Development of Diagnostic Program for Gas Compressor using Knowledge Based Management Concept

by

Khairil Ikhwan Bin Abdul Rahman

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CERTIFICATION OF APPROVAL

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

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2012

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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KHAIRIL IKHWAN BIN ABDUL RAHMAN

Abstract

Compressor maintenance is vital in oil and gas industry because it is an important equipment that runs continuously. Among all of the deterioration mechanisms, fouling is found to be the most common in oil and gas industry and it is relatively easier to be analyzed. Currently, plant engineers face difficulties in predicting the appropriate time for maintenance and usually they will follow the original equipment manufacturer (OEM) recommendations. Most plant engineers do not have a predictive tool to advise them on compressor maintenance and the necessary steps to be taken. Usually, the engineers will only attend to the equipment when problems or abnormalities arise from it, apart from the planned maintenance. Late decision made on compressor maintenance will sometimes cause problems to operation either due to late arrival of spare parts or staff availability. The objective of this project is to develop a software that will be able to assist engineers in determining the performance deterioration of gas compressor and deciding the optimum time to do maintenance. The maintenance history data is collected and analysed by the software regularly. The correlations between isentropic efficiency, isentropic head, and gas power and the compressor deterioration are studied based on two centrifugal gas compressors from January 2009 to December 2010. Later, a software that is able to produce maintenance advice based on the input parameters given by the user is created. The software is developed using Microsoft Excel 2010 and Microsoft Visual Basic. From the analysis conducted, it is found that due to fouling, isentropic efficiency and isentropic head decrease with time for low pressure compressors. In contrast, the gas power increases with time. Based on these findings, Performance Indicators Monitoring Program (PIMP) is developed.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Compressor is a machine that supplies fluid at increased pressure. It is used in oil and gas industry for many purposes, including gas transportation, well injection, and gas lifting. In production plants, compressors run continuously and therefore maintenance is important in keeping the equipment fit for operation, especially under harsh conditions. Figure 1.1 illustrates the maintenance strategies for gas compressors.

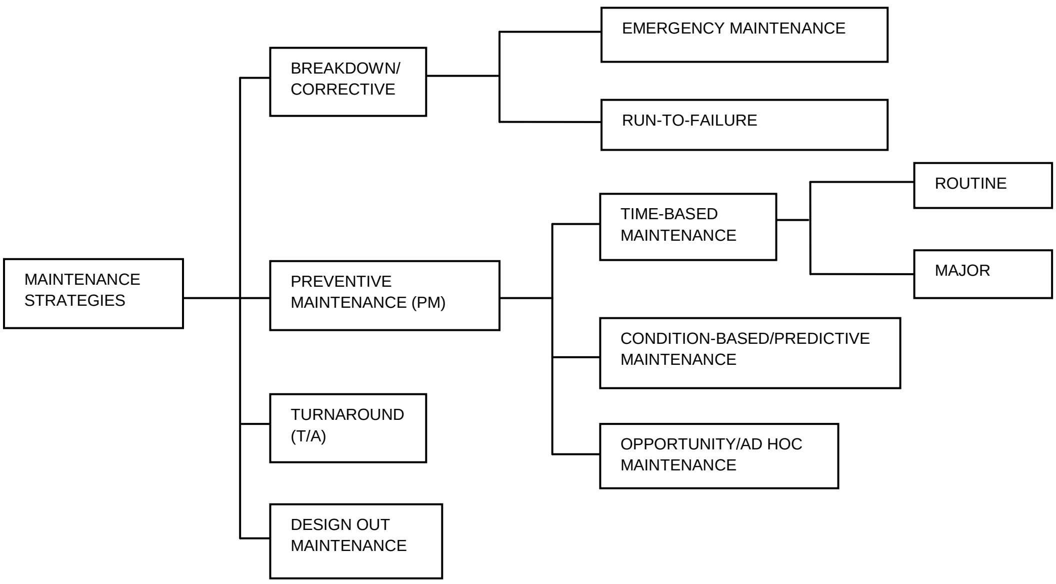

Figure 1.1: Maintenance strategies breakdown (PETRONAS, 2005)

Corrective or breakdown maintenance is a strategy adopted when an equipment is opted to operate until it seizes or cannot deliver the required tasks (PETRONAS, 2005). Breakdown maintenance carries a high risk as it can lead to destructive failures. Furthermore, large staff is needed to perform emergency repairs. If the equipment is essential in a process, it will disrupt the process. Altogether, it is the most costly maintenance strategy. When there is sufficient redundancy of equipment, or if the equipment is not critical to plant operation, run to failure maintenance can be applied.

Preventive maintenance is aimed at minimizing unexpected, expensive breakdowns. Only present activities and inspections are carried out and thus cannot accurately predict failure or wear out of equipment. Although it can reduce the maintenance cost significantly as compared to corrective maintenance, money and man-hours are often wasted due to unnecessary inspections and replacements (PETRONAS, 2005). In time-based maintenance, a particular equipment is replaced regardless of its condition, after some predetermined time or use is reached, such as cycles, running hours or calendar days. It can be divided into routine maintenance and major maintenance. Activities under routine maintenance include cleaning, inspection, lubrication, testing, adjusting and tightening, and servicing. Major maintenance are termed such because it requires partial dismantling of equipment, use of various tools and techniques, requires high skill level and more labour hours than routine maintenance. Moreover, a maintenance planner is assigned for the maintenance. The planner will schedule the equipment for a planned offline time. After performing maintenance, a test run will be conducted for the equipment.

Predictive maintenance, also known as condition-based maintenance, is the most recent maintenance strategy in plant maintenance. A deteriorated equipment will exhibit distinctive characteristics that can be perceived as symptoms and be associated with a particular defect, e.g. rubbing, misalignment, and unbalance. Some of the tools used in predictive maintenance are vibration analysis, lubrication analysis, thermography, and ultrasonic inspection (PETRONAS, 2005). Ad hoc maintenance, as characterized by its name, includes maintenance activities that are performed on the fly, or when there is a production window.

Scheduled turnaround is a major periodic maintenance activity in which plants are shut down to allow for inspections, repairs, replacements and overhauls which cannot be carried out when the equipment is in operation (PETRONAS, 2005). Even though it costs money, man-hours and loss in production, it has to be performed due to statutory requirement. In Malaysian context, Department of Safety and Health has determined that a turnaround should be held once in 3 years for oil and gas plant facilities. When critical equipment is needing excessive maintenance or its failure rate is too high, design out maintenance or redesign maintenance is performed. It requires the equipment to be redesign to be more reliable and available. If it is not possible, the equipment will be replaced with another equipment. In Table 1.1 it is shown that preventive maintenance can generate significant increase in revenue with less maintenance cost. Corrective maintenance costs more with less increase in revenue as compared to preventive maintenance. Turnaround does not contribute to revenue increment and costly, but it needs to be carried out in order to continue in operation. Design out maintenance requires fund more than the maintenance cost to purchase new equipment. However, the increase in revenue will be high because of high reliability and high efficiency of the new equipment. The maintenance cost of an undisclosed operating company for turbomachineries at an oil platform in Malaysia is reported to be between RM 3 million and RM 10 million a year (2008-2012).

Table 1.1: Costs and savings for different maintenance strategies (Jasmani, 2012)

Maintenance Strategy	Increase in Revenue (%)	Cost (% of maintenance expenditure)
Corrective	15	50
Preventive	35	20
Turnaround	0	30
Design out	50	> 100

1.2 Problem Statement

When a centrifugal gas compressor degrades in performance, the maintenance engineer will have to check the data from the gas compressor for possible failure and the root cause. The engineer will make a decision based on his experience and knowledge. Besides that, the plant engineers do not know when the optimum time for them to do maintenance is. The engineer does not have a system to advise him on what might occur and the necessary steps to be taken. Normally, they will follow the Original Equipment Manufacturer's (OEM) recommendation, although they may probably enhance the compressor's life span thru a diagnostic system that constantly monitor and analyse the equipment's operation. Also, they could not detect the compressors deteriorating performance and it is late when they realize that the compressors need maintenance. The maintenance cost for turbomachineries as shown in Table 1.2, is substantial and significant amount is due to last minute maintenance together with maintenance more frequent than necessary.

Table 1.2: Maintenance cost for turbomachineries at an undisclosed oil platform in Malaysia (Jasmani, 2012)

Year	Maintenance Cost (% of CAPEX)
2008	34.4
2009	52.8
2010	65.6
2011	103.7
2012	96.7

1.3 Objective and Scope of Study

The objective of the project is to develop a diagnostics software of centrifugal gas compressor based on thermodynamic analysis and historical data in assisting plants engineers making decisions pertaining to maintenance. At certain condition, given a set of sensor readings, operators will be advised on the type of deterioration, rate of deterioration, deviation of performance indicators, as well as the estimated optimum time to do maintenance. By analysing historical data of the compressor, correlations between degree of degradation with performance indicators deviations and displacement vibrations will be established. After that, the criteria are set to associate with the optimum time for maintenance. The degree of degradation, performance indicators deviations, displacement vibrations, and optimum time for maintenance will be displayed to the user as output in the diagnostic software.

The scope of study in this project is mainly on a type of deterioration mechanism, that is fouling or blockage, whereas erosion and corrosion, mechanical damage, internal recirculation, and surge events are not covered in this study. Besides, not all compressors are covered in this study. Only centrifugal compressors is considered.

CHAPTER 2

LITERATURE REVIEW

2.1 Centrifugal Compressor

A compressor is a device that pressurizes a working fluid. One of the basic aims of using a compressor is to compress the fluid and deliver it at a pressure higher than its original pressure (Boyce, 2002). As shown in Figures 2.1 and 2.2, a centrifugal compressor is composed of inlet guide vanes (IGVs), an inducer, an impeller, a diffuser, and a scroll for a single stage compressor or a transition piece for a multi stage centrifugal compressor. The IGVs are used in only a high-pressure ratio transonic compressor. Vaned diffusers are used in compressors for high efficiency. They are preceded by a vaneless diffuser so as to ensure that the velocity reaching the vaned diffuser is subsonic. Vaned diffusers reduce the operating margin of a centrifugal compressor, i.e. the region between surge limit and choke limit.

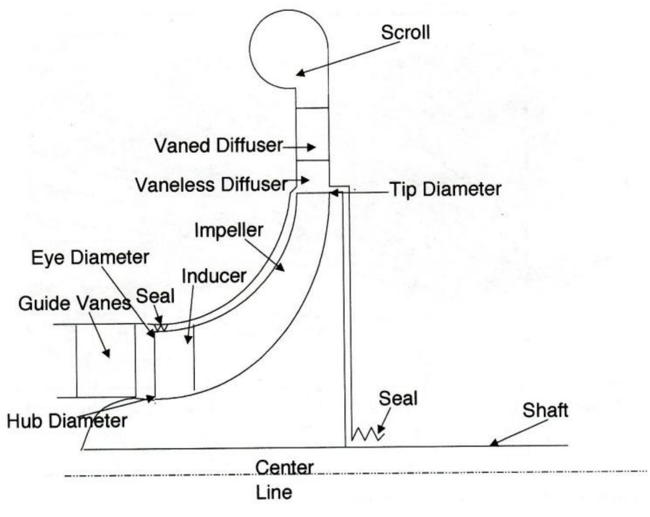

Figure 2.1: Single stage centrifugal compressor (Boyce, 2002)

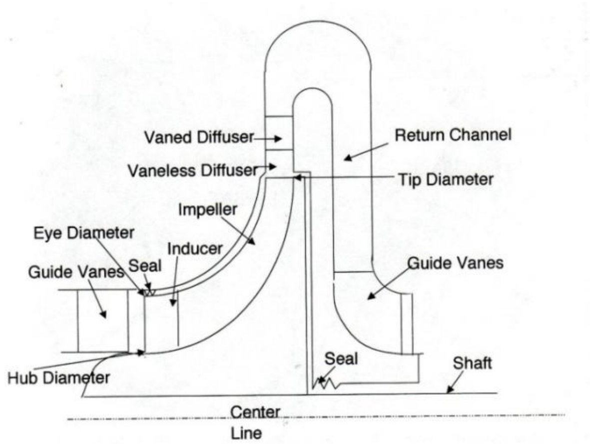

Figure 2.2: Multi stage centrifugal compressor (Boyce, 2002)

The fluid comes into the compressor through an intake duct and is given prewhirl by the IGVs (Shouman & Anderson, 1964). It then flows into an inducer without any incidence angle, and its flow direction is changed from axial to radial. The fluid is given energy at this stage by the rotor as it goes through the impeller while compressing. Then, it is discharged into a diffuser, where the kinetic energy is converted into static pressure. The flow enters the scroll from which the compressor discharge is taken. In a typical centrifugal compressor, the fluid is forced through the impeller by rapidly rotating impeller blades. The velocity of the fluid is converted to pressure, partially in the impeller and partially in the stationary diffusers (Boyce, 1993). Most of the velocity leaving the impeller is converted into pressure energy in the diffuser, as shown in Figure 2.3. The diffuser consists essentially of vanes, which are tangential to the impeller. These vane passages diverge to convert the velocity head into pressure energy.

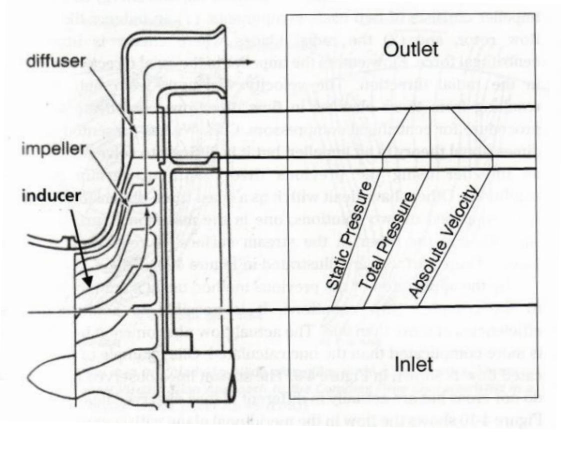

Figure 2.3: Pressure and velocity variations through a centrifugal compressor (Boyce, 2002)

2.2 Performance Fundamentals

A gas compressor has a few parameters that are measurable. Examples are suction temperature and suction pressure. However, these parameters are difficult to be analysed as the interpretation from the related data is inconsistent (Jasmani et al., 2012). For instance, an increase in discharged pressure, unaffected discharged temperature, decrease in transverse aft vibration and decrease in suction temperature. This does not provide any useful information when analysed. Therefore, when analysing parameters for gas compressors, performance indicator approach is more suitable. For this project, only compressor head, compressor efficiency, and gas power will be discussed. These performance indicators are sufficient for data analysis.

Compressor head is the amount of energy applied for a unit amount of gas being compressed (Gresh, 2000). It is often expressed in kilojoule per kilogram of gas (kJ/kg). Normally, isentropic head is related to pressure ratio and gas properties as:

$$h_{isen} = z_{ave} \times \frac{R}{MW} \times \frac{k}{k-1} \times T_s \times \left[\left(\frac{P_d}{P_s} \right)^{\frac{k-1}{k}} - 1 \right] \tag{2.1}$$

where h_{isen} is isentropic head in kJ/kg, z_{ave} is average compressibility factor, R is universal gas constant in J/mol.K, MW is molecular weight in g/mol, k is the ratio of specific heat, T_s is the suction temperature in Kelvin, P_d is discharge pressure in bar, and P_s is suction pressure in bar. Fouling will cause the compressor head to increase (Jasmani et al., 2012).

The same equation can be applied to polytropic head, by replacing ratio of specific heats, k with polytropic coefficient, n. Equation of state such as Redlich Kwong and Benedict-Webb-Rubin can be used to obtain the natural gas properties. The final selection of the equation of state will depend on the actual gas properties and process conditions and the most critical thing is to maintain consistency between all phases of testing and analysis (Jasmani et al., 2012).

System efficiency is the ratio of useful work to total work supply into a system (Çengel & Boles 2004). For the case of centrifugal compressors, energy is required to increase pressure to a desired point. However, the energy is also increasing the gas temperature. Therefore, compressor efficiency is the ratio of useful pressure work to total work. It provides a good indication of overall compressor performance. Lower compressor efficiency means less effectiveness in compression process and additional energy losses due to fouling, recirculation, or seal leakage (Jasmani et al., 2012). Compressor efficiency, like compressor head, can be expressed either in isentropic form or polytropic form:

$$\eta_{isen} = \frac{\left(\frac{P_d}{P_s}\right)^{\frac{k-1}{k}} - 1}{\left(\frac{T_d}{T_s}\right) - 1} \times 100\% \qquad (2.2)$$

where η_{isen} is isentropic efficiency in %, P_d is the discharge pressure in bar, P_s is the suction pressure in bar, k is the ratio of specific heat, T_d is the discharge pressure, and T_s is the suction pressure.

Gas power can be defined as the amount of energy required to compress a volume of gas to a specific discharged temperature and pressure (Gresh, 2000):

$$\text{Power}_{\text{gas}} = \frac{\dot{m}_{act} \times h_{isen}}{\eta_{isen}} \qquad (2.3)$$

where $\text{Power}_{\text{gas}}$ is the gas power in kW, $\dot{m}_{act}$ is the actual mass flow rate in kg/s, h_{isen} is the isentropic head in kJ/kg, and η_{isen} is the isentropic efficiency in %.

As denoted in Equation 2.3, gas power is a function of inlet gas actual mass flow rate, compressor head, and compressor efficiency. It is expressed in Watts. This parameter provides an indication whether the compression process is consuming more power than it should. Note that for gas power, the compressor head and efficiency used must be consistent, as different result will occur if it is not observed. According to Jasmani et al. (2012), fouling in compressor causes the gas power to be increased.

2.3 Deterioration Mechanisms

According to Kurz and Brun (2000), there are three major mechanisms in performance deterioration, namely mechanical damage, fouling or blockage, erosion and corrosion. Mechanical damage occurs due to cracking of internal gas path components or caused by external upstream devices, for example, filters. This deterioration mechanism is not suitable for performance monitoring from medium to long term. It is because the mechanism will induce great vibrations drastically and causing compressors to be shutdown automatically.

When a centrifugal compressor operates in natural gas, there are contaminants such as free liquids, wax, and sand alongside the various components in the natural gas itself (Kurz and Brun, 2000). Some of these matters will settle inside the compressor, particularly the rotor and stator and form layers, like shown in Figure 2.4. This phenomenon is called fouling or blockage. It restricts the gas path flow and alters the gas inlet and exit angles at the impeller vanes (Meher-Homji et al., 1993). This promotes extreme turbulence as a result of flow separation in the impeller and diffuser. Consequently, the head produced, compressor flow capacity, and compression efficiency decrease. At the same time, gas discharge temperature, gas power required, and vibrations also increase (Boyce, 1993).

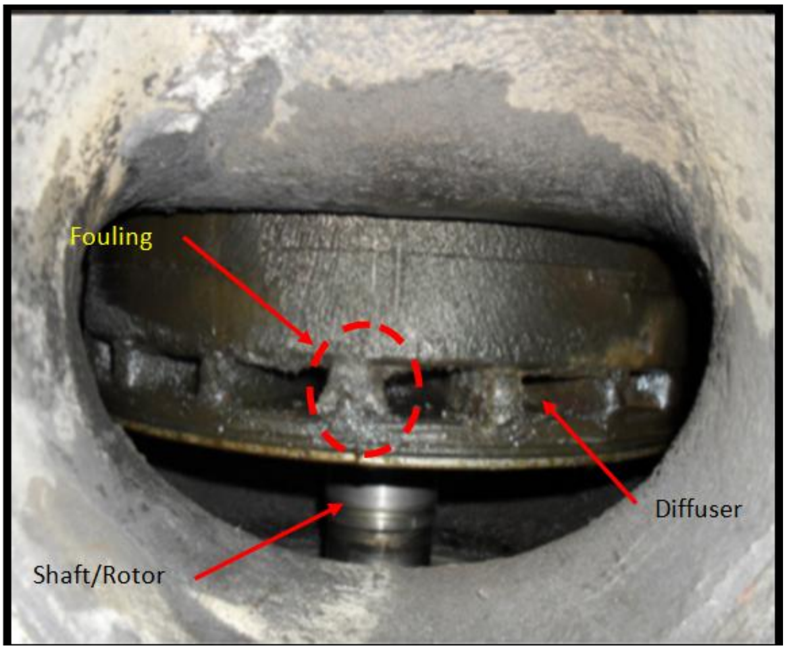

Figure 2.4: Fouling at diffuser of a centrifugal gas compressor (PETRONAS, 2010)

Erosion is caused by impingement of free solids or liquids onto either the compressor stationary or rotating parts. Ghenaiet et al. (2002) stated that erosion is crucial in sandy or dusty environment. It is caused by the ingestion of sand particles into compressor and erosion normally occurs at blade leading edge and tip. An example of eroded vane inlet can be observed in Figure 2.5. Erosion also increases the surface roughness of the affected area. The flow vectors of the impellers will be disturbed due to the changes in the dimensions. This will lower the compression efficiency and head produced. Rotor imbalance can occur at severe level of erosion due to metal loss. It will lead to high radial vibrations and erode the internal seals or damage the bearings. On the other hand, corrosion is caused by presence of water or other corrosive agents like carbon dioxide, mercury, or hydrogen sulfide, in natural gas (Denton and Johnson, 1976).

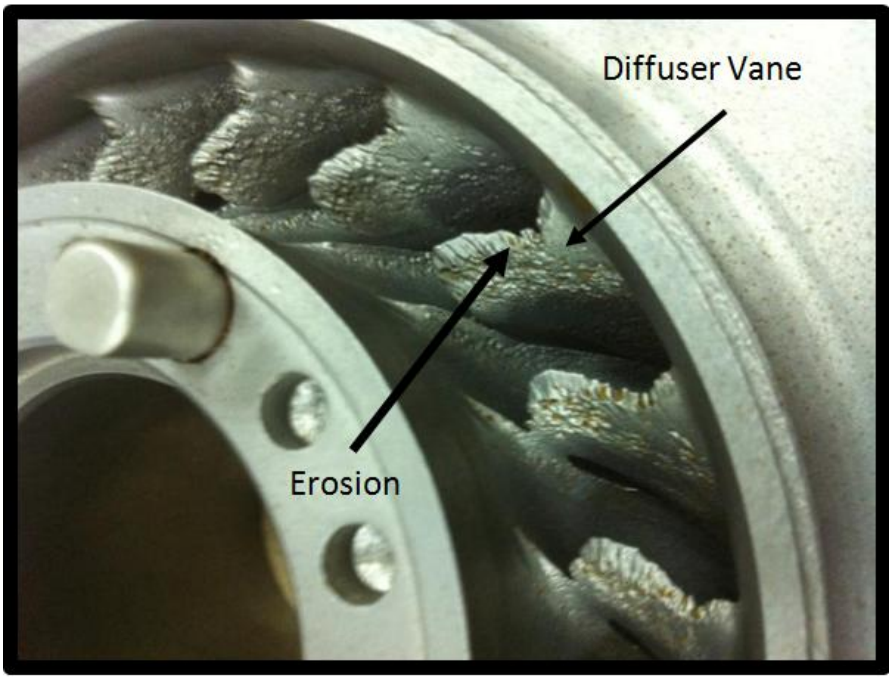

Figure 2.5: Erosion at vane inlet (PETRONAS, 2010)

Jasmani et al. (2012) suggested two more deterioration mechanisms which are increased internal recirculation, and surge events. Surging can produce severe vibrations and damage the compressor interior. The rotor axial trust will be altered when the labyrinth or honeycomb seals at the balance piston or disk are eroded.

Surge events can also cause the dry gas seal to leak at high rate as a result of pressure imbalance at the discharge side (Charchalis and Korczewski, 1997). Internal recirculation is the leakage caused by increased labyrinth seal clearances. Song and Song (2002) stated that labyrinth seals reduce leakage through gap between rotating and stationary components, and study on labyrinth seals is still lacking. Denton and Johnson (1976) has proven that leakage mass flow increase linearly with sealing gap in their study. According to Akhtar (2006), higher internal leakages will result in flow distortion within 15-20% range. It will reduce the net flow in the process by the same amount due to increase of internal flow into the choke region. This effect will be greater in multi-stage compressors where performance losses are contributed from a number of impellers, interstage seals, and balance pistons. Figure 2.6 illustrates an effect of surging on centrifugal compressors.

Figure 2.6: Dry gas seal damage due to surging (PETRONAS, 2010)

2.4 Fouling

Fouling is defined as the accumulation of dirt, scale, corrosion products or other material on surfaces (Melo et al., 1987). Fouling has many effects, particularly adverse in nature. Melo et al. (1987) stated the two effects of fouling, one of which is reducing heat transfer of the surface by increasing the heat transfer resistance through increase in thickness and increase in overall thermal conductivity. Next is the reduction in flow passage area due to wall depositions, together with the rough surface of foulant, which raises the pressure drop between downstream and upstream of a compressor. Yu (2007) added that fouling increases the capital investment. This is due to more materials needed for the compressor construction, i.e. increasing flow area and injection equipment for anti-foulant. Besides that, fouling also increases operational cost. Thermal inefficiencies as well as pressure drop increase lead to higher energy consumption. According to Müller-Steinhagen (2000), fouling causes higher maintenance cost as a result of local corrosion and additional cleaning systems. In addition, loss of production is also an effect of fouling. It is due to deteriorating product quality, inability to meet operational demands, and also downtime for cleanup. Bott (1995) stated that fouling causes the need for remedial action, and this incurs costs, i.e. introduction of anti-foulant and chemicals to clean fouled surfaces. Curlett and Impagliazzo (1981) studied the economics effect of fouling and found out that the cost penalty due to fouling is substantially high for heavily fouled equipment.

In general, fouling can be classified into five categories, based on the principal process that gives rise to the phenomenon (Müller-Steinhagen, 2000). They are crystallization, particulate, chemical reaction, corrosion, and biological fouling or biofouling. Crystallization fouling involves the crystallization of dissolved species from solution onto a surface when process conditions lead to supersaturation of the dissolved inorganic salts at the surface, which is often referred to as scaling. It also occur when deposits are formed on surfaces by freezing a liquid or a high melting point constituent of a multi-component fluid onto the subcooled surface, which is normally referred to as solidification or freezing fouling. Particulate fouling is defined as the deposition of particles suspended in liquid onto surfaces. Suspended particles may include pollutant/species always present in the feed stream or products of the chemical reactions occurring within the fluid. Chemical reaction fouling includes deposits that are formed at the surface as a result of chemical reaction within the process fluid. The surface is not a reactant, although it may act as a catalyst. In corrosion fouling, the equipment material reacts with the fluid to form corrosion products on the surface. This classification is restricted to in situ corrosion processes. Ex situ corrosion may result in either precipitation or particulate fouling, depending on whether corrosion products are soluble or insoluble at the process fluid conditions. Biofouling refers to the development and deposition of organic films consisting of micro-organisms and the attachment and growth of macro-organisms.

According to Yu (2007), there are four different fouling curves, namely linear curve, decreasing rate curve, asymptotic curve, and saw tooth curve as shown in Figure 2.7. For linear curve, the fouling resistance increases linearly with time. This is observed for very hard scales with high adhesion and indicates constant deposition rates. For decreasing rate curve, the fouling resistance also increases with time but at a decreasing rate. This behaviour is found for scales with low mechanical strength and resulting in falling deposition rate. When the fouling resistance eventually reaches a constant value, it is represented by asymptotic curve. Finally, the saw tooth curve is observed when the deposited material is rapidly removed due to periodic changes of the conditions.

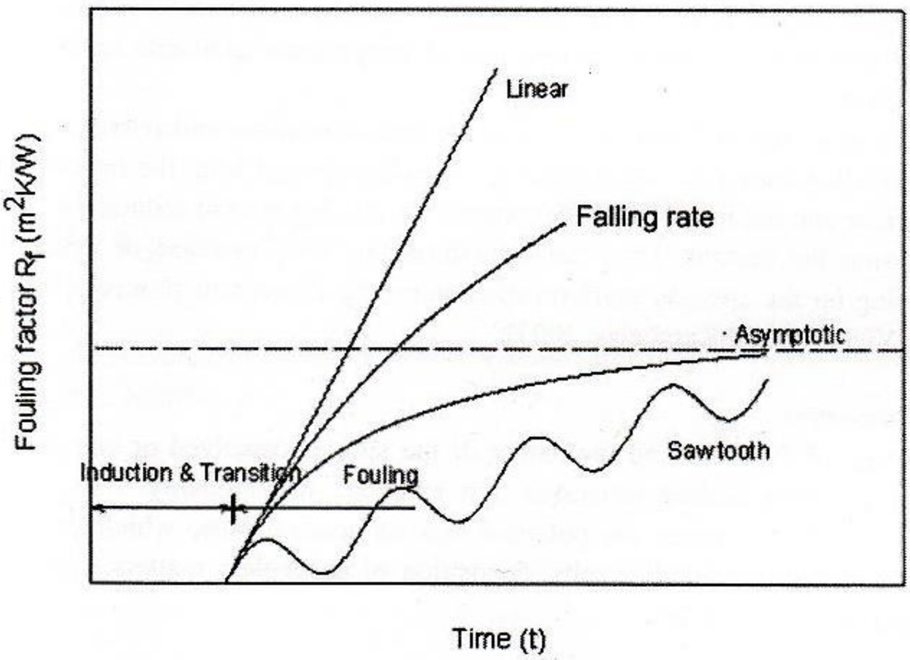

Figure 2.7: Possible fouling resistance versus time curves (Yu, 2007)

Yu (2007) stated that overall fouling process can be viewed as consisting of five sub-processes, namely initiation, transport to surface, attachment, removal, and aging. Conditions that promote subsequent fouling are established during the initiation period. For example, nucleation sites for crystallization or nutrients for biological growth are developed. Transport to surface involves mechanisms that contribute to foulant migration to the surface including diffusiophoresis, turbulent diffusion, thermophoresis, brownian diffusion, electrophoresis, and gravity. In attachment, factors that may influence the adhesion of foulant are van der Waals forces, electrostatic forces, and external force fields at wall. Removal of foulant may occur as a result of spallation, erosion or dissolution, which may or may not begin soon after initial layer is deposited. Aging of the deposit starts as soon as it has been attached on the surface. The process of aging includes changes in the crystal and chemical structures of foulant by dehydration, polymerization, and developing thermal stress, which may affect the strength of the deposit and hence the removal process. Aging is the least investigated step and is usually ignored in the modelling studies.

2.5 Measurement Parameters

The measurement parameters of a gas compressor can be categorized into five types, namely ambient and operating conditions, derived parameters, advanced measurements, standard measurements, and provisional measurements (Jasmani et al., 2010). Ambient and operating conditions measurements are measurements that have no relationship to component degradations. These measurements can be used to do corrections to all measurement data (Urban, 1980). Due to no existence of correlation between these parameters with component degradation, they will not be included for this project. The parameters that could not be physically measured, but can be derived from directly measured parameters are grouped in derived parameters. These are usually performance related parameters, and should be included in this project.

Measurement parameters that cannot be practically and accurately measured, mainly due to technological limitations, fall in advanced measurements category (Jasmani et al., 2010). These will not be used in the project because they are related to invention of new sensor, not involving existing sensor. Standard measurements are measurement parameters which the related sensors are normally installed by the original equipment manufacturer (OEM). They consist of compressor controls and safety protections sensors. This type of measurement parameters should be used in compressor diagnostics because it is readily available and avoid unfavourable modifications.

If a measurement parameter does not fall into any of the categories mentioned above, it can be classified as provisional measurements. This type of measurement parameter may be suitable for centrifugal compressor diagnostics, depending on the scope of study (Urban, 1980).

2.6 Diagnostic Methods

A diagnostic tool is developed using a diagnostic method or in combination of two or more methods. There are five classes of diagnostic methods, namely Gas Path Analysis (GPA), Genetic Algorithm (GA), Artificial Neural Network (ANN), expert system, and fuzzy logic (Li, 2002). GPA is introduced by Urban in 1967 (Urban, 1967). This method establishes relationship between engine measurable parameters differentials and immeasurable component parameter differentials at a particular engine operating condition, and it is expressed with a linear influence coefficient matrix (ICM):

$$\Delta\vec{z} = H \,.\, \Delta\vec{x} \tag{2.4}$$

where $\Delta\vec{z}$ is engine immeasurable parameter differential vector, H is influence coefficient matrix, and $\Delta\vec{x}$ is engine measurable parameter differential vector.

The method is simple and provides quick solutions to gas turbine diagnostics (Li, 2002). GPA is applied in gas turbine condition monitoring and multiple fault diagnosis (Urban, 1972, and Urban, 1974). Throughout the years, GPA has undergone several improvements particularly in exploring optimal estimation theory (Gelb, 1975) (Bryson and Ho, 1975). Such advancements include the implementation of weighted-least-squares (Lunderstadt and Fiedler, 1988), maximum-a-posteriori (Volponi, 1982), and Kalman Filter (Lupold et al., 1989, and Provost, 1988).

A neural network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use (Haykin, 1999). The application of ANN with GPA in fault diagnosis is demonstrated by Torella and Lombardo (1995). Kobayashi and Simon (2001) applied a feed forward network in their hybrid diagnostic technique, where the neural networks were used to estimate engine health parameters, while Genetic Algorithm is used for sensor bias detection and estimation. Kanelopoulus et al. (1997) have reported the advantages of ANN in terms of computational time and adaptation to a particular engine for accurate diagnosis.

Genetic Algorithm (GA) is applied as an effective optimization tool to obtain a set of engine component parameters that are used to produce a set of predicted engine dependent component parameters through a non-linear gas turbine model that best matches the measurement (Li, 2002). Three operations are typically used in GA. Selection operation chooses the strings for the next generation according to a "survival of the fittest" criterion. Crossover operation allows information exchange between strings in the form of swapping of parts of the parameter vector in an attempt to get fitter strings. Finally, mutation operation introduces new or prematurely lost information in the form of random changes applied to randomly chosen vector components. Gulati et al. (2000) and Gulati et al. (2001) combined a multiple point diagnostic approach (Stamatis et al., 1991) and GA approach (Zelda and Singh, 1999). The result is a GA, model-based multiple operation point analysis method for gas turbine fault diagnostics.

An expert system, a subset of knowledge system, is a computer program that represents and reasons with knowledge regarding some specialized subject with a view to solving problems or giving advice (Li, 2002). It is built by assembling a knowledge base which is then interpreted by an inference engine. As shown in Figure 2.8, an empty knowledge base comes from a program called shell. The end user of the application interacts with the shell via the inference engine, which uses the knowledge put in the knowledge base to answer questions, solve problems, or offer advice (Jackson, 1999).

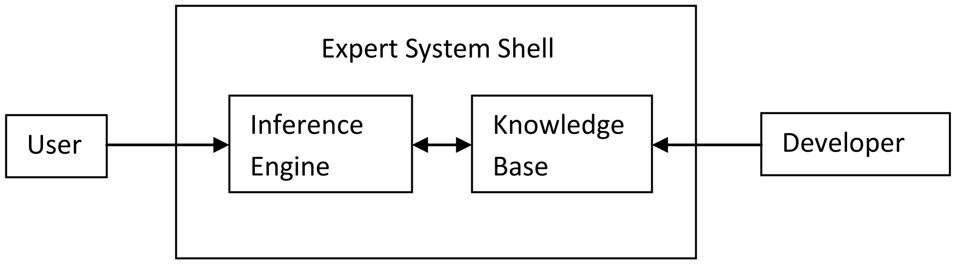

Figure 2.8: Configuration of an expert system (Li, 2002)

Doel (1990) claimed that the expert systems were not going to make jet engine diagnostic and maintenance procedures "smart" but they could add a lot of new capability that will make them more effective and more convenient. This method is being used in gas turbine diagnostics by Vivian and Singh (1995), Torella (1997), Charchalis and Korczewski (1997), and Pettigrew (2001). Meher-Homji et al. (1993) described a hybrid expert system and algorithm approaches were utilized for gas turbine condition monitoring and diagnostics. The declaration of a fault by the inference engine is normally done by comparing engine component deviations with predefined thresholds.

Fuzzy logic is a method to formalize the human capability of imprecise reasoning. Such reasoning represents the human ability to reason approximately and judge under uncertainty (Ross, 1995). It provides a system of non-linear mapping from input vector into a scalar output (Kosko, 1997). From Figure 2.9, a typical fuzzy logic system involves fuzzification, fuzzy inference and defuzzification by using a fuzzifier, an inference engine and a defuzzifier respectively. A fuzzifier maps crisp input numbers into fuzzy sets characterized by linguistic variables and membership functions. An inference engine maps fuzzy sets to fuzzy sets and determines the way in which the fuzzy sets are combined. A defuzzifier is sometimes used when crisp numbers are needed as an output of the fuzzy logic system. Combined with expert systems, ANN, GA or GPA, fuzzy logic can be used for gas turbine diagnostics. Fuster et al. (1997) introduced knowledge based-fuzzy logic hybrid system for gas turbine fault diagnostics. The uncertainty of the component parameters was expressed by fuzzy logic likelihood value and the fault symptoms were described as *True* or *False*. Tang et al. (1999) presented a fuzzy logic reasoning together with a neural network for a jet Engine condition Monitoring and fault Diagnosis (EMD) system that classifies all possible faults into three categories: gas path components, instrument sensors, and rotor or oil subsystem. Three operations (AND, OR, and NOT) were used in its inference engine.

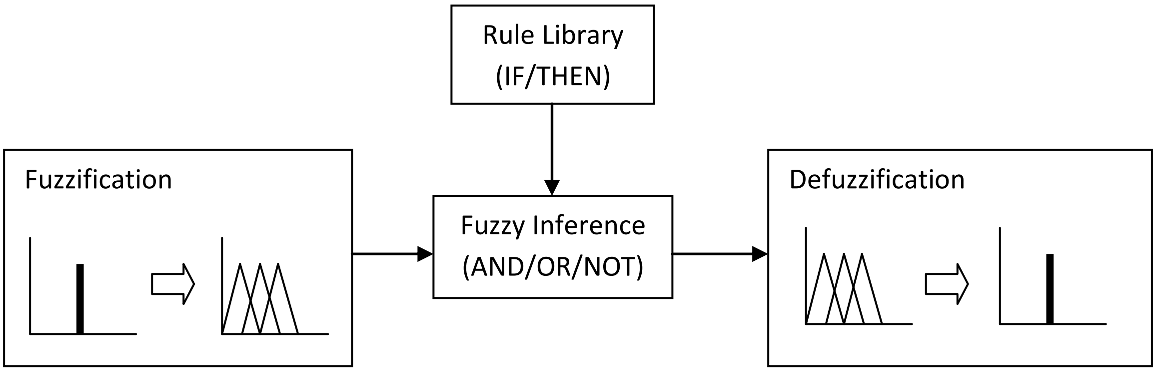

Figure 2.9: Configuration of a rule-based fuzzy logic expert system (Li, 2002)

CHAPTER 3

METHODOLOGY

3.1 Overview

There is a limitation in the availability of equipment as this study requires centrifugal compressors in operation. Hence, UTP is working in collaboration with PETRONAS Carigali Sdn. Bhd. to provide the necessary equipment, data, and expertise in relation to this study. The study involves two Solar C-16 centrifugal compressors coupled with Solar Centaur-40 gas turbines onboard Dulang offshore production platform in South China Sea operated by PETRONAS Carigali Sdn. Bhd. The compressors are used for well gas lifting. There are three stages in each turbine, namely Low Pressure Compressor (LPC), Intermediate Pressure Compressor (IPC), and High Pressure Compressor (HPC).

Initially, relevant document regarding a particular gas compressor is compiled and studied. Information of interest are product specifications, operating specifications, and maintenance history. From these documents, study is done to look for what defect happens at what condition or reading pattern. This became the base to develop the software.

The project starts with identifying the components of the system. This is to help in understanding the gas compressor system. Then, both the variable and fixed parameters are determined. These parameters are the ones that the operator can manipulate while the fixed parameters are the parameters that cannot be changed and can only be seen, but may change due to change of variable parameters. After determining the parameters and studied the related documents, an algorithm for the proposed software is created. The operation of the software starts with the gathering of readings from the proposed gas compressor. These readings are then compared with existing readings in the database. Based on this, the software will generate the desired result and suggest the steps to be taken by the engineer or operator. Once the software is ready, it will be validated by using the old database. If it is valid, the software is complete. Otherwise, the algorithm will be revised and the software is tested again. Figure 3.1 illustrates the process flow of the project.

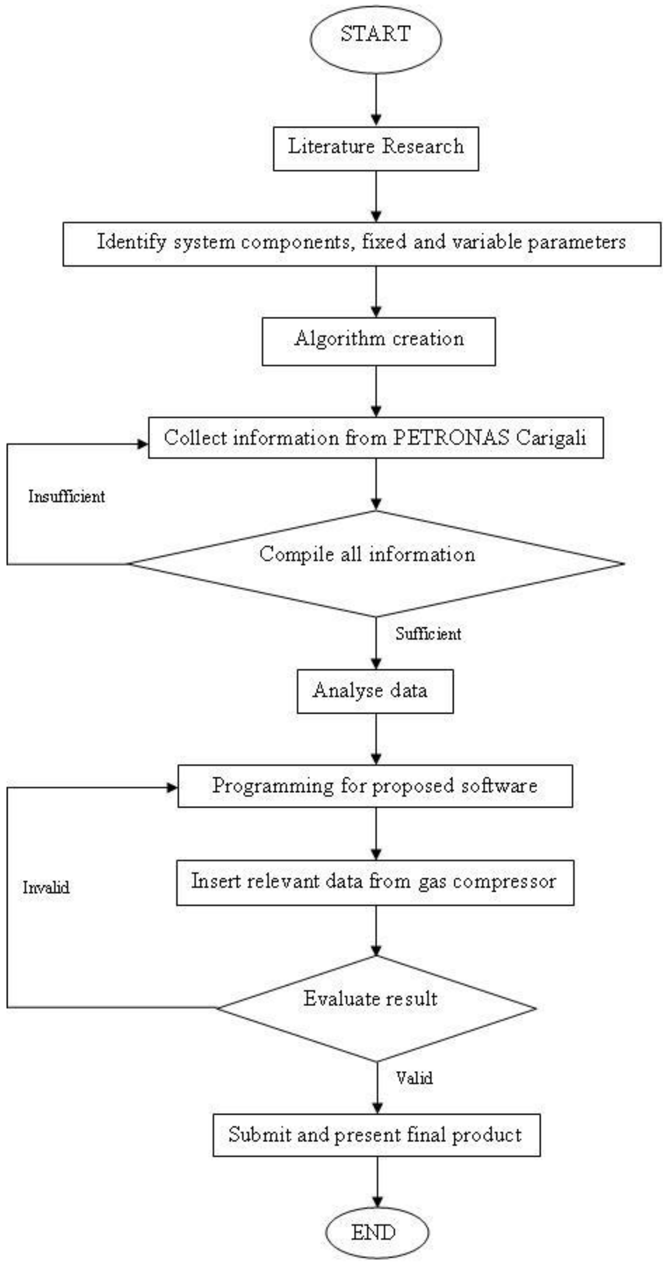

Figure 3.1: Process flow chart

3.2 Gantt Chart

The project is divided into two semesters. For the first semester, the author begins by attending briefing on Final Year Project and selecting title. After the title has been approved, he gathered information pertaining to the project, while selecting the appropriate method and tools or software to be used. In the second half of the first semester, the author performed data analysis and started on software programming. The author is deemed to submit extended proposal in Week 6 as well as interim report in Week 14. Figure 3.2 shows the Gantt chart of the project for the first semester.

No.	Tasks	Start	End	Week Number															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Briefing and Title Selection Confirmation	26/1	14/2																
1.1	Briefing	3/2	3/2																
1.2	Submission of Form 01	8/2	8/2																
1.3	Title Approval	14/2	14/2																
2	Gathering Information	8/2	29/2																
2.1	Research and Gathering Information	8/2	29/2																
2.2	Tools/Software and Method Selection	14/2	20/2																
2.3	Extended Proposal Submission	29/2	29/2																
3	Software Development	5/3	6/7																
3.1	Data Analysis	5/3	27/3																
3.2	Software Programming	30/4	6/7																
3.3	Interim Report Submission	25/4	25/4																

Figure 3.2: Gantt chart for Semester I

In second semester of the project, the author has completed his software programming and testing by end of Week 14. Based on Figure 3.3, the author is required to submit progress report in Week 9, technical paper in Week 13, and dissertation in Week 16. Besides that, he is also required to deliver a presentation in Week 11 and also in Week 15.

No.	Tasks	Start	End	Week Number															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Software Development	5/3	17/8	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
1.1	Software Programming	30/4	27/7	■	■	■	■	■	■	■	■	■	■						
1.2	Software Validation	23/7	17/8											■	■	■	■		
2	Dissertation Submission and Presentation	9/7	29/8									■	■	■	■	■	■	■	■
2.1	Progress Report Submission	11/7	11/7									■							
2.2	Pre-Edx Presentation	25/7	25/7											■					
2.3	Technical Paper Submission	8/8	8/8													■			
2.4	Oral Presentation	22/8	22/8															■	
2.5	Dissertation Submission	29/8	29/8																■

Figure 3.3: Gantt chart for Semester II

3.3 Knowledge Based System

The knowledge based system, also known as knowledge system, can be defined in many ways depending on the context. According to Stefik (1995), it offers the following seven meanings relevant to the purpose.

i. A clear and definite perception of something; the act, fact or state of knowing; understanding.

ii. Learning; all that has been perceived or grasped by the mind.

iii. Practical experience; skill; as knowledge of seamanship.

iv. Acquaintance or familiarity such as with a fact or place.

v. Cognizance; recognition.

vi. Information; the body of facts accumulated by mankind.

vii. Acquaintance with facts; range of awareness or understanding.

All these definitions are concentrating on the intermediate rational agent generated by knowledge to address the objectives of the project. The rational agent may be human or software that is able to execute a certain task in a certain domain logically. The term expert system refers to a computer system whose performance is guided by specific, expert knowledge (Stefik, 1995). It indicates that the computer has the same ability as the highest level of competency for human or better. Hence, the expert system will reflect the reliability and consistency in the results. In view of flexibility however, human experts is more preferable.

Stefik (1995) referred knowledge system as a computer system that represents and uses knowledge to carry out task. The interesting part is how to manipulate and deliver the knowledge through an integrated system that will be presented to the end user. Based on Figure 3.4, the classical formulation of knowledge based system consists of the knowledge base, two interfaces, and the search system where the inference is located. These elements may be blended or overlapped to suit the desired system.

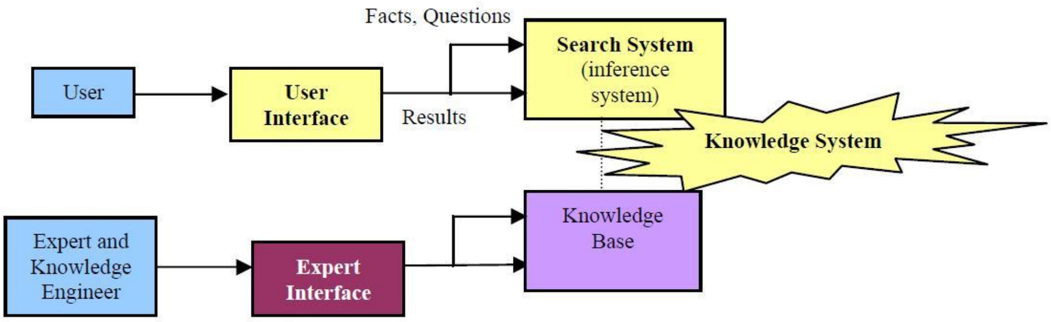

Figure 3.4: Classical characterization of knowledge system (Stefik, 1995)

Each particular component has its own vital role in knowledge system described as follows (Stefik, 1995):

i. Knowledge base – the repository for the knowledge used by the system (the rules and hints for guiding the search for solution).

ii. User interface – the part of a knowledge system that interacts with the system's primary users.

iii. Expert interface – interface by which knowledge is entered into the system. The expert interface is used by a knowledge acquisition team consisting of an expert and a knowledge engineer.

iv. Inference engine – the inference subsystem is the component that reasons its way to solutions of problems, with its search guided by the contents of the knowledge base. This part in knowledge system must include provisions for goal setting, representing and recording intermediate results, and managing memory and computational resources.

There are always ambiguity perceptions in using the word of data, information and knowledge. They seem to have the similar meaning and always being used interchangeably but the fact is that they definitely have different meanings. The worlds of knowledge engineering, information technology, or data technology need the clarity by definition to avoid misinterpretation in delivering knowledge. The differences of these words are defined by Schreiber et al. (2000) as shown in Table 3.1.

Table 3.1: Definitions of data, information and knowledge

Data	➢ The uninterpreted signals that reach our senses every minute by the zillions.
Information	➢ Data equipped with meaning.
Knowledge	➢ The whole body of data and information that people bring to bear to practical use, in order to carry out tasks and create new information.

Knowledge for some people may be data for others (Schreiber et al., 2000). For instance, an expert in computer system deals with binary numbers, therefore should understand what information the binary numbers carry and able to grasp the knowledge of the information. On the other hand, a mechanical engineer perceives the binary numbers as only data and cannot understand the information and therefore cannot grasp the knowledge represented by the binary numbers.

The benefits of the development of knowledge system are the result of advancement in computer and artificial intelligence. With the development in computer and artificial intelligence, more tasks can be achieved at a faster rate with higher reliability. According to Schreiber et al. (2000), the three main benefits of knowledge system are faster decision making, increased productivity, and increased decision making quality. Since the benefits of knowledge system outweigh the cost to develop it, it is worthwhile to concentrate on the development of knowledge system. This is parallel with the strategy of achieving higher productivity in plant operation.

3.3.1 Knowledge System Terminology

Before going in depth to knowledge based system, there are some terminologies that should be known and understood (Schreiber et al., 2000):

- Domain: A domain is some area of interest. In respect to this project, the domain is gas compressor diagnostic program.
- Task: A task is a piece of work that needs to be done by an agent. In view of this project, task that shall be performed by the knowledge system is to diagnose a gas compressor.
- Agent: An agent is any human or software system able to execute a task in a certain domain. The agents in this project are Microsoft Excel and Microsoft Visual Basic software.
- Application: An application is the context provided by the combination of a domain and a task carried out by one or more agents. In respect to this project, the application is the whole knowledge system for gas compressor diagnostic program that was developed.
- Application domain/task: These two terms are used to refer to the domain or task involved in a certain application.
- Knowledge system: Two main components are a reasoning engine (inference) and a knowledge base. In view of this project, the inference engine is the rule that is being used.

- Expert system: It can be defined as a knowledge system that is able to execute a task that, if carried out by humans, requires expertise. For this project, the knowledge system has not yet fulfils the criteria of expert system.

3.3.2 Domain Knowledge

The domain knowledge relies on the main static information and knowledge objects in an application domain. Normally there are two parts of domain knowledge, namely domain schemas and knowledge bases. Schreiber et al. (2000) defines domain schema as a schematic description of the domain specific knowledge and information through several number of type definitions, while instances of the types specified in a domain schema is contained in a knowledge base.

Domain Schema Specification

The knowledge model provides a set of modelling constructs to specify a domain schema of an application. In practice there are three main modelling constructs, namely concepts, relation, and rule (Schreiber et al., 2000).

- Concepts: A concept describes a set of objects or instances which occur in the application domain and share similar characteristics. The notion of concept is similar to what is called class or object class in other approaches.
- Relation: Relations between concepts are defined with the relation or binary relation construct. Relations can be used in the standard entity-relationship fashion, but can also be used for more complicated type of modelling.
- Rule: The dependency of a schematic form is a kind of natural rules, indicating a logical relationship between two logical statements. The logical statements in such rules are typically expressions about an attribute value of a concept. An example of rule type is “If…then…else”.

Knowledge base

A domain schema describes domain knowledge types, such as concepts, relations and rules. A knowledge base contains instances of those knowledge types. A knowledge base consists of two parts, which are uses and expressions (Schreiber et al., 2000). Uses slot defines which type of domain knowledge instances is stored in the knowledge base. Expressions slot contains the actual instances. Figure 3.5 shows the example of knowledge base (bubble sorting of processing time).

```
For counter2 = 0 To 8 Step 1
x = 8 - counter2
    For counter3 = 0 To x Step 1
        If intProsTime(counter3) > intProsTime(counter3 + 1) Then
        TempVar = intProsTime(counter3)
        intProsTime(counter3) = intProsTime(counter3 + 1)
        intProsTime(counter3 + 1) = TempVar

        TempVar = intJobNum(counter3)
        intJobNum(counter3) = intJobNum(counter3 + 1)
        intJobNum(counter3 + 1) = TempVar
        End If
    Next counter3
Next counter2
```

Figure 3.5: ‘Bubble Sort’ coding structure (Schreiber et al., 2000)

As a whole, the project will use rule type of knowledge based system to develop gas compressor diagnostic program.

3.4 Program Platform

The project uses mainly Microsoft Excel 2010. Microsoft Excel 2010 is a powerful spreadsheet tool for graph generation, and data computations. The software is used for data analysis and the creation of centrifugal compressor diagnostics software in this project. In data analysis, a list of formulae is inserted into Microsoft Excel 2010 and the results can be generated in terms of figures and charts or graphs for interpretation. For diagnostics software creation, an algorithm will be determined after all related information has been gathered and analysed. The project will use the form feature in Microsoft Excel 2010. When the diagnostics software is run, a Graphical User Interface (GUI) will appear instead of Microsoft Excel 2010 default window. When appropriate data is inserted by the user into the diagnostics software, results will be generated, such as performance indicators, rate of degradation, and estimated maintenance date.

Figure 3.6 exhibits the algorithm of the diagnostic program. In the proposed diagnostic program, a login window will be displayed at the beginning. User will enter the correct username and password to use the software. This acts as a protection for the software from unauthorized use. If the details entered are incorrect, he will need to re-enter the details. Next, a window describing the software will appear. The user will then see a window, whereby he needs to choose the database of systems that he would like to access. If he closes this window, he will exit the program.

Based on Figure 3.7, there are several options that the user can choose. If the user chooses *New*, he will enter a file name. If the file name is valid, a new database will be created. A user input window will be shown. On the other hand, if the user selects *Open*, he will choose an existing file that he wants to use for the program. Later, a user input window will appear. If *Delete* is chosen by the user, he picks a file that he wants to delete, and the file will be deleted permanently. The user will return to database selection window. Similarly, if the user closes the user input window, he will return to database selection window. In the user input window, user will insert several compressor data. This includes suction and discharge pressure, suction and discharge temperature, rotational speed, inlet standard flow rate, compressor model, and gas composition in terms of molar percent. Compressor running hours and remarks can also be entered into the program. It will be stored in the database and used as reference in the future. After that, the performance indicators and their deviations will be calculated. They are isentropic efficiency, isentropic head, and gas power. Table 3.2 gives the summary of input and output of the program.

Table 3.2: Program's input and output

Input	Output
• Suction Pressure, P_s • Suction Temperature, T_s • Discharge Pressure, P_d • Discharge Temperature, T_d • Actual Mass Flow Rate, $\dot{m}$ • Compressor Speed, N • Compressor Model • Gas Composition	• Isentropic Efficiency, η_{isen} • Isentropic Head, h_{isen} • Gas Power • Isentropic Efficiency Deviation • Isentropic Head Deviation • Gas Power Deviation

Figure 3.8 shows the process of calculating these performance indicators. From the compressor data given by the user, ratio of specific heats *k*, gas constant *R*, average compressibility factor z_{ave}, and molecular weight of the natural gas mixture MW, can be known. Subsequently, all of the data will be used in calculating isentropic efficiency, isentropic head, gas power, and their deviations. The formula can be found in Figure 3.8. If the database is new, the isentropic efficiency will be the same as its reference value, likewise the gas power. Then all the new data will be stored in the database. From the data available in the database, graphs of isentropic efficiency, isentropic head, and gas power against time will be created. Next, the results will be presented in a new window. As shown in Table 3.3, it consists of graphs of deviations of isentropic efficiency, isentropic head, and gas power against time, value of isentropic efficiency, isentropic head, and gas power corresponding to input data by user, and their deviations.

Table 3.3: Contents in program's results

Graphs	Values
• Isentropic Efficiency Deviation against Time • Isentropic Head Deviation against Time • Isentropic Efficiency Deviation against Time	• Isentropic Efficiency • Isentropic Head • Gas Power • Isentropic Efficiency Deviation • Isentropic Head Deviation • Gas Power Deviation

If the user closes this window, he will be returned to user input window. Furthermore, the result window has a section to estimate date for maintenance. The user selects one out of the three performance indicators available and set a limit in terms of percentage. The program will access the data in the database and produce an estimation based on extrapolation. The estimate date sub-process is presented in Figure 3.9. A date estimation will be displayed to the user and the user return to results window.

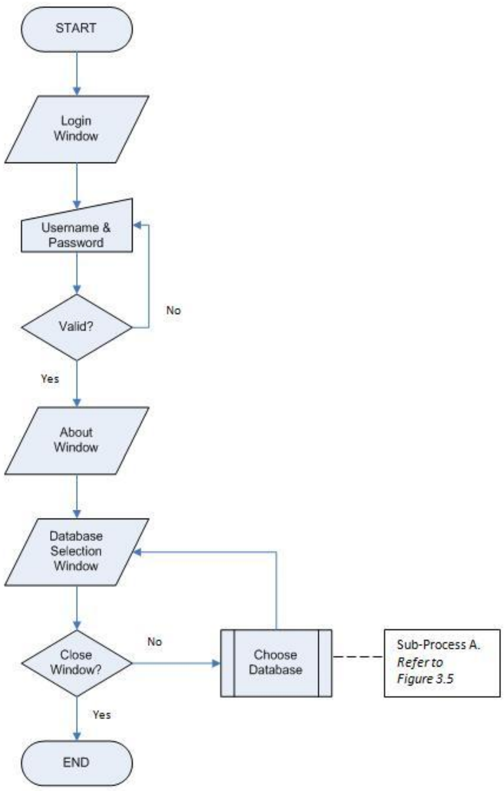

Figure 3.6: Diagnostic program algorithm (Main Process)

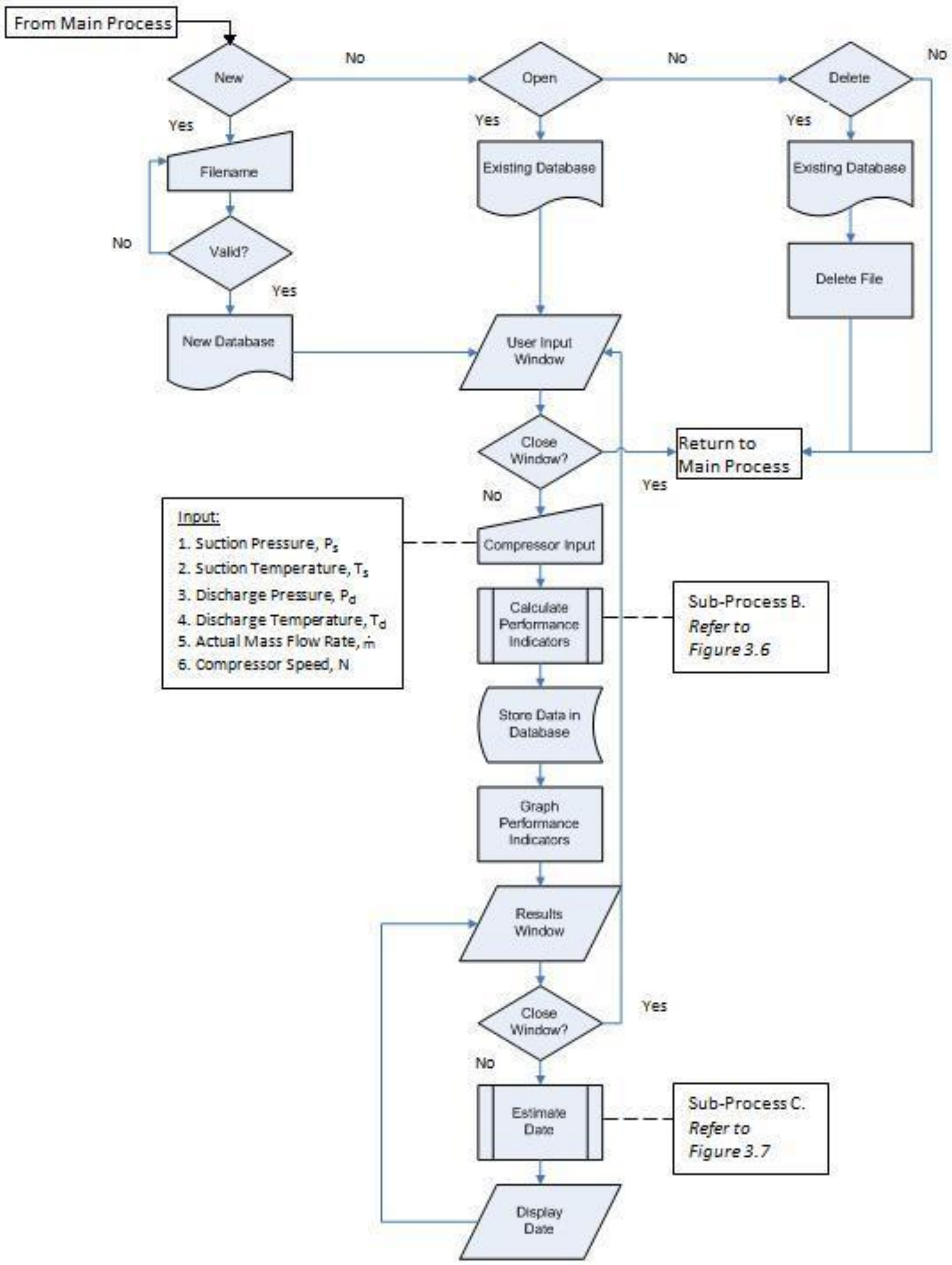

Figure 3.7: Choose Database Sub-process (Sub-Process A)

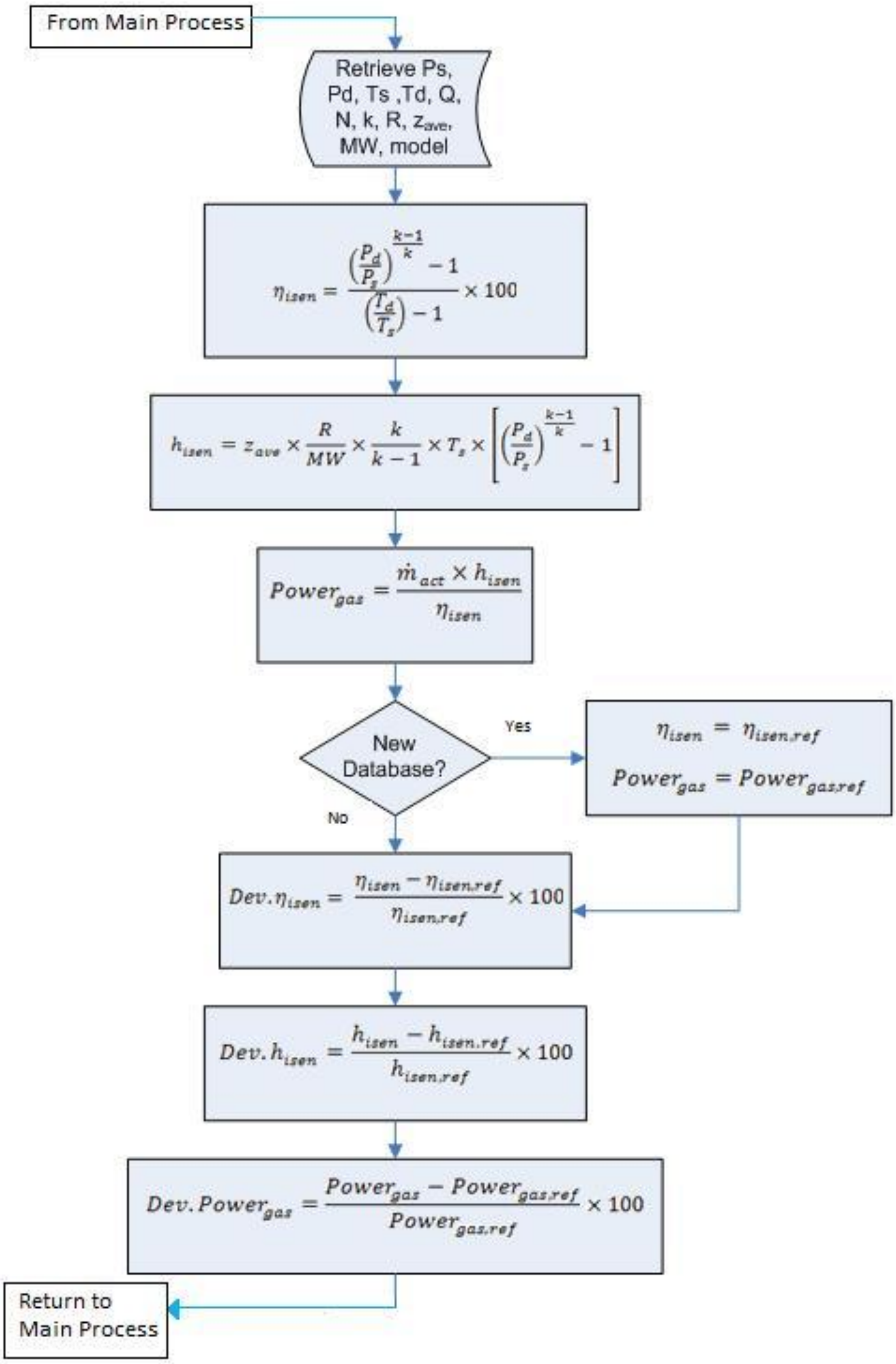

Figure 3.8: Calculate performance indicators sub-process (Sub-Process B)

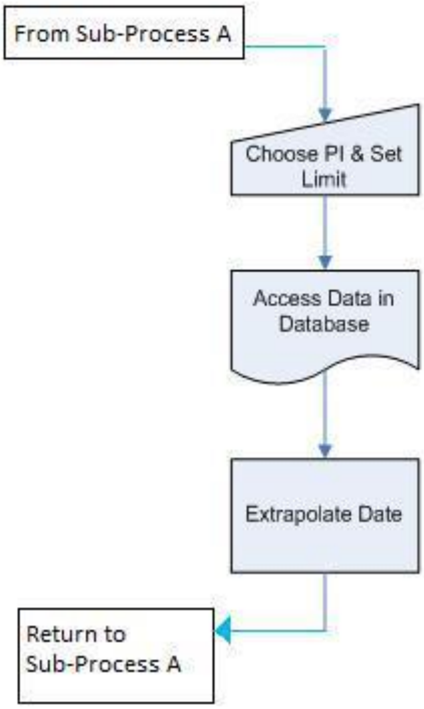

Figure 3.9: Estimate date sub-process (Sub-Process C)

Microsoft Visual Basic uses coding script to develop a program. The program coding script can be found in the Appendix.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Data Gathering and Analysis

The data is collected from PETRONAS Carigali Sdn. Bhd. They are organized and tabulated. Then, the organized data is processed to generate Locally Weighted Scatterplot Smoothing (LOESS) graphs. Based on the data gathered from the two centrifugal compressors, there are several observations that can be made. In low pressure compressor, both the isentropic head and isentropic efficiency shows decreasing trend. On the contrary, the gas power increases with time. From Figure 4.1, there is a sudden decrease in the gas power between 1/7/2010 and 15/10/2010.

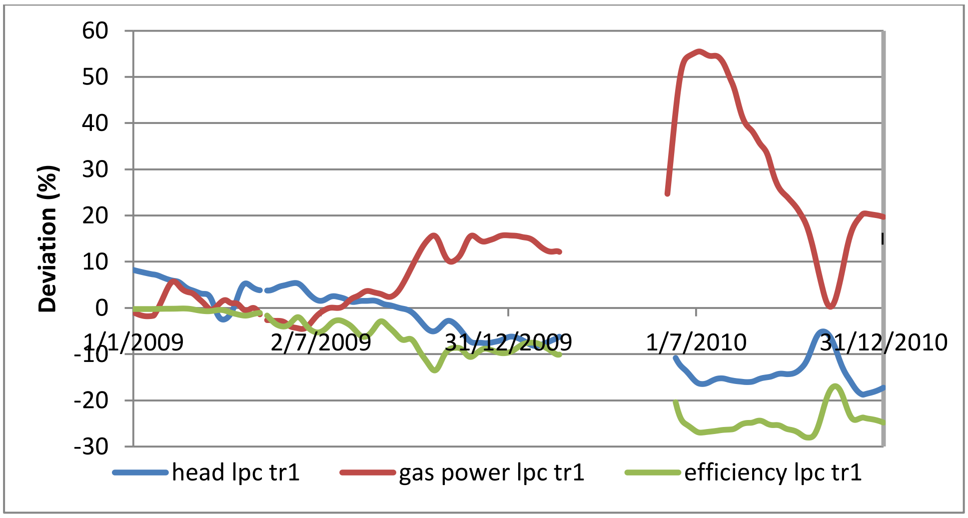

Figure 4.1: The LOESS graph of performance indicators for train 1 low pressure compressor

This is due to the declining in mass flow rate going through the compressor. The trends for all of the performance indicators are consistent for compressor and it is strong indication of fouling. Hence, the three performance indicators can be used to monitor deterioration level of low pressure compressor.

In intermediate pressure compressor, the trend for isentropic head, isentropic efficiency, and gas power are decreasing with time. Note that the value of all of the performance indicators in Figure 4.2 has risen on 1/6/2010. The reason for this is the intermediate pressure compressor has undergone replacement process from 28/3/2010 to 31/5/2010. The trend and correlation among the performance indicators are consistent and thus, the three performance indicators can be used to monitor the deterioration level of intermediate stage compressor.

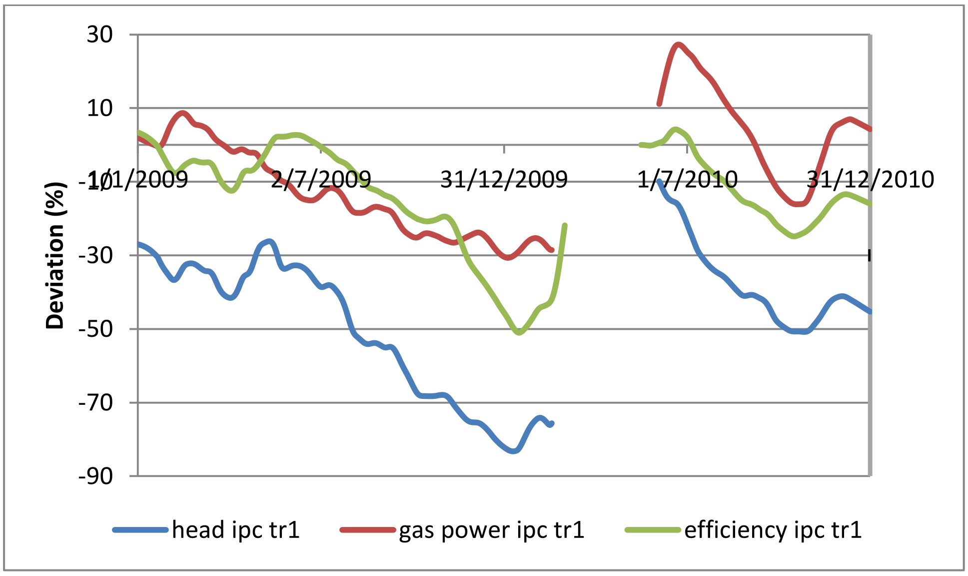

Figure 4.2: The LOESS graph of performance indicators for train 1 intermediate pressure compressor

On the other hand, the high pressure compressor has different trending in isentropic efficiency, isentropic head, and gas power. As shown in Figure 4.3, the trending and correlation among the performance indicators are inconsistent. This is due to high turbulence and the pressure ratio is considerably small. Therefore, it is not practical to monitor the deterioration of high pressure compressor solely based on the three performance indicators.

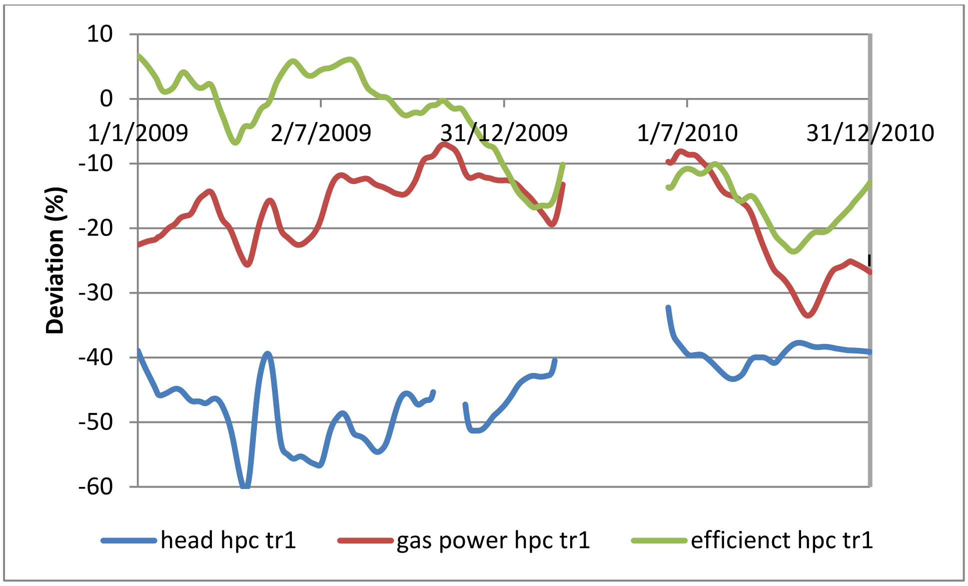

Figure 4.3: The LOESS graph of performance indicators for train 1 high pressure compressor

4.2 Program Feature

The author has developed a compressor diagnostic program named Performance Indicator Monitoring Program (PIMP). The program can be run in Microsoft Excel 2007 or its later versions. PIMP has the ability to calculate the performance indicators of centrifugal compressors from the data input by plant engineers based on thermodynamic analysis. The inputs are usually obtained from the display panel of a compressor or from the main control room. A database with compressor historical records can also be created by PIMP. It will be convenient for the plant engineers to have a database containing important data of a compressor for analysis and maintenance planning. PIMP is also capable of generating graph of deviations of performance indicators with the available database. Plant engineers can observe the trending of the performance indicators themselves and take the necessary actions. PIMP can give a date estimation for future maintenance based on one of the performance indicators' deviation.

4.3 Program Operation

The program starts by displaying a login window as shown in Figure 4.4. The user needs to enter the right username and password in order to access the program. If the user failed to enter the correct details, a message box will appear telling the user the entered details are incorrect. The user may try again. However, when the user close the window, PIMP will be closed as well, and the user need to reopen PIMP.

Figure 4.4: Login window

When the user has entered the correct details, and clicked on the *Login* button, another window will appear with description of PIMP as shown in Figure 4.5. The user will click on the *Next* button and a window as shown in Figure 4.6 is displayed prompting user to select database. There are several selections, which are *New*, *Open*, and *Delete*. If the user selects *New*, the user will insert the new file name as in Figure 4.7, and a new database will be created. The user will immediately reach the user input window of PIMP. If the user wishes to use existing database, he will click on *Open* button, select the desired database like in Figure 4.8, and the user input window of PIMP will be displayed. *Delete* button is used when the user wants to remove a database from the computer.

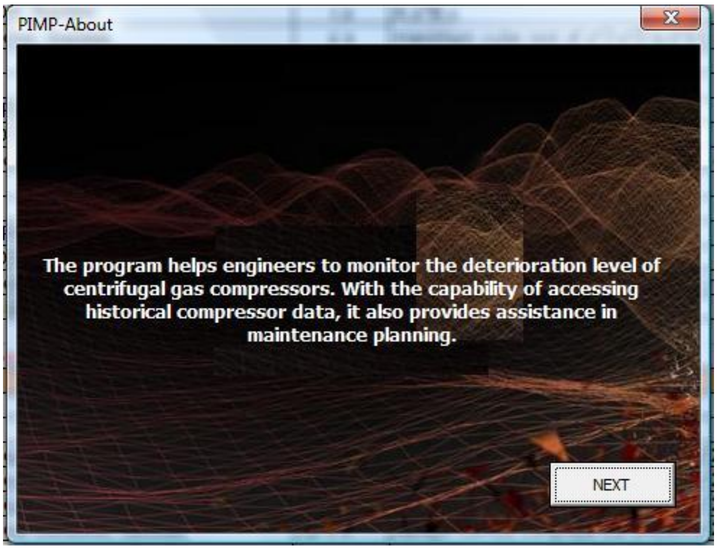

Figure 4.5: About window

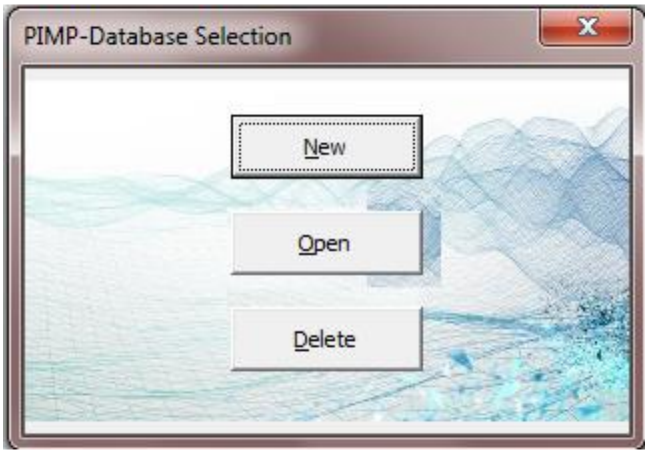

Figure 4.6: Database selection window

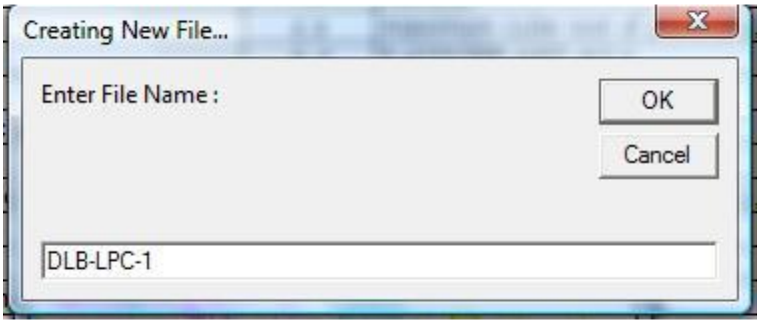

Figure 4.7: Creating new file window

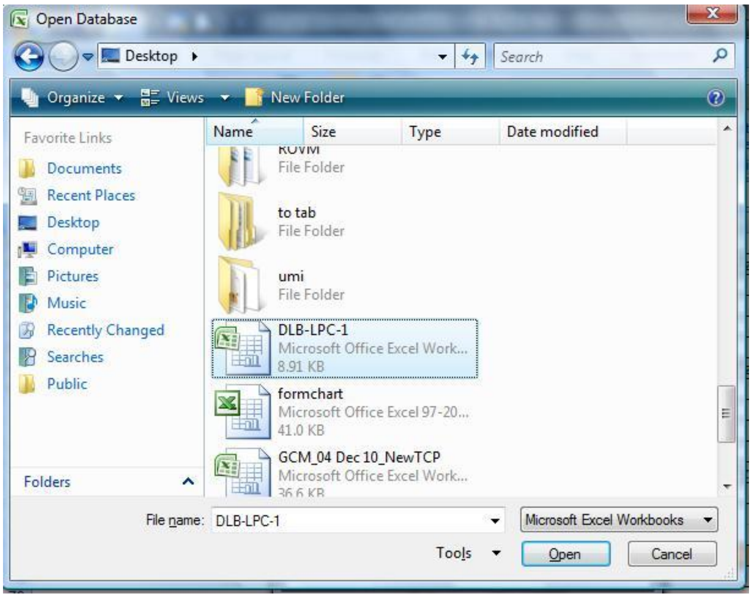

Figure 4.8: Open database window

In user input window, user will be prompted to enter the required data. This includes compressor parameters, gas composition and compressor performance map. In compressor parameters tab, the user need to fill in suction and discharge pressure, suction and discharge temperature, compressor speed, standard inlet gas flowrate, as well as date of data taken. The units available for pressure are kilopascal (gauge) and bar (gauge). User can choose between degrees Celsius and degrees Fahrenheit for temperature unit. Cubic meter per hour and kilo-cubic meter per hour are the optional units for standard inlet gas flow rate. In gas composition tab, the user will have to insert the mole percent of gas constituents. The constituents available under this tab are the common chemicals in oil and gas industry (Gas Processors Suppliers Association, 1977). Under compressor performance map, there are several compressor models that the user can choose from. When the user selects a compressor model, the associated compressor performance map is displayed. For newly created database, the user has to insert all data into PIMP. On the other hand, for existing database, the data for gas properties and compressor performance map is made available and it is taken from the latest set of data in the database. However, the user may change these data as he wishes. If the user ticks *under maintenance* check box, data will be taken from the latest data entry to be filled into the database. Figures 4.9 to 4.12 provide visuals of user input window. Once the data required is completely filled in, the user clicks on *submit* button. This will lead the user to results window.

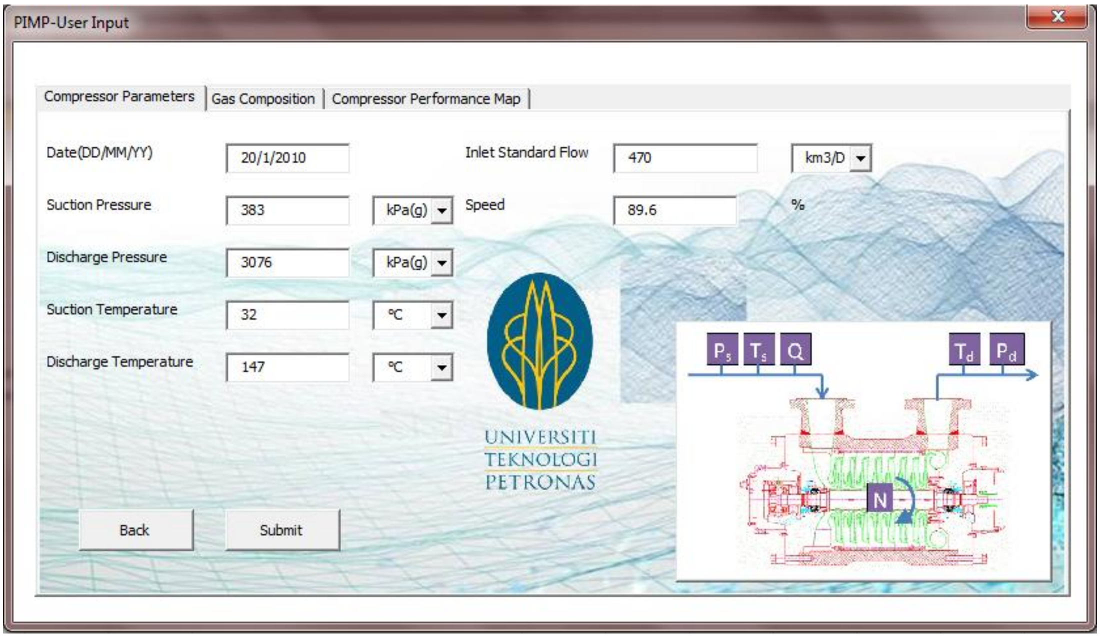

Figure 4.9: Compressor parameters tab in user input window for new database

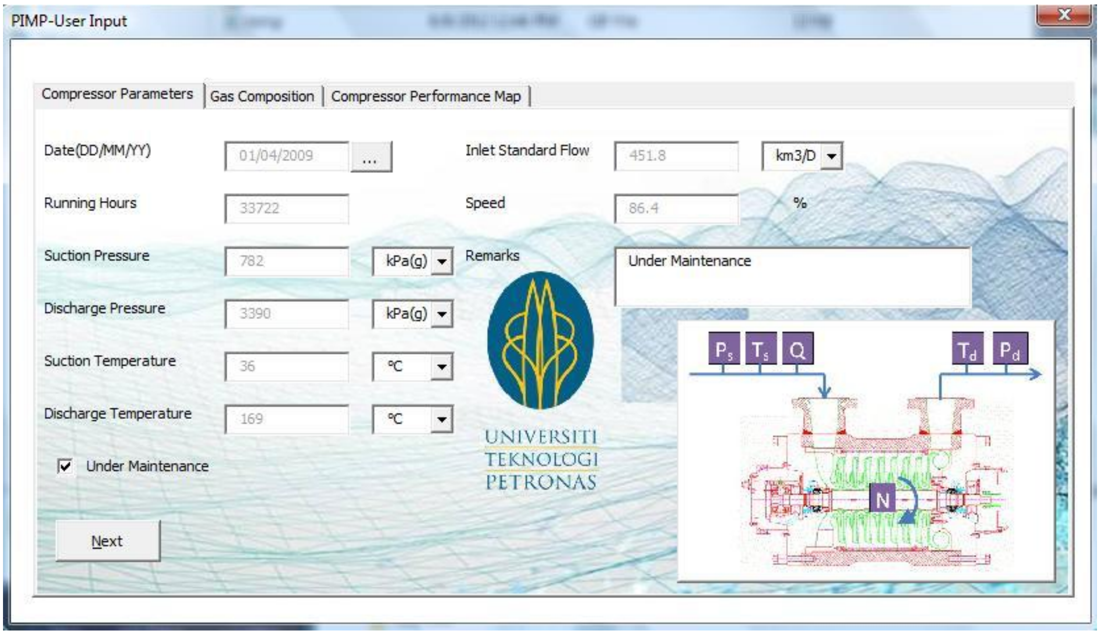

Figure 4.10: Compressor parameters tab in user input window for existing database

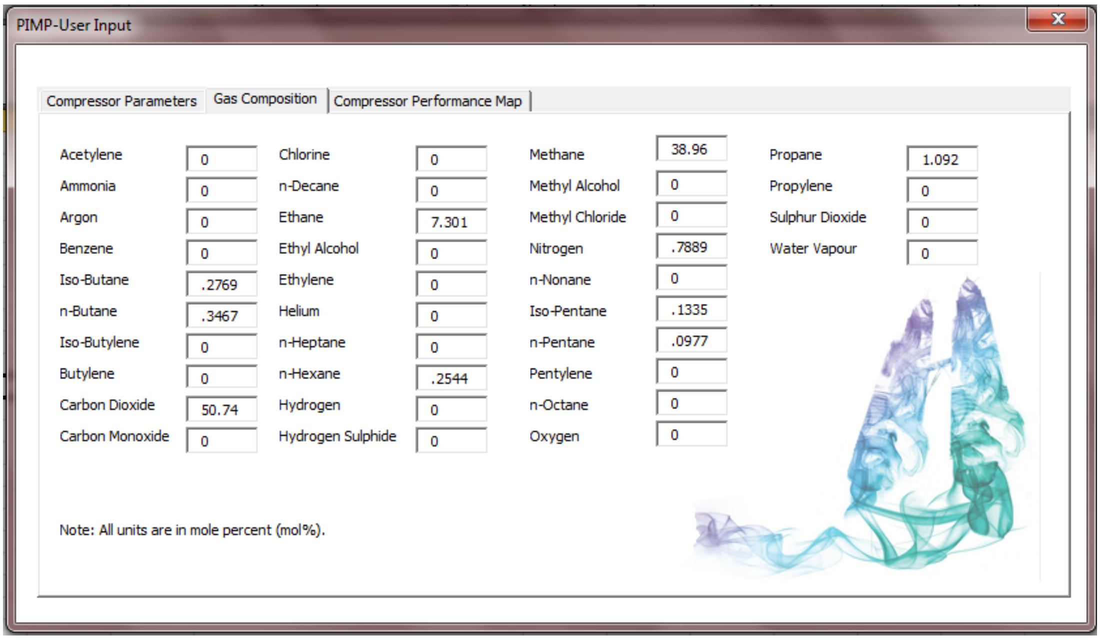

Figure 4.11: Gas composition tab in user input window

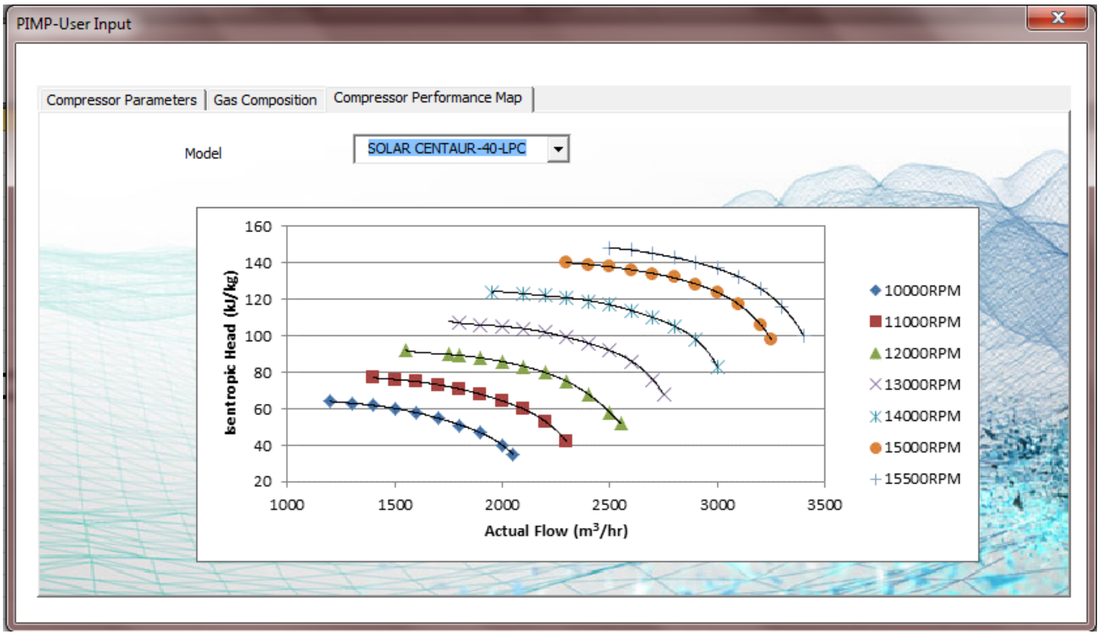

Figure 4.12: Compressor performance map tab in user input window

The result window shows the graphs of isentropic efficiency, isentropic head, and gas power based on the selected database. The performance indicators and their deviations for the latest data submitted earlier are also shown on the result window. From this window, the user can get an estimation on maintenance date. The user will choose a performance indicator as the criteria, set a limit, and click on *calculate* button. Then, the estimated date will be displayed on the window. The program is using parabolic trend to estimate the future date of maintenance. The Graphical User Interface (GUI) for results window is shown in Figure 4.13. Figure 4.14 illustrates the method of estimation using the same data as in Figure 4.13.

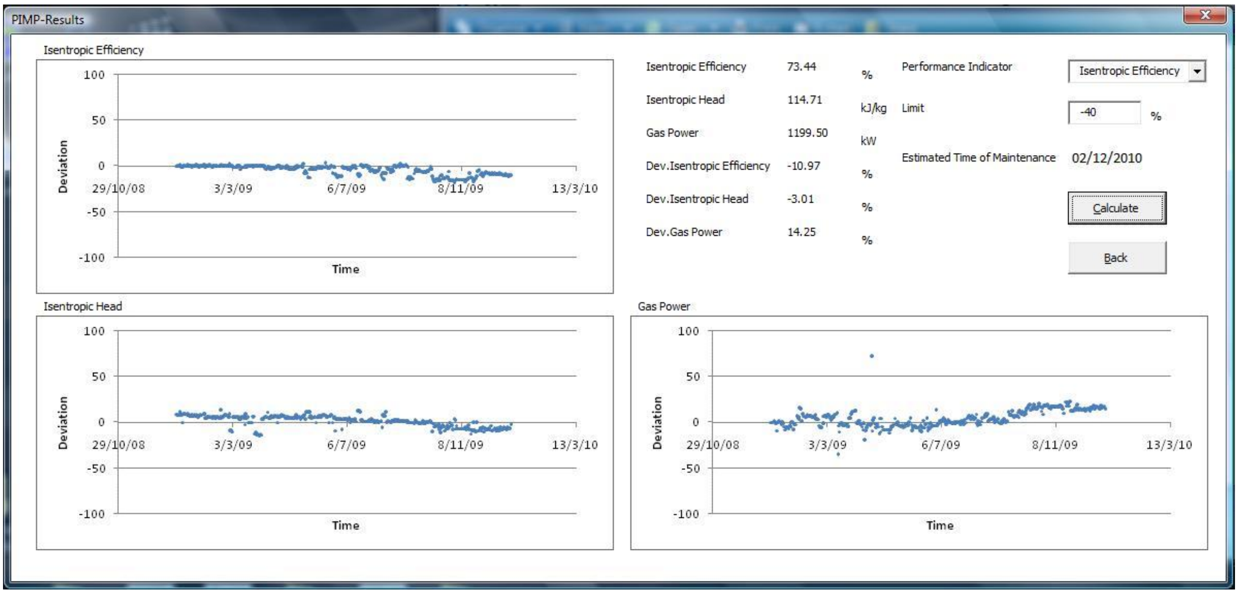

Figure 4.13: Results window

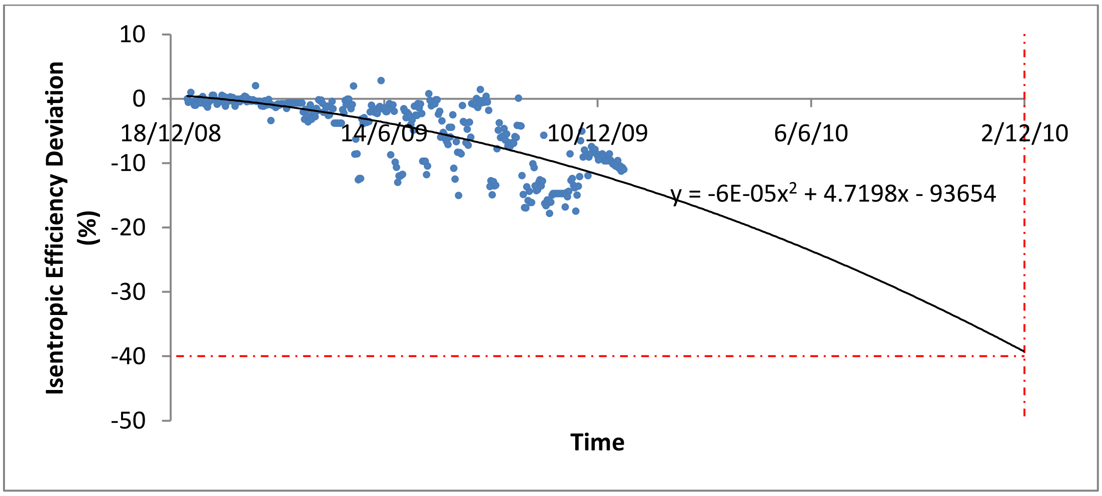

Figure 4.14: Estimation of future maintenance using parabolic model

To go to the previous window, the user can click on the close button at top right side of the window.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This project is aimed to develop a diagnostic program for gas compressors by using knowledge based management concept and performance indicators approach. The program will help plant engineers in making decisions pertaining to maintenance scheduling. Recommendations can be made with high confidence on maintenance interventions such as repair and overhaul. This will ultimately reduces the uncertainty in process and reduces downtime due to equipment breakdown or inadequate time for parts procurement process from order until delivery. The system is developed from Microsoft Excel 2007 with the help of Microsoft Visual Basic for programming purposes because they are user friendly, portable and is compatible with all Windows Operating System. The program platform provides a cheaper alternative to the costly performance monitoring and diagnostic tools widely available in the market. The maintenance cost can be greatly reduced by adopting the Microsoft Visual Basic-based software.

However, there are a few limitations that need to be observed and acknowledged. Measurement accuracy and validity are a major challenge as they highly influence the trend behaviour. Suitable locations of measurement instrumentation also need to be assessed, as well as variation of suction conditions and gas properties. Furthermore, the estimation modelling uses a second degree polynomial forecasting, which may not be applicable in all situations. The program can only cater for a single trend for each performance indicators. In other words, it will not generate a new estimation if the compressor has just undergone a maintenance activity and it significantly improves the compressor's performance. Instead, it will assume trending since the initialization of the database. Hence, the user needs to create a new database to create a better, more accurate estimation.

5.2 Recommendations

If further enhancement is to be done, studies on fouling and other deterioration mechanisms, i.e. erosion and corrosion, mechanical damage, surge events, and internal recirculation need to be carried out, either collectively or singularly. The studies shall focus on correlating performance indicators deviation of gas compressor to the respective deterioration mechanisms. For future research with respect to fouling and internal recirculation, an operating compressor shall run with two weeks to a month interval shutdowns. The deposition on the compressor surface can be studied. A bypass valve that linked compressor inlet and outlet shall be installed. The gas flow can be analysed and be associated with internal recirculation. Correlation between performance indicators with compressor fouling and internal recirculation can be established. Later, a study is needed to compile all relevant studies mentioned to create a complete diagnostic program for gas compressors.

In conclusion, the current project will assist plant engineers in maintenance related decision making. The achievement of listed objective can bring this project to new milestone in terms of enhancement intended.

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APPENDIX I: PIMP CODING SCRIPT

```
------------------------------------------
PERFORMANCE INDICATORS MONITORING PROGRAM
------------------------------------------

-----------
USER LOGIN
-----------
Private Sub CommandButton1_Click()
Dim username, password As String
username = TextBox1.Text
password = TextBox3.Text
If username = "bug" And password = "bug11956" Then
Application.Visible = True
Application.VBE.MainWindow.Visible = True
Else
   If username = "pimp" And password = "pimp123" Then

   MsgBox "Welcome", vbInformation
   Unload Me
   UserForm7.Show
   Else
   MsgBox "Login Failed", vbCritical
   End If
End If

End Sub

Private Sub Userform_QueryClose(Cancel As Integer, closemode As Integer)
   If closemode = vbFormControlMenu Then
      ActiveWorkbook.Close
      Cancel = False
   End If
End Sub
-----------
ABOUT
-----------

Private Sub CommandButton1_Click()
Unload Me
UserForm3.Show

End Sub
-----------
MAIN
-----------
Private Sub CommandButton1_Click()

Workbooks("PIMP").Sheets("sheet1").Range("B10") = 1
Workbooks("PIMP").Sheets("sheet1").Range("C10") = ""
On Error Resume Next
   Application.ScreenUpdating = False
   Application.DisplayAlerts = False
TryAgain:
Dim flname As String
   flname = InputBox("Enter File Name :", "Creating New Database...")
   If flname <> "" Then
   Workbooks("PIMP").Sheets("sheet2").Activate

   Dim NewWkbk As Workbook

      Set NewWkbk = Workbooks.Add

       Sheets("sheet1").Range("A1").Value = "Date"
       Sheets("sheet1").Range("B1").Value = "Suction Pressure"
       Sheets("sheet1").Range("C1").Value = "Discharge Pressure"
       Sheets("sheet1").Range("D1").Value = "Suction Temperature"
       Sheets("sheet1").Range("E1").Value = "Discharge Temperature"
       Sheets("sheet1").Range("F1").Value = "Standard Inlet Flow"
```

```
        Sheets("sheet1").Range("G1").Value = "Speed"
        Sheets("sheet1").Range("H1").Value = "Compressor Model"
        Sheets("sheet1").Range("AQ1").Value = "Isentropic Efficiency"
        Sheets("sheet1").Range("AR1").Value = "Isentropic Head"
        Sheets("sheet1").Range("AS1").Value = "Gas Power"
        Sheets("sheet1").Range("AT1").Value = "Dev. Isentropic Efficiency"
        Sheets("sheet1").Range("AU1").Value = "Dev. Isentropic Head"
        Sheets("sheet1").Range("AV1").Value = "Dev. Gas Power"
        Sheets("sheet1").Range("AW1").Value = "Reference Isentropic Efficiency"
        Sheets("sheet1").Range("AX1").Value = "Corrected Isentropic Head (Reference)"
        Sheets("sheet1").Range("AY1").Value = "Reference Gas Power"
        Sheets("sheet1").Range("AZ1").Value = "Remarks"
        Sheets("sheet1").Range("BA1").Value = "Running Hours"
        Sheets("sheet1").Range("B2").Value = "bar(g)"
        Sheets("sheet1").Range("C2").Value = "bar(g)"
        Sheets("sheet1").Range("D2").Value = "bar(g)"
        Sheets("sheet1").Range("E2").Value = "bar(g)"
        Sheets("sheet1").Range("F2").Value = "sm3/hr"
        Sheets("sheet1").Range("G2").Value = "%"
        Sheets("sheet1").Range("AQ2").Value = "%"
        Sheets("sheet1").Range("AR2").Value = "kJ/kg"
        Sheets("sheet1").Range("AS2").Value = "kW"
        Sheets("sheet1").Range("AT2").Value = "%"
        Sheets("sheet1").Range("AU2").Value = "%"
        Sheets("sheet1").Range("AV2").Value = "%"
        Sheets("sheet1").Range("I2:AP2").Value = "%"
        Sheets("sheet1").Range("AW2").Value = "%"
        Sheets("sheet1").Range("AX2").Value = "kJ/kg"
        Sheets("sheet1").Range("AY2").Value = "kW"
        MsgBox Workbooks("PIMP").Sheets("sheet1").Range("A10").Value
        Workbooks("PIMP").Sheets("sheet1").Range("A10").Value = flname
        MsgBox Workbooks("PIMP").Sheets("sheet1").Range("A10").Value
        Workbooks("PIMP").Sheets("sheet1").Range("B10").Value = 1
        MsgBox Workbooks("PIMP").Sheets("sheet1").Range("B10").Value
        Workbooks("PIMP").Sheets("Performance").Activate
        Range("E9:AL9").Select
        Selection.Copy
        NewWkbk.Sheets("Sheet1").Activate
        Range("I1").Select
        ActiveSheet.Paste
        Columns("B:BA").EntireColumn.AutoFit
       NewWkbk.SaveAs ThisWorkbook.Path & "\" & flname
       Dim fn As String
        fn = NewWkbk.FullName
        Workbooks("PIMP").Sheets("sheet1").Range("A11").Value = fn

       ActiveWorkbook.Close
       UserForm1.Show

    End If
End Sub

Private Sub CommandButton2_Click()


Dim fd As FileDialog
Dim FileName As String
Set fd = Application.FileDialog(msoFileDialogOpen)

Dim FileChosen As Integer
FileChosen = fd.Show
fd.Title = "Choose Database"
fd.InitialFileName = ThisWorkbook.Path
fd.InitialView = msoFileDialogViewList

fd.Filters.Clear
fd.Filters.Add "Excel workbooks", "*.xlsx"
fd.Filters.Add "Excel macros", "*.xlsm"
fd.FilterIndex = 1
fd.ButtonName = "Choose this file"
    If FileChosen <> -1 Then
```

```
    MsgBox "File Name Not Valid" & vbCrLf & vbCrLf & "Try Again."
    Exit Sub
    Else

    FileName = fd.SelectedItems(1)
    Workbooks.Open (FileName)
    Dim fn As String
    fn = ActiveWorkbook.Name
    End If


Workbooks("PIMP").Sheets("sheet1").Range("A11").Value = FileName
Workbooks("PIMP").Sheets("sheet1").Range("A10").Value = fn
Workbooks("PIMP").Sheets("sheet1").Range("C10").Value = 5

ActiveWorkbook.Close

UserForm1.Show

End Sub

Private Sub CommandButton3_Click()

Dim iReply As Integer
Dim uReply As Integer

Dim fd As FileDialog
Dim FileName As String
Set fd = Application.FileDialog(msoFileDialogOpen)

Dim FileChosen As Integer
FileChosen = fd.Show
fd.Title = "Choose Database"
fd.InitialFileName = ThisWorkbook.Path
fd.InitialView = msoFileDialogViewList

fd.Filters.Clear
fd.Filters.Add "Excel workbooks", "*.xlsx"
fd.Filters.Add "Excel macros", "*.xlsm"
fd.FilterIndex = 1
fd.ButtonName = "Delete this file"
    If FileChosen <> -1 Then

    MsgBox "File Name Not Valid" & vbCrLf & vbCrLf & "Try Again."
    Exit Sub
    Else

    FileName = fd.SelectedItems(1)
        If Dir(FileName) <> "" Then
        iReply = MsgBox(Prompt:="Are you sure? Selected file will be deleted permanently.", _
        Buttons:=vbYesNo, Title:="Deleting File")

            If iReply = vbYes Then
            Kill FileName
            uReply = MsgBox(Prompt:="File deleted.", Title:=" ")

            ElseIf iReply = vbNo Then
            Exit Sub
            End If
        Else
        MsgBox "File is out of range"
        End If

    End If
End Sub

Private Sub Image1_Click()

End Sub
```

```
Private Sub Userform_QueryClose(Cancel As Integer, closemode As Integer)

If closemode = vbFormControlMenu Then
Sheets("sheet1").Range("A11").Value = ""
Sheets("sheet1").Range("A10").Value = ""
Sheets("sheet1").Range("B10").Value = ""
Sheets("sheet1").Range("C10").Value = ""
Sheets("sheet3").Activate
ActiveWorkbook.Save
   ActiveWorkbook.Close

   Cancel = False
End If
End Sub
----------------------
USER INPUT
----------------------
Dim ChartNum As Integer

Private Sub CheckBox1_Click()
If CheckBox1.Value = True Then
TextBox42.Text = "Under Maintenance"
TextBox2.Enabled = False
TextBox3.Enabled = False
TextBox4.Enabled = False
TextBox5.Enabled = False
TextBox6.Enabled = False
TextBox7.Enabled = False
TextBox43.Enabled = False
Else
TextBox42.Text = ""
TextBox2.Enabled = True
TextBox3.Enabled = True
TextBox4.Enabled = True
TextBox5.Enabled = True
TextBox6.Enabled = True
TextBox7.Enabled = True
TextBox43.Enabled = True
End If
End Sub

Private Sub ComboBox7_Change()

End Sub

Private Sub CommandButton1_Click()

CheckBox1.Visible = True
Label45.Visible = True
If CheckBox1.Value = True Then

Dim filename20 As String
filename20 = Worksheets("sheet1").Range("A10").Value

fullname20 = Worksheets("sheet1").Range("A11").Value
Workbooks.Open (fullname20)
Dim irow20 As Long
Dim irow21 As Long
irow20 = Workbooks(filename20).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
   SearchDirection:=xlPrevious, LookIn:=xlValues).Row
irow21 = irow20 + 1
Worksheets("sheet1").Range("A" & irow21).Value = Format(TextBox1.Value, "dd/mm/yyyy")
Worksheets("sheet1").Range("H" & irow21).Value = Worksheets("sheet1").Range("H" & irow20).Value
Worksheets("sheet1").Range("I" & irow21).Value = Worksheets("sheet1").Range("I" & irow20).Value
Worksheets("sheet1").Range("J" & irow21).Value = Worksheets("sheet1").Range("J" & irow20).Value
Worksheets("sheet1").Range("K" & irow21).Value = Worksheets("sheet1").Range("K" & irow20).Value
Worksheets("sheet1").Range("L" & irow21).Value = Worksheets("sheet1").Range("L" & irow20).Value
Worksheets("sheet1").Range("M" & irow21).Value = Worksheets("sheet1").Range("M" & irow20).Value
Worksheets("sheet1").Range("N" & irow21).Value = Worksheets("sheet1").Range("N" & irow20).Value
Worksheets("sheet1").Range("O" & irow21).Value = Worksheets("sheet1").Range("O" & irow20).Value
Worksheets("sheet1").Range("P" & irow21).Value = Worksheets("sheet1").Range("P" & irow20).Value
```

```
Worksheets("sheet1").Range("Q" & irow21).Value = Worksheets("sheet1").Range("Q" & irow20).Value
Worksheets("sheet1").Range("R" & irow21).Value = Worksheets("sheet1").Range("R" & irow20).Value
Worksheets("sheet1").Range("S" & irow21).Value = Worksheets("sheet1").Range("S" & irow20).Value
Worksheets("sheet1").Range("T" & irow21).Value = Worksheets("sheet1").Range("T" & irow20).Value
Worksheets("sheet1").Range("U" & irow21).Value = Worksheets("sheet1").Range("U" & irow20).Value
Worksheets("sheet1").Range("V" & irow21).Value = Worksheets("sheet1").Range("V" & irow20).Value
Worksheets("sheet1").Range("W" & irow21).Value = Worksheets("sheet1").Range("W" & irow20).Value
Worksheets("sheet1").Range("X" & irow21).Value = Worksheets("sheet1").Range("X" & irow20).Value
Worksheets("sheet1").Range("Y" & irow21).Value = Worksheets("sheet1").Range("Y" & irow20).Value
Worksheets("sheet1").Range("Z" & irow21).Value = Worksheets("sheet1").Range("Z" & irow20).Value
Worksheets("sheet1").Range("AA" & irow21).Value = Worksheets("sheet1").Range("AA" & irow20).Value
Worksheets("sheet1").Range("AB" & irow21).Value = Worksheets("sheet1").Range("AB" & irow20).Value
Worksheets("sheet1").Range("AC" & irow21).Value = Worksheets("sheet1").Range("AC" & irow20).Value
Worksheets("sheet1").Range("AD" & irow21).Value = Worksheets("sheet1").Range("AD" & irow20).Value
Worksheets("sheet1").Range("AE" & irow21).Value = Worksheets("sheet1").Range("AE" & irow20).Value
Worksheets("sheet1").Range("AF" & irow21).Value = Worksheets("sheet1").Range("AF" & irow20).Value
Worksheets("sheet1").Range("AG" & irow21).Value = Worksheets("sheet1").Range("AG" & irow20).Value
Worksheets("sheet1").Range("AH" & irow21).Value = Worksheets("sheet1").Range("AH" & irow20).Value
Worksheets("sheet1").Range("AI" & irow21).Value = Worksheets("sheet1").Range("AI" & irow20).Value
Worksheets("sheet1").Range("AJ" & irow21).Value = Worksheets("sheet1").Range("AJ" & irow20).Value
Worksheets("sheet1").Range("AK" & irow21).Value = Worksheets("sheet1").Range("AK" & irow20).Value
Worksheets("sheet1").Range("AL" & irow21).Value = Worksheets("sheet1").Range("AL" & irow20).Value
Worksheets("sheet1").Range("AM" & irow21).Value = Worksheets("sheet1").Range("AM" & irow20).Value
Worksheets("sheet1").Range("AN" & irow21).Value = Worksheets("sheet1").Range("AN" & irow20).Value
Worksheets("sheet1").Range("AO" & irow21).Value = Worksheets("sheet1").Range("AO" & irow20).Value
Worksheets("sheet1").Range("AP" & irow21).Value = Worksheets("sheet1").Range("AP" & irow20).Value
Worksheets("sheet1").Range("AQ" & irow21).Value = Worksheets("sheet1").Range("AQ" & irow20).Value
Worksheets("sheet1").Range("AR" & irow21).Value = Worksheets("sheet1").Range("AR" & irow20).Value
Worksheets("sheet1").Range("AS" & irow21).Value = Worksheets("sheet1").Range("AS" & irow20).Value
Worksheets("sheet1").Range("AT" & irow21).Value = Worksheets("sheet1").Range("AT" & irow20).Value
Worksheets("sheet1").Range("AU" & irow21).Value = Worksheets("sheet1").Range("AU" & irow20).Value
Worksheets("sheet1").Range("AV" & irow21).Value = Worksheets("sheet1").Range("AV" & irow20).Value
Worksheets("sheet1").Range("AW" & irow21).Value = Worksheets("sheet1").Range("AW" & irow20).Value
Worksheets("sheet1").Range("AX" & irow21).Value = Worksheets("sheet1").Range("AX" & irow20).Value
Worksheets("sheet1").Range("AY" & irow21).Value = Worksheets("sheet1").Range("AY" & irow20).Value
Worksheets("sheet1").Range("AZ" & irow21).Value = TextBox42.Text
Worksheets("sheet1").Range("BA" & irow21).Value = Worksheets("sheet1").Range("BA" & irow20).Value
Workbooks(filename20).Save
Workbooks(filename20).Close

UserForm4.Show
Exit Sub
Else


If ComboBox7.Text = "kPa(g)" Then
Worksheets("Performance").Range("E30").Value = TextBox2.Value * 0.01
   Else: Worksheets("Performance").Range("E30").Value = TextBox2.Value
End If
If ComboBox2.Text = "kPa(g)" Then
Worksheets("Performance").Range("E31").Value = TextBox3.Value * 0.01
   Else: Worksheets("Performance").Range("E31").Value = TextBox3.Value
End If
If ComboBox3.Text = "°F" Then
Worksheets("Performance").Range("E32").Value = (TextBox4.Value - 32) * 5 / 9
   Else: Worksheets("Performance").Range("E32").Value = TextBox4.Value
End If
If ComboBox4.Text = "°F" Then
Worksheets("Performance").Range("E33").Value = (TextBox5.Value - 32) * 5 / 9
   Else: Worksheets("Performance").Range("E33").Value = TextBox5.Value
End If
If ComboBox5.Text = "km3/D" Then
Worksheets("Performance").Range("E34").Value = TextBox6.Value * 125 / 3
   Else: Worksheets("Performance").Range("E34").Value = TextBox6.Value
End If
Worksheets("Performance").Range("E35").Value = TextBox7.Value
If ComboBox6.Text = "SOLAR CENTAUR-40-LPC" Then
Worksheets("Performance").Range("E36").Value = 1
   Else
   If ComboBox6.Text = "SOLAR CENTAUR-40-IPC" Then
   Worksheets("Performance").Range("E36").Value = 2
```

```
      Else
      If ComboBox6.Text = "SOLAR CENTAUR-40-HPC" Then
      Worksheets("Performance").Range("E36").Value = 3
      Else: Worksheets("Performance").Range("E36").Value = 0
      End If
   End If
End If

Worksheets("Performance").Range("E10").Value = TextBox8.Value
Worksheets("Performance").Range("F10").Value = TextBox9.Value
Worksheets("Performance").Range("G10").Value = TextBox10.Value
Worksheets("Performance").Range("H10").Value = TextBox11.Value
Worksheets("Performance").Range("I10").Value = TextBox12.Value
Worksheets("Performance").Range("J10").Value = TextBox13.Value
Worksheets("Performance").Range("K10").Value = TextBox14.Value
Worksheets("Performance").Range("L10").Value = TextBox15.Value
Worksheets("Performance").Range("M10").Value = TextBox16.Value
Worksheets("Performance").Range("N10").Value = TextBox17.Value
Worksheets("Performance").Range("O10").Value = TextBox18.Value
Worksheets("Performance").Range("P10").Value = TextBox19.Value
Worksheets("Performance").Range("Q10").Value = TextBox20.Value
Worksheets("Performance").Range("R10").Value = TextBox21.Value
Worksheets("Performance").Range("S10").Value = TextBox22.Value
Worksheets("Performance").Range("T10").Value = TextBox23.Value
Worksheets("Performance").Range("U10").Value = TextBox24.Value
Worksheets("Performance").Range("V10").Value = TextBox25.Value
Worksheets("Performance").Range("W10").Value = TextBox26.Value
Worksheets("Performance").Range("X10").Value = TextBox27.Value
Worksheets("Performance").Range("Y10").Value = TextBox28.Value
Worksheets("Performance").Range("Z10").Value = TextBox29.Value
Worksheets("Performance").Range("AA10").Value = TextBox30.Value
Worksheets("Performance").Range("AB10").Value = TextBox31.Value
Worksheets("Performance").Range("AC10").Value = TextBox32.Value
Worksheets("Performance").Range("AD10").Value = TextBox33.Value
Worksheets("Performance").Range("AE10").Value = TextBox34.Value
Worksheets("Performance").Range("AF10").Value = TextBox35.Value
Worksheets("Performance").Range("AG10").Value = TextBox36.Value
Worksheets("Performance").Range("AH10").Value = TextBox37.Value
Worksheets("Performance").Range("AI10").Value = TextBox38.Value
Worksheets("Performance").Range("AJ10").Value = TextBox39.Value
Worksheets("Performance").Range("AK10").Value = TextBox40.Value
Worksheets("Performance").Range("AL10").Value = TextBox41.Value

If Worksheets("sheet1").Range("C10").Value = 5 Then
Dim filename11 As String
filename11 = Worksheets("sheet1").Range("A10").Value

fullname1 = Worksheets("sheet1").Range("A11").Value
Workbooks.Open (fullname1)
Dim irow5 As Long
irow5 = Workbooks(filename11).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
   SearchDirection:=xlPrevious, LookIn:=xlValues).Row
Workbooks("PIMP").Sheets("Performance").Range("E177").Value = Worksheets("sheet1").Range("AW" & irow5).Value
Workbooks("PIMP").Sheets("Performance").Range("E181").Value = Worksheets("sheet1").Range("AY" & irow5).Value
Workbooks(filename11).Close

   Else:
   Workbooks("PIMP").Sheets("Performance").Range("E177").Value =
Workbooks("PIMP").Sheets("Performance").Range("E173").Value
   Workbooks("PIMP").Sheets("Performance").Range("E181").Value =
Workbooks("PIMP").Sheets("Performance").Range("E175").Value
End If

Dim FileName As String
FileName = Worksheets("sheet1").Range("A10").Value
FullName = Worksheets("sheet1").Range("A11").Value
Workbooks.Open (FullName)
Dim irow As Long
irow = Workbooks(FileName).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
   SearchDirection:=xlPrevious, LookIn:=xlValues).Row + 1
   'Workbooks(filename).Sheets("sheet1").Cells(irow, 1).Select
```

```
    'Selection.NumberFormat = "[$-409]d/mmm/yy;@"
    ''TextBox1 = Format(TextBox1, "dd/mm/yy")

Workbooks(FileName).Sheets("sheet1").Cells(irow, 1) = Format(TextBox1, "dd/mm/yyyy")
Workbooks(FileName).Sheets("sheet1").Cells(irow, 52) = TextBox42.Text
Workbooks(FileName).Sheets("sheet1").Cells(irow, 53) = TextBox43.Text
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 2).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E30").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 3).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E31").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 4).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E32").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 5).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E33").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 6).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E34").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 7).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E35").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 8).Value =
Workbooks("PIMP").Worksheets("sheet1").Range("A9").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 9).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 10).Value =
Workbooks("PIMP").Worksheets("Performance").Range("F10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 11).Value =
Workbooks("PIMP").Worksheets("Performance").Range("G10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 12).Value =
Workbooks("PIMP").Worksheets("Performance").Range("H10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 13).Value =
Workbooks("PIMP").Worksheets("Performance").Range("I10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 14).Value =
Workbooks("PIMP").Worksheets("Performance").Range("J10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 15).Value =
Workbooks("PIMP").Worksheets("Performance").Range("K10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 16).Value =
Workbooks("PIMP").Worksheets("Performance").Range("L10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 17).Value =
Workbooks("PIMP").Worksheets("Performance").Range("M10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 18).Value =
Workbooks("PIMP").Worksheets("Performance").Range("N10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 19).Value =
Workbooks("PIMP").Worksheets("Performance").Range("O10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 20).Value =
Workbooks("PIMP").Worksheets("Performance").Range("P10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 21).Value =
Workbooks("PIMP").Worksheets("Performance").Range("Q10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 22).Value =
Workbooks("PIMP").Worksheets("Performance").Range("R10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 23).Value =
Workbooks("PIMP").Worksheets("Performance").Range("S10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 24).Value =
Workbooks("PIMP").Worksheets("Performance").Range("T10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 25).Value =
Workbooks("PIMP").Worksheets("Performance").Range("U10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 26).Value =
Workbooks("PIMP").Worksheets("Performance").Range("V10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 27).Value =
Workbooks("PIMP").Worksheets("Performance").Range("W10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 28).Value =
Workbooks("PIMP").Worksheets("Performance").Range("X10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 29).Value =
Workbooks("PIMP").Worksheets("Performance").Range("Y10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 30).Value =
Workbooks("PIMP").Worksheets("Performance").Range("Z10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 31).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AA10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 32).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AB10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 33).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AC10").Value
```

```
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 34).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AD10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 35).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AE10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 36).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AF10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 37).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AG10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 38).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AH10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 39).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AI10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 40).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AJ10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 41).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AK10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 42).Value =
Workbooks("PIMP").Worksheets("Performance").Range("AL10").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 43).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E173").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 44).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E174").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 45).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E175").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 46).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E183").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 47).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E184").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 48).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E185").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 49).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E177").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 50).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E180").Value
    Workbooks(FileName).Sheets("sheet1").Cells(irow, 51).Value =
Workbooks("PIMP").Worksheets("Performance").Range("E181").Value
    Workbooks(FileName).Save
    Workbooks(FileName).Close

    Dim xAxis As Axis
    Dim fn As String
    fn = Workbooks("PIMP").Worksheets("sheet1").Range("A11").Value
Dim filename2 As String
filename2 = Workbooks("PIMP").Worksheets("sheet1").Range("A10").Value
Workbooks.Open (fn)
Sheets("sheet2").Activate
If Workbooks("PIMP").Worksheets("sheet1").Range("C10").Value = 5 Then
MsgBox ActiveSheet.Name
ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Delete
ActiveSheet.ChartObjects("Dev Isentropic Head").Delete
ActiveSheet.ChartObjects("Dev Gas Power").Delete
End If
Dim irow1 As Long
irow1 = Workbooks(filename2).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
    SearchDirection:=xlPrevious, LookIn:=xlValues).Row
    ActiveWorkbook.Sheets("sheet2").Activate
     ActiveSheet.Shapes.AddChart.Select
    ActiveChart.ChartType = xlXYScatter
   ActiveChart.SeriesCollection.NewSeries
    ActiveChart.SeriesCollection(1).XValues = "='Sheet1'!$A$3:$A$" & irow1
    ActiveChart.SeriesCollection(1).Values = "='Sheet1'!$AT$3:$AT$" & irow1
   ActiveChart.Parent.Name = "Dev Isentropic Efficiency"
    ActiveChart.Axes(xlValue).Select
    ActiveChart.Axes(xlValue).MinimumScale = -100

    ActiveChart.Axes(xlValue).MaximumScale = 100
    Selection.TickLabels.NumberFormat = "0.00%"
    Selection.TickLabels.NumberFormat = "0"
    n = ActiveChart.Axes(xlCategory).MaximumScale - ActiveChart.Axes(xlCategory).MinimumScale
    MsgBox n
    m = n / 4
```

```
    MsgBox m
    ActiveChart.Axes(xlCategory).Select
    ActiveChart.Axes(xlCategory).MajorUnit = m
    Selection.TickLabels.NumberFormat = "[$-14409]d/m/yy;@"

    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    If ActiveChart.HasLegend = True Then
    ActiveChart.Legend.Select
    Selection.Delete
    End If

   ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    ActiveChart.SetElement (msoElementPrimaryCategoryAxisTitleAdjacentToAxis)
    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    ActiveChart.SetElement (msoElementPrimaryValueAxisTitleRotated)

    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    ActiveChart.Axes(xlValue, xlPrimary).AxisTitle.Text = "Deviation (%)"

      Set xAxis = ActiveChart.Axes(xlCategory)
    With xAxis
    .HasTitle = True
    .AxisTitle.Caption = "Time"
    End With
    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    ActiveChart.ChartArea.Select
    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate

    ActiveSheet.ChartObjects("Dev Isentropic Efficiency").Activate
    ActiveChart.SeriesCollection(1).Select

    Selection.MarkerSize = 2
    Selection.MarkerStyle = 8

ActiveSheet.ChartObjects ("Dev Isentropic Efficiency")
With ActiveSheet.ChartObjects("Dev Isentropic Efficiency")
.Top = 150
.Left = 750
End With

Range("A1").Select
Application.GoTo ActiveCell, True

    Dim xAxis2 As Axis
    Dim irow2 As Long
irow2 = Workbooks(filename2).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
    SearchDirection:=xlPrevious, LookIn:=xlValues).Row

    ActiveSheet.Shapes.AddChart.Select
    ActiveChart.ChartType = xlXYScatter
    ActiveChart.SeriesCollection.NewSeries
    ActiveChart.SeriesCollection(1).XValues = "='Sheet1'!$A$3:$A$" & irow2
    ActiveChart.SeriesCollection(1).Values = "='Sheet1'!$AU$3:$AU$" & irow2


    ActiveChart.Parent.Name = "Dev Isentropic Head"
    ActiveChart.Axes(xlValue).Select
    ActiveChart.Axes(xlValue).MinimumScale = -100

    ActiveChart.Axes(xlValue).MaximumScale = 100
    Selection.TickLabels.NumberFormat = "0.00%"
    Selection.TickLabels.NumberFormat = "0"
    n = ActiveChart.Axes(xlCategory).MaximumScale - ActiveChart.Axes(xlCategory).MinimumScale
    m = n / 4
    ActiveChart.Axes(xlCategory).Select
    ActiveChart.Axes(xlCategory).MajorUnit = m
    Selection.TickLabels.NumberFormat = "[$-14409]d/m/yy;@"

    ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
    If ActiveChart.HasLegend = True Then
    ActiveChart.Legend.Select
```

```
   Selection.Delete
   End If

   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   ActiveChart.SetElement (msoElementPrimaryCategoryAxisTitleAdjacentToAxis)
   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   ActiveChart.SetElement (msoElementPrimaryValueAxisTitleRotated)

   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   ActiveChart.Axes(xlValue, xlPrimary).AxisTitle.Text = "Deviation (%)"


    Set xAxis2 = ActiveChart.Axes(xlCategory)
   With xAxis2
   .HasTitle = True
   .AxisTitle.Caption = "Time"
   End With
   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   ActiveChart.ChartArea.Select
   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   'choosing marker
   ActiveSheet.ChartObjects("Dev Isentropic Head").Activate
   ActiveChart.SeriesCollection(1).Select

   Selection.MarkerSize = 2
   Selection.MarkerStyle = 8

ActiveSheet.ChartObjects ("Dev Isentropic Head")
With ActiveSheet.ChartObjects("Dev Isentropic Head")
.Top = 150
.Left = 750
End With

Range("A1").Select
Application.GoTo ActiveCell, True

Dim irow3 As Long
Dim xAxis3 As Axis
irow3 = Workbooks(filename2).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
   SearchDirection:=xlPrevious, LookIn:=xlValues).Row

   ActiveSheet.Shapes.AddChart.Select
   ActiveChart.ChartType = xlXYScatter
   ActiveChart.SeriesCollection.NewSeries
   ActiveChart.SeriesCollection(1).XValues = "='Sheet1'!$A$3:$A$" & irow3
   ActiveChart.SeriesCollection(1).Values = "='Sheet1'!$AV$3:$AV$" & irow3


   ActiveChart.Parent.Name = "Dev Gas Power"
   ActiveChart.Axes(xlValue).Select
   ActiveChart.Axes(xlValue).MinimumScale = -100

   ActiveChart.Axes(xlValue).MaximumScale = 100
   Selection.TickLabels.NumberFormat = "0.00%"
   Selection.TickLabels.NumberFormat = "0"
   n = ActiveChart.Axes(xlCategory).MaximumScale - ActiveChart.Axes(xlCategory).MinimumScale
   m = n / 4
   ActiveChart.Axes(xlCategory).Select
   ActiveChart.Axes(xlCategory).MajorUnit = m
   Selection.TickLabels.NumberFormat = "[$-14409]d/m/yy;@"

   ActiveSheet.ChartObjects("Dev Gas Power").Activate
   If ActiveChart.HasLegend = True Then
   ActiveChart.Legend.Select
   Selection.Delete
   End If

   ActiveSheet.ChartObjects("Dev Gas Power").Activate
   ActiveChart.SetElement (msoElementPrimaryCategoryAxisTitleAdjacentToAxis)
   ActiveSheet.ChartObjects("Dev Gas Power").Activate
   ActiveChart.SetElement (msoElementPrimaryValueAxisTitleRotated)
```

```
    ActiveSheet.ChartObjects("Dev Gas Power").Activate
    ActiveChart.Axes(xlValue, xlPrimary).AxisTitle.Text = "Deviation (%)"


     Set xAxis3 = ActiveChart.Axes(xlCategory)
    With xAxis3
    .HasTitle = True
    .AxisTitle.Caption = "Time"
    End With
    ActiveSheet.ChartObjects("Dev Gas Power").Activate
    ActiveChart.ChartArea.Select
    ActiveSheet.ChartObjects("Dev Gas Power").Activate

    ActiveSheet.ChartObjects("Dev Gas Power").Activate
    ActiveChart.SeriesCollection(1).Select

    Selection.MarkerSize = 2
    Selection.MarkerStyle = 8

ActiveSheet.ChartObjects ("Dev Gas Power")
With ActiveSheet.ChartObjects("Dev Gas Power")
.Top = 150
.Left = 750
End With

Range("A1").Select
Application.GoTo ActiveCell, True
Workbooks(filename2).Save
Workbooks(filename2).Close


UserForm4.Show
End If
End Sub

Private Sub CommandButton3_Click()
Unload Me
End Sub

Private Sub CommandButton4_Click()
UserForm2.Show
End Sub

Private Sub CommandButton5_Click()
Me.MultiPage1.Value = 2
End Sub

Private Sub CommandButton6_Click()
Me.MultiPage1.Value = 1
End Sub

Private Sub CommandButton7_Click()
Me.MultiPage1.Value = 0
End Sub

Private Sub CommandButton8_Click()
Me.MultiPage1.Value = 1
End Sub

Private Sub Image1_Click()

End Sub
Private Sub ComboBox6_Change()

If ComboBox6.Text = "SOLAR CENTAUR-40-LPC" Then
Set CurrentChart = Workbooks("PIMP").Worksheets("Charts").ChartObjects("LPC").Chart
    CurrentChart.Parent.Width = 450
    CurrentChart.Parent.Height = 204

    Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
```

```
    CurrentChart.Export FileName:=Fname, FilterName:="GIF"

    Image1.Picture = LoadPicture(Fname)
Else
    If ComboBox6.Text = "SOLAR CENTAUR-40-IPC" Then
    Set CurrentChart = Workbooks("PIMP").Worksheets("Charts").ChartObjects("IPC").Chart
        CurrentChart.Parent.Width = 450
        CurrentChart.Parent.Height = 204

        Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
        CurrentChart.Export FileName:=Fname, FilterName:="GIF"

        Image1.Picture = LoadPicture(Fname)
    Else
        If ComboBox6.Text = "SOLAR CENTAUR-40-HPC" Then
        Set CurrentChart = Workbooks("PIMP").Worksheets("Charts").ChartObjects("HPC").Chart
            CurrentChart.Parent.Width = 450
            CurrentChart.Parent.Height = 204

            Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
            CurrentChart.Export FileName:=Fname, FilterName:="GIF"

            Image1.Picture = LoadPicture(Fname)
        End If
    End If
End If

End Sub

Private Sub UserForm_Initialize()

MultiPage1.Value = 0
If Workbooks("PIMP").Sheets("sheet1").Range("B10").Value = 1 Then
CheckBox1.Visible = False
Label45.Visible = False
End If

ComboBox7.Text = "kPa(g)"
ComboBox2.Text = "kPa(g)"
ComboBox3.Text = "°C"
ComboBox4.Text = "°C"
ComboBox5.Text = "km3/D"

If Workbooks("PIMP").Sheets("sheet1").Range("C10").Value = 5 Then
Dim FileName As String
FileName = Sheets("sheet1").Range("A10").Value
Dim fn As String
fn = Sheets("sheet1").Range("A11").Value
Workbooks.Open (fn)
Dim irow As Long
irow = Workbooks(FileName).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
    SearchDirection:=xlPrevious, LookIn:=xlValues).Row
TextBox8.Value = Worksheets("sheet1").Cells(irow, 9).Value
TextBox9.Value = Worksheets("sheet1").Cells(irow, 10).Value
TextBox10.Value = Worksheets("sheet1").Cells(irow, 11).Value
TextBox11.Value = Worksheets("sheet1").Cells(irow, 12).Value
TextBox12.Value = Worksheets("sheet1").Cells(irow, 13).Value
TextBox13.Value = Worksheets("sheet1").Cells(irow, 14).Value
TextBox14.Value = Worksheets("sheet1").Cells(irow, 15).Value
TextBox15.Value = Worksheets("sheet1").Cells(irow, 16).Value
TextBox16.Value = Worksheets("sheet1").Cells(irow, 17).Value
TextBox17.Value = Worksheets("sheet1").Cells(irow, 18).Value
TextBox18.Value = Worksheets("sheet1").Cells(irow, 19).Value
TextBox19.Value = Worksheets("sheet1").Cells(irow, 20).Value
TextBox20.Value = Worksheets("sheet1").Cells(irow, 21).Value
TextBox21.Value = Worksheets("sheet1").Cells(irow, 22).Value
TextBox22.Value = Worksheets("sheet1").Cells(irow, 23).Value
TextBox23.Value = Worksheets("sheet1").Cells(irow, 24).Value
TextBox24.Value = Worksheets("sheet1").Cells(irow, 25).Value
TextBox25.Value = Worksheets("sheet1").Cells(irow, 26).Value
TextBox26.Value = Worksheets("sheet1").Cells(irow, 27).Value
```

```
TextBox27.Value = Worksheets("sheet1").Cells(irow, 28).Value
TextBox28.Value = Worksheets("sheet1").Cells(irow, 29).Value
TextBox29.Value = Worksheets("sheet1").Cells(irow, 30).Value
TextBox30.Value = Worksheets("sheet1").Cells(irow, 31).Value
TextBox31.Value = Worksheets("sheet1").Cells(irow, 32).Value
TextBox32.Value = Worksheets("sheet1").Cells(irow, 33).Value
TextBox33.Value = Worksheets("sheet1").Cells(irow, 34).Value
TextBox34.Value = Worksheets("sheet1").Cells(irow, 35).Value
TextBox35.Value = Worksheets("sheet1").Cells(irow, 36).Value
TextBox36.Value = Worksheets("sheet1").Cells(irow, 37).Value
TextBox37.Value = Worksheets("sheet1").Cells(irow, 38).Value
TextBox38.Value = Worksheets("sheet1").Cells(irow, 39).Value
TextBox39.Value = Worksheets("sheet1").Cells(irow, 40).Value
TextBox40.Value = Worksheets("sheet1").Cells(irow, 41).Value
TextBox41.Value = Worksheets("sheet1").Cells(irow, 42).Value
ComboBox6.Value = Worksheets("sheet1").Cells(irow, 8).Value
Workbooks("PIMP").Sheets("Performance").Range("E177").Value =
Workbooks(FileName).Worksheets("sheet1").Cells(irow, 49).Value
Workbooks("PIMP").Sheets("Performance").Range("E181").Value =
Workbooks(FileName).Worksheets("sheet1").Cells(irow, 51).Value
Workbooks(FileName).Close
End If

End Sub

=================
CALENDAR
=================

Option Explicit

Private WithEvents Calendar1 As cCalendar

Private Sub UserForm_Initialize()
Set Calendar1 = New cCalendar
Calendar1.Add_Calendar_into_Frame Me.Frame1
End Sub

Private Sub UserForm_Activate()
Calendar1.Value = Now()
End Sub

Private Sub Calendar1_DblClick()
UserForm1.TextBox1 = Format(Calendar1.Value, "dd/mm/yyyy")
Unload Me


End Sub

Private Sub Userform_QueryClose(Cancel As Integer, closemode As Integer)
Set Calendar1 = Nothing
End Sub

===============
RESULT
===============

Private Sub UserForm_Initialize()

Dim FullName As String
Dim FileName As String
FullName = Workbooks("PIMP").Worksheets("sheet1").Range("A11").Value
FileName = Workbooks("PIMP").Worksheets("sheet1").Range("A10").Value


If UserForm1.CheckBox1.Value = True Then
Workbooks.Open (FullName)
irow = Workbooks(FileName).Sheets("sheet1").Cells.Find(What:="*", SearchOrder:=xlRows, _
   SearchDirection:=xlPrevious, LookIn:=xlValues).Row
Label17.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AQ" & irow).Value, "0.00")
Label5.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AR" & irow).Value, "0.00")
```

```
Label6.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AS" & irow).Value, "0.00")

Label13.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AT" & irow).Value, "0.00")
Label14.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AU" & irow).Value, "0.00")
Label15.Caption = Format(Workbooks(FileName).Worksheets("sheet1").Range("AV" & irow).Value, "0.00")
Workbooks(FileName).Close
Else
Label17.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E173").Text
Label5.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E174").Text
Label6.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E175").Text

Label13.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E183").Text
Label14.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E184").Text
Label15.Caption = Workbooks("PIMP").Worksheets("Performance").Range("E185").Text
End If

Workbooks.Open (FullName)
Set CurrentChart = Workbooks(FileName).Worksheets("sheet2").ChartObjects("Dev Isentropic Efficiency").Chart
   CurrentChart.Parent.Width = 420
   CurrentChart.Parent.Height = 170


   Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
   CurrentChart.Export FileName:=Fname, FilterName:="GIF"


   Image1.Picture = LoadPicture(Fname)

   Set CurrentChart = Workbooks(FileName).Worksheets("sheet2").ChartObjects("Dev Isentropic Head").Chart
   CurrentChart.Parent.Width = 420
   CurrentChart.Parent.Height = 170


   Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
   CurrentChart.Export FileName:=Fname, FilterName:="GIF"


   Image2.Picture = LoadPicture(Fname)

   Set CurrentChart = Workbooks(FileName).Worksheets("sheet2").ChartObjects("Dev Gas Power").Chart
   CurrentChart.Parent.Width = 420
   CurrentChart.Parent.Height = 170


   Fname = ThisWorkbook.Path & Application.PathSeparator & "temp.gif"
   CurrentChart.Export FileName:=Fname, FilterName:="GIF"


   Image3.Picture = LoadPicture(Fname)


   Workbooks(FileName).Save
   Workbooks(FileName).Close
   Workbooks("PIMP").Worksheets("sheet1").Range("B10").Value = ""
   Workbooks("PIMP").Worksheets("sheet1").Range("C10").Value = 5

End Sub
```