# Design & Cad Model Of Air Flow Governor Of Gas Turbine

Ms.M.G.Pawar[1],Acshay Pachbudhe[2], Rahul Thaware[3]
[1]*Asst. Professor,* Department of Mechanical Engineering, DBACER, Nagpur
[2] UG Student, Department of Mechanical Engineering, DBACER, Nagpur
[3] UG Student, Department of Mechanical Engineering, DBACER, Nagpur

Mamta_p23@yahoo.co.in

**Abstract**- There is different component of gas Turbine. In our Project We have design Air flow Governor of Gas turbine. The project relates to a gas turbine engine arrangement for constant volume combustion including a combustion chamber arranged downstream of a compressor supplying combustion air and upstream of a turbine accepting exhaust gases from the combustion chamber as driving gases. An Air Flow Governor is arranged between the combustion chamber and the compressor for intermittent blocking of the flow between the compressor and the combustion chamber during constant volume combustion within the combustion chamber, while the exit end of the combustion chamber leading to the turbine is closed before heat addition and open before heat addition. This project deals with improving the thermal efficiency of gas turbines. This is achieved by improving the heat addition process of gas turbines. Instead of heat addition at constant pressure, heat must be added at constant volume. The main objective is to increase the thermal efficiency of gas turbine by converting the process of heat addition, which was usually done at constant pressure, into constant volume. In or project we have design. we selected Kawasaki L30A gas turbine

Keywords: *constant volume combustion, valve, Air Flow Governor*, Stress Analysis, Cad Model,

## 1. INTRODUCTION

A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between.
There are basically two types of gas turbines based on the mode
Of heat addition:

1. Constant pressure gas turbines
2. Constant volume gas turbines

Constant pressure gas turbines are widely used due to their simplicity of action whereas the constant volume gas turbines are less popular.

[1] Problem statement

The basic problem with the traditional gas turbines is of less thermal efficiency up to 40%traditional gas turbines operate on brayton cycle which limits the thermal efficiency to this limit. This efficiency can be improved up to 80% but it requires many types of machinery installed externally employing various waste heat recovery mechanisms there needs to be such a turbine which is more efficient and eliminates the heavy machinery in waste heat recovery systems. In order to improve the thermal efficiency of gas turbines, we have developed 'Air Flow Governer in gas turbine' which leading to increased power output at same fuel consumption.

1.2 Objectives

- The main objective is to increase the thermal efficiency of gas turbine by converting the process of heat addition, which was usually done at constant pressure, into constant volume.
- To reduce the fuel consumption.
- To reduce the bulk of additional machinery required for waste heat recovery systems.

To reduce the size of gas turbine by reducing the rate of air flow entering through the compressor.

1.3 Introduction to Air Flow Governor

At first we thought of making a reservoir for storing the compressed air from the compressor and supply that air at regular intervals to the combustor. But by storing the compressed the air may lose its temperature essential for auto ignition of fuel.
While designing the combustor we came to this conclusion that the combustor must stay closed till the heat addition process gets completed and gets open as soon as the pressure rises to a certain level. And all this happen automatically. Hence we merged the reservoir and combustor; and reservoir became the Air Flow Governor as it governs the flow of air from the compressor to various parts of the gas turbine.

**2. CONSTRUCTION AND WORKING:**The Explode Combustor Gas Turbine basically comprises of the following components:

1. Axial compressor
2. Air flow governor
3. Explode combustor
4. Compressor turbine
5. Free power turbine

Axial compressor: the explode combustor gas turbine adopts a multistage axial flow compressor consisting of 14 stages capable of producing compressed air of 24bar by compressing 86 kg of air per second. Its main function is to provide compressed air for combustion.

Air flow governor: consists of 4 outlet pipes two of which carry the compressed air to the gate arrangement in the combustor and the rest two pipes supply the compressed air to the combustor. And it has a pressure relief valve which maintains optimum pressure inside the combustor.

Explode combustor: It basically comprises of 4 inlet valves and an outlet gate and a fuel injector. Its main function is to carry out combustion at constant volume and discharge the combustion products on the turbine.

Compressor turbine: It is two stage turbine coupled to compressor shaft. High pressure stage receives combustion products directly from the combustor whereas the low pressure stage receives combustion products from the first stage as well as pressure relief valve ends over this turbine. Its main function is to keep the axial compressor in working condition.

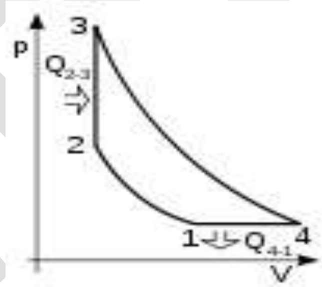


**Fig -1**: Humphrey cycle

**3.DESIGN OF AIR FLOW GOVERNOR**

This part regulates the flow of compressed air in the gas turbine.
It mainly comprises of:
1. Inlet from compressor
2. Outlet to inlet valves
3. Outlet to gates
4. Pressure relief valve

**3.1** Curvature of cylinder:
ID=300cm OD=400cm
Dimensions of curved cylinder: It is thin cylinder: (Rm/t)>10 OD=100cm
Wall thickness of cylinder:
t= (P*D)*FOS/(2*Sd ) t=(2*2*100)*15/(2*0.8*365)=10.27cm
**t=10cm**

3.2 Design Of Inlet Valve
For outer pipe:
OD=40cm , ID=20cm
For inner pipe
OD=10cm ID=6cm
Cross joint: 5cm thick, 20cmdeep

Valve design:

Rod length=60cm  Curvature=Φ100cm

3.3 Design Of Outlet Gates

Force=Pressure*area

Force on inner side of gates:= (22cm*12cm)*20MP=5360N

Pressure on outer side of gate=20bar=2MPa

Hence area of outer side of gate=5360N/2M

(40cm*25cm) + (20cm*84cm) = 2680cmxcm

| SN | Constraints | Values |
|---|---|---|
| 1 | PRESSURE | 20BAR |
| 2 | MATERIAL | SAE 1050 |
| 3 | Syt | 365MPa |
| 4 | FACTOR OF SAFETY | 15 |
| 5 | THICKNESS | 10CM |

Table No.1 Air Flow Governor Design

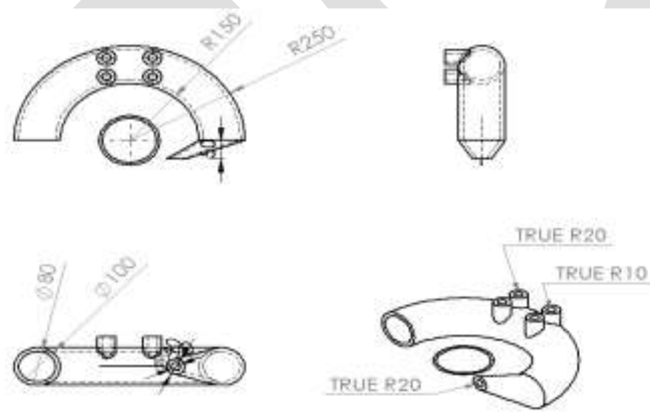


Figure N.o 2 Drawing Of AFG

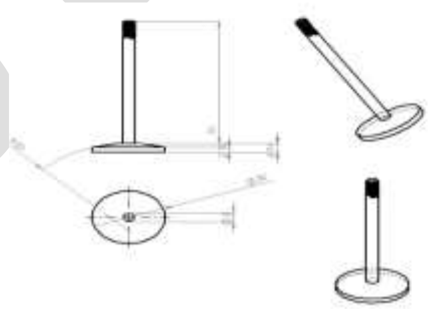

Figure No.3. Part Drawing Of Valve

# 4.MATERIAL PROPERTIES OF EACH COMPONENT:

**Material Inlet valves: Alluminium alloy 2014-T6**

| SN | Property | Value | Units |
|---|---|---|---|
| 1 | Elastic modulus | 72400 | N/mm^2 |
| 2 | Poisson Ratio | 0.33 | N/A |
| 3 | Shear Modulus | 28000 | N/mm^2 |
| 4 | Density | 2800 | Kg/m^3 |
| 5 | Tensile strength | 470 | N/mm^2 |
| 6 | Compressive Strength | 470 | N/mm^2 |
| 7 | Yield strength | 415 | N/mm^2 |
| 8 | Thermal Expansion Coefficient | 2.3e-0.005 | /K |
| 9 | Thermal Conductivity | 115 | W/(m.K) |
| 10 | Specific Heat | 880 | J/(kg.K) |

TABLE 2.Aluminium Alloy 2014-T6 Properties

**Gates and AFG: Steel AISI 304**

| SN | Property | Value | Units |
|---|---|---|---|
| 1 | Elastic modulus | 190000 | N/mm^2 |
| 2 | Poisson Ratio | 0.29 | N/A |
| 3 | Shear Modulus | 75000 | N/mm^2 |
| 4 | Density | 8000 | Kg/m^3 |
| 5 | Tensile strength | 517.02 | N/mm^2 |
| 6 | Compressive Strength | | N/mm^2 |
| 7 | Yield strength | 206.81 | N/mm^2 |
| 8 | Thermal Expansion Coefficient | 1.8e-0.005 | /K |
| 9 | Thermal Conductivity | 16 | W/(m.K) |
| 10 | Specific Heat | 500 | J/(kg.K) |
| 11 | Material Damping Ratio | N/A | |

Table 3 Steel AISI 304 Properties

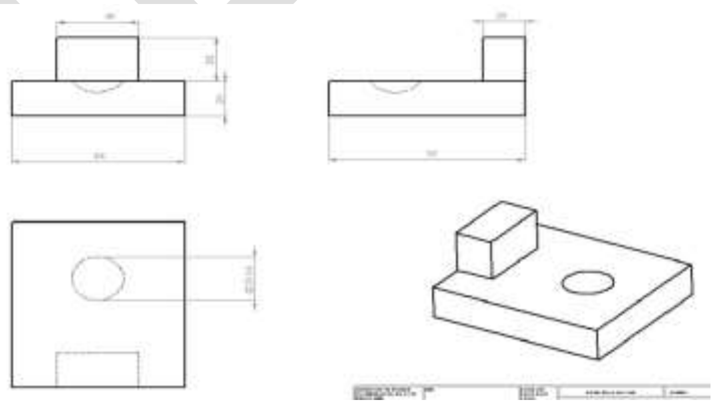

Figure No. 4.Part Drawing Of Outlet Gates

## 5.CAD GEOMETRY

Figure No 5. Cad Model of AFG

Figure No.6 Cad Model of Valve

### 1. STRESS ANALYSIS OF AIR FLOW GOVERNOR

**Model name: Air Flow Governor**
**Current Configuration: Default**

| **Solid Bodies** | | | |
|---|---|---|---|
| **Document Name and Reference** | **Treated As** | **Volumetric Properties** | |
| **Cut-Loft1**  | **Solid Body** | **Mass:15953 kg**<br>**Volume:1.99413 m^3**<br>**Density:8000 kg/m^3**<br>**Weight:156349 N** | |

Table No. 4.Model Information

| **Solid Bodies** | | | |
|---|---|---|---|
| **Document Name and Reference** | **Treated As** | **Volumetric Properties** | |

| | | | |
|---|---|---|---|
| **Cut-Loft1**<br> | **Solid Body** | **Mass:15953 kg**<br>**Volume:1.99413 m^3**<br>**Density:8000 kg/m^3**<br>**Weight:156349 N** | |

Table No 5. Direct vector control block diagram.

| **Model Reference** | **Properties** | | **Components** |
|---|---|---|---|
|  | **Name:**<br>**Model type:**<br><br>**Default failure criterion:**<br>**Yield strength:**<br>**Tensile strength:**<br>**Elastic modulus:**<br>**Poisson's ratio:**<br>**Mass density:**<br>**Shear modulus:**<br>**Thermal expansion coefficient:** | **AISI 304**<br>**Linear Elastic Isotropic**<br>**Unknown**<br><br>**2.06807e+008 N/m^2**<br>**5.17017e+008 N/m^2**<br>**1.9e+011 N/m^2**<br>**0.29**<br>**8000 kg/m^3**<br>**7.5e+010 N/m^2**<br>**1.8e-005 /Kelvin** | **SolidBody 1(Cut-Loft1)(Air Flow Governor)** |
| **Curve Data:N/A** | | | |

Table no.6 Material Properties of AFG

| **Fixture name** | **Fixture Image** | **Fixture Details** |
|---|---|---|
| **Fixed-1** |  | Entities: **7 face(s)**<br>Type: **Fixed Geometry** |

**Resultant Forces**

| **Components** | **X** | **Y** | **Z** | **Resultant** |
|---|---|---|---|---|
| **Reaction force(N)** | **-4.95** | **2518.79** | **10076.3** | **10386.3** |
| **Reaction Moment(N·m)** | **0** | **0** | **0** | **0** |

Table No.7 Fixtures

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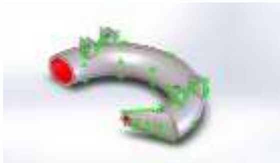
| Load name | Load Image | Load Details |
|---|---|---|
| **Pressure-1** |  | Entities: **2 face(s)**<br>Type: **Normal to selected face**<br>Value: **2e+006**<br>Units: **N/m^2** |

Table no.8.Loads

| | |
|---|---|
| Total Nodes | 16346 |
| Total Elements | 8224 |
| Maximum Aspect Ratio | 16.586 |
| % of elements with Aspect Ratio < 3 | 90.5 |
| % of elements with Aspect Ratio > 10 | 0.243 |
| % of distorted elements(Jacobian) | 0 |
| Time to complete mesh(hh;mm;ss): | 00:00:03 |


Table No 9 Mesh Information Details

## Reaction Forces

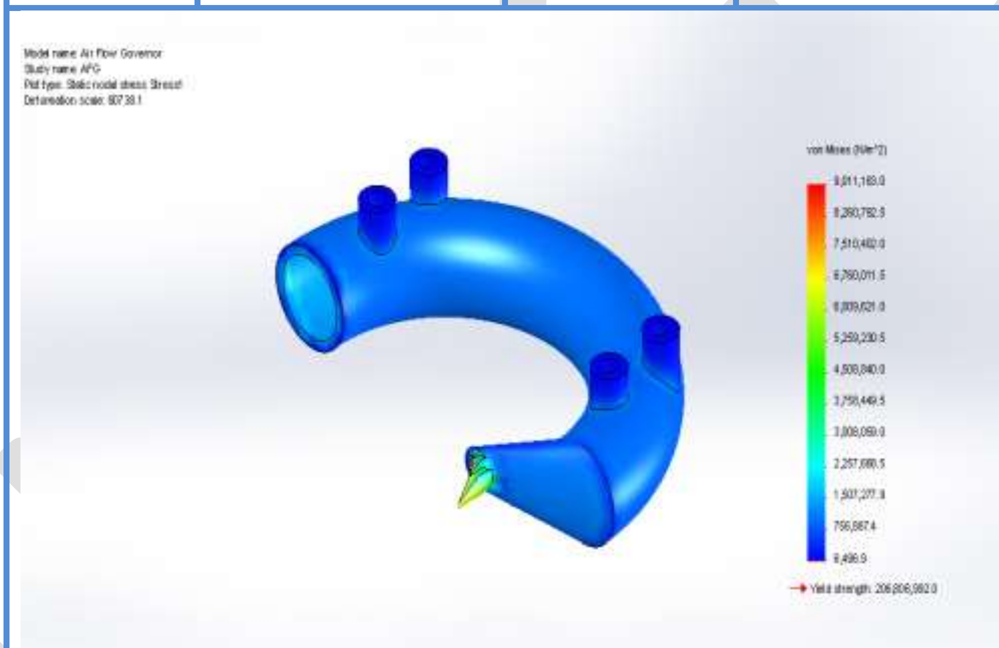
| Selection set | Units | Sum X | Sum Y | Sum Z | Resultant |
|---|---|---|---|---|---|
| Entire Model | N | -4.95 | 2518.79 | 10076.3 | 10386.3 |

## Reaction Moments

| Selection set | Units | Sum X | Sum Y | Sum Z | Resultant |
|---|---|---|---|---|---|
| Entire Model | N·m | 0 | 0 | 0 | 0 |

Table No 10. Resultant Forces

| | Type | Min | Max |
|---|---|---|---|
| Stress1 | VON: von Mises Stress | 6496.88 N/m^2<br>Node: 60 | 9.01118e+006 N/m^2<br>Node: 6742 |




**Air Flow Governor-AFG-Stress-Stress1**

Figure No 7. Von Mises Stress

| Name | Type | Min | Max |
|---|---|---|---|
| Displacement1 | URES: Resultant Displacement | 0 mm<br>Node: 1 | 0.000631933 mm<br>Node: 1591 |

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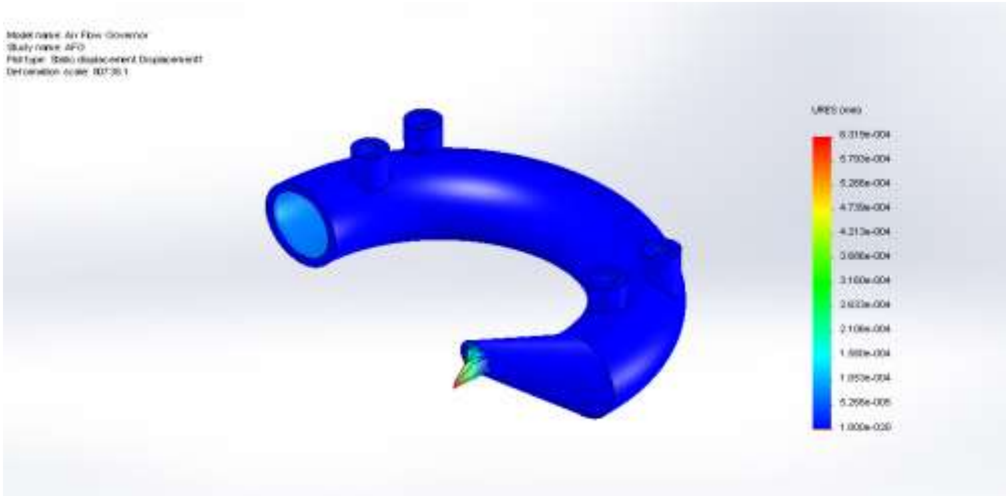
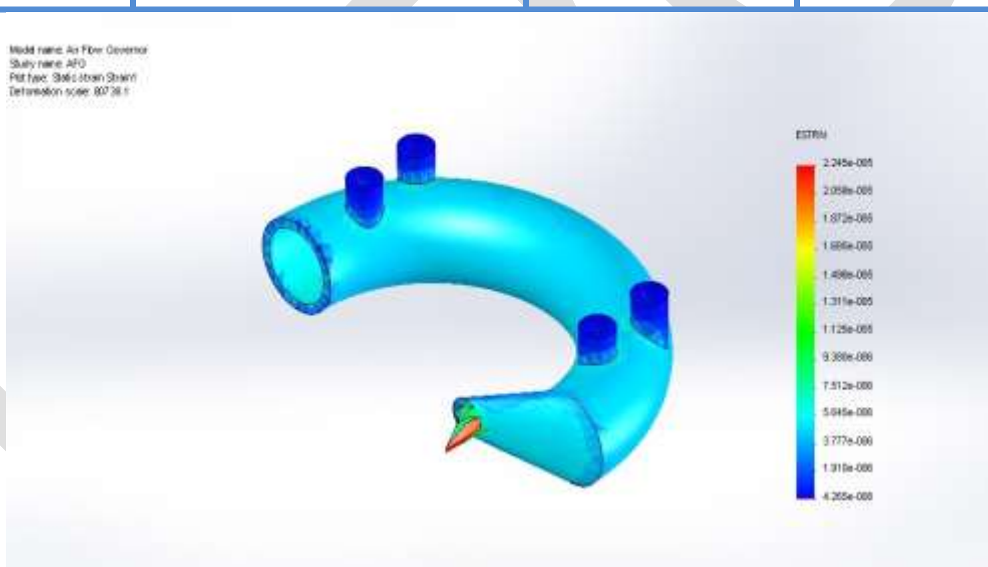


**Air Flow Governor-AFG-Displacement-Displacement1**

Figure no 8.Result Displacement

| Name | Type | Min | Max |
|---|---|---|---|
| Strain1 | ESTRN: Equivalent Strain | 4.26524e-008<br>Element: 5205 | 2.24514e-005<br>Element: 4504 |



**Air Flow Governor-AFG-Strain-Strain1**

Figure No 9. Equivalent Strain

## 7. RESULT & CONCLUSION

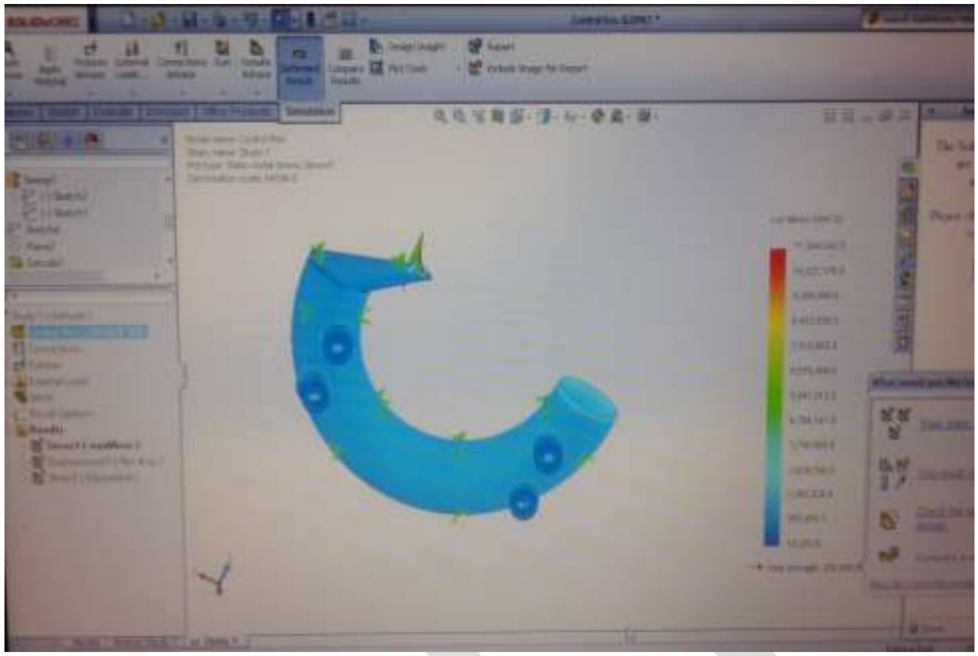


Fig.10 Static Flow Analysis of AFG

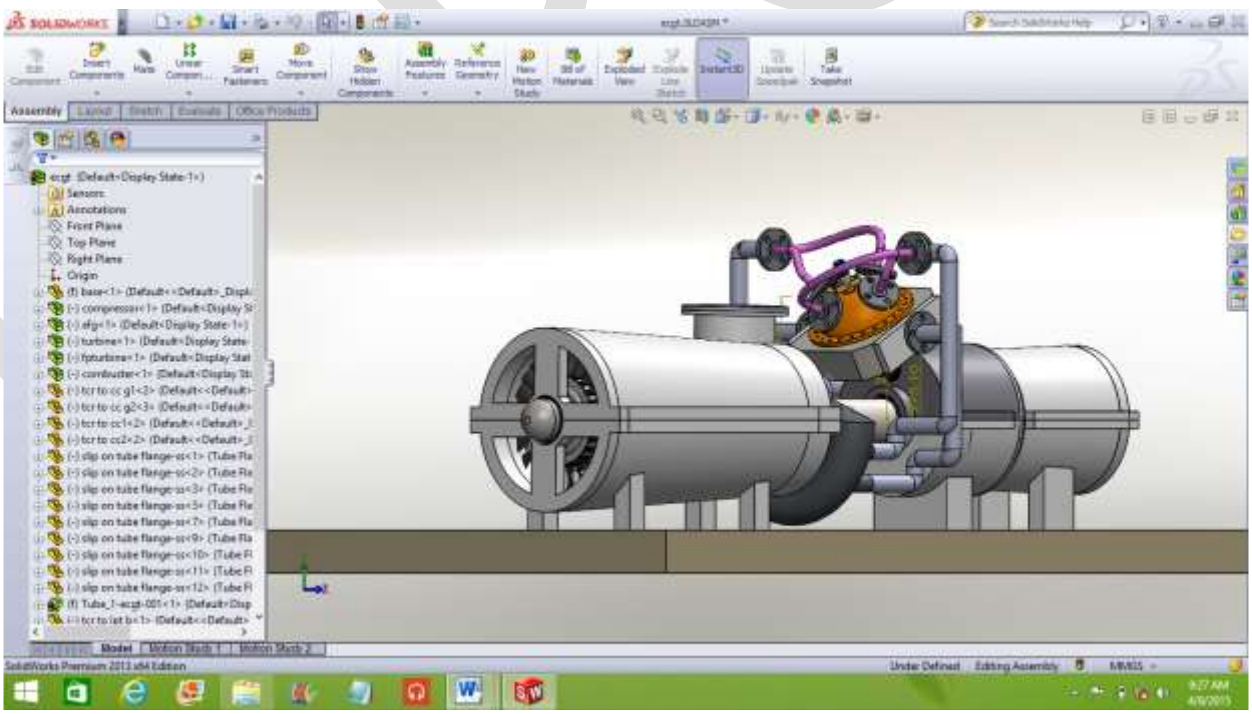


Fig .11 Complete Assembly of Gas Turbine

Thus, a Gas Turbine is developed which makes constant volume heat addition less complicated. By putting all the possible technology together, it finally comes out with efficient, economical and easy handling element. This Gas Turbine will be a great combination of efficiency and lowered material cost. The Air Flow Governor is working at 20 Bar pressure

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