CERTIFICATION OF APPROVAL

MODELING AND DESIGN VERIFICATION OF PARTIAL STROKE TEST (PST) PLANT USING HYSYS AND DEVELOPMENT OF PST PROCEDURE FOR METSO NELES EMERGENCY SHUTDOWN VALVE

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.

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AMIRA FARHANA BINTI SHUKARI

ABSTRACT

Industries are concern on plant safety in order to reduce the risk of massive release of toxic materials, having an uncontrollable fire or a devastating explosion or any combination of the above [1]. Therefore, emergency shutdown (ESD) valves have to be sure are operated with fault-free to guard the process plant from potential disaster. Regular checking has to be performed in order to guarantee the function of the valves by testing the valves using Full Stroke Testing (FST) and Partial Stroke Testing (PST). Since this project is collaboration between Universiti Teknologi Petronas (UTP) and PETRONAS Improvement Working Group (IWG) of Skill Group 14 (SKG14), discussion session is conducted once in a few months to compare the latest update of valves performance from four vendors which are FISHER, METSO NELES, ROTORK and MESONEILAN that may be used in PETRONAS plants if they satisfy the standard required. Since the mini plant has not been built in the lab, a simulation model for the plant would be built and shall be verified and validated using HYSYS which is a chemical engineering software. As for this design, since there is only pure water involved in the flow process, thus the NRTL is chosen for the fluid packages. Before that, the pure water H_2O must be well-defined in the component type and enter the simulation environment. The designing part is done in the PFD. In order to ensure that the plant is converged, all the specification needed for the equipment involved must be defined appropriately. The plant is only involved with water; hence the liquid mole fraction must be configured as 1.0 mole. The simulation is conducted to verify and validate that the designed plant have a continuous flow. Besides that, it also verified that the volume of the tank is sufficient enough to provide the real flow to all the valves.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ESD	Emergency Shutdown
PST	Partial Stroke Testing
FST	Full Stroke Test
PLC	Programmable Logic Controller
SIL	Safety Integrity Level
DCS	Distributed Control System
RCI	Remote Communication Interface
μC	Microcontroller
HART	Highway Addressable Remote Transducer
PC	Personal Computer
LED	Light Emitting Diodes
PR	Prestage
SV	Spool Valve
FDT	Field Device Tool
APC	Advance Process Control
UTP	Universiti Teknologi Petronas

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Safety instrument systems integrate emergency shutdown valves which are normally in a fully opened or fully closed state and controlled by a logic solver or a Programmable Logic Controller (PLC) in an emergency situation. Furthermore, the emergency shutdown valves are the most important components in the safety loop (sensor, safety logic and final element), because most of the problems that occur are related to the functionality of the final element (valve). [2]

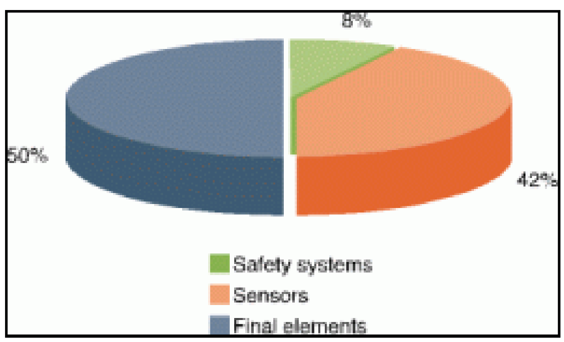


Figure 1: Safety loop failure sources

ESD valve partial stroke testing (PST) is a method whereby a portion of the valve assembly is tested at a more frequent interval than the full test rate. In simple words: an accelerated (partial) proof test.[3] There are few advantages of partial stroke test which are providing an improvement to the Safety Integrity Level (SIL) of the Safety Instrumented Function (SIF), meanwhile providing predictive maintenance data. Besides that, it may allow extension of the full stroke test (FST) and also overcome IEC61511 architectural constraints. In addition, PST also reduces the need for valve bypasses because valve is always available to respond to a process demand during the test period.

As for this project, previously for the first phase, Metso Neles vendor has been installing VG800 which is powered by 24 VDC supply using a HART. During trip, the device is off and cannot collect any information. The VG800 will record supply pressure, stroking times and size. For the second phase of this project, the vendor has upgraded the device and will be using the VG9000. It is also powers by 24 VDC using HART. The major difference is during the trip, the device is powered and generally it can collect diagnostics information. It also performs pneumatic test after the valve is energized. This latest device is able to record start time, temperature, stroking times, speed and stroke size deviation. Even though the device is being upgraded, the previous device is still operating simultaneously. The data will be based on the two devices which are VG800 and VG9000.

During the partial stroke test ValvGuard will move the actuator/valve through the spool valve by reducing the air pressure in the actuator until it reaches the breakaway pressure. Then the actuator will start move with a preset pressure drop (e.g. 0.05 bar) until it reaches the maximum pre-defined stroke size, which is about 20%. Once the 20% stroke is achieved ValvGuard will increase the pressure again in the actuator to the normal position. During this Automatic Partial Stroke, ValvGuard will measure the average breakaway pressure to Open and average breakaway pressure to Close and will record this as a Load Factor. Apart from that, Full Stroke Test (FST) will also be conducted together with PST to ensure that the ESD valve is able to automatically shut-off if by chances any emergency occurs during the execution of PST onwards.

1.2 Problem Statement

Turn-arounds are being planned further apart, ranging from three to five years. The inability to conduct full stroke test within the required period, causing safety issues to arise due to ESD valves being stuck in position due to the very long period in one fixed condition. A number of failures in PST around the world have given rise to concern on the reliability of PST. The facility is meant for comparison and verification of the technology used for partial stroke test of ESD valves. The work includes the development of the controller to execute the FST and PST sequences, data mining and analysis. In order to ensure proper operation of ESD service, ESD valves must be actuated and to do so without interrupting processes, Partial Stroke Test (PST) is the best solution since it can reliably move an on/off valve between shutdowns. Therefore, it can improve ESD valve integrity and confirm availability.

As for continuation of the Phase I, Phase II will be conducted in early semester. A small plant is planned to be built in the lab in building 23 because FST and PST will be done with load (liquid). This test is important to study the failure modes during the test period. The major problem to proceed with this Phase II is to finalize the appropriate, effective and convenient design to meet the expectation of the Phase II.

1.3 Objective

This project is collaboration between Universiti Teknologi PETRONAS (UTP) and the Improvement Working Group (IWG) SKG14 of PETRONAS. The objective of this project is to conduct a study of ESD Valve performances when it is partially stroked with 10% - 20% closing. Two different valves are being tested using vendor's software. The performance of two different valves is studied and compared the technology used for FST and PST.

This project is divided into two phases. Phase I involve developing the PLC programming and conduct the PST and FST without load. The testing need to be done based on PETRONAS testing specification which requires 90 days of testing or 540 strokes. Phase I is comprehensively completed in the end of November 2009.

Phase II involves study of the failures mode of the valves during the test period. Failure mode which cover the mechanical failure mode, pneumatics failure mode and electronics failure mode will be introduced. PST and FST will be done with load (liquid).The performance of the ESD valves will be analyzed and various aspects of valve failures will be observed. Phase II is commenced to modify the existing Instrument Air Supply by providing a vessel downstream of the instrument air compressor. This vessel is to provide sufficient air supply for Partial Stroke Testing (PST) valve to be in fully open condition for approximate X time. Due to the modification, it requires checking on the longest time for FST/PST test to be done and also the requirement of instrument air for all PST valves to be in fully open position and the minimum requirement of air for one valve to be PST/FST.

The simulation which is HYSYS is conducted to verify and validate that the designated plant have a continuous flow. Besides that, it also verified that the volume of the tank is sufficient enough to provide the real flow to all the valves. Due to insufficient data for the equipment, I have estimated the value for the pump rating, the pressure and also the temperature based on the calculation on the final draft of mini plant. The design need to be modified with the appropriate set of data for the specification of all the equipment to ensure that the final design of the plant is converged.

In order to design PST Phase II, some specifications require checking which are:

a. Pump rating: List of pump datasheet/ specification Supplier contacts.
b. To check vessel capacity.
c. Piping Type- PVC. Does it can withstand the operating pressure?
d. Liquid- water
e. Pressure drop of reducer.
f. Selection of flow transmitter
g. Selection of pressure gauge.
h. Hook up/ installation drawing for PST valves (Flanged and Wafer type).

The figure below is the first process design for Phase II of this project. It involves 4 vendors which are Fisher, Masoneilon, Metso and Rotork.

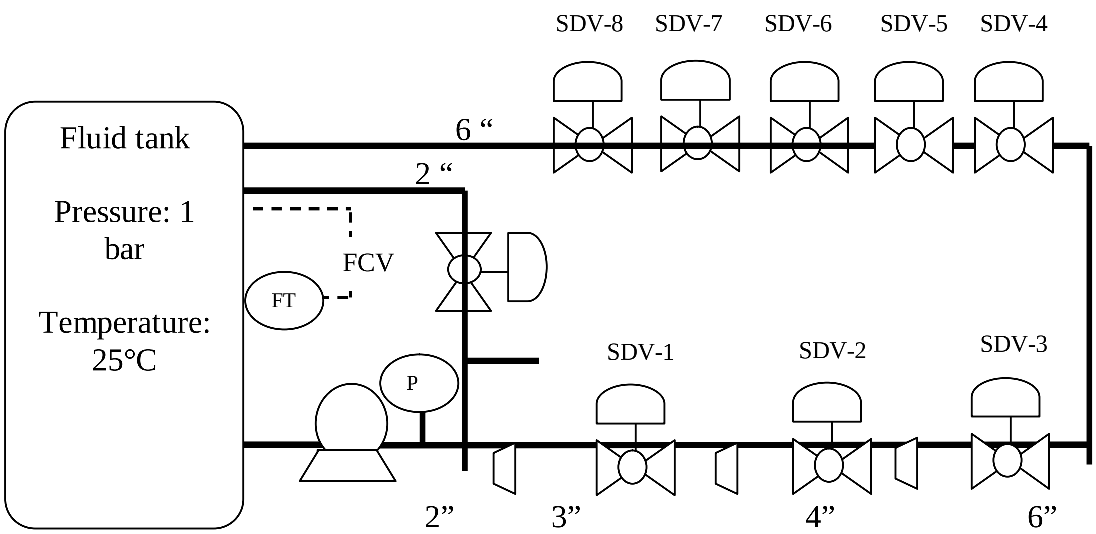


Figure 1: Process Design of Phase II

1.4 Scope of Study

Scope of study of the project is to explore and verify Partial Stroke Test (PST) and Full Stroke Test (FST) technology that will be used in the project to ensure ESD valve performance. Four vendors are involved which are Metso Neles, Fisher, Masoneilan and Rotork. For each vendor, different software is used to conduct testing which as follow, FieldCare (Metso Neles), AMS Valvelink (Fisher), Valvue ESD (Masoneilan) and Smart Positioner (Rotork).

In this project, two types of ESD valve which are ball type and butterfly type from Metso Neles vendor are being tested and their performances are monitored in order to ensure the valves can operate without error. Furthermore, software that is used to execute the PST is FieldCare software and for FST, Programmable Logic Controller (PLC) from YOKOGAWA together with the WideField2software. There are two parts during the testing which are Pneumatic Test which measures the pressure change through the spool valve and Valve Test which physically moves the valve by desired stroke size. [4]

Besides that, for the verification and modeling the plant, the self study and research has been conducted to explore the HYSYS software as the powerful engineering simulation tools. Furthermore, in order to yield the desired result, few data such as pressure, temperature, speed of the pump and molar flow must be taken into consideration. However, since the plant is not built yet, all the data used in the software is estimated value.

CHAPTER 2
LITERATURE REVIEW

2.1 Emergency Shutdown Valve

Emergency shutdown valves means it operates at 0 and 100% which it remains either fully open or fully close depending upon the process requirement. It is an actuated valve installed in a pipeline that isolates a process unit from an upstream or downstream (gaseous or liquid) inventory upon activation of the process unit alarm and shutdown system.[5] In this project, two types of valve are used which are ball and butterfly valve.

2.1.1 Ball Valve

Ball valve is a valve that opens by turning a handle attached to a ball inside the valve. The ball has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked. The handle or lever will be in line with the port position letting the observer sees the valve's position. The ball valve is a part of the family of quarter turn valves. Ball valves are durable and usually work to achieve perfect shutoff even after years of disuse, thus an excellent choice for shutoff applications. Ball valves are used extensively in industry because they are very versatile, pressures up to 10,000 psi, temperatures up to 200 Deg C. They are easy to repair, operate manually or by actuators. The body of ball valves may be made of metal, plastic or metal with a ceramic center. [6]

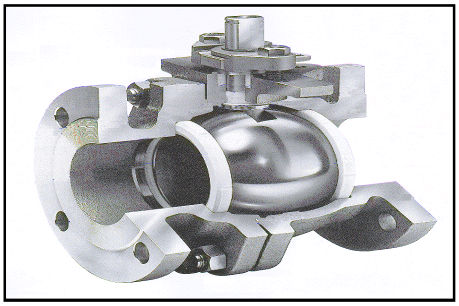


Figure 2: Ball type

2.1.2 Butterfly Valve

A butterfly valve is a type of flow control device, typically used to regulate a fluid flowing through a section of pipe. A plate or disc is positioned in the center of the pipe. The disc has a rod through it connected to an actuator on the outside of the valve. Rotating the actuator turns the disc either parallel or perpendicular to the flow. Unlike a ball valve, the disc is always present within the flow; therefore a pressure drop is always induced in the flow, regardless of valve position. A butterfly valve is from a family of valves called quarter-turn valves. The butterfly is a metal disc mounted on a rod. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn so that it allows an almost unrestricted passage of the fluid. [7]

Figure 3: Butterfly type

2.2 Partial Stroke Test

The definition of Partial Stroke Testing (PST) is to close a valve partially, and after a few seconds, will return it to the initial position. Even the impact of the valve movement on process flow is negligible since it is so small but the movement is still sufficient to reveal several types of dangerous failure. PST is introduced to detect failures without disturbing the process, that otherwise require functional tests [8].

PST can be used to replace Full Stroke Test (FST) as an alternative to reduce the FST interval required to achieve Safety Integrity Level (SIL). In order to implement PST, FieldCare Software is used which is developed by Metso Neles. Other than that, the Neles ValvGuard system also plays an important role where it automatically tests the valves based on programmed testing interval. The interval for the test stroke can vary from every minute up to once a year or more. In this project, for every testing period, six stroke tests will be done for each valve with 15 minutes interval for each stroke.

2.2.1 Safety Integrity Level (SIL)

Safety Integrity Level (SIL) is defined as a relative level of risk-reduction provided by a safety function, or to specify a target level of risk reduction. Four SILs are defined, with SIL4 being the most dependable and SIL1 being the least. Partial Stroke Test (PST) is one of the most effective techniques for enabling a single valve to achieve safety integrity level (SIL) 2 performance or possibly even SIL 3. The statistical measure of availability in an emergency is called the Probability of Failure on Demand (PFD).

PST improves the ESD valve performance, as measured by the Average Probability of Failure on Demand (PFD_{AVG}). The amount of the reduction is dependent on the valve and its application environment. The probability to fail on demand (PFD) can be calculated using the dangerous failure rate (λD) and the testing interval (TI). The mathematical relationship, assuming that systematic failures are minimized through design practice, is as follows:

$$PFD = \lambda D * TI/2$$

The equation shows that the relationship between PFD and TI is linear. The longer testing interval (TI) yields larger PFD [9]. PFD calculations consist of two parts: on-line testing and off-line testing. When dealing with safety valves, the on-line diagnostics part relates to PST and the off-line part to periodic maintenance. With frequent on-line testing, better diagnostic coverage, shorter mean times for repair and good communication methods, it is possible to achieve lower PFD which is preferable.

2.2.2 Neles ValvGuard System

Neles ValvGuard can take care of Emergency Shutdown (ESD) valve testing automatically, and using Partial Stroke Test (PST) where the ESD valve is closed only partially and not affecting the flow in the pipeline. Whereas traditional systems require testing while the process is completely shutdown, but with Neles Valve guard the valve performance is tested and monitor automatically on continuous, real time basis, without disturbing the process. Furthermore, a clear signal will be given to the control room to show the valve status (OK, testing, alarm). Based on information data, plant production can be optimized and predictive maintenance plans can be made if needed.

Neles ValvGuard system is able to check the condition of the whole valve package by partial stroke test conducted whilst the plant is running. In addition, ValvGuard performs a separate pneumatic test which verifies all components and the system integrity up to a change of air pressure in the actuator. Testing, logging and reporting can be automated centralized and simplified. Malfunctions and alerts are transmitted in real time to the Distributed Control System (DCS). ValvGuard can be installed to existing valves or incorporated in new installations. Automated valve testing done by the ValvGuard system adds value by both lowering maintenance costs and increasing safety.

Neles ValvGuard VG9000H is a 4-20 mA loop-powered microcontroller-based intelligent safety valve controller and partial stroke test device with HART communication.The device stays alive even at 3.7 mA input signal and communicates via HART. Optional RCI unit is required if the safety system output is binary (DO) 24 VDC. The VG9000H contains a Local User Interface enabling local configuration. A PC with FieldCare software can be used for advanced configuration and diagnostics. The powerful 32-bit microcontroller controls the valve position during partial stroke and other special testing. The measurements include:

- Input signal
- Valve position with contactless sensor
- Actuator pressures, 2 independent measurements
- Supply pressure
- Device temperature
- Housing pressure

2.2.2.1 System Architecture

VG9000H can be connected directly to safety system analog output module (AO, 4-20mA). See Figure 4 for the general wiring priciple.VG9000H can also be connected to safety system digital output module (DO, 0/24 VDC) via RCI unit. See Figure 5 for the wiring principle with RCI. There is also a Local Control Panel option (LCP). It can be used together with VG900H or VG9000H with RCI. See Figure 7 for the wiring principles with LCP.

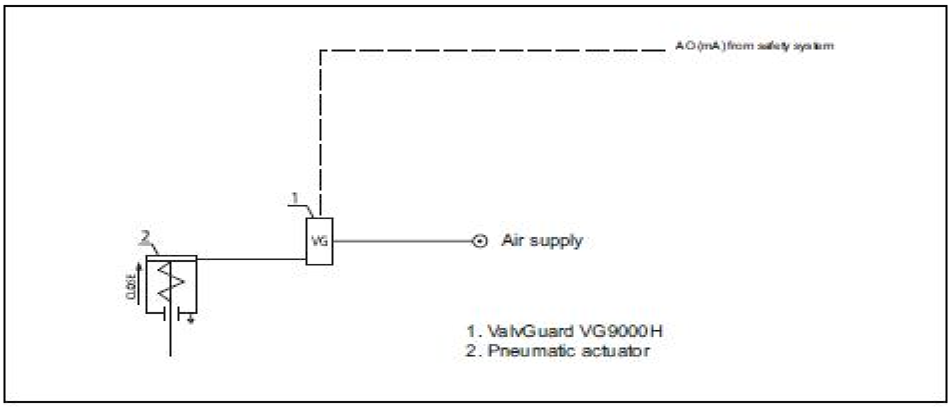


Figure 4: General Wiring Principle of VG9000H

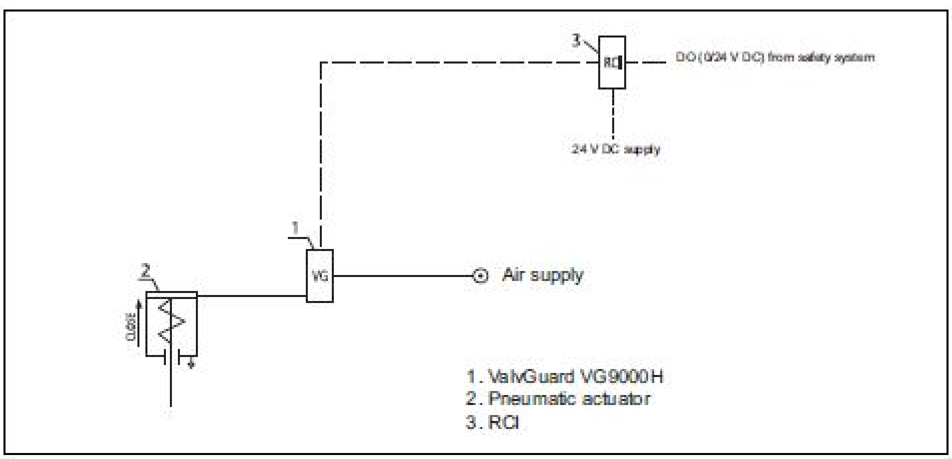


Figure 5: Wiring Principle with RCI

Neles ValvGuard comprises two components which are Remote Communication Interface (RCI) and the VG9000H a 'smart field device'. RCI is usually installed close to the control room and VG9000H is mounted on the field located at ESD valve actuator. The general arrangement is shown in Figure 6.

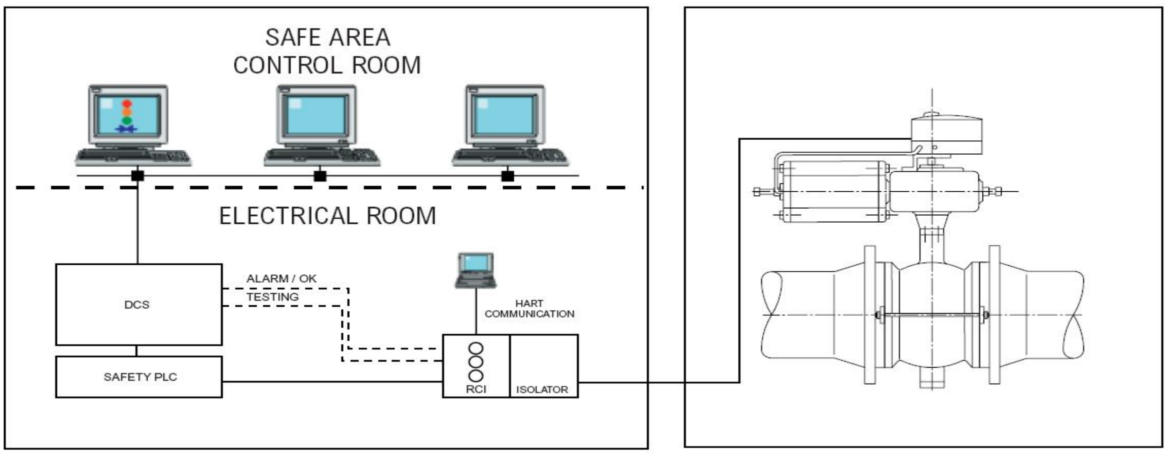


Figure 6: ValvGuard System

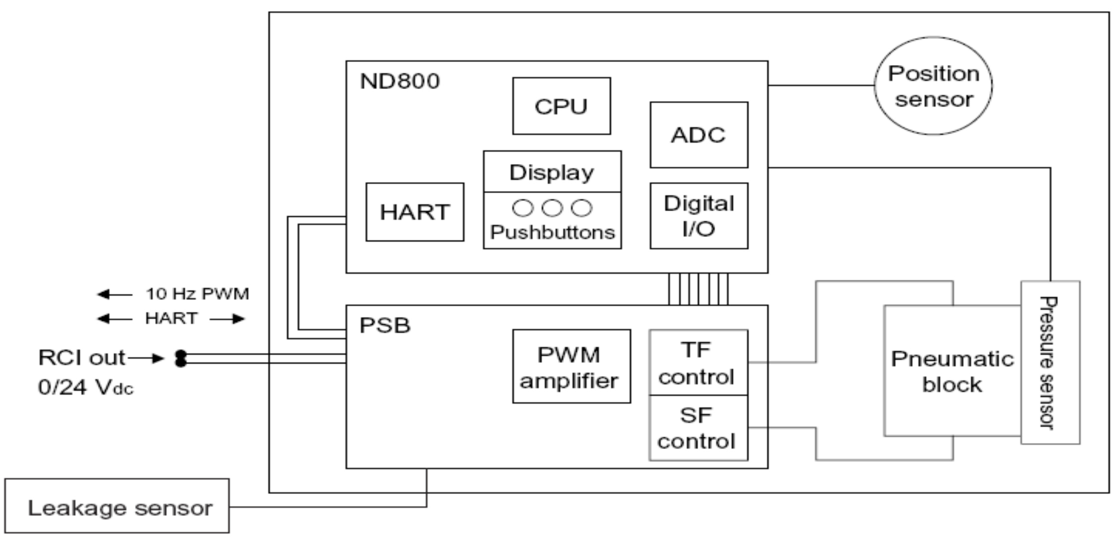


Figure 7: VG9000H Hardware Schematic Diagram

2.2.2.2 Basic Functionality

Advanced self-diagnostics guarantees that all measurements operate correctly. Failure of any measurement does not cause the valve to go to fail-safe position. After connections of electric signal and pneumatic supply the micro controller (μC) reads the input signal, position sensor(α) and pressure sensors (Ps, P1, P2). This information is used to run the partial stroke tests and other tests. A difference between setpoint according to partial stroke settings and position sensor (α) measurement is detected by the control algorithm inside the μC. The μC calculates a new value for prestage (PR) coil current based on this information. Changed current to the PR changes the pilot pressure to the spool valve. Reduced pilot pressure moves the spool and the actuator pressures change accordingly. The spool opens the flow to the driving side of the double-acting actuator (or air side in the single acting-actuator) and opens the flow out from the other side of the actuator in case of double- acting. The increasing pressure will move the piston. The actuator and feedback shaft rotate clockwise.

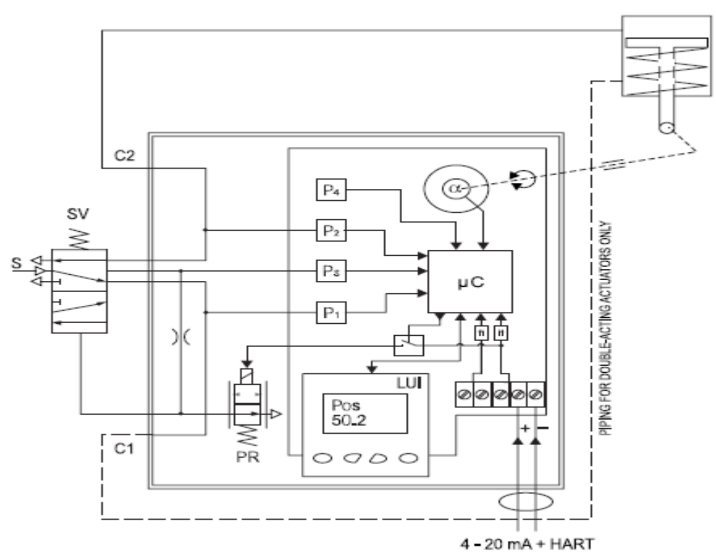


Figure 8: Principle of operation

Figure 9: Neles ValvGuard (VG9000H)

2.2.2.3 Operation Principle

Remote communication from the control room with the VG9000H is made via Highway Addressable Remote Transducer (HART) protocol and a Personal Computer (PC) fitted with a suitable modem wired to the Remote Communication Interface (RCI). There is a second real-time communication system which enables the µC to send messages to the RCI and further on to the plant DCS system. The RCI is usually mounted in the control cabinet of the plant safety PLC and connected to its output. The nominal safety PLC output is 24 V but a 15 % variance on this is acceptable.

The RCI has two functions:

1. To transmit HART signals to and from the VG9000H field device. A suitable modem is connected between the PC and the RCI to facilitate this.

2. To receive real-time signals from the VG9000H field unit. These signals are displayed on three Light Emitting Diodes (LED) mounted on the RCI casing. The RCI also has relay potential free contact outputs which correspond with the LED display. Three signals are given which Green

indicates OK, Yellow indicates Test and Red indicates Alarm. (*Refer to Figure* 10).

Figure 10: Remote Communication Interface (RCI)

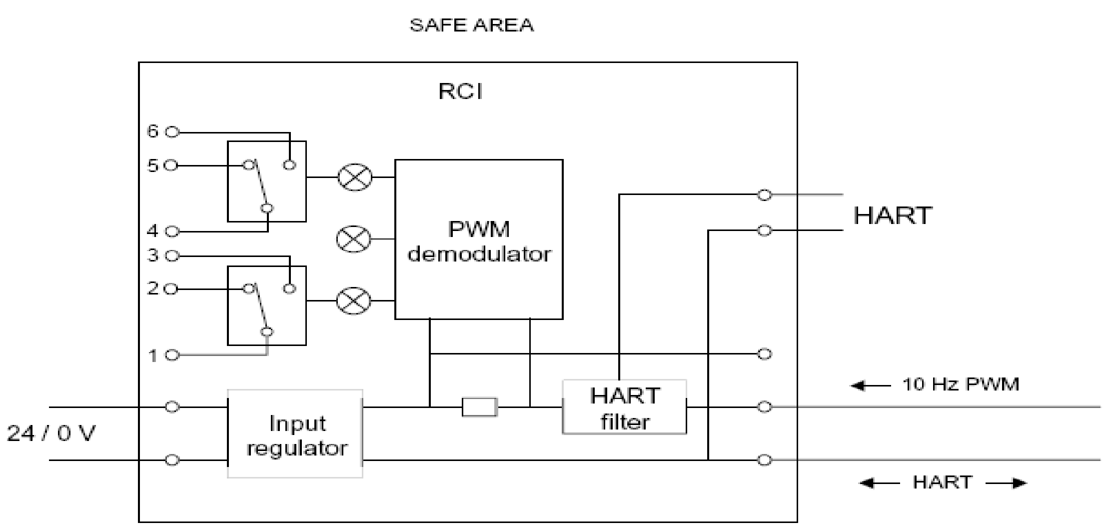


Figure 11: RCI circuit diagram

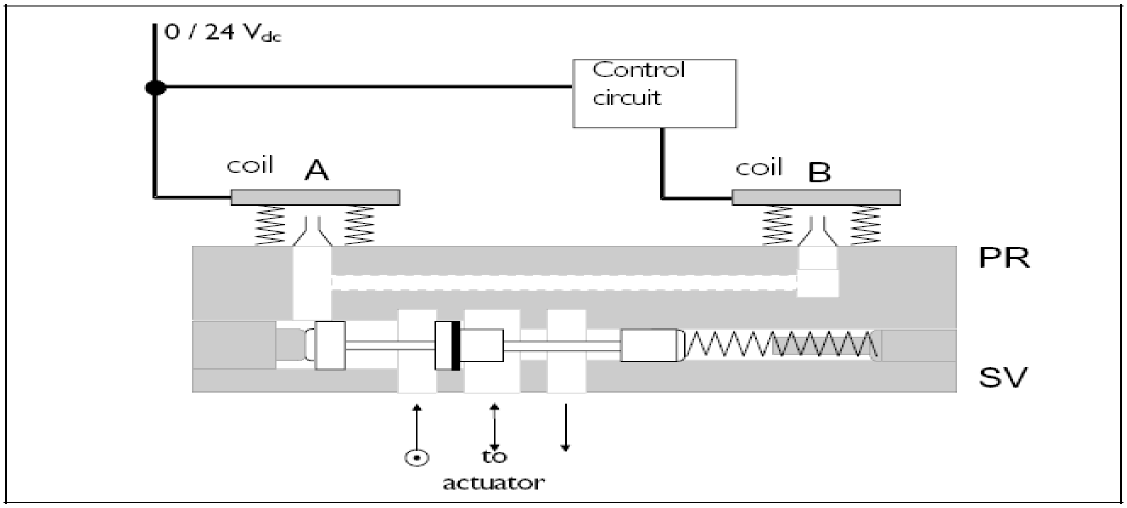


Figure 12: Prestage (PR) and spool valve (SV) units

In service, the 24 Vdc supply powers the prestage (PR) redundant coils, A and B (*refer to Figure 12*) which control the air pressure on the spool valve (SV) in such a position that keeps the SV return spring compressed. The SV is arranged so that the actuator air supply is maintained on the actuator piston in opposition to the actuator return spring thereby keeping the ESD valve open.

When an emergency occurs, the power at the control room is switched to 0 v, this de-energizes both PR coils and vents the pressure on the SV causing the SV return spring to change the SV position to shut off the air supply and to vent the air above the actuator piston. The actuator spring then closes the ESD valve. When power is restored the PR coils are energized back and air pressure once more causes the SV to compress the SV return spring. Air supply pressure is again applied to the actuator piston which opens the ESD valve.

It is also possible for the µC to operate the ESD valve. This is done during commissioning and diagnostic testing. The µC takes power from the 24 Vdc supply which is applied to PR coil (B). During a test the µC is able to isolate PR coil (B) from the power supply causing the voltage to drop to zero. This causes the same valve closing action as already described in respect of 0 V on PR coils (A and B) since these are in parallel.

As the ESD valve begins to close, the position sensor monitors the valve position. When the valve reaches the pre programmed travel point, the µC once again energizes the PR coil (B), which causes the ESD valve to open or close again. During partial closure testing the µC monitors the output from the position sensor and compares this with the actuator air pressure. If the relationship between these parameters shows an error the test is aborted. [10]

2.2.3 FieldCare Software

FieldCare is a scalable field management tool for the configuration, diagnostics and condition monitoring of intelligent field devices. It is used for configuration and condition monitoring of the VG9000H field device. Data collected during testing is automatically posted to a database, which can be accessed by authorized personnel. FieldCare software is used to interrogate, configure and collect data when connected to VG9000H.

It provides real-time information under operational process conditions, and its ability to browse and store data makes prediction of device condition extremely accurate. The information it provides supports predictive maintenance and can be used to plan regular maintenance activities, ensuring sufficient time to order spare parts and plan for service operations. FieldCare lowers the cost of ownership as it can manage any device and any communication protocol, helps plan maintenance activities and, as part of the process control system, will be a valuable addition no matter what developments may be introduced in the future.

FieldCare is universal Field Device Tool (FDT)-based software. FDT is an open software specification supported by major instrument and control system suppliers. It consists of an FDT frame application and Device Type Managers (DTM). It is independent of communication protocol. A DTM is a user interface for device operation that is developed by the vendor and can be used in any frame application. [11]

2.3 Full Stroke Test

Full Stroke means whenever emergency happens; the valve will be forced to fully close. In order to control the Full Stroke Test, Programmable Logic Control (PLC) is used in the project together with the WideField2 Software (YOKOGAWA).

2.3.1 Programmable Logic Controller (PLC)

Programmable Logic Controller (PLC) is used to control the Full Stroke Test (FST) execution which it is a digital operated electronics system, designed for industrial environment to implement specific functions such as logic, sequencing, timing, counting and arithmetic to control the outputs. The function of PLC is to continual scanning of a program which means running through all conditions within a guaranteed period. In this project, PLC is used to force the valve to fully open or close for FST.

Figure 13: Programmable Logic Controller

For this Full Stroke Test, ladder logic which is primarily used to develop software for PLC used in industrial control applications is taken into concern (*refer to Figure 14*). It is a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay-based logic hardware is used to develop software for the PLC.

Figure 14: Ladder Logic for Programmable Logic Controller

Ladder logic can be thought of as a rule-based language, rather than a procedural language. A "rung" in the ladder represents a rule. When implemented in a PLC, the rules are typically executed sequentially by software, in a continuous loop (scan). By executing the loop fast enough, typically many times per second, the effect of simultaneous and immediate execution is relatively achieved to within the tolerance of the time required to execute every rung in the loop (the scan time). [12]

When Full Stroke Test (FST) is executed for ball valve, I00002 will send signal to Y00203 (ball valve) to respond to be fully close after 5seconds. There are timers involved which are T00001 and T00002. After 20 seconds, then the ball valve received another signal that gives command to it to respond to be fully open back.

On the other hand, for butterfly valve Full Stroke Test, I00003 will send the signal to Y00204 (butterfly valve) to respond to be fully closed after 2 seconds. Timers involved are T00003 and T00004 which are used to set the Y00204 to be fully close or open. After 20 seconds, the valve will receive another signal that asks it to fully open back. The orange color indicates that there is connection between them.

Table 1: Summarization of PLC Setup

I00001	'I' stands for Internal Relay. Forced Set I00001 in order to change both valves from fully closed to fully opened. It is used as a start-up signal for the valves
I00002	Internal Relay number 2 which is used for FST signal for ball valve. Forced Set I00002 to start the FST on ball valve
I00003	Internal Relay number 3 which is used for FST signal for butterfly valve
Y203	'Y' stands for output. Y203 represent the ball valve
Y204	Y204 represent the butterfly valve
T00001	'T' stands for Timer. T00001 is triggered by I00002 signal which will activate the timer for 5 seconds before start doing the FST (fully closed) to the ball valve
T00002	T00001 signal will forced set T00002 which will activate its timer for 20 seconds before sending a signal for the ball valve to move back from fully closed to fully opened condition.
T00003	T00003 is triggered by I00003 signal which will activate the timer for 2 seconds before start doing the FST (fully closed) to the butterfly valve
T00004	T00003 signal will forced set T00004 which will activate its timer for 20 seconds before sending a signal for the butterfly valve to move back from fully closed to fully opened condition

2.4 HYSYS Software

HYSYS is a powerful engineering simulation tool, has been uniquely created with respect to the program architecture, interface design, engineering capabilities and interactive operation. The integrated steady state and dynamic modeling capabilities, where the same model can be evaluated from either perspective with full sharing of process information represent a significant advancement in the beginning software industry. [13]

The various components that comprise HYSYS provide an extremely powerful approach to steady state modeling. At a fundamental level, the comprehensive selection of operations and property methods allow to model a wide range of processes with confidence. Perhaps, the most important is how the HYSYS approach to modeling maximizes your return on simulation time through increased process understanding.

The inherent flexibility contributed through its design combined with the unparallel accuracy and robustness provided by property package calculations leads to a presentation of the more realistic model.

HYSYS is widely used in universities and colleges in introductory and advanced courses especially in chemical engineering. In industry, the software is used in research, development, modeling and design. HYSYS serves as the engineering platform for modeling process for Upstream, through Gas Processing and Cryogenic facilities, to Refining and Chemicals processes.

There are several key aspects of HYSYS which have been designed specifically to maximize the engineer’s efficiency in using simulation technology. Usability and efficiency are two obvious attributes which HYSYS has and continues to excel at. The single model concept is key not only to the individual engineer’s efficiency but to the efficiency of an organization.

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

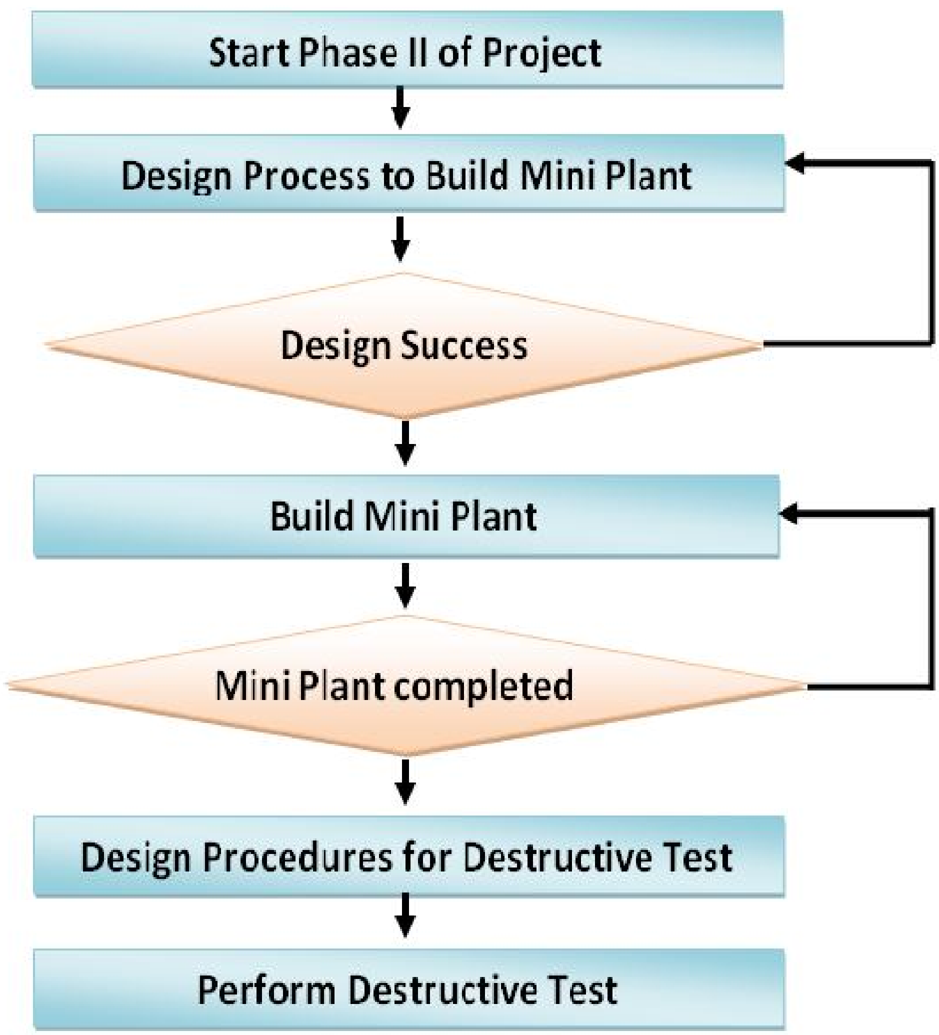


Figure 15: Project flow diagram

The project flow diagram (*refer figure 15*) explains the flow the project throughout the semesters. We provide the procedures to conduct the testing for operators, thus it will be much easier if it is going to be implemented it in the plant. Besides that, we are also working on the design of the mini plant in the lab. Few criteria will be taken into consideration such as the size of the tank, the piping, the speed of the pump and etc. Once the design of the mini plant is approved by PETRONAS, we can proceed with Phase II of this project which is the destructive testing.

3.2 Tools and Equipments Used

Several tools and software are required in order to implement this project which is as follow:

- Programmable Logic Control – It is used to control the Full Stroke Test, scanning of a program which means running through all conditions within a guaranteed period.
- WideField2 Software – It is develop by vendor YOKOGAWA for simulate Full Stroke Testing.
- FieldCare Software – It is develop by vendor Metso Neles to perform Partial Stroke Test and collect diagnostics information

3.3 Testing Procedures

Testing is done every day and it takes approximately about one hour and a half since six strokes are executed for both valves and one stroke takes about 15 minutes. Before we start the test, first of all, an Excel file is open and we decided the testing time with 15 minutes intervals for each stroke. In the same Excel file, load factor and breakdown pressure is also recorded.

Next step before we can start the testing is to set up those three softwares which are WideField2 Software, HART server and FieldCare software. FieldCare software is used to conduct PST where VG800 is means for Ball Valve and VG800 (1) is means for Butterfly valve. While for conducting FST, WideField2 software is used. The overall steps involved during the testing are as follow:

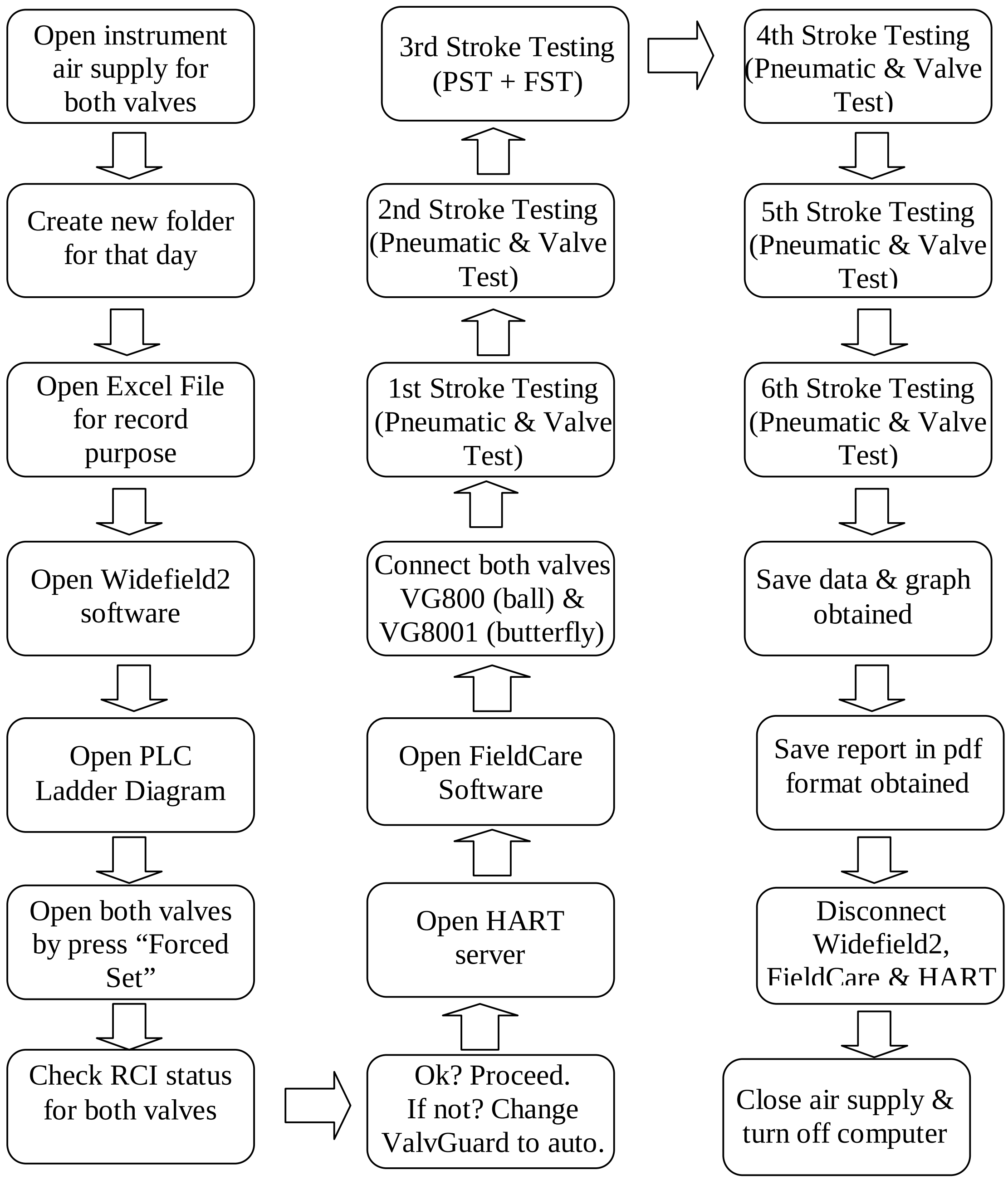


Figure 16: Testing Flow Diagram

Using HYSYS, the Partial Stroke test rig is modeled and verified. The procedure to perform the verification using HYSYS is shown in Figure 17.Figure 18 shows the flow chart to determine the suitable fluid packages before entering the simulation environment. This plant only involves pure water, thus the fluid packages used is NRTL.

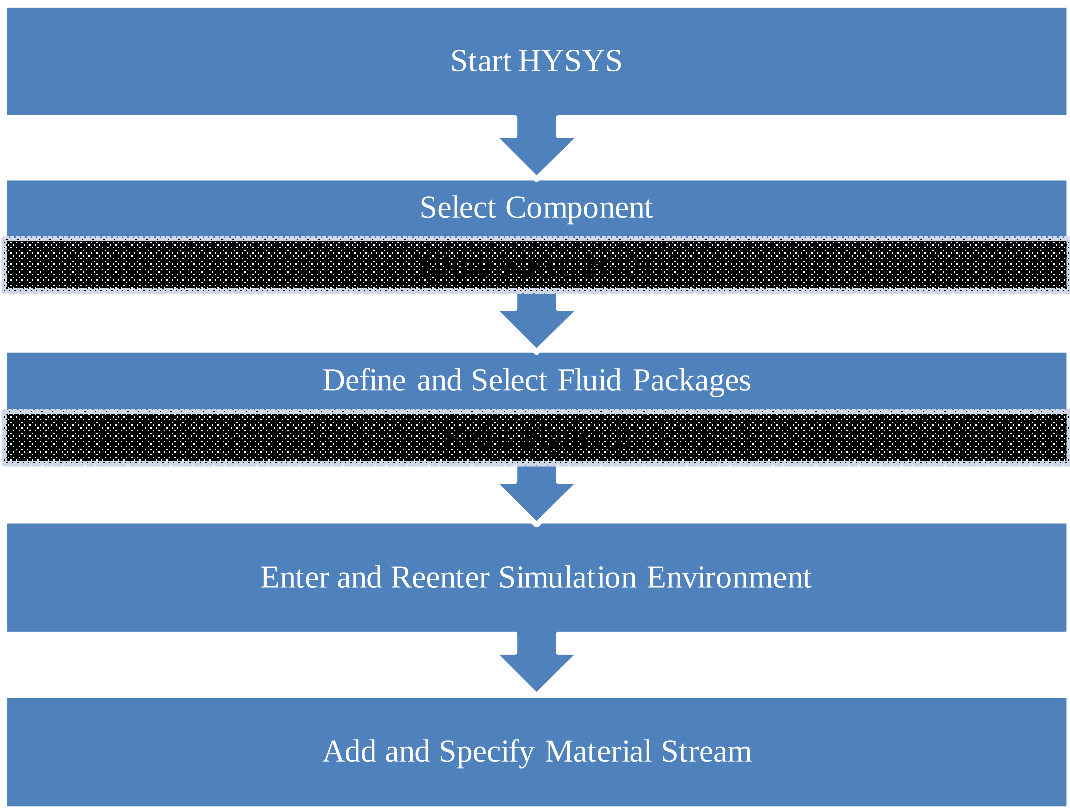


Figure 17: Flow Chart for the Procedure of Designing Using HYSYS

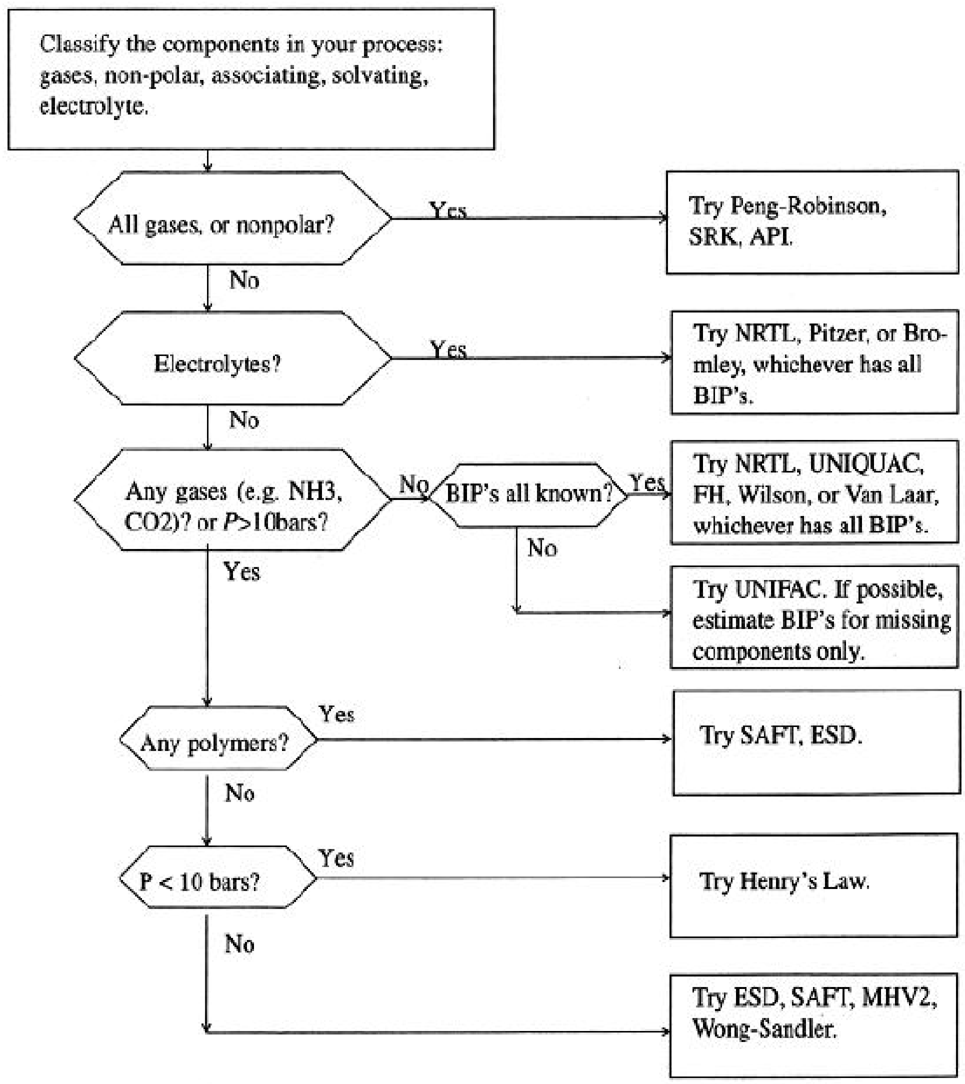


Figure 18: Flow Chart to Determine the Suitable Fluid Packages

CHAPTER 4

RESULT AND DISCUSSION

4.1 Design Mini Plant in Phase II

After completion of Phase I, the project commenced to enter the Phase II which is to conduct Phase II Test (Destructive Test or Real Flow Medium Test). Consecutively, to perform Phase II Test which is performing the partial stroke testing with real flow going into the ESD valve, a mini plant must be built. Thus, at this moment the mini plant design which is needed in order to build the mini plant is in progress. The mini plant consists of eight ESD valves that are ball and butterfly type from Metso Neles, Fisher, Mesoneilan, and Rotork.

4.1.1 First Draft of Mini Plant

In the first draft of the mini plant, all eight ESD valves is planned to be located in one single loop (*refer Figure 19*) where four of them are at one side of the loop and another four ESD valves are located at the other side of the loop. A flow control valve is also needed to control the flow and to bypass the ESD valves if one of them has problem. Other than that, a water tank is needed to store water that will flow into the pipeline during the Phase II test and a pump is also crucial in order to increase the flow rate inside the pipeline.

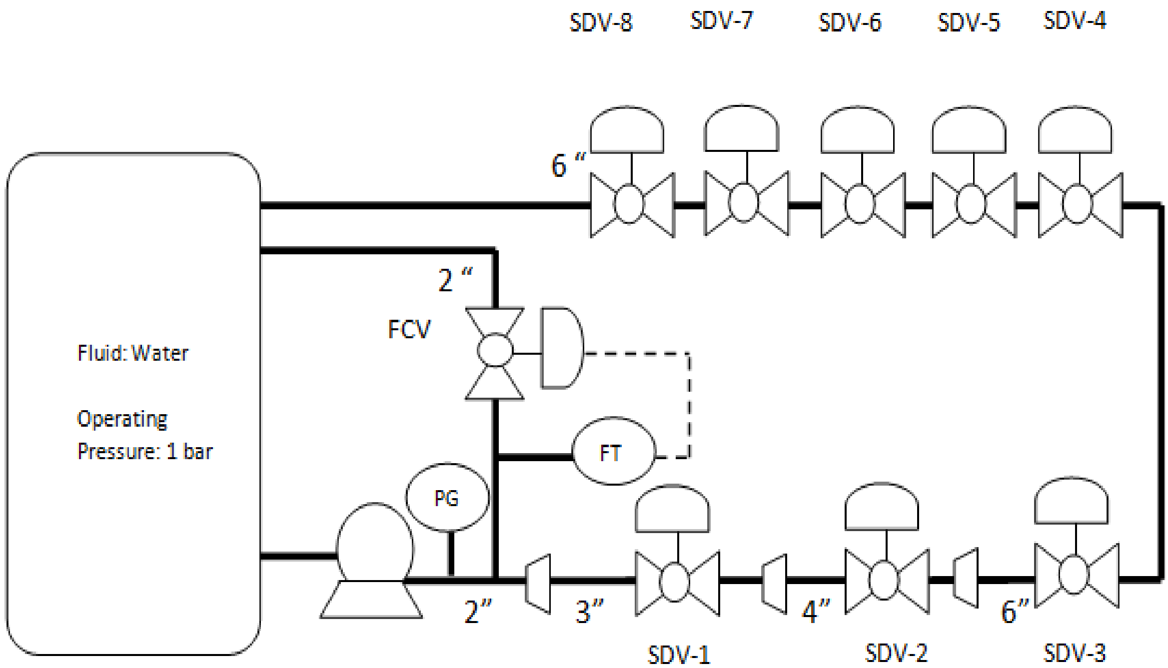


Figure 19: First Draft of Mini Plant

Size of the emergency shutdown valves is different from one vendor to another and the data is recorded in the table below:

Table 2: Size of Emergency Shutdown Valve

Brand	**Ball Valve**	**Butterfly Valve**
Fisher	6 inch	3 inch
Mesoneilan	6 inch	4 inch
Metso Neles	6 inch	6 inch
Rotork	6 inch	6 inch

The arrangement of the eight ESD valves in the first draft is based on increasing in size which starts from the smallest size that is 3 inches to the bigger size of valve and the biggest size is 6 inches. This arrangement is chosen because of the safety purpose where the pressure of flow will be increased step by step. Between the valves, reducer is used in order to increase the size of the pipeline. Apart from that, the size of water tank, length of the pipeline, output discharge of water pump, and the exact location of the mini plant are another crucial matter to be decided.

4.1.2 Second Draft of Mini Plant

After done more self study and having discussion with supervisor regarding the project, the second draft of the process design is initiated which is an improvement version of the first draft. Based on the previous design, the amount of pressure drop that may occurred in the pipeline is concerned since the water from the tank will flow through all eight ESD valves before it returns back to the water tank. This means that, more valves in the pipeline in one single loop, more constraint for the water flow and more pressure drop will happen which may lead to decrease in volumetric flow rate inside the pipeline when the water reaches at the end of the loop.

Therefore, in the second draft of the process design it is decided that only four valves will be in the operation at one time when the testing is conducted which means that the arrangement of the valves is designed to be four valves in one loop. This means that the plant will have two different loop s for the water flow to conduct the Phase II Test called loop A and loop B. If the valve to be tested is located in loop A, thus the water will only flow through loop A and at that moment loop B will be isolated from the process. The isolation process can be done by installing two hand valves for each loop which is located at beginning and ending of the loop.

In this second draft, some of the design criteria are also decided such as the pump rating is decided to be 45 l / min equivalent to 0.045 m^3/ min which is possible to be purchased, the gap between each ESD valve is 1 m each and there are two size of pipeline which are 2 inch and 6 inch diameter pipe. The detailed measurement of the PST test rig is shown in *figure 43*.

The proposed size of the water tank is 0.1963 m^3 which it is 1 m in height and 0.25 m in radius. Detailed calculation has been done before determining the water tank size. From the calculation, it must be determined that those size of tank will be enough to store water to fill the pipeline of the longest testing path with water flow in order to conduct the testing or in other words the path used for testing the ESD valve located at the farthest location from the water tank. If that particular tank size is enough to supply water for the biggest volume of pipeline which means the longest testing path, thus, it should be more than enough to supply water for the smaller volume of pipeline loop which means the shorter testing path. This assumption can be made since only one valve can be tested at one time.

In the calculation, the biggest volume of the water flow in pipeline is calculated first as bench mark. Then, by taking into consideration the output discharge of water pump, the time taken for the water to fill the pipeline is calculated and the testing time is estimated. Next, the minimum volume of water tank required to sustain water to flow fully in the pipeline for that particular time is determined. After that, by using the proposed radius and height, the volume of the tank is calculated. Finally, comparison is made between the volume of tank and the minimum volume of water tank required. From the calculation, it is proven that the water tank size proposed is reasonable.

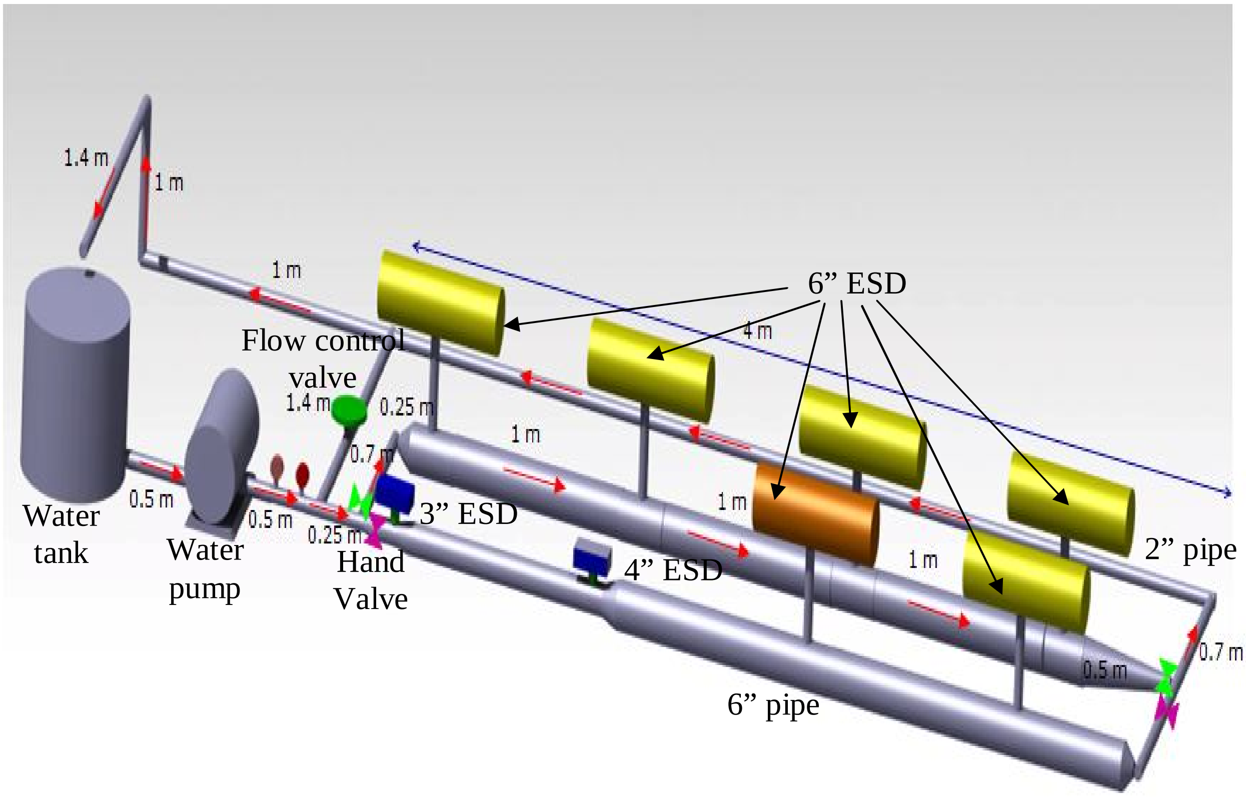


Figure 20: Second Draft of Mini Plant

The detailed calculation of the project is shown below:

Volume for 2” pipe diameter,

r = 1" = 0.0254 m

l = 0.5 + 0.5 + 0.25 + 0.7 + 0.7 + 4 + 1 + 1 + 1.4 = 10.05m

A = πr^2 = $\pi(0.0254)^2$ = 0.00203m^2

V = Al = 0.00203x10.05 = 0.0204m^3

Volume for 6" pipe diameter,

r = 3" = 0.0762
l = 0.25 + 1 + 1 + 1 + 0.5 = 3.75
$A = \pi r^2 = \pi(0.0762)^2 = 0.01824m^2$
$V = Al = 0.01824x3.75 = 0.0684m^3$

$$V_{total} = V_{2"} + V_{6"} = 0.0204 + 0.0684 = 0.0888m^3$$

The output discharge of the available pump is $45\, {}^{l}/_{min} = 0.045\, {}^{m^3}/_{min}$

$\therefore Volumetric\ flow\ rate, \dot{V}$

$\dot{V} = \frac{V}{t}$

$t = \frac{V}{\dot{V}} = \frac{0.0888}{0.045} = 1.97min = 118.4s \approx 120s$

$t_{testing} = 80s$

Total time required = $t + t_{testing} = 120 + 80 = 200s = 3.333min$

$\therefore minimum\ volume\ tank\ required = V_{piping} = 0.045\, m^3/min \times 3.333min$
$= 0.15m^3$

By using hand valves at beginning and ending of each branch, the ***total time has been reduced*** since the flow is directed to either of the branches depending on the location of the valve to be tested. This is because only one valve will be tested at one time.

To re-check the volume of the tank with the specified *r* and *h*,

$$V_{tank} = \pi r^2 h = \pi \times 0.25^2 \times 1 = 0.196m^3$$

Thus, the size of the tank is valid because:

$$V_{tank} > V_{piping}$$
$$0.196m^3 > 0.15m^3$$

Therefore, the summary of the second draft is:

1. Minimum volume tank required = 0.15 m^3
2. Tank size = 0.196 m^3 (1 m in height and 0.25 m in radius)

3. Water pump rating = 45 *l* / min = 0.045 m^3/ min

4.1.3 Final Draft of Mini Plant

For the final draft, the mini plant design is more or less the same with the second draft design but it has been decided to have lesser valves in one single loop. After having discussion with PETRONAS, the amount of valves which is four in one loop in second draft has been decreased to two valves in one loop for the final draft (*refer to Figure 21*). Thus, there are four different loops called Loop A, Loop B, Loop C, and Loop D in the final draft of the mini plant design. By having lesser valves in a single loop, we can decrease the constraint for the water flow thus lessen the pressure drop in the pipeline which will then decrease the percentage of having low volumetric flow rate inside the pipeline when the water reaches the end of the loop.

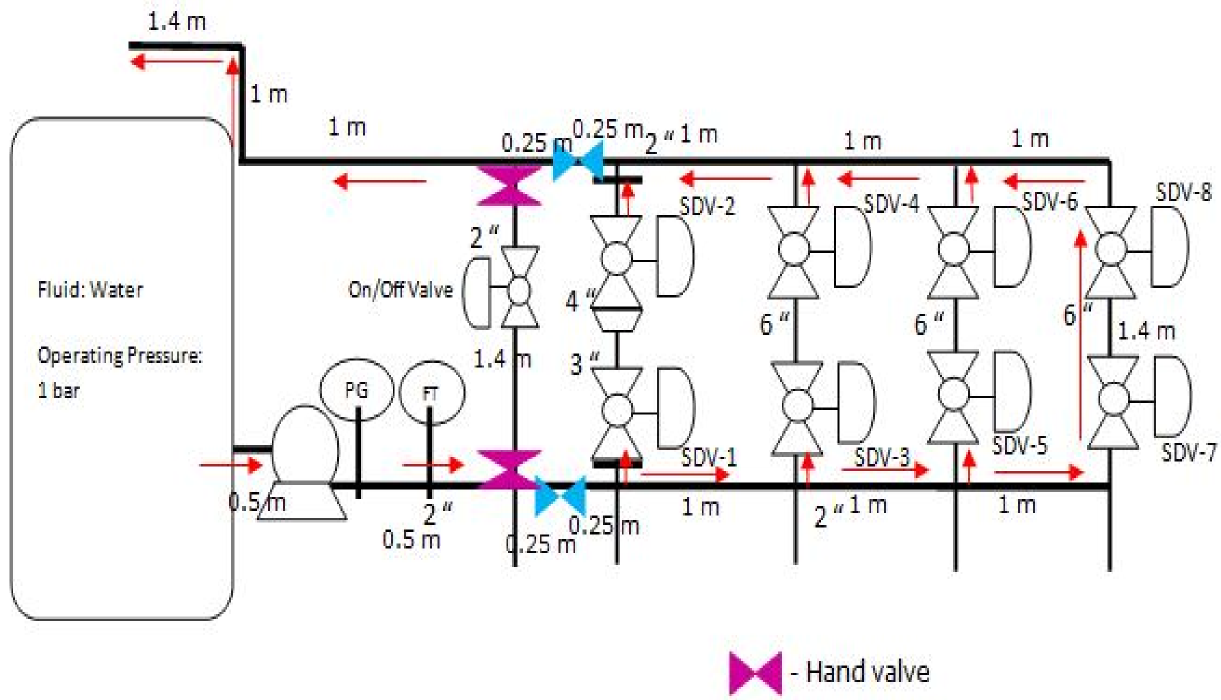


Figure 1: Final draft of Mini Plant

The similar concept like in the second draft, at one operation time only one loop of valve will be operated, hence if one valve in that particular loop let say Loop A is having problem only another one valve's operation is affected which compare to second draft, if one valve is having problem in that loop it will affected another three valves operation. Therefore, by having the new design, the probability of one valve cannot be operated has been reduced.

For the final draft, same design criteria like second draft are used such as the pump rating is 45 l / min equivalent to 0.045 m^3/ min which is possible to be purchased, the gap between each ESD valve is 1 m each and there are two size of pipeline which are 2 inch and 6 inch diameter pipe. The detailed measurement of the PST test rig is shown in *figure 20*.

The water tank size proposed is 0.1963 m^3 which it is 1 m in height and 0.25 m in radius and it is coincidentally the same with second draft. Detailed calculation for the final draft has been done before determining the water tank size and is shown below. While doing the calculation, the same concept is used which is the longest path used for the water to flow during the testing is taking into concerned since if the water in the tank is enough to test the valve located in the farthest location, it should be more than enough to supply water for valve located at closer location from the water tank. This assumption can be made since only one valve can be tested at one time.

First step in the calculation, the biggest volume of the water flow in pipeline which referred to the longest path taken by the water to flow in pipeline is calculated first as bench mark. Since we know the output discharge of water pump, the time taken for the water to fill the pipeline is then calculated and the testing time is estimated. The total time required is then estimated.

After that, the minimum volume of water tank required to sustain water to flow fully in the pipeline for that particular time is determined. Then, volume of water tank is calculated by using the proposed radius and height. Lastly, volume of tank obtained from calculation is compared with the minimum volume of tank required. From the calculation, it is proven that the water tank size proposed for the final draft is reasonable.

For safety purpose, a pressure gauge, a flow transmitter and an on/off valve (safety valve) will be installed in the loop. Whenever the pressure gauge senses any excessive pressure inside the impulse line, it will send signal to safety valve to open in order to avoid back pressure to the pump which can damage it. On the other hand, if the flow transmitter measure low flow rate in the impulse line, it will send signal to pump to stop pumping since if the pump is still pumping without any flow through it, it will also damage the pump.

The detailed calculation of the project is shown below:

Volume for 2” pipe diameter,

r = 1" = 0.0254 m

l = 0.5 + 0.5 + 0.25 + 0.25 + 3 + 3 + 0.25 + 0.25 + 1 + 2.4 = 11.4 m

A = πr^2 = $\pi(0.0254)^2$ = 0.00203m^2

$$V = Al = 0.00203x11.4 = 0.023142\ m^3$$

Volume for 6” pipe diameter,

r = 3" = 0.0762m

l = (0.35m x 6) + 1.4+ = 3.5m

$A = \pi r^2 = \pi(0.0762)^2 = 0.01824m^2$

$V = Al = 0.01824x3.75 = 0.06384m^3$

$V_{total} = V_{2"} + V_{6"} = 0.023142 + 0.06384 = 0.086982m^3$

The output discharge of the available pump is $45\ ^{l}/_{min} = 0.045\ ^{m^3}/_{min}$

$\therefore Volumetric\ flow\ rate, \dot{V}$

$$\dot{V} = \frac{V}{t}$$

$$t = \frac{V}{\dot{V}} = \frac{0.086982}{0.045} = 1.933min = 115.98s \approx 120s$$

$t_{testing} = 80s$

Total time required = $t + t_{testing} = 120 + 80 = 200s = 3.333min$

$\therefore minimum\ volume\ tank\ required = V_{piping} = 0.045\ m^3/min \times 3.333min$

$= 0.14985m^3$

Re-check the volume of the tank with the specified r and h,

$V_{tank} = \pi r^2 h = \pi \times 0.25^2 \times 1 = 0.1963 m^3$

Thus the size of the tank is valid because:
$V_{tank} > V_{piping}$

$$0.1963 m^3 > 0.14985 m^3$$

Therefore, the summary of the final draft is:

1. Minimum volume tank required = 0.14985 m^3
2. Tank size proposed= 0.1963 m^3 (1 m in height and 0.25 m in radius)
3. Water pump rating = 45 *l* / min = 0.045 m^3/ min

4.2 Modeling and Verification of PST Test Rig Using HYSYS

4.2.1 Steady State Analysys

Summary of the final draft:

1. Minimum volume tank required= 0.14985m^3
2. Tank size proposed= 0.1963 m^3
3. Water pump rating= 45 *l*/min = 0.045 m^3/min

For the first design of mini plant as shown in Figure 22, on / off valve and the farthest ball and butterfly valve are conducting at the same time have been taking into consideration. Hence, Tee is used to separate the two junctions. However, while getting familiarizes with the software and performing the design as well, few important criteria in the component specifications have been neglected. Thus, there is no valid data in Figure 23, Figure 24 and Figure 25.

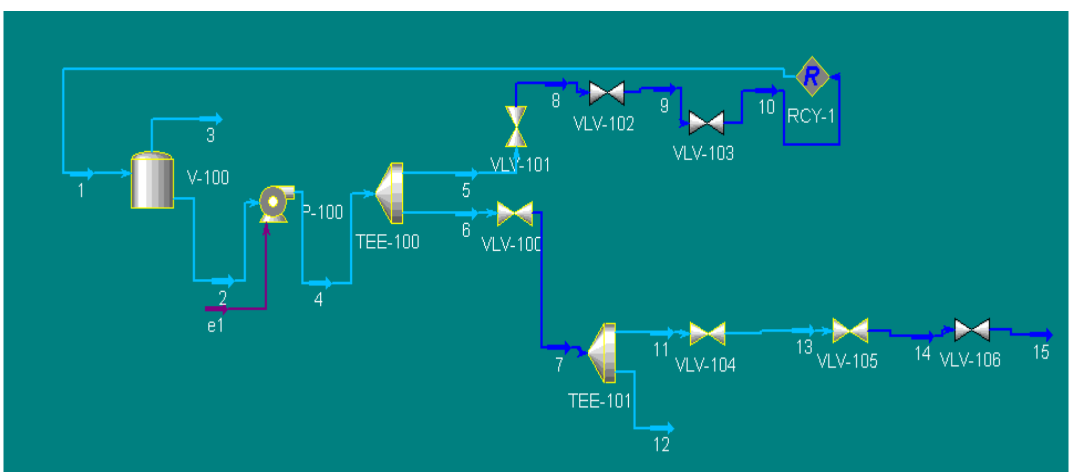
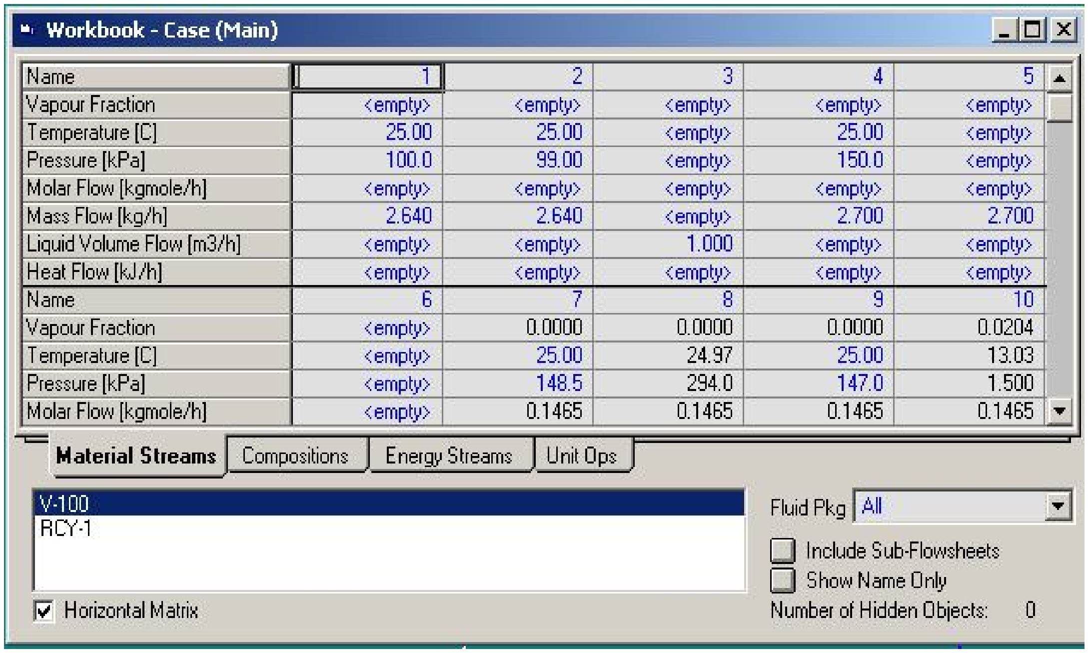
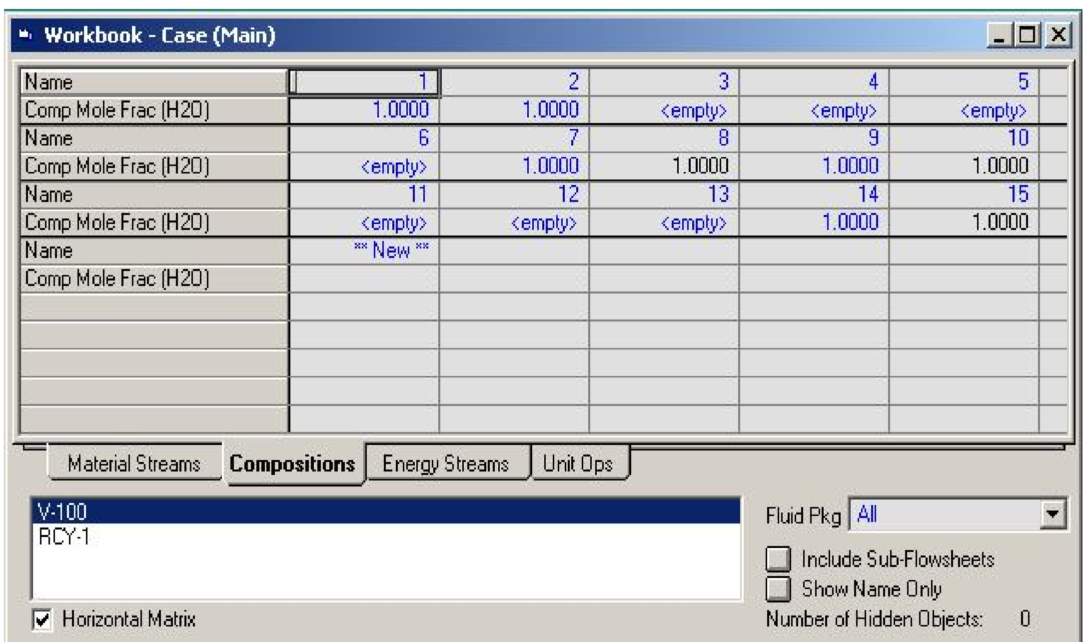


Figure 22: The First Design of Mini Plant using HYSYS



Name	1	2	3	4	5
Vapour Fraction	<empty>	<empty>	<empty>	<empty>	<empty>
Temperature [C]	25.00	25.00	<empty>	25.00	<empty>
Pressure [kPa]	100.0	99.00	<empty>	150.0	<empty>
Molar Flow [kgmole/h]	<empty>	<empty>	<empty>	<empty>	<empty>
Mass Flow [kg/h]	2.640	2.640	<empty>	2.700	2.700
Liquid Volume Flow [m3/h]	<empty>	<empty>	1.000	<empty>	<empty>
Heat Flow [kJ/h]	<empty>	<empty>	<empty>	<empty>	<empty>
Name	6	7	8	9	10
Vapour Fraction	<empty>	0.0000	0.0000	0.0000	0.0204
Temperature [C]	<empty>	25.00	24.97	25.00	13.03
Pressure [kPa]	<empty>	148.5	294.0	147.0	1.500
Molar Flow [kgmole/h]	<empty>	0.1465	0.1465	0.1465	0.1465

Figure 23: Material Stream Specifications



Name	1	2	3	4	5
Comp Mole Frac (H2O)	1.0000	1.0000	<empty>	<empty>	<empty>
Name	6	7	8	9	10
Comp Mole Frac (H2O)	<empty>	1.0000	1.0000	1.0000	1.0000
Name	11	12	13	14	15
Comp Mole Frac (H2O)	<empty>	<empty>	<empty>	1.0000	1.0000
Name	** New **				
Comp Mole Frac (H2O)					

Figure 24: Composition Stream Specifications

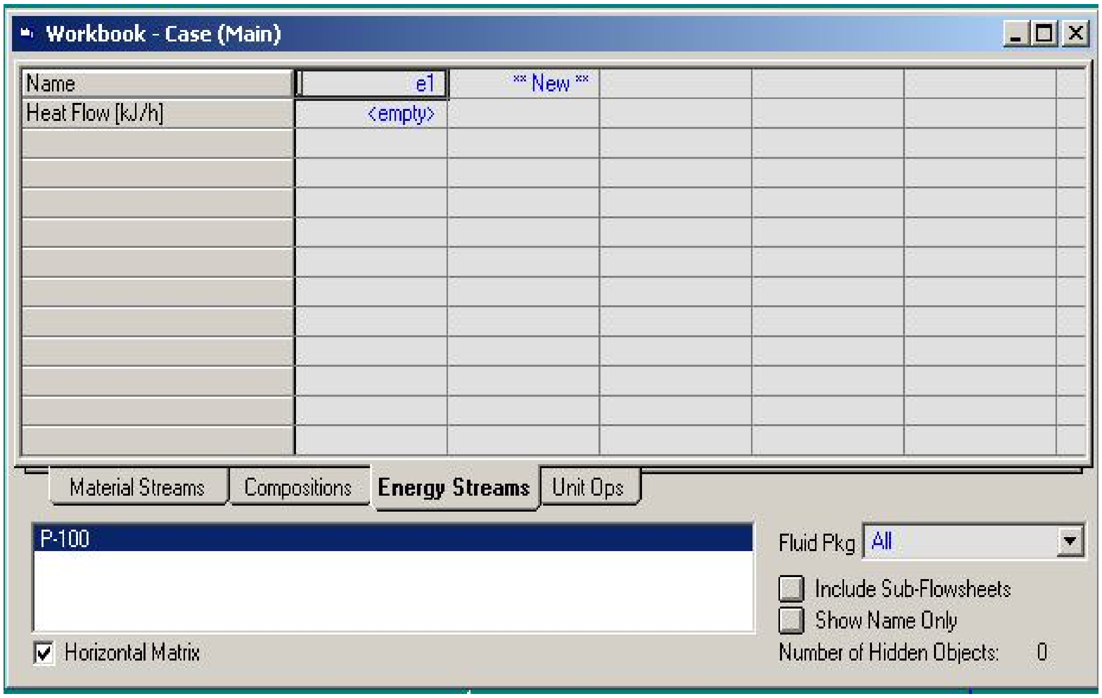


Figure 25: The Energy Stream Specification

However, some modifications have been done in designing the plant. The longest path taken by the water to flow in pipeline is now taken into consideration. The second design as shown in Figure 26 is improved a lot since all the streams are running well (dark blue indication for the stream). At first, the outlet of the recycle is assumed to be fed back to the water inlet. After looking at the specification table in Figure 27, Figure 28 and Figure 29, the pressure is too high. Supposedly, the temperature for the inlet water is 1bar (100 kPa) but it turns out to be more than 500 kPa. So, the design shall be modified again to get the desired value.

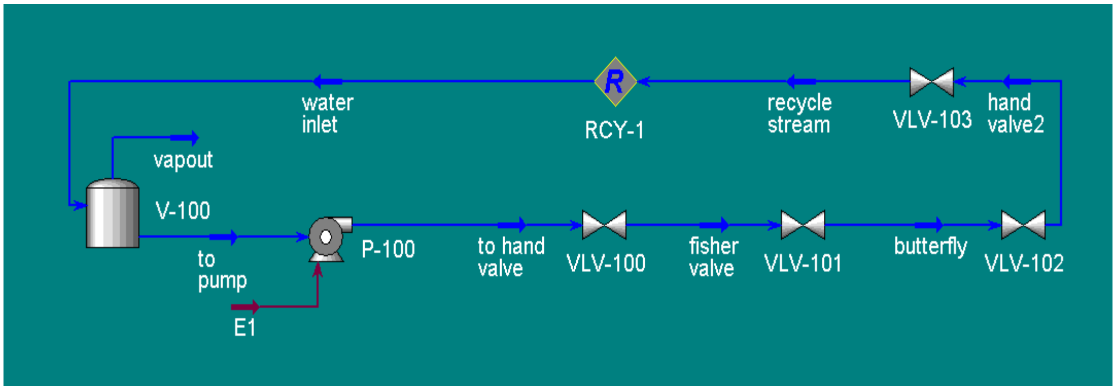
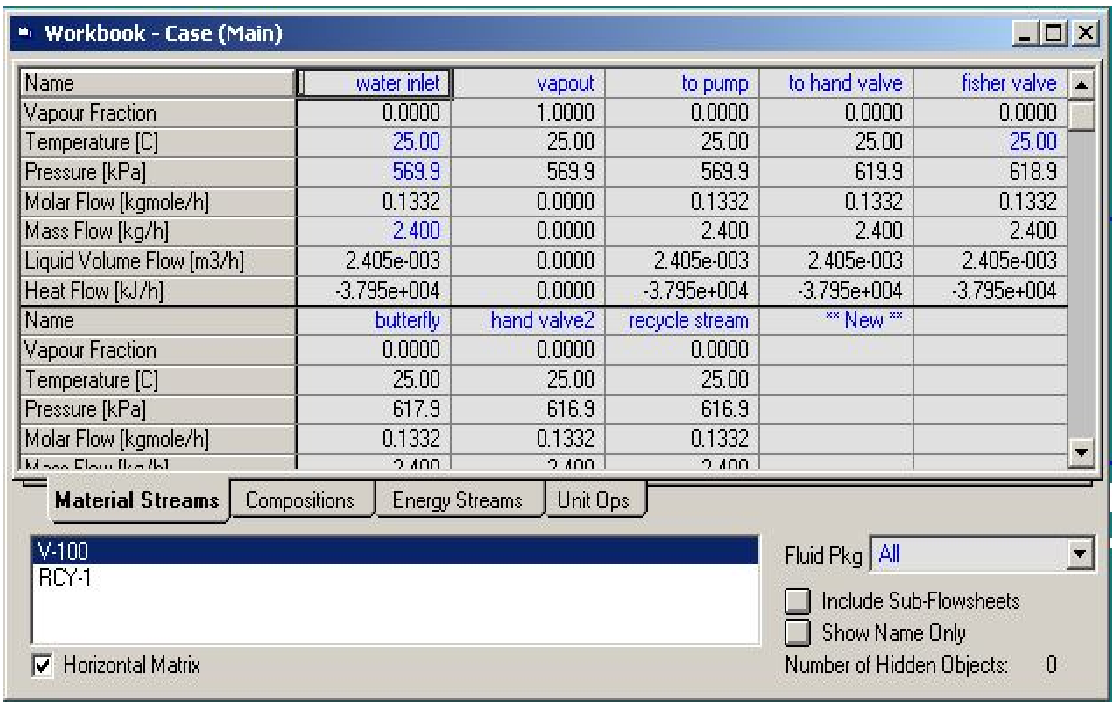


Figure 26: The Second Design of Mini Plant using HYSYS



Name	water inlet	vapout	to pump	to hand valve	fisher valve
Vapour Fraction	0.0000	1.0000	0.0000	0.0000	0.0000
Temperature [C]	25.00	25.00	25.00	25.00	25.00
Pressure [kPa]	569.9	569.9	569.9	619.9	618.9
Molar Flow [kgmole/h]	0.1332	0.0000	0.1332	0.1332	0.1332
Mass Flow [kg/h]	2.400	0.0000	2.400	2.400	2.400
Liquid Volume Flow [m3/h]	2.405e-003	0.0000	2.405e-003	2.405e-003	2.405e-003
Heat Flow [kJ/h]	-3.795e+004	0.0000	-3.795e+004	-3.795e+004	-3.795e+004
Name	butterfly	hand valve2	recycle stream	** New **	
Vapour Fraction	0.0000	0.0000	0.0000		
Temperature [C]	25.00	25.00	25.00		
Pressure [kPa]	617.9	616.9	616.9		
Molar Flow [kgmole/h]	0.1332	0.1332	0.1332		

Figure 27: The Material Stream Specification

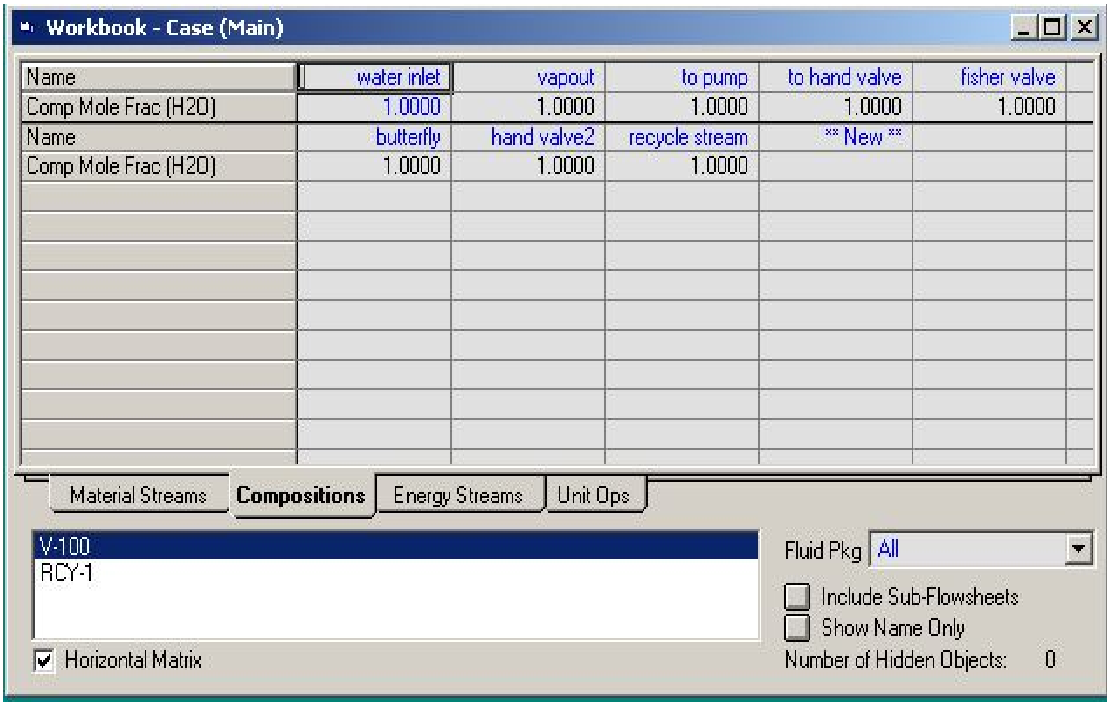


Figure 28: The Composition Stream Specification

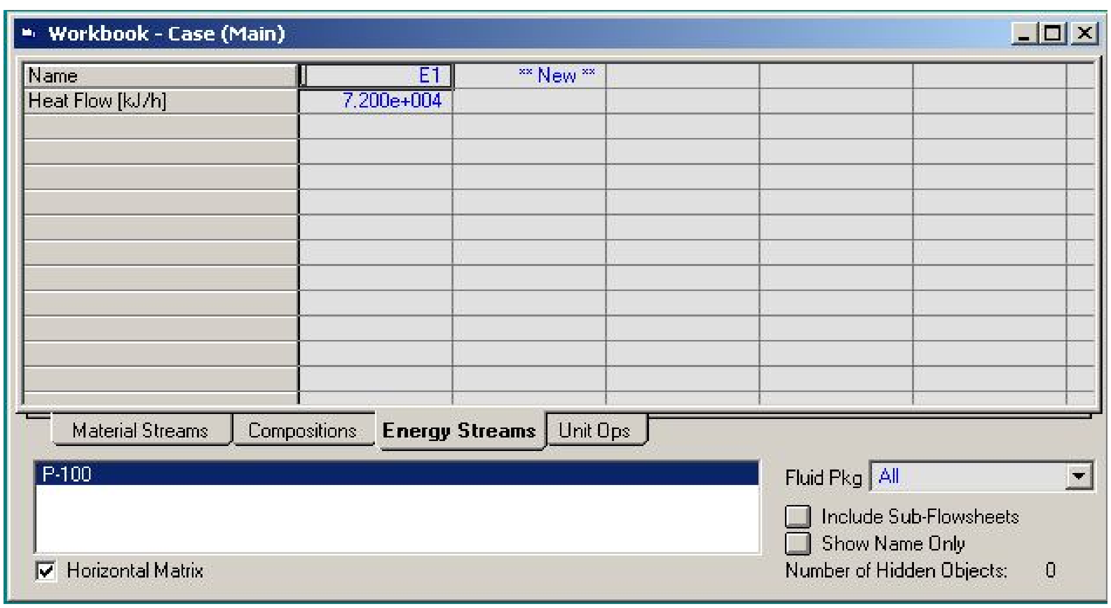


Figure 29: The Energy Stream Specification

To modify the design to get the desired pressure, the mixer is added to the plant.. By using the mixer, the pressure and temperature of the inlet must be the same. Thus, a valve shall be added in between the recycle stream and the mixer. Besides that, the pressure drop of the valve, VLV-104 shown in Figure 30 shall be adjusted accordingly. However, after adding the mixer, the plant is no longer converged. The error indicators state that too many variables are set for Pump P-100, so either the material flow or the energy flow must be eliminated. But, if the material flow is eliminated, there will be no flow through the plant. Conversely, if the energy flow is eliminated, the error message is appeared. Based on my reading on the HYSYS tutorial and manual guideline, it needs sufficient data in order to get the desired value. Since the plant is not yet built in the lab, so there is no datasheet provided for the plant. Using the estimated data regarding the calculation of the final draft of the mini plant, the plant is not converged which means there must be adequate data to support some of the specification of the component and equipment to achieve high accuracy for the desired data. In addition, for pump specification, the differential pressure, the pump curve, the pump rating and the torque are very vital. As for the valve, the HYSYS software has plenty of valves manufactures which included FISHER and MASONEILAN. As for this design, the FISHER valve has been chosen. The valve opening can be specified in the design.

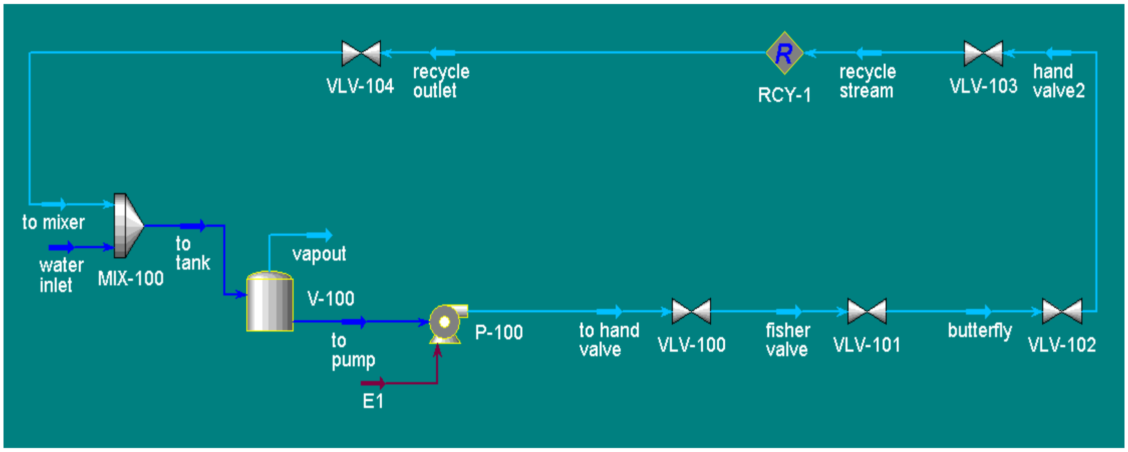
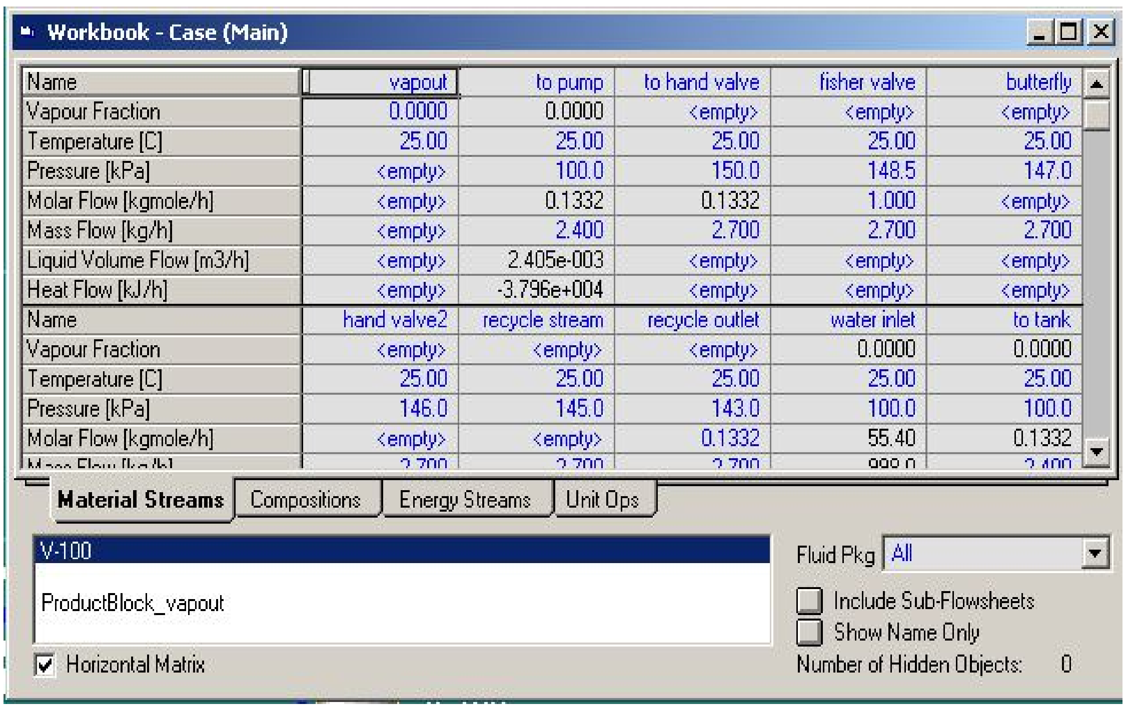


Figure 30: The designed plant using HYSYS


Workbook - Case (Main)

Name	vapout	to pump	to hand valve	fisher valve	butterfly
Vapour Fraction	0.0000	0.0000	<empty>	<empty>	<empty>
Temperature [C]	25.00	25.00	25.00	25.00	25.00
Pressure [kPa]	<empty>	100.0	150.0	148.5	147.0
Molar Flow [kgmole/h]	<empty>	0.1332	0.1332	1.000	<empty>
Mass Flow [kg/h]	<empty>	2.400	2.700	2.700	2.700
Liquid Volume Flow [m3/h]	<empty>	2.405e-003	<empty>	<empty>	<empty>
Heat Flow [kJ/h]	<empty>	-3.796e+004	<empty>	<empty>	<empty>
Name	hand valve2	recycle stream	recycle outlet	water inlet	to tank
Vapour Fraction	<empty>	<empty>	<empty>	0.0000	0.0000
Temperature [C]	25.00	25.00	25.00	25.00	25.00
Pressure [kPa]	146.0	145.0	143.0	100.0	100.0
Molar Flow [kgmole/h]	<empty>	<empty>	0.1332	55.40	0.1332
Mass Flow [kg/h]	2.700	2.700	2.700	998.0	2.400

Material Streams | Compositions | Energy Streams | Unit Ops

V-100

ProductBlock_vapout

Fluid Pkg: All

Include Sub-Flowsheets

Show Name Only

Horizontal Matrix

Number of Hidden Objects: 0

Figure 31: The Material Stream Specification

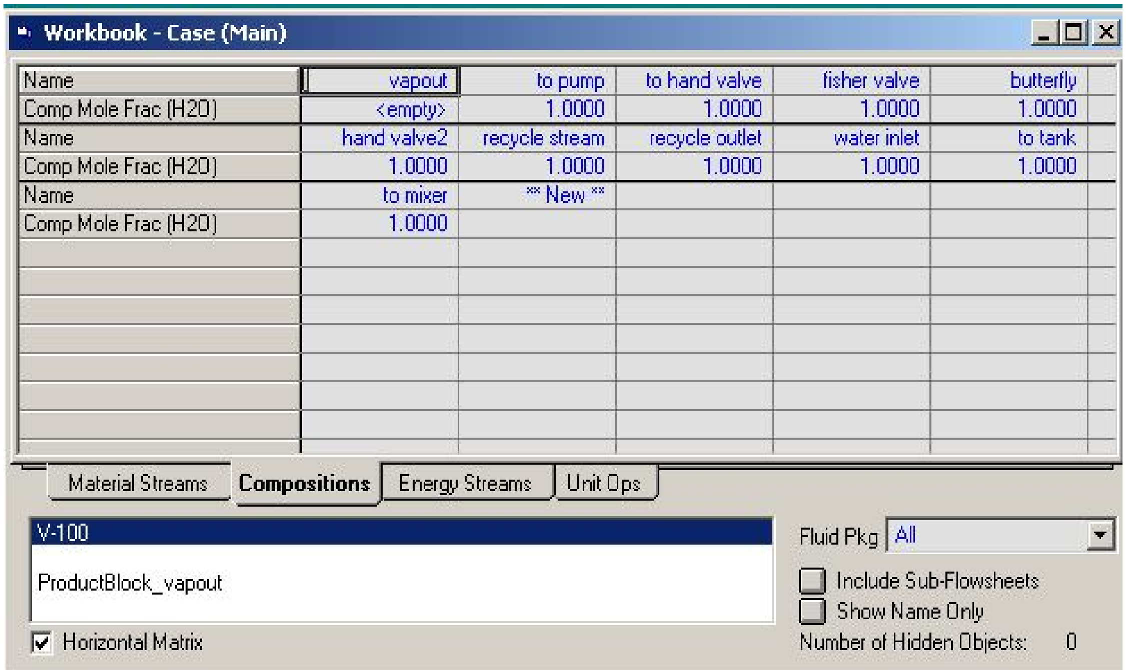


Figure 32: The Composition Stream Specification

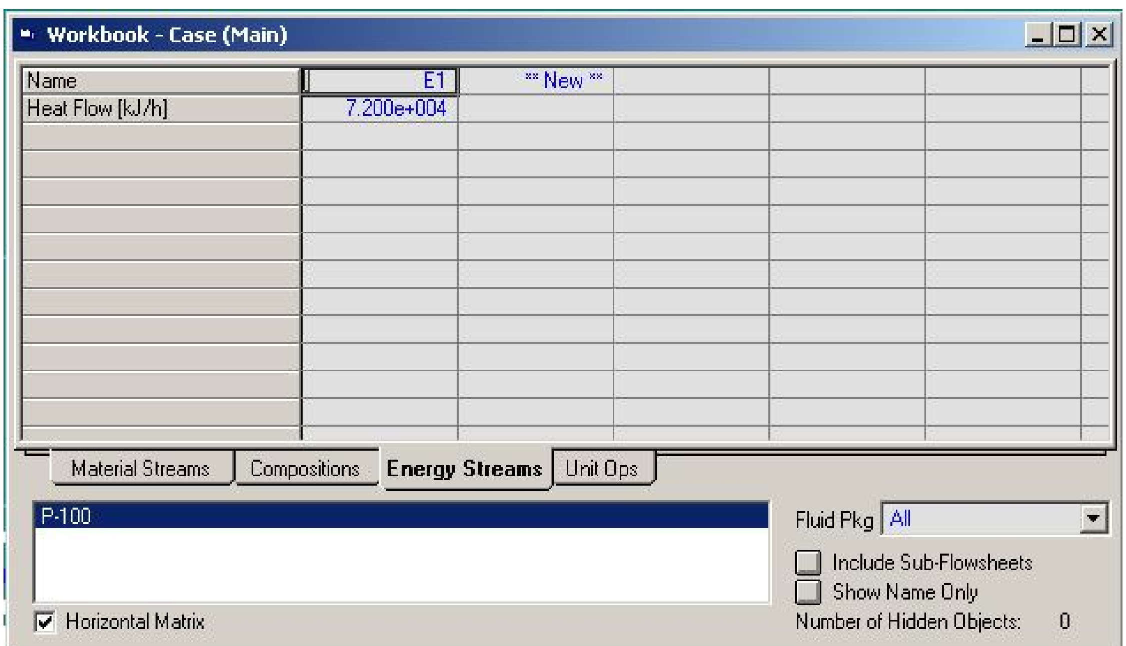


Figure 33: The Energy Stream Specification

As shown in Figure 34, it is a closed-loop system. The pump in this design is estimated to be running at 2000 rpm.The level controller, LIC-100 is added to the tank.The built-in level transmitter will measure the liquid level of the tank. Then,it will send the signal to the level controller,LIC-100 to regulate the speed of the pump. If the liquid level of the tank is below the minimum value, the pump will not operating. Thus, it can avoid the pump from getting damage if there is no liquid flows through it. However, if the liquid level of the tank is higher than the maximum value, the pump will receive a signal to operate at higher speed, so that the flow rate of the water is increasing so that the tank will not overflow. In this design, all the control valves are functioning simultaneously. The material stream specification such as the temperature, the pressure and also the molar flow for each of the device is shown in Figure 35. The valve is estimated to have a pressure drop of one percent. The composition stream specification is shown in Figure 36. Since the medium is only pure water,so the composition mole fraction is 1. The heat flow of the pump is calculated to be 0.1588 as shown in Figure 37.

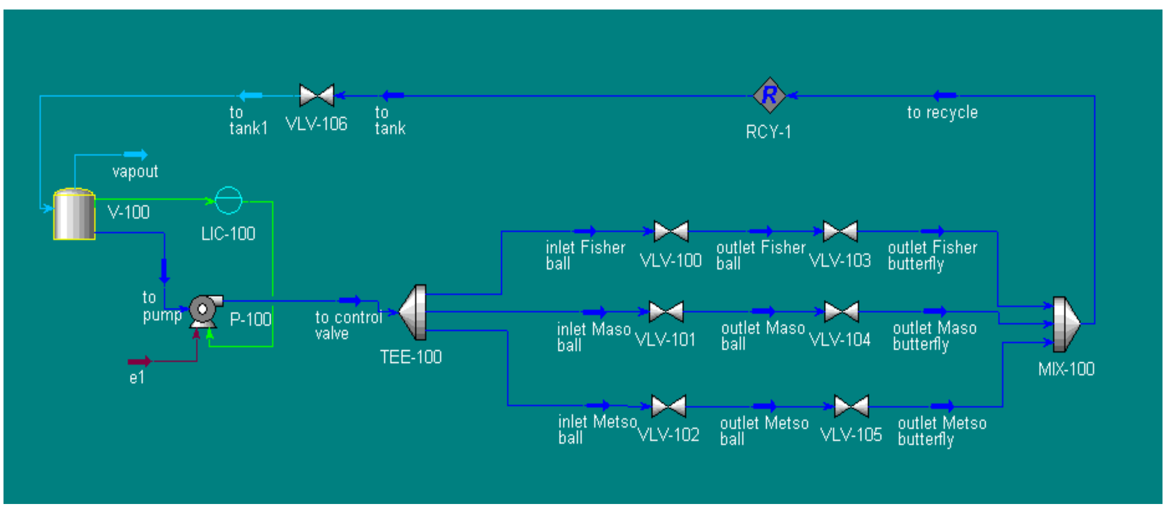
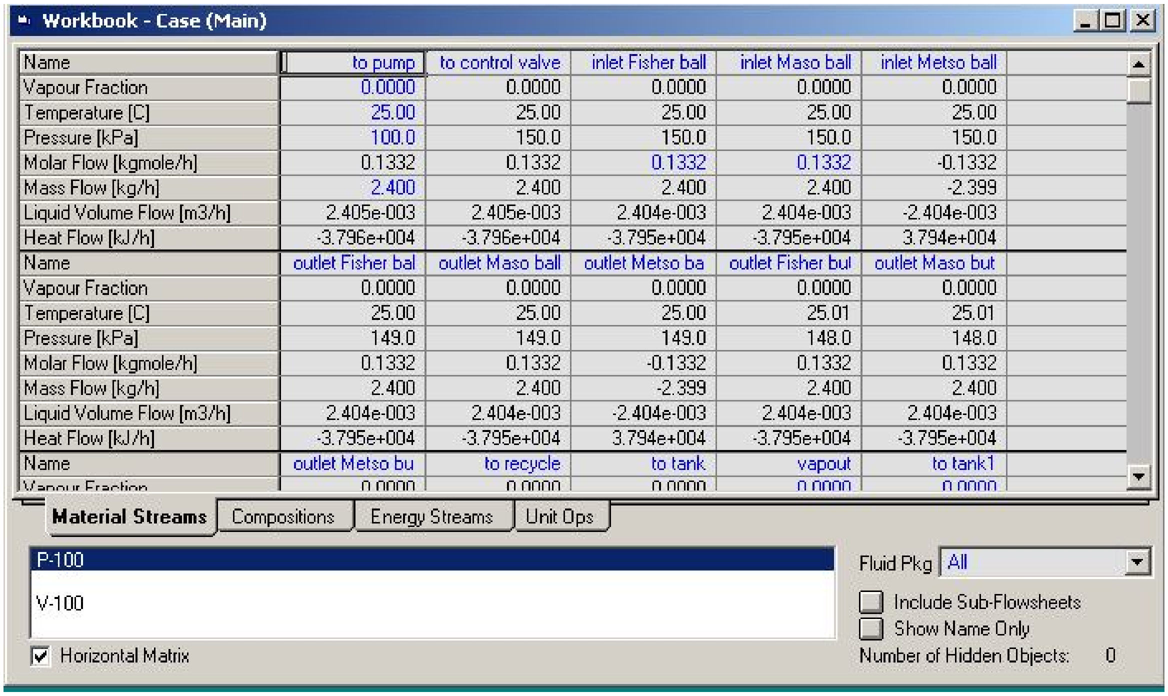


Figure 34: Design for 3 control valves working simultaneously



Name	to pump	to control valve	inlet Fisher ball	inlet Maso ball	inlet Metso ball
Vapour Fraction	0.0000	0.0000	0.0000	0.0000	0.0000
Temperature [C]	25.00	25.00	25.00	25.00	25.00
Pressure [kPa]	100.0	150.0	150.0	150.0	150.0
Molar Flow [kgmole/h]	0.1332	0.1332	0.1332	0.1332	-0.1332
Mass Flow [kg/h]	2.400	2.400	2.400	2.400	-2.399
Liquid Volume Flow [m3/h]	2.405e-003	2.405e-003	2.404e-003	2.404e-003	-2.404e-003
Heat Flow [kJ/h]	-3.796e+004	-3.796e+004	-3.795e+004	-3.795e+004	3.794e+004
Name	outlet Fisher bal	outlet Maso ball	outlet Metso ba	outlet Fisher but	outlet Maso but
Vapour Fraction	0.0000	0.0000	0.0000	0.0000	0.0000
Temperature [C]	25.00	25.00	25.00	25.01	25.01
Pressure [kPa]	149.0	149.0	149.0	148.0	148.0
Molar Flow [kgmole/h]	0.1332	0.1332	-0.1332	0.1332	0.1332
Mass Flow [kg/h]	2.400	2.400	-2.399	2.400	2.400
Liquid Volume Flow [m3/h]	2.404e-003	2.404e-003	-2.404e-003	2.404e-003	2.404e-003
Heat Flow [kJ/h]	-3.795e+004	-3.795e+004	3.794e+004	-3.795e+004	-3.795e+004
Name	outlet Metso bu	to recycle	to tank	vapout	to tank1
Vapour Fraction	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 35: Material Stream Specifications

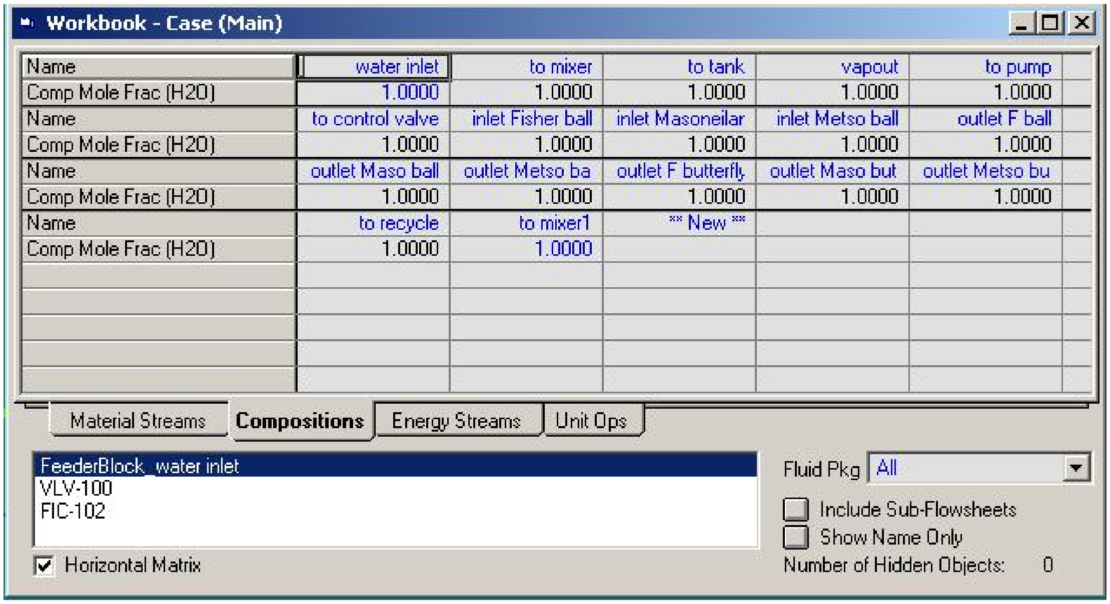


Figure 36: Composition Stream Specifications

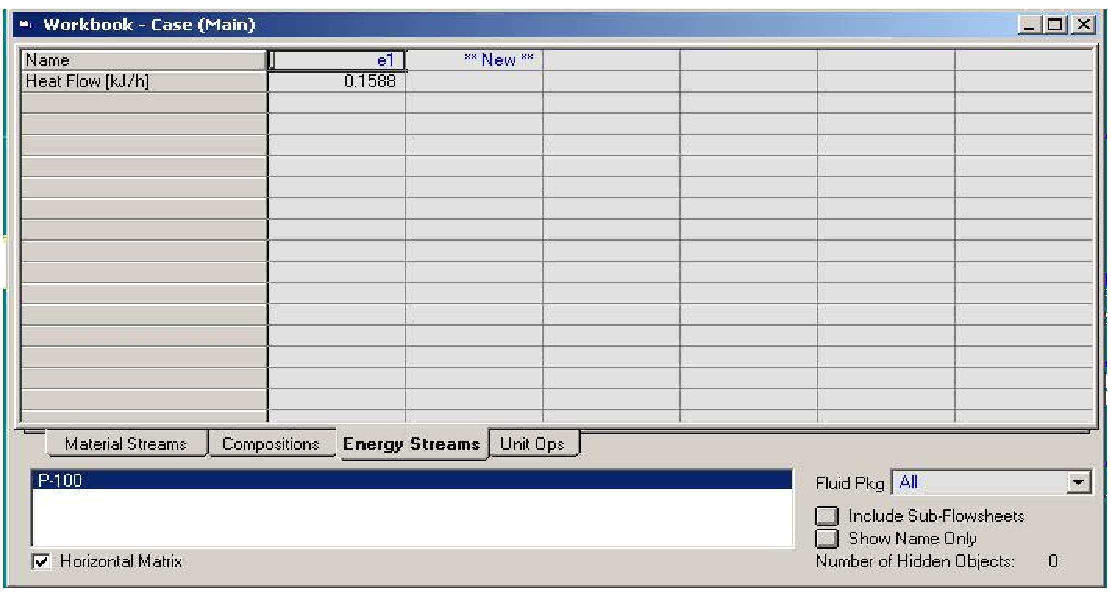


Figure 37: Energy Stream Specifications

Figure 38 shows the design when the Fisher ball valve and Fisher butterfly valve are functioning. In this case, Masoneilan and Metso ball valve and butterfly valve are ignored. The level controller, LIC-100 is added to the tank.The built-in level transmitter will measure the liquid level of the tank. Then,it will send the signal to the level controller,LIC-100 to regulate the speed of the pump. Although only Fisher valve is functioning, the plant is converged. Since the Masoneilan and Metso ball and butterfly valve are ignored, the value is found to be empty in Figure 39. The recycle part is slightly challenging because during the simulation testing, the recycle shows an error. Thus to counter this error, the sensitivity of the parameter has been adjusted which in this case, the flow to be increased to 20. This changes yields the desired result which is the plant is completed and converged. The composition mole fraction remains the same which is 1 because using the similar medium. The heat flow of the pump is now changed to the lower value which is 0.6794 as shown in Figure 41.

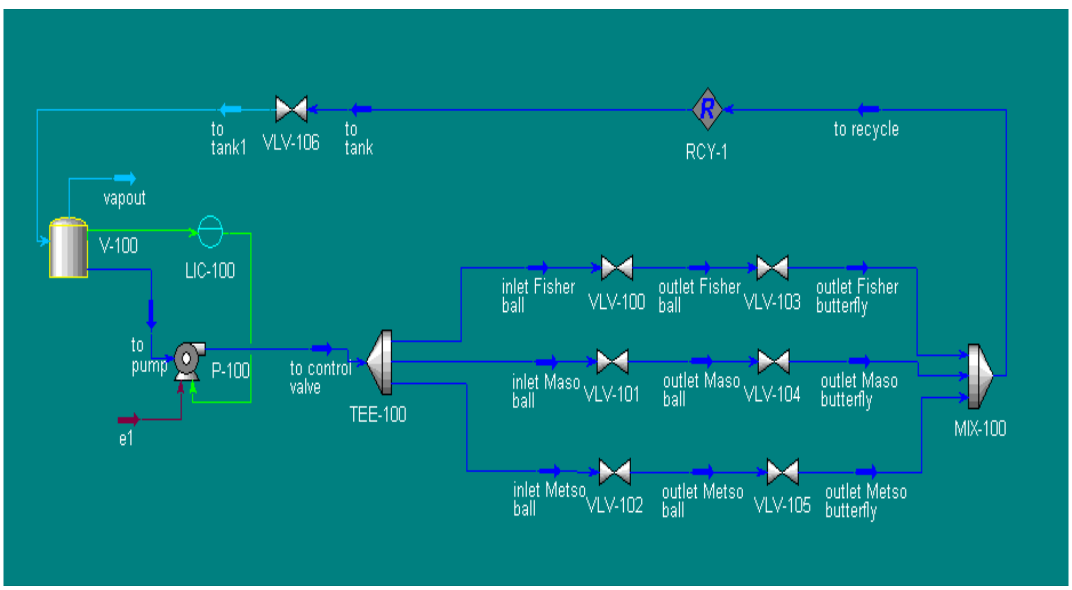


Figure 38: Design for Fisher valves working alone

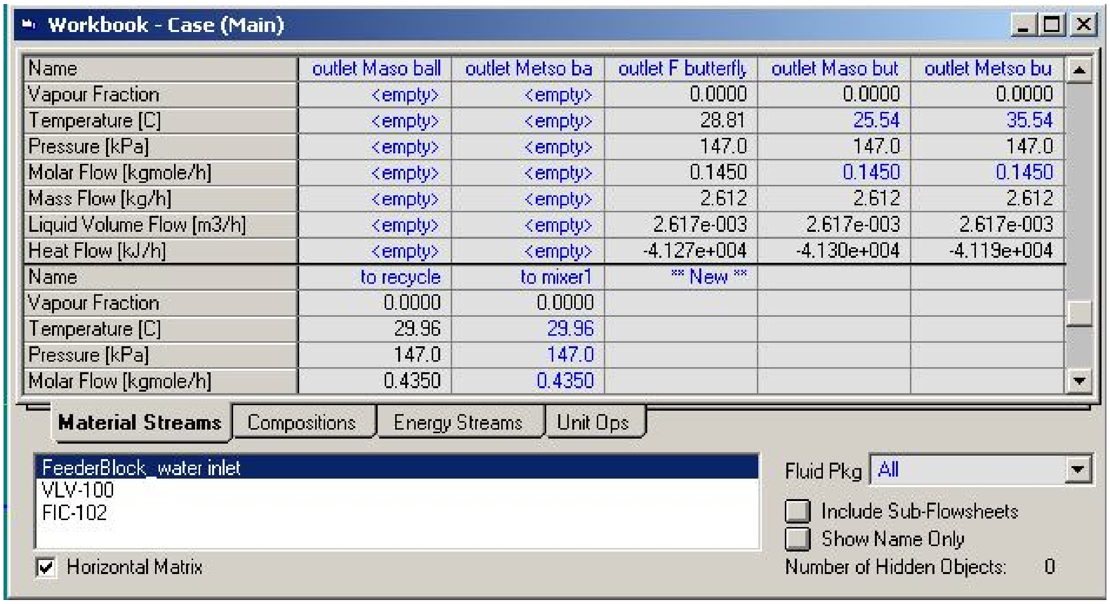


Figure 39: Material Stream Specifications

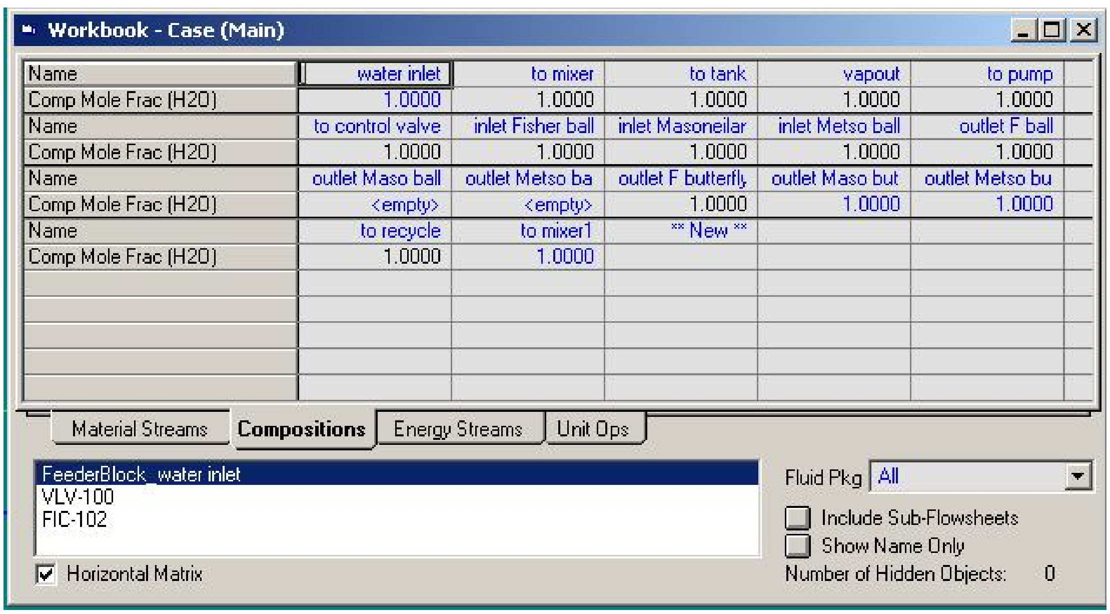


Figure 40: Composition Stream Specifications

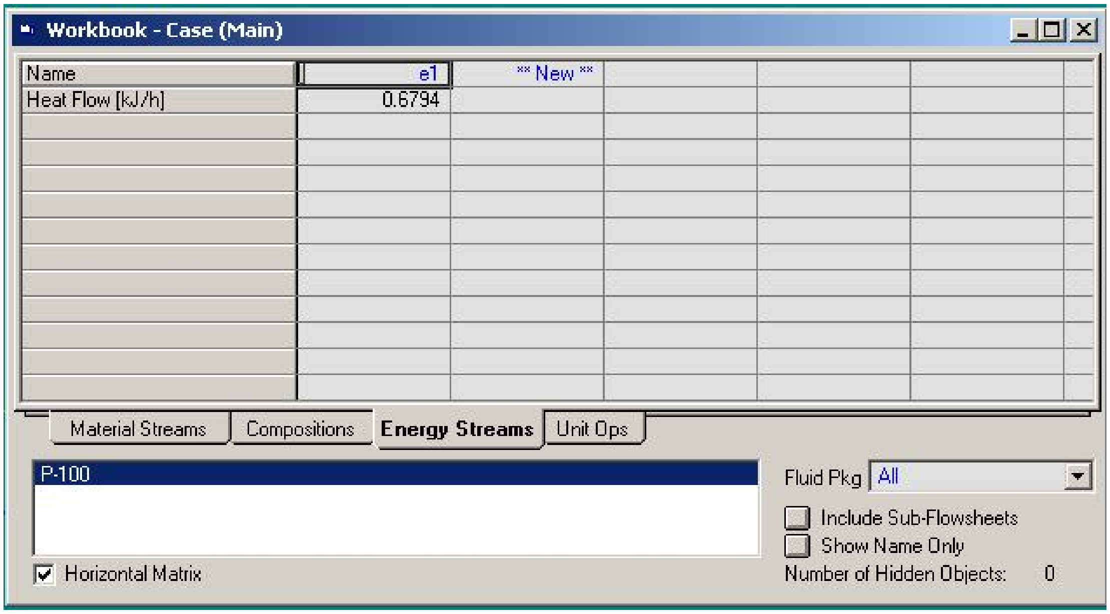


Figure 41: Energy Stream Specifications

Figure 42 shows the design when the Masoneilan ball valve and Fisher butterfly valve are functioning. In this case, Fisher and Metso ball valve and butterfly valve are ignored. The level controller, LIC-100 is added to the tank.The built-in level transmitter will measure the liquid level of the tank. Then,it will send the signal to the level controller,LIC-100 to regulate the speed of the pump. Although only Masoneilan valve is functioning, the plant is converged. Since the Fisher and Metso ball and butterfly valve are ignored, the value is found to be empty in Figure 43. The recycle part is slightly challenging because during the simulation testing, the recycle shows an error. Thus to counter this error, the sensitivity of the parameter has been adjusted which in this case, the flow to be increased to 20. This changes yields the desired result which is the plant is completed and converged. The composition mole fraction remains the same which is 1 because using the similar medium. The heat flow of the pump is now changed to the lower value which is 0.6777 as shown in Figure 45.

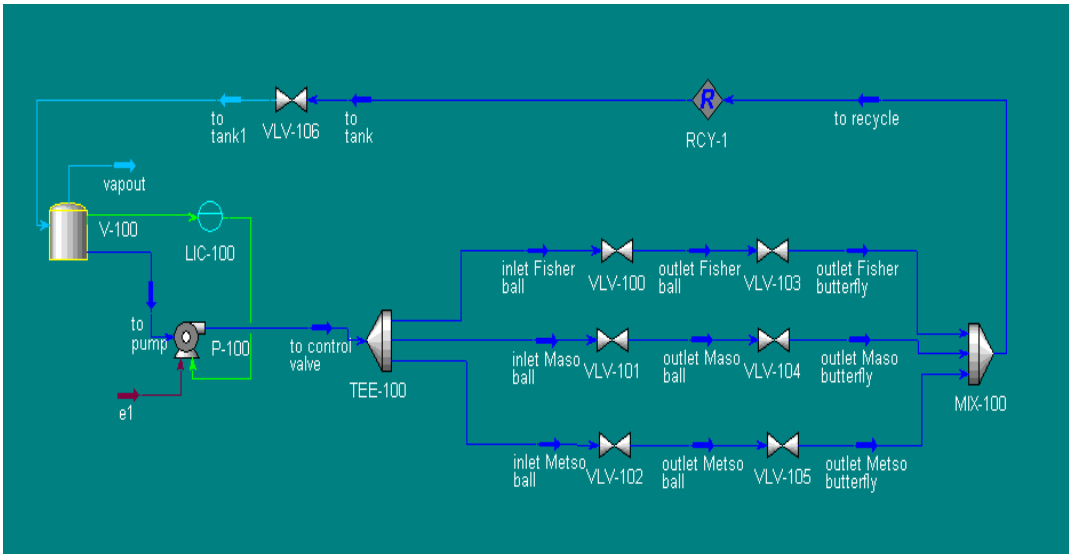
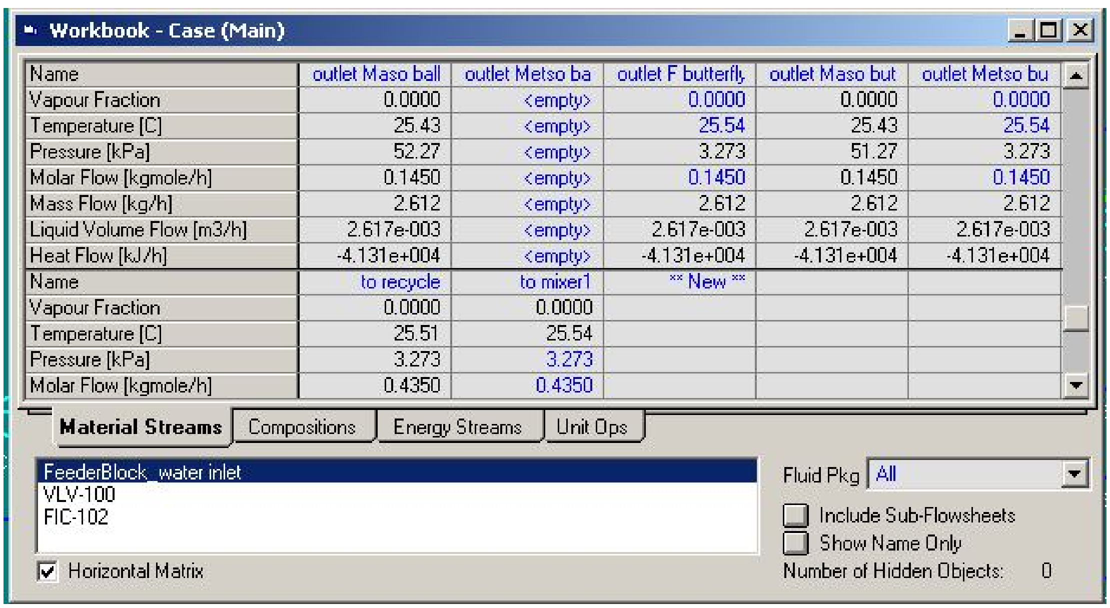


Figure 42: Design for Masoneilan valves working alone



Name	outlet Maso ball	outlet Metso ba	outlet F butterfly	outlet Maso but	outlet Metso bu
Vapour Fraction	0.0000	<empty>	0.0000	0.0000	0.0000
Temperature [C]	25.43	<empty>	25.54	25.43	25.54
Pressure [kPa]	52.27	<empty>	3.273	51.27	3.273
Molar Flow [kgmole/h]	0.1450	<empty>	0.1450	0.1450	0.1450
Mass Flow [kg/h]	2.612	<empty>	2.612	2.612	2.612
Liquid Volume Flow [m3/h]	2.617e-003	<empty>	2.617e-003	2.617e-003	2.617e-003
Heat Flow [kJ/h]	-4.131e+004	<empty>	-4.131e+004	-4.131e+004	-4.131e+004
Name	to recycle	to mixer1	** New **		
Vapour Fraction	0.0000	0.0000			
Temperature [C]	25.51	25.54			
Pressure [kPa]	3.273	3.273			
Molar Flow [kgmole/h]	0.4350	0.4350			

Figure 43: Material Stream Specifications

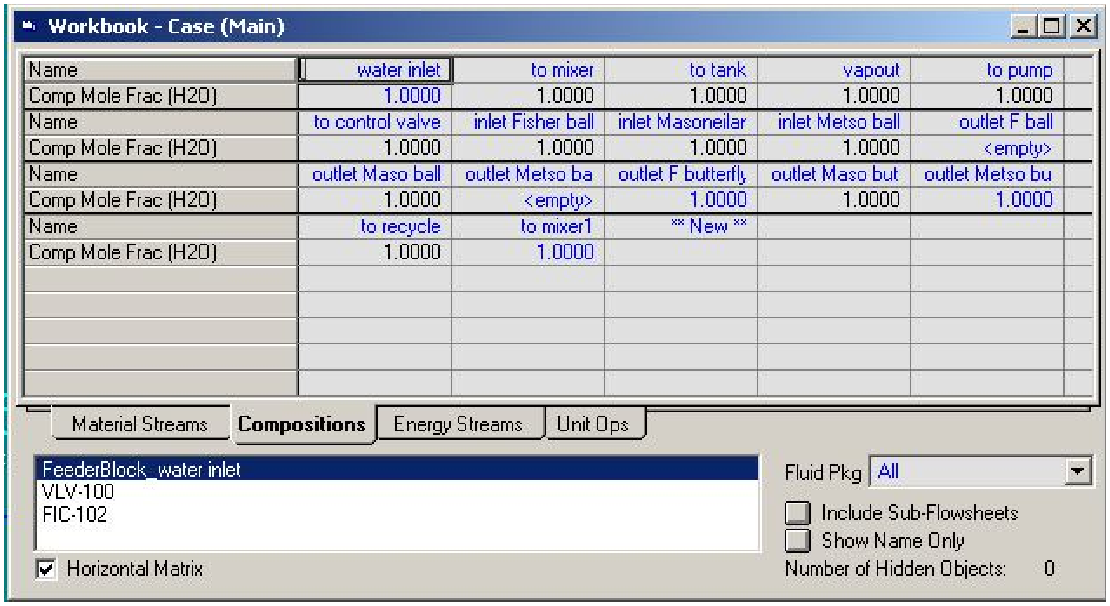


Figure 44: Composition Stream Specifications

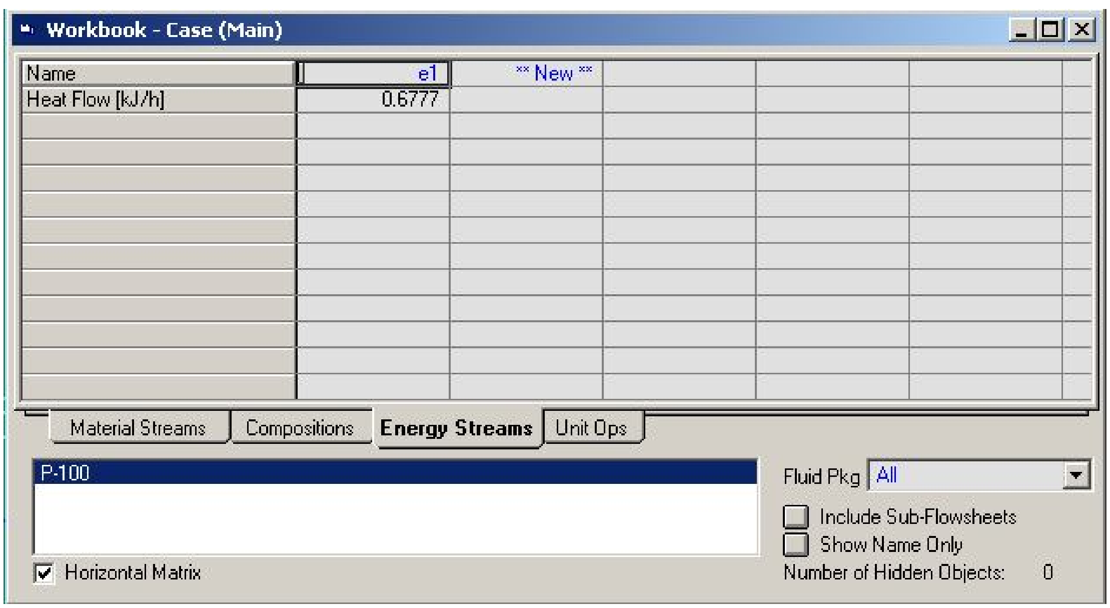


Figure 45: Energy Stream Specifications

Figure 46 shows the design when the Metso ball valve and Fisher butterfly valve are functioning. In this case, Fisher and Masoneilan ball valve and butterfly valve are ignored. The level controller, LIC-100 is added to the tank.The built-in level transmitter will measure the liquid level of the tank. Then,it will send the signal to the level controller,LIC-100 to regulate the speed of the pump.Although only Metso valve is functioning, the plant is converged. Since the Fisher and Masoneilan ball and butterfly valve are ignored, the value is found to be empty in Figure 47. The recycle part is slightly challenging because during the simulation testing, the recycle shows an error. Thus to counter this error, the sensitivity of the parameter has been adjusted which in this case, the flow to be increased to 20. However there is still an error occurred and the recycle is not solved. Hence, I have tried to modify the sensitivity of the pressure to be 30 and also the flow to be increased to 40.This changes yields the desired result which is the plant is completed and converged. The composition mole fraction remains the same which is 1 because using the similar medium. The heat flow of the pump is now changed to the higher value which is 574.8 as shown in Figure 49. The higher value is obtained because the sensitivity of the pressure has been changed.

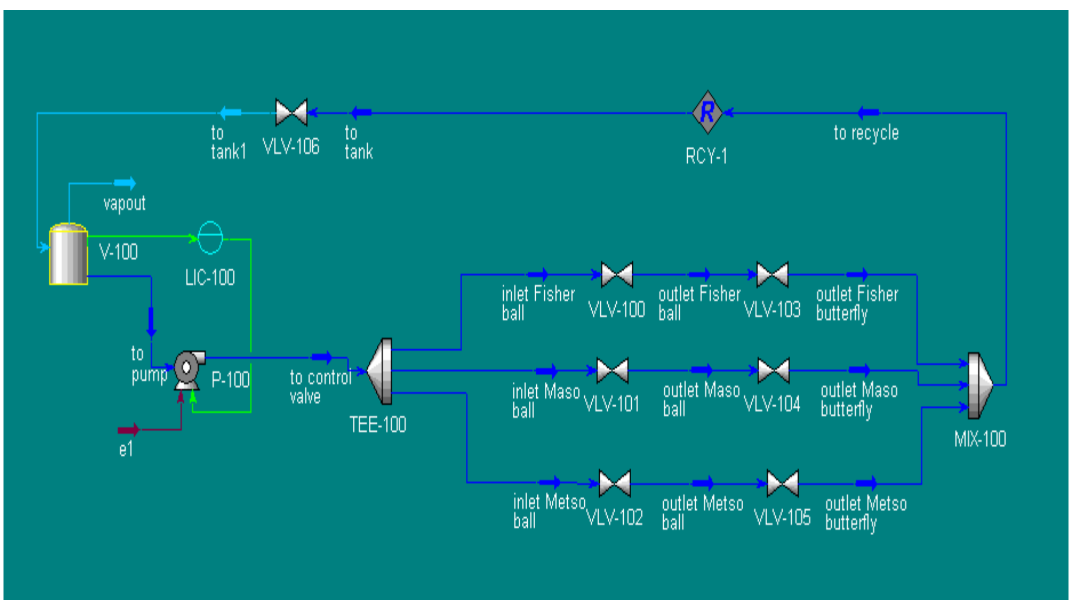


Figure 46: Design for Metso valve working alone

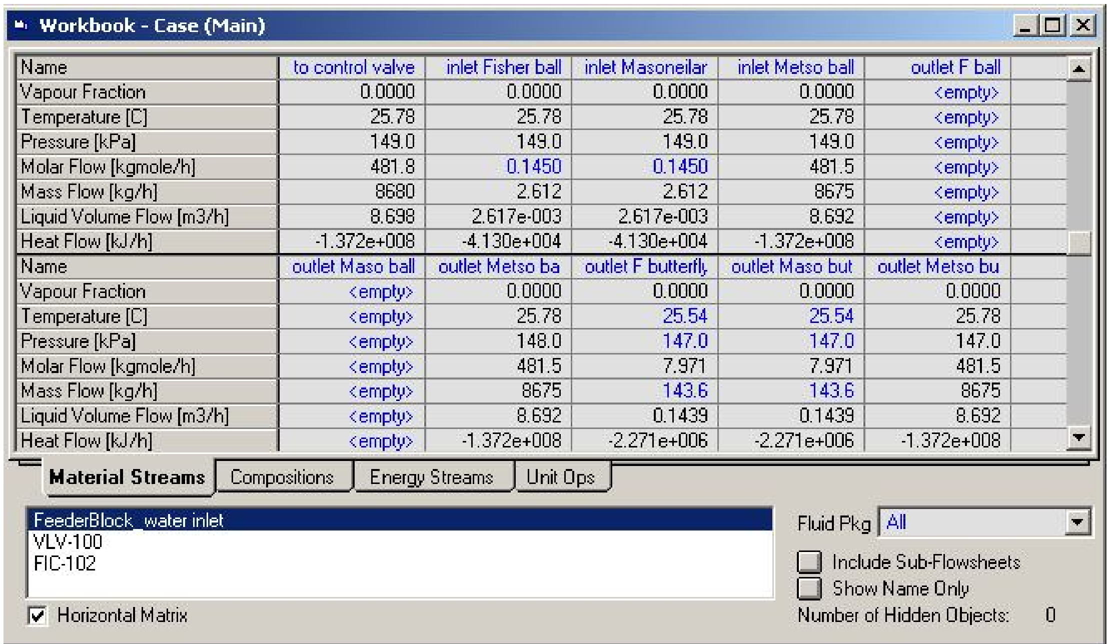


Figure 47: Material Stream Specifications

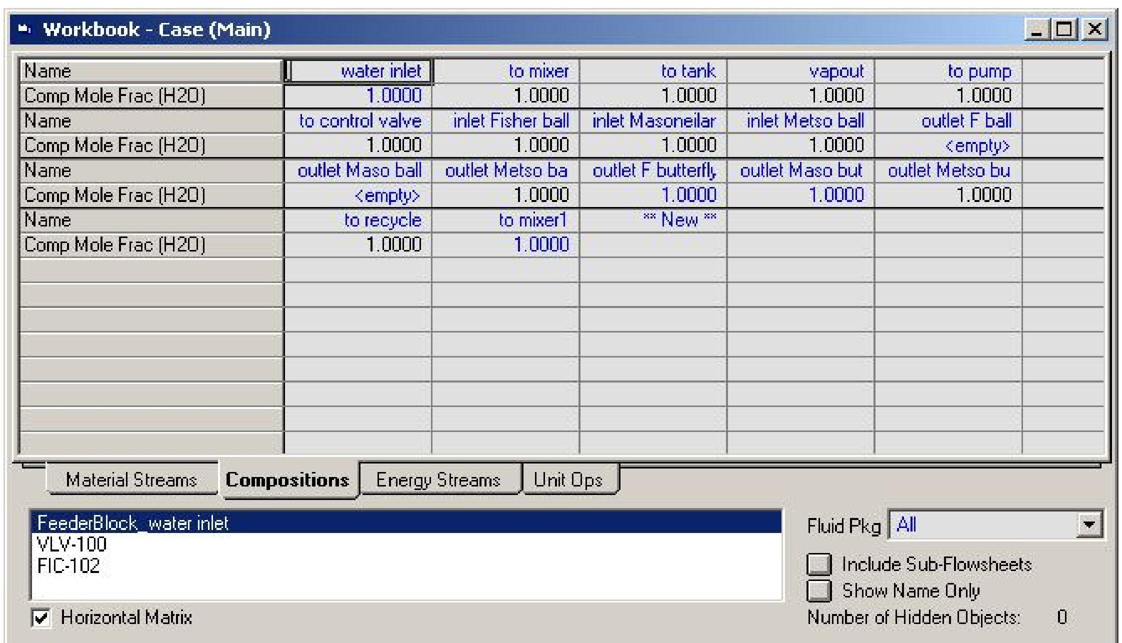


Figure 48: Composition Stream Specifications

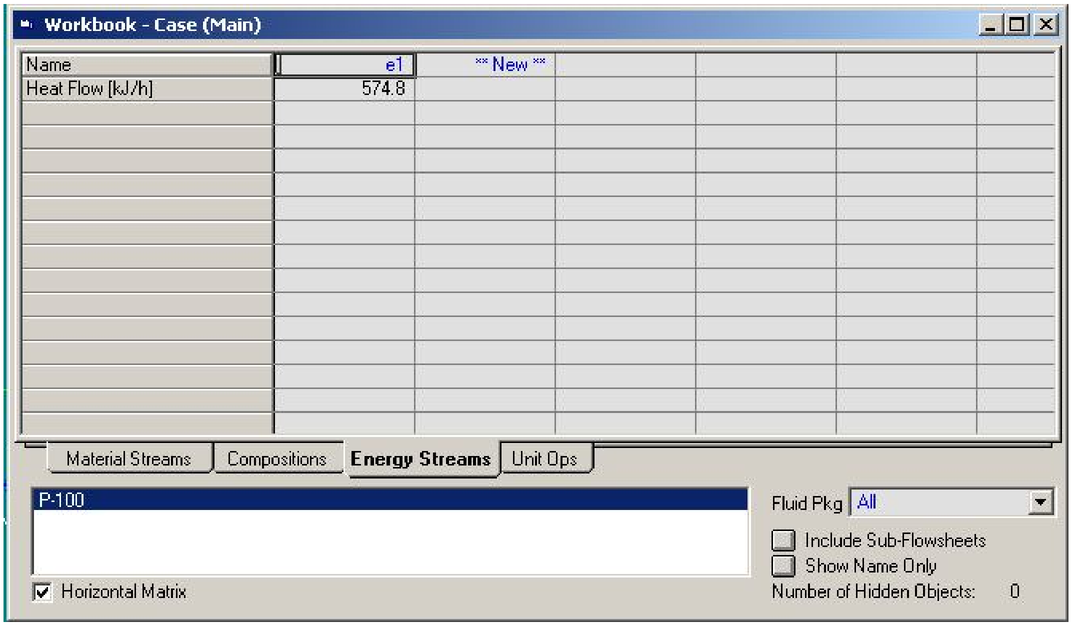


Figure 49: Energy Stream Specifications

4.2.2 Dynamic State Analysis

The dynamic state analysis is important to determine the functionality of the equipment and the reliability of each of them. The equipment such as the valve, the pump and also the controller will regulate accordingly and made changes automatically depending on the changes of the inlet. In steady state, after some modification the plant is converged. However, in dynamic state, the plant is no longer converged. A few criteria shall be taken into consideration such as the flow rate, the pressure, the speed of the pump, and the size of the tank.

4.3 Hook-up Diagram

Besides that, we have conducted a testing with GTS PETRONAS in order to produce a hook-up diagram as follows:

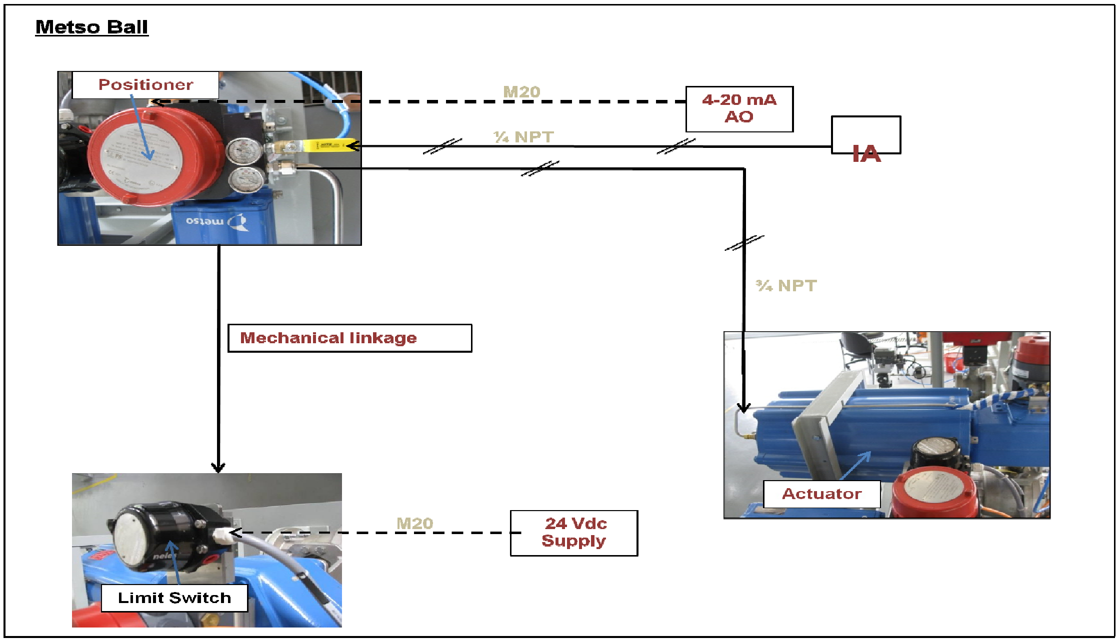


Figure 50: Hook-up diagram for Metso Ball Valve

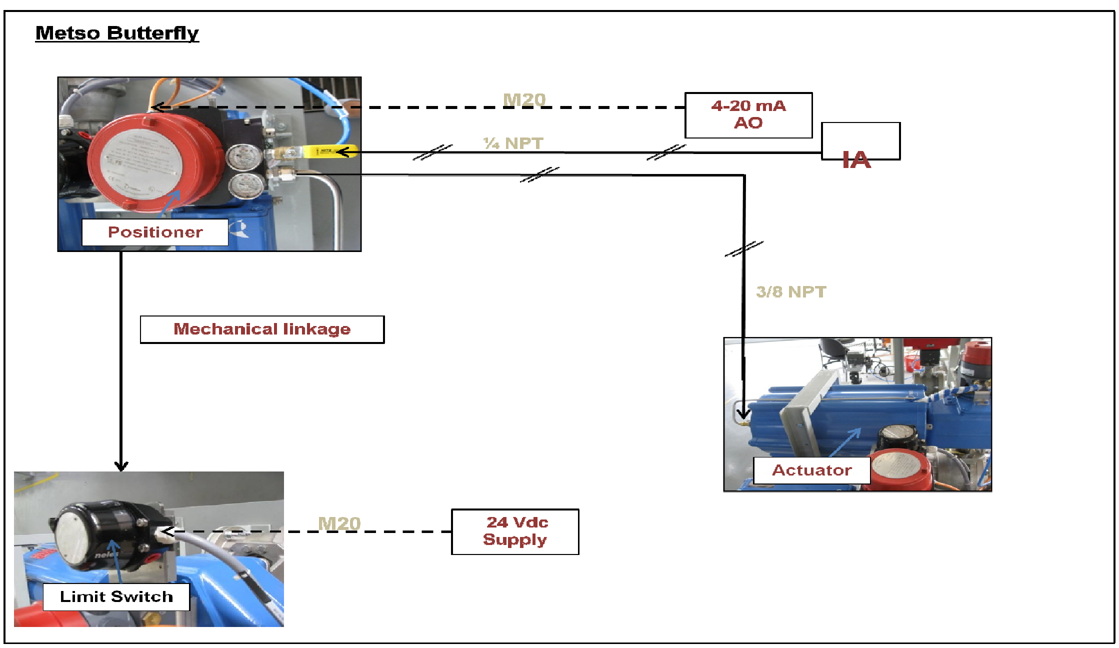


Figure 51: Hook-up diagram for Butterfly Valve

4.4 Test Procedures

Test procedures were prepared to be a guide for PETRONAS engineers, technicians and researchers to use in conducting the testing accordingly. The summary of the procedure are as follows:

- Check instrument air supply to the valve is in open condition.
- To start using the program,select and double click on WideField2 Icon to start using PLC program-WideField Software by Yokogawa.

Figure 52: Wide Field 2 Icon

- Select and click "Open Project" tab to open existing project file.
- Select folder "METSO" and click open.
- Next, select "METSO" project and click open.
- Select and double click on "Component Definition".

a) To test Metso Ball and Butterfly Valves:

- Select "METSO" from "Block List", click "Select" (which will appear under "Block Name") and then click "OK".
- To download project file. Go to "Online", select "Download" and click on "Project".
- Transferring configuration will start to download
- Wait until transfer configuration completed. Then, the following prompt "Download is completed. Switch to Run mode?" Select "YES".
- Next, go to "Online" and select "Program Monitor" to start program monitor.

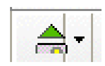
- Double click on “METSO” to upload the ladder diagram.
- Upon successful uploading the ladder diagram will be displayed.
- Valve is put to open position to stimulate normal operation. To initiate opening of the valve, right click at I00001 and select “Force Set”. Both Metso Ball and butterfly valves should be in open condition.
- Observe indication at IS barrier and RCI:
  i. At RCI, LED should lit at OK
  ii. At IS barrier, LED should lit at PWR and OUT
- Next, is to start HART Server:
  i. Click “Start” at PC toolbar
  ii. Select “Program”
  iii. Select “HART Server” folder
  iv. Select “HART Server” application
- Then proceed to open FieldCare Software. To start using the program, select and double click on “FieldCare” Icon. Enter following details and click “Login”:

Figure 53: FieldCare Icon

- FieldCare window will prompt. Select “Create Project” and click “Open”.
- “Host PC” appear under network tag. Right click “Host PC” and select “Add Device”.
- “Add New Device” window will appear. Select “HART OPC Client” at Device List and click “OK”.
- HART OPC Client will be under “Host OPC”. Right click at “HART OPC Client”, select “Create Network”.

- “Select communication channel” window will prompt and indicate 5 channels name. Click “OK”.
- Program will start scanning for all channel.
- After scanning completed, all Metso ValveGuard will appear in Network View pane.
- Double click valve guard at network pane; VG800 (Butterfly Valve) and VG9000H (Ball Valve)

<u>Metso Ball Valve</u>

- At VG9000 window, click upload data icon  and select “All View”.
- Expand “Monitoring” at VG window, select “Device Variables” and click “Start” to initiate valve signature.

b) Pneumatic Test

- For Manual Pneumatic Testing, expand “Pneumatic Test” and select “Manual Pneumatic Test”. Click “Start Test” to initiate testing.
- To obtain result from Pneumatic Testing, expand “Pneumatic Testing” and select “Pneumatic Test Results”. Print screen window showing the test result.
- Review valve signature under “Monitoring”> “Device Variables”. Right click at the graph and select “Export”. “Exporting” window will pop up and select “JPG” and select destination to save the graph by select “File” and click “Browse”. Finally click “Export”.

c) Partial Stroke Test

- Initiate Partial Stroke testing by expand “Partial Stroke Test” at VG window and select “Manual Partial Stroke Test”.
- Select the Stroke Size by entering value at “Test Stroke Size” and click “Start test” then click “OK”.

- To obtain result from Partial Stroke testing, expand “Partial Stroke Test” and select “Partial Stroke Test Results”
- Right click at graph showing the result of Partial Stroke (Pressure Difference versus Valve Position). Select “Export”. “Exporting” window will pop up and select “JPG” and select destination to save the graph by select “File” and click “Browse”. Finally click “Export”.

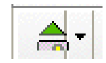
d) Emergency Trip Test

- Expand “Emergency Trip Test” and select “Emergency Trip Test”. Click “Start Test” and a window will prompt, click “OK”. A “Safety Guarantee” window will prompt and require initiator of Emergency Test to fill in their name.
- To obtain result from Emergency testing, expand “Emergency Trip Test” and select “Emergency Trip Test Results”.
- Enter following name in the “Safety Guarantee” window to ensure the responsible personnel understand the risk involved.
- Right click at graph showing the result of Emergency Trip Test (Valve Position versus Time). Select “Export”. “Exporting” window will pop up and select “JPG” and select destination to save the graph by select “File” and click “Browse”. Finally click “Export”.

e) Emergency Trip Signal Collided with Partial Stroke Test

- Start partial stroke test as mention above. During partial stroke is conducted (before valve start reaching end point of partial stroke), open ladder diagram and right click at I00002, select “Forced Set” to imitate shutdown signal/ emergency trip.
- Several prompt will indicate the test failed
- Expand “Online Diagnostic” and select “Event Log”. There will be log showing “Manual partial stroke cancelled”.

<u>Metso Butterfly Valve</u>

- At VG800X window, click upload data icon  and select “All”.

b) Pneumatic Test

- For Manual Pneumatic Testing, expand “Testing” and select “Pneumatic Test”. Click “Start Individual Test” to initiate testing.
- To obtain result from Pneumatic Testing, graph will appear after test completed right click at the graph and select “Export”. “Exporting” window will pop up and select “JPG” and select destination to save the graph by select “File” and click “Browse”. Finally click “Export”.

c) Partial Stroke Test

- Initiate Partial Stroke testing by expand “Testing” and select “Valve Test”.
- Select the Stroke Size by entering value at “Test Stroke Size” together with “Pressure Step” and click “Start Individual Test”.
- To obtain result from Partial Stroke Testing, graph will appear after test completed right click at the graph and select “Export”. “Exporting” window will pop up and select “JPG” and select destination to save the graph by select “File” and click “Browse”. Finally click “Export”

d) Emergency Trip Signal Collided with Partial Stroke Test

- Start partial stroke test as in Step 40-41. During partial stroke is conducted (before valve start reaching end point of partial stroke), open ladder diagram and right click at I00001, select “Forced Reset” to initiate shutdown signal/ emergency trip.
- A prompt will pop up indicate the test failed.
- To generate report from test done, click “File” and select “Print”
- Report Configuration window will prompt, enter report name and click “Print”.

4.4.1 Pneumatic Test for Spool Valve Checking

Pneumatic test is done to test the spool valve condition inside the VG800 and VG9000 either they are in good condition or not. Here the spool valve acts like a limit switch which it control the opening and closing of valve since it controls the instrument air supply into the valve diaphragm. During the test, pressure is released from the actuator diaphragm by de-energizing the spool valve for a few seconds. When the spool valve is been de-energized, the pressure will drop but not exceed the breakaway pressure to avoid valve from moving, and then it will be sensed by a pressure sensor located inside the VG800 and VG9000 and an action will be taken to compensate the pressure drop which is by energizing it back in fast manner, then the pressure drop will recover (*refer figure 54 and 55*).

The important thing that must observed here is the time taken for the pressure drop to recover back where the faster the time taken the better the performance of the spool valve because it shows that the spool valve is reliable since it can respond to any changes of pressure in fast response. Pneumatic test is done at every stroke before conducting valve tests due to safety purpose. Therefore for every testing, six pneumatic test graphs of are obtained for each valve type. The samples of graphs below are taken during the last stroke while developing the test procedure is as follow:

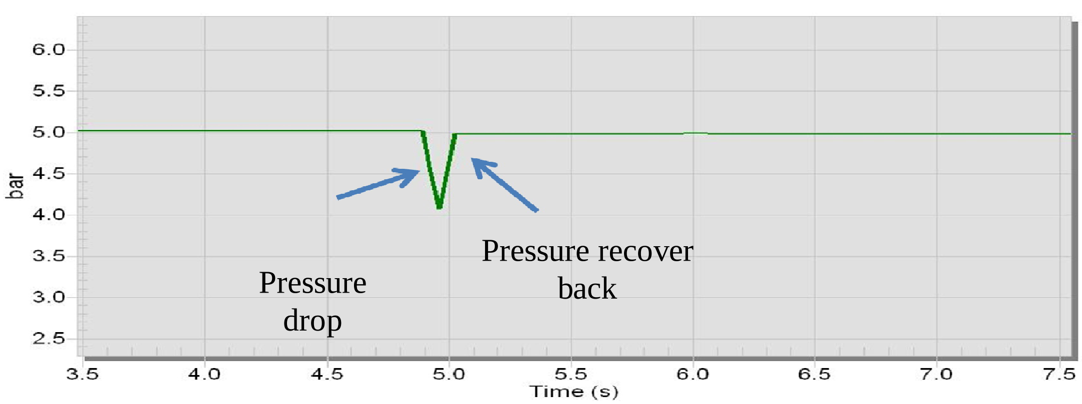


Figure 54: Pneumatic Test for Ball Valve

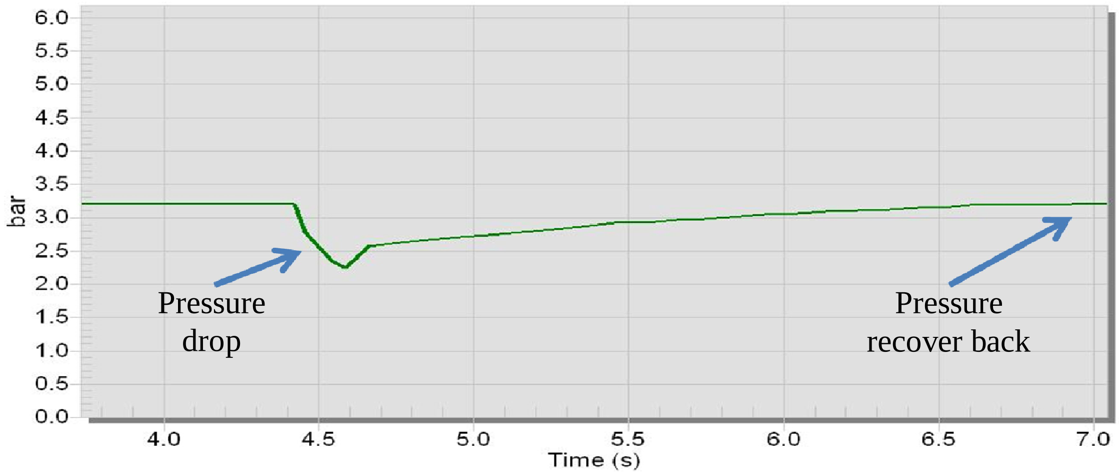


Figure 55: Pneumatic Test for Butterfly Valve

The graphs (*refer figure 54 and 55*) show that the spool valve for ball and butterfly valve are in good condition since the pressure drop for a moment only, then it recovers back in fast response which is just a few seconds. Therefore, if any changes happen, the spool valve will take action to compensate the changes in fast manner that is very important to prevent danger when emergency occurs.

4.4.2 Valve Test (Partial Stroke Test)

Valve Test is referring to the Partial Stroke Test (PST) which is done six times for both valves, ball and butterfly type. The valve test is set to have 20% valve stroking with 0.05 bar pressure. Before the test is executed, the valve must be ensured to be at fully open condition because during the test, both valves will be stroked 20% which means 80% opening remains.

However, during third stroke test for both valves, Full Stroke Test will be executed to overwrite the PST. From the valve test, one graph is obtained that is the valve signature. From the graph, the testing criteria such as breakaway pressure and load factor can be observed.

The valve signatures (*refer figure 56 and 57*) are the samples of result for valve test for ball and butterfly valve where the testing criteria are labeled. The value of breakaway pressure and load factor can be known by analyzing the valve signature. The samples of valve signature that were taken from the last stroke when developing the test procedure show that both valve have good performance since it can stroke 20% closing and then return back to the initial condition (fully open).

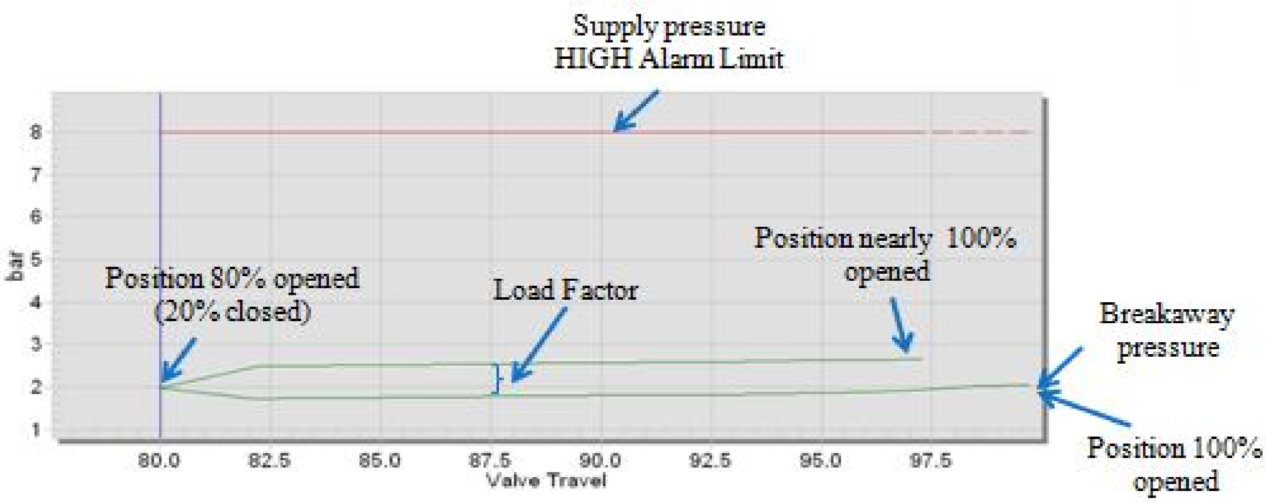


Figure 56: Valve Test for Ball type Graph

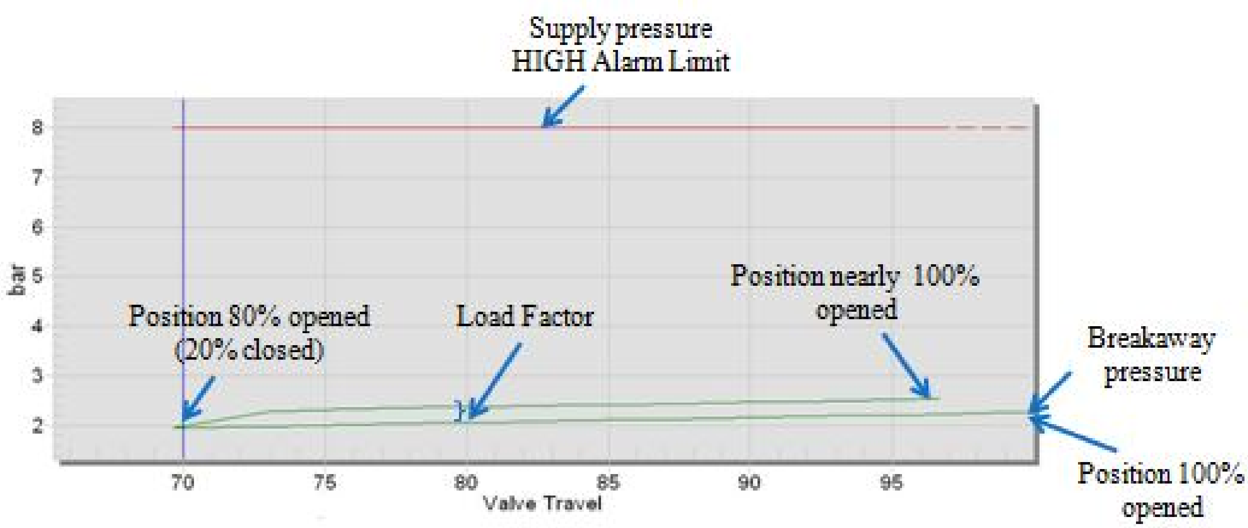


Figure 57: Valve Test for Butterfly type Graph

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The first objective of this project is to model and verify the Partial Stroke test rig using HYSYS. Based on the design performed using HYSYS, it can be concluded that the final draft of the plant can be verified and validated using HYSYS provided there are sufficient data about the specification of all the components and the equipments involved. However, during the testing, most of the data used are estimated value but eventually it yields the desired result. All the designs are completed and converged which also provide reliable data to be compared to the actual value in the real design of the mini plant later in the future.

If the plant is built in the lab, Phase II will be conducted which involves study of the failures mode of the valves during the test period. Failure mode which cover the mechanical failure mode, pneumatics failure mode and electronics failure mode will be introduced. PST and FST will be done with load (liquid).The performance of the ESD valves will be analyzed and various aspects of valve failures will be observed. Phase II is commenced to modify the existing Instrument Air Supply by providing a vessel downstream of the instrument air compressor. This vessel is to provide sufficient air supply for Partial Stroke Testing (PST) valve to be in fully open condition for approximate X time. Due to the modification, it requires checking on the longest time for FST/PST test to be done and also the requirement of instrument air for all PST valves to be in fully open position and the minimum requirement of air for one valve to be PST/FST.

Many users consider PST as a cost effective alternative to on-line Full Stroke Test (FST). The use of PST can eliminate the need for full flow bypasses, reducing engineering, capital, and installation costs, as well as potentially removing a bypass that could be inadvertently left open.

As for now, we are only working on the design of the mini plant in the lab. Besides that, we have provided the procedures of each valve thus it is very useful for the operators to conduct the testing. In addition, we also conducted a testing with GTS PETRONAS in order to produce a hook-up diagram for all the valves.

The design has been verified via HYSYS and the summary is presented in Table 3.

Table 3: Summarization of verification via HYSYS

Parameter	Value	
Water in tank	Min=0.1m Max=1.1m 1.1m>1m	Sufficient
Pump size (capacity)	$0.050m^3/min > 0.045m^3/min$	t- 3.333min :reasonable Flow rate-0.050m3/min :reasonable Pressure 150kPa: reasonable

Based on the verification, the water in the tank is sufficient enough to sustain water to flow fully in the pipeline for that particular time determined. The pump capacity which is between 0.045-0.050 m^3/min is possible to be purchased. The flow rate and the pressure of the pump represented by Delta P are reasonable.

5.2 Recommendations

Phase I has been completed by November 2009, thus the project will enter new phase which is Phase II. During Phase II, failure mode testing will be conducted where disturbance may be introduced to the valve such as tighten the packing of the valve or give flow of medium (silicone) through the valve.

In addition, the series of the ValvGuard used from Metso Neles will be upgraded. For the current testing, VG800 is replaced by VG9000. The VG9000 has the same function as VG800 but it comes with extensive safety valve testing capabilities and improved diagnostics data. Thus, more data can be gathered. Besides that, VG9000 is maintained powered during the trip hence, it allows diagnostics information collection. Comparing to the other vendors, VG9000 is the only valve that can monitor the position of the valve during on-line testing. Hence, it is more reliable and convenient for emergency shutdown valve.

There is limitation of the equipment such computer to do the testing. As there is only one computer, only one testing from one particular vendor can be done. So, there is time consuming as students have to take turn in order to use the computer. Therefore, it would be efficient if PETRONAS can provide a computer to each controller connected to the individual PST test rig.

Regarding the summarization of the verification of the design via HYSYS, it is recommended that the orientation of the control valve is shifted as per design in the final design draft of the mini plant. If the size of the tank is decided to be bigger, the pump size must also change accordingly. Instead of using the level controller to regulate the speed of the pump, the pressure controller can also be used to replace the level controller. The pressure controller will measure the pressure of the outlet of the pump and then send the signal to the pressure controller to regulate the pressure in the tank or regulate the speed of the pump. By adding the level controller or the pressure controller, we can compensate the error of the output and obtain the desired value.

Based on the HYSYS verification, it is recommended that the design part which is known as the step testing to create Advance Process Control (APC) design and finally doing the APC implement. By designing and implementing APC, the system can determine the flow rate of the valve and also the minimum volume of water tank required to flow fully in the pipe line for that particular time required. Moreover, by using APC, it can determine the shortest path to take for the water to flow smoothly in the pipeline. Since some calculations have been done for the final draft of the mini plant, we can compare the values to configure the accurate and adequate value for each component and equipment besides the verification and the validation of design of the plant.

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APPENDICES

APPENDIX A

Gantt chart for FYP1 and FYP2

No	Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic														
2	Data Gathering on Topic														
3	Submission of Preliminary Report														
4	Familiarization with PST testing														
5	Controller/PLC programming														
6	Testing procedures and requirement identification														
7	Conduct testing (FST and PST)														
8	Submission of Progress Report														
9	Seminar														
10	Results Gathering														
11	Submission of Interim Report														
12	Oral Presentation														

No	Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Method and Procedure Planning for Sem 2 – any Improvement or additional testing														
2	Continue testing (FST and PST)														
3	Submission of Progress Report 1														
6	Results Gathering & Discussion														
7	Submission of Progress Report 2														
8	Seminar														
9	Conclusion and Recommendation														
10	Poster Exhibition														
11	Submission of Dissertation (softbound)														
12	Oral Presentation														
13	Submission of Dissertation (hardbound)														

APPENDIX B

Partial Stroke Test graph obtained from Metso Ball Valve (VG9000H):

A prompt indicated that the test was failed: