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JUDUL: **ANALYSIS OF GAUGE GLASS FAILURE POSSIBILITY FOR BOILER**

SESI PENGAJIAN: 2007/2008

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ANALYSIS OF GAUGE GLASS FAILURE POSSIBILITY FOR BOILER

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A report submitted in partial fulfillment of the
requirements for the award of the degree of
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To whom I love

ABSTRACT

The heating process in the boiler is an operation that carried in 24 hours a day. The boiler operates under high temperature and pressure. There is always a possibility for the fitting of the boiler to have failure. The purpose of this study is to find the failure possibility of the gauge glass through literature and simulation. The gauge glass will fail due to stress, temperature and fittings problem. This analysis is concentrate on the glass as the glass is brittle and have higher tendency to fail rather than other fittings and connector. As the failure due to stress and temperature is unavoidable, the inspection must be done periodically. During the inspection, overall boiler must be checked to make sure there is no faultiness to the part that attached to the boiler especially gauge glass. If the is a problem occur during inspection, this gauge glass have to be repair or replace.

ABSTRAK

Proses pemanasan di dalam dandang berlaku 24 jam sehari. Dandang bekerja di bawah suhu dan tekanan yang tinggi. Oleh sebab itu, terlalu banyak kemungkinan untuk komponen-komponen yang berada di sekitar dandang mengalami kerosakan. Tujuan kajian ini dijalankan adalah untuk mencari kemungkinan-kemungkinan kerosakan yang berlaku pada penunjuk aras air pada dandang melalui rujukan dan simulasi. Penunjuk aras air ini akan mengalami kerosakan berdasarkan tekanan, suhu dan komponen lain yang mengalami masalah. Analisis ini bertumpu pada kaca penunjuk takat air kerana kaca ini rapuh dan mempunyai kemungkinan yang tinggi untuk mengalami kerosakan berbanding komponen yang lain. Oleh sebab kerosakan terhadap tekanan dan suhu tidak dapat dielakkan, pengujian mesti dilakukan berkala. Semasa sesi pengujian, keseluruhan dandang hendaklah diperiksa untuk memastikan tiada kerosakan berlaku terutamanya pada penunjuk takat air ini. Jika terdapat apa-apa kerosakan pada alatan dandang, hendaklah segera diperbaiki atau ditukar.

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LIST OF SYMBOLS

σ_t	Tangential stress
σ_r	Radial stress
P_o	Outer pressure
P_i	Inner pressure
r_o	Outer radius
r_i	Inner radius
n_d	Factor of safety

LIST OF APENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

A boiler is a container that fed with water. By applying heat, this water continuously evaporates into steam. In technical terms, a boiler is defined as a closed vessel where water or some other liquid is heated, steam or vapor is generated and superheated. This function is accomplished under pressure or vacuum for use external combustion of fuels, electricity or solar energy.

As boiler operates under pressure, there is always the potential for explosion. The input for the boiler is fuel and feedwater, whereas the output of the boiler is combustion and steam. Like the product of combustion, the blowdown of water from the boiler is also a waste.

A water column is installed on the boiler for reducing turbulence in the gauge glass so that the boiler operator can take an accurate reading of the water level. The gauge glass acts as a primary water level indicator. The secondary level indicator is try cocks. Try cocks is a fitting that attached to the gauge glass and the water column.

The piping for miscellaneous accessories, such as water level indicators, water columns, gauge cocks, pressure gauge and vents should be designed with the value of pressure not more than the maximum allowable working pressure of the boiler unless all the accessories will not working correctly and fail.

1.2 Problem statement.

There are two major problem of gauge glass failure indication. They are;

Turbulence

There are some turbulence flow when the water and steam balancing each other. The turbulence must be reducing to get a correct reading from the gauge glass. The gauge glass will give a false indication of water level as the turbulence occurs and affecting some measurement point.

Pressure

As the pressure drop, the steams will condensate faster when the steams enter the small opening of the cock and valve. This will raise the water level and indicates a false water level. Besides, the leakage at the connection will drop the pressure relatively to the friction of the steam flowing so the pressure in the glass is lower than the pressure inside the drum and destruct the contact between water and steam flow to the gauge and the result is false high level indication.

1.3 Objectives of the study

The objective of study is;

i. To investigate the possibility failure of gauge glass during performing testing.
ii. To analyze gauge glass failure using CAE failure analysis software.

1.4 Scope of the study

The study is divided into two main sections;

i. There will be an analysis study of the gauge glass failure through literature.

ii. The project will investigate the mechanism of the gauge glass by the analysis using CAE failure analysis.

CHAPTER 2

LITERATURE REVIEW

A steam generator is a complex integration of heating system, superheater, reheater, boiler or evaporator, econominizer and air preheater along with various supplementary such as pulverizes burner, fan, strokes, dust collectors and precipitators, ash-handling equipment, and vent or stack. The boiler is one of the steam generator divisions where segment change or boiling occurs from liquid to vapor, essentially at constant demands and heat. However, the expression 'boiler' is usually used to indicate the total system generator.

A steam generator generates steam by burning fuel in its furnace at the desired tempo at the desired pressure and temperature. Inside the boiler, the fuel and air are forced into the furnace by the burner. The fuel will burned to produce heat. From the burner, the heat pass through the boiler and being suck up by the stream that will transform the water into gaseous state-steam.

Generally there are two types of boiler. They are fire-tube boiler and water-tube boiler. Each of the boilers having their own specialties and have the same task, to provide a correct amount of high quality steam in a safe condition, efficiently and at the correct pressure. Fire-tube boilers are suitable for small steam requirement. The view of fire-tube boiler is as shown in Figure 2.1.

The fire tube boiler has low first cost during startup. During operation, the fire tube boiler can be handled by unskilled labour because of high reliability to the boiler itself. This type of boiler also can give quick response to the load changes.

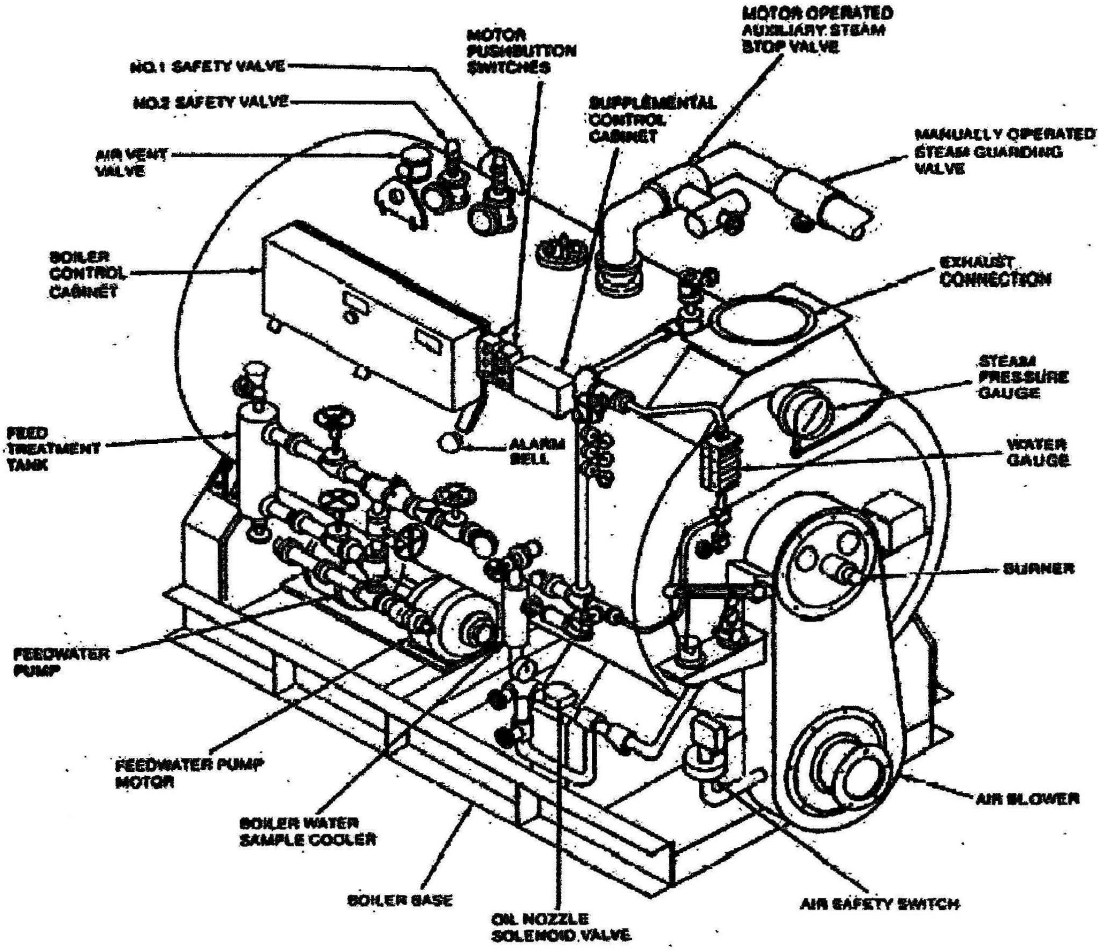

Figure 2.1 Out view of fire-tube boiler

Factories that have lack of space but still want to use the boiler, package boilers are the most excellent choices. Package boiler is highly compact and the large surface area of heat transfer is provided in a small volume. The furnace volumes are less since the boiler is pressurized. The complete unit of package boiler unit is mostly fabricated in the plant. The set of the boiler will be taken to the side and installed. The setting will be taken in small space. The package boiler is uncomplicated to operate.

All the tube and piping at the boiler must be insulated. The common insulation is by using 85% of magnesia and glass wool. The other option usage of insulation material is Fluorocarbon, Atlas, Buna-N, FEP encapsulated Silicone and Ethylene Propylene. The insulation is vital since the pressure inside the furnace is above atmospheric; carefulness is required to make the casting sealed against leakage.

2.1 Circulation inside the boiler

The flow of water and steam within the boiler circuit is called circulation. The heat from furnace can be carried away by providing sufficient circulation. The circulation is caused by density difference when it is normal circulation. The circulation is forced and controlled via pump.

The density of steam-water blend in the riser is less than that of saturated water in downcomer. When the boiler is full with steam structure, the riser tube will not be stand with. Bubbles originate from the heated surface. Therefore, the wetted surface must be firstly considered.

High rate of heat transfer will cause bubble formation. Te bubble may unite and form an unstable vapour layer which continually disintegrate and restructuring but with a constant higher heat transfer, the vapour layer may be stable. A vapour layer have a great thermal resistance as the film have lower thermal conductivity than liquid layer and the vapour layer will blanketing the surface where the layer form. As the result, the heat will be absorbed, carried, transfer and stored to the wall. Consequently, this will increase the internal energy and the temperature of the wall may exceed the melting temperature and the wall may intend to rupture or leaking. The flow inside water-tube boiler is shown in Figure 2.2.

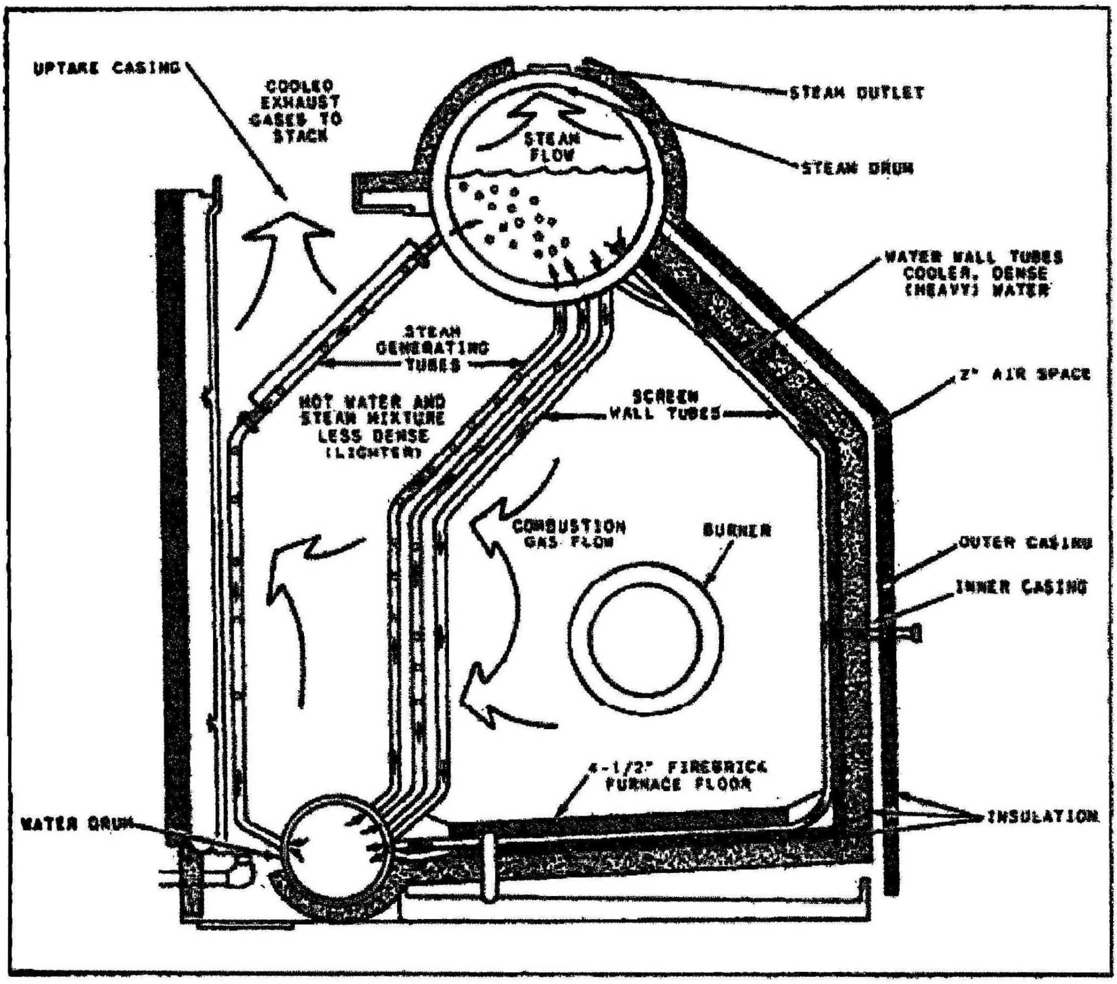

Figure 2.2 Flow inside water-tube boiler

2.2 Control of the water-steam system.

There are two main controls inside the boiler, water control and steam control. These two controls must correspond to each other in a correct condition so that the boiler can be operated in good ways.

The water and steam flow is controlled to fulfill the requirement from the output device and at the same time maintaining the level of water inside the boiler drum. Normally, the water level is maintained half-full of the drum. A high steam produce and low water supply would lower the water level in the drum.

For automatic control system, as shown in Figure 2.3, the system use sensors to send signals to the controller. Then, the controller will activate the suitable valve in desired direction. For example in the case high steam output and low feedwater supply, when the water level in the drum is low, the drum level sensor will responds to the error between definite drum level and the set point and send the impulse to the controller. When the controller received the impulse, the controllers will forward the signal to the feedwater sensor so that the feedwater valve opening will amplify to meet the steam flow demand. The communication between the sensors will look forward to the changes in drum level.

Sometimes, the steam control can be labeled as boiler master. The system will maintains the steam pressure by regulating fuel and combustion air flows to meet the desired pressure for the boiler. The system is schematically described in Figure 2.4. A steam pressure sensor is active directly on the fuel flow and air flow controls, such as the pulverized coal power drives and forced draught fan, to affect the desired changes. A trimming signal from fuel flow an air flow sensors maintains the appropriate fuel-air ratio. Usually, about 5 seconds delay to allow when changing coal flow and air flow to ensure the prevention of a momentary rich mixture between fuel-air ratio and thus assume smoke-free combustion (Malek, 2004).

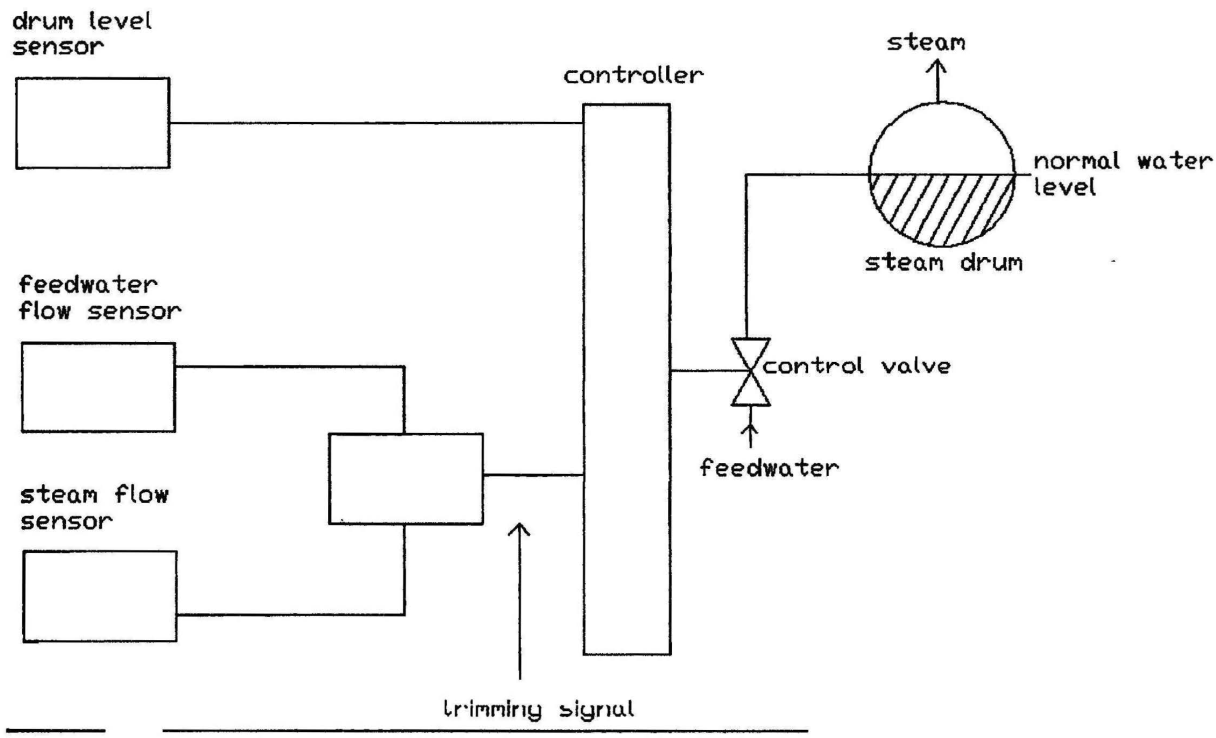

Figure 2.3 Schematic of a three-element feedwater control system.

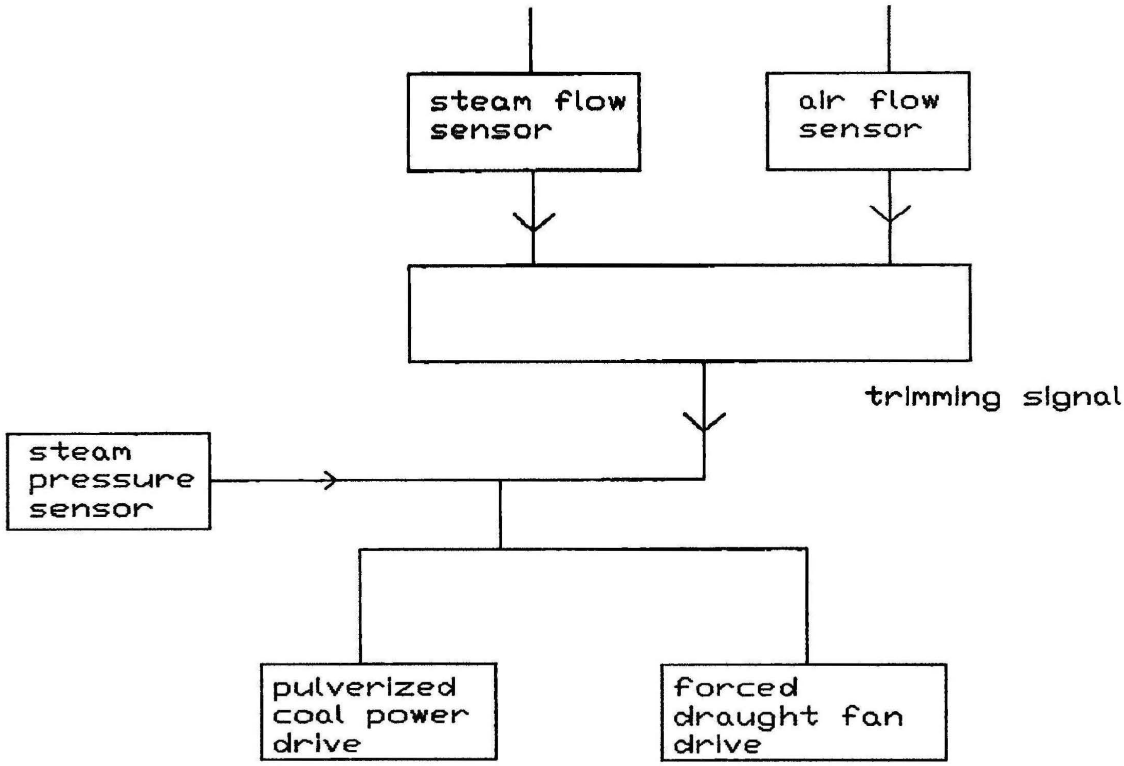

Figure 2.4 Schematic of a steam control system.

2.3 Impurities

Solids precipitation at drum can be removed by blowdown in the way of discontinuous or continuous. Pure water will have low electrical conductivity. This can be concluding as if there is a high conductivity in the drum, there must be a lot of solid precipitation inside. The amount of blowdown is usually expressed by percentage. Thus

% blowdown = (quantity of water blowdown/quantity of feedwater) x 100

The continuous blowdown has the advantages of easier to control the concentration of the water.

2.4 Gauge glass and water column.

The purpose of the gauge glass is to show level of the water inside the boiler. The bottom of the glass must be atleast 3 inch above the tubes. The passage leading glass can be approving clear by taking this step:

1. The top valve on column and top valve on glass must be closed. The drain valve on glass being opened. If water blows freely from drain, the water passages from boiler column and from column to glass are clear.

2. The bottom valves on column and glass being closed while the top valve being open. If the steam blows freely from drain valve at bottom of glass, steam passage from boiler to column and from column to glass are clear.

3. The drain valves on glass are closed and drain valve on column are opened. If steam blows freely from column drain, the column itself can be conclude as crystal clear.

4. The column drain valves are closed and the bottom valves of column and glass are opened. The water will rise quickly to its correct level in the glass when the valve is closed. If action is sluggish, some obstruction may still be in the pipes or valves. The entire drain valve must be surely tightly closed and all other valves widely opened.

This is the proper procedure in testing the water level and water column, as simply opening the drain valve, without touching any of other valves, the glass does not prove that both top and bottom connection are clear.

A water column is a hollow casting, or forging, connected by pipes at top and bottom to the boiler's steam and water spaces (Higgins A, 1945). The steam pipe connection to top of water column must not be lower than top of the glass and water pipe connection must not be higher than bottom of glass. The minimum of the connecting pipes must not less than 1 inch. Usage of the tees and cross connection at practicable turns of the piping may be easily examined and cleaned by removing the plug.

2.5 The fittings.

Valve are not absolutely essential on steam and water connections to the water column, but, if used, they must be outside screw and lever-lifting gate valves, stop-cocks with lever handles or other valve types that offer a straight way passage and show by position of operating mechanism whether the valves are open or closed.

The water gauge glass with its steam, water, and drain valves is placed on the water column and also required gauge cocks. Damper regulators, feedwater regulators, steam gauges and other pieces apparatus that do not require or permit escape of an appreciable amount of steam or water may be connected to the pipes leading from water column to boiler.

2.6 Glass and connection.

For pressure that not exceeds 250 psi, cast-iron water column can be used and malleable-iron columns for pressures not exceeding 350 psi. Steel columns can be use for pressure more than 350 psi.

The gauge must be well lighted and placed so that water level can be easily seen all the times. Water glasses or water-glass guards that obscure water level is not recommended. Quick-closing valves with level handle and hanging chains shut off steam and water connections without danger of operator being schedule if a glass breaks.

It is important to fit the gauge glass at correct distance above highest point of boiler heating surface that might be damaged by low water.

On a very high boiler the water-gauge glass is sometimes set with top tilted outward so that it may be more easily seen, and special forms of gauges are sometimes used with lamps and mirrors to project gauge reading to floor level. Flat glasses are used in gauge for very high steam pressures and maybe constructed to make water appear black and steam white. In one particular make of high-pressure water gauge, water space appears green in colour and steam space red. These colours make the gauge more possible to read (Higgins A, 1945).

2.7 Gauge cocks.

Gauge cocks can be describe as a small globe valves with side outlets and wheel or lever handles, also can be a spring type cocks. The gauge cocks is used to check on the water gauge or a temporary water level finder when a gauge glass breaks by observing whether water or steam blows out when a cock is opened. When there are possible replacement for the gauge glass on the boiler head or shell, gauge cocks are also directly attached. Gauge glass will be placed on side of column when a water column is used.

According to ASME Code, every boiler must have three or more gauge cocks located within the visible length of the water glass except when a boiler has two way glasses independently connect to the boiler at least 2 ft apart. Locomotive boiler not over 36 inch in diameter, or other firebox water-leg boilers with not more than 50 sq ft heating surface, must have only two gauge cocks. Bottom gauge cock is placed level with visible bottom of water glass and others are spaced vertically in suitable distances.

CHAPTER 3

METHODOLOGY

The analysis is conduct in two main stages. The first stage is determining the failure possibility through literature. The calculation is focused on the glass as the failure tendency is attracted with the glass. The second stage is analysis by using failure software. The software that is currently being used is Algor. The analysis is base on opening crack propagation mode.

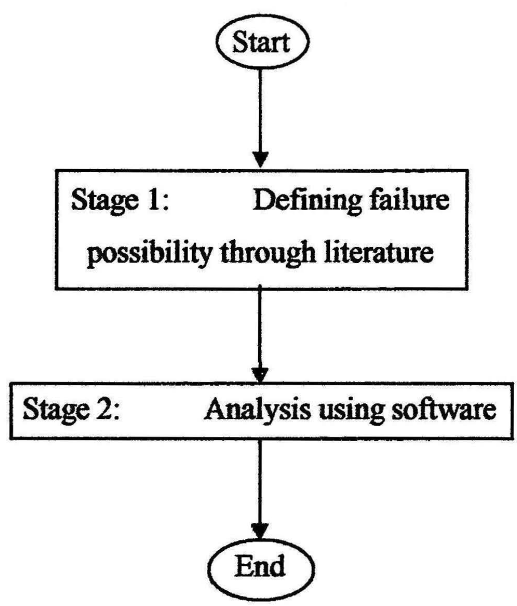

Figure 3.1 Methodology step

3.1 Failure possibility through literature

As the boiler operates in high pressure and temperature, there are many possibility of failure for the indicator. Failure for gauge glass can be divided into 2 category, indication failure and cracking of the glass.

The caution steps must be taken by the boiler man for self safety purpose. This is important to the secure environment while the boiler is under operation.

3.2 Stress distribution in cylinder

Cylindrical pressure vessel and pipes or tubes carrying fluids at high pressures develop both radial and tangential stresses with values that depend to the radius of the element that being analyze. In determining the radial stress σ_r and the tangential stress σ_t, there is an important to assume that the longitudinal elongation is constant around the circumference of the cylinder.

By designing the inside radius of the cylinder is labeled as r_i, the outside radius by r_o, the internal pressure by p_i, and the external pressure by p_o. Then the tangential and radial stress magnitudes can be determined.

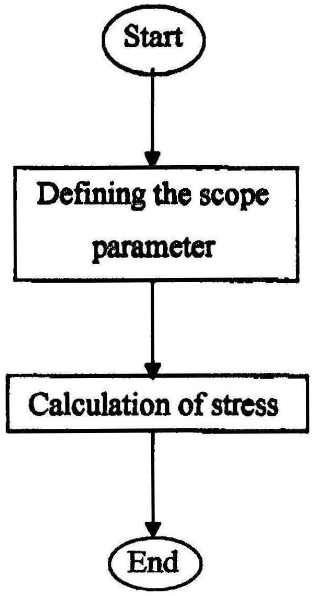

Figure 3.2 Step calculate stress distribution inside the gauge glass

3.3 Design factor and Factor of safety

There are always be an uncertainty due to effect of thermomechanical on the gauge glass as the gauge glass located next to the boiler and the boiler is operated under certain pressure and temperature and the connection is being attached directly to the boiler shell. Uncertainties can be address by using mathematical methods. The primary techniques are the deterministic and stochastic methods. The deterministic method establishes a design factor based on absolute uncertainties of a loss of function parameter or preferably as the load that causes failure and the maximum allowable parameter or in other word, could be maximum allowable load. The design factor is defined as

$$nd = \frac{loss - of - function\ parameter}{maximum\ allowable\ parameter} \tag{3.1}$$

$$n_d = \left(\frac{strength}{stress}\right)^2 \tag{3.2}$$

for cylinders in contact that have nonlinear relationship between stress and load (Beer, E. Russell Johnston, & DeWolf, 2002). The margin of safety can be determine from equation

$$\text{Margin of safety} = n_d - 1.00 \tag{3.3}$$

3.4 Reliability

Stochastic methods are based on the statistical nature of the design parameters and focus on the probability of survival of the design function or reability. Reliability, can be expressed by range number of

$$0 \leq R < 1 \tag{3.4}$$

The number is a fracture value to the percentage that the part will perform in proper function without failure. To achieve high percentage of reliability, the combination of materials, processing and geometry must be consider.

3.5 Software analysis

In order to analyze the failure, Algor software is used to prove the analysis. By using the software, the tangential stress and the radial stress can be obtained. Algor also can calculate the surface temperature of inner and outer radius of the glass. The other information that can get from the software analysis is uniform distribution of pressure inside the glass and also the diagram of temperature distribution as the glass is cooling down.

After the result is obtained, the comparison can be made between the result from the software calculation and the manual calculation. From the comparison, the reliability of the glass can be obtained as the theory of avoiding the failure will be proved.

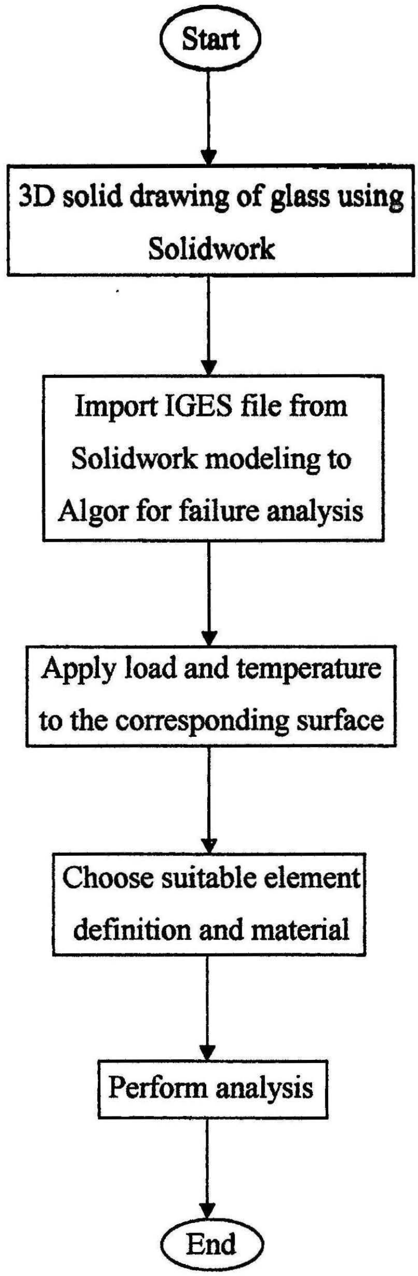

Figure 3.3 Performing testing by using software

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The result is divided into two sections. The first section is devoted to a manual calculation to determine the stress distribution. All these formula is calculated focus on the glass failure. The comparison can be made the result obtain from manual calculation and the result obtains from simulation using CAE analysis software. The result from simulation is important to show the validation of manual calculation.

In the second section, the result from the simulation using software will be introduced. The diagram from the result will show the distribution flow of corresponding parameter that analysis.

In the overall analysis, the stress and the thermal loading is assume to be uniform from the central point of the gauge glass.

4.2 Stress distribution

As the $P_o = 0$, the equation E3-2 is being use to calculate the tangential and radial stress distribution.

Thus, the tangential stress is

$$\sigma_t = \frac{r_i^2 p_i}{r_o^2 - r_i^2}\left(1 + \frac{r_o^2}{r_i^2}\right)$$

$$= \frac{\left(\frac{41}{64}\right)^2 250}{\left(\frac{3}{4}\right)^2 - \left(\frac{41}{64}\right)^2}\left(1 + \frac{\left(\frac{3}{4}\right)^2}{\left(\frac{41}{64}\right)^2}\right)$$

$= 1599.11$ lb/in^2

The radial stress is

$$\sigma_t = \frac{r_i^2 p_i}{r_o^2 - r_i^2}\left(1 - \frac{r_o^2}{r_i^2}\right)$$

$$= \frac{\left(\frac{41}{64}\right)^2 250}{\left(\frac{3}{4}\right)^2 - \left(\frac{41}{64}\right)^2}\left(1 - \frac{\left(\frac{3}{4}\right)^2}{\left(\frac{41}{64}\right)^2}\right)$$

$= -250$ lb/in^2

4.2.1 Stress Distribution by Using Software

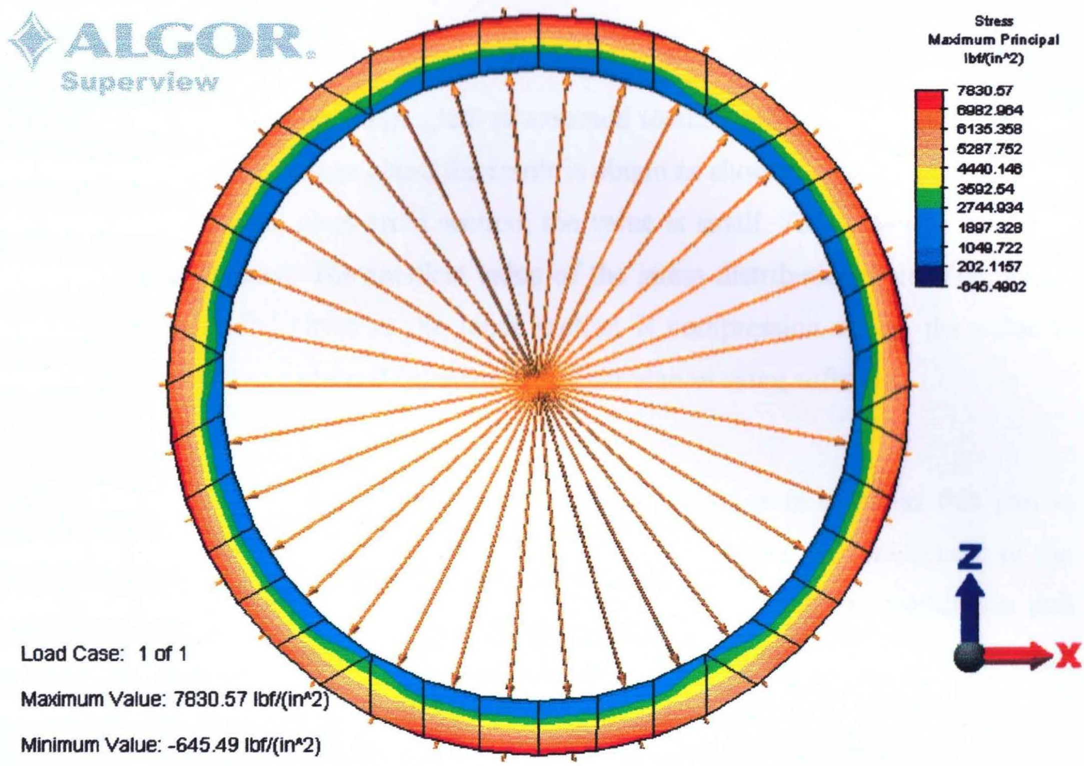

Figure 4.1 Stress distribution along the gauge glass cross section area

4.2.2 Discussion

Stress distribution

As the stress at the gauge glass is assumed loading uniformly distributed from the inner surface of the gauge glass, the result is obtain as shown in the figure 4.1. From the inner section of the glass cross section, the value is small. This is where the radial stress can be calculated. The smallest value of the stress distribution is in blue colour contour. As the radial stress at the inner section is compression stress, the value is negative as shown using manual calculation and simulation using software.

The outer section of the glass cross section, the value is larger as this part is pushed by the inner side pressure. The outer area is also larger than inner area of the glass. The value of the pressure is positive as shown by manual calculation and simulation by using software. This indicates the outer section of the gauge glass having tensile stress and labeled by red colour contour.

The tangential stress is considered when there is a shearing occurred at the overall part of the gauge glass. As the gauge glass is attached to the steam gate and water gate at the end of the gauge and the gauge glass operated under high condition, there are always have a tendency of gauge glass due to tangential stress although the major cause of the gauge glass failure due to stress distribution is contributed by radial stress.

4.3 Distribution of Temperature

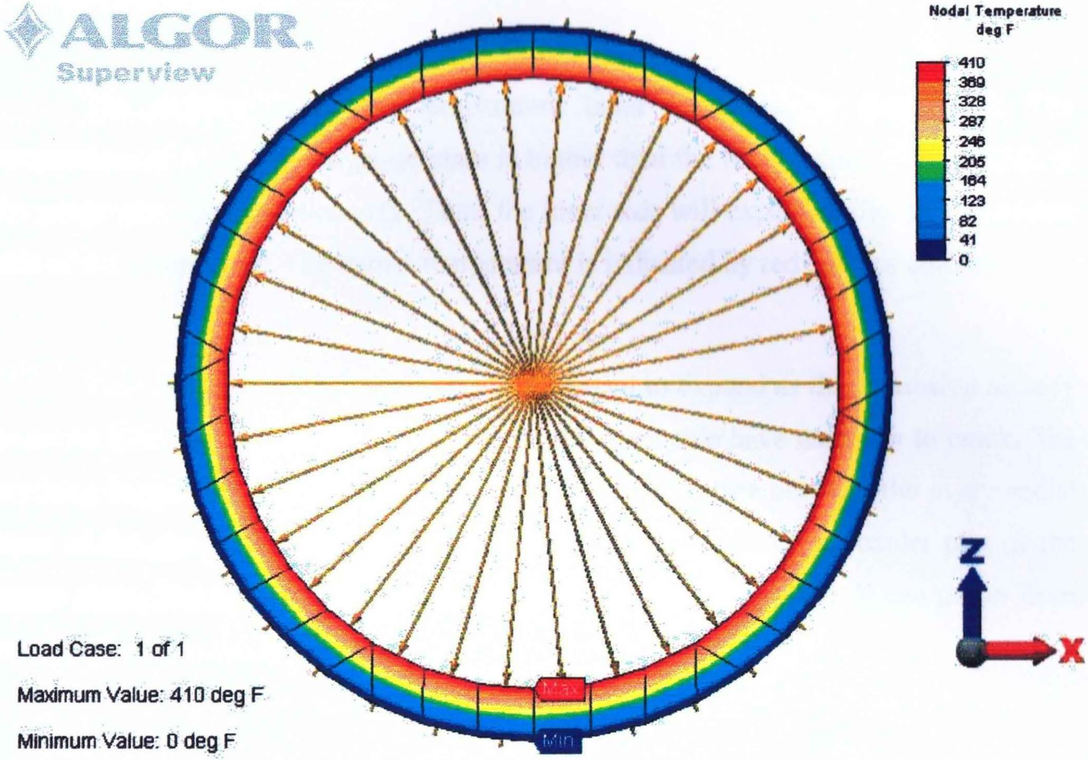

Figure 4.2 Temperature distribution of along gauge glass area

4.3.1 Discussion

Temperature distribution

The distribution of the temperature polar is shown by Figure 4.2. The temperature of inner side of gauge glass is higher than the temperature at the outside of the gauge glass cross section area. Thus, the inner side will expand earlier than the outer side of the gauge glass. The higher temperature is indicated by red contour colour.

The outer side of the gauge glass will forced to expand as the expansion already occurred from the inner side. This will make the outer side have tendency to crack. The cracking happened when there are differences of temperature between the every radial layer of the glass cross section. The blue colour contour shows the cooler part of the gauge glass. The cracking does not need specific area to take place. It can go on from every perimeter.

4.4 Factor of Safety, Margin of Safety and Reliability

Factor of safety can be calculated by using

$$\text{Factor of safety, } n = \frac{\textit{Yield Strength}}{\textit{Given Load}}$$

$$= \frac{1000\,psi}{250\,psi}$$

$$= 4$$

$$\text{Margin of safety is, } n - 1 = 4 - 1$$

$$= 3$$

According to Lev Tsirulnikov Ph.D., John Guarco, and Timothy, 2003, from the book Industrial Burners Handbook, the reliability of this product is more than 10 years under appropriate handling condition.

4.4.1 Discussion

Factor of Safety, Margin of Safety and Reliability

Factor of Safety is important as it indicates the trust worthy of using the gauge. As the factor can be calculated using mathematical method, the value obtained addresses the tendency of failure for the gauge glass. The Factor of Safety is an identical factor when linear relationship exists between the stress and the load given. Factor of Safety value must be more than 1 as the working stress must not exceed the yielding stress. Factor of Safety below 1 indicates that the fracture will occurred just after the load is applied. Thus, as the manual calculation is performed, the value obtain is 4. The gauge glass can carry maximum four times load bigger than current loading.

Margin of Safety value is 3. This value is important to address that if the working pressure is beyond the safety boundaries of 3, with competence handling of boiler operation, the gauge glass can undergo the heavy task. The working pressure is 250 psi, with the margin of safety of 3; the gauge glass can work with maximum of 750 psi without cracking (with appropriate boiler operation handling).

As the reliability of the gauge glass is 10 years with proper handling of boiler operation, it shows that the major factor of gauge glass fracture is not because of the geometry, properties and design of the gauge glass. The biggest factor is the way the boiler operated. The boiler operator must follow the steps to run the boiler and fully understand the optimization of output without causing a failure to the operation.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The major factor that influences the possibility of gauge glass failure is inconstant pressure that flow through the gauge glass. As the gauge glass have small value of cross section area, the heat transfer towards the cross section area are very fast and heat transfer do not give much contribution on the failure analysis.

Proper handling of the boiler operation can reduce the turbulence flow inside the gauge glass. Following the principle of starting to function the gauge cocks will control the shock impact from the steam and the water during entering the gauge glass in the initial condition of operation.

The manual calculation and the simulation using failure software show the distribution of stress and temperature in the gauge glass. Unstable relation of stress and temperature can cause fatal failure of gauge glass and even worst to the output of boiler operation.

5.2 Recommendation

As the investigation of gauge glass failure possibility has significance in boiler operation, it is recommended for further analysis to undergo an experimental analysis. The experimental analysis is important to get the fracture mechanics. The exact geometry can be obtained to get the angle of fracture.

Thus, performing the simulation on the gauge glass connection such as the connector can achieve maximum understanding on gauge glass failure.

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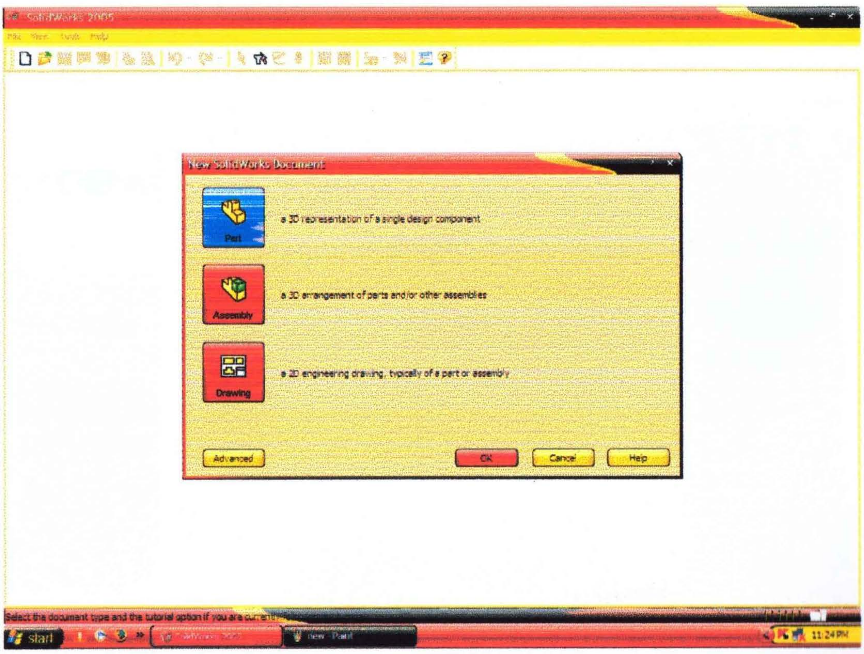
APPENDICES

APPENDIX A

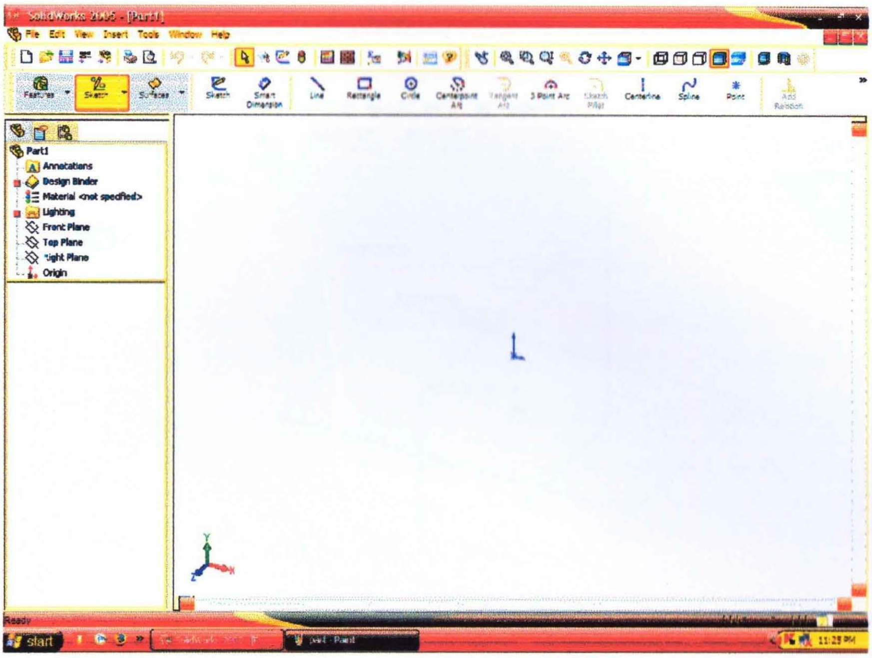
Steps for 3D Solid Drawing by Using Solidwork

1. Open Solidwork program to draw solid glass. Click new at top left button.

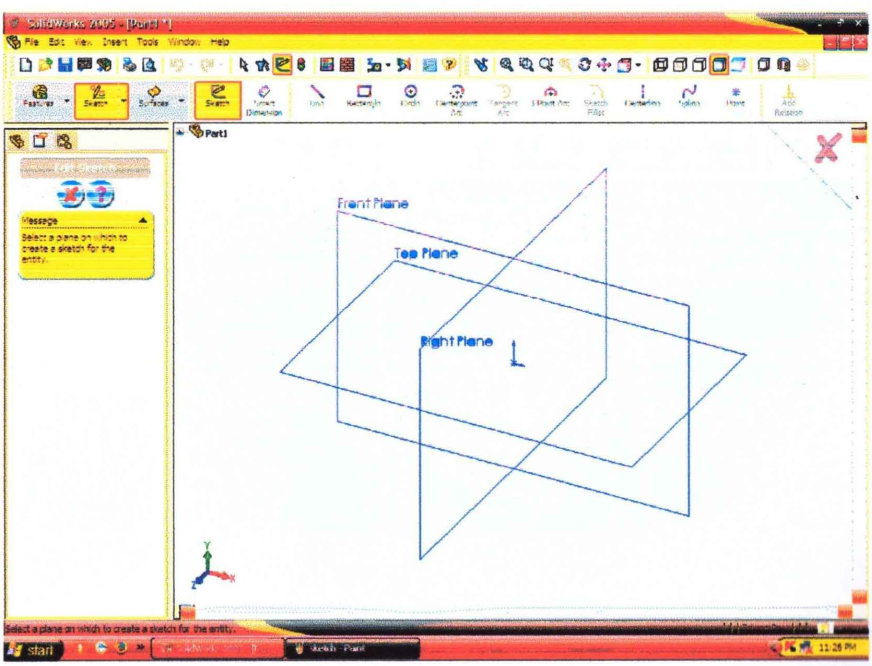
2. 3 types of task display; Part, Assembly and 2d Drawing. Choose part.



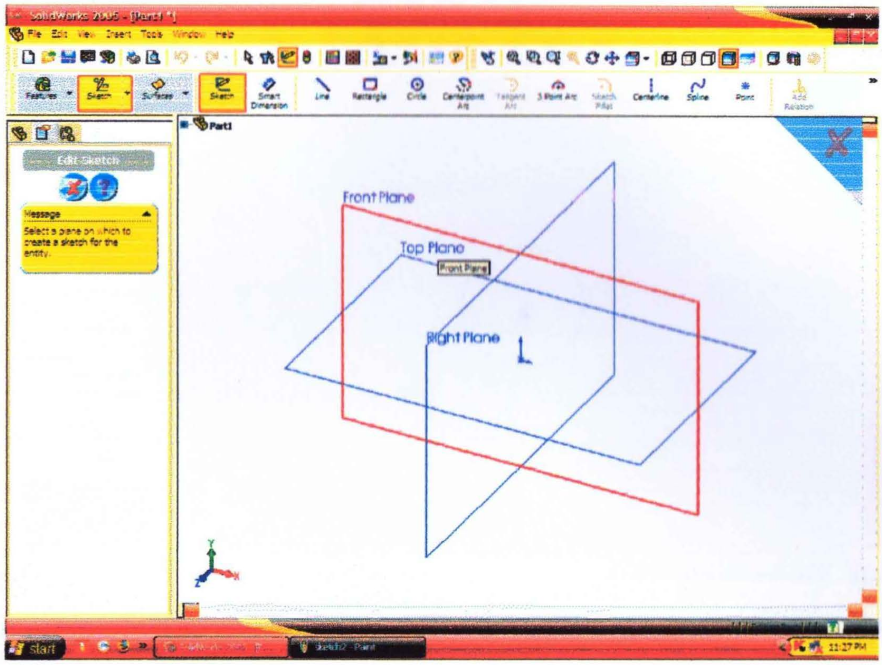
3. Click sketch button to start drawing the glass.



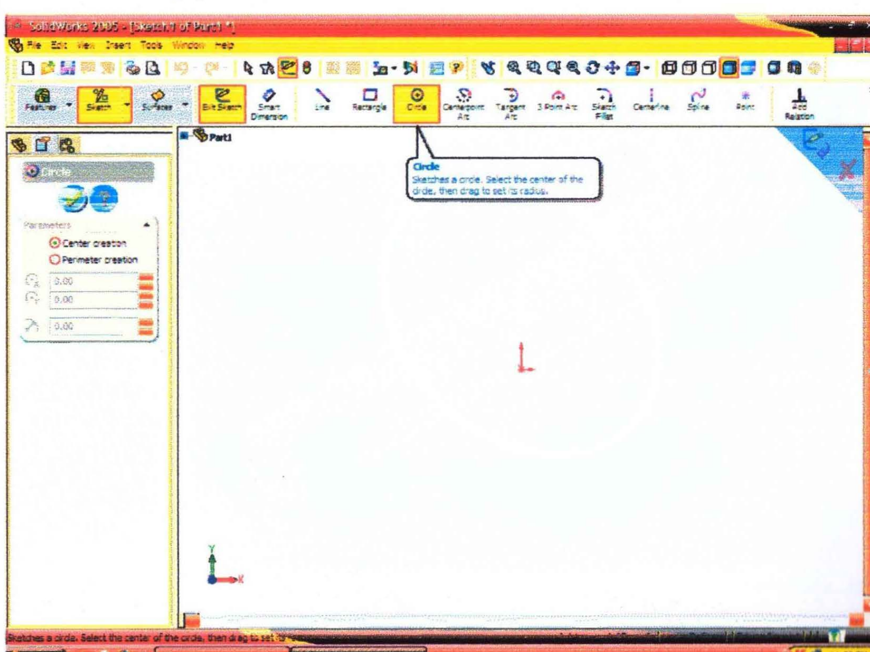
4. On the menu displayed, click sketch to activate the sketching tools.



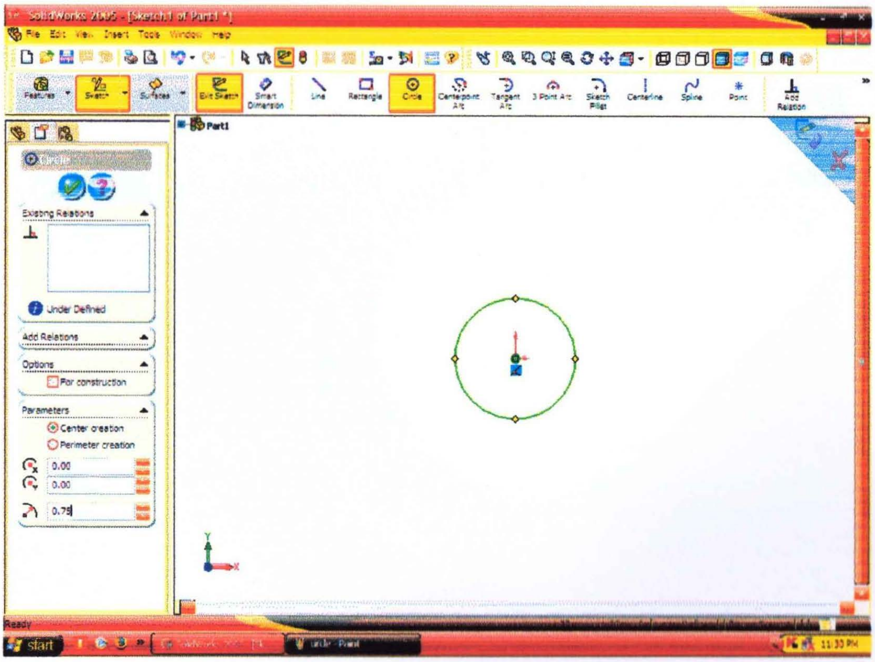
5. A menu display to choose plane of first part orientation. To select, let the plane highlight in red colour, then click.



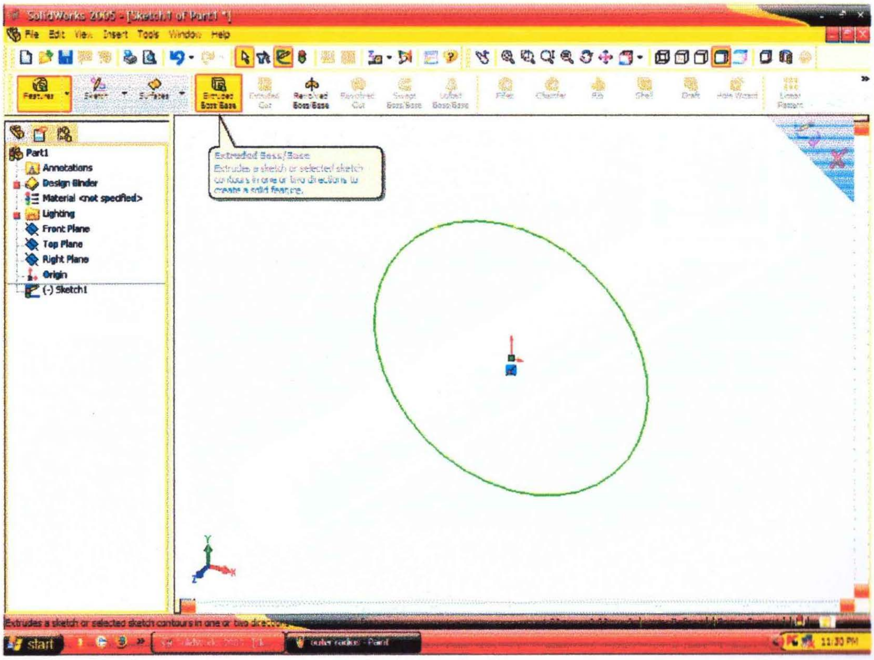
6. After choosing plane, click the circle button to draw a circle.



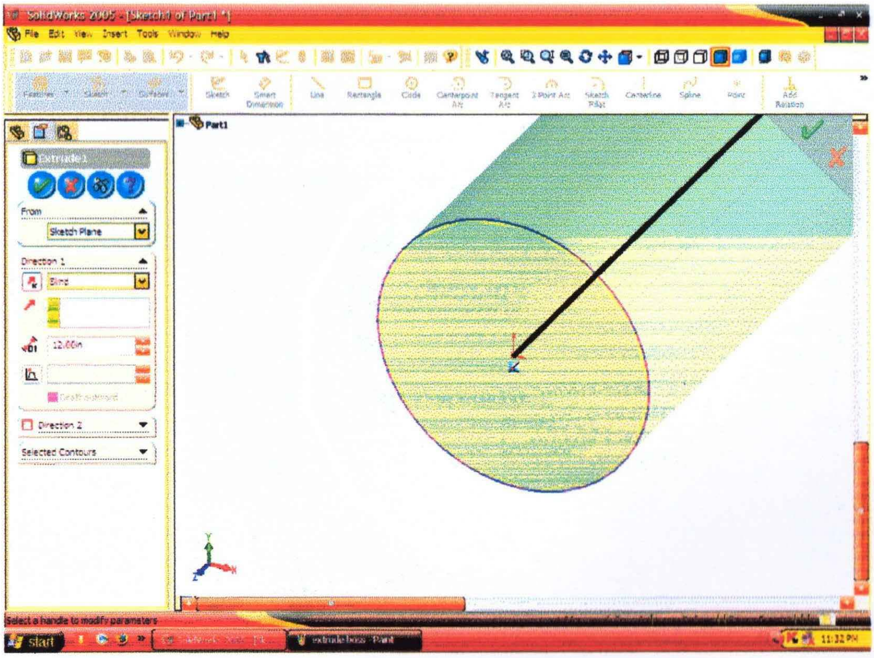
7. After drawing a circle, put the correct value for outer radius of the glass.



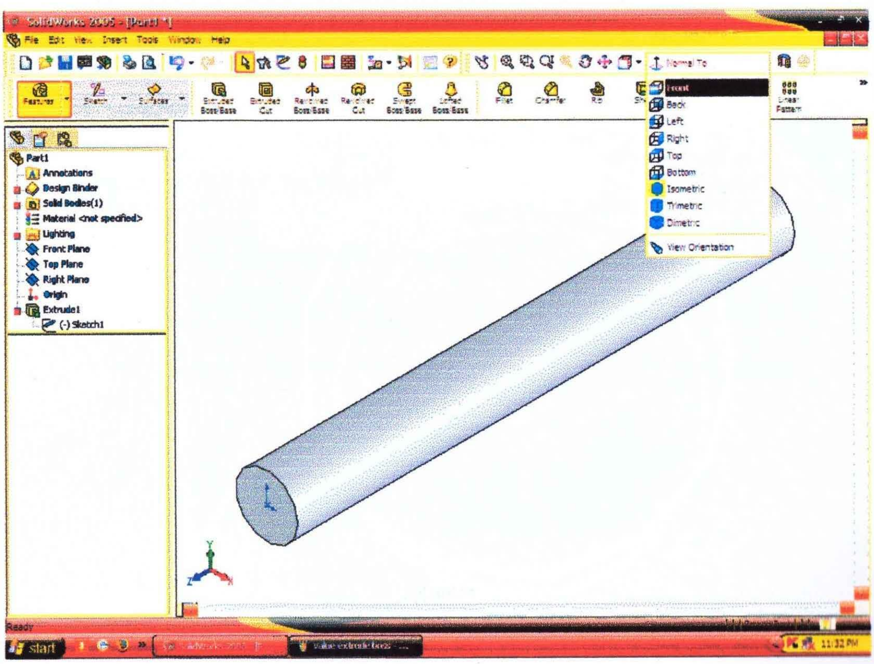
8. Click the Features button and followed by Extruded Boss button.



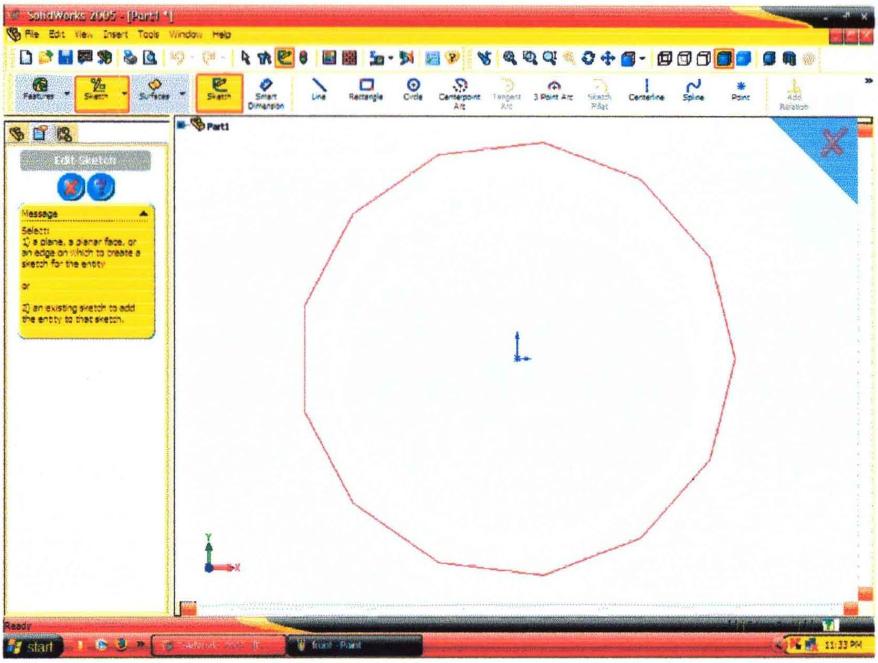
9. Insert the value of glass length.



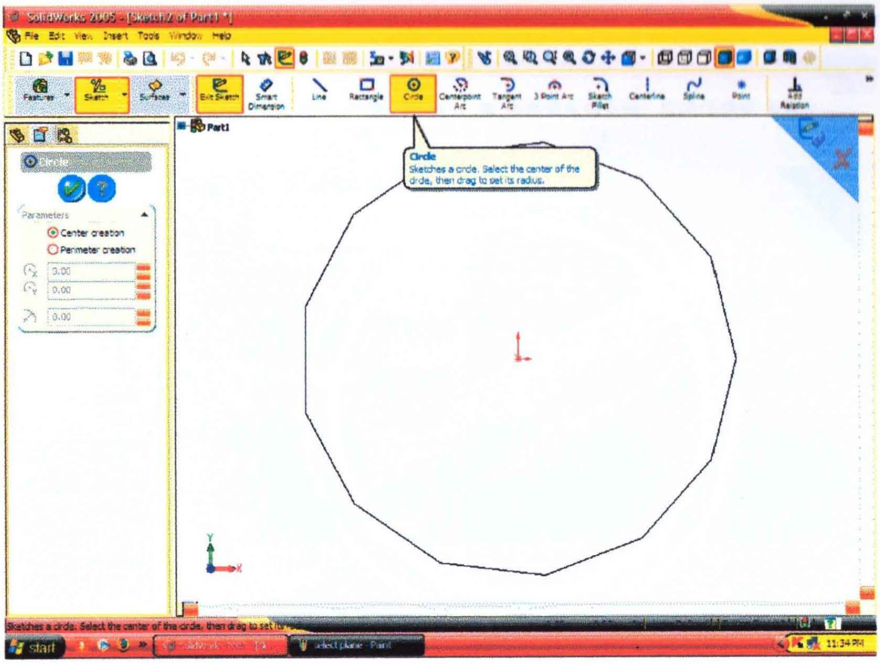
10. Select front axis to draw second circle for inner radius.



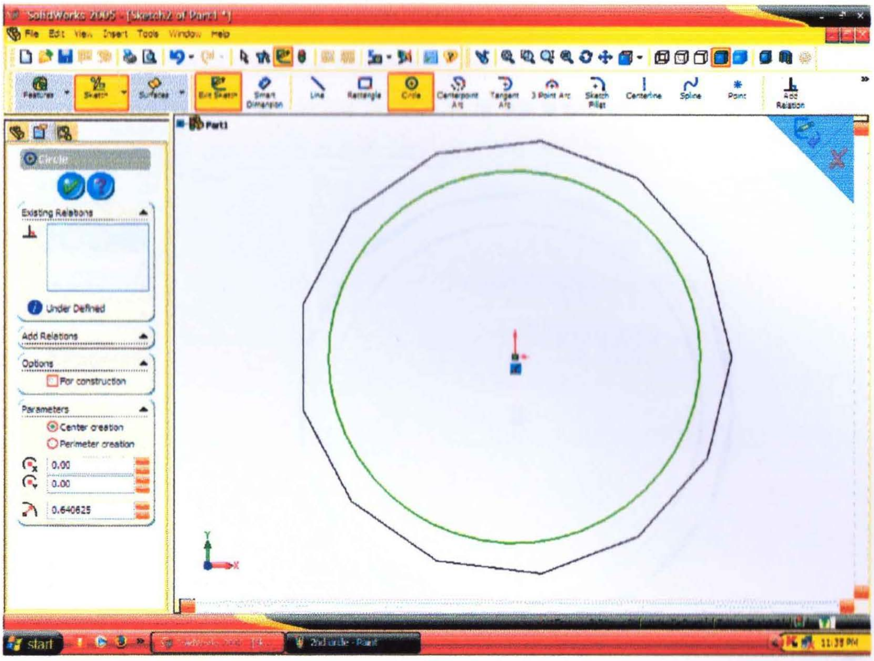
11. Select plane to sketch.



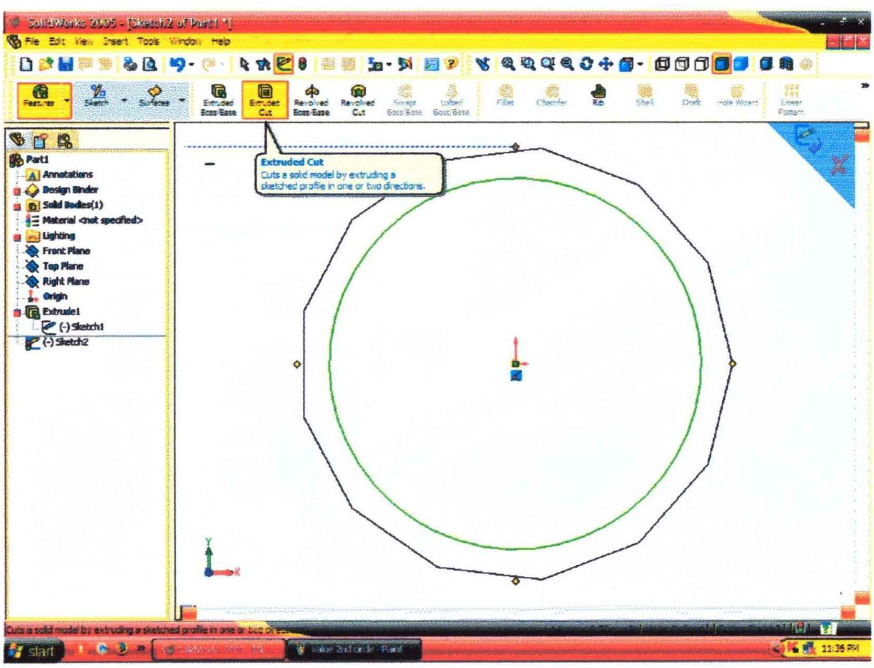
12. Click Circle button to draw the second circle.



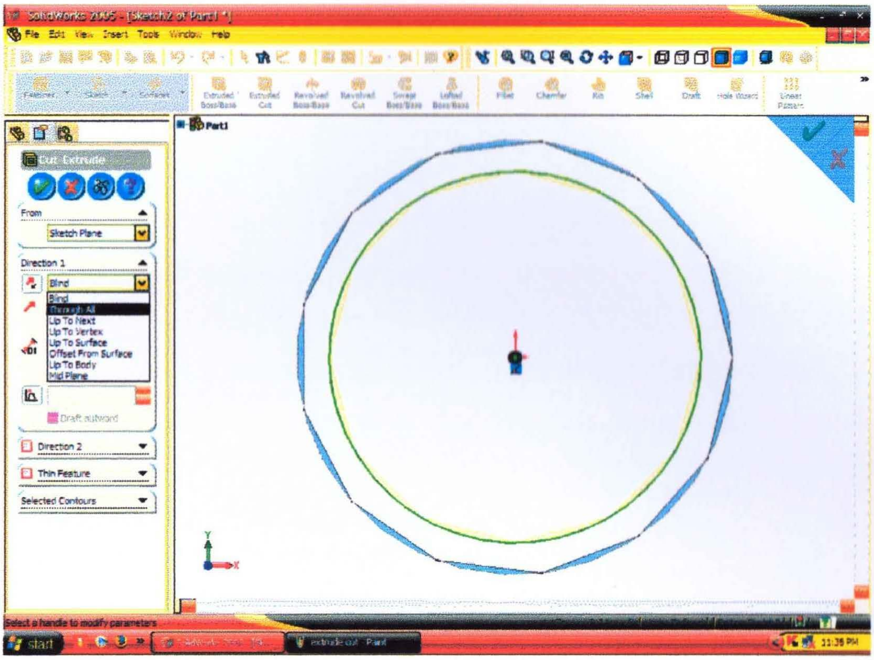
13. Insert value for inner radius.



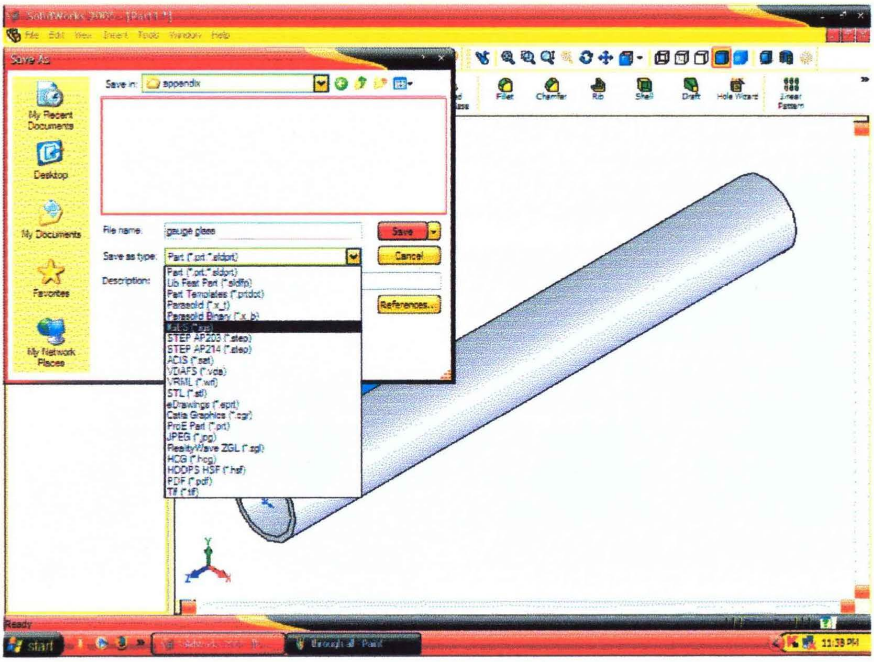
14. Click the Features button and followed by Extrude Cut to cut the corresponding inner cross section.



15. In the Cut-Extrude menu, in the Direction 1 box, choose Through All to cut the glass into hollow.



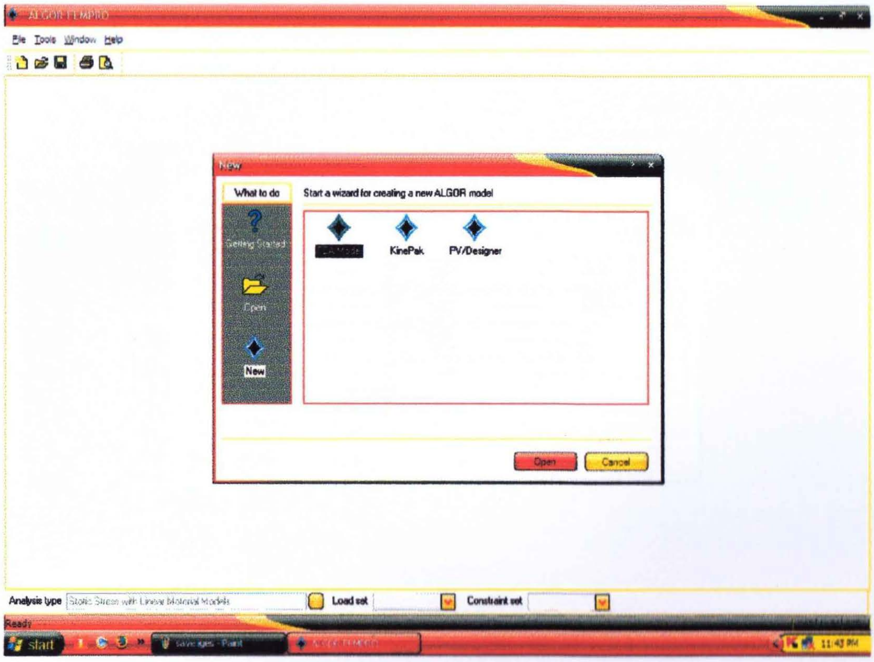
16. Save the file in *IGES format to use in Algor.



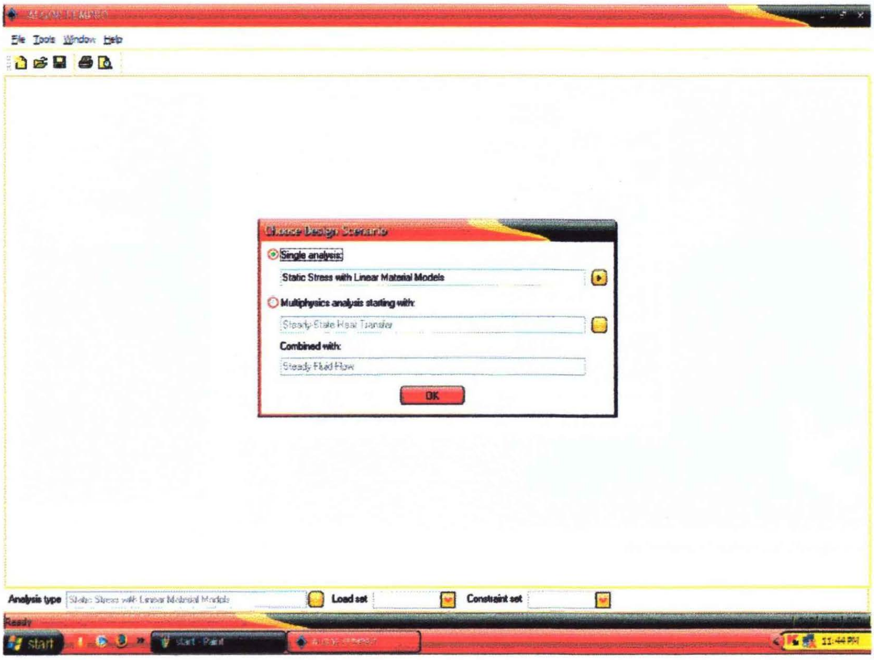
APPENDIX B

Steps for Software Analysis Using Algor

1. Select FEA model and open.

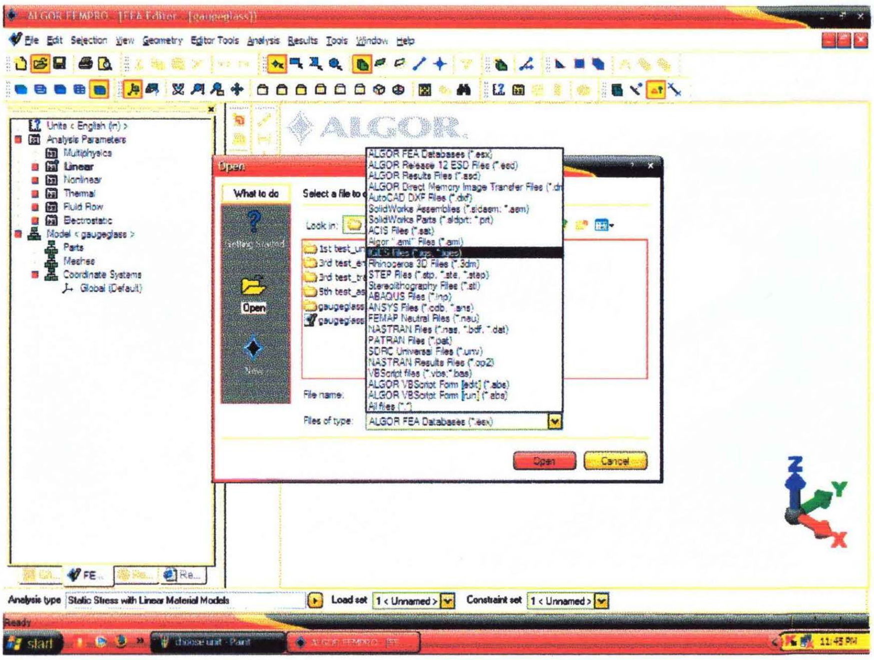


2. Choose design scenario as single analysis; Static Stress with Linear Material Model.

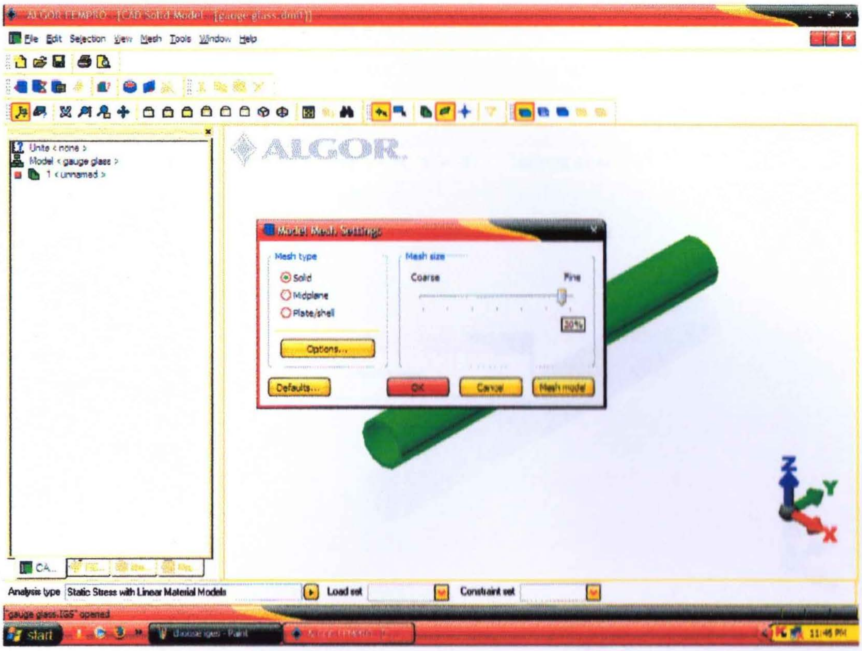


3. Choose desired unit definitions.

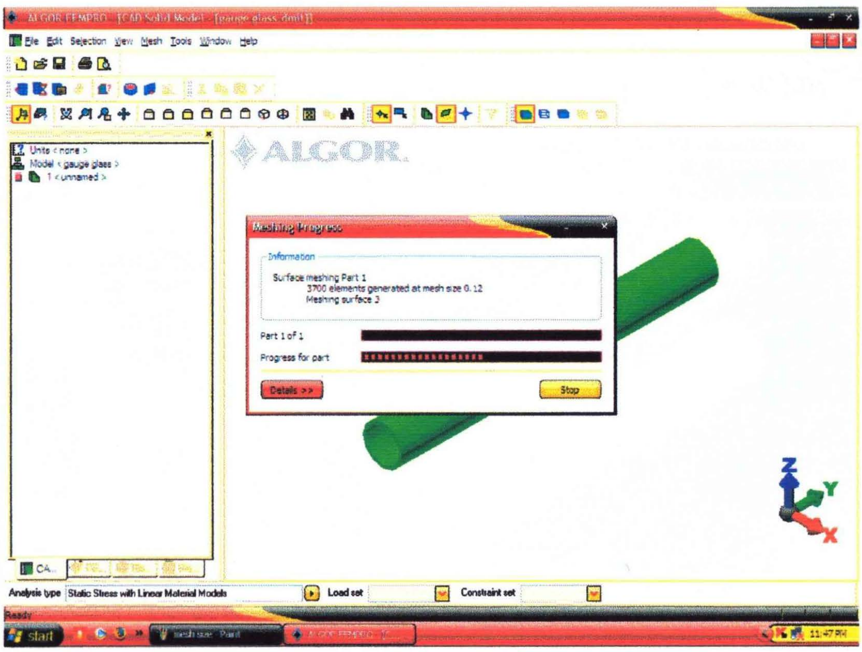
4. Select *IGES file to find the 3D solid drawing that have been converted.



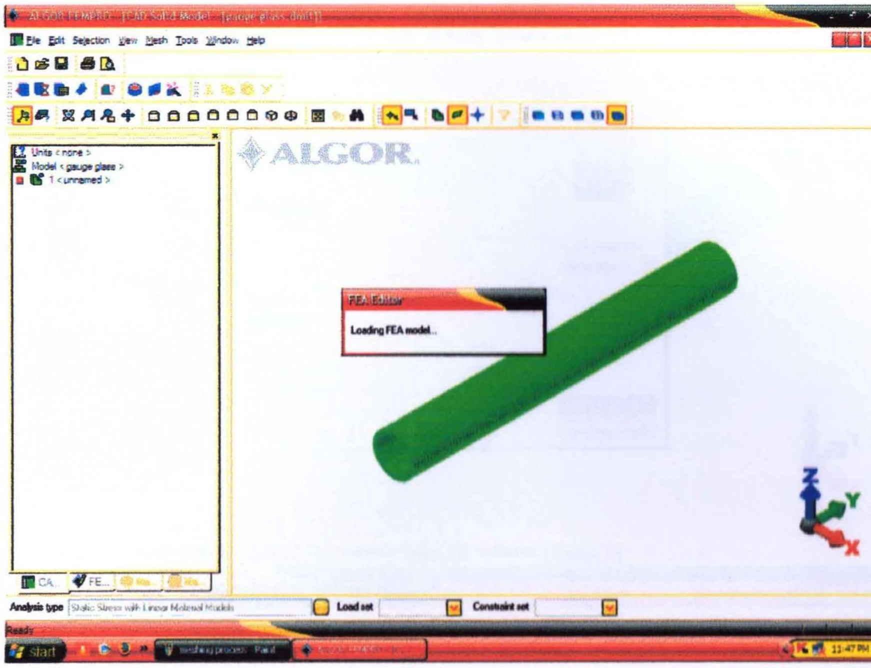
5. Select the mesh size and click Mesh Model button.



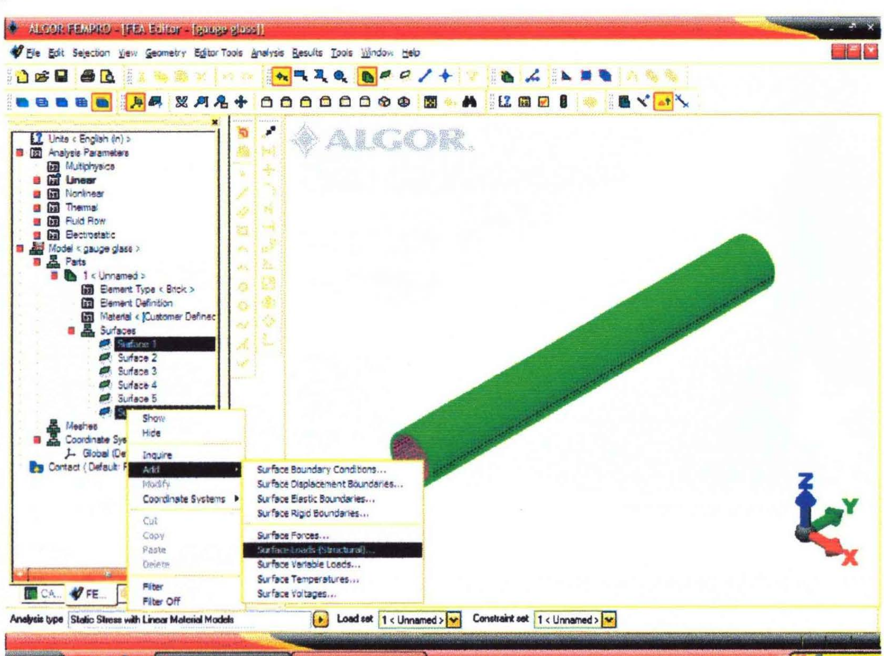
6. Meshing is in progress.



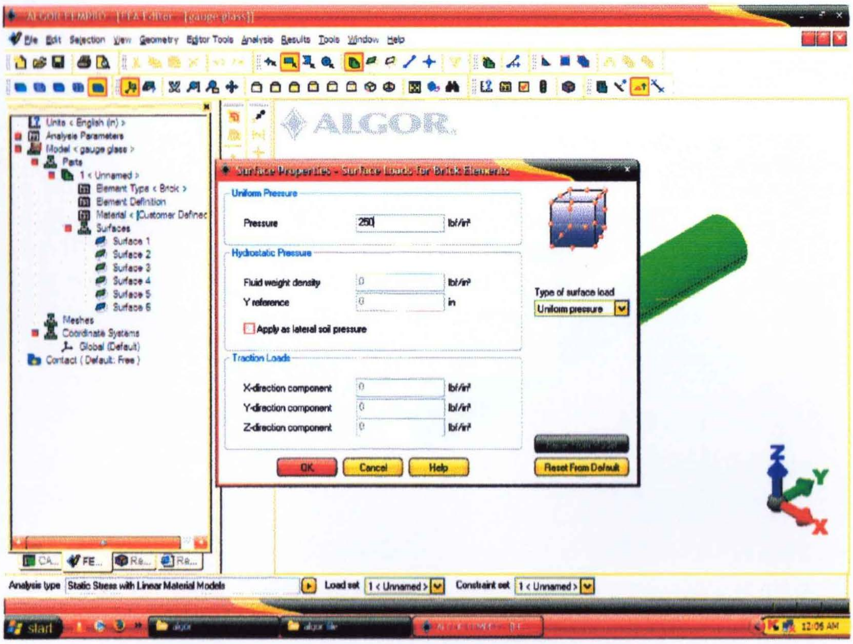
7. After finish meshing the model, the Finite Element Analysis model will loaded automatically in seconds.



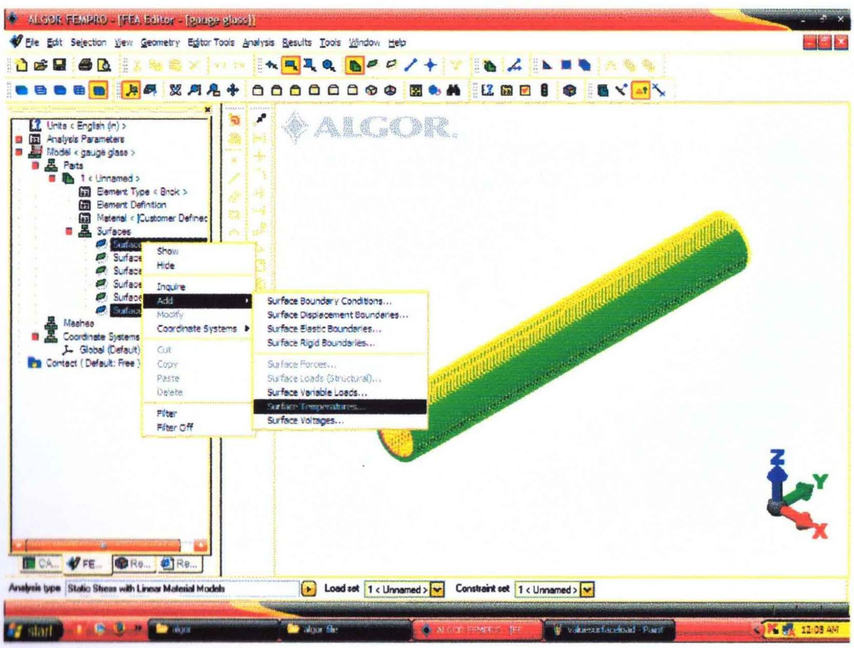
8. Set the material properties and select the inner surface of the glass to apply pressure.



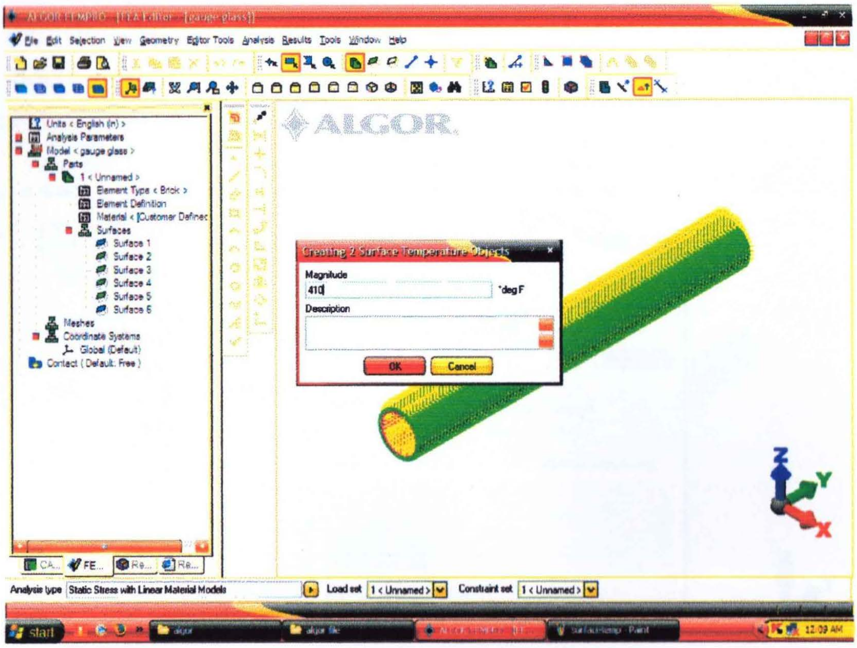
9. Select the type of the surface load and insert the value of corresponding load.



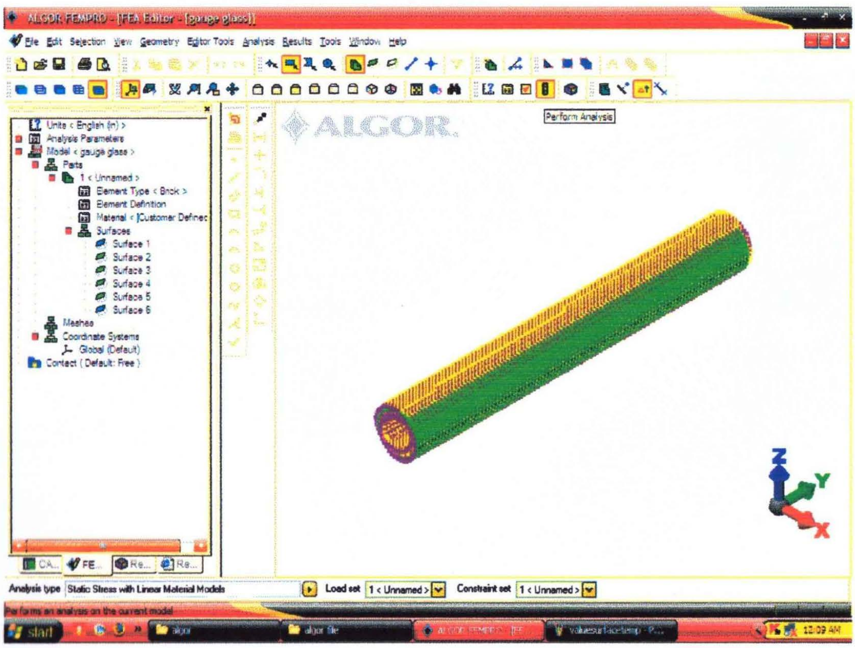
10. Select the inner surface again to set the surface temperature.



11. Insert the surface temperature value and some description if desirable.



12. Click the Perform Analysis button to perform analysis on the model.



13. The window Structural-Static Stress with Linear Material Model will appear to show the progress of analysis. The window will close when finish analyzing the model and the result will show.