# CFD Analysis of Gas Turbine Enclosing

Sengottaiyan K
Asst. Prof.,Department of Mechanical Engineering,
R.M.K. Engineering College
Kavaraipettai,Tiruvallur(D.T)
Tamil Nadu,India.

Darshanik Mekapati
Department of Mechanical Engineering,
R.M.K. Engineering College
Kavaraipettai,Tiruvallur(D.T)
Tamil Nadu,India.

***Abstract*—Improving the heat transfer rate of gas turbine casing by increasing the flow rate of exhaust fans to reduce the temperature of turbine compartment and to prevent failing of gas leak detectors due to high temperature by making use of ANSYS fluent for analyzing and simulation.**

***Keywords*— Casing, turbine compartment, mesh, mathematical models, boundary conditions, reference, solution initialization, calculation.***

## I. INTRODUCTION

Computational fluid dynamics is a branch of study which deals with simulation of flow and thermal problems by making use of numerical methods and matrices to solve the complex problems in engineering. The most widely used method in CFD is finite volume method which is a combination of finite element and finite difference methods. However the basics of the CFD lies in navier stokes equation. In the initial stages of development the CFD simulation is used for space craft and fighter jets simulation to visualize the flow of air and to measure drag of wings particularly for hyper sonic aircrafts and aircrafts with high maneuverability. Later due to high advances in computers various solvers are developed with more features and simple operation and easy modeling of cad geometries. CFD and FEA methods are numerical methods and hence the results of CFD and fea vary with real time applications and these methods are not hundred percent accurate.

## II. GAS TURBINES

A gas turbine is an internal combustion engine. Like all internal combustion engines, gas turbines compress air, take in fuel for combustion, and use the resultant volume of hot gases to develop shaft horsepower**.** Gas turbines are the major prime movers in gas and combined cycle power plants. These gas turbines are the major propelling systems in air craft and ships. This paper has considered an industrial gas turbine of a combined cycle power plant. There are four basic components of gas turbines namely.

A. Air inlet and filter equipments
B. Compressor
C. Combustion chamber
D. Turbine wheels.

All gas turbines work on the basic power cycle called Brayton cycle.

### *A. Air inlet and filter equipments*

These equipments are also called as air filters and main purpose of these equipments is to prevent the inlet of moisture, dust particles, and other foreign materials which prevents the successful operation of compressor and the compressor cannot compress the air upto the mandated pressure ratio.

### *B. Compressor*

The compressor sucks in the atmospheric air and increases the pressure by making the air to flow in between the stator and rotor blades of varying surface area. Compressor is the high power consuming equipment in the gas turbine. The compressor rotor blades and the turbine wheels are mounted on the same shaft. The stator blades of compressor are part of casing. The general maximum pressure of the air at compressor outlet is around 9 to 11 bar. Part of compressed air is bled to a centrifugal compressor for boosting the pressure so that this boosted pressure air can atomize the liquid fuel to spray formation that is fed to combustion chamber so that the back firing of liquid fuels is prevented. The function of the gas turbine compressor is to efficiently compress the required mass of air and deliver the air to the combustion section. There are two basic types of compressors used for gas turbine applications; centrifugal compressors and axial flow compressors. Axial flow compressors are most often used in power plant applications because of their ability to pump large volumes of air at a high efficiency. Both the centrifugal and axial-flow compressors compress air by imparting momentum to the air by means of rotating elements and then converting that momentum to pressure in suitable stationary passages. In the centrifugal type compressor, air is drawn in at the center, or ‘eye’ of a rapidly rotating vane disc. Centrifugal action on the rotating air mass forces it to the tips of the disc where it is flung off at high tangential velocity. Suitably shaped stator blades receive this fast moving air stream and slow it down in such a manner as to increase the pressure. About half of the pressure rise occurs in the rotor and the remainder in the stator passages. The rotor is constructed with several rows of fixed blades which impart momentum to the air and force it rearward. Following each row of rotor blades is a row of stationary Stator blades. An axial flow compressor draws in air from the atmosphere and moves it Parallel to the axis of rotation. The air is compressed in both the rotor and stator Blade passages, by continually diffusing the air flow from a high velocity to a low velocity, with a corresponding rise in pressure. Each consecutive pair of rotor and stator blades constitutes a pressure stage.

### *C. Combustion chamber*

The gas turbines can operate in liquid fuels or gaseous fuels. In both cases the ignition of the fuels of the fuels is done in a chamber or cans called combustion cans. In case of

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 03, March-2019

liquid fuels the high pressure air is fed to combustion cans along with the normal compressed air from the compressor exit. This results in atomizing the fuel into spray which is then ignited by means of sparkers. The high temperature gases that are formed during the ignition are directed to flow over turbine wheels. In case of gaseous fuels like natural gas the fuel is ignited by sparkers directly without any atomization. The four types of combustors designs are

- Can-Type Combustor
- Annular Combustor
- Can-Annular Combustor
- Silo Combustor

### *D. Turbine wheels*

The high temperature gases that are formed during the combustion are expanded by making them flow over turbine wheels. Usually there are 3 stages of turbine wheels and the gases are expanded in these 3 stages. Hence the power is derived from the turbine. Majority of the power developed is utilized in running the compressor and the remaining is utilized for running the alternator.

## III. GAS TURBINE ENCLOSING

The entire shaft of compressor and turbines are supported on hydro static bearings and this bearings are mounted in casing which covers the entire gas turbine and protects it from any physical damages and gas leaks. This casing is fixed in a compartment called enclosing. This enclosing consists of an insulation sandwiched between mild steel plates. It also consists of the exhaust fans which are present at top of the enclosing. The main purpose of these fans is to remove the heat generated by the casing. The fans intakes the hot air present in the enclosing and it delivers this hot air to the atmosphere by means of a vent. In this way the casing is cooled and temperature is controlled in the enclosing.

### *A. Present problem of enclosing*

The enclosing not only houses the casing but also many auxillaries like thermocouples, lightings, blower fans, fire extinguishers, gas leak detectors etc. hence each device can withstand a range of temperatures. Hence temperature raising above specified limit of these devices results in malfunctioning. The current problem with some enclosing are high temperatures than designed range. Due to this the sensors like gas leakage detectors are losing the efficiency and are costly to replace frequently. Hence the CFD analysis is done to rectify the problem of effective cooling of enclosing.

## IV. CFD ANALYSIS

There are 3 major steps in CFD analysis.

A. Preprocessing
B. Solution
C. Post processing

The most commonly used method in CFD software's is finite volume method. ANSYS workbench and fluent solver is used for simulation of the enclosing. Since it is difficult to model the casing an approximate shape is assumed irrespective of its surface area. However the enclosing is modeled according to the dimensions. Catia v5 is used for modeling the casing and enclosing. For simplicity casing and enclosing are modeled in part modeling and the part is saved in Initial Graphics Exchange Specification Initial Graphics Exchange Specification (.IGES) format which will be used for importing the model into ANSYS.

### *A. Preprocessing*

The geometry of the enclosing and casing is modeled in catiav5 and imported to ANSYS workbench. The following steps are followed.

#### *1) Meshing:*

The imported geometry is to be opened in meshed model by clicking on mesh option in the project space. Once the file is opened generate mesh option is selected and after a few seconds the geometry is divided into number of smaller elements. This process is called as meshing or discretisation of domain. The meshed model of enclosing is shown in Fig. 3.

#### *2) Refining the generated mesh:*

The generated mesh may sometimes will not be uniform. In order to make the mesh to be uniformly distributed refinement option is selected and select the faces that are to be refined. After selecting the faces generate mesh is selected to define the updated and refined mesh.

#### *3) Sizing the generated mesh:*

The size of the elements can be decreased such that the final results depends on the mesh size effectively. We can observe considerable change in results with larger mesh size. The smaller the mesh size and larger the number of elements the more accurate the results will be. But the computation time will also be high and sometimes the solver may crash if the mesh size is too small and refinement is very high and the number of elements is also more. Because the solver should solve the matrix equations most probably 8*8 matrix sizes for all the elements that are present in the domain.

### *B. Solution*

After the completion of meshing the geometry setup option is selected and energy and turbulence equation are activated in models option. Then the materials and boundary conditions are selected and define the inlet velocity of air as 0.5 m/s, outlet mass flow rate of 12.5kg/s , casing temperatures of 213deg, 345deg, 269deg are defined. The defined flow rate value is the current operating value. Click on solution methods and run calculate option. The solver will take few minutes and it will give the solution saying the solution is converged. Again select the boundary conditions and change value of outlet flow rate from 12.5kg/s to 30.5kg/s and follow the steps.

### *C. Post processing*

Click on results option and select temperature counters of enclosing by selecting wall temperatures.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 03, March-2019

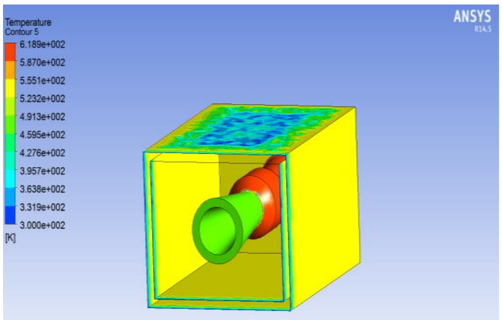

Fig. 1. Temperature distribution of enclsoing.(*at flow rate of 12.5kg/s*)

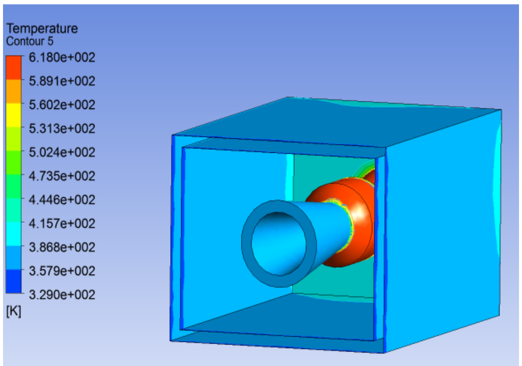

Fig. 2. Temperature distribution of enclosing(at flow rate of 30.5kg/s)

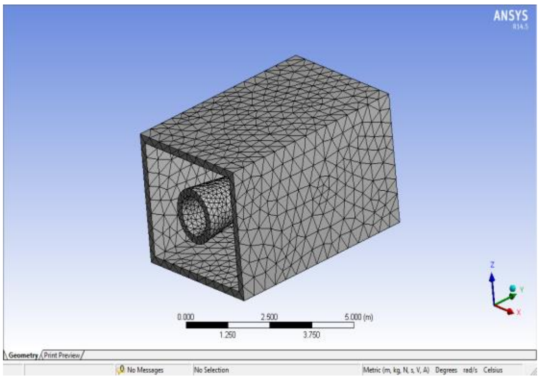

Fig. 3. Meshed model of enclosing

## V. CONCLUSION

Hence by increasing the flow rate of exhaust fans from 12.5kg/s to 30.5kg/s the temperature in the enclosing is dropped from 240deg to 140.7 deg and these results in the efficient functioning of the gas leak sensors and other auxillaries without any malfunctioning

## REFERENCES

[1] P. Akin, A. Buryan, and S. Aradag, “Analysis of flow over a circular cylinder by CFD and reduced order modeling,” research gate article, January 2010.

[2] H.D. Karaca, G.D. Ozen, C. “Nonlinear modeling and control of flow over aerofoils using CFD simulations”, Citing article, september 2016.

[3] P. Akin, A. Buryan, and S. Aradag, “Effects of air blowing on turbulent flow over a circular cylinder,”Article, January 2012.

[4] Peter M Blasco, Jose Palacios, and Sven Schmitz. In-vestigation of Wind Turbine Power Generation During Atmospheric Icing by Multi-Disciplinary Experimenta-tion. In33rd Wind Energy Symposium, 2015

[5] Thomas Reid, Guido Baruzzi, Isik Ozcer, DavidSwitchenko, and Wagdi Habashi. FENSAP-ICE Simula-tion of Icing on Wind Turbine Blades, Part 1: PerformanceDegradation. In51st AIAA Aerospace Sciences Meetingincluding the New Horizons Forum and Aerospace Expo-sition 07-10 January 2013, Grapevine (Dallas Ft. WorthRegion), Texas, 2013.

[6] D. Davino and P. Krejˇc´ı and A. Pimenov and D. Rachinskii and C. Visone. Analysis of an operator-differential model for magnetostrictive energy harvesting. Submitted to Communications in NonlinearScience and Numerical Simulation.

[7] Y. Guo, C. Wassgren, B. Hancock, W. Ketterhagen, andJ. Curtis. Validation and time step determination of dis-crete element modelling of flexible fibers.Powder Tech-nology, 249:386–395, 2013.

[8] A.L. Jensen, H. Sørensen, L. Rosendahl, and F. Lykholt-Ustrup. Towards simulation of clogging effects in wastew-ater pumps: A review of the state-of-the-art in cloth mod-elling and challenges in the simulation of clogging effects.ASME-JSME-KSME 2015 Joint Fluids Engineering Con-ference, pages 2543–2549, July, 2015.

[9] A. Guardone and D. Isola and G.Quaranta. Arbitrary Lagrangian Eulerian formulation for two-dimensional flows using dynamic meshes with edge swapping. J. Comput. Phys. 230(2011) 7706-7722.2.A. Guardone and D. Isola and G.Quaranta. Finite-volume solution of two-dimensional compressibleflows over dynamic adaptive grids. J. Comput. Phys. 285(2015) 1-23.