320	70	70.5	0.000572335	20650	70	2668065.469	4258.904878	0.980254444	38115.22098	6.90449153
296	319	69	69.5	0.000564159	20424	69	2656961.153	4262.903474	0.980818603	38506.68338	6.910974012
297	318	68	68.5	0.000555983	20196	68	2645209.913	4265.677254	0.981374585	38900.14578	6.915470835
298	317	67	67.5	0.000547806	19966	67	2632805.748	4267.200625	0.981922391	39295.60818	6.917940507
299	316	66	66.5	0.00053963	19734	66	2619742.658	4267.447797	0.982462021	39693.07057	6.918341221
300	315	65	65.5	0.000531454	19500	65	2606014.643	4266.392786	0.982993475	40092.53297	6.916630848
301	314	64	64.5	0.000523278	19264	64	2591615.704	4264.00941	0.983516753	40493.99537	6.912766944
302	313	63	63.5	0.000515101	19026	63	2576539.839	4260.27129	0.984031855	40897.45777	6.906706744
303	312	62	62.5	0.000506925	18786	62	2560761.05	4255.151854	0.98453878	41302.92016	6.898407168
304	311	61	61.5	0.000498749	18544	61	2544333.336	4248.624331	0.985037529	41710.38256	6.887824817
305	310	60	60.5	0.000490573	18300	60	2527190.698	4240.661754	0.985528102	42119.84496	6.874915971
306	309	59	59.5	0.000482397	18054	59	2509347.134	4231.23696	0.986010498	42531.30736	6.859636595
307	308	58	58.5	0.00047422	17806	58	2490796.646	4220.322591	0.986484719	42944.76975	6.841942336
308	307	57	57.5	0.000466044	17556	57	2471533.233	4207.891092	0.986950763	43360.23215	6.821788521
309	306	56	56.5	0.000457868	17304	56	2451550.895	4193.914711	0.987408631	43777.69455	6.79913016
310	305	55	55.5	0.000449692	17050	55	2430843.632	4178.3655	0.987858323	44197.15695	6.773921944
311	304	54	54.5	0.000441516	16794	54	2409405.445	4161.215316	0.988299838	44618.61934	6.746116247
312	303	53	53.5	0.000433339	16536	53	2387230.332	4142.435819	0.988733177	45042.08174	6.715673124
313	302	52	52.5	0.000425163	16276	52	2364312.295	4121.998471	0.989158341	45467.54414	6.682540313
314	301	51	51.5	0.000416987	16014	51	2340645.333	4099.874542	0.989575327	45895.00654	6.646673233
315	300	50	50.5	0.000408811	15750	50	2316223.447	4076.035102	0.989984138	46324.46894	6.608024984
316	299	49	49.5	0.000400634	15484	49	2291040.635	4050.451025	0.990384773	46755.93133	6.56654835
317	298	48	48.5	0.000392458	15216	48	2265090.699	4023.092991	0.990777231	47189.39373	6.522195795
318	297	47	47.5	0.000384282	14946	47	2238368.238	3993.931483	0.991161513	47624.85613	6.474919466
319	296	46	46.5	0.000376106	14674	46	2210866.652	3962.936766	0.991537619	48062.31853	6.424671191
320	295	45	45.5	0.00036793	14400	45	2182580.142	3930.078991	0.991905548	48501.78092	6.371402461
321	294	44	44.5	0.000359753	14124	44	2153502.706	3895.327991	0.992265302	48943.24332	6.315064526
322	293	43	43.5	0.000351577	13846	43	2123628.346	3858.653485	0.992616879	49386.70572	6.255608207
323	292	42	42.5	0.000343401	13566	42	2092951.061	3820.024973	0.99296028	49832.16812	6.192984072
324	291	41	41.5	0.000335225	13284	41	2061464.851	3779.411761	0.993295505	50279.63051	6.127142362
325	290	40	40.5	0.000327049	13000	40	2029163.718	3736.782958	0.993622553	50729.09291	6.058032997
326	289	39	39.5	0.000318872	12714	39	1996041.657	3692.107476	0.993941426	51180.55531	5.985605579
327	288	38	38.5	0.000310696	12426	38	1962092.673	3645.354032	0.994252122	51634.01771	5.90960939
328	287	37	37.5	0.00030252	12136	37	1927310.764	3596.491146	0.994554642	52089.4801	5.830593396
329	286	36	36.5	0.000294344	11844	36	1891689.93	3545.487142	0.994848985	52546.9425	5.747906245
330	285	35	35.5	0.000286167	11550	35	1855224.171	3492.310149	0.995135153	53006.4049	5.661696266
331	284	34	34.5	0.000277991	11254	34	1817907.488	3436.928097	0.995413144	53467.8673	5.571911469
332	283	33	33.5	0.000269815	10956	33	1779733.88	3379.308721	0.995682959	53931.32969	5.478499547
333	282	32	32.5	0.000261639	10656	32	1740697.347	3319.419562	0.995944598	54396.79209	5.381407676
334	281	31	31.5	0.000253463	10354	31	1700791.889	3257.227962	0.996198061	54864.25449	5.280583512
335	280	30	30.5	0.000245286	10050	30	1660011.507	3192.701067	0.996443347	55333.71689	5.175973193
336	279	29	29.5	0.00023711	9744	29	1618350.199	3125.805828	0.996680457	55805.17928	5.067523339
337	278	28	28.5	0.000228934	9436	28	1575801.967	3056.509	0.996909391	56278.64168	4.955180054
338	277	27	27.5	0.000220758	9126	27	1532360.81	2984.777139	0.997130149	56754.10408	4.838889121
339	276	26	26.5	0.000212582	8814	26	1488020.726	2910.576609	0.997342731	57231.56648	4.718596005
340	275	25	25.5	0.000204405	8500	25	1442775.722	2833.673573	0.997547136	57711.02888	4.594245856
341	274	24	24.5	0.000196229	8184	24	1396619.791	2754.634003	0.997743365	58192.49127	4.465783502
342	273	23	23.5	0.000188053	7866	23	1349546.934	2672.82367	0.997931418	58675.95367	4.333153456
343	272	22	22.5	0.000179877	7546	22	1301551.153	2588.408151	0.998111295	59161.41607	4.196299911
344	271	21	21.5	0.0001717	7224	21	1252626.448	2501.352628	0.998282995	59648.87847	4.055166742
345	270	20	20.5	0.000163524	6900	20	1202766.817	2411.622884	0.998446519	60138.34086	3.909697506
346	269	19	19.5	0.000155348	6574	19	1151966.262	2319.183308	0.998601867	60629.80326	3.759835443
347	268	18	18.5	0.000147172	6246	18	1100218.782	2223.998891	0.998749039	61123.26566	3.605523473
348	267	17	17.5	0.000138996	5916	17	1047516.377	2126.034229	0.998888035	61618.72806	3.4467042
349	266	16	16.5	0.000130819	5584	16	993859.0473	2025.253722	0.999018854	62116.19045	3.283319909
350	265	15	15.5	0.000122643	5250	15	939234.7928	1921.821573	0.999141498	62615.65285	3.115312565
351	264	14	14.5	0.000114467	4914	14	883639.6135	1815.101789	0.999255965	63117.11525	2.942623817
352	263	13	13.5	0.000106291	4576	13	827067.5094	1705.65818	0.999362255	63620.57765	2.765194997
353	262	12	12.5	9.81146E-05	4236	12	769512.4805	1593.254361	0.99946037	64126.04004	2.582967115
354	261	11	11.5	8.99384E-05	3894	11	710968.6269	1477.853751	0.999550308	64633.50244	2.395880866
355	260	10	10.5	8.17621E-05	3550	10	651429.6484	1359.419571	0.99963207	65142.96484	2.203876627
356	259	9	9.5	7.35859E-05	3204	9	590889.8451	1237.914848	0.999705656	65654.42724	2.006894455
357	258	8	8.5	6.54097E-05	2856	8	529343.1171	1113.30241	0.999771066	66167.88963	1.804874089
358	257	7	7.5	5.72335E-05	2506	7	466783.4642	985.5448919	0.9998283	66683.35203	1.597754952
359	256	6	6.5	4.90573E-05	2154	6	403204.8886	854.60473	0.999877357	67200.81443	1.385476147
360	255	5	5.5	4.08811E-05	1800	5	338801.3841	720.4441655	0.999918238	67720.27683	1.167976459

t_m (min) =	99.7686012
σ^2 =	5250.75376
Pe =	49562.25046
s^3 =	704.4771792

72.46208498

mean real liquid velocity, u (m/s)	0.000157798
distance, L (m)	1.8

ε	0.279493102
μ_{gas} (lb/ft.s)	1.23E-05
U_{gas} (ft/s)	7.77E-02
D_s (ft) = $6V_p/A_p$	8.75E-03
G_{gas} (kg/m.s^2)	0.010578879
L_{column} (ft)	4.9212

ΔP (lb/ft^2) =	7.65605071
ΔP (N/m^2) =	366.5724138
ΔP_{exp} (mbar) =	5.233557853
ΔP_{exp} (N/m^2) =	523.3557853

H_o =	0.03042086

μ_{liquid} (lb/ft.s)	6.55E-04
U_{liquid} (ft/s)	5.18E-04
ρ_{liquid} (lb/ft^3)	62.2608
nominal packing size (ring diameter), d (ft)	0.026246
g (ft/s^2)	32.17
g (m/s^2)	9.80665

H_o (Exp) =	0.720506898
V_{liquid} (m^3)	6.80E-03
V_{column} (m^3)	9.44E-03

$V_{stagnant}$ (m^3)	0.00444936
T_d (min)	188.756

Pressure Drop (Experimental)

4.635452	5.068604	3.054474	5.367691	5.229691
5.104828	7.23613	5.071838	4.660141	4.769363
4.3331155	5.06955	6.039062	5.119049	5.211441
5.096954	7.775055	5.110628	3.077271	4.731842
3.617659	5.091949	4.579529	5.213654	5.181519
4.481323	3.801987	5.105362	5.779465	4.707352
4.828995	7.695175	4.6082	5.168477	5.065857
4.781616	5.087738	5.099121	5.06636	5.10553
4.327133	7.777344	4.539566	6.186707	4.570145
7.320694	5.08493	5.312195	5.065857	5.198318
6.045746	4.373611	4.893539	6.034546	5.998642
5.968079	5.080902	5.076646	5.068359	5.094589
5.068649	4.742294	5.263565	5.807861	5.377365
7.555573	5.176529	4.830399	5.107758	7.725021
5.068192	4.710388	5.251297	5.631546	4.207138
7.539017	5.161453	4.779327	5.068146	5.114594
5.067749	4.689621	5.06636	4.249008	7.532806
7.773392	4.689621	5.104752	5.104875	5.114426
5.678276	5.09404	7.483215	5.081633	7.483215
7.668152	4.712616	3.524872	4.350418	5.09407
5.076599	5.08049	3.366638	5.079514	3.326508
4.874435	4.891449	4.004929	4.721619	5.095612
5.151352	5.066803	5.678253	5.182033	4.453613
4.72139	5.399551	5.15979	4.696167	4.164413
5.135071	5.066803	5.07547	5.148209	5.069447
4.702484	5.335236	5.642731	4.715286	7.602005
5.12735	4.907776	4.687363	5.147095	5.066777
4.308075	5.30658	5.513794	4.711731	4.38736
4.711166	4.847687	5.102402	5.550888	4.338928
5.115952	5.26535	5.514969	5.058868	4.713043
4.656433	4.792038	5.052628	5.48848	4.618439
5.454071	5.226837	5.465591	5.064804	3.675293
5.028122	4.749847	5.066803	5.031906	4.486343
4.968307	7.779358	7.603226	5.066803	5.131653
5.077713	6.42453	5.076324	5.039474	5.074966
6.915482	5.06636	5.283249	6.060684	5.119904
6.620331	5.065903	5.074081	5.082474	1.421326
7.278046	5.080276	5.93985	6.771469	5.109436
7.278046	5.067703	5.072281	6.381605	4.404465
7.622604	7.393753	5.082794	5.070435	5.101318
5.098587	5.119446	5.052933	5.646499	3.851715
4.326172	7.532806	5.114349	5.06955	
5.080399	5.481552	4.631729	5.072021	
5.273804	5.068192	5.106064	5.08403	
2.633221	5.420746	4.404419	7.774155	
5.247253	4.968919	5.100952	5.076233	
5.073288	7.398727	4.985123	5.093597	
5.21463	5.066803	4.910583	4.474762	
4.741089	5.097687	4.8396	5.08612	
6.143234	5.072891	5.073181	4.41124	

G =	10		L =	0.05

t (min)	C (mS)	C-250	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2$*C*Δt	$(t-tm)^3$*E*Δt	F (t)	σ^2	s^3
0	250	0		0	0	0	0	0	0	#DIV/0!	0
1	254	4	2	3.68392E-05	4	4	39514.84168	-36.17100173	3.68392E-05	9878.710421	-0.056279177
2	258	8	6	7.36784E-05	16	8	77447.41613	-70.1803563	0.000110518	9680.927017	-0.109195004
3	262	12	10	0.000110518	36	12	113821.7234	-102.0933078	0.000221035	9485.143613	-0.158848997
4	264	14	13	0.000128937	56	14	130079.0429	-115.4774391	0.000349972	9291.360209	-0.179673631
5	270	20	17	0.000184196	100	20	161991.5361	-159.8865571	0.000534168	9099.576805	-0.248770656
6	300	50	35	0.00046049	300	50	445489.67	-387.2769218	0.000994658	8909.793401	-0.602571822
7	330	80	65	0.000736784	560	80	697760.7998	-600.1571989	0.001731442	8722.009997	-0.933796456
8	360	110	95	0.001013078	880	110	936984.9252	-798.9907475	0.00274452	8536.226593	-1.243165507
9	420	170	140	0.001565666	1530	170	1419915.342	-1195.141645	0.004310186	8352.443189	-1.859544522
10	450	200	185	0.00184196	2000	200	1634131.957	-1360.397576	0.006152146	8170.659785	-2.116669495
11	510	260	230	0.002394548	2860	260	2077627.859	-1710.46889	0.008546694	7990.876381	-2.661352065
12	570	320	290	0.002947136	3840	320	2500189.753	-2036.329043	0.011493829	7813.092977	-3.168808713
13	630	380	350	0.003499724	4940	380	2902177.638	-2335.846778	0.014993553	7637.309573	-3.634390201
14	720	470	425	0.004328606	6580	470	3507857.3	-2791.027467	0.019322159	7463.526169	-4.342614837
15	780	530	500	0.004881194	7950	530	3864623.566	-3039.2963	0.024203352	7291.742765	-4.728901225
16	840	590	560	0.005433782	9440	590	4201958.023	-3265.668934	0.029637134	7121.959362	-5.081461185
17	870	620	605	0.005710076	10540	620	4311589.094	-3311.390244	0.035347209	6954.175958	-5.152257574
18	930	680	650	0.006262663	12240	680	4616106.936	-3502.752873	0.041609873	6788.392554	-5.450002473
19	960	710	695	0.006538957	13490	710	4703472.496	-3525.728767	0.04814883	6624.60915	-5.485751151
20	990	740	725	0.006815251	14800	740	4782491.052	-3540.915411	0.054964082	6462.825746	-5.50938032
21	1020	770	755	0.007091545	16170	770	4853342.603	-3548.674982	0.062055627	6303.042342	-5.52145359
22	1050	800	785	0.007367839	17600	800	4916207.15	-3549.363103	0.069423467	6145.258938	-5.522524252
23	1080	830	815	0.007644133	19090	830	4971264.693	-3543.328749	0.0770676	5989.475534	-5.51313528
24	1120	870	850	0.008012525	20880	870	5077052.153	-3571.971403	0.085080125	5835.69213	-5.557700953
25	1140	890	880	0.008196721	22250	890	5068676.766	-3612.45535	0.093276847	5683.908726	-5.465098748
26	1160	910	900	0.008380917	23660	910	5036054.043	-3450.364998	0.101657764	5534.125322	-5.368491142
27	1165	915	912.5	0.008426966	24705	915	4928502.855	-3331.287647	0.11008473	5386.341918	-5.183216338
28	1170	920	917.5	0.008473015	25760	920	4821313.833	-3214.432806	0.118557745	5240.558514	-5.001399578
29	1175	925	922.5	0.008519064	26825	925	4714516.977	-3099.810195	0.12707681	5096.77511	-4.82305599
30	1180	930	927.5	0.008565113	27900	930	4608142.287	-2987.428426	0.135641923	4954.991706	-4.648198973
31	1185	935	932.5	0.008611162	28985	935	4502219.763	-2877.295008	0.144253085	4815.208302	-4.47684021
32	1190	940	937.5	0.008657211	30080	940	4396779.405	-2769.416344	0.152910297	4677.424898	-4.308989664
33	1195	945	942.5	0.00870326	31185	945	4291851.212	-2663.797733	0.161613557	4541.641495	-4.144855577
34	1200	950	947.5	0.008749309	32300	950	4187465.186	-2560.443366	0.170362866	4407.858091	-3.983844473
35	1198	948	949	0.00873069	33180	948	4053718.803	-2441.329636	0.179093756	4276.074687	-3.798513065
36	1197	947	947.5	0.00872168	34092	947	3926537.845	-2328.572985	0.187815436	4148.291283	-3.623072781
37	1196	946	946.5	0.00871247	35002	946	3801508.453	-2219.415094	0.196527906	4018.507879	-3.45323184
38	1194	944	945	0.00869405	35872	944	3674731.904	-2111.556252	0.205221956	3892.724475	-3.285412134
39	1192	942	943	0.008675631	36738	942	3550342.489	-2007.38228	0.213897587	3768.941071	-3.123325791
40	1190	940	941	0.008657211	37600	940	3428328.207	-1906.62055	0.222554798	3647.157667	-2.968859807
41	1185	935	937.5	0.008611162	38335	935	3298094.936	-1804.010605	0.231165961	3527.374263	-2.80689578
42	1180	930	932.5	0.008565113	39060	930	3170919.499	-1705.243934	0.239731074	3409.590859	-2.653222763
43	1175	925	927.5	0.008519064	39775	925	3046771.896	-1610.420194	0.248250138	3293.807455	-2.50568463
44	1170	920	922.5	0.008473015	40480	920	2925622.127	-1519.440146	0.256723153	3180.024051	-2.364126975
45	1165	915	917.5	0.008426966	41175	915	2807440.192	-1432.205659	0.26515012	3068.240647	-2.228397111
46	1160	910	912.5	0.008380917	41860	910	2692196.091	-1348.619704	0.273531037	2958.457243	-2.09834407
47	1155	905	907.5	0.008334866	42535	905	2579859.825	-1268.586359	0.281865905	2850.673839	-1.973818606
48	1150	900	902.5	0.008288819	43200	900	2470401.392	-1192.010807	0.290154725	2744.890435	-1.854873191
49	1140	890	895	0.008196721	43610	890	2350585.258	-1112.549061	0.298351446	2641.107031	-1.731037088
50	1130	880	885	0.008104623	44000	880	2234604.792	-1037.074403	0.306456069	2539.323628	-1.613604575
51	1120	870	875	0.008012525	44370	870	2122399.995	-965.4535641	0.314468595	2439.540224	-1.502168295
52	1110	860	865	0.007920427	44720	860	2013910.865	-897.5554832	0.322389022	2341.75682	-1.396524326
53	1100	850	855	0.007828329	45050	850	1909077.403	-833.2513109	0.330217351	2245.973416	-1.296472195
54	1090	840	845	0.007736231	45360	840	1807839.61	-772.4144077	0.337953583	2152.190012	-1.201814854
55	1080	830	835	0.007644133	45650	830	1710137.484	-714.9203447	0.345597716	2060.406608	-1.112358704
56	1070	820	825	0.007552035	45920	820	1615911.027	-660.646903	0.353149751	1970.623204	-1.027913583
57	1060	810	815	0.007459937	46170	810	1525100.238	-609.4740744	0.360609689	1882.8398	-0.948292767
58	1050	800	805	0.007367839	46400	800	1437645.117	-561.2840809	0.367977528	1797.056396	-0.873312971
59	1044	794	797	0.007312581	46846	794	1360338.756	-516.5737369	0.375290109	1713.272992	-0.805859134
60	1038	788	791	0.007257322	47280	788	1285613.795	-476.2476448	0.38254743	1631.489588	-0.744114969
61	1032	782	785	0.007202063	47702	782	1213434.236	-440.2214016	0.389749493	1551.706184	-0.684949185
62	1026	776	779	0.007146804	48112	776	1143764.077	-404.4119505	0.396896298	1473.92278	-0.629232552
63	1020	770	773	0.007091545	48510	770	1076587.32	-370.737561	0.403987843	1398.139376	-0.576837904
64	1012	762	766	0.007017867	48768	762	1009159.251	-338.2300857	0.41100571	1324.355972	-0.52825888
65	1004	754	758	0.006944189	49010	754	944439.7166	-307.840569	0.417949899	1252.572568	-0.47897523
66	996	746	750	0.00687051	49236	746	882360.7167	-279.4795248	0.424820409	1182.789164	-0.43484772
67	988	738	742	0.006796832	49446	738	822874.2613	-253.0592352	0.431617241	1115.005761	-0.393739869
68	980	730	734	0.006723153	49640	730	765932.3203	-228.4937507	0.438340394	1049.222357	-0.355517846

142	558	308	309.5	0.002836618	43736	308	533225.1432	204.3340456	0.762939768	1731.250465	0.317927383
143	555	305	306.5	0.002808989	43615	305	553717.4536	217.286409	0.765748757	1815.467061	0.336080221
144	552	302	303.5	0.002781359	43488	302	574306.4644	230.6558729	0.768530116	1901.683657	0.356882035
145	549	299	300.5	0.00275373	43355	299	594980.1757	244.4377694	0.771283848	1989.900253	0.38032556
146	546	296	297.5	0.002726101	43216	296	615714.5873	258.6267674	0.774009947	2080.116849	0.402402502
147	543	293	294.5	0.002698471	43071	293	636493.6994	273.2168727	0.776708418	2172.333445	0.425103536
148	540	290	291.5	0.002670842	42920	290	657299.512	288.2014261	0.77937926	2266.550041	0.448418302
149	537	287	288.5	0.002643212	42763	287	678114.0249	303.5731131	0.782022472	2362.766637	0.472335411
150	534	284	285.5	0.002615583	42600	284	698919.2383	319.3239443	0.784638055	2460.983233	0.49684244
151	531	281	282.5	0.002587954	42431	281	719697.1521	335.445275	0.787226008	2561.199829	0.521925938
152	528	278	279.5	0.002560324	42256	278	740429.7663	351.9277956	0.789786333	2663.416425	0.547571418
153	525	275	276.5	0.002532695	42075	275	761099.0809	368.7615332	0.792319027	2767.633022	0.573763363
154	522	272	273.5	0.002505065	41888	272	781687.096	385.935852	0.794824093	2873.849618	0.600485225
155	519	269	270.5	0.002477436	41695	269	802175.8115	403.4394528	0.797301529	2982.066214	0.627719424
156	516	266	267.5	0.002449807	41496	266	822547.2274	421.2603736	0.799751335	3092.28281	0.655447347
157	513	263	264.5	0.002422177	41291	263	842783.3437	439.3859891	0.802173513	3204.499406	0.683649351
158	510	260	261.5	0.002394548	41080	260	862866.1605	457.803011	0.80456806	3318.716002	0.712304759
159	507	257	258.5	0.002366918	40863	257	882777.6777	476.4974678	0.806934979	3434.932598	0.741391865
160	504	254	255.5	0.002339289	40640	254	902499.8953	495.454605	0.809274268	3553.149194	0.77088793
161	501	251	252.5	0.00231166	40411	251	922014.6133	514.6596849	0.811585927	3673.36579	0.800769183
162	498	248	249.5	0.00228403	40176	248	941304.4317	534.0961868	0.813869958	3795.582386	0.83101082
163	495	245	246.5	0.002256401	39935	245	960350.7506	553.7477088	0.816126358	3919.798982	0.861587009
164	492	242	243.5	0.002228771	39688	242	979135.7699	573.5969779	0.81835513	4046.015578	0.892470863
165	489	239	240.5	0.002201142	39435	239	997641.4696	593.6260701	0.820556272	4174.232174	0.923634543
166	486	236	237.5	0.002173513	39176	236	1015849.91	613.8163901	0.822729784	4304.44877	0.955049061
167	483	233	234.5	0.002145883	38911	233	1033743.03	634.1486816	0.824875668	4438.665366	0.986684476
168	480	230	231.5	0.002118254	38640	230	1051302.651	654.6030254	0.826993922	4570.881962	1.018509794
169	478	228	229	0.002099834	38532	228	1073218.471	678.1331068	0.829093756	4707.098558	1.055120713
170	476	226	227	0.002081415	38420	226	1095041.225	702.0073304	0.83117517	4845.315155	1.09226709
171	474	224	225	0.002062995	38304	224	1116759.112	726.2153271	0.833238165	4985.531751	1.129932791
172	472	222	223	0.002044575	38184	222	1138360.133	750.7462854	0.835282741	5127.748347	1.168100994
173	470	220	221	0.002026156	38060	220	1159832.287	775.5889518	0.837308897	5271.964943	1.20675419
174	468	218	219	0.002007736	37932	218	1181163.575	800.7316309	0.839316633	5418.181539	1.245874181
175	466	216	217	0.001989317	37800	216	1202341.997	826.1621851	0.84130595	5566.398135	1.286442084
176	464	214	215	0.001970897	37664	214	1223355.552	851.8680346	0.843276847	5716.614731	1.325438323
177	462	212	213	0.001952477	37524	212	1244192.241	877.8361579	0.845229324	5868.831327	1.36584264
178	460	210	211	0.001934058	37380	210	1264840.064	904.0530911	0.847163382	6023.047923	1.406634085
179	458	208	209	0.001915638	37232	208	1285287.02	930.5049283	0.84907902	6179.264519	1.447791022
180	456	206	207	0.001897219	37080	206	1305521.11	957.1773217	0.850976239	6337.481115	1.489291126
181	454	204	205	0.001878799	36924	204	1325530.333	984.0554811	0.852855038	6497.697711	1.531111386
182	452	202	203	0.001860379	36764	202	1345302.69	1011.124175	0.854715417	6659.914307	1.573228101
183	450	200	201	0.00184196	36600	200	1364826.181	1038.367728	0.856557377	6824.130903	1.615816885
184	448	198	199	0.00182354	36432	198	1384088.805	1065.770025	0.858380917	6990.347499	1.65825266
185	446	196	197	0.001805121	36260	196	1403078.563	1093.314507	0.860186038	7158.564095	1.701109665
186	444	194	195	0.001786701	36084	194	1421783.454	1120.984175	0.861972739	7328.780691	1.744161448
187	442	192	193	0.001768281	35904	192	1440191.479	1148.761585	0.86374102	7500.997287	1.78738087
188	440	190	191	0.001749862	35720	190	1458290.638	1176.628853	0.865490882	7675.213884	1.830740103
189	438	188	189	0.001731442	35532	188	1476068.93	1204.567652	0.867222325	7851.43048	1.874210634
190	436	186	187	0.001713023	35340	186	1493514.356	1232.559215	0.868935347	8029.647076	1.91776326
191	434	184	185	0.001694603	35144	184	1510614.916	1260.584329	0.87062995	8209.863672	1.96136809
192	432	182	183	0.001676183	34944	182	1527358.609	1288.623343	0.872306134	8392.080268	2.004994548
193	430	180	181	0.001657764	34740	180	1543733.435	1316.656162	0.873963898	8576.296864	2.048611363
194	428	178	179	0.001639344	34532	178	1559727.396	1344.662248	0.875603242	8762.51346	2.092186587
195	426	176	177	0.001620925	34320	176	1575328.49	1372.620623	0.877224167	8950.730056	2.135687575
196	424	174	175	0.001602505	34104	174	1590524.717	1400.509868	0.878826672	9140.946652	2.179080999
197	422	172	173	0.001584085	33884	172	1605304.079	1428.308113	0.880410757	9333.163248	2.222332841
198	420	170	171	0.001565666	33660	170	1619654.574	1455.993059	0.881976423	9527.379844	2.265408397
199	418.5	168.5	169.25	0.001551851	33531.5	168.5	1638426	1487.95726	0.883528274	9723.59644	2.31514213
200	417	167	167.75	0.001538036	33400	167	1656942.777	1520.033615	0.885066311	9921.813036	2.365050365
201	415.5	165.5	166.25	0.001524222	33265.5	165.5	1675195.904	1552.206749	0.886590532	10122.02963	2.41510918
202	414	164	164.75	0.001510407	33128	164	1693176.381	1584.460954	0.888100939	10324.24623	2.465294136
203	412.5	162.5	163.25	0.001496592	32987.5	162.5	1710875.209	1616.780193	0.889597532	10528.46282	2.515580279
204	411	161	161.75	0.001482778	32844	161	1728283.387	1649.148095	0.891080309	10734.67942	2.565942139
205	409.5	159.5	160.25	0.001468963	32697.5	159.5	1745391.915	1681.547961	0.892549272	10942.89602	2.61635373
206	408	158	158.75	0.001455148	32548	158	1762191.793	1713.962756	0.894004421	11153.11261	2.666788551
207	406.5	156.5	157.25	0.001441334	32395.5	156.5	1778674.021	1746.375116	0.895445754	11365.32921	2.717219583
208	405	155	155.75	0.001427519	32240	155	1794829.6	1778.767346	0.896873273	11579.5458	2.767619295
209	403.5	153.5	154.25	0.001413704	32081.5	153.5	1810649.529	1811.121416	0.898286977	11795.7624	2.817959635
210	402	152	152.75	0.001399889	31920	152	1826124.808	1843.418973	0.899686867	12013.979	2.86821204
211	400.5	150.5	151.25	0.001386075	31755.5	150.5	1841246.437	1875.641321	0.901072942	12234.19559	2.918347428
212	399	149	149.75	0.00137226	31588	149	1856005.416	1907.769438	0.902445202	12456.41219	2.968336201
213	397.5	147.5	148.25	0.001358445	31417.5	147.5	1870392.746	1939.783973	0.903803647	12680.62879	3.018148248
214	396	146	146.75	0.001344631	31244	146	1884399.426	1971.665238	0.905148278	12906.84538	3.06775294

288	310	60	60.5	0.000552588	17280	60	2111812.409	3848.862883	0.972186406	35196.87349	5.677337927
289	309	59	59.5	0.000543378	17051	59	2098812.315	3845.730509	0.972729784	35573.09009	5.672484204
290	308	58	58.5	0.000534168	16820	58	2085175.788	3841.247303	0.973263953	35951.30668	5.665488695
291	307	57	57.5	0.000524959	16587	57	2070896.827	3835.38515	0.973788911	36331.52328	5.656367655
292	306	56	56.5	0.000515749	16352	56	2055969.433	3828.11571	0.97430466	36713.73987	5.645056891
293	305	55	55.5	0.000506539	16115	55	2040387.606	3819.410426	0.974811199	37097.95647	5.631612267
294	304	54	54.5	0.000497329	15876	54	2024145.346	3809.240517	0.975308528	37484.17307	5.615688704
295	303	53	53.5	0.000488119	15635	53	2007236.852	3597.576981	0.975796648	37872.38966	5.597541178
296	302	52	52.5	0.00047891	15392	52	1989855.525	3584.390597	0.976275557	38262.60626	5.577024221
297	301	51	51.5	0.0004697	15147	51	1971395.986	3569.651921	0.976745257	38654.82285	5.554092024
298	300	50	50.5	0.00046049	14900	50	1952451.972	3553.331288	0.977205747	39049.03945	5.528698429
299	299.5	49.5	49.75	0.000455885	14800.5	49.5	1952540.174	3571.474312	0.977661632	39445.25605	5.556927519
300	299	49	49.25	0.00045128	14700	49	1952330.159	3589.070734	0.978112912	39843.47264	5.58430614
301	298.5	48.5	48.75	0.000446675	14598.5	48.5	1951818.928	3606.106771	0.978559587	40243.68924	5.610812847
302	298	48	48.25	0.00044207	14496	48	1951003.48	3622.568531	0.979001658	40645.90583	5.636426024
303	297.5	47.5	47.75	0.000437465	14392.5	47.5	1949880.815	3638.442009	0.979439123	41050.12243	5.661123883
304	297	47	47.25	0.000432861	14288	47	1948447.934	3653.713093	0.979871984	41456.33903	5.684884465
305	296.5	46.5	46.75	0.000428256	14182.5	46.5	1946701.836	3668.367559	0.980300239	41864.55562	5.707685636
306	296	46	46.25	0.000423651	14076	46	1944639.522	3682.39107	0.98072389	42274.77222	5.729505097
307	295.5	45.5	45.75	0.000419046	13968.5	45.5	1942257.991	3695.769183	0.981142936	42686.98881	5.750320366
308	295	45	45.25	0.000414441	13860	45	1939554.243	3708.46734	0.981557377	43101.20541	5.770108799
309	294.5	44.5	44.75	0.000409836	13750.5	44.5	1936525.279	3720.530877	0.981967213	43517.42201	5.788847576
310	294	44	44.25	0.000405231	13640	44	1933168.099	3731.865015	0.982372444	43935.6386	5.806513704
311	293.5	43.5	43.75	0.000400626	13528.5	43.5	1929479.701	3742.534868	0.982773071	44355.8552	5.823084021
312	293	43	43.25	0.000396021	13416	43	1925457.087	3752.465437	0.983169092	44778.07179	5.83853519
313	292.5	42.5	42.75	0.000391416	13302.5	42.5	1921097.257	3761.661614	0.983560508	45202.28839	5.852843704
314	292	42	42.25	0.000386812	13188	42	1916397.209	3770.108181	0.98394732	45628.50499	5.865985884
315	291.5	41.5	41.75	0.000382207	13072.5	41.5	1911353.946	3777.789807	0.984329527	46058.72158	5.877937877
316	291	41	41.25	0.000377602	12956	41	1905964.465	3784.691052	0.984707128	46486.93818	5.888675662
317	290.5	40.5	40.75	0.000372997	12838.5	40.5	1900225.768	3790.796367	0.985080125	46919.15478	5.898176042
318	290	40	40.25	0.000368392	12720	40	1894134.855	3796.09009	0.985448517	47353.37137	5.90641165
319	289.5	39.5	39.75	0.000363787	12600.5	39.5	1887688.725	3800.55845	0.985812304	47789.58797	5.913360948
320	289	39	39.25	0.000359182	12480	39	1880884.378	3804.179564	0.986171486	48227.80456	5.918998222
321	288.5	38.5	38.75	0.000354577	12358.5	38.5	1873718.815	3806.94344	0.986526064	48668.02116	5.923298592
322	288	38	38.25	0.000349972	12236	38	1866189.035	3808.831974	0.986876036	49110.23776	5.926237
323	287.5	37.5	37.75	0.000345367	12112.5	37.5	1858292.038	3809.826954	0.987221404	49554.45435	5.927788221
324	287	37	37.25	0.000340763	11988	37	1850024.825	3809.916055	0.987562166	50000.67095	5.927926855
325	286.5	36.5	36.75	0.000336158	11862.5	36.5	1841384.395	3809.082843	0.987898324	50448.88754	5.926627331
326	286	36	36.25	0.000331553	11736	36	1832367.749	3807.306771	0.988229877	50899.10414	5.923863906
327	285.5	35.5	35.75	0.000326948	11608.5	35.5	1822971.886	3804.573185	0.988556824	51351.32074	5.919610668
328	285	35	35.25	0.000322343	11480	35	1813193.807	3800.865319	0.988879167	51805.53733	5.913841523
329	284.5	34.5	34.75	0.000317738	11350.5	34.5	1803030.511	3796.166295	0.989196906	52261.75393	5.906530219
330	284	34	34.25	0.000313133	11220	34	1792478.998	3790.459126	0.989510039	52719.97052	5.897650322
331	283.5	33.5	33.75	0.000308528	11088.5	33.5	1781536.269	3783.726715	0.989818567	53180.18712	5.887175231
332	283	33	33.25	0.000303923	10956	33	1770199.323	3775.951854	0.99012249	53642.40372	5.87507817
333	282.5	32.5	32.75	0.000299318	10822.5	32.5	1758465.16	3767.117223	0.990421809	54106.62031	5.861332193
334	282	32	32.25	0.000294714	10688	32	1746330.781	3757.205393	0.990716522	54572.83691	5.845910181
335	281.5	31.5	31.75	0.000290109	10552.5	31.5	1733793.185	3746.198824	0.991006631	55041.0535	5.828784843
336	281	31	31.25	0.000285504	10416	31	1720849.373	3734.079867	0.991292135	55511.2701	5.809928718
337	280.5	30.5	30.75	0.000280899	10278.5	30.5	1707496.344	3720.83076	0.991573034	55983.4867	5.78931417
338	280	30	30.25	0.000276294	10140	30	1693731.099	3706.433631	0.991849328	56457.70329	5.766913393
339	279.5	29.5	29.75	0.000271689	10000.5	29.5	1679550.637	3690.8705	0.992121017	56933.91989	5.742698409
340	279	29	29.25	0.000267084	9860	29	1664951.958	3674.123273	0.992388101	57412.13648	5.716641067
341	278.5	28.5	28.75	0.000262479	9716.5	28.5	1649932.063	3656.173747	0.99265058	57892.35308	5.688713045
342	278	28	28.25	0.000257874	9578	28	1634487.951	3637.00361	0.992908455	58374.56966	5.658885849
343	277.5	27.5	27.75	0.000253269	9432.5	27.5	1618616.622	3616.594437	0.993161724	58858.78627	5.627130813
344	277	27	27.25	0.000248665	9288	27	1602315.077	3594.927693	0.993410389	59345.00287	5.593419098
345	276.5	26.5	26.75	0.00024406	9142.5	26.5	1585580.316	3571.984734	0.993654448	59833.21946	5.557721695
346	276	26	26.25	0.000239455	8996	26	1568409.338	3547.746804	0.993893903	60323.43606	5.52000942
347	275.5	25.5	25.75	0.00023485	8848.5	25.5	1550799.143	3522.195038	0.994128753	60815.65266	5.480252921
348	275	25	25.25	0.000230245	8700	25	1532746.731	3495.310457	0.994358998	61309.86925	5.438422671
349	274.5	24.5	24.75	0.00022564	8550.5	24.5	1514249.103	3467.073976	0.994584638	61806.08585	5.394488972
350	274	24	24.25	0.000221035	8400	24	1495303.259	3437.466397	0.994805673	62304.30244	5.348421954
351	273.5	23.5	23.75	0.00021643	8248.5	23.5	1475906.197	3406.468412	0.995022104	62804.51904	5.300191576
352	273	23	23.25	0.000211825	8096	23	1456054.92	3374.060602	0.995233929	63306.73564	5.249767623
353	272.5	22.5	22.75	0.00020722	7942.5	22.5	1435746.425	3340.223438	0.995441149	63810.95223	5.19711971
354	272	22	22.25	0.000202616	7788	22	1414977.714	3304.93728	0.995643765	64317.16883	5.142217279
355	271.5	21.5	21.75	0.000198011	7632.5	21.5	1393745.787	3268.182378	0.995841776	64825.38543	5.0850296
356	271	21	21.25	0.000193406	7476	21	1372047.642	3229.938872	0.996035181	65335.60202	5.025525772
357	270.5	20.5	20.75	0.000188801	7318.5	20.5	1349880.282	3190.18879	0.996223982	65847.81862	4.963674721
358	270	20	20.25	0.000184196	7160	20	1327240.704	3148.90605	0.996408178	66362.03521	4.899445202
359	269.5	19.5	19.75	0.000179591	7000.5	19.5	1304125.91	3106.07646	0.996587769	66878.25181	4.832805797
360	269	19	19.25	0.000174986	6840	19	1280532.9	3061.677718	0.996762758	67396.46841	4.763724916

t_m (min) =	100.391702
σ^2 =	5546.475065
Pe =	46919.74091
s^3 =	784.384593

74.47466055

mean real liquid velocity, u (m/s)	0.000157798
distance, L (m)	1.8

ε	0.290086792
μ_{gas} (lb/ft.s)	1.23E-05
U_{gas} (ft/s)	1.04E-01
D_p (ft) = $6V_p/A_p$	8.75E-03
G_{gas} (kg/m.s^3)	0.014102505
L_{column} (ft)	4.9212

ΔP (lb/ft^2) =	9.20243327
ΔP (N/m^2) =	440.6133531
ΔP_{exp} (mbar) =	5.275482606
ΔP_{exp} (N/m^2) =	527.5482606

H_o =	0.03042086

μ_{liquid} (lb/ft.s)	6.55E-04
U_{liquid} (ft/s)	5.18E-04
ρ_{liquid} (lb/ft^3)	62.2608
nominal packing size (ring diameter), d (ft)	0.026246
g (ft/s^2)	32.17
g (m/s^2)	9.80665

H_o (Exp) =	0.709911208
V_{liquid} (m^3)	6.70E-03
V_{column} (m^3)	9.44E-03

$V_{stagnant}$ (m^3)	0.004418215
T_a (min)	188.756

Pressure Drop (Experimental)

6.148209	4.849426	6.214005	5.075562	5.260406
5.069595	5.255814	4.732834	4.633967	4.37793
7.569382	4.805893	5.068237	5.073669	5.05658
5.069595	4.320602	4.946289	6.32579	5.071304
7.813828	6.037003	5.335938	5.121277	5.08493
4.888887	5.066406	4.874603	5.042664	4.722641
5.068192	7.650436	4.82933	5.11586	5.077301
5.322968	7.815875	4.779999	4.148758	5.26915
5.321716	5.067307	8.651733	4.552826	5.247711
4.894348	7.372192	4.701141	4.89502	4.364029
5.284912	4.804916	6.743423	5.066849	5.083694
4.440643	5.242325	5.947922	6.568893	5.068192
5.0923	4.769318	5.871277	5.066406	5.070526
4.966919	5.197632	5.08139	5.196091	5.090454
5.086197	4.735188	4.447952	5.066803	5.069595
7.534805	3.926224	5.068192	5.090988	5.062108
5.414017	7.616409	5.085052	4.714661	5.090729
5.385437	7.605957	5.076721	6.11853	5.277481
5.311096	5.067307	5.084579	5.92305	5.120634
4.875717	7.299545	5.075455	5.758743	5.068192
5.26944	4.790237	5.408508	5.10614	3.467255
4.408401	5.196945	5.075058	5.620773	5.081345
5.090012	4.775024	5.875214	5.108215	5.284424
5.099121	3.141037	5.073669	5.621002	5.077133
5.080475	6.016524	4.237377	5.06459	4.757628
4.921768	4.713943	5.108231	5.518188	5.086411
6.269501	4.718246	4.476898	5.067352	
5.066406	5.636437	5.104645	5.067795	
7.397049	5.556412	4.60318	5.077087	
5.33638	5.512711	5.098267	5.082108	
5.290558	5.038147	4.5354	5.075058	
4.822495	5.443468	4.882141	4.579117	
5.238969	5.85553	4.820618	5.07457	
4.377625	5.089068	6.262634	4.606522	
5.093237	5.067749	5.066406	5.114105	
4.687637	6.682922	5.192459	5.014297	
7.718506	5.067307	6.972244	4.539413	
7.409088	7.380661	4.772049	5.102844	
5.345581	5.066895	5.190186	4.606354	
4.891113	7.603851	5.87615	5.220673	
5.277267	5.073669	5.722672	4.767929	
4.825195	6.259668	5.655197	5.087494	
5.236786	5.072327	5.081284	5.696121	
4.369431	4.112381	4.355042	5.341095	
5.099411	5.071381	5.068192	4.859924	
7.652359	4.149521	5.068165	5.060822	
5.067307	5.097046	5.078354	5.035049	
7.412796	3.646822	4.390564	5.269608	
5.067307	5.106842	5.076309	5.104813	
5.308914	5.066849	5.066868	5.061249	

G =	12.5		L =	0.05							
t (min)	**C (mS)**	**C-250**	**Area**	**E (1/min)**	**t*C*Δt**	**C*Δt**	**$(t-tm)^2$*C*Δt**	**$(t-tm)^3$*E*Δt**	**F (t)**	**σ^2**	**s^3**
0	250	0		0	0	0	0	0	0	#DIV/0!	0
1	255	5	2.5	4.00593E-05	5	5	49954.95146	-40.00516157	4.00593E-05	9990.990293	-0.062180145
2	260	10	7.5	8.01186E-05	20	10	97920.8041	-77.63287604	0.000120178	9792.08041	-0.120665017
3	265	15	12.5	0.000120178	45	15	143927.5579	-112.9544966	0.000240356	9595.170528	-0.17556552
4	270	20	17.5	0.000160237	80	20	188005.2129	-146.0404149	0.000400593	9400.260645	-0.226991064
5	275	25	22.5	0.000200296	125	25	230183.7691	-176.9600613	0.000600889	9207.350762	-0.275049565
6	280	30	27.5	0.000240356	180	30	270493.2264	-205.7819047	0.000841245	9016.44088	-0.319847444
7	310	60	45	0.000480711	420	60	529651.8598	-398.6973473	0.001321956	8827.530997	-0.619696507
8	340	90	75	0.000721067	720	90	777655.9003	-579.1528148	0.002043024	8640.621115	-0.900178993
9	420	170	130	0.001362016	1530	170	1437470.909	-1059.027766	0.003405039	8455.711232	-1.646050129
10	490	240	205	0.001922846	2400	240	1985472.324	-1446.849487	0.005327885	8272.801349	-2.248842588
11	560	310	275	0.002483676	3410	310	2508486.355	-1807.861607	0.007811561	8091.891467	-2.809995916
12	640	390	350	0.003124624	4680	390	3086062.818	-2199.419436	0.010936186	7912.981584	-3.41856436
13	700	450	420	0.003605336	5850	450	3481232.266	-2453.163319	0.014541521	7736.071701	-3.812959254
14	780	530	490	0.004246285	7420	530	4007415.764	-2791.848757	0.018787806	7561.161619	-4.339379067
15	850	600	565	0.004807115	9000	600	4432951.162	-3052.790586	0.02359492	7388.251936	-4.744961751
16	910	660	630	0.005287826	10560	660	4763445.755	-3242.224529	0.028882746	7217.342054	-5.039389509
17	960	710	685	0.005688419	12070	710	5004388.841	-3366.125895	0.034571165	7048.432171	-5.231979781
18	1000	750	730	0.006008893	13500	750	5161141.716	-3430.214383	0.040580058	6881.522288	-5.331592714
19	1060	810	780	0.006489605	15390	810	5440456.049	-3572.265002	0.047069663	6716.612406	-5.552382425
20	1090	840	825	0.00672996	16800	840	5505110.119	-3570.611436	0.053799623	6553.702523	-5.549812286
21	1120	870	855	0.006970316	18270	870	5581729.597	-3582.775015	0.06076994	6392.79264	-5.537632111
22	1150	900	885	0.007210672	19800	900	5610494.482	-3549.062713	0.067980611	6233.882758	-5.516319038
23	1180	930	915	0.007451028	21390	930	5651584.774	-3529.775743	0.075431639	6076.972875	-5.486341241
24	1210	960	945	0.007691383	23040	960	5685180.473	-3505.209547	0.083123022	5922.062993	-5.448157927
25	1220	970	965	0.007771502	24250	970	5596078.517	-3405.438572	0.090894524	5769.15311	-5.293083695
26	1240	990	980	0.007931739	25740	990	5562060.795	-3340.174983	0.098826263	5618.243227	-5.191644199
27	1260	1010	1000	0.008091976	27270	1010	5524026.676	-3273.076704	0.106918239	5469.333345	-5.087353138
28	1270	1020	1015	0.008172095	28560	1020	5428871.931	-3173.200602	0.115090334	5322.423462	-4.932116408
29	1280	1030	1025	0.008252213	29870	1030	5332838.987	-3074.342958	0.123342547	5177.513579	-4.778460669
30	1290	1040	1035	0.008332332	31200	1040	5235987.645	-2976.556989	0.131674879	5034.603697	-4.626474747
31	1300	1050	1045	0.00841245	32550	1050	5138378.505	-2879.901989	0.140087329	4893.693814	-4.476240476
32	1310	1060	1055	0.008492569	33920	1060	5040070.967	-2784.423329	0.148579898	4754.783931	-4.327837702
33	1315	1065	1062.5	0.008532628	35145	1065	4916035.862	-2677.601557	0.157112527	4617.874049	-4.161804296
34	1318	1068	1066.5	0.008556664	36312	1068	4767805.73	-2568.339155	0.16566919	4482.964166	-3.991977409
35	1320	1070	1069	0.008572688	37450	1070	4654556.083	-2459.569004	0.174241878	4350.054284	-3.822915631
36	1319	1069	1069.5	0.008564676	38484	1069	4510265.365	-2347.186012	0.182806554	4219.144401	-3.648238402
37	1318	1068	1068.5	0.008556664	39516	1068	4368370.466	-2236.343763	0.191363218	4090.234518	-3.479064561
38	1316	1066	1067	0.00854064	40508	1066	4224904.062	-2130.982552	0.199903858	3963.324636	-3.312192703
39	1314	1064	1065	0.008524616	41496	1064	4084073.297	-2027.22847	0.208428474	3838.414753	-3.150927415
40	1310	1060	1062	0.008492569	42400	1060	3938435.163	-1923.383261	0.216921043	3715.50487	-2.99952052
41	1305	1055	1057.5	0.00845251	43255	1055	3792297.712	-1821.631909	0.225373553	3594.594988	-2.831368052
42	1300	1050	1052.5	0.00841245	44100	1050	3649469.38	-1723.785216	0.233786003	3475.685105	-2.67928484
43	1295	1045	1047.5	0.008372391	44935	1045	3509920.108	-1629.74974	0.242158394	3358.775223	-2.53312501
44	1290	1040	1042.5	0.008332332	45760	1040	3373619.954	-1539.432973	0.250490726	3243.86534	-2.392745381
45	1280	1030	1035	0.008252213	46350	1030	3224884.121	-1445.725287	0.25874294	3130.955457	-2.247095239
46	1260	1010	1020	0.008091976	46460	1010	3050246.03	-1342.996387	0.266834916	3020.045575	-2.087423364
47	1240	990	1000	0.007931739	46530	990	2882024.335	-1245.839473	0.274766655	2911.135692	-1.936412106
48	1230	980	985	0.00785162	47040	980	2748141.293	-1165.946889	0.282618275	2804.225809	-1.812234818
49	1220	970	975	0.007771502	47530	970	2618336.449	-1089.69718	0.290389777	2699.315927	-1.694030523
50	1215	965	967.5	0.007731443	48250	965	2505531.833	-1022.667664	0.298121219	2596.406044	-1.589546341
51	1210	960	962.5	0.007691383	48960	960	2395678.315	-958.6260203	0.305812603	2495.496162	-1.490306218
52	1205	955	957.5	0.007651324	49660	955	2288739.896	-897.6895961	0.313463927	2396.586279	-1.395281691
53	1200	950	952.5	0.007611265	50350	950	2164692.577	-839.3767119	0.321075191	2299.676396	-1.304845792
54	1195	945	947.5	0.007571205	51030	945	2063504.355	-783.8066317	0.328646397	2204.766514	-1.218273047
55	1190	940	942.5	0.007531146	51700	940	1965145.233	-730.8995929	0.336177543	2111.856631	-1.136039474
56	1185	935	937.5	0.007491087	52360	935	1889585.21	-680.5767914	0.34366863	2020.948748	-1.05782259
57	1180	930	932.5	0.007451028	53010	930	1796794.265	-632.7603842	0.351119657	1932.036866	-0.983501402
58	1175	925	927.5	0.007410968	53650	925	1706742.459	-587.3734902	0.358530625	1845.126983	-0.912956414
59	1170	920	922.5	0.007370909	54280	920	1619399.733	-544.3401894	0.365901534	1760.217101	-0.846069622
60	1165	915	917.5	0.00733085	54900	915	1534736.104	-503.5855233	0.373232384	1677.307218	-0.78272452
61	1160	910	912.5	0.00729079	55510	910	1452721.575	-465.0354946	0.380523174	1596.397335	-0.722806093
62	1150	900	905	0.007210672	55800	900	1365738.707	-426.2490181	0.387733846	1517.487453	-0.662520153
63	1140	890	895	0.007130553	56070	890	1282114.037	-389.8775231	0.394864399	1440.57757	-0.605987827
64	1130	880	885	0.007050435	56320	880	1201787.565	-355.8225288	0.401914834	1365.667687	-0.553058046
65	1120	870	875	0.006970316	56550	870	1124699.29	-323.9874773	0.40888515	1292.757805	-0.503574728
66	1110	860	865	0.006890197	56760	860	1050789.213	-294.2777333	0.415775348	1221.847922	-0.457396781
67	1100	850	855	0.006810079	56950	850	979997.3336	-266.8005845	0.422585426	1152.93804	-0.414378104
68	1090	840	845	0.00672996	57120	840	912263.6518	-240.8852414	0.429315387	1086.028157	-0.374377582

142	616	366	369	0.00293234	51972	366	616599.0444	202.7658466	0.768417258	1684.696843	0.31516113
143	610	360	363	0.002884269	51480	360	638403.3056	214.3781944	0.771301526	1767.78696	0.333208684
144	604	354	357	0.002836198	50976	354	655918.4854	226.2071842	0.774137724	1852.877077	0.351594519
145	598	348	351	0.002788126	50460	348	675108.5838	238.2341641	0.77692585	1939.967195	0.37028809
146	592	342	345	0.002740055	49932	342	693937.6007	250.4383283	0.779665906	2029.057312	0.38925706
147	586	336	339	0.002691984	49392	336	712369.5363	262.7977175	0.78235789	2120.147429	0.408467297
148	580	330	333	0.002643913	48840	330	730388.3905	275.2892184	0.785001803	2213.237547	0.427882875
149	574	324	327	0.002595842	48276	324	747898.1832	287.8885642	0.787597645	2308.327664	0.447466076
150	568	318	321	0.002547771	47700	318	764922.8545	300.5703344	0.790145415	2405.417782	0.467177391
151	562	312	315	0.0024997	47112	312	781406.4645	313.3079548	0.792645115	2504.507899	0.486975513
152	556	306	309	0.002451628	46512	306	797312.993	326.0736972	0.795096743	2605.598016	0.506817348
153	550	300	303	0.002403557	45900	300	812606.4401	338.8388802	0.7975003	2708.688134	0.526657998
154	544	294	297	0.002355486	45276	294	827250.6058	351.5728682	0.799855787	2813.778251	0.546450765
155	538	288	291	0.002307415	44640	288	841210.0901	364.2450722	0.802163202	2920.868368	0.566147231
156	532	282	285	0.002259344	43992	282	854448.293	376.8229494	0.804422545	3029.958486	0.585697064
157	526	276	279	0.002211273	43332	276	866929.4145	389.2730033	0.806633818	3141.048603	0.605048221
158	520	270	273	0.002163202	42660	270	878617.4546	401.5605837	0.80879702	3254.138721	0.624146844
159	518	268	269	0.002147178	42612	268	902953.3286	419.9173092	0.810944197	3369.228838	0.652676759
160	516	266	267	0.002131154	42560	266	927360.8421	438.6978756	0.813075352	3486.318955	0.681869451
161	514	264	265	0.00211513	42504	264	951827.9952	457.898232	0.815190482	3605.409073	0.711712624
162	512	262	263	0.002099107	42444	262	976342.7878	477.5139429	0.817289589	3726.49919	0.742201383
163	510	260	261	0.002083083	42380	260	1000893.22	497.540188	0.819372672	3849.589307	0.773328237
164	508	258	259	0.002067059	42312	258	1025467.292	517.9717629	0.821439731	3974.679425	0.805085096
165	506	256	257	0.002051036	42240	256	1050053.003	538.8030781	0.823490768	4101.769542	0.837463273
166	504	254	255	0.002035012	42164	254	1074638.354	560.0281599	0.825525778	4230.85966	0.870453483
167	502	252	253	0.002018988	42084	252	1099211.344	581.6406498	0.827544766	4361.949777	0.904045842
168	500	250	251	0.002002964	42000	250	1123759.974	603.6338051	0.829547731	4495.039894	0.938229871
169	498	248	249	0.001986941	41912	248	1148272.243	626.000496	0.831534671	4630.130012	0.97299449
170	496	246	247	0.001970917	41820	246	1172736.152	648.7332165	0.833505586	4767.220129	1.008328024
171	494	244	245	0.001954893	41724	244	1197139.7	671.824064	0.835460482	4906.310246	1.044218199
172	492	242	243	0.00193887	41624	242	1221470.888	695.2847592	0.837399351	5047.400364	1.080652143
173	490	240	241	0.001922846	41520	240	1245717.715	719.0466364	0.839322197	5190.490481	1.117616388
174	488	238	239	0.001906822	41412	238	1269868.182	743.1606451	0.841229019	5335.580599	1.155096865
175	486	236	237	0.001890798	41300	236	1293910.289	767.5973503	0.843119817	5482.670716	1.193078911
176	484	234	235	0.001874775	41184	234	1317832.035	792.3469327	0.844994592	5631.760833	1.231547263
177	482	232	233	0.001858751	41064	232	1341621.421	817.3991681	0.846853343	5782.850951	1.27048606
178	480	230	231	0.001842727	40940	230	1365266.446	842.7435279	0.84869607	5935.941068	1.309878645
179	478	228	229	0.001826704	40812	228	1388755.11	868.3689788	0.850522774	6091.031185	1.349708561
180	476	226	227	0.00181068	40680	226	1412075.414	894.264183	0.852333454	6248.121303	1.389957557
181	474	224	225	0.001794656	40544	224	1435215.358	920.4173983	0.85412811	6407.21142	1.430607579
182	472	222	223	0.001778632	40404	222	1458162.941	946.8164977	0.855906742	6568.301538	1.47163978
183	470	220	221	0.001762609	40260	220	1480906.164	973.4489696	0.857669351	6731.391655	1.513034713
184	468	218	219	0.001746585	40112	218	1503433.028	1000.301918	0.859415936	6896.481772	1.554772333
185	466	216	217	0.001730561	39960	216	1525731.528	1027.362062	0.861146497	7063.57189	1.596831998
186	464	214	215	0.001714538	39804	214	1547789.67	1054.615738	0.862861034	7232.662007	1.639192469
187	462	212	213	0.001698514	39644	212	1569595.45	1082.048894	0.864559548	7403.752124	1.681831907
188	460	210	211	0.00168249	39480	210	1591136.871	1109.647098	0.866242038	7576.842242	1.724727878
189	458	208	209	0.001666466	39312	208	1612401.931	1137.395526	0.867908505	7751.932359	1.767857348
190	456	206	207	0.001650443	39140	206	1633378.63	1165.278981	0.869558947	7929.022477	1.811196686
191	454	204	205	0.001634419	38964	204	1654054.969	1193.281871	0.871193368	8108.112594	1.854721665
192	452	202	203	0.001618395	38784	202	1674418.948	1221.388225	0.872811761	8289.202711	1.898407457
193	450	200	201	0.001602372	38600	200	1694458.566	1249.581686	0.874414133	8472.292829	1.942228639
194	448	198	199	0.001586348	38412	198	1714161.823	1277.845511	0.876000481	8657.382946	1.986159189
195	446	196	197	0.001570324	38220	196	1733516.72	1306.162574	0.877570805	8844.473063	2.030172487
196	444	194	195	0.0015543	38024	194	1752511.257	1334.515365	0.879125105	9033.563181	2.074241316
197	442	192	193	0.001538277	37824	192	1771133.433	1362.885988	0.880663382	9224.653298	2.118337862
198	440	190	191	0.001522253	37620	190	1789371.249	1391.256162	0.882185635	9417.743416	2.162433711
199	438	188	189	0.001506229	37412	188	1807212.704	1419.607224	0.883691864	9612.833533	2.206499853
200	436	186	187	0.001490206	37200	186	1824645.799	1447.920124	0.885182069	9809.92365	2.25050668
201	434	184	185	0.001474182	36984	184	1841658.533	1476.175426	0.886656251	10009.01377	2.294423988
202	432	182	183	0.001458158	36764	182	1858238.907	1504.353318	0.888114409	10210.10389	2.338220967
203	430	180	181	0.001442134	36540	180	1874374.92	1532.433592	0.889556544	10413.194	2.381866222
204	428	178	179	0.001426111	36312	178	1890054.573	1560.395681	0.890982654	10618.28412	2.425327752
205	426	176	177	0.001410087	36080	176	1905265.866	1588.218554	0.892392741	10825.37424	2.468572959
206	424	174	175	0.001394063	35844	174	1919996.798	1615.880914	0.893786804	11034.46435	2.51156865
207	422	172	173	0.001378039	35604	172	1934235.369	1643.361	0.895164844	11245.55447	2.554281032
208	420	170	171	0.001362016	35360	170	1947969.58	1670.636687	0.89652686	11458.64459	2.596675715
209	418	168	169	0.001345992	35112	168	1961187.431	1697.685463	0.897872852	11673.73471	2.638717711
210	416	166	167	0.001329968	34860	166	1973876.921	1724.484434	0.89920282	11890.82482	2.680371434
211	414	164	165	0.001313945	34604	164	1986026.05	1751.010321	0.900516765	12109.91494	2.721600702
212	412	162	163	0.001297921	34344	162	1997622.82	1777.23948	0.901814686	12331.00506	2.762368732
213	410	160	161	0.001281897	34080	160	2008655.228	1803.147802	0.903096583	12554.09518	2.802638148
214	408	158	159	0.001265873	33812	158	2019111.276	1828.710914	0.904362456	12779.18529	2.842370971

288	324	74	74.4	0.000592877	21312	74	2588953.194	3879.749246	0.970171854	34985.65398	6.030306128
289	323.2	73.2	73.6	0.000586468	21154.8	73.2	2588421.106	3899.689934	0.970758322	35360.9441	6.0613
290	322.4	72.4	72.8	0.000580058	20996	72.4	2587433.677	3918.932431	0.971338381	35736.03421	6.091206671
291	321.6	71.6	72	0.000573649	20835.6	71.6	2585986.102	3937.458463	0.97191203	36117.12433	6.120003771
292	320.8	70.8	71.2	0.00056724	20673.6	70.8	2584073.583	3955.249684	0.972479269	36498.21445	6.147656689
293	320	70	70.4	0.00056083	20510	70	2581691.32	3972.287473	0.973040099	36881.30457	6.174136578
294	319.2	69.2	69.6	0.000554421	20344.8	69.2	2578834.512	3988.553136	0.97359452	37266.39468	6.199420347
295	318.4	68.4	68.8	0.000548011	20178	68.4	2575498.36	4004.027805	0.974142531	37653.4848	6.223472672
296	317.6	67.6	68	0.000541602	20009.6	67.6	2571678.064	4018.692457	0.974684133	38042.57492	6.246265965
297	316.8	66.8	67.2	0.000535192	19839.6	66.8	2567368.824	4032.527916	0.975219325	38433.66504	6.267770482
298	316	66	66.4	0.000528783	19668	66	2562565.84	4045.514853	0.975746107	38826.75515	6.287956117
299	315.2	65.2	65.6	0.000522373	19494.8	65.2	2557284.312	4057.633783	0.97627046	39221.84527	6.306792606
300	314.4	64.4	64.8	0.000515964	19320	64.4	2551459.439	4068.86507	0.976786444	39618.93539	6.324249432
301	313.6	63.6	64	0.000509554	19143.6	63.6	2545146.422	4079.188923	0.977295998	40018.02551	6.340295627
302	312.8	62.8	63.2	0.000503145	18965.6	62.8	2538320.461	4088.585395	0.977799143	40419.11562	6.354900793
303	312	62	62.4	0.000496735	18786	62	2530976.756	4097.034366	0.978295678	40822.20574	6.368033069
304	311.2	61.2	61.6	0.000490326	18604.8	61.2	2523110.506	4104.51565	0.978786204	41227.29586	6.379661237
305	310.4	60.4	60.8	0.000483916	18422	60.4	2514716.913	4111.006774	0.97927012	41634.38597	6.389753519
306	309.6	59.6	60	0.000477507	18237.6	59.6	2505791.175	4116.493198	0.979747626	42043.47609	6.398277977
307	308.8	58.8	59.2	0.000471097	18051.6	58.8	2496328.493	4120.94821	0.980218724	42454.56621	6.405202416
308	308	58	58.4	0.000464688	17864	58	2486324.067	4124.352941	0.980683411	42867.65633	6.4104944
309	307.2	57.2	57.6	0.000458278	17674.8	57.2	2475773.097	4126.686369	0.98114169	43282.74644	6.414121254
310	306.4	56.4	56.8	0.000451869	17484	56.4	2464670.782	4127.927319	0.981593558	43699.83656	6.416050065
311	305.6	55.6	56	0.000445459	17291.6	55.6	2453012.323	4128.05446	0.982039018	44118.92668	6.416247681
312	304.8	54.8	55.2	0.00043905	17097.6	54.8	2440792.92	4127.04631	0.982478068	44540.0168	6.41468071
313	304	54	54.4	0.00043264	16902	54	2428007.773	4124.881231	0.982910706	44963.10691	6.411315521
314	303.2	53.2	53.6	0.000426231	16704.8	53.2	2414652.082	4121.537432	0.983336939	45388.19703	6.406118244
315	302.4	52.4	52.8	0.000419821	16506	52.4	2400721.047	4116.992968	0.98375676	45815.28715	6.399054771
316	301.6	51.6	52	0.000413412	16305.6	51.6	2386209.867	4111.225741	0.984170172	46244.37727	6.390090752
317	300.8	50.8	51.2	0.000407002	16103.6	50.8	2371113.743	4104.213498	0.984577174	46675.46738	6.379191602
318	300	50	50.4	0.000400593	15900	50	2355427.875	4095.933833	0.984977767	47108.5575	6.366322493
319	299.2	49.2	49.6	0.000394183	15694.8	49.2	2339147.463	4086.364165	0.98537195	47543.64762	6.35144836
320	298.4	48.4	48.8	0.000387774	15488	48.4	2322267.706	4075.481641	0.985759724	47980.73774	6.3345339
321	297.6	47.6	48	0.000381364	15279.6	47.6	2304783.806	4063.263933	0.986141089	48419.82785	6.315543567
322	296.8	46.8	47.2	0.000374955	15069.6	46.8	2286690.961	4049.687439	0.986516044	48860.91797	6.294441581
323	296	46	46.4	0.000368545	14858	46	2267984.372	4034.729183	0.986884589	49304.00809	6.271191918
324	295.2	45.2	45.6	0.000362136	14644.8	45.2	2248659.239	4018.365837	0.987246725	49749.0982	6.245758319
325	294.4	44.4	44.8	0.000355726	14430	44.4	2228710.761	4000.573916	0.987602452	50196.18832	6.218104282
326	293.6	43.6	44	0.000349317	14213.6	43.6	2208134.14	3981.329785	0.987951769	50645.27844	6.18819307
327	292.8	42.8	43.2	0.000342908	13995.6	42.8	2186924.574	3960.609652	0.988294676	51096.36856	6.155987704
328	292	42	42.4	0.000336498	13776	42	2165077.264	3938.389573	0.988631174	51549.45867	6.121450967
329	291.2	41.2	41.6	0.000330089	13554.8	41.2	2142587.41	3914.645449	0.988961263	52004.54879	6.084545402
330	290.4	40.4	40.8	0.000323679	13332	40.4	2119450.212	3889.353028	0.989284942	52461.63891	6.045233315
331	289.6	39.6	40	0.00031727	13107.6	39.6	2095660.869	3862.487904	0.989602211	52920.72903	6.00347677
332	288.8	38.8	39.2	0.00031086	12881.6	38.8	2071214.583	3834.025516	0.989913071	53381.81914	5.959237595
333	288	38	38.4	0.000304451	12654	38	2046106.552	3803.941152	0.990217622	53844.90926	5.912477375
334	287.2	37.2	37.6	0.000298041	12424.8	37.2	2020331.977	3772.209944	0.990515563	54309.99938	5.863157461
335	286.4	36.4	36.8	0.000291632	12194	36.4	1993886.058	3738.806869	0.990807196	54777.0895	5.81123896
336	285.6	35.6	36	0.000285222	11961.6	35.6	1966763.994	3703.706754	0.991092417	55246.17961	5.756682743
337	284.8	34.8	35.2	0.000278813	11727.6	34.8	1938960.987	3666.884266	0.991371229	55717.26973	5.69944944
338	284	34	34.4	0.000272403	11492	34	1910472.235	3628.313929	0.991643633	56190.35985	5.639489444
339	283.2	33.2	33.6	0.000265994	11254.8	33.2	1881292.939	3587.9701	0.991909626	56665.44997	5.576782906
340	282.4	32.4	32.8	0.000259584	11016	32.4	1851418.299	3545.826991	0.99216921	57142.54008	5.511289744
341	281.6	31.6	32	0.000253175	10775.6	31.6	1820843.514	3501.858657	0.992422385	57621.6302	5.442949628
342	280.8	30.8	31.2	0.000246765	10533.6	30.8	1789563.786	3456.039	0.99266915	58102.72032	5.371731995
343	280	30	30.4	0.000240356	10290	30	1757574.313	3408.341768	0.992909506	58585.81043	5.297596041
344	279.5	29.5	29.75	0.00023635	10148	29.5	1742591.566	3393.248163	0.993145856	59070.90055	5.274136006
345	279	29	29.25	0.000232344	10005	29	1727181.729	3377.07941	0.9933762	59557.99067	5.249004862
346	278.5	28.5	28.75	0.000228338	9861	28.5	1711341.802	3359.819352	0.993606538	60047.08079	5.222177502
347	278	28	28.25	0.000224332	9716	28	1695068.785	3341.451739	0.99383087	60538.1709	5.193626664
348	277.5	27.5	27.75	0.000220326	9570	27.5	1678359.678	3321.960223	0.994051196	61031.26102	5.163332941
349	277	27	27.25	0.00021632	9423	27	1661211.481	3301.32836	0.994267516	61526.35114	5.131264774
350	276.5	26.5	26.75	0.000212314	9275	26.5	1643621.193	3279.539611	0.99447963	62023.44126	5.097398455
351	276	26	26.25	0.000208308	9126	26	1625585.816	3256.57734	0.994688138	62522.53137	5.061708127
352	275.5	25.5	25.75	0.000204302	8976	25.5	1607102.348	3232.424815	0.994892441	63023.62149	5.024167763
353	275	25	25.25	0.000200296	8825	25	1588167.79	3207.065208	0.995092737	63526.71161	4.984751268
354	274.5	24.5	24.75	0.000196291	8673	24.5	1568779.142	3180.481594	0.995289026	64031.80173	4.943432275
355	274	24	24.25	0.000192285	8520	24	1548933.404	3152.656953	0.995481312	64538.89184	4.900184351
356	273.5	23.5	23.75	0.000188279	8366	23.5	1528627.576	3123.574169	0.995669591	65047.98196	4.85498069
357	273	23	23.25	0.000184273	8211	23	1507858.658	3093.216028	0.995853864	65559.07208	4.807795139
358	272.5	22.5	22.75	0.000180267	8055	22.5	1486623.649	3061.565222	0.996034131	66072.1622	4.758600195
359	272	22	22.25	0.000176261	7898	22	1464919.551	3028.604346	0.996210391	66587.25231	4.707369005
360	271.5	21.5	21.75	0.000172255	7740	21.5	1442743.362	2994.315899	0.996382646	67104.34243	4.654074368

t_m (min) =	100.9549413		
σ^2 =	5554.168662		74.52629511
Pe =	46854.74799	mean real liquid velocity, u (m/s)	0.000157796
ε^3 =	800.9695384	distance, L (m)	1.8
		ε	0.300684482
ΔP (lb/ft^2) =	10.40387158	μ_{gas} (lb/ft.s)	1.23E-05
ΔP (N/m^2) =	498.1383301	U_{gas} (ft/s)	1.29E-01
ΔP_{exp} (mbar) =	5.313289683	D_p (ft) = $6V_p/A_p$	6.75E-03
ΔP_{exp} (N/m^2) =	531.3289683	G_{gas} ($kg/m.s^2$)	0.017628131
		L_{column} (ft)	4.9212
H_o =	0.03042086	μ_{liquid} (lb/ft.s)	6.55E-04
		U_{liquid} (ft/s)	5.18E-04
		ρ_{liquid} (lb/ft^3)	62.2608
		nominal packing size (ring diameter), d (ft)	0.026246
		g (ft/s^2)	32.17
		g (m/s^2)	9.80665
H_o (Exp) =	0.699315518		
V_{liquid} (m^3)	6.60E-03		
V_{column} (m^3)	9.44E-03		

$V_{stagnant}$ (m^3)	0.004390053
T_d (min)	188.756

Pressure Drop (Experimental)

5.077988	7.648407	4.7677	6.022018	4.701447
5.067749	5.067749	7.36818	4.998474	5.080475
4.451096	7.372406	7.090973	5.370941	4.496292
5.031555	4.982315	4.767258	3.233353	5.094177
5.41806	5.301651	5.211044	4.437576	5.090729
4.976486	5.068649	4.736298	5.427582	5.071381
4.916382	7.663589	5.184298	5.129639	5.082153
4.848755	5.069672	4.709717	5.068192	4.639966
3.31926	5.067307	5.161896	5.14238	5.068192
7.529663	5.199142	4.690964	5.067307	4.300339
5.078766	7.375473	4.69722	5.158264	4.743118
3.646408	5.193466	5.880966	5.067307	5.070938
5.067749	4.730225	4.809036	5.239578	5.914902
4.457413	5.077759	5.147141	4.91832	5.073227
4.993851	4.299133	7.55629	5.068649	6.421432
4.63075	5.075912	5.068893	5.077133	5.071747
5.067749	5.073334	5.090454	7.610184	6.629712
3.294662	6.616959	5.085922	6.305771	5.070938
5.081619	6.143997	5.094513	5.06636	4.791275
3.83493	5.066849	5.228271	6.065536	5.069672
5.078308	5.908157	4.753113	5.06636	3.765167
5.108063	4.70401	4.723358	5.132141	5.094879
5.067307	5.153915	4.703842	5.107773	3.191727
4.900543	4.719818	5.673462	3.719543	5.069138
5.0784	5.12326	5.119858	5.088318	6.842682
4.756577	4.698669	6.259277	4.391129	5.067307
5.067307	4.646378	5.124176	5.089905	4.867053
3.911392	7.275177	6.725784	4.438385	
6.238998	5.067749	5.114258	5.086823	
5.207092	7.423065	4.252106	4.33902	
3.366896	7.38269	5.104355	5.082733	
5.078247	5.067307	3.550049	4.345901	
7.619827	7.369278	5.096924	5.080048	
5.075455	4.927063	3.700653	4.314941	
5.067307	7.199463	5.069138	5.076859	
7.099228	5.08676	7.530197	4.291885	
4.887848	6.004745	6.068237	5.074646	
5.153458	7.656066	7.403717	5.073669	
5.068817	7.794128	7.713348	3.659683	
5.193054	5.090759	7.609329	6.798763	
4.084213	7.797409	5.075958	6.810287	
5.078247	5.086151	7.603134	5.066406	
4.766434	7.788696	4.684036	6.343094	
5.075058	5.068192	5.08371	5.066406	
5.073425	7.474167	5.115891	6.062988	
5.067307	5.067749	6.075958	5.066406	
3.218491	7.608963	6.539993	5.847244	
5.083237	5.067307	4.526703	5.093246	
7.772491	5.067749	5.114471	4.682281	
5.078766	4.997482	3.475327	5.096832	

G =	15		L =	0.1							
t (min)	C (mS)	C-30	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2$*C*Δt	$(t-tm)^3$*E*Δt	F (t)	σ^2	s^3
0	30	0		0	0	0	0	0	0	#DIV/0!	0
1	32	2	1	2.69232E-05	2	2	7275.420312	-5.907015136	2.69232E-05	3637.710156	-0.020263343
2	34	4	3	5.38463E-05	8	4	14072.33316	-11.2360876	8.07695E-05	3518.083291	-0.03854412
3	36	6	5	8.07695E-05	18	6	20402.73855	-16.01596166	0.000161539	3400.456426	-0.054940934
4	38	8	7	0.000107693	32	8	26278.63648	-20.27473547	0.000269232	3284.82956	-0.069550173
5	40	10	9	0.000134616	50	10	31712.02595	-24.03988099	0.000403847	3171.202695	-0.082466008
6	60	30	20	0.000403847	180	30	91787.2749	-68.34536009	0.000807695	3059.57583	-0.234450982
7	120	90	60	0.001211542	630	90	285495.4068	-194.1154989	0.002019237	2949.948965	-0.665891134
8	180	150	120	0.002019237	1200	150	426346.3149	-305.9828926	0.004038473	2842.322099	-1.0496395
9	260	230	190	0.003096163	2070	230	629439.9038	-443.264998	0.007134636	2736.695234	-1.520570144
10	340	310	270	0.004173089	3100	310	816251.1943	-583.8334624	0.011307725	2633.068369	-1.934166544
11	440	410	360	0.005519247	4510	410	1037891.016	-702.9616781	0.016826972	2531.441504	-2.411430059
12	510	480	445	0.006461557	5760	480	1167271.026	-774.6772119	0.023288529	2431.814638	-2.658128116
13	600	570	525	0.007673099	7410	570	1330487.031	-885.3155128	0.030961628	2334.187773	-2.968368417
14	680	650	610	0.008750025	9100	650	1455064.59	-926.7501795	0.039711653	2238.560908	-3.179111052
15	750	720	685	0.009692336	10800	720	1544352.511	-962.8294348	0.049403989	2144.934042	-3.302876832
16	820	790	755	0.010634646	12640	790	1622112.67	-989.472955	0.060038635	2053.307177	-3.394274397
17	880	850	820	0.011442341	14450	850	1669128.265	-995.6829117	0.071480975	1963.680312	-3.415576947
18	930	900	875	0.01211542	16200	900	1688448.102	-984.4785742	0.083596395	1876.053447	-3.377141742
19	980	950	925	0.012788498	18050	950	1700905.252	-968.8450614	0.096384893	1790.426581	-3.323512755
20	1000	970	960	0.01305773	19400	970	1655595.725	-920.7495735	0.109442623	1706.799716	-3.158526656
21	1040	1010	990	0.013596193	21210	1010	1641424.579	-890.7722127	0.123038816	1625.172851	-3.05569273
22	1050	1020	1015	0.013730809	22440	1020	1578456.905	-834.2938036	0.136769625	1545.545986	-2.861949973
23	1060	1030	1025	0.013865425	23690	1030	1511956.694	-779.8056274	0.15063505	1467.91912	-2.675034484
24	1080	1050	1040	0.014134656	25200	1050	1461908.668	-734.3123951	0.164769706	1392.292255	-2.518975127
25	1100	1070	1060	0.014403888	26750	1070	1410971.967	-689.7340056	0.179173594	1318.66539	-2.366054033
26	1110	1080	1075	0.014538503	28080	1080	1346801.606	-640.2351442	0.193712097	1247.038524	-2.196253821
27	1140	1110	1095	0.014942351	29970	1110	1306926.942	-603.6664472	0.208654448	1177.411659	-2.070877674
28	1152	1122	1116	0.01510389	31416	1122	1246178.539	-558.4019946	0.223758338	1109.784794	-1.915534512
29	1155	1125	1123.5	0.015144274	32625	1125	1174677.67	-510.9727706	0.238902612	1044.157929	-1.752833965
30	1150	1120	1122.5	0.015076967	33600	1120	1098194.791	-462.9200886	0.253979579	980.5310634	-1.587994621
31	1120	1090	1105	0.014673119	33790	1090	1001605.576	-408.7217984	0.268652698	918.9041981	-1.402073628
32	1110	1080	1085	0.014538503	34560	1080	928019.5195	-366.2011788	0.283191202	859.2773328	-1.25621149
33	1100	1070	1075	0.014403888	35310	1070	857766.0003	-326.9319028	0.297595089	801.6504676	-1.121502697
34	1080	1050	1060	0.014134656	35700	1050	783324.7824	-288.0143322	0.311729745	746.0236023	-0.988000398
35	1068	1038	1044	0.013973117	36330	1038	718707.813	-254.5809024	0.325702863	692.396737	-0.873310821
36	1060	1030	1034	0.013865425	37080	1030	659992.9679	-224.6983655	0.339568287	640.7698718	-0.771488266
37	1050	1020	1025	0.013730809	37740	1020	602965.8666	-197.3490113	0.353299096	591.1430065	-0.67698333
38	1040	1010	1015	0.013596193	38380	1010	548951.3026	-172.2804479	0.366895289	543.5161412	-0.590986476
39	1032	1002	1006	0.0134885	39078	1002	498865.0545	-149.8520984	0.38038379	497.889276	-0.514050574
40	1020	990	996	0.013326962	39600	990	449719.7866	-129.0301926	0.393710751	454.2624107	-0.442623396
41	1008	978	984	0.013165423	40098	976	403557.5634	-110.3531561	0.406876174	412.6355454	-0.378553947
42	1000	970	974	0.01305773	40740	970	361618.4197	-94.06890545	0.419933904	373.0086801	-0.322692678
43	990	960	965	0.012923114	41280	960	321966.5423	-79.37366758	0.432857018	335.3818149	-0.272282336
44	980	950	955	0.012788498	41800	950	284767.2021	-66.36956452	0.445645516	299.7549496	-0.227673309
45	960	930	940	0.012519267	41850	930	247499.1184	-54.35192865	0.458164783	266.1280843	-0.186448107
46	940	910	920	0.012250035	41860	910	213396.1093	-43.990105	0.470414819	234.5012191	-0.15090305
47	920	890	900	0.011980804	41830	890	182338.1749	-35.13317112	0.482395622	204.8743538	-0.120520346
48	900	870	880	0.011711572	41760	870	154205.315	-27.63684609	0.494107195	177.2474885	-0.09480437
49	880	850	860	0.011442341	41650	850	128877.5298	-21.3625106	0.505549535	151.6206233	-0.073281662
50	860	830	840	0.011173109	41500	830	106234.8191	-16.17920684	0.516722644	127.993758	-0.055500928
51	840	810	820	0.010903878	41310	810	86157.1631	-11.9616386	0.527626522	106.3668927	-0.04103304
52	820	790	800	0.010634646	41080	790	68524.62168	-8.591171196	0.538261168	86.74002744	-0.029471035
53	810	780	785	0.01050003	41340	780	53908.2665	-6.032977391	0.548761198	69.11316216	-0.020695443
54	800	770	775	0.010365415	41580	770	41164.44862	-4.054622915	0.559126613	53.48629691	-0.013908923
55	780	750	760	0.010096183	41250	750	29894.57373	-2.540702794	0.569222796	39.85943164	-0.008715592
56	750	720	735	0.009692336	40320	720	20327.44778	-1.4539851	0.578915131	28.23256637	-0.004987662
57	740	710	715	0.00955772	40470	710	13210.04778	-0.76704944	0.588472851	18.6057011	-0.002631276
58	720	690	700	0.009288488	40020	690	7575.39672	-0.337693219	0.59776134	10.97883583	-0.001159104
59	700	670	680	0.009019257	39530	670	3585.820273	-0.111671237	0.606780596	5.351970556	-0.000383075
60	690	660	665	0.008884641	39600	660	1138.569489	-0.020130905	0.615665237	1.725105286	-6.90568E-05
61	680	650	655	0.008750025	39650	650	63.6560106	-0.000269428	0.624415263	0.098240017	-9.2424E-07
62	672	642	646	0.008642333	39804	642	302.6225875	0.002796923	0.633057595	0.471374747	9.59452E-06
63	660	630	636	0.008480794	39690	630	1792.040971	0.040686242	0.641538389	2.844509477	0.00013957
64	630	600	615	0.008076948	38400	600	4330.586524	0.156617542	0.649615335	7.217644207	0.000537259
65	620	590	595	0.007942331	38350	590	8018.659573	0.397937148	0.657557666	13.59077894	0.001365078
66	612	582	586	0.007834638	38412	582	12782.99775	0.808461289	0.665392304	21.96391367	0.002766474
67	600	570	576	0.007673099	38190	570	18432.11759	1.410981863	0.673065403	32.3370484	0.004840212
68	591.5	561.5	565.75	0.007558676	38182	561.5	25104.76763	2.25972392	0.680624079	44.71018313	0.007751726

142	116	86	87	0.001157696	12212	86	559687.7052	608.1323682	0.939342133	6510.322153	2.0861269
143	114	84	85	0.001130772	12012	84	560506.4042	616.3496799	0.940472905	6672.695288	2.114317453
144	112	82	83	0.001103849	11808	82	560639.6107	624.0432512	0.941576755	6837.068423	2.140709374
145	110	80	81	0.001076926	11600	80	560275.3246	631.179957	0.942653681	7003.441557	2.165191031
146	108	78	79	0.001050003	11388	78	559401.546	637.726026	0.943703684	7171.814692	2.187648577
147	106	76	77	0.00102308	11172	76	558006.2748	643.6470409	0.944726764	7342.187827	2.207957944
148	104	74	75	0.000996157	10952	74	556077.5112	648.907938	0.94572292	7514.560962	2.226004853
149	102	72	73	0.000969234	10728	72	553603.2549	653.4730076	0.946692154	7688.934096	2.241664805
150	100	70	71	0.00094231	10500	70	550571.5062	657.3058938	0.947634464	7865.307231	2.254813065
151	98	68	69	0.000915387	10268	68	546970.2649	660.3695944	0.948549852	8043.680366	2.265322762
152	96	66	67	0.000888464	10032	66	542787.531	662.6264614	0.949438316	8224.0535	2.273064687
153	94	64	65	0.000861541	9792	64	538011.3047	664.0382003	0.950299857	8406.426635	2.277907497
154	92	62	63	0.000834618	9548	62	532629.5857	664.5658706	0.951134474	8590.79977	2.27971761
155	90	60	61	0.000807695	9300	60	526630.3743	664.1698856	0.951942169	8777.172905	2.278359228
156	89.5	59.5	59.75	0.000800964	9282	59.5	533449.9693	679.9516508	0.952743133	8965.546039	2.332496778
157	89	59	59.25	0.000794233	9263	59	540199.2313	695.8263744	0.953537366	9155.919174	2.386953211
158	88.5	58.5	58.75	0.000787502	9243	58.5	546875.1001	711.7873098	0.954324868	9348.292309	2.441705384
159	88	58	58.25	0.000780771	9222	58	553474.5957	727.8275489	0.95510564	9542.665444	2.496729599
160	87.5	57.5	57.75	0.000774041	9200	57.5	559994.7183	743.9400218	0.95587968	9739.038578	2.552001605
161	87	57	57.25	0.00076731	9177	57	566432.4676	760.1174973	0.95664699	9937.411713	2.607496594
162	86.5	56.5	56.75	0.000760579	9153	56.5	572784.8439	776.3525825	0.957407569	10137.78485	2.663189207
163	86	56	56.25	0.000753848	9128	56	579048.847	792.6377232	0.958161416	10340.15798	2.719053529
164	85.5	55.5	55.75	0.000747118	9102	55.5	585221.477	808.9652035	0.958908535	10544.53112	2.775063092
165	85	55	55.25	0.000740387	9075	55	591299.7339	825.3271458	0.959648922	10750.90425	2.831190874
166	84.5	54.5	54.75	0.000733656	9047	54.5	597280.6176	841.7155112	0.960382578	10959.27739	2.887409297
167	84	54	54.25	0.000726925	9018	54	603181.1282	858.1220992	0.961109503	11169.65052	2.943690231
168	83.5	53.5	53.75	0.000720194	8988	53.5	608938.2656	874.5385476	0.961829698	11382.02366	3.00000499
169	83	53	53.25	0.000713464	8957	53	614609.0299	890.9563334	0.962543161	11596.39679	3.056324335
170	82.5	52.5	52.75	0.000706733	8925	52.5	620170.4211	907.3667706	0.963249894	11812.76993	3.112618474
171	82	52	52.25	0.000700002	8892	52	625619.4391	923.7610133	0.963949896	12031.14306	3.168857057
172	81.5	51.5	51.75	0.000693271	8858	51.5	630953.084	940.1300529	0.964643167	12251.5162	3.225009185
173	81	51	51.25	0.00068654	8823	51	636168.3558	956.4647196	0.965329708	12473.88933	3.281043401
174	80.5	50.5	50.75	0.00067981	8787	50.5	641262.2545	972.7556823	0.966009517	12698.26246	3.336927695
175	80	50	50.25	0.000673079	8750	50	646231.78	988.9934481	0.966682596	12924.6356	3.392629503
176	79.5	49.5	49.75	0.000666348	8712	49.5	651073.9323	1005.168363	0.967348944	13153.00873	3.448115707
177	79	49	49.25	0.000659617	8673	49	655785.7116	1021.27061	0.968008562	13383.38187	3.503352635
178	78.5	48.5	48.75	0.000652886	8633	48.5	660364.1177	1037.290213	0.968661448	13615.755	3.55830606
179	78	48	48.25	0.000646156	8592	48	664806.1506	1053.217032	0.969307604	13850.12814	3.612941201
180	77.5	47.5	47.75	0.000639425	8550	47.5	669108.8105	1069.040767	0.969947029	14086.50127	3.667222724
181	77	47	47.25	0.000632694	8507	47	673269.0972	1084.750956	0.970579723	14324.87441	3.72111474
182	76.5	46.5	46.75	0.000625963	8463	46.5	677284.0107	1100.336975	0.971205686	14565.24754	3.774580806
183	76	46	46.25	0.000619233	8418	46	681150.5511	1115.78804	0.971824919	14807.62068	3.827583924
184	75.5	45.5	45.75	0.000612502	8372	45.5	684865.7184	1131.093203	0.97243742	15051.99381	3.880086544
185	75	45	45.25	0.000605771	8325	45	688426.5126	1146.241356	0.973043191	15298.36695	3.93205056
186	74.5	44.5	44.75	0.00059904	8277	44.5	691829.9336	1161.221229	0.973642232	15546.74006	3.983437311
187	74	44	44.25	0.000592309	8228	44	695072.9815	1176.021392	0.974234541	15797.11322	4.034207586
188	73.5	43.5	43.75	0.000585579	8178	43.5	698152.6563	1190.630251	0.97482012	16049.48635	4.084321615
189	73	43	43.25	0.000578848	8127	43	701065.9579	1205.036052	0.975398967	16303.85949	4.133739077
190	72.5	42.5	42.75	0.000572117	8075	42.5	703809.8864	1219.226879	0.975971085	16560.23262	4.182419095
191	72	42	42.25	0.000565386	8022	42	706381.4417	1233.190655	0.976536471	16818.60575	4.23032024
192	71.5	41.5	41.75	0.000558655	7968	41.5	708777.6239	1246.915141	0.977095126	17078.97889	4.277400526
193	71	41	41.25	0.000551925	7913	41	710995.433	1260.387936	0.977847051	17341.35202	4.323817415
194	70.5	40.5	40.75	0.000545194	7857	40.5	713031.8889	1273.598477	0.978192245	17605.72516	4.368927815
195	70	40	40.25	0.000538463	7800	40	714883.9318	1286.528042	0.978730708	17872.09829	4.413286078
196	69.5	39.5	39.75	0.000531732	7742	39.5	716546.6214	1299.169746	0.97926244	18140.47143	4.456854004
197	69	39	39.25	0.000525002	7683	39	718022.938	1311.508541	0.979787442	18410.84456	4.498980837
198	68.5	38.5	38.75	0.000518271	7623	38.5	719303.8814	1323.53122	0.980305712	18683.2177	4.540223268
199	68	38	38.25	0.00051154	7562	38	720388.4516	1335.224412	0.980817252	18957.59083	4.580335434
200	67.5	37.5	37.75	0.000504809	7500	37.5	721273.6488	1346.574587	0.981322062	19233.96397	4.619270917
201	67	37	37.25	0.000498078	7437	37	721956.4728	1357.568051	0.98182014	19512.3371	4.656982745
202	66.5	36.5	36.75	0.000491348	7373	36.5	722433.9238	1368.190951	0.982311487	19792.71024	4.693423393
203	66	36	36.25	0.000484617	7308	36	722703.0014	1378.429289	0.982796104	20075.08337	4.728544781
204	65.5	35.5	35.75	0.000477886	7242	35.5	722760.706	1388.26883	0.98327399	20359.45651	4.762298274
205	65	35	35.25	0.000471155	7175	35	722604.0374	1397.695293	0.983745145	20645.82964	4.784634684
206	64.5	34.5	34.75	0.000464424	7107	34.5	722229.9968	1406.694159	0.98420967	20934.20278	4.825504268
207	64	34	34.25	0.000457694	7038	34	721635.581	1415.250765	0.984667263	21224.57591	4.854856731
208	63.5	33.5	33.75	0.000450963	6968	33.5	720817.793	1423.350267	0.985118226	21516.94905	4.882641221
209	63	33	33.25	0.000444232	6897	33	719773.6319	1430.977741	0.985562458	21811.32218	4.908806334
210	62.5	32.5	32.75	0.000437501	6825	32.5	718500.0977	1438.11798	0.98599996	22107.69531	4.933300111
211	62	32	32.25	0.00043077	6752	32	716994.1904	1444.755695	0.98643073	22406.06845	4.956070038
212	61.5	31.5	31.75	0.00042404	6678	31.5	715252.9099	1450.875417	0.98685477	22706.44158	4.977063048
213	61	31	31.25	0.000417309	6603	31	713273.2563	1456.461515	0.987272079	23008.81472	4.99622552
214	60.5	30.5	30.75	0.000410578	6527	30.5	711052.2295	1461.498195	0.987682857	23313.18785	5.013503278

t_m (min) =	61.31343263		
σ^2 =	1932.899647		43.96475459
Pe =	33659.16765	mean real liquid velocity, u (m/s)	0.000315596
s^3 =	480.7151941	distance, L (m)	1.8
		ε	0.334590689
ΔP (lb/ft^2) =	8.573250997	μ_{gas} (lb/ft.s)	1.23E-05
ΔP (N/m^2) =	410.4880478	U_{gas} (ft/s)	1.65E-01
ΔP_{exp} (mbar) =	5.324202374	D_p (ft) = $6V_p/A_p$	8.75E-03
ΔP_{exp} (N/m^2) =	532.4202374	G_{gas} (kg/m.s^2)	0.021153757
		L_{column} (ft)	4.9212
H_o =	0.039627784	μ_{liquid} (lb/ft.s)	6.55E-04
		U_{liquid} (ft/s)	1.04E-03
		ρ_{liquid} (lb/ft^3)	62.2606
		nominal packing size (ring diameter), d (ft)	0.026246
		g (ft/s^2)	32.17
		g (m/s^2)	9.80665
H_o (Exp) =	0.665409311		
V_{liquid} (m^3)	6.28E-03		
V_{column} (m^3)	9.44E-03		

$V_{stagnant}$ (m^3)	0.003306457
T_d (min)	94.378

Pressure Drop (Experimental)

7.797363	7.601151	4.460037	5.590317	6.535507
5.085434	5.096436	5.065411	5.072479	5.104263
3.380219	7.789276	4.348206	5.071838	5.08696
5.081883	5.090683	7.636032	3.659406	5.06955
4.335526	7.793854	7.614716	6.467176	5.088669
5.078659	5.085693	7.611343	5.068315	5.092712
4.309998	5.081253	5.075821	5.070404	7.55513
5.075958	4.760208	7.601288	5.081619	5.102722
4.28627	5.20372	5.073746	5.070847	5.067749
5.075867	4.72767	5.662518	5.067261	5.067703
5.030319	5.176132	5.072769	7.089508	5.330139
5.121811	4.702454	6.36879	5.067307	5.255844
5.063843	4.275146	5.071838	7.615738	4.872528
4.544342	7.186675	6.869797	5.076187	5.086777
5.056976	7.205658	5.107162	7.605515	4.800735
5.022751	7.071472	4.481827	5.073792	5.218094
5.232712	5.105164	5.099777	5.06636	4.344879
6.603226	7.494308	3.545746	6.717651	5.079147
6.228134	5.098465	5.762257	5.178238	4.313431
7.314926	7.16243	5.62262	5.182861	5.158629
5.069081	5.069092	5.089539	4.707306	4.287537
5.266281	7.634415	5.495316	5.156158	4.517212
5.224548	5.068192	5.043015	4.688171	5.992447
6.150024	5.064061	5.405441	5.141663	4.49556
5.065903	5.079941	4.981903	5.030899	5.065903
5.965927	7.374313	5.102661	5.02243	6.464722
5.068726	7.315872	4.502167	4.52388	5.065903
7.546829	5.26593	4.917496	7.590393	5.168228
5.068649	4.787598	4.836162	5.072769	4.723053
7.793228	5.225937	3.390106	5.069092	4.706421
5.084885	4.74855	3.558411	5.074127	
3.234436	5.194122	5.080948	5.068192	
5.221039	4.716141	7.612961	7.599548	
4.756653	4.72197	5.076599	5.068192	
5.164769	4.935043	5.848651	5.083664	
4.722015	6.032562	5.06636	5.067749	
5.170654	5.752716	5.06636	5.067703	
4.69841	5.114227	3.575226	5.067307	
4.745941	6.637421	5.076416	5.252838	
5.12735	5.070847	5.06546	5.081833	
4.715851	6.24559	5.076187	4.344131	
5.062408	5.065903	5.335785	5.181839	
5.021439	5.069168	5.074158	4.751144	
5.134636	5.132141	5.073624	5.177704	
5.270126	5.118546	5.06636	4.715103	
5.226883	5.107193	5.169098	5.158737	
4.358537	5.022873	3.992722	4.693832	
5.060002	5.371109	5.16069	5.139847	
5.075867	4.536392	4.733414	4.904266	
4.599686	5.092346	5.137245	4.700592	

G =	20			L =	0.1

t (min)	C (mS)	C-5	Area	E (1/min)	t*C*Δt	C*Δt	$(t-t_m)^2 \cdot C \cdot \Delta t$	$(t-t_m)^3 \cdot E \cdot \Delta t$	F (t)	σ^2	s^3
0	5	0		0	0	0	0	0	0	#DIV/0!	0
1	6	1	0.5	1.563E-05	1	1	3712.248357	-3.535208409	1.563E-05	3712.248357	-0.011826439
2	8	3	2	4.68901E-05	6	3	10774.16983	-10.0919464	6.25201E-05	3591.389944	-0.033760892
3	10	5	4	7.81502E-05	15	5	17362.68765	-15.99187967	0.00014067	3472.533531	-0.053498117
4	12	7	6	0.00010941	28	7	23489.73982	-21.28807224	0.00025008	3355.677117	-0.071148723
5	30	25	16	0.000390751	125	25	81020.51761	-72.09121629	0.000640831	3240.820704	-0.241166916
6	80	75	50	0.001172252	450	75	234597.3218	-205.0755005	0.001813084	3127.964291	-0.686045251
7	120	115	95	0.001797454	805	115	346987.406	-297.8817768	0.003610537	3017.107878	-0.996512883
8	180	175	145	0.002735255	1400	175	508944.0063	-428.9886668	0.006345793	2908.251465	-1.435108713
9	260	255	215	0.003985658	2295	255	714355.7362	-590.964718	0.01033145	2801.395052	-1.976972077
10	300	295	275	0.004610859	2950	295	795476.8984	-645.6420748	0.01494231	2696.538639	-2.159885886
11	360	355	325	0.005548861	3905	355	920757.19	-732.9314163	0.020490971	2593.682225	-2.451897557
12	450	445	400	0.006955364	5340	445	1109307.486	-865.6807245	0.027446334	2492.825812	-2.89598781
13	520	515	480	0.008049466	6695	515	1232894.241	-942.8551079	0.0354958	2393.969399	-3.154161601
14	580	575	545	0.008987268	8050	575	1320639.967	-989.4867762	0.044483068	2297.112986	-3.310093026
15	630	625	600	0.009768769	9375	625	1378410.358	-1009.582297	0.054251837	2202.256573	-3.377386077
16	660	655	640	0.01023767	10480	655	1381657.105	-991.6353863	0.064489506	2109.40016	-3.318016802
17	720	715	685	0.011175472	12155	715	1443258.779	-1013.498541	0.07566496	2018.543748	-3.390487206
18	750	745	730	0.011644373	13410	745	1437617.063	-987.0667643	0.087309353	1929.687333	-3.302064167
19	780	775	760	0.012113274	14725	775	1428193.963	-958.2741551	0.099422627	1842.83092	-3.205743404
20	810	805	790	0.012582175	16100	805	1415169.478	-927.4159842	0.112004802	1757.974507	-3.102512635
21	840	835	820	0.013051076	17535	835	1398723.608	-894.7782684	0.125055877	1675.118094	-2.99332201
22	870	865	850	0.013519977	19030	865	1379036.354	-860.627771	0.138575854	1594.261681	-2.879084013
23	900	895	880	0.013988878	20585	895	1356287.714	-825.2320018	0.152564732	1515.405267	-2.760673479
24	930	925	910	0.014457779	22200	925	1330657.69	-788.8392164	0.16702251	1438.548854	-2.638927598
25	925	920	922.5	0.014379628	23000	920	1254597.046	-724.1398275	0.181402139	1363.692441	-2.422486114
26	920	915	917.5	0.014301478	23790	915	1181114.966	-663.2657149	0.195703617	1290.836028	-2.21884278
27	917.2	912.2	913.6	0.014257714	24629.4	912.2	1112865.405	-607.5454404	0.209961331	1219.979615	-2.032440067
28	914.4	909.4	910.8	0.01421395	25463.2	909.4	1046831.44	-555.1335795	0.224175281	1151.123202	-1.85710509
29	911.6	906.6	908	0.014170186	26291.4	906.6	982996.2705	-505.9175963	0.238345467	1084.266769	-1.692461378
30	908.75	903.75	905.175	0.01412584	27112.5	903.75	921292.1267	-459.7605689	0.252471108	1019.410375	-1.538050684
31	905.9	900.9	902.325	0.014081095	27927.9	900.9	861759.4845	-416.5821302	0.266552203	958.5539622	-1.393604752
32	903.05	898.05	899.475	0.014036549	28737.6	898.05	804381.1639	-376.2724802	0.280588752	895.697549	-1.258755598
33	900	895	896.525	0.013988878	29535	895	748972.8166	-338.6471327	0.29457763	836.8411359	-1.132686456
34	891	886	890.5	0.013848207	30124	886	691086.4643	-301.8634569	0.308425837	779.9847227	-1.009163852
35	882	877	881.5	0.013707537	30695	877	635937.5275	-267.6589201	0.322133374	725.1283096	-0.89540745
36	873	868	872.5	0.013566867	31248	868	583532.0061	-236.4814049	0.335700241	672.2718964	-0.791108369
37	864	859	863.5	0.013426197	31783	859	533795.9001	-207.9821703	0.349126438	621.4154832	-0.695789021
38	855	850	854.5	0.013285526	32300	850	486675.2096	-182.0158512	0.362411964	572.5590701	-0.608903111
39	846	841	845.5	0.013144856	32799	841	442115.9345	-158.4404586	0.37555682	525.7026569	-0.53003564
40	837	832	836.5	0.013004186	33280	832	400064.0748	-137.1173796	0.388561006	480.8462438	-0.458702901
41	828	823	827.5	0.012863515	33743	823	360465.6306	-117.9113774	0.401424521	437.9898306	-0.394452484
42	819	814	818.5	0.012722845	34188	814	323266.6018	-100.6905914	0.414147366	397.1334175	-0.336843269
43	810	805	809.5	0.012582175	34615	805	288412.9885	-85.32653675	0.425729541	358.2770043	-0.285445434
44	798	793	799	0.012394615	34892	793	254686.5288	-71.42390116	0.439124156	321.4205911	-0.238936529
45	786	781	787	0.012207054	35145	781	223806.623	-59.21663454	0.45133121	286.564176	-0.198099192
46	774	769	775	0.012019494	35374	769	195101.2711	-48.57209275	0.463350704	253.7077648	-0.162489685
47	762	757	763	0.011831933	35579	757	168698.4732	-39.36213309	0.475182637	222.8513517	-0.13167933
48	750	745	751	0.011644373	35760	745	144526.2292	-31.46311432	0.48682701	193.9949385	-0.105254504
49	738	733	739	0.011456813	35917	733	122512.5391	-24.75589684	0.498283823	167.1385253	-0.082816647
50	726	721	727	0.011269252	36050	721	102585.4029	-19.12584172	0.509553075	142.2821122	-0.063982255
51	714	709	715	0.011081692	36159	709	84672.82061	-14.48281264	0.520634767	119.425899	-0.048382883
52	702	697	703	0.010894132	36244	697	68702.79225	-10.66117397	0.531528898	98.56926588	-0.035665147
53	690	685	691	0.010706571	36305	685	54603.31781	-7.619791704	0.54223547	79.71267272	-0.025490719
54	675	670	677.5	0.010472121	36180	670	42113.8279	-5.218686125	0.55270759	62.85645958	-0.017458161
55	660	655	662.5	0.01023767	36025	655	31440.03039	-3.404580621	0.562945261	48.0000464	-0.011389446
56	645	640	647.5	0.01000322	35840	640	22491.92528	-2.084057984	0.57294848	35.14363324	-0.006971662
57	630	625	632.5	0.009768769	35625	625	15179.51255	-1.169247815	0.58271725	24.28722009	-0.00391152
58	615	610	617.5	0.009534319	35380	610	9412.792226	-0.577926526	0.592251568	15.43080693	-0.001933355
59	600	595	602.5	0.009299868	35105	595	5101.764293	-0.233497341	0.601551437	8.574393769	-0.000781126
60	585	580	587.5	0.009065418	34800	580	2156.428755	-0.064990295	0.610616855	3.717980611	-0.000217414
61	570	565	572.5	0.008830967	34485	565	486.7856111	-0.007062236	0.619447822	0.861567453	-2.36255E-05
62	555	550	557.5	0.008596517	34100	550	2.834862415	3.18109E-06	0.628044339	0.005154295	1.06416E-08
63	540	535	542.5	0.008362067	33705	535	614.5765085	0.010295487	0.636406406	1.148741137	3.44416E-05
64	535	530	532.5	0.008283916	33920	530	2274.933829	0.073687351	0.644690322	4.292327979	0.000246442
65	520	515	522.5	0.008049466	33475	515	4859.498133	0.233315227	0.652739788	9.435914821	0.000780516
66	510	505	510	0.007893166	33330	505	8372.64834	0.532854238	0.660632954	16.57950166	0.001782573
67	500	495	500	0.007736865	33165	495	12732.92881	1.009368399	0.668369819	25.72308851	0.003376671
68	490	485	490	0.007580565	32980	485	17880.33754	1.696885495	0.675950384	36.86667535	0.005676642

142	85.6	80.6	81.4	0.00125976	11445.2	80.6	516766.2634	646.7456945	0.93678434	6411.492102	2.163577858
143	84	79	79.8	0.001234772	11297	79	519238.2194	657.9551177	0.938019112	6572.635688	2.201077079
144	82.4	77.4	78.2	0.001209764	11145.6	77.4	521349.3159	668.7769094	0.939228877	6735.779275	2.237286236
145	80.8	75.8	76.6	0.001184756	10991	75.8	523089.953	679.167684	0.940413633	6900.922862	2.272107023
146	79.2	74.2	75	0.001159748	10833.2	74.2	524450.5306	689.151456	0.941573381	7068.066449	2.30543913
147	77.6	72.6	73.4	0.00113474	10672.2	72.6	525421.4486	698.6396392	0.942708122	7237.210036	2.337180235
148	76	71	71.8	0.001109732	10508	71	525993.1072	707.6210478	0.943817854	7408.353623	2.367226012
149	74.4	69.4	70.2	0.001084724	10340.6	69.4	526155.9063	716.0638953	0.944902578	7581.49721	2.395470124
150	72.8	67.8	68.6	0.001059716	10170	67.8	525900.246	723.9357954	0.945962294	7756.640796	2.421804228
151	71.2	66.2	67	0.001034708	9996.2	66.2	525216.5262	731.2037612	0.946997002	7933.784363	2.446117974
152	69.6	64.6	65.4	0.0010097	9819.2	64.6	524095.1469	737.834206	0.948006702	8112.92797	2.468299
153	68	63	63.8	0.000984692	9639	63	522526.5081	743.7929426	0.948991394	8294.071557	2.488232942
154	66.4	61.4	62.2	0.000959684	9455.6	61.4	520501.0098	749.0451841	0.949951078	8477.215144	2.505803423
155	64.8	59.8	60.6	0.000934676	9269	59.8	518009.0521	753.5555427	0.950885754	8662.358731	2.520892061
156	63.2	58.2	59	0.000909668	9079.2	58.2	515041.0349	757.2880308	0.951795422	8849.502317	2.533378466
157	61.6	56.6	57.4	0.00088466	8886.2	56.6	511587.3582	760.2060606	0.952680081	9038.645904	2.54314024
158	60	55	55.8	0.000859652	8690	55	507638.422	762.2724441	0.953539733	9229.789491	2.550052975
159	59.4	54.4	54.7	0.000850274	8649.6	54.4	512607.5594	777.7461962	0.954390007	9422.933078	2.60181779
160	58.8	53.8	54.1	0.000840896	8608	53.8	517452.5248	793.1849485	0.955230902	9618.076665	2.653465507
161	58.2	53.2	53.5	0.000831518	8565.2	53.2	522169.7174	808.5772979	0.95606242	9815.220252	2.704957997
162	57.6	52.6	52.9	0.00082214	8521.2	52.6	526755.5379	823.9116243	0.95688456	10014.36384	2.756256381
163	57	52	52.3	0.000812762	8476	52	531206.3861	839.1760805	0.957697321	10215.50743	2.807321026
164	56.4	51.4	51.7	0.000803384	8429.6	51.4	535516.662	854.3585942	0.958500705	10418.65101	2.858111547
165	55.8	50.8	51.1	0.000794006	8382	50.8	539688.7658	869.4468683	0.95929471	10623.7946	2.908586805
166	55.2	50.2	50.5	0.000784628	8333.2	50.2	543713.0969	884.4263801	0.960079336	10830.93819	2.958704908
167	54.6	49.6	49.9	0.00077525	8283.2	49.6	547586.0559	899.2903824	0.960854588	11040.08177	3.008423212
168	54	49	49.3	0.000765872	8232	49	551310.0426	914.0199025	0.961620459	11251.22536	3.057698319
169	53.4	48.4	48.7	0.000756493	8179.6	48.4	554875.457	928.6037429	0.962376953	11464.36895	3.10649608
170	52.8	47.8	48.1	0.000747115	8126	47.8	558280.6991	943.0284808	0.963124069	11679.51253	3.15474159
171	52.2	47.2	47.5	0.000737737	8071.2	47.2	561522.1669	957.2804685	0.963861806	11896.65612	3.202419194
172	51.6	46.6	46.9	0.000728359	8015.2	46.6	564596.2663	971.3456331	0.964590165	12115.79971	3.249472482
173	51	46	46.3	0.000718981	7958	46	567499.3915	985.2104768	0.965309146	12336.94329	3.295854292
174	50.4	45.4	45.7	0.000709603	7899.6	45.4	570227.9444	998.8600766	0.96601875	12560.08688	3.34151671
175	49.8	44.8	45.1	0.000700225	7840	44.8	572778.3249	1012.280084	0.966718975	12785.23047	3.386411066
176	49.2	44.2	44.5	0.000690847	7779.2	44.2	575146.9332	1025.455727	0.967409823	13012.37405	3.430487941
177	48.6	43.6	43.9	0.000681469	7717.2	43.6	577330.1692	1038.372007	0.968091292	13241.51764	3.47369716
178	48	43	43.3	0.000672091	7654	43	579324.4328	1051.0137	0.968763383	13472.66123	3.515987796
179	47.4	42.4	42.7	0.000662713	7589.6	42.4	581126.1241	1063.365358	0.969426097	13705.80481	3.55730617
180	46.8	41.8	42.1	0.000653335	7524	41.8	582731.6432	1075.411307	0.970079432	13940.9484	3.597605848
181	46.2	41.2	41.5	0.000643957	7457.2	41.2	584137.3899	1087.13565	0.970723389	14178.09199	3.636827646
182	45.6	40.6	40.9	0.000634579	7389.2	40.6	585339.7644	1098.522263	0.971357968	14417.23558	3.674919625
183	45	40	40.3	0.000625201	7320	40	586335.1665	1109.554797	0.97198317	14658.37916	3.711827092
184	44.4	39.4	39.7	0.000615823	7249.6	39.4	587119.9963	1120.216676	0.972598993	14901.52275	3.747494604
185	43.8	38.8	39.1	0.000606445	7178	38.8	587690.6536	1130.491107	0.973205438	15146.66634	3.781865963
186	43.2	38.2	38.5	0.000597067	7105.2	38.2	588043.539	1140.361062	0.973802505	15393.80992	3.814884218
187	42.6	37.6	37.9	0.000587689	7031.2	37.6	588175.052	1149.809292	0.974390194	15642.95351	3.846491667
188	42	37	37.3	0.000578311	6956	37	588081.5926	1158.818324	0.974968505	15894.0971	3.876629853
189	41.4	36.4	36.7	0.000568933	6879.6	36.4	587759.5609	1167.370458	0.975537439	16147.24068	3.905239567
190	40.8	35.8	36.1	0.000559555	6802	35.8	587205.3569	1175.447772	0.976096994	16402.38427	3.932260847
191	40.2	35.2	35.5	0.000550177	6723.2	35.2	586415.3806	1183.032114	0.976647171	16659.52786	3.957632977
192	39.6	34.6	34.9	0.000540799	6643.2	34.6	585386.032	1190.105112	0.97718797	16918.67144	3.98129449
193	39	34	34.3	0.000531421	6562	34	584113.711	1196.648166	0.977719391	17179.81503	4.003183164
194	38.4	33.4	33.7	0.000522043	6479.6	33.4	582594.8178	1202.642451	0.978241434	17442.95862	4.023236027
195	37.8	32.8	33.1	0.000512665	6396	32.8	580825.7523	1208.066918	0.978754099	17708.1022	4.04138935
196	37.2	32.2	32.5	0.000503287	6311.2	32.2	578802.9145	1212.908292	0.979257386	17975.24579	4.057578654
197	36.6	31.6	31.9	0.000493909	6225.2	31.6	576522.7043	1217.141074	0.979751295	18244.38938	4.071738707
198	36	31	31.3	0.000484531	6138	31	573981.5219	1220.747539	0.980235826	18515.53296	4.083803522
199	35.4	30.4	30.7	0.000475153	6049.6	30.4	571175.7672	1223.707737	0.980710979	18788.67655	4.093706362
200	34.8	29.8	30.1	0.000465775	5960	29.8	568101.8401	1226.001493	0.981176754	19063.82014	4.101379733
201	34.2	29.2	29.5	0.000456397	5869.2	29.2	564756.1408	1227.608407	0.981633151	19340.96373	4.106755393
202	33.6	28.6	28.9	0.000447019	5777.2	28.6	561135.0691	1228.507855	0.98208017	19620.10731	4.109764344
203	33	28	28.3	0.000437641	5684	28	557235.0252	1228.678987	0.98251781	19901.2509	4.110336834
204	32.4	27.4	27.7	0.000428263	5589.6	27.4	553052.4089	1228.100726	0.982946073	20184.39449	4.108402361
205	31.8	26.8	27.1	0.000418885	5494	26.8	548583.6203	1226.751773	0.983364958	20469.53807	4.103889669
206	31.2	26.2	26.5	0.000409507	5397.2	26.2	543825.0595	1224.610603	0.983774465	20756.68166	4.098726748
207	30.6	25.6	25.9	0.000400129	5299.2	25.6	538773.1263	1221.655465	0.984174594	21045.82525	4.088840837
208	30	25	25.3	0.000390751	5200	25	533424.2206	1217.864364	0.984565344	21336.96883	4.074158419
209	29.6875	24.6875	24.84375	0.000385866	5159.6875	24.6875	533993.4004	1227.510215	0.984951211	21630.11242	4.106426908
210	29.375	24.375	24.53125	0.000380982	5118.75	24.375	534428.1152	1236.662638	0.985332193	21925.25601	4.13771385
211	29.0625	24.0625	24.21875	0.000376098	5077.1875	24.0625	534728.4902	1245.910979	0.98570829	22222.39959	4.167983537
212	28.75	23.75	23.90625	0.000371213	5035	23.75	534886.6505	1254.644447	0.986079504	22521.54318	4.19719987
213	28.4375	23.4375	23.59375	0.000366329	4992.1875	23.4375	534906.7211	1263.052134	0.986445833	22822.68677	4.225326358
214	28.125	23.125	23.28125	0.000361444	4948.75	23.125	534784.8269	1271.123013	0.986807277	23125.83035	4.252326116

288	5	0	0.15625	0	0	0	0	0	1	#DIV/0!	0
			63979.4		3962129.5	63979.4	127875747.9	147119.2353			

G =	25		L =	0.1

t (min)	C (mS)	C-5	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2$*C*Δt	$(t-tm)^3$*E*Δt	F (t)	σ^2	s^3
0	5	0		0	0	0	0	0	0	#DIV/0!	0
1	6	1	0.5	3.51154E-05	1	1	4094.604491	-9.200598456	3.51154E-05	4094.604491	-0.025253101
2	7	2	1.5	7.02309E-05	4	2	7935.252595	-17.55190563	0.000105346	3967.626297	-0.048175133
3	8	3	2.5	0.000105346	9	3	11527.94431	-25.09373555	0.000210693	3842.648104	-0.068875373
4	10	5	4	0.000175577	20	5	18598.34955	-39.83132433	0.00038627	3719.669911	-0.109325983
5	15	10	7.5	0.000351154	50	10	35986.91718	-75.80801168	0.000737424	3598.691718	-0.208072053
6	25	20	15	0.000702309	120	20	69594.27048	-144.1595347	0.001439733	3479.713524	-0.395678104
7	50	45	32.5	0.001580195	315	45	151323.0899	-308.141139	0.003019928	3362.735331	-0.845762315
8	80	75	60	0.002633658	600	75	243581.7853	-487.4552158	0.005653586	3247.757138	-1.337929927
9	110	105	90	0.003687121	945	105	329151.7891	-647.1393675	0.009340708	3134.778944	-1.776216817
10	140	135	120	0.004740585	1350	135	408213.1014	-788.2457971	0.014081292	3023.800751	-2.163516992
11	177	172	153.5	0.006039856	1892	172	501349.4799	-950.4639094	0.020121148	2914.822558	-2.608815798
12	200	195	183.5	0.006847511	2340	195	547529.651	-1018.807887	0.026968659	2807.844364	-2.796346245
13	230	225	210	0.007900974	2925	225	608144.8885	-1110.241538	0.034869634	2702.866171	-3.047306361
14	260	255	240	0.008954438	3570	255	662971.4343	-1187.053447	0.043824072	2599.887978	-3.258133837
15	290	285	270	0.010007901	4275	285	712169.2886	-1250.169403	0.053831973	2498.909784	-3.431369703
16	315	310	297.5	0.010885787	4960	310	743978.7932	-1279.847213	0.06471776	2399.931591	-3.512827094
17	340	335	322.5	0.011763673	5695	335	771469.3883	-1300.081778	0.076481433	2302.953398	-3.568365384
18	360	355	345	0.012465982	6390	355	783831.1976	-1293.355102	0.088947415	2207.975204	-3.549902516
19	375	370	362.5	0.012992714	7030	370	782548.8941	-1263.759696	0.101940128	2114.997011	-3.468671301
20	385	380	375	0.013343868	7600	380	769127.1508	-1215.076314	0.115283996	2024.018818	-3.335048665
21	390	385	382.5	0.013519445	8085	385	744990.6404	-1150.784489	0.128803441	1935.040625	-3.158585565
22	395	390	387.5	0.013695022	8580	390	720744.3482	-1088.022068	0.142498464	1848.062431	-2.986320055
23	405	400	395	0.014046177	9200	400	705233.6952	-1039.842886	0.156544641	1763.084238	-2.854081508
24	406	401	400.5	0.014081292	9624	401	673722.5239	-969.7226811	0.170625933	1680.106045	-2.661620913
25	408	403	402	0.014151523	10075	403	644448.5241	-904.9570474	0.184777456	1599.127851	-2.483857137
26	410	405	404	0.014221754	10530	405	615660.6115	-842.9128641	0.19899921	1520.149658	-2.313562991
27	412	407	406	0.014291985	10989	407	587370.7861	-783.5549317	0.213291195	1443.171465	-2.150641862
28	415	410	408.5	0.014397331	11480	410	560959.2413	-728.8234956	0.227688526	1368.193271	-1.999670242
29	418	413	411.5	0.014502678	11977	413	534923.8272	-676.0223096	0.242191204	1295.215078	-1.855494516
30	415	410	411.5	0.014397331	12300	410	501937.1227	-616.708658	0.256588535	1224.236885	-1.692695474
31	410	405	407.5	0.014221754	12555	405	467679.77	-558.434228	0.270810289	1155.258691	-1.532747711
32	408	403	404	0.014151523	12696	403	438577.0407	-508.0593587	0.284961812	1088.280498	-1.394482609
33	405	400	401.5	0.014046177	13200	400	409320.9219	-459.7948041	0.299007989	1023.302305	-1.262009737
34	400	395	397.5	0.0138706	13430	395	379328.024	-412.7831727	0.312878588	960.3241116	-1.132975794
35	390	385	390	0.013519445	13475	385	346248.1785	-364.627165	0.326398034	899.3459182	-1.000800654
36	385	380	382.5	0.013343868	13680	380	319339.7355	-325.0786555	0.339741902	840.3677249	-0.89224563
37	380	375	377.5	0.013168291	13875	375	293771.0743	-288.7327537	0.352910192	783.3895316	-0.792491658
38	375	370	372.5	0.012992714	14060	370	269512.1952	-255.4258866	0.365902906	728.4113383	-0.701073508
39	370	365	367.5	0.012817136	14235	365	246533.0979	-224.9906948	0.378720042	675.433145	-0.617537313
40	365	360	362.5	0.012641559	14400	360	224803.7826	-197.2660329	0.391361601	624.4549516	-0.541440773
41	360	355	357.5	0.012465982	14555	355	204294.2492	-172.0949694	0.403827583	575.4767583	-0.472353157
42	355	350	352.5	0.012290405	14700	350	184974.4978	-149.3247865	0.416117986	528.498565	-0.409855294
43	350	345	347.5	0.012114827	14835	345	166814.5282	-128.8069804	0.428232815	483.5203717	-0.353539584
44	345	340	342.5	0.01193925	14960	340	149784.3407	-110.3972611	0.440172066	440.5421784	-0.303009989
45	340	335	337.5	0.011763673	15075	335	133853.935	-93.95555244	0.451935739	399.5639851	-0.25788204
46	334	329	332	0.01155288	15134	329	118632.7255	-79.10554966	0.463488719	360.5857918	-0.217122884
47	328	323	326	0.011342288	15181	323	104525.2543	-66.02808893	0.474831007	323.6075985	-0.181228867
48	322	317	320	0.011131595	15216	317	91495.52144	-54.5843651	0.485962602	288.6294052	-0.149819005
49	316	311	314	0.010920902	15239	311	79507.52689	-44.6406297	0.496883505	255.6512119	-0.122526198
50	310	305	308	0.01071021	15250	305	68526.27065	-36.06819088	0.507593714	224.6730185	-0.098997222
51	304	299	302	0.010499517	15249	299	58512.75274	-28.74341335	0.518093231	195.6948252	-0.07889273
52	298	293	296	0.010288825	15236	293	49433.97315	-22.54771858	0.528382056	168.7166319	-0.06188726
53	292	287	290	0.010078132	15211	287	41252.93188	-17.3875845	0.538460188	143.7384386	-0.047669222
54	286	281	284	0.009867439	15174	281	33933.62893	-13.09454581	0.548327627	120.7602453	-0.035940911
55	280	275	278	0.009656747	15125	275	27440.0643	-9.625193731	0.557984374	99.78205199	-0.026418498
56	275	270	272.5	0.009481169	15120	270	21817.04184	-6.886682393	0.567465543	80.80385866	-0.018902041
57	270	265	267.5	0.009305592	15105	265	16913.60132	-4.745008992	0.576771135	63.82586537	-0.013023739
58	265	260	262.5	0.009130015	15080	260	12700.34273	-3.116984389	0.58590115	48.84747206	-0.008555261
59	260	255	257.5	0.008954438	15045	255	9145.66608	-1.923633297	0.594855588	35.86927875	-0.005279842
60	255	250	252.5	0.008778861	15000	250	6222.771359	-1.090194288	0.603634448	24.89108544	-0.002992282
61	250	245	247.5	0.008603283	14945	245	3898.858571	-0.546119774	0.612237732	15.91289212	-0.001498946
62	245	240	242.5	0.008427706	14880	240	2144.327715	-0.225076036	0.620665438	8.934698814	-0.000617772
63	240	235	237.5	0.008252129	14805	235	929.7787934	-0.064943197	0.628917566	3.956505504	-0.000178251
64	235	230	232.5	0.008076552	14720	230	225.0118045	-0.007815237	0.636994118	0.978312193	-2.14507E-05
65	230	225	227.5	0.007900974	14625	225	0.028748658	1.02414E-08	0.644895093	0.000118883	2.81099E-11
66	225	220	222.5	0.007725397	14520	220	224.8236259	0.007960861	0.65262049	1.021925572	2.19053E-05
67	220	215	217.5	0.00754982	14405	215	869.4024363	0.061391775	0.66017031	4.043732262	0.000168503
68	215	210	212.5	0.007374243	14280	210	1903.76318	0.201263361	0.667544553	9.065538951	0.000552467

142	43	38	38.5	0.001334387	5396	38	225365.8109	609.4504321	0.916934422	5930.679234	1.5727731
143	42	37	37.5	0.001299271	5291	37	225170.9385	616.8304212	0.918233693	6085.701041	1.693029132
144	41	36	36.5	0.001264156	5184	36	224738.0225	623.5362716	0.919497849	6242.722847	1.711434839
145	40	35	35.5	0.00122904	5075	35	224061.0629	629.5260486	0.92072689	6401.744654	1.727875122
146	39.5	34.5	34.75	0.001211483	5037	34.5	226415.4429	644.0916359	0.921938372	6562.766461	1.767853636
147	39	34	34.25	0.001193925	4996	34	228678.8011	658.5546846	0.923132297	6725.788267	1.80755071
148	38.5	33.5	33.75	0.001176367	4956	33.5	230842.1375	672.8966504	0.924308665	6890.810074	1.846915445
149	38	33	33.25	0.00115881	4917	33	232908.4521	687.0985675	0.925467474	7057.831881	1.885895784
150	37.5	32.5	32.75	0.001141252	4875	32.5	234872.7448	701.1410486	0.926608726	7226.853687	1.924436516
151	37	32	32.25	0.001123694	4832	32	236732.0159	715.0042852	0.92773242	7397.875494	1.962489272
152	36.5	31.5	31.75	0.001106136	4788	31.5	238483.265	728.6680473	0.928838557	7570.897301	1.999992525
153	36	31	31.25	0.001088579	4743	31	240123.4923	742.1116836	0.929927135	7745.919108	2.036891593
154	35.5	30.5	30.75	0.001071021	4697	30.5	241649.6979	755.3141217	0.930998156	7922.940914	2.073128639
155	35	30	30.25	0.001053463	4650	30	243058.8816	768.2538671	0.93205162	8101.962721	2.108644666
156	34.5	29.5	29.75	0.001035906	4602	29.5	244348.0436	780.9090045	0.933087525	8282.984528	2.143379523
157	34	29	29.25	0.001018348	4553	29	245514.1837	793.2571969	0.934105873	8466.006334	2.1772719
158	33.5	28.5	28.75	0.00100079	4503	28.5	246554.302	805.2756862	0.935106663	8651.028141	2.210259334
159	33	28	28.25	0.000983232	4452	28	247465.3985	816.9412927	0.936089696	8838.049948	2.242278201
160	32.5	27.5	27.75	0.000965675	4400	27.5	248244.4732	828.2304154	0.93705557	9027.071754	2.273263725
161	32	27	27.25	0.000948117	4347	27	248888.5261	839.1190318	0.938003687	9218.093561	2.303149969
162	31.5	26.5	26.75	0.000930559	4293	26.5	249394.5572	849.5826982	0.938934246	9411.115368	2.331869843
163	31	26	26.25	0.000913001	4238	26	249759.5665	859.5965494	0.939647248	9606.137174	2.359355099
164	30.5	25.5	25.75	0.000895444	4182	25.5	249980.554	869.1352988	0.940742692	9803.158981	2.385536332
165	30	25	25.25	0.000877886	4125	25	250054.5197	878.1732385	0.941620578	10002.18079	2.41034298
166	29.5	24.5	24.75	0.000860328	4067	24.5	249976.4836	886.8842392	0.942480906	10203.20259	2.433703326
167	29	24	24.25	0.000842771	4008	24	249749.3856	894.8417501	0.943323677	10406.2244	2.455544496
168	28.5	23.5	23.75	0.000825213	3948	23.5	249364.2659	902.0187991	0.944148889	10611.24621	2.475792457
169	28	23	23.25	0.000807655	3887	23	248820.1643	908.7879927	0.944956545	10818.26801	2.494372024
170	27.5	22.5	22.75	0.000790097	3825	22.5	248114.021	914.9215161	0.945746842	11027.28982	2.511206851
171	27	22	22.25	0.00077254	3762	22	247242.8558	920.391133	0.946519182	11238.31163	2.526219439
172	26.5	21.5	21.75	0.000754982	3698	21.5	246203.6688	925.1681858	0.947274164	11451.33343	2.538331129
173	26	21	21.25	0.000737424	3633	21	244993.4601	929.2235953	0.948011588	11666.35524	2.550462108
174	25.5	20.5	20.75	0.000719867	3567	20.5	243609.2295	932.5278613	0.948731455	11883.37705	2.559531406
175	25	20	20.25	0.000702309	3500.	20	242047.9771	935.0510618	0.949433763	12102.39885	2.566456894
176	24.875	19.875	19.9375	0.000697919	3498	19.875	244927.9856	954.777524	0.950131683	12323.42066	2.620600585
177	24.75	19.75	19.8125	0.00069353	3495.75	19.75	247792.2387	974.6442807	0.950825213	12546.44247	2.675129344
178	24.625	19.625	19.6875	0.000689141	3493.25	19.625	250639.9864	994.6456957	0.951514353	12771.46427	2.730030448
179	24.5	19.5	19.5625	0.000684751	3490.5	19.5	253470.4788	1014.760028	0.952199105	12998.48608	2.785290883
180	24.375	19.375	19.4375	0.000680362	3487.5	19.375	256282.9653	1035.03943	0.952879466	13227.50789	2.840897346
181	24.25	19.25	19.3125	0.000675972	3484.25	19.25	259076.6966	1055.419949	0.953555439	13458.52969	2.896836244
182	24.125	19.125	19.1875	0.000671583	3480.75	19.125	261850.9225	1075.91653	0.954227021	13691.5515	2.953093696
183	24	19	19.0625	0.000667193	3477	19	264604.8929	1096.524006	0.954894215	13926.57331	3.009655531
184	23.875	18.875	18.9375	0.000662804	3473	18.875	267337.8578	1117.237115	0.955557019	14163.59511	3.06650729
185	23.75	18.75	18.8125	0.000658415	3468.75	18.75	270049.0673	1136.050479	0.956215433	14402.61692	3.123634224
186	23.625	18.625	18.6875	0.000654025	3464.25	18.625	272737.7713	1158.958619	0.956869458	14643.63873	3.181021294
187	23.5	18.5	18.5625	0.000649636	3459.5	18.5	275403.2199	1179.955953	0.957519094	14886.66054	3.238653175
188	23.375	18.375	18.4375	0.000645246	3454.5	18.375	278044.663	1201.036789	0.95816434	15131.68234	3.296514249
189	23.25	18.25	18.3125	0.000640857	3449.25	18.25	280661.3507	1222.195334	0.958805197	15378.70415	3.354588611
190	23.125	18.125	18.1875	0.000636467	3443.75	18.125	283252.5329	1243.425688	0.959441664	15627.72596	3.412860066
191	23	18	18.0625	0.000632078	3438	18	285817.4597	1264.721843	0.960073742	15878.74776	3.471312131
192	22.875	17.875	17.9375	0.000627689	3432	17.875	288355.381	1286.07769	0.960701431	16131.76957	3.529928033
193	22.75	17.75	17.8125	0.000623299	3425.75	17.75	290865.5469	1307.487013	0.96132473	16386.79138	3.58869071
194	22.625	17.625	17.6875	0.00061891	3419.25	17.625	293347.2073	1328.943489	0.96194364	16643.81318	3.64758281
195	22.5	17.5	17.5625	0.00061452	3412.5	17.5	295799.6123	1350.440692	0.96255816	16902.83499	3.706586694
196	22.375	17.375	17.4375	0.000610131	3405.5	17.375	298222.0118	1371.972089	0.963168291	17163.8568	3.765684432
197	22.25	17.25	17.3125	0.000605741	3398.25	17.25	300613.6559	1393.531043	0.963774032	17426.8786	3.824857805
198	22.125	17.125	17.1875	0.000601352	3390.75	17.125	302973.7945	1415.11081	0.964375384	17691.90041	3.884088306
199	22	17	17.0625	0.000596963	3383	17	305301.6777	1436.704543	0.964972347	17958.92222	3.943357138
200	21.875	16.875	16.9375	0.000592573	3376	16.875	307596.5554	1456.305287	0.96556492	18227.94402	4.002845214
201	21.75	16.75	16.8125	0.000588184	3368.75	16.75	309857.6776	1479.905983	0.966153103	18498.96583	4.06193316
202	21.625	16.625	16.6875	0.000583794	3358.25	16.625	312084.2944	1501.499468	0.966736898	18771.98764	4.121201311
203	21.5	16.5	16.5625	0.000579405	3349.5	16.5	314275.6558	1523.078471	0.967316302	19047.00944	4.180429713
204	21.375	16.375	16.4375	0.000575015	3340.5	16.375	316431.0117	1544.635617	0.967891318	19324.03125	4.239598125
205	21.25	16.25	16.3125	0.000570626	3331.25	16.25	318549.6122	1566.163426	0.968461944	19603.05306	4.298686014
206	21.125	16.125	16.1875	0.000566237	3321.75	16.125	320630.7072	1587.654311	0.96902818	19884.07486	4.357672559
207	21	16	16.0625	0.000561847	3312	16	322673.5467	1609.100583	0.969590027	20167.09667	4.416536651
208	20.875	15.875	15.9375	0.000557458	3302	15.875	324677.3808	1630.494444	0.970147485	20452.11848	4.47525689
209	20.75	15.75	15.8125	0.000553068	3291.75	15.75	326641.4594	1651.827992	0.970700553	20739.14028	4.533811587
210	20.625	15.625	15.6875	0.000548679	3281.25	15.625	328565.0326	1673.093221	0.971249232	21028.16209	4.592178766
211	20.5	15.5	15.5625	0.000544289	3270.5	15.5	330447.3504	1694.282017	0.971793521	21319.1839	4.650336159
212	20.375	15.375	15.4375	0.0005399	3259.5	15.375	332287.6627	1715.386163	0.972333421	21612.2057	4.708261211
213	20.25	15.25	15.3125	0.00053551	3248.25	15.25	334065.2195	1736.397336	0.972868932	21907.22751	4.765931077
214	20.125	15.125	15.1875	0.000531121	3238.75	15.125	335839.2709	1757.307107	0.973400053	22204.24932	4.823322623

288	9.05	4.05	4.125	0.000142218	1166.4	4.05	201422.1452	1577.362288	0.998151172	49733.86301	4.329423797
289	8.9	3.9	3.975	0.00013695	1127.1	3.9	195705.4508	1539.466415	0.998288122	50160.86482	4.225410092
290	8.75	3.75	3.825	0.000131683	1087.5	3.75	189862.1498	1500.168689	0.998419805	50629.90662	4.117548691
291	8.6	3.6	3.675	0.000126416	1047.6	3.6	183891.3424	1459.448631	0.998546221	51080.92843	4.005783379
292	8.45	3.45	3.525	0.000121148	1007.4	3.45	177792.1283	1417.285635	0.998667369	51533.95024	3.890057599
293	8.3	3.3	3.375	0.000115881	966.9	3.3	171563.8077	1373.658965	0.99878325	51988.97204	3.770314442
294	8.15	3.15	3.225	0.000110614	926.1	3.15	165204.8806	1328.547764	0.998893864	52445.99385	3.646496654
295	8	3	3.075	0.000105346	885	3	158715.047	1281.931045	0.99899921	52905.01566	3.518546636
296	7.85	2.85	2.925	0.000100079	843.6	2.85	152093.2068	1233.787695	0.999099289	53366.03746	3.386406439
297	7.7	2.7	2.775	9.48117E-05	801.9	2.7	145338.48	1184.096476	0.999194101	53829.05927	3.250017768
298	7.55	2.55	2.625	8.95444E-05	759.9	2.55	138449.9067	1132.836023	0.999283645	54294.08108	3.109321982
299	7.4	2.4	2.475	8.42771E-05	717.6	2.4	131426.6469	1079.984843	0.999367922	54761.10288	2.964260092
300	7.25	2.25	2.325	7.90097E-05	675	2.25	124267.7806	1025.521319	0.999446932	55230.12469	2.814772762
301	7.1	2.1	2.175	7.37424E-05	632.1	2.1	116972.4076	969.4237062	0.999520674	55701.1465	2.660800309
302	6.95	1.95	2.025	6.84751E-05	588.9	1.95	109539.6282	911.6701336	0.999589149	56174.1683	2.502282705
303	6.8	1.8	1.875	6.32078E-05	545.4	1.8	101988.5422	852.2386039	0.999652357	56649.19011	2.339159571
304	6.65	1.65	1.725	5.79405E-05	501.6	1.65	94258.24966	791.1069932	0.999710298	57126.21192	2.171370165
305	6.5	1.5	1.575	5.26732E-05	457.5	1.5	86407.65059	726.2530515	0.999762971	57605.23372	1.998853476
306	6.35	1.35	1.425	4.74058E-05	413.1	1.35	78416.44497	663.6544022	0.999810377	58086.25553	1.821548026
307	6.2	1.2	1.275	4.21385E-05	368.4	1.2	70283.13281	597.2885422	0.999852515	58569.27734	1.639392071
308	6.05	1.05	1.125	3.68712E-05	323.4	1.05	62007.0141	529.1328421	0.999889386	59054.29914	1.4523235
309	5.9	0.9	0.975	3.16039E-05	278.1	0.9	53587.18886	459.1645461	0.99992099	59541.32095	1.260279853
310	5.75	0.75	0.825	2.63366E-05	232.5	0.75	45022.75707	387.3607719	0.999947327	60030.34276	1.063198326
311	5.6	0.6	0.675	2.10693E-05	186.6	0.6	36312.81874	313.6985108	0.999968396	60521.36456	0.861015765
312	5.45	0.45	0.525	1.58019E-05	140.4	0.45	27456.47387	238.1546278	0.999984198	61014.38637	0.653668673
313	5.3	0.3	0.375	1.05346E-05	93.9	0.3	18452.82245	160.7058613	0.999994733	61509.40818	0.441093201
314	5.15	0.15	0.225	5.26732E-06	47.1	0.15	9300.964498	81.32882351	1	62006.42998	0.223225157
315	5	0	0.075	0	0	0	0	0	1	#DIV/0!	0
			28477.5		1850727	28477.5	74103206.11	240138.2398			

G =	22.5		L =	0.15							
t (min)	C (mS)	C-15	Area	E (1/min)	$t*C*\Delta t$	$C*\Delta t$	$(t-tm)^2*C*\Delta t$	$(t-tm)^3*E*\Delta t$	F (t)	σ^2	s^3
0	15	0		0	0	0	0	0	0	#DIV/0!	0
1	20	5	2.5	0.000110604	5	5	9062.166745	-8.534187635	0.000110604	1812.433349	-0.046908351
2	22	7	6	0.000154845	14	7	12098.01588	-11.12554568	0.000265449	1728.287983	-0.061151608
3	25	10	8.5	0.000221207	30	10	16461.42617	-14.77407514	0.000486656	1648.142617	-0.081206031
4	30	15	12.5	0.000331811	60	15	23489.95875	-20.56254509	0.000818466	1565.99725	-0.113022484
5	60	45	30	0.000995432	225	45	66953.33478	-57.12828392	0.001813898	1487.851884	-0.314006876
6	90	75	60	0.001659053	450	75	105877.9888	-87.99885249	0.003472952	1411.706518	-0.483687639
7	180	165	120	0.003649916	1155	165	220697.59	-178.5473997	0.007122869	1337.561151	-0.981369732
8	270	255	210	0.005640782	2040	255	322681.0252	-253.9154737	0.012763651	1265.415785	-1.395652016
9	330	315	285	0.006968025	2835	315	376510.182	-287.9445924	0.019731676	1195.270419	-1.582693821
10	440	425	370	0.009401303	4250	425	479028.1474	-355.751058	0.029132979	1127.125053	-1.955393559
11	510	495	460	0.010949753	5445	495	525184.9448	-376.4120158	0.040082731	1060.979686	-2.079950015
12	630	615	555	0.013604238	7380	615	613053.1069	-428.1625759	0.05368697	998.8343201	-2.353405069
13	690	675	645	0.014931481	8775	675	630915.0439	-426.6812454	0.068618451	934.6889539	-2.345262903
14	750	735	705	0.016258724	10290	735	642789.5369	-420.4928781	0.084877175	874.5435876	-2.311248406
15	780	765	750	0.016922345	11475	765	624544.6393	-394.7422623	0.10179952	816.3982214	-2.169709576
16	840	825	795	0.018249588	13200	825	627206.6054	-382.5517157	0.120049108	760.2528551	-2.102703967
17	876	861	843	0.019045934	14637	861	607958.5479	-357.3621017	0.139095042	706.1074888	-1.964248696
18	924	909	885	0.020107728	16362	909	594451.5694	-336.272917	0.15920277	653.9621226	-1.848331526
19	960	945	927	0.020904074	17955	945	570606.8347	-310.1620551	0.180106843	603.8167563	-1.704812596
20	990	975	960	0.021567695	19500	975	541779.6053	-282.5060235	0.201674538	555.67139	-1.5528116
21	1000	985	980	0.021788902	20685	985	501683.1334	-250.602213	0.22346344	509.5260238	-1.377440607
22	1020	1005	995	0.022231316	22110	1005	467707.5609	-223.1915102	0.245694756	465.3806575	-1.226777073
23	1000	985	995	0.021788902	22655	985	416886.7619	-189.7178338	0.267483658	423.2352912	-1.04276827
24	990	975	980	0.021567695	23400	975	373512.6769	-161.7166839	0.289051353	383.089925	-0.88887933
25	980	965	970	0.021346488	24125	965	332871.4992	-136.7572557	0.310397841	344.9445587	-0.751689281
26	960	945	955	0.020904074	24570	945	291816.2369	-113.4344993	0.331301915	308.7991925	-0.623495234
27	930	915	930	0.020240452	24705	915	251308.251	-92.12949491	0.351542367	274.6538262	-0.506391607
28	920	905	910	0.020019245	25340	905	219470.1562	-75.60282702	0.371561612	242.5084599	-0.415552611
29	912	897	901	0.019842279	26013	897	190489.695	-61.40590325	0.391403891	212.3630937	-0.337518905
30	900	885	891	0.019576831	26550	885	163032.6687	-48.94851458	0.410980722	184.2177274	-0.269046593
31	880	865	875	0.019134417	26815	865	136732.5924	-38.02761899	0.430115138	158.0723611	-0.209019649
32	870	855	860	0.018913209	27360	855	114507.5806	-29.3134825	0.449028348	133.9269949	-0.161122205
33	860	845	850	0.018692002	27885	845	94455.47617	-22.09080154	0.46772035	111.7816286	-0.121422579
34	840	825	835	0.018249588	28050	825	75599.91643	-16.00862807	0.485969938	91.63626234	-0.087991778
35	820	805	815	0.017807174	28175	805	59160.17134	-11.2167717	0.503777112	73.49069608	-0.061664227
36	800	785	795	0.017364759	28260	785	45016.24091	-7.540812232	0.521141871	57.34552982	-0.041446241
37	780	765	775	0.016922345	28305	765	33048.12512	-4.804947397	0.538064216	43.20016355	-0.0264105
38	760	745	755	0.016479931	28310	745	23135.82398	-2.851992878	0.554544147	31.05479729	-0.015676042
39	740	725	735	0.016037517	28275	725	15159.33749	-1.533382298	0.570581664	20.90943102	-0.00842827
40	720	705	715	0.015595102	28200	705	8998.665656	-0.711167222	0.586176767	12.76406476	-0.003908946
41	690	675	690	0.014931481	27675	675	4467.621485	-0.254250482	0.601108248	6.618698497	-0.001397493
42	680	665	670	0.014710274	27930	665	1644.765935	-0.057219551	0.615818522	2.473332233	-0.000314509
43	660	645	655	0.01426766	27735	645	211.5380503	-0.002679798	0.630086381	0.32796597	-1.47296E-05
44	630	615	630	0.013604238	27060	615	112.2988191	0.001061511	0.64369062	0.182599706	5.83462E-06
45	600	585	600	0.012940617	26325	585	1191.781564	0.037628437	0.656631237	2.037233442	0.000206826
46	570	555	570	0.012276996	25530	555	3269.986284	0.175578575	0.668908232	5.891867178	0.000965072
47	560	545	550	0.012055788	25615	545	6401.842969	0.485353754	0.680964021	11.74650091	0.002667758
48	540	525	535	0.011613374	25200	525	10290.59569	1.007813653	0.692577395	19.60113465	0.00553947
49	520	505	515	0.01117096	24745	505	14875.16304	1.765854319	0.703748355	29.45576839	0.009815968
50	510	495	500	0.010949753	24750	495	20448.64905	2.907324101	0.714698108	41.31040212	0.015980171
51	500	485	490	0.010728546	24735	485	26755.04239	4.395767722	0.725426653	55.16503586	0.024161544
52	480	465	475	0.010286131	24180	465	33024.14636	6.156303755	0.735712785	71.0196696	0.03383826
53	460	445	455	0.009843717	23585	445	39549.06496	8.247621207	0.745556502	88.87430333	0.045332683
54	450	435	440	0.00962251	23490	435	47297.08762	10.90953114	0.755179012	108.7289371	0.059964479
55	440	425	430	0.009401303	23375	425	55498.01759	14.02881074	0.764580315	130.5835708	0.077109869
56	420	405	415	0.008958889	22680	405	62547.47284	17.19436949	0.773539203	154.4382045	0.094509232
57	390	375	390	0.008295267	21375	375	67609.81435	20.08159005	0.781834471	180.2928383	0.110378904
58	380	365	370	0.00807406	21170	365	75973.82729	24.2484796	0.789908531	208.147472	0.133271311
59	360	345	355	0.007631646	20355	345	82110.72648	28.02137294	0.797540177	238.0021058	0.154020096
60	340	325	335	0.007189232	19500	325	87703.44033	31.87002322	0.804729408	269.8567395	0.175174288
61	330	315	320	0.006968025	19215	315	95669.08257	36.88067811	0.811697433	303.7113732	0.202716562
62	312	297	306	0.006569852	18414	297	100851.1041	41.1094699	0.818267285	339.566007	0.225959111
63	300	285	291	0.006304403	17955	285	107584.8626	46.22558831	0.824571688	377.4208407	0.254079969
64	288	273	279	0.006038955	17472	273	113916.1499	51.47492707	0.830610642	417.2752744	0.282933075
65	280	265	269	0.005861989	17225	265	121669.4257	57.66978945	0.836472631	459.1299082	0.316983273
66	275	260	262.5	0.005751385	17160	260	130775.9809	64.6790409	0.842224016	502.9845419	0.356609083
67	270	255	257.5	0.005640782	17085	255	139953.9898	72.52820868	0.847864798	548.8391756	0.398652903
68	260	245	250	0.005419575	16660	245	146189.9833	76.99370765	0.853284373	596.6938094	0.434190661

142	29.6	14.6	14.65	0.000322962	2073.2	14.6	141443.8759	307.9832618	0.978797297	9687.936706	1.69272688
143	29.5	14.5	14.55	0.00032075	2073.5	14.5	143343.9744	315.2711837	0.979118047	9885.79134	1.732895035
144	29.4	14.4	14.45	0.000318538	2073.6	14.4	145233.302	322.6392408	0.979436585	10085.84597	1.773393724
145	29.3	14.3	14.35	0.000316326	2073.5	14.3	147111.2587	330.0653722	0.979752912	10287.50061	1.814211619
146	29.2	14.2	14.25	0.000314114	2073.2	14.2	148977.2444	337.5474638	0.980067026	10491.35524	1.855337101
147	29.1	14.1	14.15	0.000311902	2072.7	14.1	150830.6592	345.0833483	0.980378928	10697.20987	1.896758257
148	29	14	14.05	0.00030969	2072	14	152670.9031	352.6708057	0.980688618	10905.06451	1.938462884
149	28.9	13.9	13.95	0.000307478	2071.1	13.9	154497.3761	360.3075625	0.980996096	11114.91914	1.980438487
150	28.8	13.8	13.85	0.000305266	2070	13.8	156309.4781	367.9912923	0.981301362	11326.77378	2.022672278
151	28.7	13.7	13.75	0.000303054	2068.7	13.7	158106.6092	375.7196157	0.981604415	11540.62841	2.065151178
152	28.6	13.6	13.65	0.000300842	2067.2	13.6	159888.1694	383.4901	0.981905257	11756.48304	2.107861817
153	28.5	13.5	13.55	0.00029863	2065.5	13.5	161653.5586	391.3002596	0.982203887	11974.33768	2.150790532
154	28.4	13.4	13.45	0.000296418	2063.6	13.4	163402.177	399.1475556	0.982500304	12194.19231	2.193923368
155	28.3	13.3	13.35	0.000294205	2061.5	13.3	165133.4244	407.0293963	0.98279451	12416.04694	2.23724608
156	28.2	13.2	13.25	0.000291993	2059.2	13.2	166846.7006	414.9431386	0.983086503	12639.90158	2.280744128
157	28.1	13.1	13.15	0.000289781	2056.7	13.1	168541.4064	422.8860785	0.983376284	12865.75621	2.324402684
158	28	13	13.05	0.000287569	2054	13	170216.941	430.8554709	0.983663854	13093.61085	2.368206626
159	27.9	12.9	12.95	0.000285357	2051.1	12.9	171872.7047	438.8485095	0.983949211	13323.46548	2.412140539
160	27.8	12.8	12.85	0.000283145	2048	12.8	173508.0974	446.8623371	0.984232356	13555.32011	2.45618872
161	27.7	12.7	12.75	0.000280933	2044.7	12.7	175122.5193	454.8940432	0.984513289	13789.17475	2.50033517
162	27.6	12.6	12.65	0.000278721	2041.2	12.6	176715.3702	462.9406643	0.98479201	14025.02938	2.544563801
163	27.5	12.5	12.55	0.000276509	2037.5	12.5	178286.0502	470.9991639	0.985068519	14262.88401	2.588857432
164	27.4	12.4	12.45	0.000274297	2033.6	12.4	179833.9592	479.0665323	0.985342816	14502.73865	2.633199791
165	27.3	12.3	12.35	0.000272085	2029.5	12.3	181358.4974	487.1395867	0.985614901	14744.59328	2.677573513
166	27.2	12.2	12.25	0.000269873	2025.2	12.2	182859.0646	495.2151713	0.985884773	14988.44792	2.721961143
167	27.1	12.1	12.15	0.000267661	2020.7	12.1	184335.0608	503.2900571	0.986152434	15234.30255	2.766344931
168	27	12	12.05	0.000265449	2016	12	185785.8862	511.3609621	0.986417882	15482.15718	2.810706839
169	26.9	11.9	11.95	0.000263236	2011.1	11.9	187210.9406	519.4245511	0.986681119	15732.01182	2.855028534
170	26.8	11.8	11.85	0.000261024	2006	11.8	188609.6241	527.477436	0.986942143	15983.86645	2.899291395
171	26.7	11.7	11.75	0.000258812	2000.7	11.7	189981.3367	535.5181755	0.987200956	16237.72108	2.943476504
172	26.6	11.6	11.65	0.0002566	1995.2	11.6	191325.4783	543.5372752	0.987457556	16493.57572	2.987564656
173	26.5	11.5	11.55	0.000254388	1989.5	11.5	192641.449	551.5371675	0.987711944	16751.43035	3.031536351
174	26.4	11.4	11.45	0.000252176	1983.6	11.4	193928.6488	559.512312	0.98796412	17011.28499	3.075371799
175	26.3	11.3	11.35	0.000249964	1977.5	11.3	195186.4777	567.4589949	0.988214084	17273.13962	3.119050917
176	26.2	11.2	11.25	0.000247752	1971.2	11.2	196414.3356	575.3735295	0.988461836	17536.99425	3.162553332
177	26.1	11.1	11.15	0.00024554	1964.7	11.1	197611.6226	583.252156	0.988707376	17802.84889	3.205858377
178	26	11	11.05	0.000243328	1958	11	198777.7387	591.0910615	0.988950704	18070.70352	3.248945094
179	25.9	10.9	10.95	0.000241116	1951.1	10.9	199912.0839	598.8863798	0.98919182	18340.55815	3.291792233
180	25.8	10.8	10.85	0.000238904	1944	10.8	201014.0581	606.634192	0.989430723	18612.41279	3.334378254
181	25.7	10.7	10.75	0.000236692	1936.7	10.7	202083.0614	614.3305258	0.989667415	18886.26742	3.376681323
182	25.6	10.6	10.65	0.00023448	1929.2	10.6	203118.4938	621.9713559	0.989901895	19162.12206	3.418679315
183	25.5	10.5	10.55	0.000232267	1921.5	10.5	204119.7552	629.552604	0.990134162	19439.97669	3.460349813
184	25.4	10.4	10.45	0.000230055	1913.6	10.4	205086.2458	637.0701385	0.990364218	19719.83132	3.501670108
185	25.3	10.3	10.35	0.000227843	1905.5	10.3	206017.3654	644.519775	0.990592061	20001.68596	3.5426172
186	25.2	10.2	10.25	0.000225631	1897.2	10.2	206912.514	651.8972758	0.990817692	20285.54059	3.583167796
187	25.1	10.1	10.15	0.000223419	1888.7	10.1	207771.0918	659.1983501	0.991041111	20571.39522	3.623298312
188	25	10	10.05	0.000221207	1880	10	208592.4986	666.4166541	0.991262318	20859.24986	3.662984873
189	24.9	9.9	9.95	0.000218995	1871.1	9.9	209376.1345	673.553791	0.991481314	21149.10449	3.70220331
190	24.8	9.8	9.85	0.000216783	1862	9.8	210121.3994	680.5993106	0.991698097	21440.95913	3.740929165
191	24.7	9.7	9.75	0.000214571	1852.7	9.7	210827.6935	687.5507099	0.991912667	21734.81376	3.779137685
192	24.6	9.6	9.65	0.000212359	1843.2	9.6	211494.4168	694.4034328	0.992125026	22030.66839	3.816803828
193	24.5	9.5	9.55	0.000210147	1833.5	9.5	212120.9688	701.1528699	0.992335173	22328.52303	3.853902258
194	24.4	9.4	9.45	0.000207935	1823.6	9.4	212706.75	707.7943588	0.992543108	22628.37766	3.890407349
195	24.3	9.3	9.35	0.000205723	1813.5	9.3	213251.1603	714.3231842	0.99274883	22930.23229	3.926293182
196	24.2	9.2	9.25	0.000203511	1803.2	9.2	213753.5997	720.7345775	0.992952341	23234.08693	3.961533547
197	24.1	9.1	9.15	0.000201298	1792.7	9.1	214213.4682	727.023717	0.993153639	23539.94156	3.996101942
198	24	9	9.05	0.000199086	1782	9	214630.1658	733.1857281	0.993352726	23847.7962	4.029971572
199	23.9	8.9	8.95	0.000196874	1771.1	8.9	215003.0924	739.2156828	0.9935496	24157.65083	4.063115352
200	23.8	8.8	8.85	0.000194662	1760	8.8	215331.6481	745.1086004	0.993744262	24469.50546	4.095505903
201	23.7	8.7	8.75	0.00019245	1748.7	8.7	215615.2328	750.8594468	0.993936713	24783.3601	4.127115558
202	23.6	8.6	8.65	0.000190238	1737.2	8.6	215853.2467	756.4631349	0.994126951	25099.21473	4.157916353
203	23.5	8.5	8.55	0.000188026	1725.5	8.5	216045.0896	761.9145248	0.994314977	25417.06936	4.187880037
204	23.4	8.4	8.45	0.000185814	1713.6	8.4	216190.1616	767.2084226	0.994500791	25736.924	4.216978065
205	23.3	8.3	8.35	0.000183602	1701.5	8.3	216287.8626	772.3395825	0.994684393	26058.77863	4.245181599
206	23.2	8.2	8.25	0.00018139	1689.2	8.2	216337.5928	777.302705	0.994865783	26382.63326	4.272461511
207	23.1	8.1	8.15	0.000179178	1676.7	8.1	216338.752	782.0924374	0.99504496	26708.4879	4.298788381
208	23	8	8.05	0.000176966	1664	8	216290.7403	786.7033742	0.995221926	27036.34253	4.324132497
209	22.9	7.9	7.95	0.000174754	1651.1	7.9	216192.9576	791.1300566	0.99539668	27366.19717	4.348463855
210	22.8	7.8	7.85	0.000172542	1638	7.8	216044.804	795.3689729	0.995569221	27698.0518	4.371752159
211	22.7	7.7	7.75	0.000170329	1624.7	7.7	215845.6795	799.4065581	0.995739551	28031.90643	4.393966822
212	22.6	7.6	7.65	0.000168117	1611.2	7.6	215594.9841	803.2491943	0.995907668	28367.76107	4.415076964
213	22.5	7.5	7.55	0.000165905	1597.5	7.5	215292.1178	806.8832105	0.996073573	28705.6157	4.435051414
214	22.4	7.4	7.45	0.000163693	1583.6	7.4	214936.4805	810.3048824	0.996237267	29045.47033	4.453858709

t_m (min) =	43.57268313		
σ^2 =	1030.896782		32.10761253
Pe =	28046.7902	mean real liquid velocity, u (m/s)	0.000473394
s^3 =	431.9608232	distance, L (m)	1.8

		ε	0.368496895
ΔP (lb/ft^2) =	9.7190163	μ_{gas} (lb/ft.s)	1.23E-05
ΔP (N/m^2) =	465.3473982	U_{gas} (ft/s)	2.33E-01
ΔP_{exp} (mbar) =	5.402167298	D_p (ft) = $6V_p/A_p$	8.75E-03
ΔP_{exp} (N/m^2) =	540.2167298	G_{gas} ($kg/m.s^3$)	0.031730636
		L_{column} (ft)	4.9212

H_p =	0.046610522	μ_{liquid} (lb/ft.s)	6.55E-04
		U_{liquid} (ft/s)	1.55E-03
		ρ_{liquid} (lb/ft^3)	62.2608
		nominal packing size (ring diameter), d (ft)	0.026246
		g (ft/s^2)	32.17
		g (m/s^2)	9.80665

H_p (Exp) =	0.631503105
V_{liquid} (m^3)	5.96E-03
V_{column} (m^3)	9.44E-03

$V_{stagnant}$ (m^3)	0.002901898
T_d (min)	52.91866867

Pressure Drop (Experimental)

5.590302	7.606674	7.59613	5.09227	5.110336
5.104141	5.487106	5.074081	7.698364	5.096756
5.522079	5.13649	5.06636	5.08696	5.069046
5.067261	6.147658	5.184326	7.535904	6.913635
5.067307	5.122421	7.608871	5.089127	5.068146
7.616384	6.818116	5.161102	7.532069	5.493149
5.077454	5.110107	4.364609	5.103439	4.626983
5.075912	4.641693	5.150955	5.003998	5.106308
4.28598	5.102707	4.705505	5.066803	4.564392
5.074081	4.595169	5.133224	5.305496	5.101273
5.064331	5.096878	4.717651	5.280289	5.091858
5.05249	4.929611	5.132599	5.238602	5.133072
6.809616	5.290375	4.66391	4.353271	5.539322
7.469086	4.853561	5.470016	5.079559	5.443909
5.096832	5.266876	4.656464	5.076813	4.49942
7.778915	4.86346	5.469147	7.174133	5.104004
5.090683	5.234116	4.615524	4.837219	4.508347
7.79306	4.759674	4.546112	5.238342	5.092636
5.068192	5.066406	7.742966	4.784256	6.983597
5.081177	5.065903	5.085693	5.206955	5.086548
5.067261	4.394135	5.069992	4.743332	7.531655
5.075621	7.629379	5.083679	5.081299	5.107529
4.576004	4.420258	7.771194	4.308258	4.452927
6.092606	5.151169	5.067703	4.697021	5.10231
6.816971	5.132599	7.419922	4.749573	5.071335
7.085983	5.576477	5.066803	4.715995	5.093491
5.069992	5.064346	4.984207	7.049438	3.074722
7.636429	5.507233	5.084488	5.106705	5.088181
5.094803	5.032364	5.068604	7.239227	7.77124
7.563644	5.408554	5.206192	5.069092	5.455109
5.091309	4.954391	3.150421	7.146835	4.603745
4.446807	5.392166	5.186981	5.068146	5.097733
5.252869	4.964417	4.712509	5.068146	5.144806
4.791443	5.343292	5.154251	7.777969	5.121155
5.210312	4.88295	5.066803	5.082428	5.065857
4.748581	4.807373	6.812592	5.087219	6.372375
5.196854	4.182541	5.225449	4.310425	4.637695
4.723145	5.15979	3.037186	4.334	5.152847
6.159851	4.716003	5.182602	4.941055	5.506195
5.06635	5.140488	4.721527	5.12944	5.137634
5.89093	5.636246	5.079559	5.628387	6.121201
5.065903	5.094849	4.698227	5.070389	5.071747
5.991989	5.507233	5.07457	6.534439	6.712524
5.068649	4.641388	4.275757	5.065414	5.069901
5.068192	5.419952	5.074081	6.295853	5.526749
5.082031	5.017151	7.26297	5.065414	
4.237885	7.391281	6.876883	5.065414	
4.929489	5.066803	7.2621	5.121826	
5.441711	7.395477	5.069092	5.123489	
5.454269	5.066757	7.381577	6.994186	

Appendix 8

G =	30		L =	0.15							
t (min)	C (mS)	C-5	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2*C*\Delta t$	$(t-tm)^3*E*\Delta t$	F (t)	σ^2	s^3
0	5	0		0	0	0	0	0	0	#DIV/0!	0
1	11.25	6.25	3.125	0.000184284	6.25	6.25	11736.74997	-14.99650129	0.000184284	1877.679995	-0.069599742
2	17.5	12.5	9.375	0.000368568	26	12.5	22402.63712	-27.9641671	0.000552853	1792.21097	-0.129783526
3	23.75	18.75	15.625	0.000552853	56.25	18.75	32035.18146	-39.04342591	0.001105705	1708.541944	-0.18120309
4	30	25	21.875	0.000737137	100	25	40671.62297	-48.37028343	0.001842842	1626.872919	-0.224489645
5	60	55	40	0.001621701	275	55	65096.21414	-98.69432759	0.003464544	1547.203893	-0.458046821
6	140	135	95	0.00398054	610	135	198387.2072	-224.2393314	0.007445083	1469.534868	-1.040709385
7	200	195	165	0.005749668	1365	195	271803.8393	-299.2087249	0.013194752	1393.865842	-1.388647237
8	300	295	245	0.008698216	2360	295	389458.061	-417.2421903	0.021892968	1320.196817	-1.936448261
9	400	395	345	0.011646764	3555	395	493168.4776	-513.8100505	0.033539732	1248.527791	-2.384626008
10	480	475	435	0.014005602	4750	475	559957.9138	-566.8843324	0.047545334	1178.858766	-2.630947217
11	540	535	505	0.015774731	5865	535	594486.5111	-584.3113132	0.063320065	1111.18974	-2.711826973
12	600	595	565	0.01754366	7140	595	622084.8254	-593.0947675	0.080863925	1045.520715	-2.752591652
13	640	635	615	0.018723279	8255	635	623475.8228	-576.0374796	0.099587203	981.8516894	-2.673427571
14	680	675	655	0.019902698	9450	675	621123.2982	-555.5496337	0.119489901	920.1626639	-2.578343068
15	700	695	685	0.020492407	10425	695	598056.9787	-517.2846843	0.139982309	860.5136384	-2.40075201
16	720	715	705	0.021082117	11440	715	574033.6982	-479.5604455	0.161064426	802.8446129	-2.225764175
17	740	735	725	0.021671827	12495	735	549174.0567	-442.6184655	0.182736252	747.1755874	-2.054221211
18	750	745	740	0.021966681	13410	745	516662.3886	-401.1809601	0.204702934	693.5065619	-1.861907042
19	770	765	755	0.022556391	14535	765	491005.7153	-366.7613816	0.227259325	641.8375364	-1.702256351
20	775	770	767.5	0.022703818	15400	770	455969.7534	-327.1650237	0.249963143	592.1685109	-1.518394246
21	760	755	762.5	0.022261536	15855	755	411097.1115	-282.8468462	0.272224679	544.4994854	-1.31271069
22	750	745	750	0.021966681	16390	745	371628.6926	-244.733769	0.294191361	498.8304599	-1.135825408
23	740	735	740	0.021671827	16905	735	334643.6543	-210.4474674	0.315863187	455.1614344	-0.976700443
24	720	715	725	0.021082117	17160	715	295647.0723	-177.2619538	0.336945304	413.4924089	-0.822684307
25	700	695	705	0.020492407	17375	695	259807.2514	-148.1128296	0.357437712	373.8233834	-0.687401317
26	680	675	685	0.019902698	17550	675	226904.1916	-122.6648325	0.37734041	336.1543579	-0.5692955
27	660	655	665	0.019312988	17685	655	196817.6927	-100.596853	0.396653398	300.4853324	-0.466876566
28	640	635	645	0.018723279	17780	635	169428.3549	-81.60193493	0.415376677	266.8163069	-0.37871991
29	620	615	625	0.018133569	17835	615	144615.578	-65.38727482	0.433510246	235.1472814	-0.303468814
30	610	605	610	0.017838714	18150	605	124314.3448	-52.54269676	0.451348961	205.4782559	-0.243854088
31	580	575	590	0.01695415	17825	575	102240.3074	-40.19828051	0.468303111	177.8092303	-0.186562846
32	560	555	565	0.016364441	17760	555	84437.81389	-30.70910481	0.484667551	152.1402048	-0.142522961
33	550	545	550	0.016069586	17985	545	70016.79274	-23.39985936	0.500737137	128.4711793	-0.108600276
34	530	525	535	0.015479876	17850	525	56071.13076	-17.08588577	0.516217013	106.8021538	-0.079296712
35	510	505	515	0.014890167	17675	505	44002.2296	-12.11084698	0.53110716	87.13312833	-0.056207232
36	500	495	500	0.014595312	17820	495	34384.7309	-8.449947756	0.545702492	69.46410282	-0.03921676
37	480	475	485	0.014005602	17575	475	25552.86173	-5.526059952	0.559708094	53.79507732	-0.025646805
38	470	465	470	0.013710747	17670	465	18658.61409	-3.484963898	0.573418841	40.12605181	-0.016174038
39	460	455	460	0.013415893	17745	455	12947.94697	-2.038591132	0.586834734	28.45702631	-0.009451952
40	440	435	445	0.012826183	17400	435	8172.760349	-1.044523681	0.599660917	18.7880008	-0.004847703
41	430	425	430	0.012531328	17425	425	4725.584501	-0.464616102	0.612192245	11.1189753	-0.002156314
42	420	415	420	0.012236474	17430	415	2261.729163	-0.155684375	0.624428719	5.449949791	-0.000722541
43	410	405	410	0.011941619	17415	405	721.274336	-0.028381241	0.636370338	1.780924287	-0.000131719
44	395	390	397.5	0.011499337	17160	390	43.84052481	-0.000430438	0.647869674	0.111898782	-1.99769E-06
45	380	375	382.5	0.011057054	16875	375	166.0774767	0.003258807	0.658926729	0.442873277	1.51243E-05
46	370	365	370	0.0107622	16790	365	1012.454437	0.049719297	0.669688928	2.773847772	0.000230751
47	360	355	360	0.010467345	16685	355	2522.211905	0.198228621	0.680156273	7.104822267	0.000919992
48	340	335	345	0.009877635	16080	335	4500.991915	0.486461108	0.690033908	13.43579676	0.002257698
49	330	325	330	0.00958278	15925	325	7074.200858	0.973156213	0.699616689	21.76677126	0.004516482
50	320	315	320	0.009287926	15750	315	10110.78991	1.689003429	0.708904614	32.09774575	0.007838775
51	300	295	305	0.008698216	15045	295	13106.47247	2.57588162	0.717602831	44.42872025	0.011954835
52	290	285	290	0.008403361	14820	285	16746.513	3.785058224	0.726006192	58.75969474	0.017566693
53	280	275	280	0.008108507	14575	275	20649.93404	5.276182813	0.734114699	75.09066924	0.024487109
54	270	265	270	0.007813652	14310	265	24756.73559	7.055459594	0.74192835	93.42164373	0.032744849
55	260	255	260	0.007518797	14025	255	29006.91765	9.122008264	0.749447147	113.7626182	0.042335836
56	255	250	252.5	0.00737137	14000	250	34020.88818	11.70191225	0.756818517	136.0835927	0.054309339
57	250	245	247.5	0.007223942	13965	245	39301.56897	14.67709039	0.764042459	160.4145672	0.068117335
58	240	235	240	0.006929087	13630	235	43685.2023	17.68281505	0.770971547	186.7455417	0.0820671
59	230	225	230	0.006634233	13275	225	48392.21615	20.92570924	0.777605779	215.0765162	0.097117583
60	220	215	220	0.006339378	12900	215	52762.6105	24.3712812	0.783945157	245.4074907	0.113108708
61	210	205	210	0.006044523	12505	205	56936.38537	27.97796268	0.78998968	277.7384652	0.129847552
62	205	200	202.5	0.005897096	12400	200	62413.86794	32.50985527	0.795886776	312.0694397	0.150880362
63	200	195	197.5	0.005749668	12285	195	67938.08077	37.39045791	0.801636444	348.4004142	0.173531558
64	195	190	192.5	0.005602241	12160	190	73478.96385	42.60650528	0.807238685	386.7313887	0.197739574
65	190	185	187.5	0.005454814	12025	185	79006.53719	48.14119377	0.812693498	427.0623632	0.223426425
66	185	180	182.5	0.005307386	11880	180	84490.80078	53.97418154	0.818000885	469.3933377	0.250497702
67	180	175	177.5	0.005159959	11725	175	89901.75463	60.08158847	0.823160843	513.7243122	0.278842577
68	175	170	172.5	0.005012531	11580	170	95209.39873	66.43599621	0.828173375	560.0552867	0.308333798

142	27	22	22.25	0.000648681	3124	22	209848.0428	604.3022659	0.970573493	9538.547399	2.804606291
143	26.5	21.5	21.75	0.000633938	3074.5	21.5	209299.885	608.8950358	0.97120743	9734.878374	2.825921636
144	26	21	21.25	0.000619195	3024	21	208597.3963	613.0019502	0.971826625	9933.209348	2.844982084
145	25.5	20.5	20.75	0.000604452	2972.5	20.5	207737.5766	616.6004532	0.972431078	10133.54032	2.861682981
146	25	20	20.25	0.00058971	2920	20	206717.4259	619.6676347	0.973020787	10335.8713	2.875917971
147	24.5	19.5	19.75	0.000574967	2866.5	19.5	205533.9443	622.1802311	0.973595754	10540.20227	2.887579095
148	24	19	19.25	0.000560224	2812	19	204184.1317	624.1146246	0.974155978	10746.53325	2.896556742
149	23.5	18.5	18.75	0.000545481	2756.5	18.5	202664.9881	625.4468443	0.97470146	10954.86422	2.902739661
150	23	18	18.25	0.000530739	2700	18	200973.5135	626.1525646	0.975232198	11165.1952	2.906014954
151	22.5	17.5	17.75	0.000515996	2642.5	17.5	199106.708	626.2071068	0.975748194	11377.52617	2.906268087
152	22	17	17.25	0.000501253	2584	17	197061.5715	625.5854374	0.976249447	11591.85714	2.90338288
153	21.5	16.5	16.75	0.00048651	2524.5	16.5	194835.104	624.2621703	0.976735958	11808.18812	2.897241511
154	21	16	16.25	0.000471768	2464	16	192424.3055	622.2115648	0.977207725	12026.51909	2.887724517
155	20.5	15.5	15.75	0.000457025	2402.5	15.5	189826.176	619.4075266	0.97766475	12246.85007	2.874710792
156	20	15	15.25	0.000442282	2340	15	187037.7156	615.8236075	0.978107032	12469.18104	2.85807759
157	19.85	14.85	14.925	0.000437859	2331.45	14.85	188498.6534	626.1917333	0.978544892	12693.51202	2.906198739
158	19.7	14.7	14.775	0.000433437	2322.6	14.7	189921.692	636.5189933	0.978978328	12919.84299	2.954126227
159	19.55	14.55	14.625	0.000429014	2313.45	14.55	191305.9312	646.798992	0.979407342	13148.17397	3.001836373
160	19.4	14.4	14.475	0.000424591	2304	14.4	192650.4711	657.0252282	0.979831933	13378.50494	3.049297003
161	19.25	14.25	14.325	0.000420168	2294.25	14.25	193954.4118	667.191094	0.980252101	13610.83591	3.09647745
162	19.1	14.1	14.175	0.000415745	2284.2	14.1	195216.8531	677.289876	0.980667846	13845.16689	3.143346557
163	18.95	13.95	14.025	0.000411322	2273.85	13.95	196436.8952	687.314754	0.981079169	14081.49786	3.189872671
164	18.8	13.8	13.875	0.0004069	2263.2	13.8	197613.638	697.2588021	0.981486068	14319.82884	3.236023648
165	18.65	13.65	13.725	0.000402477	2252.25	13.65	198748.1814	707.1149881	0.981888545	14560.15981	3.281766851
166	18.5	13.5	13.575	0.000398054	2241	13.5	199833.6256	716.8761737	0.982286599	14802.49079	3.32706915
167	18.35	13.35	13.425	0.000393631	2229.45	13.35	200875.0705	726.5351143	0.98268023	15046.82176	3.371896925
168	18.2	13.2	13.275	0.000389208	2217.6	13.2	201869.6161	736.0844593	0.983069438	15293.15274	3.416216059
169	18.05	13.05	13.125	0.000384785	2205.45	13.05	202816.3624	745.516752	0.983454224	15541.48371	3.459991945
170	17.9	12.9	12.975	0.000380363	2193	12.9	203714.4094	754.8244294	0.983834586	15791.81469	3.503189484
171	17.75	12.75	12.825	0.00037594	2180.25	12.75	204562.8572	763.9998223	0.984210526	16044.14566	3.545773082
172	17.6	12.6	12.675	0.000371517	2167.2	12.6	205360.8056	773.0351557	0.984582043	16298.47663	3.587706655
173	17.45	12.45	12.525	0.000367094	2153.85	12.45	206107.3547	781.9225482	0.984949138	16554.80761	3.628953623
174	17.3	12.3	12.375	0.000362671	2140.2	12.3	206801.6046	790.6540121	0.985311809	16813.13858	3.669476918
175	17.15	12.15	12.225	0.000358249	2126.25	12.15	207442.6551	799.2214539	0.985670057	17073.46956	3.709238975
176	17	12	12.075	0.000353826	2112	12	208029.6064	807.6166736	0.986023883	17335.80053	3.748201738
177	16.85	11.85	11.925	0.000349403	2097.45	11.85	208561.5584	815.8313655	0.986373286	17600.13151	3.78632666
178	16.7	11.7	11.775	0.00034498	2082.6	11.7	209037.611	823.8571172	0.986718266	17866.46248	3.823574696
179	16.55	11.55	11.625	0.000340557	2067.45	11.55	209456.8644	831.6854107	0.987058824	18134.79346	3.859906319
180	16.4	11.4	11.475	0.000336134	2052	11.4	209818.4185	839.3076214	0.987394958	18405.12443	3.895281497
181	16.25	11.25	11.325	0.000331712	2036.25	11.25	210121.3733	846.7150188	0.98772667	18677.4554	3.929659712
182	16.1	11.1	11.175	0.000327289	2020.2	11.1	210364.8288	853.8987663	0.988053958	18951.78638	3.962999953
183	15.95	10.95	11.025	0.000322866	2003.85	10.95	210547.885	860.8499208	0.988376824	19228.11735	3.995260716
184	15.8	10.8	10.875	0.000318443	1987.2	10.8	210669.6419	867.5594336	0.988695268	19506.44833	4.026400003
185	15.65	10.65	10.725	0.00031402	1970.25	10.65	210729.1996	874.0181493	0.989009288	19786.7793	4.058375324
186	15.5	10.5	10.575	0.000309598	1953	10.5	210725.6579	880.2168068	0.989318885	20069.11028	4.085143699
187	15.35	10.35	10.425	0.000305175	1935.45	10.35	210658.117	886.1460386	0.98962406	20353.44125	4.112661651
188	15.2	10.2	10.275	0.000300752	1917.6	10.2	210525.6767	891.796371	0.989924812	20639.77223	4.138885212
189	15.05	10.05	10.125	0.000296329	1899.45	10.05	210327.4372	897.1582244	0.990221141	20928.1032	4.163769924
190	14.9	9.9	9.975	0.000291906	1881	9.9	210062.4983	902.2219128	0.990513047	21218.43418	4.187270833
191	14.75	9.75	9.825	0.000287483	1862.25	9.75	209729.9602	906.9776442	0.990800531	21510.76515	4.209342493
192	14.6	9.6	9.675	0.000283061	1843.2	9.6	209328.9228	911.4155205	0.991083591	21805.09612	4.229938967
193	14.45	9.45	9.525	0.000278638	1823.85	9.45	208858.4861	915.5255373	0.991362229	22101.4271	4.249013824
194	14.3	9.3	9.375	0.000274215	1804.2	9.3	208317.7501	919.2975842	0.991636444	22399.75807	4.266520139
195	14.15	9.15	9.225	0.000269792	1784.25	9.15	207705.8148	922.7214445	0.991906236	22700.08905	4.282410498
196	14	9	9.075	0.000265369	1764	9	207021.7802	925.7867954	0.992171605	23002.42002	4.295636992
197	13.85	8.85	8.925	0.000260946	1743.45	8.85	206264.7463	928.483208	0.992432552	23306.751	4.309151219
198	13.7	8.7	8.775	0.000256524	1722.6	8.7	205433.8131	930.8001473	0.992689076	23613.08197	4.319904286
199	13.55	8.55	8.625	0.000252101	1701.45	8.55	204528.0807	932.726972	0.992941176	23921.41295	4.328846805
200	13.4	8.4	8.475	0.000247678	1680	8.4	203548.6489	934.2529348	0.993188854	24231.74392	4.335928898
201	13.25	8.25	8.325	0.000243255	1658.25	8.25	202488.6179	935.3871821	0.99343211	24544.07489	4.341100193
202	13.1	8.1	8.175	0.000238832	1636.2	8.1	201353.0875	936.0587544	0.993670942	24858.40587	4.344309825
203	12.95	7.95	8.025	0.00023441	1613.85	7.95	200139.1579	936.3165858	0.993905352	25174.73684	4.345506437
204	12.8	7.8	7.875	0.000229987	1591.2	7.8	198845.929	936.1296043	0.994135338	25493.06782	4.34463618
205	12.65	7.65	7.725	0.000225564	1568.25	7.65	197472.5008	935.4862318	0.994360902	25813.39879	4.341652711
206	12.5	7.5	7.575	0.000221141	1545	7.5	196017.9733	934.3753842	0.994582043	26135.72977	4.336497194
207	12.35	7.35	7.425	0.000216718	1521.45	7.35	194481.4464	932.785471	0.994798762	26460.06074	4.329118303
208	12.2	7.2	7.275	0.000212295	1497.6	7.2	192862.0204	930.7048956	0.995011057	26786.39172	4.319462217
209	12.05	7.05	7.125	0.000207873	1473.45	7.05	191158.795	928.1219553	0.99521893	27114.72269	4.307474622
210	11.9	6.9	6.975	0.00020345	1449	6.9	189370.8703	925.0246414	0.995422379	27445.05366	4.293100714
211	11.75	6.75	6.825	0.000199027	1424.25	6.75	187497.3463	921.4016388	0.995621406	27777.38464	4.276285194
212	11.6	6.6	6.675	0.000194604	1399.2	6.6	185537.3231	917.2403265	0.995816011	28111.71561	4.256972272
213	11.45	6.45	6.525	0.000190181	1373.85	6.45	183489.9005	912.528777	0.996006192	28448.04659	4.235105663
214	11.3	6.3	6.375	0.000185759	1348.2	6.3	181354.1786	907.254757	0.99619195	28786.37756	4.210628592

t_m (min) =	44.33451275
σ^2 =	1291.743917
Pe =	22384.82665
s^3 =	455.0981181

35.94083913

mean real liquid velocity, u (m/s)	0.000473394
distance, L (m)	1.8

ΔP (lb/ft^2) =	11.68870383
ΔP (N/m^2) =	589.232235
ΔP_{exp} (mbar) =	5.440066062
ΔP_{exp} (N/m^2) =	544.0066062

ε	0.385449999
μ_{gas} (lb/ft.s)	1.23E-05
U_{gas} (ft/s)	3.11E-01
D_p (ft) = $6V_p/A_p$	8.75E-03
G_{gas} (kg/m.s^2)	0.042307515
L_{column} (ft)	4.9212

H_o =	0.046610522

μ_{liquid} (lb/ft.s)	6.55E-04
U_{liquid} (ft/s)	1.55E-03
ρ_{liquid} (lb/ft^3)	62.2606
nominal packing size (ring diameter), d (ft)	0.026246
g (ft/s^2)	32.17
g (m/s^2)	9.80665

H_o (Exp) =	0.614550001
V_{liquid} (m^3)	5.80E-03
V_{column} (m^3)	9.44E-03

$V_{stagnant}$ (m^3)	0.002787623
T_d (min)	62.91866667

Pressure Drop (Experimental)

5.1492	4.568767	5.955017	7.342896	3.776785	5.082291
5.139832	6.727234	5.124023	6.544952	5.063843	7.780533
6.08812	7.176773	4.115555	5.0634	7.443069	5.047119
5.12207	5.067032	5.06842	5.065796	4.952026	5.065843
6.585052	5.820114	5.677078	5.140274	5.310822	7.502777
5.068468	5.068879	5.530396	4.700882	4.440782	4.7106663
7.016888	5.630829	4.636627	4.865936	5.52655	5.114777
5.067078	5.054672	5.111954	7.362137	5.040649	4.492554
5.647809	5.568115	7.420074	7.274033	5.100601	6.420578
5.104797	5.05101	5.095551	5.096329	7.354156	5.082897
5.089874	4.909103	5.128738	5.746155	5.069275	5.071121
5.239227	7.541	6.58374	5.080536	6.522217	5.182373
4.360626	5.54866	5.06842	5.516878	4.729568	5.068619
5.07683	5.031647	4.295837	5.064651	4.694412	4.114243
4.324982	5.432922	5.292496	5.391861	7.360413	5.063354
5.076745	5.030289	4.392136	4.84938	4.779999	
6.58287	5.315289	5.085648	5.708954	5.078476	
5.0634	4.862259	5.084789	5.068803	5.076904	
6.109497	4.792923	5.333832	5.499191	5.088488	
5.063446	5.321472	5.098237	4.2366801	7.794403	
5.814438	4.028641	5.039474	5.066589	5.100693	
4.701263	4.702988	5.066589	5.665436	7.488237	
5.122406	5.070683	5.987289	5.068298	5.065643	
4.653976	6.230408	5.097214	4.718063	5.830658	
5.10791	5.069321	5.738388	7.597382	4.696457	
4.605255	6.864197	5.098404	4.828888	5.118623	
4.517467	5.06752	5.52066	5.253815	4.529178	
7.777435	7.317261	5.035522	4.780834	5.160376	
5.077438	5.066254	4.870265	5.077087	4.705139	
7.617584	5.069809	7.767609	5.312958	5.129578	
5.074127	6.638321	5.077393	4.899292	7.354645	
7.601791	5.067429	7.602148	5.084	5.069427	
5.07164	6.358248	5.063843	5.054352	7.770523	
7.168274	4.294992	7.374684	7.158936	5.063843	
5.063889	5.290253	4.857193	5.066569	5.362488	
5.063446	7.798264	4.780899	7.45311	4.492752	
4.683792	5.103485	7.524506	5.101181	5.523254	
4.52977	5.068678	4.868257	5.595827	5.377747	
5.064503	6.505127	5.072464	5.054779	5.065353	
5.104856	4.712418	7.592224	4.069138	5.068878	
5.098649	5.07683	5.069519	7.409164	6.79776	
4.511536	4.277145	7.156647	5.065353	5.067474	
5.088928	6.577103	5.0634	5.602234	6.206438	
4.418671	6.225037	6.096802	5.055679	5.0625	
5.082153	4.71875	5.062943	5.117386	7.577545	
4.352005	5.147141	5.067888	4.23465	6.743068	
5.078033	5.018021	6.63562	5.154556	4.727588	
4.71933	5.137665	5.066574	4.683685	5.077896	
5.162872	4.502518	6.059677	5.063843	4.290009	
4.689575	5.144272	4.274582	4.755142	5.321503	

G =	37.5

L =	0.15

t (min)	C (mS)	C-5	Area	E (1/min)	t*C*Δt	C*Δt	$(t-tm)^2$*C*Δt	$(t-tm)^3$*E*Δt	F (t)	$σ^2$	s^3
0	5	0		0	0	0	0	0	0	#DIV/0!	0
1	6	1	0.5	5.6823E-05	1	1	2306.024253	-6.292455507	5.6823E-05	2306.024253	-0.023115914
2	7	2	1.5	0.000113646	4	2	4421.964181	-11.81495795	0.000170469	2210.982091	-0.043403334
3	8	3	2.5	0.000170469	9	3	6353.819784	-16.61580116	0.000340938	2117.939928	-0.061038938
4	10	5	4	0.000284115	20	5	10134.48863	-25.92639406	0.000625053	2026.897765	-0.095242891
5	25	20	12.5	0.00113646	100	20	38757.11205	-96.9474661	0.001761514	1937.855603	-0.356145427
6	50	45	32.5	0.002557036	270	45	63288.60479	-203.6014319	0.00431855	1850.81344	-0.747948573
7	80	75	60	0.004261727	525	75	132432.8458	-316.2165064	0.008580277	1765.771277	-1.161657747
8	120	115	95	0.006534648	920	115	193513.8482	-451.0695404	0.015114925	1682.729114	-1.657045414
9	160	155	135	0.008807569	1395	155	248261.4775	-564.5761165	0.023922493	1601.686952	-2.074022254
10	200	195	175	0.01108049	1950	195	296915.7339	-658.35003	0.035002983	1522.644789	-2.416509344
11	240	235	215	0.013353411	2585	235	339716.6172	-733.9485261	0.048356394	1445.602626	-2.696227367
12	270	265	250	0.015058102	3180	265	363198.5229	-764.042507	0.063414496	1370.560464	-2.806780372
13	295	290	277.5	0.016478677	3770	290	376280.3073	-770.1806152	0.079893173	1297.518301	-2.829329277
14	320	315	302.5	0.017899253	4410	315	386339.9836	-766.6180237	0.097792425	1226.476138	-2.824323672
15	340	335	325	0.019035713	5025	335	387740.3819	-749.5722403	0.116828139	1157.433976	-2.753622516
16	355	350	342.5	0.019888059	5600	350	381637.1346	-716.0877638	0.136716197	1090.391813	-2.630614269
17	370	365	357.5	0.020740404	6205	365	374252.6224	-680.9656314	0.157456601	1025.34965	-2.501589634
18	380	375	370	0.021306834	6750	375	360865.3079	-636.1014898	0.178765236	962.3074876	-2.336777267
19	382	377	376	0.02142228	7163	377	339777.0275	-579.6217735	0.200187516	901.265325	-2.129293858
20	384	379	378	0.021535926	7580	379	319202.5765	-526.3859985	0.221723442	842.2231623	-1.933727346
21	385	380	379.5	0.021592749	7980	380	298366.7798	-475.0764809	0.243316192	785.1809996	-1.745233443
22	384	379	379.5	0.021535926	8338	379	276722.6192	-424.8853256	0.264852118	730.1388369	-1.560855295
23	380	375	377	0.021306834	8625	375	253911.2528	-375.4323018	0.286160752	677.0966742	-1.379165067
24	375	370	372.5	0.021024519	8880	370	231640.1693	-329.3398595	0.307185271	626.0545115	-1.209860243
25	370	365	367.5	0.020740404	9125	365	210609.5073	-287.4715519	0.327925675	577.0123488	-1.056053167
26	365	360	362.5	0.020456289	9360	360	190789.267	-249.5766818	0.348381964	529.9701862	-0.916842879
27	360	355	357.5	0.020172174	9585	355	172149.4483	-215.4113706	0.368554138	484.9280235	-0.791333468
28	355	350	352.5	0.019888059	9800	350	154660.0513	-184.7385583	0.388442197	441.8858608	-0.678654073
29	345	340	345	0.019319828	9860	340	136286.8574	-155.047688	0.407762025	400.8436981	-0.569582667
30	330	325	332.5	0.018467483	9750	325	117585.499	-127.0905669	0.426229508	361.8015354	-0.466878876
31	320	315	320	0.017899253	9765	315	102299.2024	-104.7556467	0.444128761	324.7593727	-0.384829496
32	310	305	310	0.017331023	9760	305	88383.74907	-85.48447485	0.461459784	289.7172101	-0.313961603
33	300	295	300	0.016762792	9735	295	75719.13897	-68.93215244	0.478222576	256.6750474	-0.253228598
34	290	285	290	0.016194562	9690	285	64305.37214	-54.867418	0.494417138	225.6328847	-0.201633975
35	280	275	280	0.015626332	9625	275	54062.44855	-43.07264759	0.51004347	196.590722	-0.15823133
36	270	265	270	0.015058102	9540	265	44930.36822	-33.24385484	0.525101571	169.5485593	-0.122124356
37	260	255	260	0.014489871	9435	255	36849.13114	-25.17089085	0.539591442	144.5063966	-0.092466846
38	250	245	250	0.013921641	9310	245	29758.73732	-18.83644428	0.553513084	121.464234	-0.068462691
39	240	235	240	0.013353411	9165	235	23599.18675	-13.43804131	0.566866494	100.4220713	-0.04936588
40	230	225	230	0.012785181	9000	225	18310.47943	-9.386045649	0.579651675	81.37990858	-0.034480501
41	220	215	220	0.01221695	8815	215	13832.61537	-6.304858524	0.591868625	64.3377459	-0.023160743
42	215	210	212.5	0.011932835	8820	210	10352.07247	-4.130053295	0.60380146	49.29558321	-0.01517213
43	210	205	207.5	0.01164872	8815	205	7431.951208	-2.542738458	0.61545018	36.25342053	-0.009340983
44	205	200	202.5	0.011364605	8800	200	5042.251569	-1.438620068	0.626814785	25.21125784	-0.005284903
45	200	195	197.5	0.01108049	8775	195	3152.973556	-0.720422942	0.637895275	16.16909516	-0.00264654
46	190	185	190	0.01051226	8510	185	1688.482508	-0.289656692	0.648407535	9.126932478	-0.001064816
47	180	175	180	0.009944029	8225	175	714.6347135	-0.082094446	0.658351564	4.084769792	-0.000301581
48	175	170	172.5	0.009659914	8160	170	177.2432082	-0.010283816	0.668011478	1.042607107	-3.77785E-05
49	170	165	167.5	0.009375799	8085	165	0.073329793	-8.78422E-08	0.677387277	0.000444423	-3.22696E-10
50	160	155	160	0.008807569	7750	155	148.5338695	0.008282203	0.686194846	0.958281739	3.0352E-05
51	155	150	152.5	0.008523454	7650	150	567.4178582	0.066054048	0.6947183	3.916119054	0.000242656
52	150	145	147.5	0.008239339	7540	145	1286.723674	0.21780522	0.702957638	8.87395637	0.000800127
53	145	140	142.5	0.007955223	7420	140	2216.451116	0.501126727	0.710912862	15.83179369	0.001840935
54	140	135	137.5	0.007671108	7290	135	3346.600185	0.946810814	0.71858397	24.789631	0.003478197
55	135	130	132.5	0.007386993	7150	130	4647.170861	1.578830962	0.725970983	35.74748832	0.005799981
56	130	125	127.5	0.007102878	7000	125	6088.163204	2.414341891	0.733073842	48.70530563	0.008869307
57	125	120	122.5	0.006818763	6840	120	7639.577154	3.483879557	0.739892604	63.66314295	0.012724145
58	120	115	117.5	0.006534648	6670	115	9271.41273	4.730381153	0.746427252	80.62098026	0.017377416
59	115	110	112.5	0.006250533	6490	110	10953.66993	6.211085106	0.752677785	99.57881758	0.022816992
60	110	105	107.5	0.005966418	6300	105	12656.34876	7.89573109	0.758644203	120.5366549	0.029005694
61	107.5	102.5	103.75	0.00582436	6252.5	102.5	14706.18545	10.011544	0.764488563	143.4944922	0.035778327
62	105	100	101.25	0.005682302	6200	100	16845.23295	12.42338314	0.770150865	168.4523295	0.04563844
63	102.5	97.5	98.75	0.005540245	6142.5	97.5	19052.49127	15.13385946	0.77589111	195.4101668	0.055595624
64	100	95	96.25	0.005398187	6080	95	21314.9804	18.1421745	0.781089297	224.3680042	0.066848945
65	97	92	93.5	0.005227718	5980	92	23489.97742	21.32820629	0.786317016	255.3258415	0.078351126
66	94	89	90.5	0.005057249	5874	89	25657.24741	24.75394589	0.791374265	288.2836788	0.090935895
67	91	86	87.5	0.004888678	5762	86	27798.77039	28.39968358	0.796261045	323.2415161	0.104328848
68	88	83	84.5	0.004716311	5644	83	29896.54633	32.24161838	0.800977356	360.1993534	0.118442548

142	23	18	18.125	0.001022814	2556	18	155611.4277	822.1486078	0.94864318	8645.079315	3.020238474
143	22.75	17.75	17.875	0.001008609	2538.25	17.75	156768.6594	837.1707301	0.947851789	8832.037152	3.075423621
144	22.5	17.5	17.625	0.000994403	2520	17.5	157867.4123	852.0087572	0.948846191	9020.994989	3.129932477
145	22.25	17.25	17.375	0.000980197	2501.25	17.25	158906.1863	866.6445393	0.949626389	9211.952827	3.183898368
146	22	17	17.125	0.000965991	2482	17	159883.4813	881.0595861	0.95058238	9404.910664	3.238653367
147	21.75	16.75	16.875	0.000951786	2462.25	16.75	160797.7974	895.2350661	0.951544166	9599.868501	3.288728296
148	21.5	16.5	16.625	0.00093758	2442	16.5	161647.6348	909.151807	0.952481746	9796.826339	3.339852723
149	21.25	16.25	16.375	0.000923374	2421.25	16.25	162431.4929	922.7902953	0.95340512	9995.784176	3.389954963
150	21	16	16.125	0.000909168	2400	16	163147.8722	936.1306769	0.954314288	10196.74201	3.438962081
151	20.75	15.75	15.875	0.000894963	2378.25	15.75	163795.2726	949.1527565	0.955209251	10399.69985	3.486799887
152	20.5	15.5	15.625	0.000880757	2356	15.5	164372.1942	961.8359981	0.956090008	10604.65769	3.533392941
153	20.25	15.25	15.375	0.000866551	2333.25	15.25	164877.1368	974.1595245	0.956956559	10811.61553	3.578664548
154	20	15	15.125	0.000852345	2310	15	165308.6004	986.1021177	0.957808904	11020.57336	3.622536762
155	19.85	14.85	14.925	0.000843822	2301.75	14.85	166788.2383	1004.405895	0.958652726	11231.5312	3.689777369
156	19.7	14.7	14.775	0.000835298	2293.2	14.7	168233.9888	1022.87183	0.959488025	11444.48904	3.756878962
157	19.55	14.55	14.625	0.000826775	2284.35	14.55	169644.952	1040.888625	0.9603146	11659.44687	3.823600033
158	19.4	14.4	14.475	0.000818252	2275.2	14.4	171020.2279	1059.044777	0.961133051	11876.40471	3.890498323
159	19.25	14.25	14.325	0.000809728	2265.75	14.25	172358.9163	1077.128576	0.961942779	12095.36255	3.956930821
160	19.1	14.1	14.175	0.000801205	2256	14.1	173660.1174	1095.12811	0.962743984	12316.32039	4.023053766
161	18.95	13.95	14.025	0.000792681	2245.95	13.95	174922.9312	1113.031263	0.963536665	12539.27822	4.068822644
162	18.8	13.8	13.875	0.000784158	2235.6	13.8	176146.4576	1130.625713	0.964320823	12764.23606	4.15418219
163	18.65	13.65	13.725	0.000775634	2224.95	13.65	177329.7967	1148.498933	0.965096457	12991.1939	4.219116389
164	18.5	13.5	13.575	0.000767111	2214	13.5	178472.0484	1166.038193	0.965863568	13220.15174	4.283548472
165	18.35	13.35	13.425	0.000758587	2202.75	13.35	179572.3128	1183.430557	0.966822155	13451.10957	4.34744092
166	18.2	13.2	13.275	0.000750064	2191.2	13.2	180629.6898	1200.662686	0.967372219	13684.06741	4.410745463
167	18.05	13.05	13.125	0.00074154	2179.35	13.05	181643.2795	1217.721634	0.96811376	13919.02525	4.473413077
168	17.9	12.9	12.975	0.000733017	2167.2	12.9	182612.1618	1234.593853	0.968846777	14155.98308	4.53539399
169	17.75	12.75	12.825	0.000724494	2154.75	12.75	183535.4968	1251.265189	0.96957127	14394.94092	4.596637677
170	17.6	12.6	12.675	0.00071597	2142	12.6	184412.3244	1267.721885	0.97028724	14635.89876	4.65709286
171	17.45	12.45	12.525	0.000707447	2128.95	12.45	185241.7646	1283.949776	0.970994687	14878.8566	4.716707511
172	17.3	12.3	12.375	0.000698923	2115.6	12.3	186022.9175	1299.934497	0.97169361	15123.81443	4.775428851
173	17.15	12.15	12.225	0.0006904	2101.95	12.15	186754.8831	1315.661475	0.97238401	15370.77227	4.833203349
174	17	12	12.075	0.000681876	2088	12	187436.7613	1331.115933	0.973065886	15619.73011	4.889976722
175	16.85	11.85	11.925	0.000673353	2073.75	11.85	188067.6522	1346.282891	0.973739239	15870.68795	4.945693938
176	16.7	11.7	11.775	0.000664829	2059.2	11.7	188646.6557	1361.147163	0.974404069	16123.64578	5.000299205
177	16.55	11.55	11.625	0.000656306	2044.35	11.55	189172.8718	1375.693359	0.975060374	16378.60362	5.053735993
178	16.4	11.4	11.475	0.000647782	2029.2	11.4	189645.4006	1389.905884	0.975708157	16635.56146	5.105947011
179	16.25	11.25	11.325	0.000639259	2013.75	11.25	190063.3421	1403.768939	0.976347416	16894.5193	5.156874218
180	16.1	11.1	11.175	0.000630736	1998	11.1	190425.7962	1417.266521	0.976978152	17155.47713	5.206458825
181	15.95	10.95	11.025	0.000622212	1981.95	10.95	190731.8629	1430.38242	0.977600364	17418.43497	5.254641286
182	15.8	10.8	10.875	0.000613689	1965.6	10.8	190980.6423	1443.100224	0.978214052	17683.39281	5.301361309
183	15.65	10.65	10.725	0.000605165	1948.95	10.65	191171.2344	1455.403316	0.978819218	17950.35064	5.346557847
184	15.5	10.5	10.575	0.000596642	1932	10.5	191302.7391	1467.274873	0.979415859	18219.30848	5.390169103
185	15.35	10.35	10.425	0.000588118	1914.75	10.35	191374.2564	1478.697869	0.980003978	18490.26632	5.432132528
186	15.2	10.2	10.275	0.000579595	1897.2	10.2	191384.8864	1489.655072	0.980583572	18763.22416	5.472384821
187	15.05	10.05	10.125	0.000571071	1879.35	10.05	191333.729	1500.129047	0.981154644	19038.18199	5.510861931
188	14.9	9.9	9.975	0.000562548	1861.2	9.9	191219.8843	1510.102154	0.981717192	19315.13983	5.547499054
189	14.75	9.75	9.825	0.000554024	1842.75	9.75	191042.4523	1519.556547	0.982271216	19594.09767	5.582230636
190	14.6	9.6	9.675	0.000545501	1824	9.6	190800.5329	1528.474177	0.982816717	19875.05551	5.61499037
191	14.45	9.45	9.525	0.000536978	1804.95	9.45	190493.2261	1536.83679	0.983353695	20158.01334	5.645711199
192	14.3	9.3	9.375	0.000528454	1785.6	9.3	190119.632	1544.625926	0.983882149	20442.97118	5.674325313
193	14.15	9.15	9.225	0.000519931	1765.95	9.15	189678.8505	1551.822927	0.98440208	20729.92902	5.700764151
194	14	9	9.075	0.000511407	1746	9	189169.9817	1558.408921	0.984913487	21018.88686	5.724958402
195	13.85	8.85	8.925	0.000502884	1725.75	8.85	188592.1255	1564.364835	0.985416371	21309.84469	5.748638002
196	13.7	8.7	8.775	0.00049436	1705.2	8.7	187944.382	1569.871394	0.985910731	21602.80253	5.766332135
197	13.55	8.55	8.625	0.000485837	1684.35	8.55	187225.8511	1574.309117	0.986396568	21897.76037	5.783369235
198	13.4	8.4	8.475	0.000477313	1663.2	8.4	186435.6329	1578.258317	0.986873881	22194.7182	5.797876984
199	13.25	8.25	8.325	0.00046879	1641.75	8.25	185572.8273	1581.499104	0.987342671	22493.67604	5.809782312
200	13.1	8.1	8.175	0.000460266	1620	8.1	184636.5344	1584.011382	0.987802938	22794.63388	5.819011399
201	12.95	7.95	8.025	0.000451743	1597.95	7.95	183625.8541	1585.774853	0.988254681	23097.59172	5.82548987
202	12.8	7.8	7.875	0.00044322	1575.6	7.8	182539.8865	1586.769012	0.9886979	23402.54955	5.829141803
203	12.65	7.65	7.725	0.000434696	1552.95	7.65	181377.7315	1586.973149	0.989132597	23709.50739	5.829891723
204	12.5	7.5	7.575	0.000426173	1530	7.5	180138.4892	1586.366353	0.989558769	24018.46523	5.827662601
205	12.35	7.35	7.425	0.000417649	1506.75	7.35	178821.2595	1584.927505	0.989976418	24329.42307	5.822376859
206	12.2	7.2	7.275	0.000409126	1483.2	7.2	177425.1425	1582.635282	0.990385544	24642.3809	5.813956168
207	12.05	7.05	7.125	0.000400602	1459.35	7.05	175949.2381	1579.468158	0.990786147	24957.33874	5.802321446
208	11.9	6.9	6.975	0.000392079	1435.2	6.9	174392.6464	1575.404401	0.991178225	25274.29658	5.78739286
209	11.75	6.75	6.825	0.000383555	1410.75	6.75	172754.4873	1570.422074	0.991561781	25593.25441	5.769089826
210	11.6	6.6	6.675	0.000375032	1386	6.6	171033.8009	1564.499038	0.991936813	25914.21225	5.747331008
211	11.45	6.45	6.525	0.000366509	1360.95	6.45	169229.7471	1557.612948	0.992303321	26237.17009	5.722034318
212	11.3	6.3	6.375	0.000357985	1335.6	6.3	167341.4059	1549.74125	0.992661306	26562.12793	5.693116918
213	11.15	6.15	6.225	0.000349462	1309.95	6.15	165367.8774	1540.861194	0.993010768	26889.08576	5.660496218
214	11	6	6.075	0.000340938	1284	6	163308.2616	1530.94982	0.993351706	27218.0436	5.624084873

t_m (min) =	49.02108134		
σ^2 =	1764.190396		42.00226655
Pe =	16390.21714	mean real liquid velocity, u (m/s)	0.000473394
s^3 =	538.250384	distance, L (m)	1.8
		ε	0.396045689
ΔP (lb/ft²) =	14.53725099	μ_{gas} (lb/ft.s)	1.23E-05
ΔP (N/m²) =	696.0449171	U_{gas} (ft/s)	3.88E-01
ΔP_{exp} (mbar) =	5.500419843	D_p (ft) = $6V_p/A_p$	8.75E-03
ΔP_{exp} (N/m²) =	550.0419843	G_{gas} (kg/m.s³)	0.052884393
		L_{column} (ft)	4.9212
H_o =	0.046610522	μ_{liquid} (lb/ft.s)	6.55E-04
		U_{liquid} (ft/s)	1.55E-03
		ρ_{liquid} (lb/ft³)	62.2608
		nominal packing size (ring diameter), d (ft)	0.026246
		g (ft/s²)	32.17
		g (m/s²)	9.80665
H_o (Exp) =	0.603954311		
V_{liquid} (m³)	5.70E-03		
V_{column} (m³)	9.44E-03		

$V_{stagnant}$ (m³)	0.002084638
T_d (min)	62.91866667

Pressure Drop (Experimental)

5.791397	4.328232	5.070709	5.193039	5.099304	5.921265
5.478333	5.152481	4.209564	4.741272	5.064331	5.100235
5.065277	4.706131	5.068024	5.162567	7.526016	5.639526
5.473129	5.159164	5.097504	4.685715	7.53537	5.066589
5.064835	5.065643	5.271179	5.140808	5.050812	5.019756
7.371307	5.129456	4.780594	4.703568	5.468552	
5.064835	4.646439	4.781754	5.065946	4.987244	
7.167786	5.105667	4.298645	6.030472	5.342789	
4.764481	4.313766	7.602676	6.135834	4.886932	
5.209869	7.765945	5.072495	5.063889	5.086197	
4.720184	7.769734	7.406799	5.795639	4.388168	
6.212448	7.652985	5.063889	4.718933	7.771606	
5.063889	5.073807	6.739136	5.1203	7.381516	
5.11261	7.61058	5.063934	4.657898	7.388408	
5.092865	5.664769	5.176955	5.114197	4.898849	
7.654556	7.367569	4.699356	4.156158	5.245285	
5.067078	5.064377	4.772278	5.721648	5.063889	
7.781525	7.039261	5.608105	5.557404	5.202116	
5.085358	5.063889	6.509857	5.039076	4.718384	
7.777618	5.067566	5.06842	5.413452	4.712463	
5.065735	5.38337	6.139771	4.977951	5.381699	
5.064789	5.305283	5.067108	5.100647	5.169706	
5.070465	5.063934	5.829849	4.465393	6.813477	
6.892014	5.242584	5.101698	5.085297	5.097382	
6.343521	4.804825	5.590164	7.531615	7.369895	
5.999756	5.199417	4.646957	7.395142	5.06662	
5.064377	4.713455	7.527786	4.915222	7.50592	
5.748581	5.165359	5.068223	5.312103	5.066177	
5.101944	4.685883	7.537735	4.823578	7.536301	
5.579666	5.042221	5.065277	5.233597	5.065277	
5.055054	6.165314	7.53627	4.757736	5.065231	
5.463913	6.664474	5.0495	5.081619	4.701065	
5.008865	5.066788	5.468552	4.312912	4.699631	
4.499985	6.098175	4.987106	7.312912	4.650528	
4.360184	5.06633	4.903625	6.708572	5.082596	
5.129852	5.855255	5.077988	4.766144	7.195036	
5.93895	5.101944	4.605743	5.210373	5.209976	
5.110123	5.610138	5.076339	4.721619	5.173126	
6.843675	4.648346	7.766951	5.163727	4.035416	
5.098541	4.263184	5.074631	4.293655	5.149948	
3.918488	7.506607	7.606583	4.618698	4.606335	
5.091553	7.769806	5.064377	7.199554	5.073456	
5.065735	5.06287	5.064331	6.099731	5.838382	
7.381165	7.530548	5.063889	5.063889	4.31486	
7.557765	5.064331	5.102646	5.163696	4.695964	
6.913193	7.409027	5.063889	4.685089	5.362015	
5.063889	5.064835	6.918076	5.139191	7.367661	
6.346664	4.92186	5.067566	5.058868	5.231232	
4.733063	4.837036	5.067566	4.208603	4.789291	
5.156693	3.211319	5.065735	6.932983	4.617203	