Design And Cfd Analysis Of Centrifugal Compressor For A Gas Turbine Blade

ABSTRACT

A turbine blade is the individual component which makes up the turbine section of a gas turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines. Air is compressed, raising the pressure and temperature, through the compressor stages of the engine. The temperature is then greatly increased by combustion of fuel inside the combustor, which sits between the compressor stages and the turbine stage.

In this project,the turbine blade is modeling in CATIA V5 software. The modeling is done to changing the base of the blade to increase the cooling efficiency. The design of centrifugal compressor is complex, and to improve the performance and efficiency. In this project we are doing cfd for two models to find out maximum flow rate and pressure on it by giving the mass flow rates as input. The modeling and flow rates are taken from journals.

In these thesis, CFD is doing to know the flow of fluid over the turbine blade. Analysis is done in Ansys.

INTRODUCTION TO TURBINE

The word "**turbine**" was coined in 1822 by the French mining engineer Claude Burdin from the Latin turbo, or vortex, in a memoir, "Des turbines hydrauliquesou machines rotatoires à grandevitesse" (Hydraulic turbines or high-speed rotary machines), which he submitted to the Académie royale des sciences in Paris. Benoit Fourneyron, a former student of Claude Burdin, built the first practical water turbine.

A turbine is a rotary engine that extracts energy from a fluid flow and converts it into useful work.

The simplest turbines have one moving part, a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades, or the blades react to the flow, so that they move and impart rotational energy to the rotor. **Gas**, **steam**, and **water** turbines usually have a casing around the blades that contains and controls the working fluid.

TYPES OF TURBINES

STEAM TURBINE

A **steam** turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator – about 90% of all electricity generation in the United States is by use of steam turbines. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible process.

Steam Turbine

GAS TURBINEA **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.

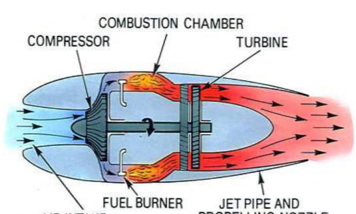


Fig: 2 Gas Turbine

SHROUDED TURBINE

Shrouded turbine, many turbine rotor blades have shrouding at the top, which interlocks with that of adjacent blades, to increase damping and thereby reduce blade flutter. In large land-based electricity generation steam turbines, the shrouding is often complemented, especially in the long blades of a low-pressure turbine, with lacing wires. These wires pass through holes drilled in the blades at suitable distances from the blade root and are usually brazed to the blades at the point where they pass through.

SHROUDED-LESS TURBINE

Shroud less turbine, Modern practice is, wherever possible, to eliminate the rotor shrouding, thus reducing the centrifugal load on the blade and the cooling requirements.

CONTRA-ROTATING TURBINE

Contra-rotating, also referred to as **coaxial contra-rotating**, is a technique whereby parts of a mechanism rotate in opposite directions about a common axis, usually to minimize the effect of torque.Examples include some aircraft propellers, resulting in the maximum power of a single piston or turbo-prop engine to drive two propellers in opposite rotation.

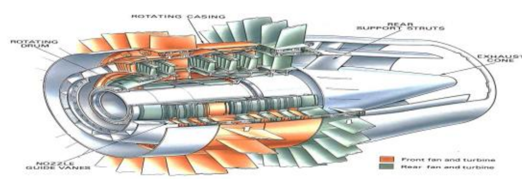


Fig: 3 Contra Rotating Turbines

STATOR LESS TURBINE

Stator less turbine, Multi-stage turbines have a set of static (meaning stationary) inlet guide vanes that direct the gas flow onto the rotating rotor blades. In a stator less turbine the gas flow exiting an upstream rotor impinges onto a downstream rotor without an intermediate set of stator vanes (that rearrange the pressure/velocity energy levels of the flow) being encountered.

CERAMIC TURBINE

Ceramic turbine, Conventional high-pressure turbine blades (and vanes) are made from nickel based alloys and often utilize intricate internal air-cooling passages to prevent the metal from overheating. In recent years, experimental ceramic blades have been manufactured and tested in gas turbines, with a view to increasing Rotor Inlet

Temperatures and/or, possibly, eliminating air cooling. Ceramic blades are more brittle than their metallic counterparts, and carry a greater risk of catastrophic blade failure. This has tended to limit their use in jet engines and gas turbines, to the stator (stationary) blades.

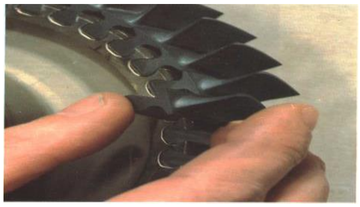


Fig : 4 Ceramic Turbine

GAS TURBINE ENGINE

A simple gas turbine is comprised of three main sections: **a compressor**, **a combustor** and **a turbine**. The gas turbine operates on the principle of the **Brayton** cycle where compressed air is mixed with fuel and burned under constant pressure conditions. The resulting hot gas is expanded through a turbine to perform work.

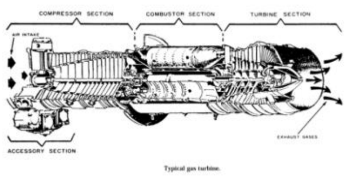


Fig: 5 Gas Turbine Engine

A **compressor** is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids.

A **combustion chamber** is the part of an engine in which fuel is burned. Energy is added to the gas stream in the combustor, where fuel is mixed with air and ignited. In the high pressure environment of the combustor, combustion of the fuel increases the temperature. The products of the combustion are forced into the turbine section.

A **turbine** is a rotary engine that extracts energy from a fluid flow and converts it into useful work.

The simplest turbines have one moving part, a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades, or the blades react to the flow, so that they move and impart rotational energy to the rotor.

1.2.1 WORKING CYCLE

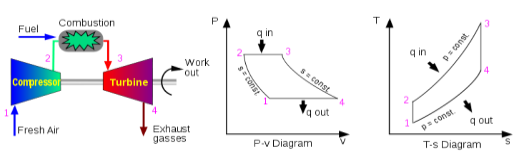


Fig: 6 Working Cycle

The working cycle of the gas turbine engine is similar to that of the four-stroke piston engine. However, in the gas turbine engine, combustion occurs at a constant pressure, whereas in the piston engine it occurs at a constant volume. Both engine cycles show that in each instance there is induction, compression, combustion and exhaust. These processes are intermittent in the case of the piston engine whilst they occur continuously in the gas turbine. In the piston engine only one stroke is utilized in the production of power, the others being involved in the charging, compressing and exhausting of the working fluid.

In contrast, the turbine engine eliminates the three 'idle' strokes, thus enabling more fuel to be burnt in a shorter time; hence it produces a greater power output for a given size of engine.

In a **gas turbine engine**, a single turbine section is made up of a disk or hub that holds many turbine blades. That turbine section is connected to a compressor section via a shaft (or "spool"), and that compressor section can either be axial or centrifugal. Air is compressed, raising the pressure and temperature, through the compressor stages of the engine. The pressure and temperature are then greatly increased by combustion of fuel inside the combustor, which sits between the compressor stages and the turbine stages. The high temperature and high pressure exhaust gases then pass through the turbine stages. The turbine stages extract energy from this flow, lowering the pressure and temperature of the air, and transfer the kinetic energy to the compressor stages along the spool. This is process is very similar to how an axial compressor works, only in reverse.

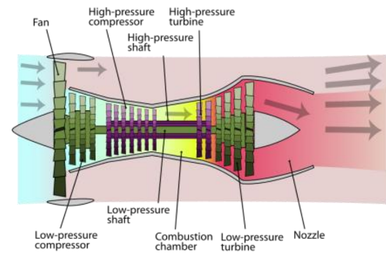


Fig: 7 Cut section view of a gas turbine engine

There,thehigh velocity and volume of the gas flow is directed through a nozzle over the turbine's blades, spinning the turbine which powers the compressor and, for some turbines, drives their mechanical output. The energy given up to the turbine comes from the reduction in the temperature and pressure of the exhaust gas.

THEORY OF OPERATION

A working fluid contains potential energy (pressure head) and kinetic energy (velocity head). The fluid may be compressible or incompressible. Several physical principles are employed by turbines to collect this energy:

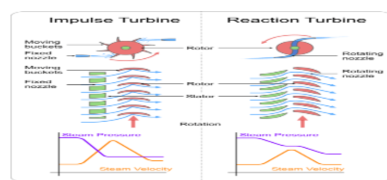


Fig: 8 Impulse and reaction Turbines

Impulse turbines change the direction of flow of a high velocity fluid or gas jet. The resulting impulse spins the turbine and leaves the fluid flow with diminished kinetic energy. There is no pressure change of the fluid or gas in the turbine blades (the moving blades), as in the case of a steam or gas turbine, all the pressure drop takes place in the stationary blades (the nozzles). Before reaching the turbine, the fluid's pressure head is changed to velocity head by accelerating the fluid with a nozzle. Pelton wheels and de Laval turbines use this process exclusively. Impulse turbines do not require a pressure casement around the rotor since the fluid jet is created by the nozzle prior to reaching the blading on the rotor. Newton's second law describes the transfer of energy for impulse turbines.

Reaction turbines develop torque by reacting to the gas or fluid's pressure or mass. The pressure of the gas or fluid changes as it passes through the turbine rotor blades. A pressure casement is needed to contain the working fluid as it acts on the turbine stage(s) or the turbine must be fully immersed in the fluid flow (such as with wind turbines). The casing contains and directs the working fluid and, for water turbines, maintains the suction imparted by the draft tube. Francis turbines and most steam turbines use this concept. For compressible working fluids, multiple turbine stages are usually used to harness the expanding gas efficiently. Newton's third law describes the transfer of energy for reaction turbines.

PERFORMANCE AND EFFICIENCY

The type of operation for which the engine is designed dictates the performance requirement of a gas turbine engine. The performance requirement is mainly determined by the amount of shaft horsepower (s.h.p.) the engine develops for a given set of conditions.

The majority of aircraft gas turbine engines are rated at standard day conditions of 59 ^{0}F and 29.92 inches Hg. This provides a baseline to which gas turbine engines of all types can be compared.

The need for high efficiency in the engine becomes more important as fuels become more costly. Engine efficiency is primarily defined by the specific fuel consumption (s.f.c.) of the engine at a given set of conditions.

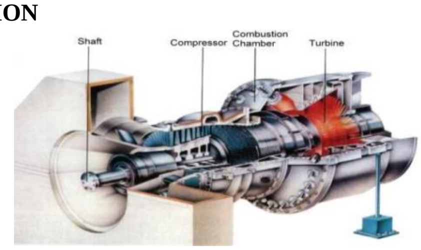
Many factors affect both the efficiency and the performance of the engine. The mass flow rate of air through the engine will dictate engine performance. Any restrictions acting against the smooth flow of air through the engine will limit the engine's performance.

The pressure ratio of the compressor, the engine operating temperatures (turbine inlet temperature), and the individual component efficiencies will also influence both the performance and the efficiency of the overall engine.

All these factors are considered during the design of the engine. An optimum pressure ratio, turbine inlet temperature, and air mass flow rate are selected to obtain the required performance in the most efficient manner.

In addition, individual engine components are designed to minimize flow losses to maximize component efficiencie

ENGINE SECTION



Inlet

The air inlet duct must provide clean and unrestricted airflow to the engine. Clean and undisturbed inlet airflow extends engine life by preventing erosion, corrosion, and foreign object damage (FOD). Consideration of atmospheric conditions such as dust, salt, industrial pollution, foreign objects (birds, nuts and bolts), and temperature (icing conditions) must be made when designing the inlet system. Fairings should be installed between the engine air inlet housing and the inlet duct to ensure minimum airflow losses to the engine at all airflow conditions.

The inlet duct assembly is usually designed and produced as a separate system rather than as part of the design and production of the engine.

Diffuser

Air leaves the compressor through exit guide vanes, which convert the radial component of the air flow out of the compressor to straight-line flow. The air then enters the diffuser section of the engine, which is a very divergent duct. The primary function of the diffuser structure is aerodynamic. The divergent duct shape converts most of the air's velocity (Pi) into static pressure (PS). As a result, the highest static pressure and lowest velocity in the entire engine is at the point of diffuser discharge and combustor inlet. Other aerodynamic design considerations that are important in the diffuser section arise from the need for a short flow path, uniform flow distribution, and low drag loss.

In addition to critical aerodynamic functions, the diffuser also provides:

- Engine structural support, including engine mounting to the nacelle
- Support for the rear compressor bearings and seals
- Bleed air ports, which provide pressurized air for:
- Airframe "customer" requirements (air conditioning, etc.)
- engine inlet anti-icing
- control of acceleration bleed air valves
- Mounting for the fuel nozzles.

Combustor

Once the air flows through the diffuser, it enters the combustion section, also called the combustor. The combustion section has the difficult task of controlling the burning of large amounts of fuel and air. It must release the heat in a manner that the air is expanded and accelerated to give a smooth and stable stream of uniformly-heated gasat all starting and operating conditions. This task must be accomplished with minimum pressure loss and maximum heat release. In addition, the combustion liners must position and control the fire to prevent flame contact with any metal parts.

The engine in this example uses a can-annular combustion section. Six combustion liners (cans) are positioned within an annulus created by inner and outer combustion cases.

Combustion takes place in the forward end or primary zone of the cans. Primary air (amounting to about one fourth of the total engine's total airflow) is used to support the combustion process.

Turbine

The turbine converts the gaseous energy of the air/burned fuel mixture out of the combustor into mechanical energy to drive the compressor, driven accessories, and, through a reduction gear, the propeller. The turbine converts gaseous energy into mechanical energy by expanding the hot, high-pressure gases to a lower temperature and pressure.

As the mass of the high velocity gas flows across the turbine blades, the gaseous energy is converted to mechanical energy. Velocity, temperature, and pressure of the gas are sacrificed in order to rotate the turbine to generate shaft power.

The efficiency of the turbine is determined by how well it extracts mechanical energy from the hot, high-velocity gasses. Since air flows from a high-pressure zone to a low pressure zone, this task is accomplished fairly easily. The use of properly positioned airfoils allows a smooth flow and expansion of gases through the blades and vanes of the turbine.

All the air must flow across the airfoils to achieve maximum efficiency in the turbine. In order to ensure this, seals are used at the base of the vanes to minimize gas flow around the vanes instead of through the intended gas path. In addition, the first three stages of the turbine blades have tip shrouds to minimize gas flow around the blade tips.

1.5.5 Exhaust

After the gas has passed through the turbine, it is discharged through the exhaust. Though most of t he gaseous energy is converted to mechanical energy by the turbine, a significant amount of power remains in the exhaust gas. This gas energy is accelerated through the convergent duct shape of the exhaust to make it more useful as jet thrust - the principle of equal and opposite reaction means that the force of the exhausted air drives the airplane forward.

EFFECTS OF ATMOSPHERIC CONDITIONS

The performance of the gas turbine engine is dependent on the mass of air entering the engine. At a constant speed, the compressor pumps a constant volume of air into the engine with no regard for air mass or density.

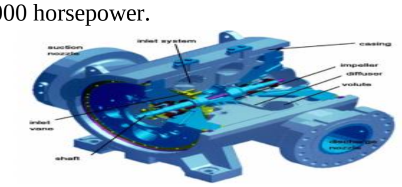
If the density of the air decreases, the same volume of air will contain less mass, so less power is produced. If air density increases, power output also increases as the air mass flow increases for the same volume of air.

Atmospheric conditions affect the performance of the engine since the density of the air will be different under different conditions. On a cold day, the air density is high, so the mass of the air entering the compressor is increased.

As a result, higher horsepower is produced. In contrast, on a hot day, or at high altitude, air density is decreased, resulting in a decrease of output shaft power.

Compressor

The compressor is responsible for providing the turbine with all the air it needs in an efficient manner. In addition, it must supply this air at high static pressures. The example of a large turboprop axial flow compressor will be used. The compressor is assumed to contain fourteen stages of rotor blades and stator vanes. The overall pressure ratio (pressure at the back of the compressor compared to pressure at the front of the compressor) is approximately 9.5:1. At 100% (>13,000) RPM, the engine compresses approximately 433 cubic feet of air per second. At standard day air conditions, this equals approximately 33 pounds of air per second. The compressor also raises the temperature of the air by about 550□F as the air is compressed and moved rearward. The power required to drive a compressor of this size at maximum rated power is approximately 7000 horsepower.



In general terms, the compressor rotor blades convert mechanical energy into gaseous energy. This energy conversion greatly increases total pressure (Pt). Most of the increase is in the form of velocity (Pi), with a small increase in static pressure (Ps) due to the divergence of the blade flow paths.

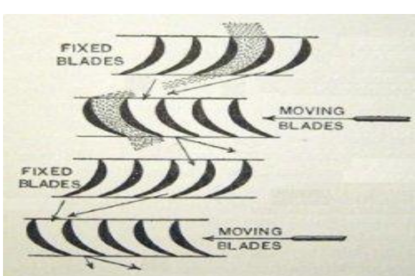


Fig: 9 Flow in Compressor blades

The efficiency of a compressor is primarily determined by the smoothness of the airflow. During design, every effort is made to keep the air flowing smoothly through the compressor to minimize airflow losses due to friction and turbulence. This task is a difficult one, since the air is forced to flow into ever-higher pressure zones.

Figure 11. Gas Path for Natural Gas.

All components used in the flow path of the compressor are shaped in the form of airfoils to maintain the smoothest airflow possible. Just as is the case for the wings of an airplane, the angle at which the air flows across the airfoils is critical to performance. The blades and vanes of the compressor are positioned at the optimum angles to achieve the most efficient airflow at the compressor's maximum rated speed.

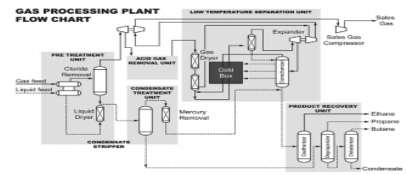


Figure 18. Gas Plant.

Feature-based Modeling:

In CATIA V5, solid models are created by integrating a number of building blocks called features.

CATIA enables the creation of 3D parts, from 3D sketches, sheetmetal, composites, molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die.

Parametric modeling:

The parametric nature of a software package is defined as its ability to use the standard properties or parameters in defining the shape and size of a geometry.

Sketched Features

It is based upon a 2D sketch. Generally that sketch is transformed into a solid by extrusion, shafts, sweeping or lofting.

Applied Features

It is Created directly on the solid model like Fillets and chamfers.

Driving Dimensions

These dimensions are used while creating a feature. These include the sketch geometry associated dimensions and those associated along with the feature. A simple example of this would be feature like a cylindrical boss. The boss's dia. is controlled by the diameter of the sketched circle, the length to which that circle was extruded when the feature was made controls the height of the boss.

Relations These include such information as parallelism, tangency, concentricity, equality, etc.

Solid Modeling

It is the most perfect type of geometric model which is used in CAD systems. It contains all the work frame and surface geometry necessary to fully describe the edge and faces of the model. In addition to the information related to the geometry, it has information called topology that relates all the geometry together. This intelligence makes operations such a filleting and selecting an edge and also specifying a radius.

Fully Associative

A CATIA model is one which associates the drawings and assembles it. When we Change Catia models geometry then the models are automatically reflected in the associative drawings and assemblies.**Constraints**

By which you can guarantee that design concepts such as through holes and/or equal radii etc are captured and maintained is called constraints. Parallel, perpendicular, horizontal, vertical, etc know as geometrical constraint and length, height, width, etc know as dimensional constraint.

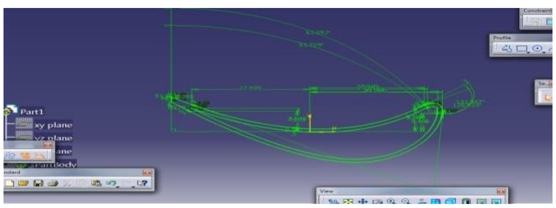
Associatively:

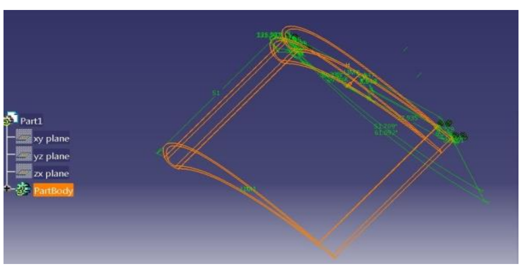
Associatively ensures that if any modification is made in the model in any one of the workbenches of CATIA V5, it is automatically reflected in the other workbenches immediately.

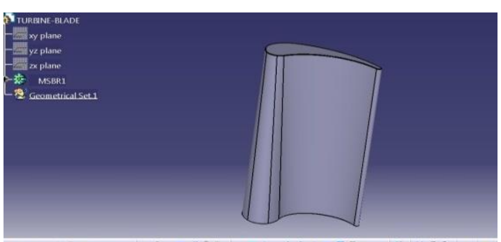
B-Rep modeling: Most of the components Designed using CATIA V5 are based on B-Rep modeling technique i.e. models are created by extruding the boundary of the model in a specified direction.

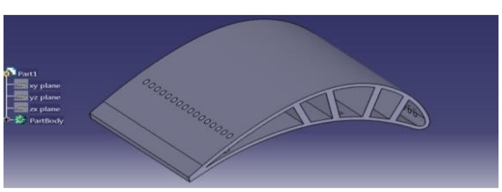
Modules in CATIA

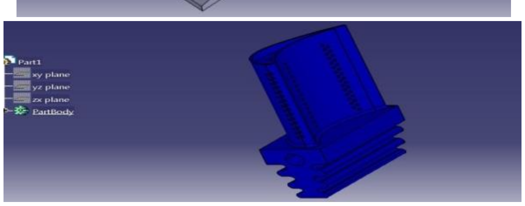
- Sketcher
- Sheet metal
- Part Design
- Assembly Design
- Drafting

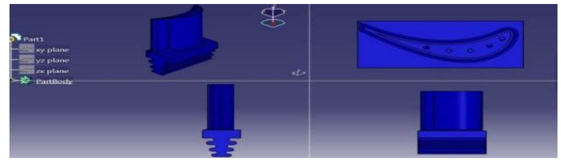


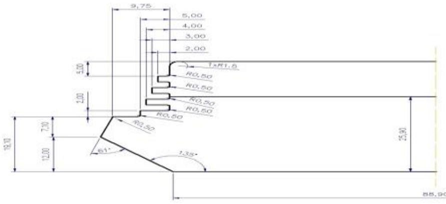


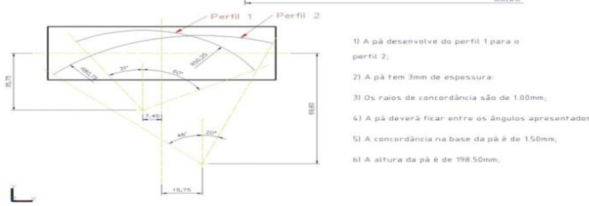


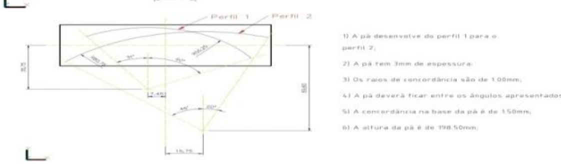








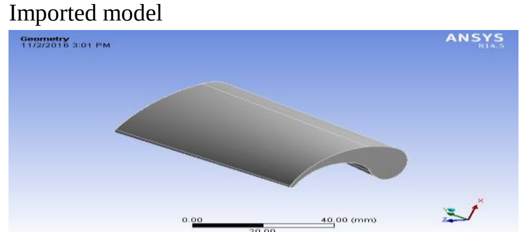




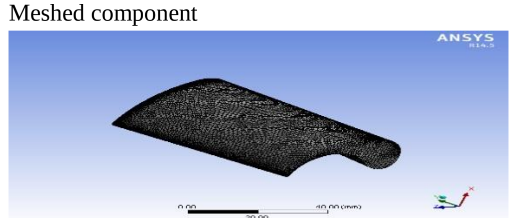
CFD analysis of modal 272MS

Model 1

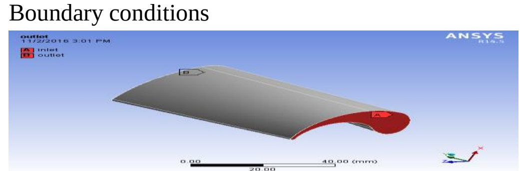
Imported model



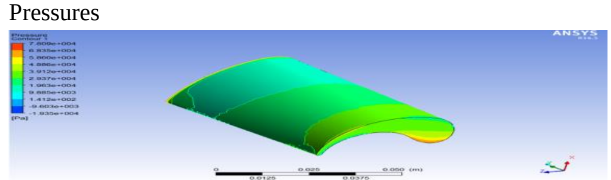
Meshed component



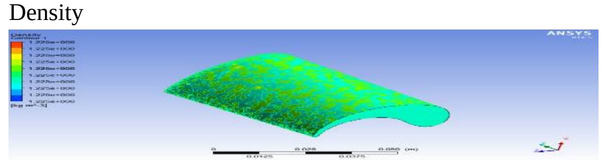
Boundary conditions



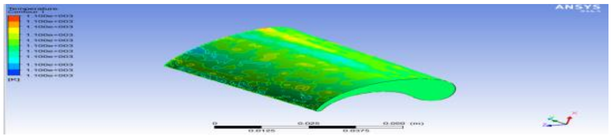
Pressures



Density



Temperature



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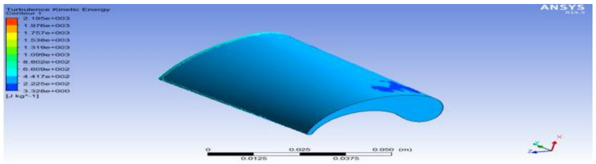
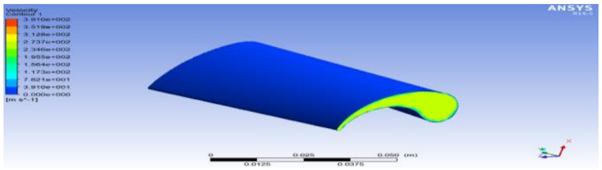
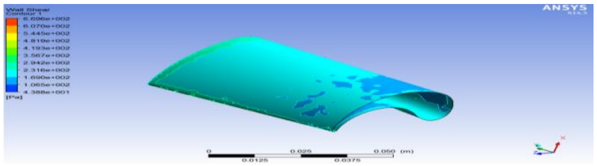


Velocity



Wall shear



Mass flow rate

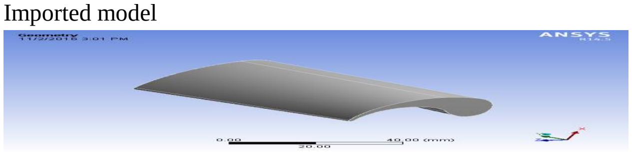
```
                         "Flux Report"

             Mass Flow Rate                          (kg/s)
-------------------------------- --------------------
                      inlet                0.15424861
     interior-turbine-blade               -0.25799707
                     outlet               -0.15424418
         wall-turbine-blade                         0
         ---------------- --------------------
                        Net             4.4256449e-06
```

Total Heat transfer rate

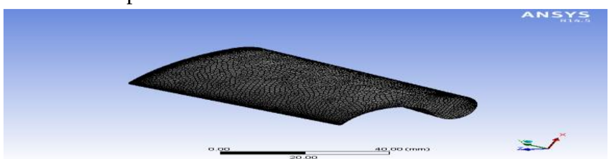
```
!                         "Flux Report"

        Total Heat Transfer Rate                        (w)
-------------------------------- --------------------
                      inlet                 124479.57
                     outlet                -124476.14
         wall-turbine-blade                         0
         ---------------- --------------------
                        Net                 3.4296875
```

CFD analysis of modal 204MS

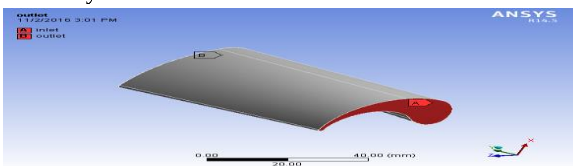
Imported model



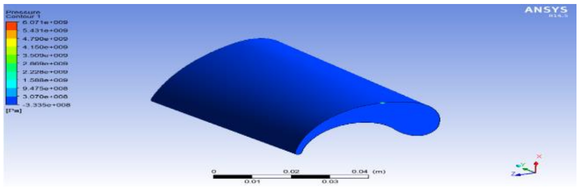
Meshed component



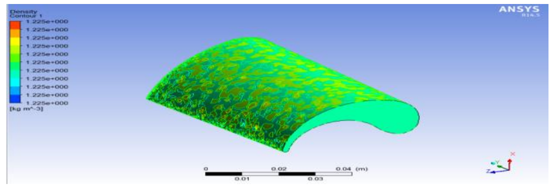
Boundary conditions



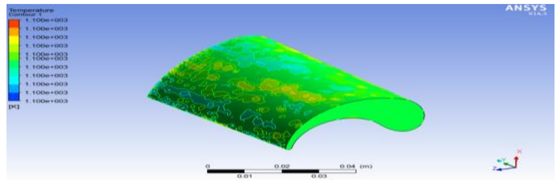
Pressure



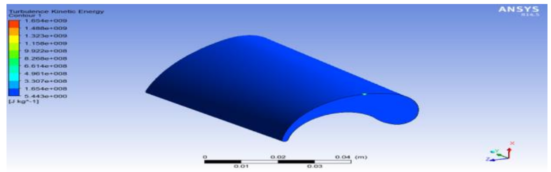
Density



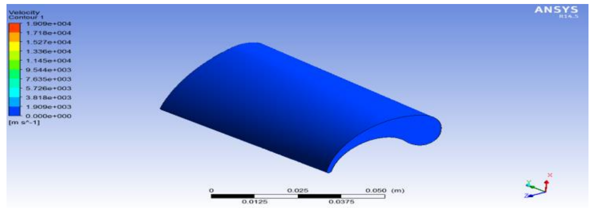
Temperature



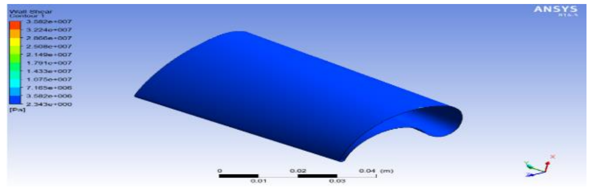
Turbulence



Velocity



Wall shear



Mass flow rate

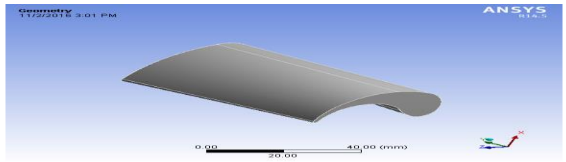
```
                         "Flux Report"

             Mass Flow Rate                          (kg/s)
-------------------------------- --------------------
                      inlet                0.11568828
            interior-part_1               -0.21620342
                     outlet               -0.11558354
                wall-part_1                         0
         ---------------- --------------------
                        Net            0.00010474026
```

Total Heat transfer rate

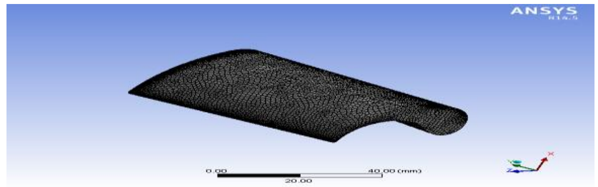
```
                         "Flux Report"

        Total Heat Transfer Rate                        (w)
-------------------------------- --------------------
                      inlet                 93361.164
                     outlet                -93276.516
                wall-part_1                         0
         ---------------- --------------------
                        Net                 84.648438
```

CFD analysis of modal 340MS

Imported model



Meshed component



Boundary conditions

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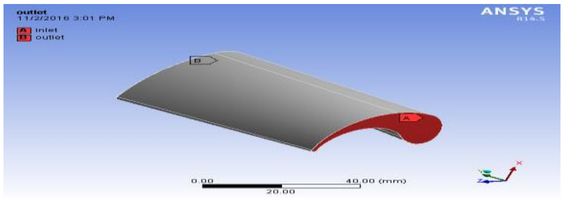
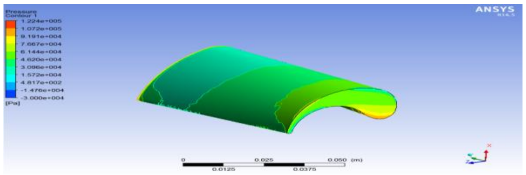
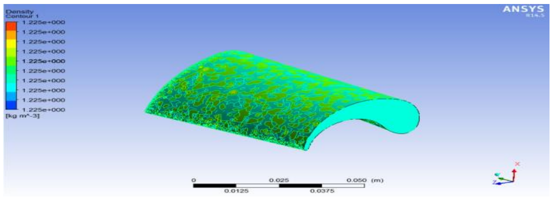


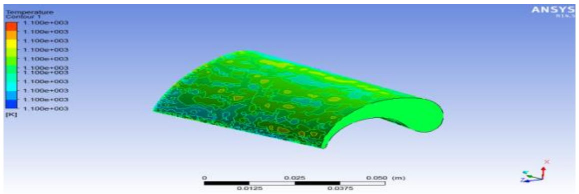
Pressure



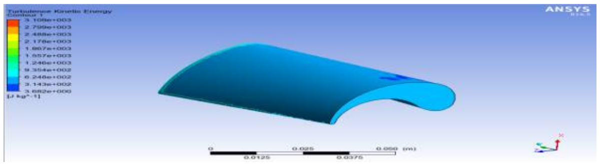
Density



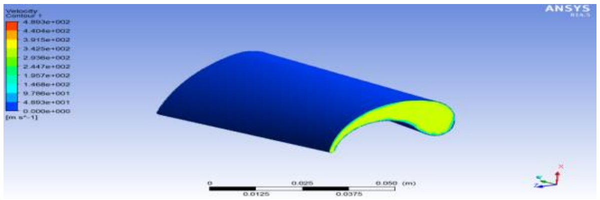
Temperature



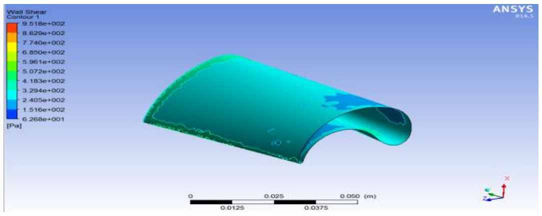
Turbulence



Velocity



Wall shear



Mass flow rate

"Flux Report"

Mass Flow Rate	(kg/s)
inlet	0.19281097
interior-turbine-blade	-0.32247928
outlet	-0.19280553
wall-turbine-blade	0
Net	5.4389238e-06

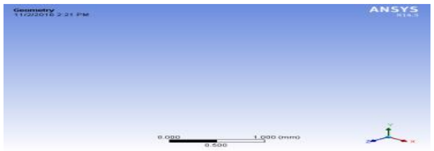
Total Heat transfer rate

"Flux Report"

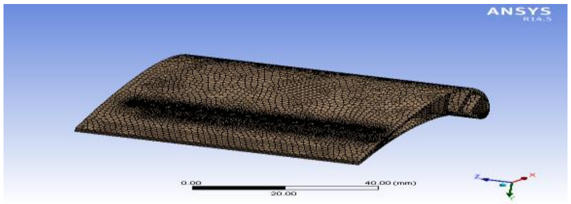
Total Heat Transfer Rate	(w)
inlet	155599.42
outlet	-155595.69
wall-turbine-blade	0
Net	3.734375

CFD analysis of modal 272MS

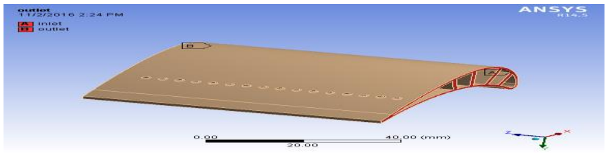
Imported model



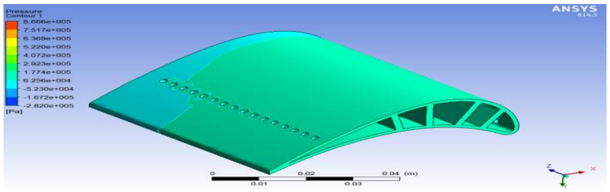
Meshed component



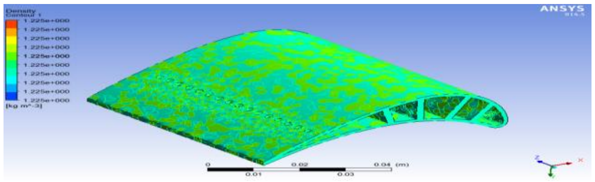
Boundary conditions



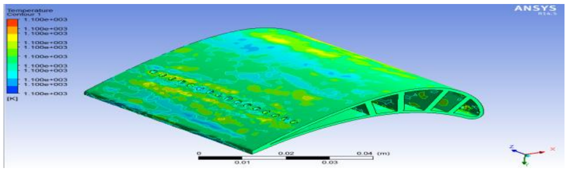
Pressure



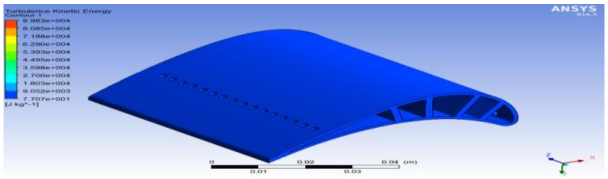
Density



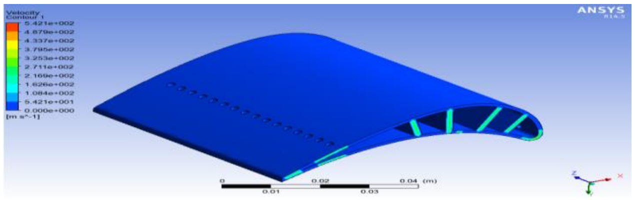
Temperature



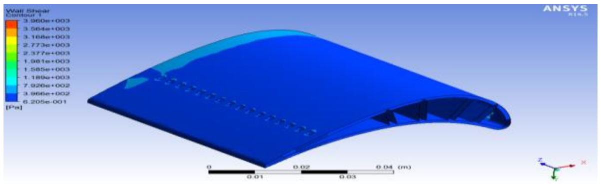
Turbulence



Velocity



Wall shear



Mass flow rate

"Flux Report"

Mass Flow Rate	(kg/s)
inlet	0.081357166
interior-partbody	2.6691623
outlet	-0.081416629
wall-partbody	0
Net	-5.9463084e-05

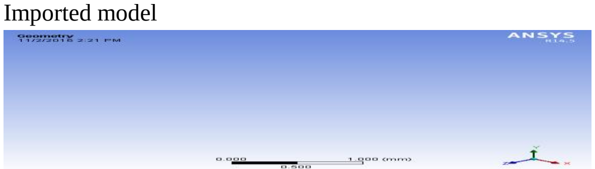
Total Heat transfer rate

"Flux Report"

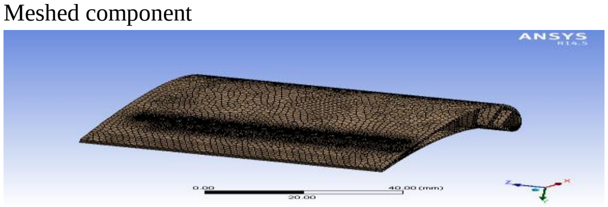
Total Heat Transfer Rate	(w)
inlet	65655.734
outlet	-65703.695
wall-partbody	0
Net	-47.960938

CFD analysis of modal 204m/s

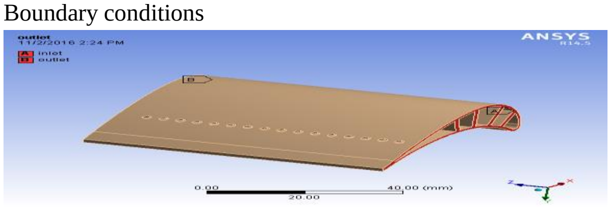
Imported model



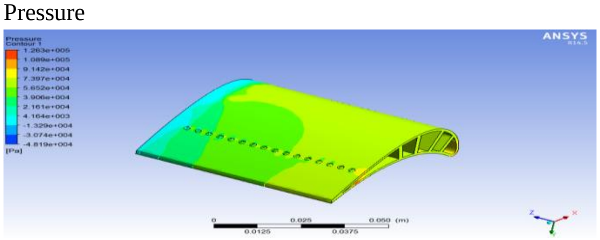
Meshed component



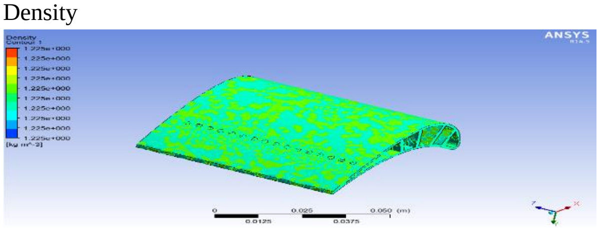
Boundary conditions



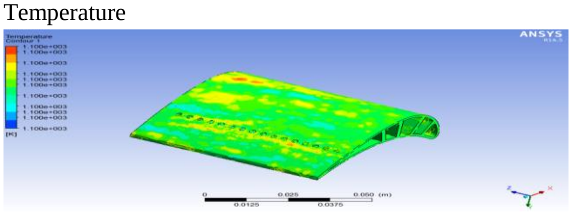
Pressure



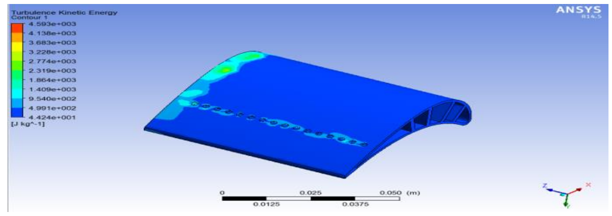
Density



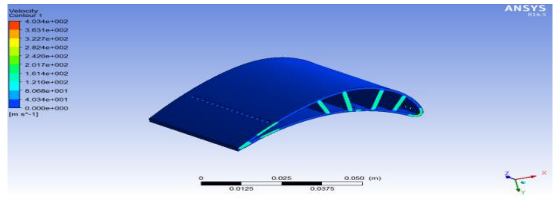
Temperature



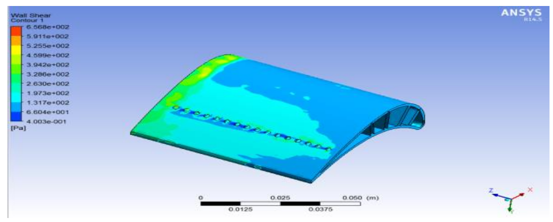
Turbulence



Velocity



Wall shear



Mass flow rate

"Flux Report"

Mass Flow Rate	(kg/s)
inlet	0.061017871
interior-partbody	2.0820374
outlet	-0.061014902
wall-partbody	0
Net	2.9690564e-06

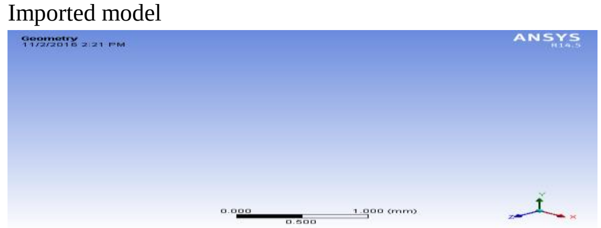
Total Heat transfer rate

"Flux Report"

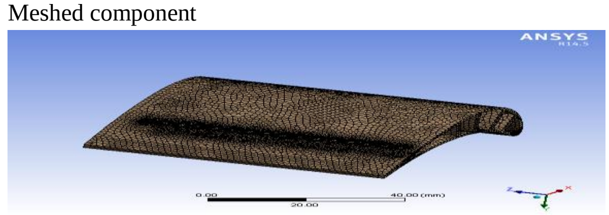
Total Heat Transfer Rate	(w)
inlet	49241.766
outlet	-49239.414
wall-partbody	0
Net	2.3515625

CFD analysis of modal 304m/s

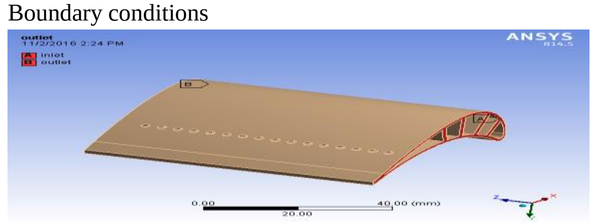
Imported model



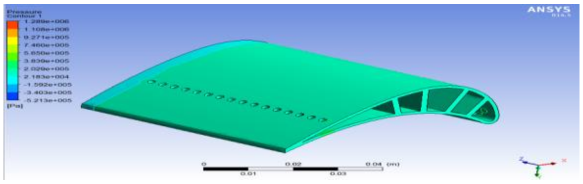
Meshed component



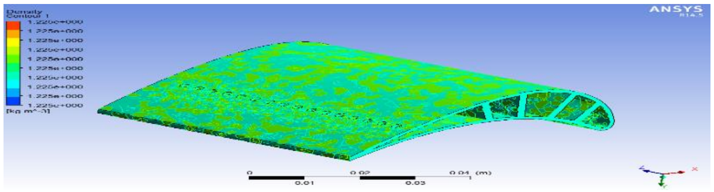
Boundary conditions



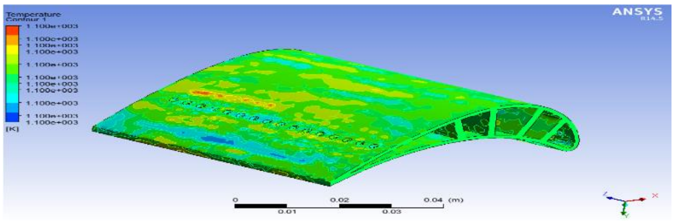
Pressure



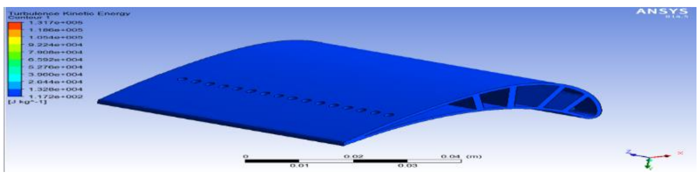
Density



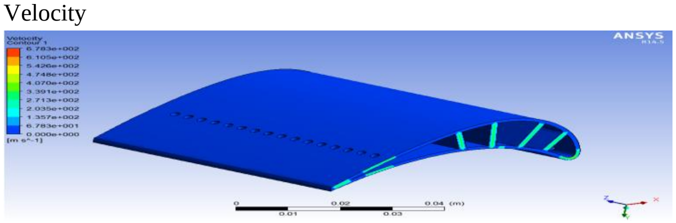
Temperature



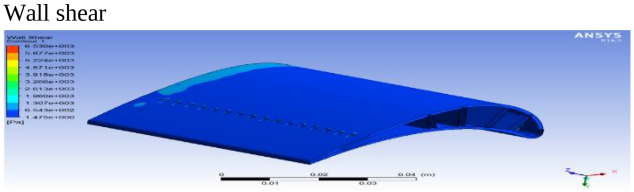
Turbulence



Velocity



Wall shear



Mass flow rate

```
                    "Flux Report"

     Mass Flow Rate                              (kg/s)
-------------------------------- --------------------
                    inlet                0.10169649
  interior-partbody                       3.3370757
                   outlet               -0.10177635
           wall-partbody                          0
  ------------------------------ --------------------
                      Net            -7.9855323e-05
```

Total Heat transfer rate

```
                         "Flux Report"

Total Heat Transfer Rate                          (w)
-------------------------------- --------------------
                           inlet          82069.711
                          outlet         -82134.125
                   wall-partbody                  0
           ---------------------- --------------------
                             Net         -64.414063
```

Results table

Models	Model 1 272ms	Model 1 204ms	Model 1 340ms	Model2 272ms	Model2 204ms	Model2 1304 ms
Pressure(pa)	7.809e4	6.071e9	1.224e5	8.666e5	1.263e5	1.289e6
Density, (kg m^{-3})	1.225	1.225	1.225	1.225	1.225	1.225
Temperature	1000	1000	1000	1000	1000	1000
Turbulence J kg^{-1}	2195	1.654e9	3.109e3	8.983e4	4.593e3	1.317e5
Velocity M s^{-1}	391	1.909e4	4.893e2s	5.421e2	4.034e2	6.783e2
Wall shear Pa	6696	3.582e7	9.518e2	3.960e3	6.568e2	6.53e3
Mass flow rate, Kg/s	4.4256449e-06	0.0001047402 6	5.4389238e-06	5.9463084e-05	2.9690564e-06	7.9855323e-05
Total heat flow rate, w	3.4296875	84.648438	3.734375	47.960938	2.3515625	64.414063

CONCULSION

Turbine blade is the individual component which makes up the turbine section of a gas turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines.

In these thesis we are doing CFD for turbine blade and modeling is designed on CATIA v5 software .in these we designed two models to find the flow on turbine blade .As input we given mass flow rates 204,272,340 m/s for the two models .As comparing the pressure and flow rates the second model is better than first model . We can use these flow rates and fluid flow is also we can maintain. For the turbine blade modification we can improve better results by doing anaylsis and several flow rates also.

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