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FLOW MODELLING IN CENTRIFUGAL PUMP TO STUDY THE PRESSURE AND VELOCITY VARIATIONS WITH DIFFERENT IMPELLER PROLFILES

A project report submitted in partial fulfillment of the requirement

for the award of degree of

BACHELOR OF TECHNOLOGY

In

MECHANICAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the thesis entitled "**FLOW MODELLING IN CENTRIFUGAL PUMP TO STUDY THE PRESSURE AND VELOCITY VARIATIONS WITH DIFFERENT IMPELLER PROLFILES**" submitted by **K.BHASKAR(17341A0347),ADAPA ANAJANEYA DORA(17341A0301),GUNAPU PADMA(17341A0335),KELIKOTI SAI KIRAN(17341A0349),DEVULAPALLI ADITYA SANTOSH(17341A0325),KARRA SAI KIRAN(16341A0347)** has been carried out in partial fulfilment of the requirement for the award of degree of **Bachelor of Technology** in **Electronics and Communication Engineering** of **GMRIT, Rajam** affiliated to **JNTUK, KAKINADA** is a record of bonafide work carried out by them under my guidance & supervision. The results embodied in this report have not been submitted to any other University or Institute for the award of any degree.

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ABSTRACT

In all the industrial and domestic application the usage of centrifugal pumps has been increased in the recent past due to its constructional and the functional advantages for pump various fluids like water, Fuels, Lubricants, Coolants and many other industrial solvents. A centrifugal pump is a rota dynamic pump that uses a rotating impeller to increase the pressure of a fluid. Its purpose is to convert energy of a prime mover first in to velocity or kinetic energy and then in to pressure energy that is being pumped. There are several types of impellers with varying vane profiles having different performance characteristics in terms of pressure distribution and velocity variations. Based on these performance characteristics centrifugal pumps are selected to suit the specific application. In the current study, an attempt has been made to do the flow modelling and simulation of the performance characteristics for the different impellor vane profiles enabling the user to select a suitable centrifugal pump for their applications.

The raise in static pressure and velocity are observed from inlet to outlet of impeller at varying flow rates and impeller speed based on the geometry of the vane. In the present study, a 3D model of centrifugal pump is developed for two different types of vane geometries and the analysis is carried out using a CFD computational tool to study the pressure variation and velocity variation of centrifugal pump with impeller geometry.

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INTRODUCTION

1.1 Basic Concept of Centrifugal pump:

A centrifugal pump transfers input power to kinetic energy of the fluid being pumped. This energy, through the specifics of the pump design, is converted to pressure energy that causes the fluid to flow. The most common type of centrifugal pump is termed the “volute pump”. In this type of pump, fluid enters the pump at the center of a rotating impeller. The rotating impeller causes a rapid radial acceleration of the fluid from the eye of the impeller to the pumps circumferential casing. This creates a vacuum at the center of the impeller, resulting in continual entry of more process fluid. The fluid exits the pump through a discharge port located at the outer perimeter of the casing.

1.2 Classification of Centrifugal pumps:

Centrifugal pumps are classified in several ways. Pumps may be classified:

•In terms of energy conversions (volute type and diffuser vane ring type);

•In terms of fluid flow through the pump (radial, mixed flow and axial flow);

•As either single stage or multistage i.e. in terms of number of stages;

•According to the design of the casing;

•According to the design of the impeller; and

• In terms of their application.

1.2.1 Centrifugal Pump Classification by Flow:

Centrifugal pumps can be classified based on the manner in which fluid flows through the pump. The manner in which fluid flows through the pump is determined by the design of the pump casing and the impeller. The three types of flow through a centrifugal pump are radial flow, axial flow, and mixed flow.

1.2.1.1 Radial Flow Pumps:

In a radial flow pump, the liquid enters at the center of the impeller and is directed out along the impeller blades in a direction at right angles to the pump shaft. The impeller of a typical radial flow pump and the flow through a radial flow pump are shown.

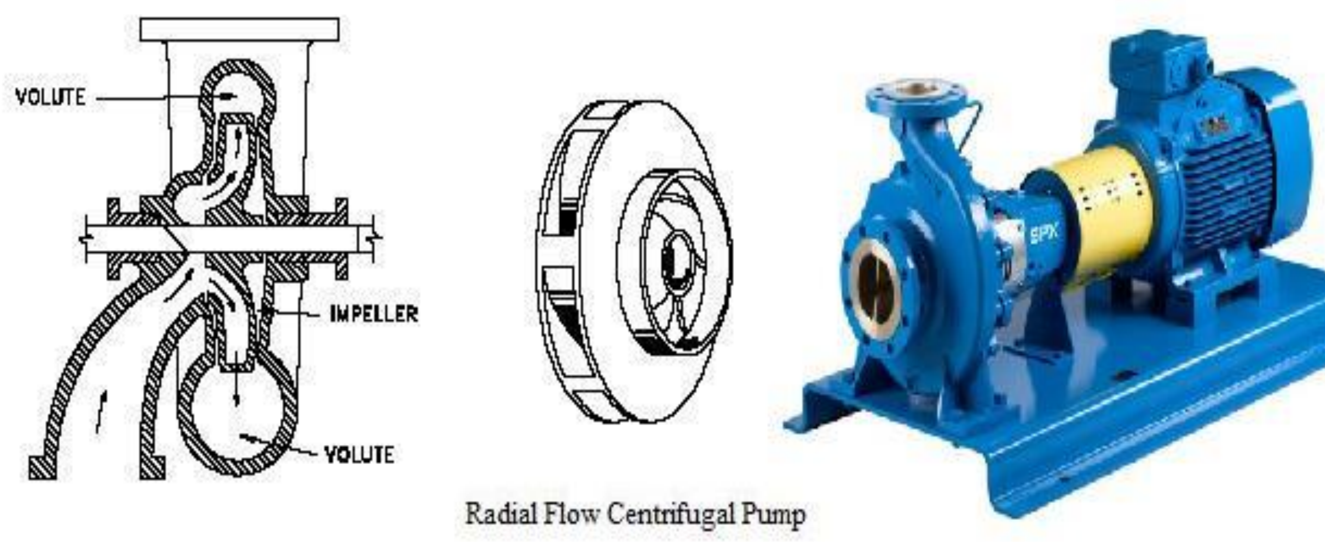


Fig 1. Radial Flow Pump

1.2.1.2 Axial Flow Pumps:

In an axial flow pump, the impeller pushes the liquid in a direction parallel to the pump shaft. Axial flow pumps are sometimes called propeller pumps because they operate essentially the same as the propeller of a boat. Axial pumps are used for the promotion of incompressible fluids and are employed for large volume flows at relatively low delivery heads. As with all types of centrifugal pumps, the energy transmission in axial flow pumps is carried out exclusively through flow-related processes. The impeller of a typical axial flow pump and the flow through a radial flow pump are shown.

Fig 2. Axial Flow Pump

1.2.1.3 Mixed Flow Pumps:

Mixed flow pumps borrow characteristics from both radial flow and axial flow pumps. As liquid flows through the impeller of a mixed flow pump, the impeller blades push the liquid out away from the pump shaft and to the pump suction at an angle greater than 90 degree. The impeller of a typical mixed flow pump and the flow through a mixed flow pump are shown.

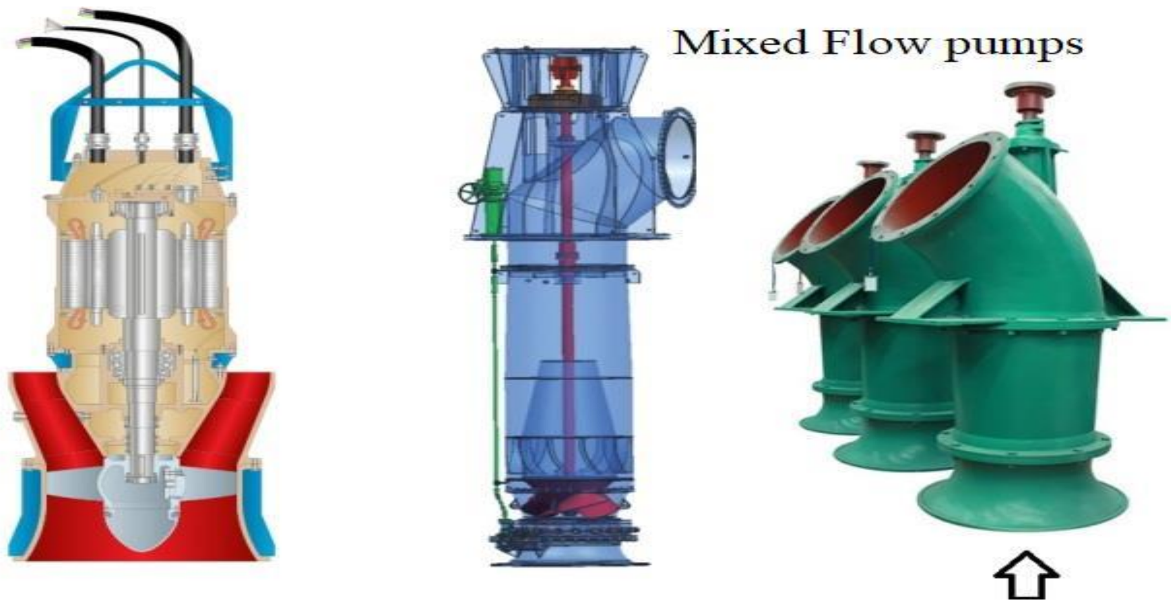


Fig.3. Mixed Flow Pump

1.2.2 Centrifugal Pump Classification by Number of stages:

A centrifugal pump with a single impeller that can develop a differential pressure of more than 150 psi between the suction and the discharge is difficult and costly to design and construct.

A more economical approach to developing high pressures with a single centrifugal pump is to include multiple impellers on a common shaft within the same pump casing. Internal channels in the pump casing route the discharge of one impeller to the suction of another impeller. Picture shows a diagram of the arrangement of the impellers of a five-stage horizontal pump and ten stage vertical multistage pump. The water enters the pump from the top left and passes through each of the four impellers in series, going from left to right. The water goes from the volute surrounding the discharge of one impeller to the suction of the next impeller.

Fig 4. Multi Stage Centrifugal Pump

A pump stage is defined as that portion of a centrifugal pump consisting of one impeller and its associated components. Most centrifugal pumps are single stage pumps, containing only one impeller. A pump containing seven impellers within a single casing would be referred to as a seven-stage pump or, or generally, as a multi-stage pump.

1.2.3 Centrifugal Pump Classification According to the Design of Casing:

Centrifugal pumps are also classified in terms of the design of the casing. Both axially and radially split single casings are used for centrifugal pumps. Axially and radially split single casing are illustrated in Figures 8 and 9 respectively. The discharge connections are usually located in the lower half thereby enabling the upper half to be lifted and the rotor laid bare for inspection or removal without disconnecting the pump, either from its foundation or from the suction and discharge piping. The disadvantage of this type is the difficulty in maintaining a seal at the joint when at higher pressures. As the working pressure increases, radially split casings are preferred because of the inherent strength in their construction.

Fig 5. Split casing Double suction centrifugal pump

1.2.4 Centrifugal Pump Classification According to the Design of Impeller:

Impellers of pumps are classified based on the number of points that the liquid can enter the impeller and also on the amount of webbing between the impeller blades. Impellers can be either single suction or double-suction. A single-suction impeller allows liquid to enter the center of the blades from only one direction. A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously. Figure shows simplified diagrams of single and double-suction impellers. Impellers can be open, semi-open, or enclosed. The open impeller consists only of blades attached to a hub. The semi-open impeller is constructed with a circular plate (the web) attached to one side of the blades. The enclosed impeller has circular plates attached to both sides of the blades. Enclosed impellers are also referred to as shrouded impellers. picture shows the examples of open, semi-open, and enclosed impellers.

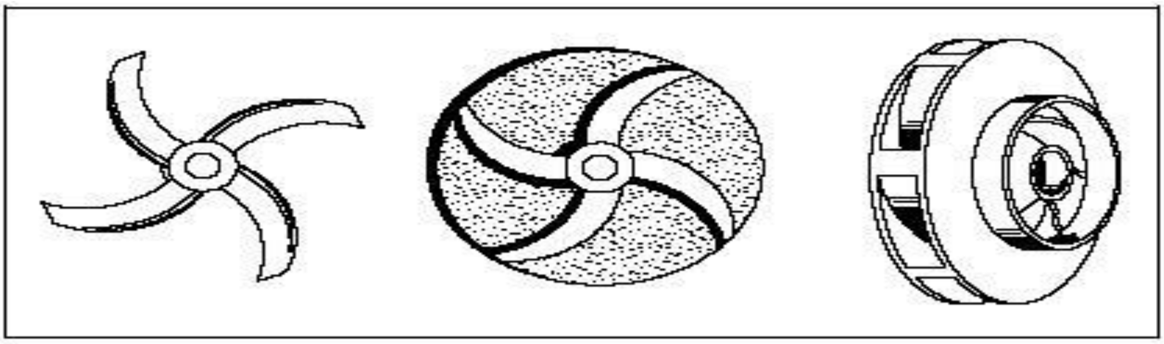


Fig 6.Open, Semi-Open, and Enclosed Impellers

The impeller sometimes contains balancing holes that connect the space around the hub to the suction side of the impeller. The balancing holes have a total cross-sectional area that is considerably greater than the cross-sectional area of the annular space between the wearing ring and the hub. The result is suction pressure on both sides of the impeller hub, which maintains a hydraulic balance of axial thrust.

1.2.5 Centrifugal Pump Classification in terms of use or Application:

One of the more important methods of classifying these pumps is in terms of their application like Pump used to feed water into a boiler is called Boiler Feed Water Pump. Intended application is a major factor in impeller and casing design, materials used and other mechanical and hydraulic features.

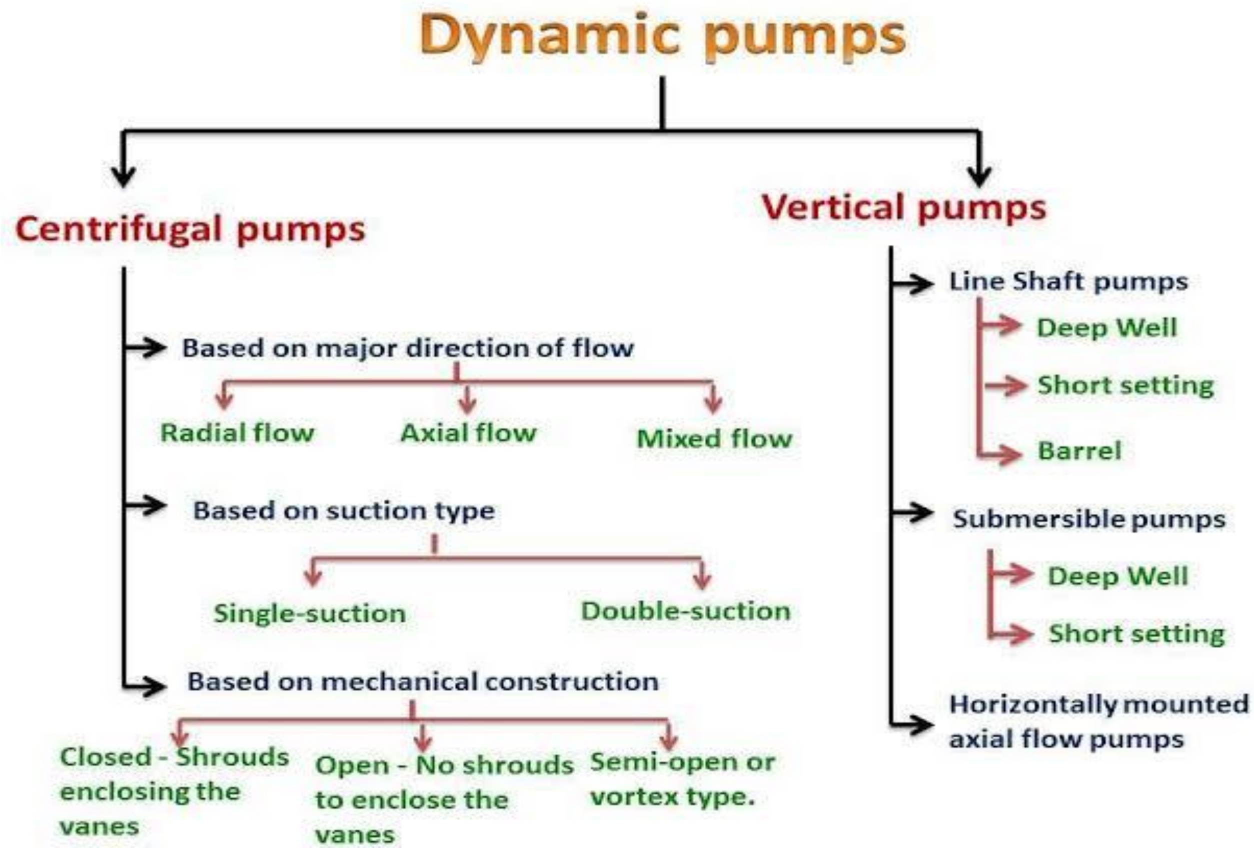


Fig 7. Classification of Centrifugal pump

1.3 Working Principle of Centrifugal Pump:

Centrifugal pumps are used to induce flow or raise a liquid from a low level to a high level. These pumps work on a very simple mechanism. A centrifugal pump converts rotational energy, often from a motor, to energy in a moving fluid.

The two main parts that are responsible for the conversion of energy are the impeller and the casing. The impeller is the rotating part of the pump and the casing is the airtight passage which surrounds the impeller. In a centrifugal pump, fluid enters into the casing, falls on the impeller blades at the eye of the impeller, and is whirled tangentially and radially outward until it leaves the impeller into the diffuser part of the casing. While passing through the impeller, the fluid is gaining both velocity and pressure.

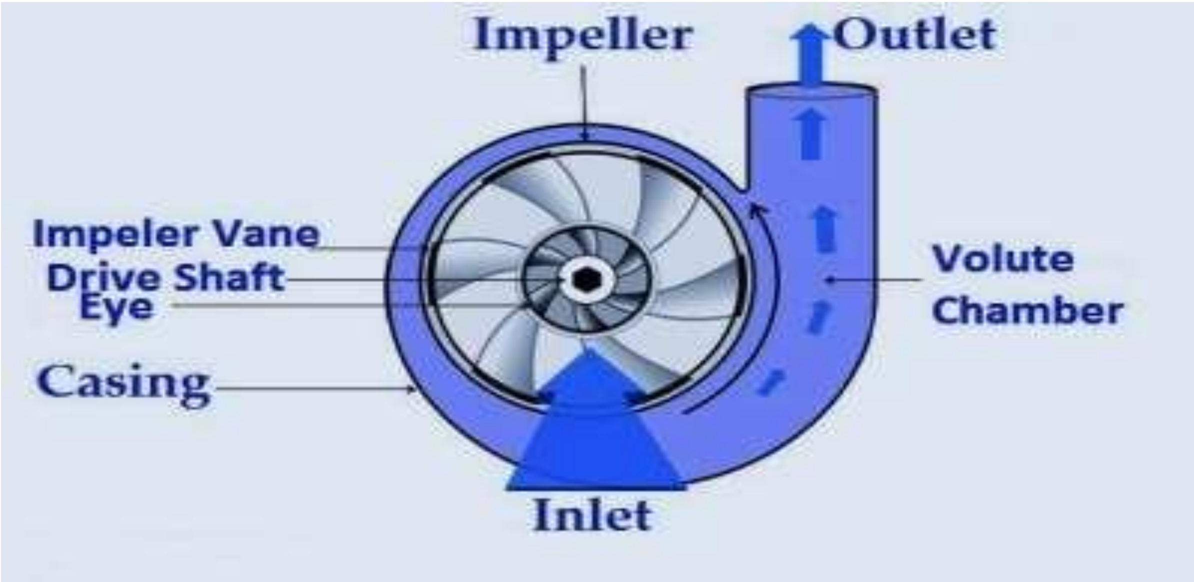


Fig 8. Centrifugal pump

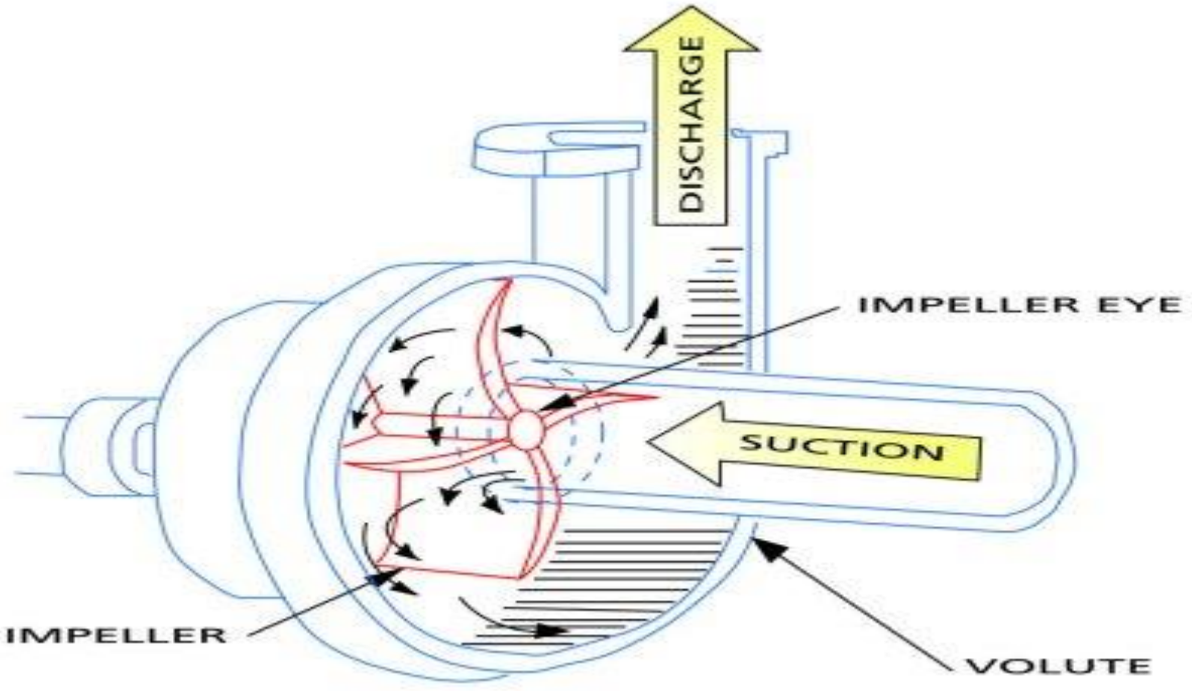


Fig 9. Centrifugal Pump Working Principle

1.4Factors affecting the performance of a centrifugal pump:

- **Working Fluid Viscosity:** It can be defined as resistance to shear when energy is applied. In general, a centrifugal pump is suitable for low viscosity fluids since the pumping action generates high liquid shear.

- **Specific density and gravity of working fluid:** The density of a fluid is its mass per unit of volume. A fluid's mass per unit volume and gravity of a fluid is the ratio of a fluid's density to the density of water. It directly affects the input power required to pump a particular liquid. If you are working with a fluid other than water, it is important to consider the specific density and gravity since the weight will have a direct effect on the amount of work performed by the pump.

- **Operating temperature and pressure:** Pumping conditions like temperature and pressures are an important consideration for any operation. For example – High-temperature pumping may require special gaskets, seals and mounting designs. Similarly, an adequately designed pressure retaining casing may be required for high-pressure conditions.

- **Net Positive Suction Head (NPSH) and Cavitation:** NPSH is a term that refers to the pressure of a fluid on the suction side of a pump to help determine if the pressure is high enough to avoid cavitation. Cavitation refers to the formation of bubbles or cavities in liquid, developed in areas of relatively low pressure around an impeller and can cause serious damage to the impeller and lead to decreased flow/pressure rates among other things. One must ensure that the system's net positive suction head available (NPSHA) is greater than the pump's net positive suction head required (NPSHR), with an appropriate safety margin.

- **Vapour pressure of the working fluid:** The vapor pressure of a fluid is the pressure, at a given temperature, at which a fluid will change to a vapor. It must be determined in order to avoid cavitation as well as bearing damage caused by dry running when the fluid has evaporated.

1.5 Applications of Centrifugal Pumps:

The fact that centrifugal pumps are the most popular choice for fluid movement makes them a strong contender for many applications and as mentioned previously, they are used across numerous industries. Supplying water, boosting pressure, pumping water for domestic requirements, assisting fire protection systems, hot water circulation, sewage drainage and regulating boiler water are among the most common applications. Outlined below are some of the major sectors that make use of these pumps:

a) Oil &Energy– pumping crude oil, slurry, mud; used by refineries, power generation plants

Industrial & Fire Protection Industry – Heating and ventilation, boiler feed applications, air conditioning, pressure boosting, fire protection sprinkler systems.

b) Waste Management, Agriculture & Manufacturing – Wastewater processing plants, municipal industry, drainage, gas processing, irrigation, and flood protection.

c) Pharmaceutical, Chemical &Food Industries- paints, hydrocarbons, petrochemical, cellulose, sugar refining, food and beverage production.

d) Various industries (Manufacturing, Industrial, Chemicals, Pharmaceutical, Food Production, Aerospace etc.) – for the purposes of cryogenics and refrigerants.

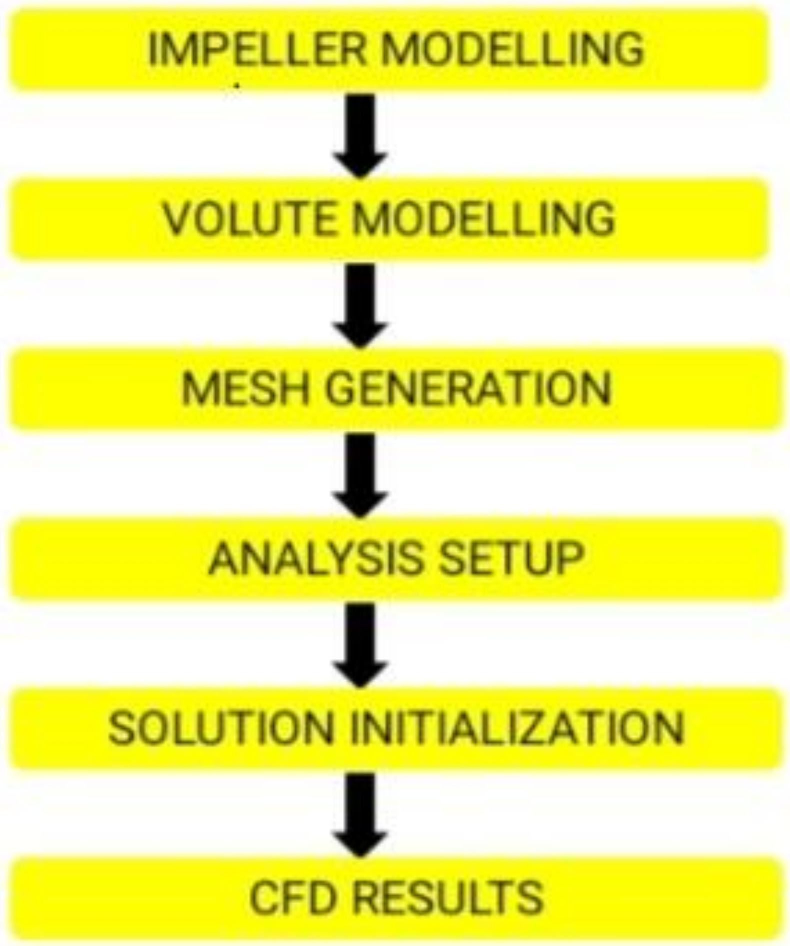
CHAPTER- 2

METHODOLOGY

2.1 Introduction to Methodology:

Our project deals with the study of the pressure variation and velocity variation of the centrifugal pump with various impeller profiles. First, we do the modeling of the closed and semi open impellers in CATIA V5 software. Then we import the modeled part into Ansys Fluent software. Then we do the meshing at both the inlet and outlet of the centrifugal pump. Then we select the material for the impeller and fluid medium. Then we apply the boundary conditions for both the solid and fluid domains of the centrifugal pump. Then we crate the mesh interface between the solid and fluid domains. Then we start the solution initialization and perform the run calculations at various rotational speeds of the impeller. Then we perform the Computational Fluid Dynamics (CFD) and we obtain the pressure variation and velocity variation of both the closed and semi open impellers by varying the rotational speed of the impeller and also by varying the blade number. Finally with the results obtained we decide the best impeller profile between the closed and semi open impellers of the centrifugal pump.

2.1 Procedure:



CHAPTER-3

MODELLING OF CENTRIFUGAL PUMP IN CATIA V5

3.1 Introduction to software tool:

CATIA V5 is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

CATIA is a multi-platform 3D software suite developed by Dassault systems, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and also addresses every design-to-manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi-directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

The first release of CATIA was way back in 1977, and the software suite is still going strong more than 30 years later. While CATIA V6 is just being released, the most popular version of CATIA is V5 which was introduced in 1998. That said, it is important to note that each version of CATIA introduces considerable additional functionality. For example, V4 (introduced in 1992) offered enhancements to the Assembly Modelling Product including easy-to-use graphical tree-based assembly management. V5 and V6 saw changes in the way data is handled. Dassault systems typically offers new updates, releases and bug fixes for each version. The CATIA software is written in C++. It runs on both Unix and Windows.

CATIA offers many workbenches that can be loosely termed as modules. A few of the important workbenches and their brief functionality description is given below:

Part Design: The most essential workbench needed for solid modelling. This CATIA module makes it possible to design precise 3D mechanical parts with an intuitive and flexible user interface, from sketching in an assembly context to iterative detailed design.

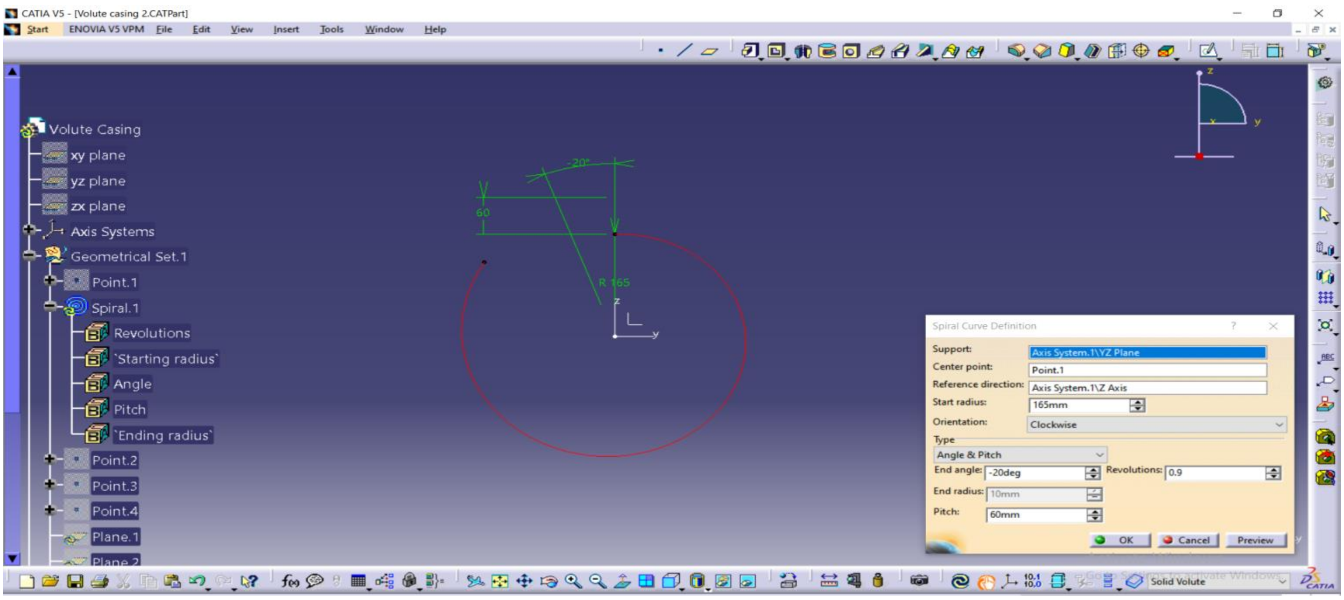
Generative Shape Design: allows you to quickly model both simple and complex shapes using wireframe and surface features. It provides a large set of tools for creating and editing shape designs. Though not essential, knowledge of Part Design will be very handy in better utilization of this module.

Assembly: The basics of product structure, constraints, and moving assemblies and parts can be learned quickly. This is the workbench that allows connecting all the parts to form a machine or a component.

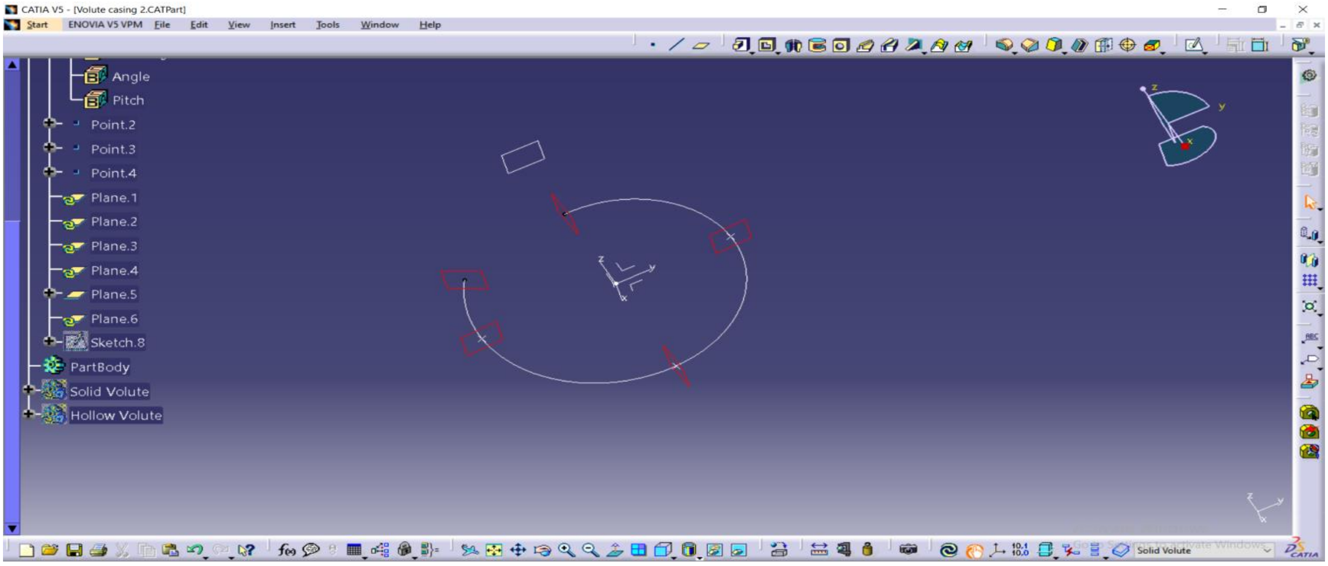
3.2 DETAIL STEP BY STEP PROCESSOR OF THE MODELLING PROCESS:

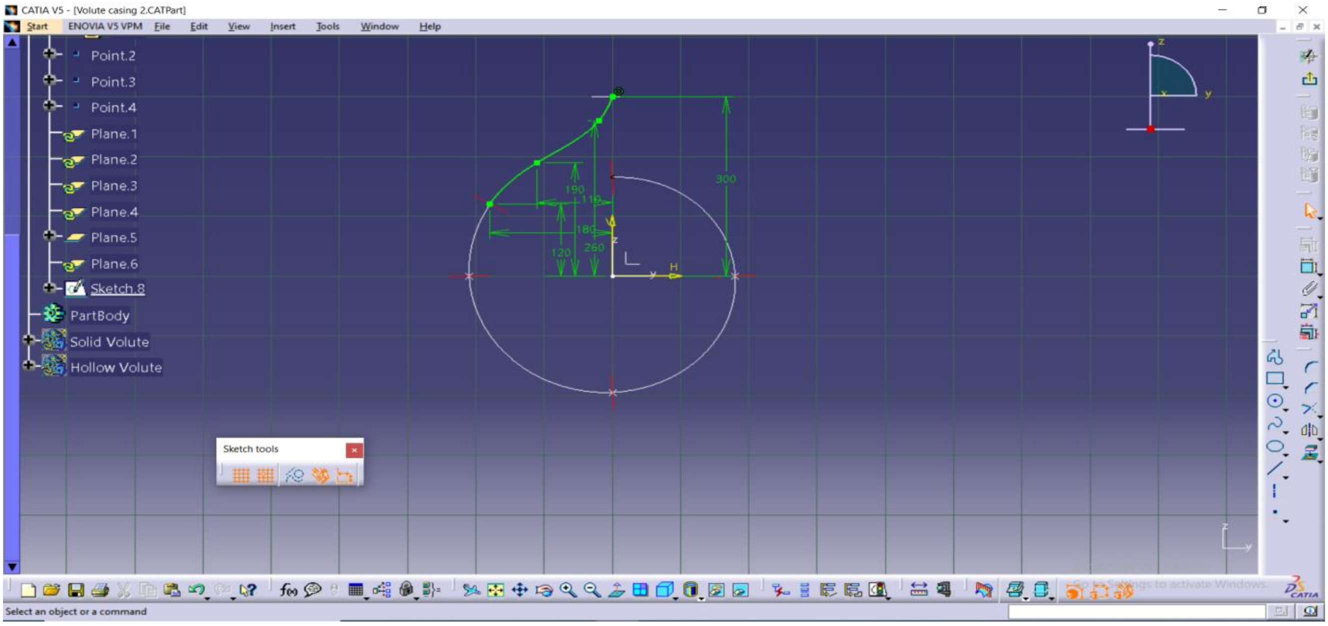
3.2.1 Volute Modelling:

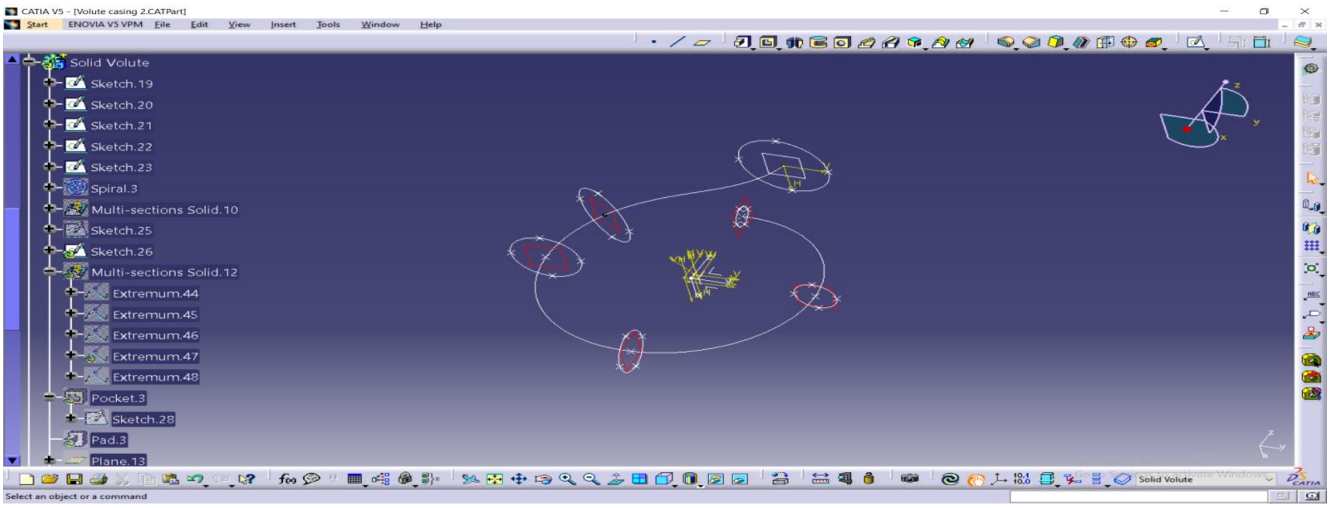
1) Creating a spiral curve of radius 165mm.



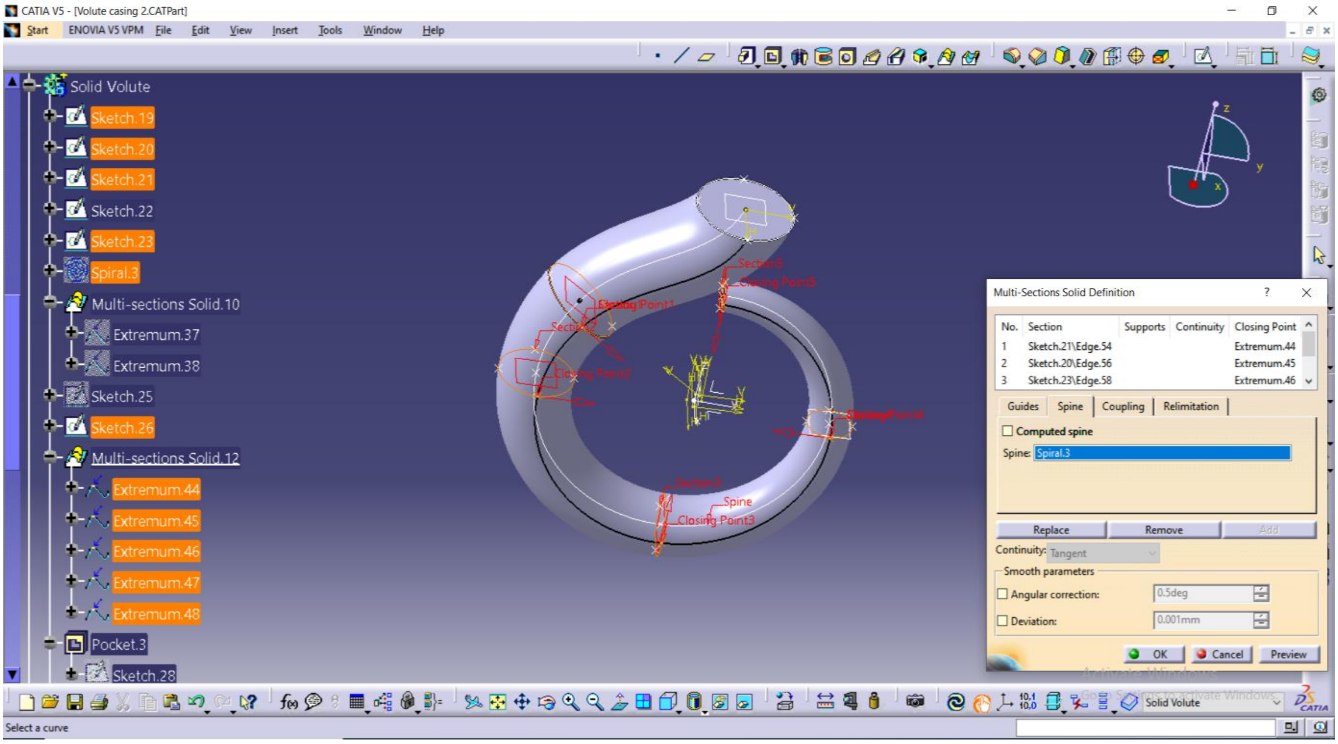
2) Creating a hollow volute:



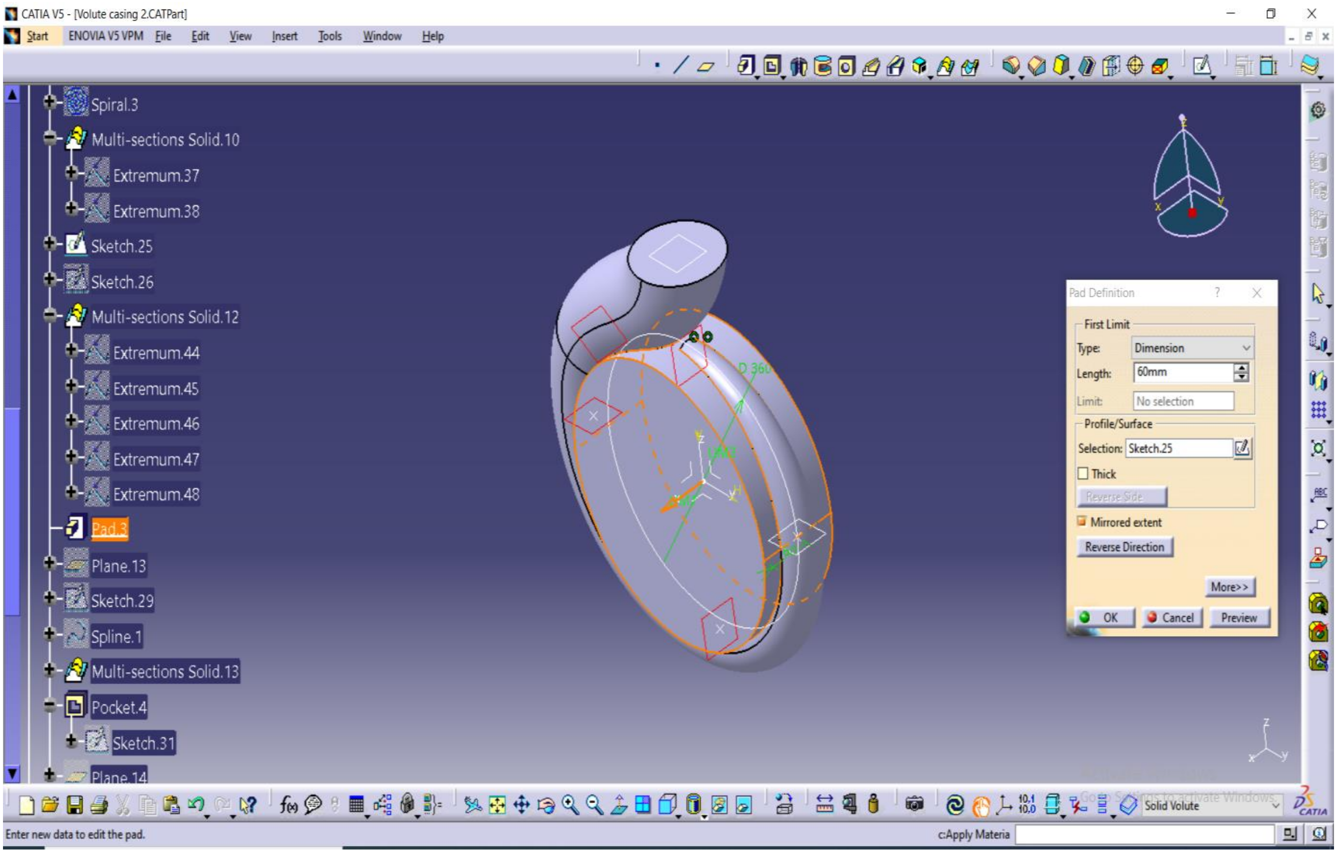




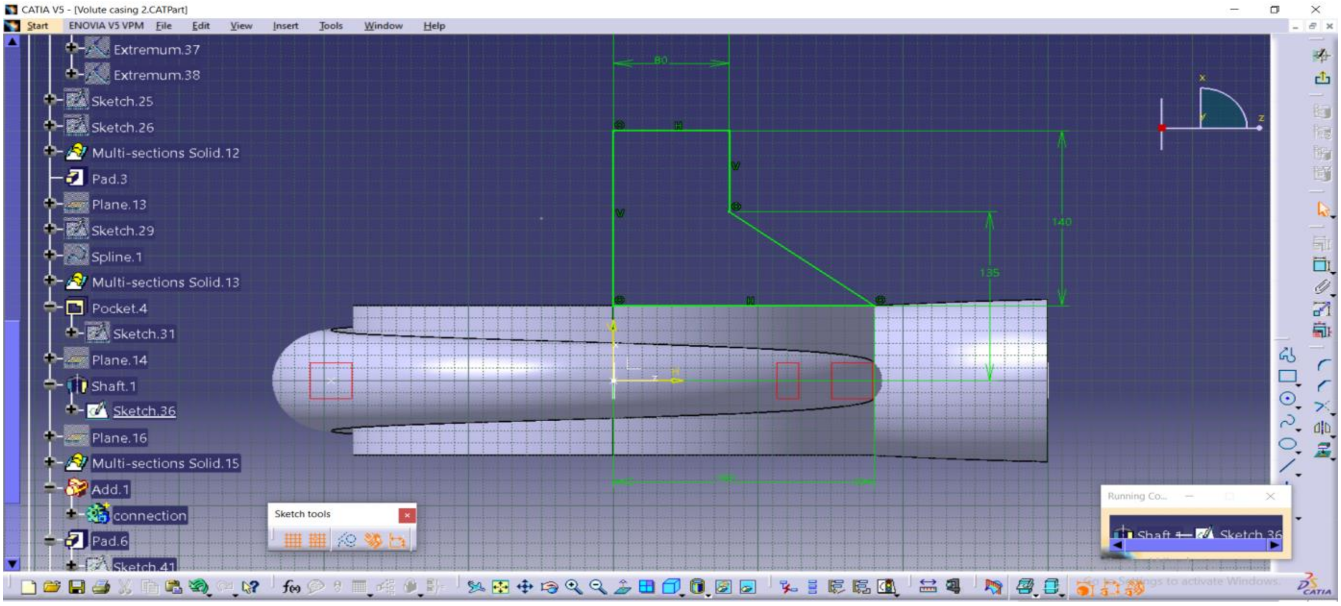
3) Using Multi-Section Solid option



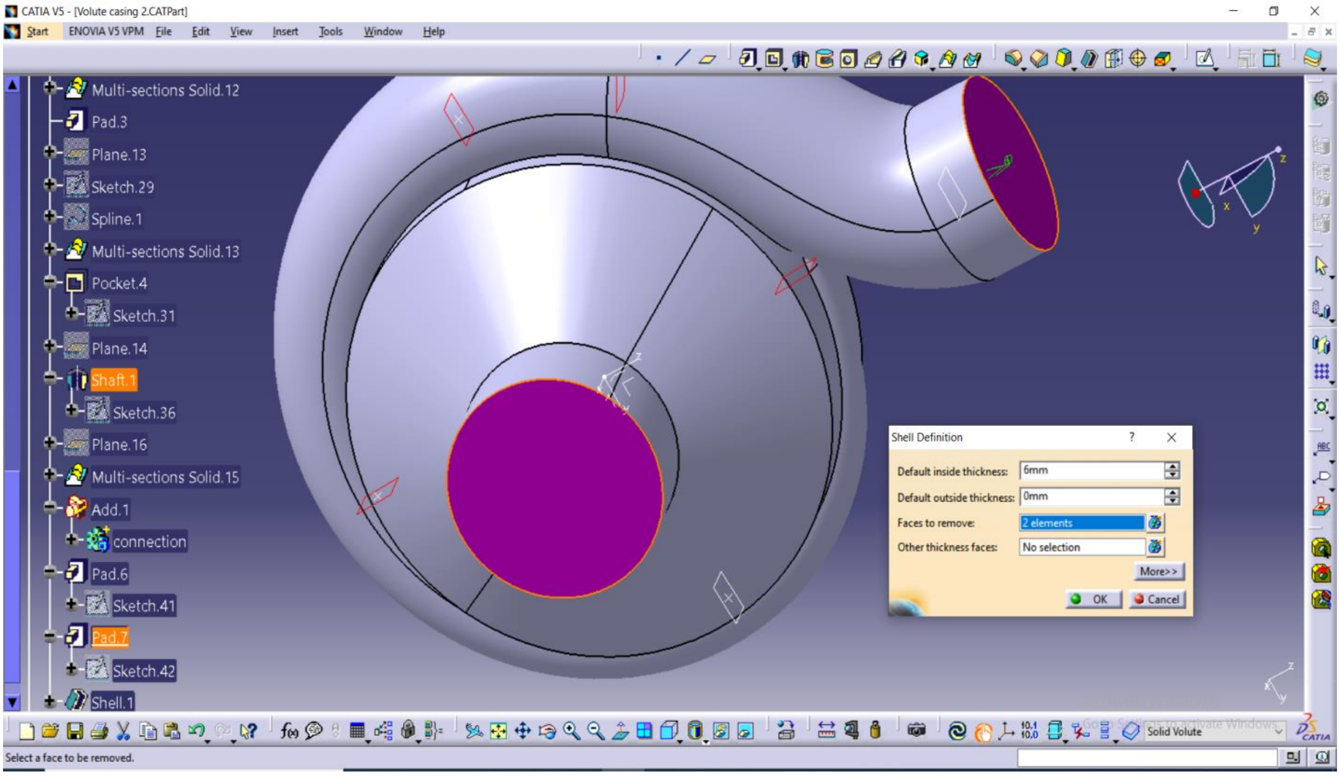
4) Using Pad Definition give length 60mm



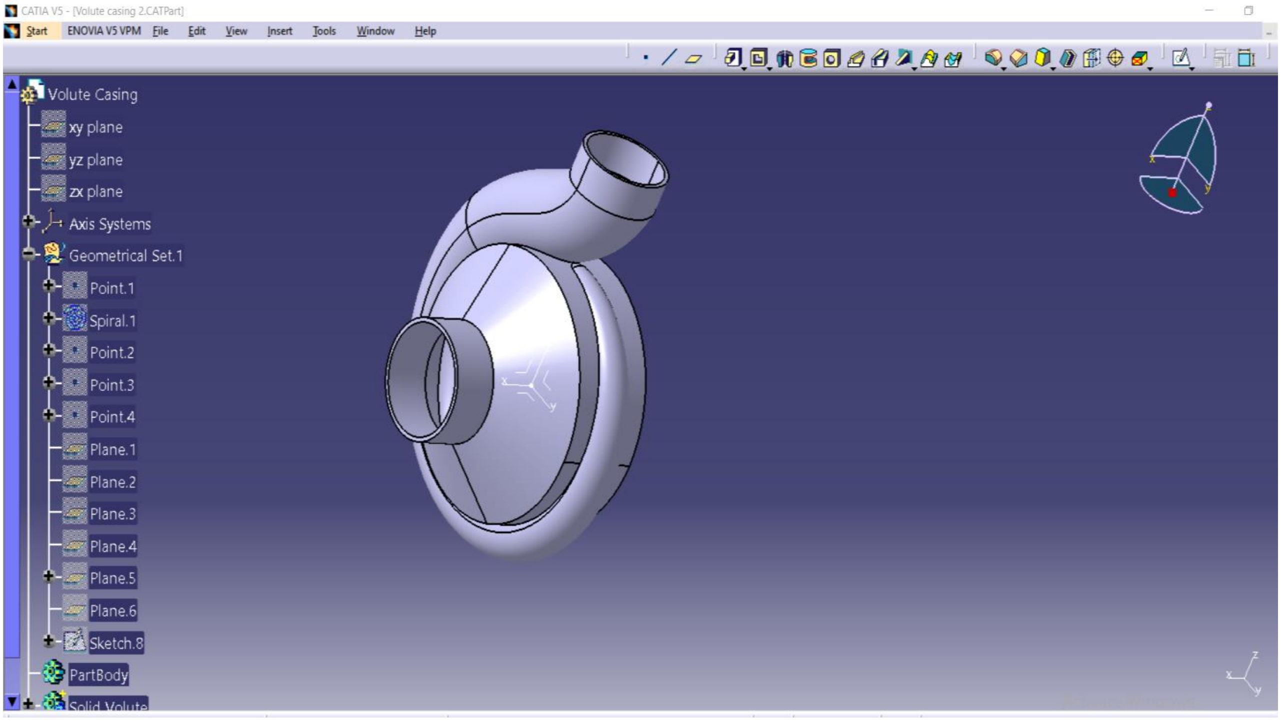
5)Drawing the outer surface sketch



6)Now we create the outer shell by using Shell definition

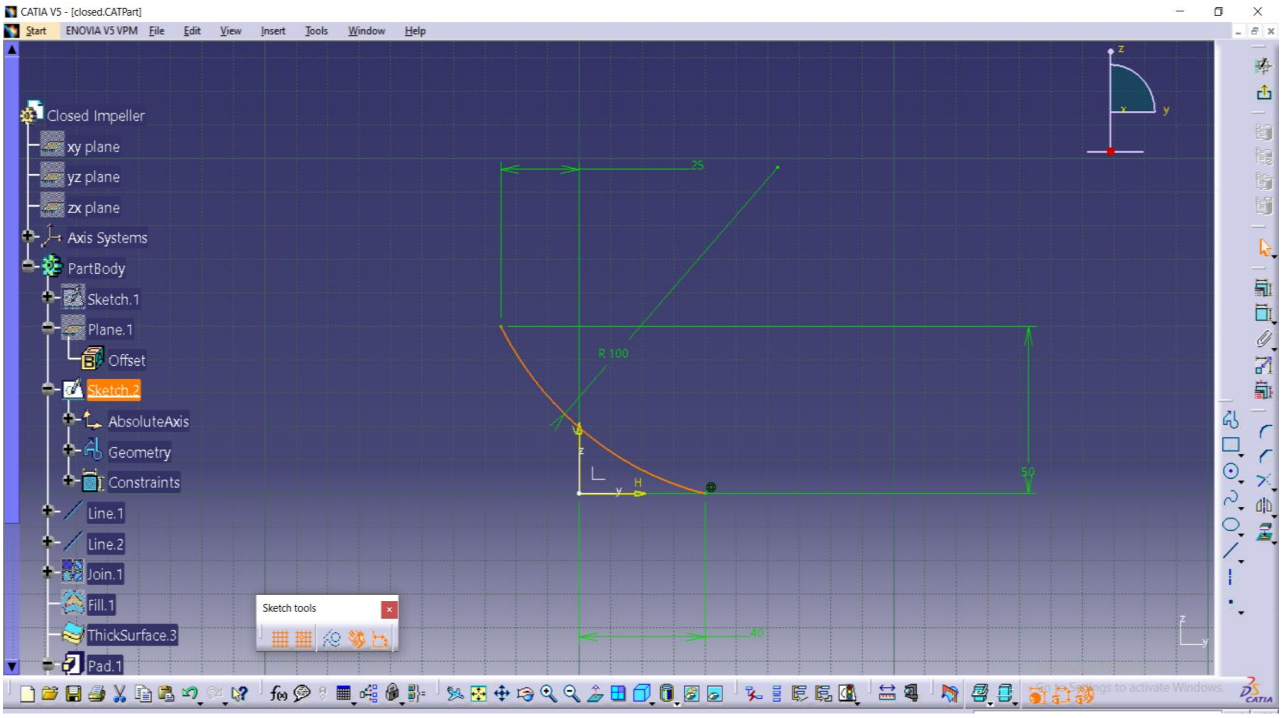


7) Completion of volute casing modelling

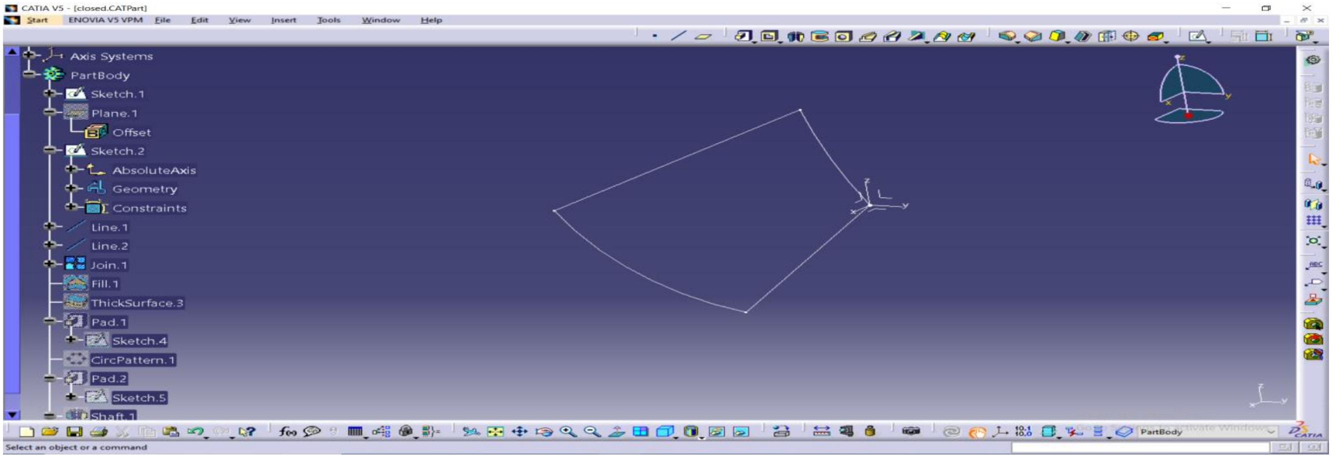


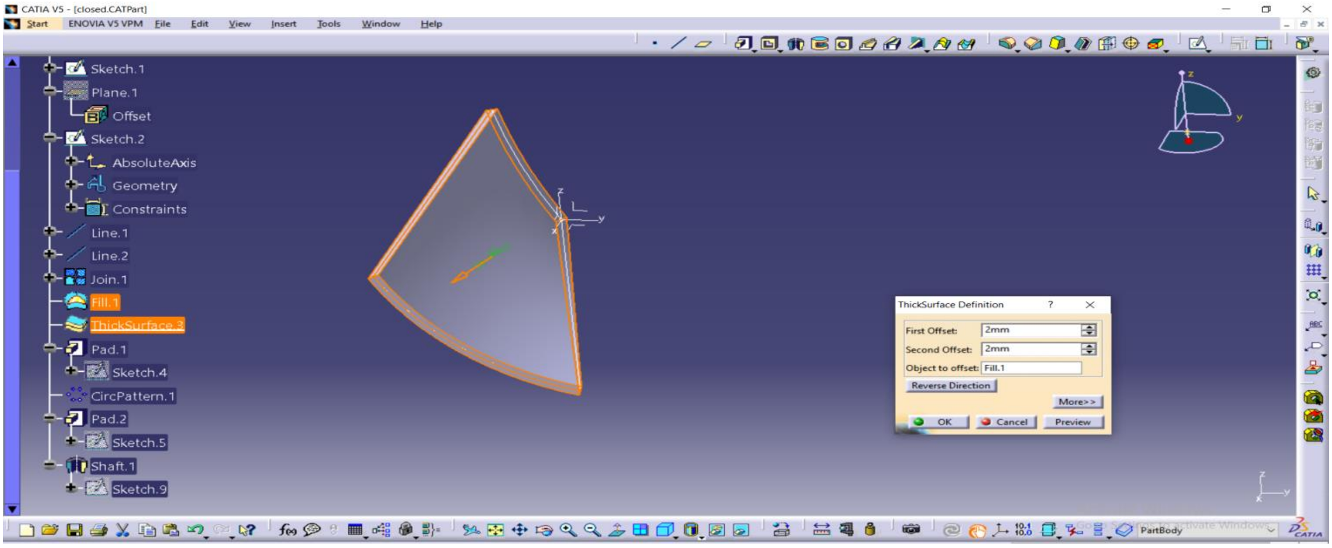
3.2.2. Semi Open and closed impeller modelling:

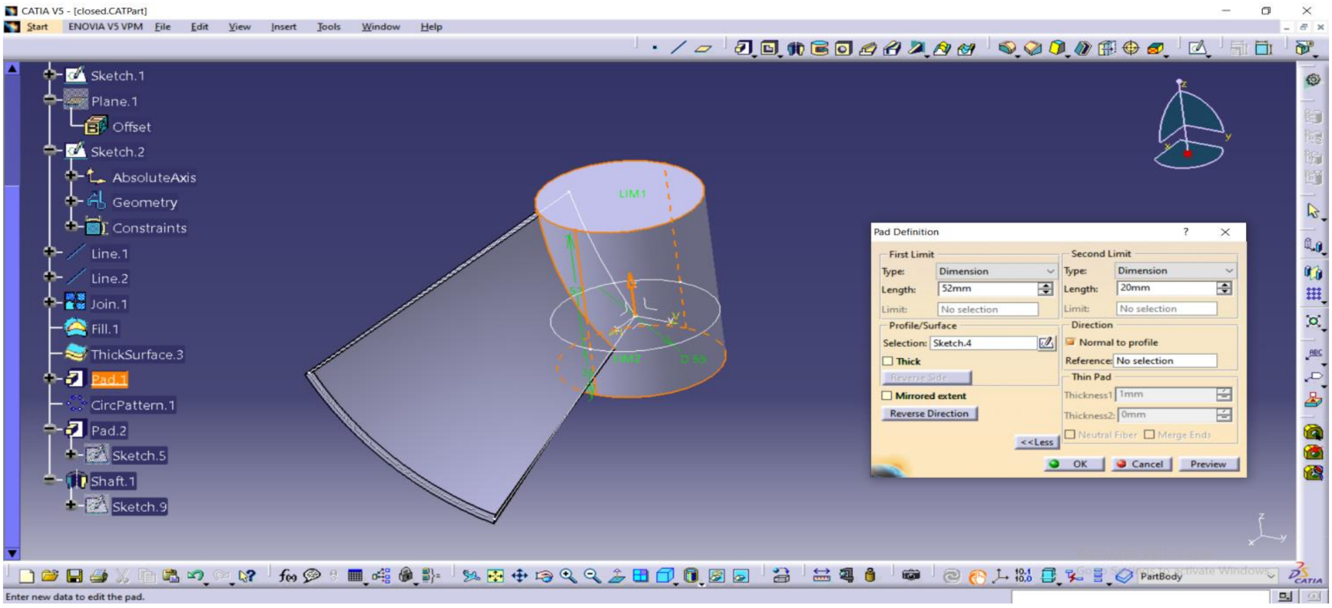
1)Create a curve of radius 100mm.



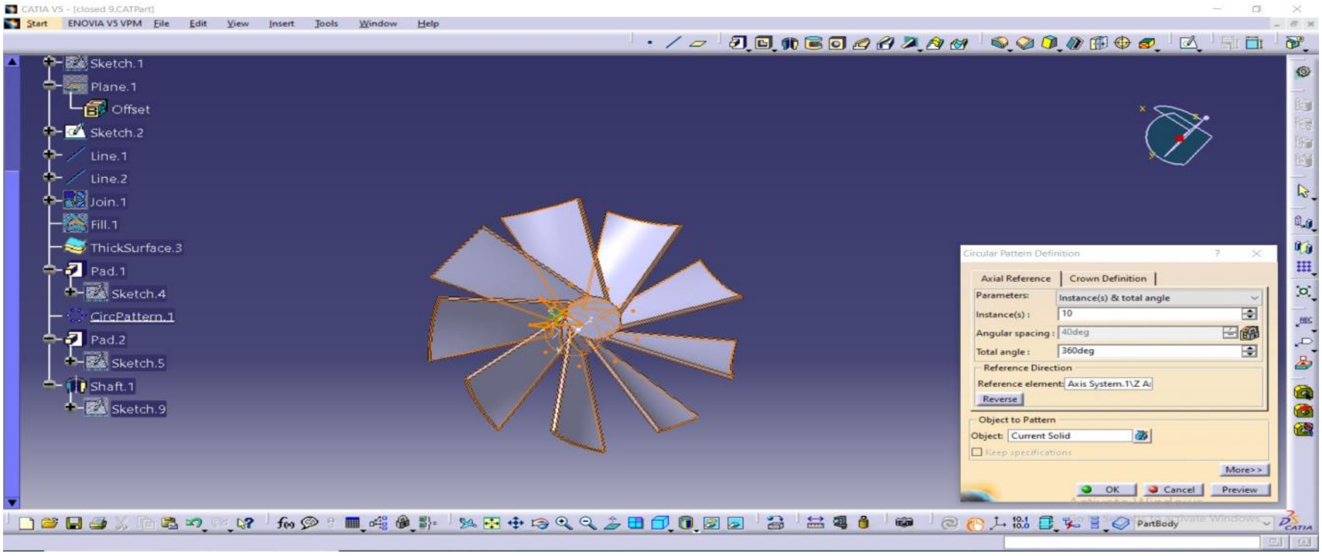
2)Creating a blade surface of thickness 2mm

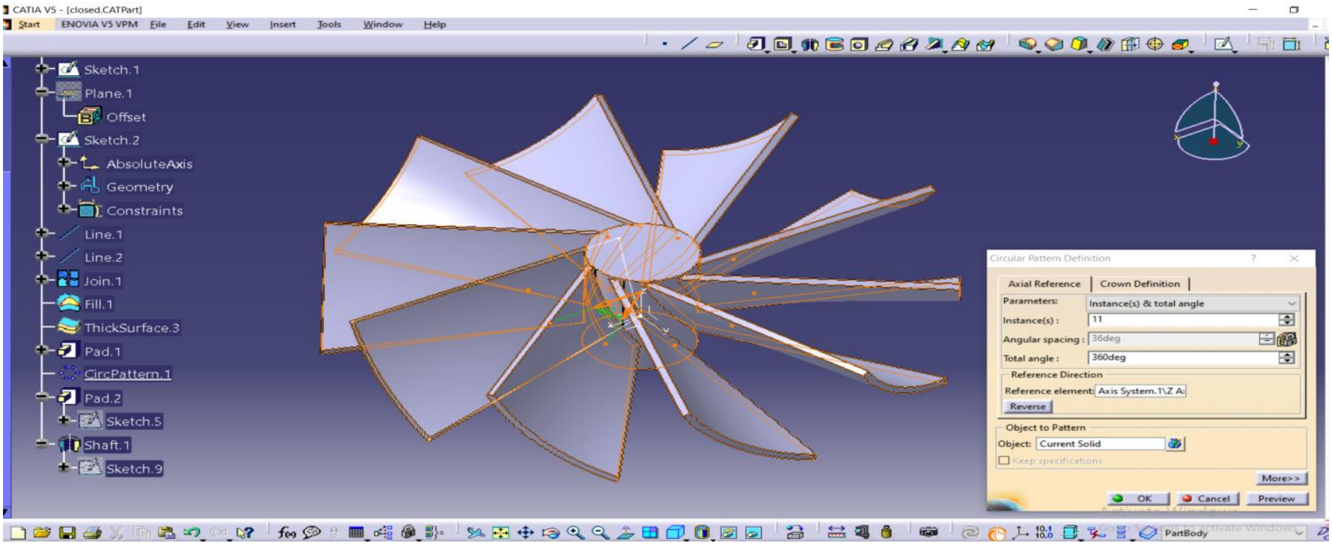


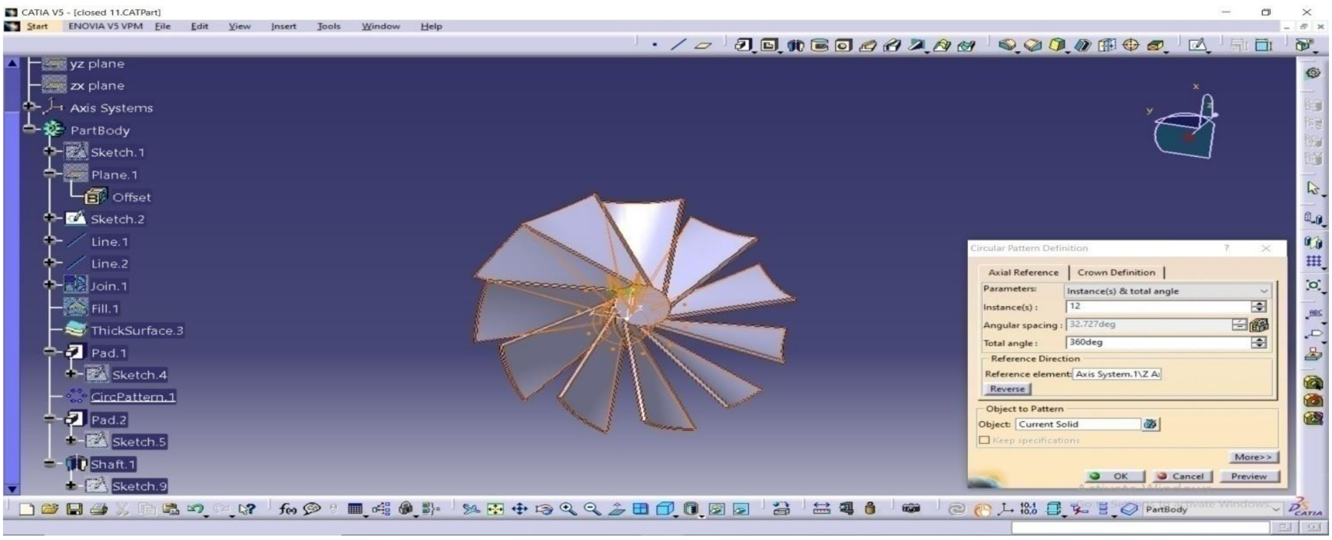




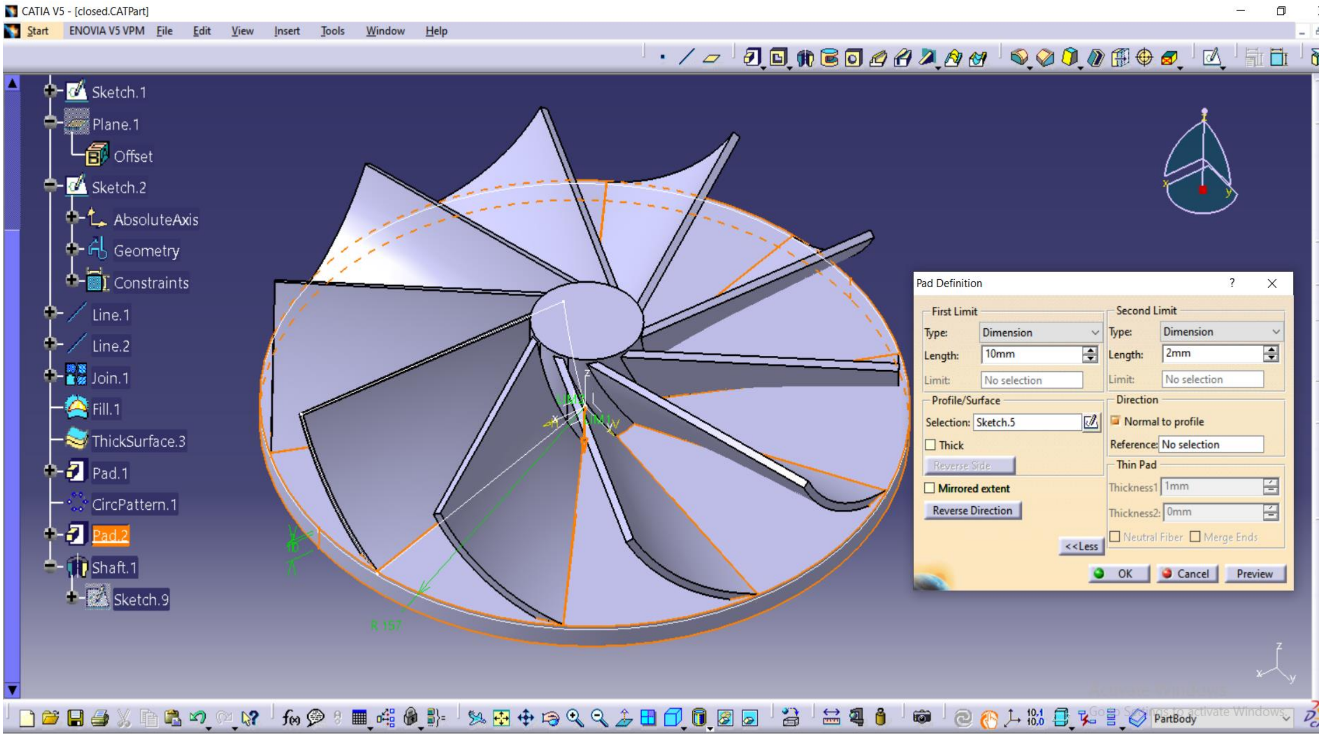
3) Using Circular Pattern, create 9,10,11 instances with angle of 360 deg.

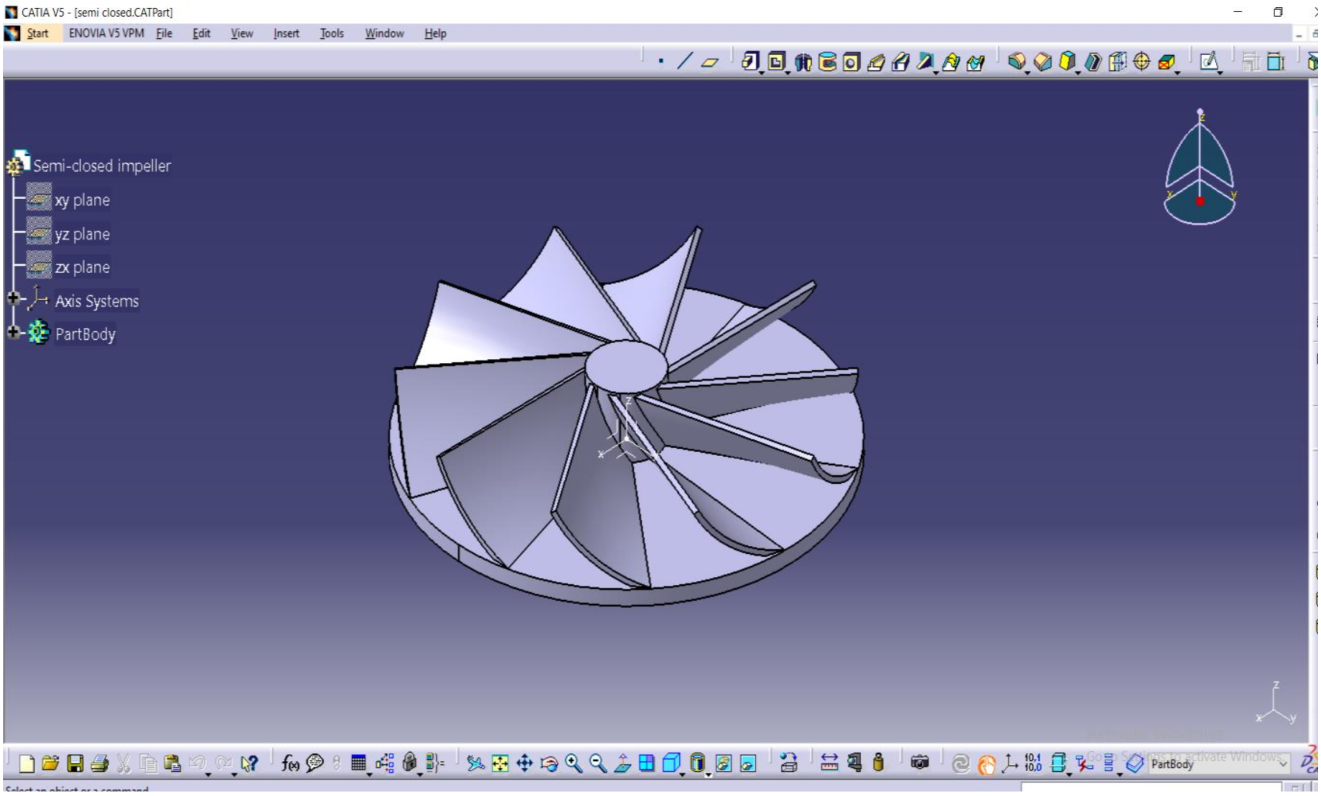




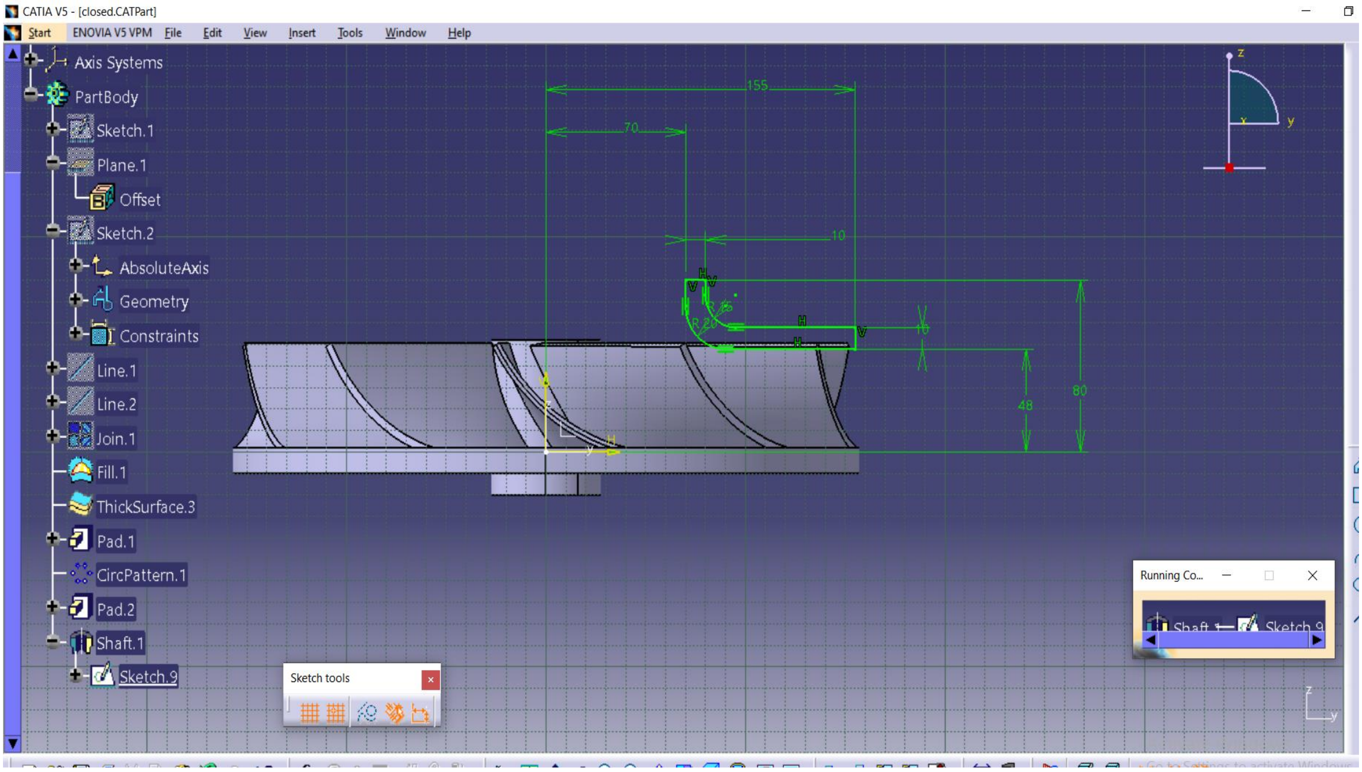


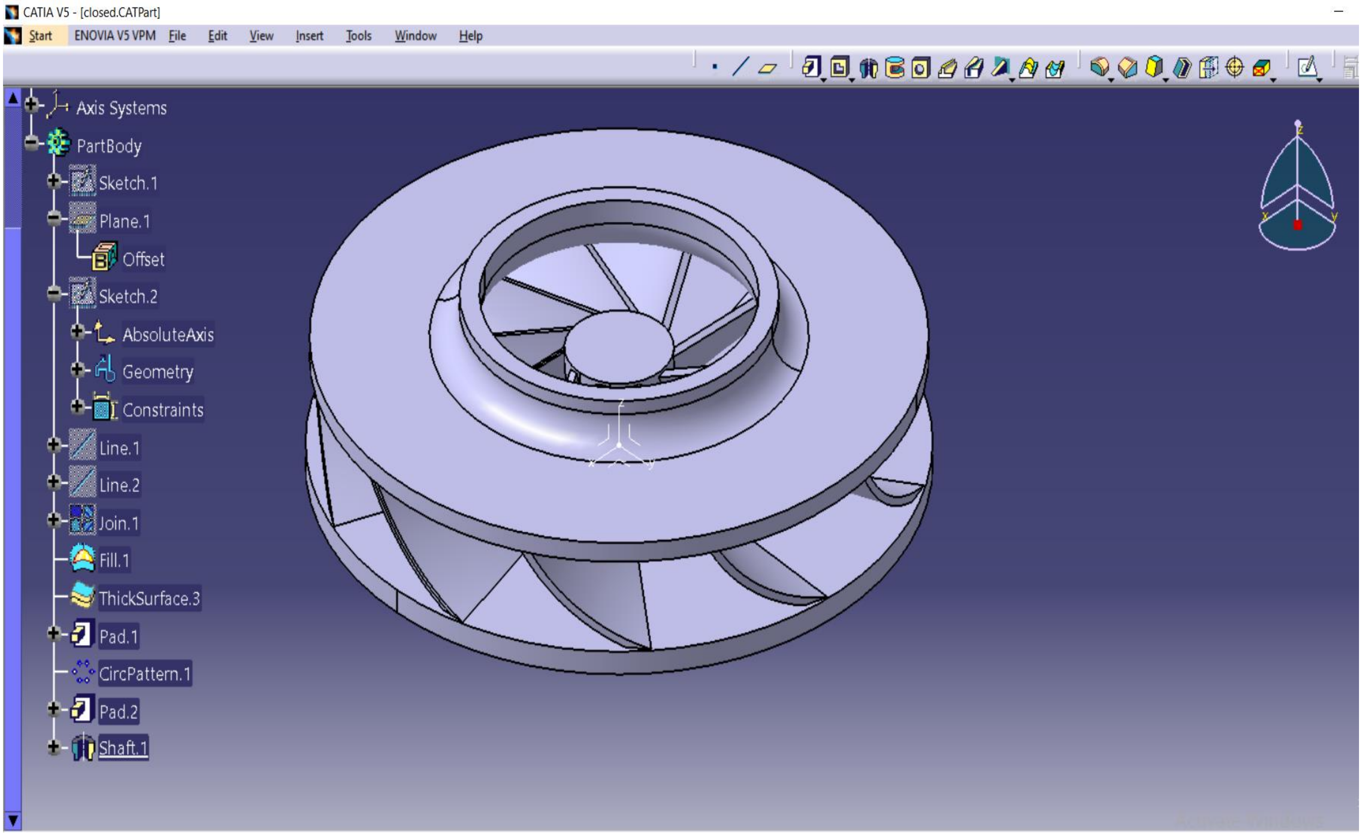
4) Modelling of Semi open impeller.





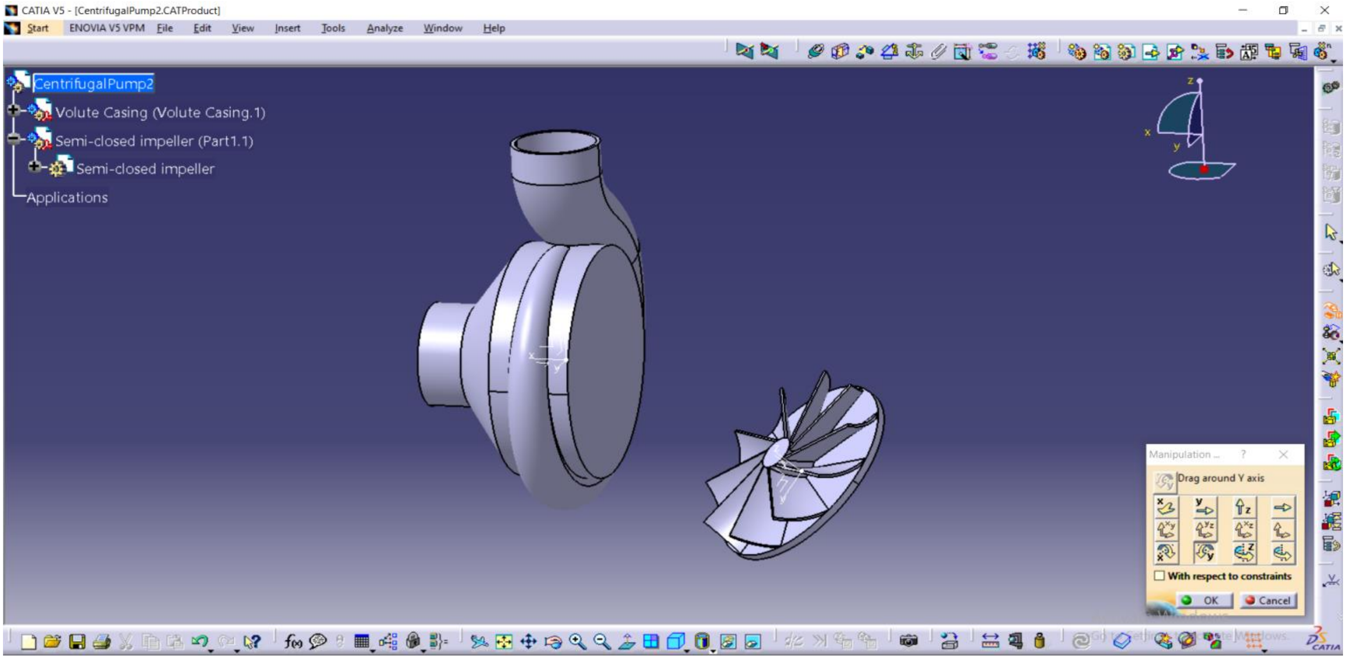
5) Modelling of Closed Impeller

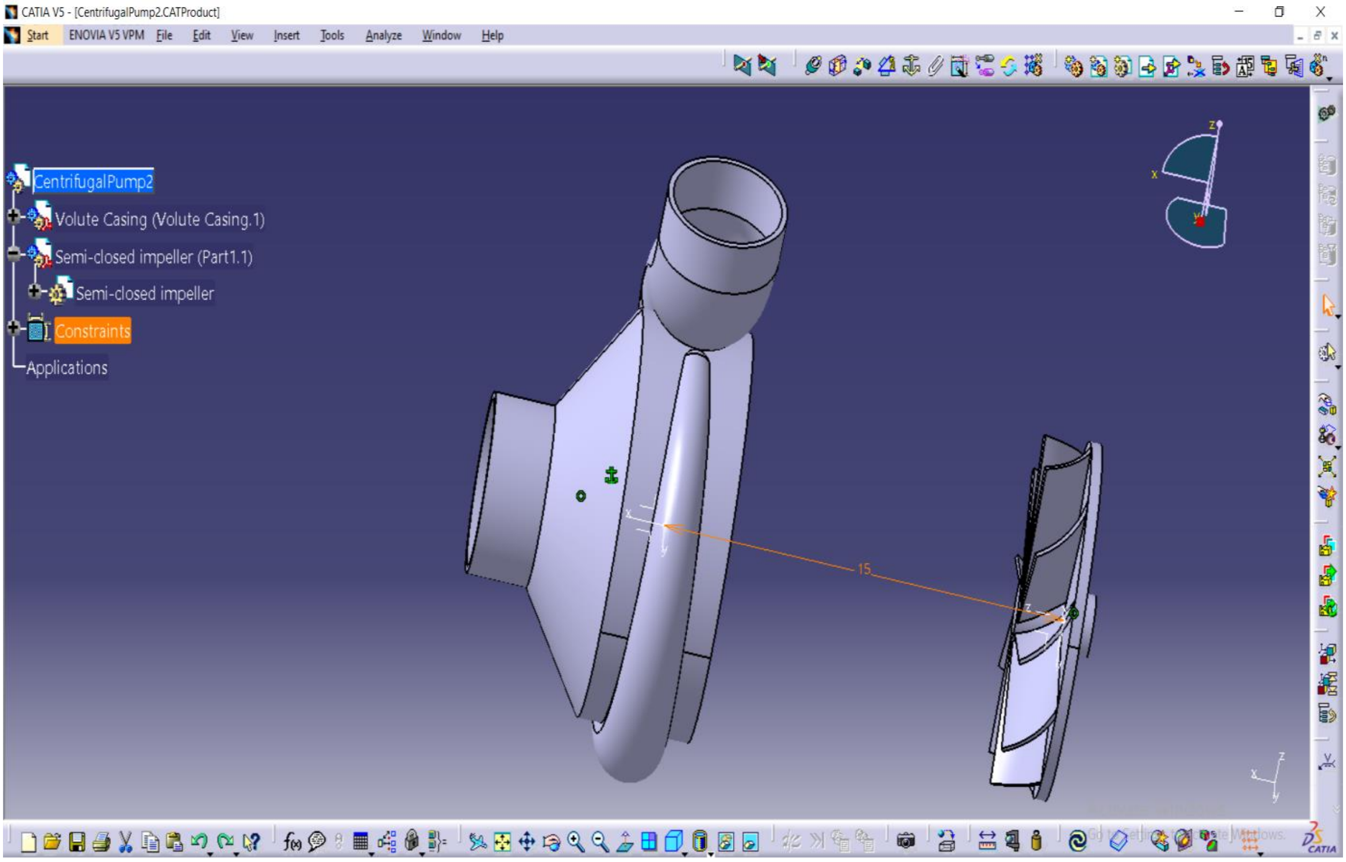




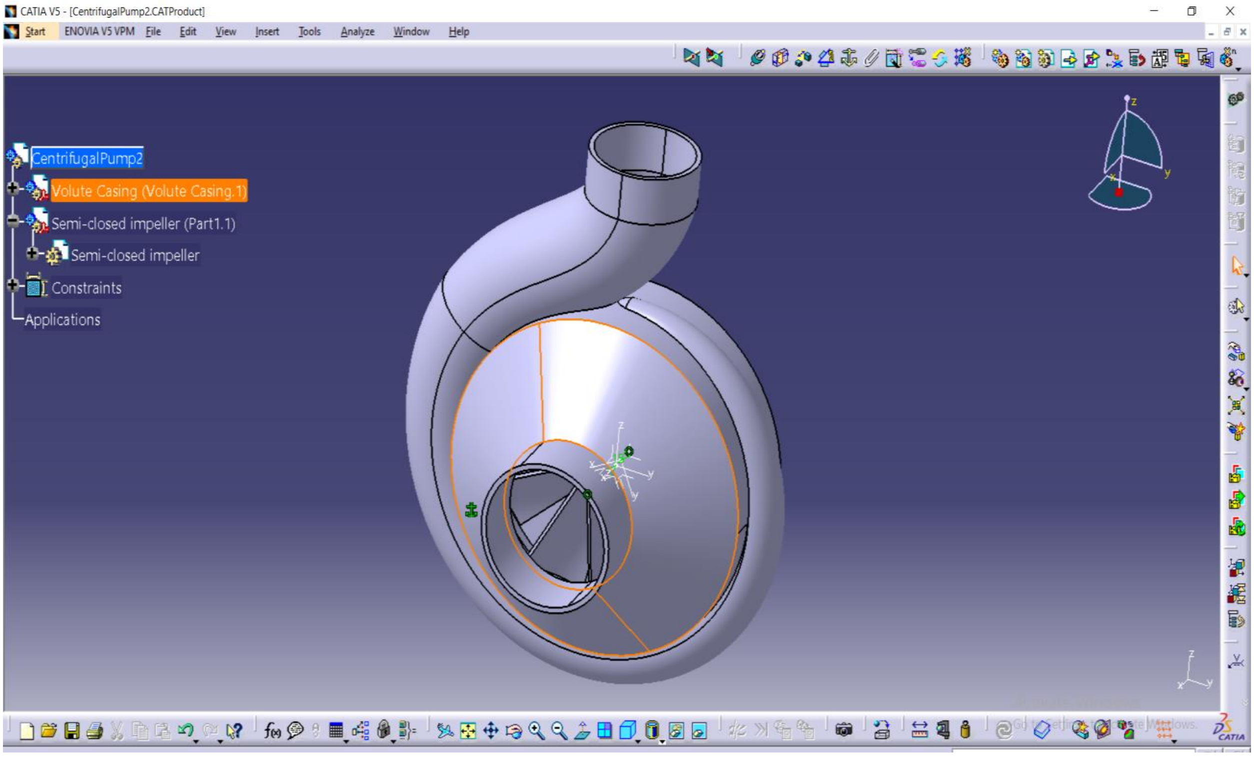
3.2.3 Assembly of impeller and volute casing:

1)Using coincidence and contact constraint we assemble the impellers and volute casing.

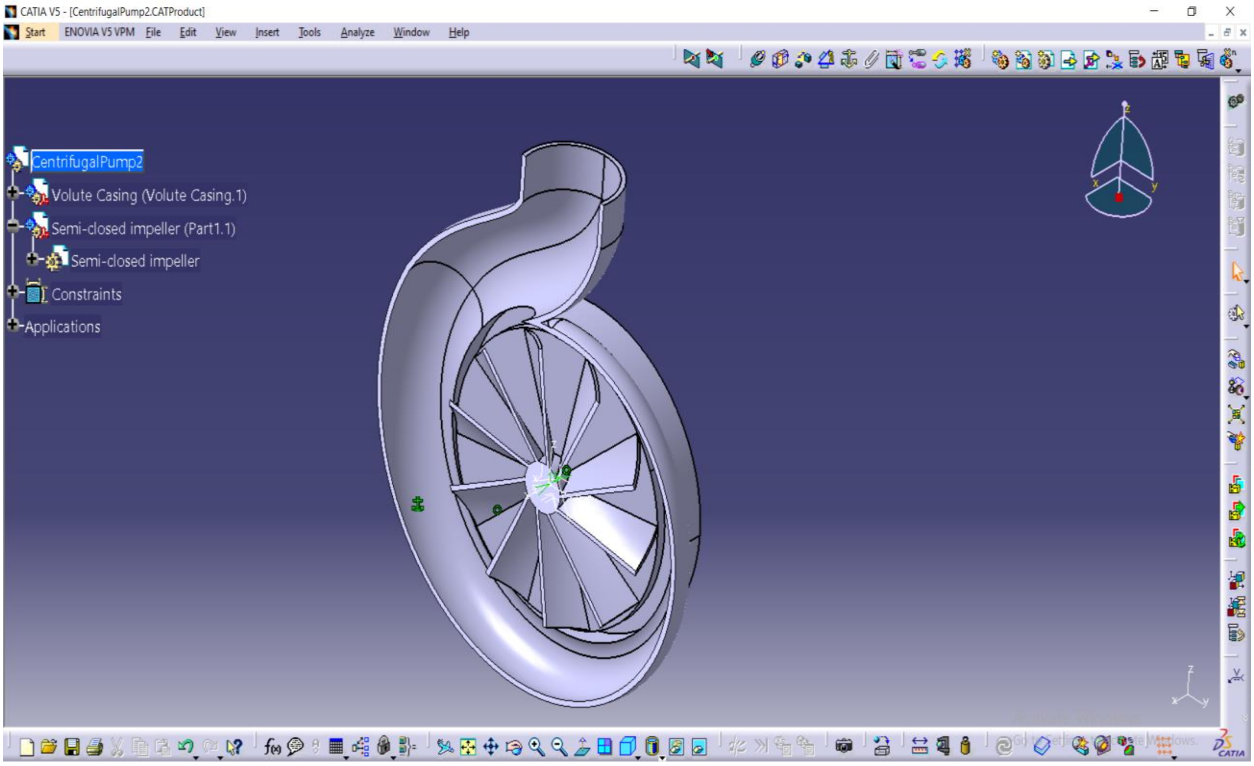




2) Now we get the final assembled part of centrifugal pump



3) Cut Sectional view



CHAPTER-4

ANALYSIS

Analysis is essentially a decision-making process in which analytical tools derived from basic sciences, mathematics, statistics, and engineering fundamentals are utilized for the **purpose** of developing a product model that is convertible into an actual product.

After design to analyse the properties(material) of the model we use different Analysis methods such as Manual testing methods such as Tensile test, Hardness test, Compression test, Shear test etc for understanding the mechanical properties of the material. On the other hand due to inaccurate results of these manual methods many computer aided analysis tools are emerged to give accurate results. This type of analysis decreases lead time, superior and efficient designs and reduced manufacturing costs.

Simulation is a very helpful and valuable work tool in manufacturing. It can be used in industrial field allowing the system's behaviour to be learnt and tested. Simulation provides a low cost, secure and fast analysis tool. It also provides benefits, which can be reached with many different system configurations.

Simulation software allows us to quantitatively evaluate the impact of today's choices on future developments. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist.There are Different types of Simulation software's used for delivering solutions:

1. Any Logic.
2. MATLAB.
3. SimScale
4. Ansys
5. COMSOL Multiphysics
6. Simulink 7.Arena.

ANSYS can import all kinds of CAD geometries (3D and 2D) from different CAD ***software's*** and perform simulations, and also it has the capability of creating user friendly criteria. Using the Ansys simulation system can offer a number of significant advantages when designing tools. In essence, the software provides solutions to various engineering challenges with the help of the theory of finite elements in structural calculations.

It also recognizes that the analysis power required by different companies and amount of funding for analysis software varies. Therefore, they have created a suite of software varies. Therefore, they have created a suite of software that spans the need as well as the price points. Ansys is one of the engineering simulation and 3D design software delivers product modelling solutions with unmatched scalability and a comprehensive Multiphysics software solution and offers a dynamic environment with a complete range of analysis tools, from preparing geometry for analysis to connecting additional physics for even greater fidelity.

. The different Ansys products are:

1. Ansys Blade Modeler
2. Ansys CFD Enterprise
3. Ansys CFD Premium
4. Ansys Aqua
5. Ansys Autodynamic
6. Ansys Design Space
7. Ansys Work Bench
8. Ansys Electronics Desktop
9. Ansys HFSS
10. Ansys Icepak etc….

4.1 CFD ANALYSIS INTRODUCTION:

Computational Fluid Dynamics (CFD) is the analysis of fluid flows using numerical solution methods. Using CFD, you are able to analyze complex problems involving fluid-fluid, fluid-solid or fluid-gas interaction. Engineering fields where CFD analyses are frequently used are for example aerodynamics and hydrodynamics, where quantities such as lift and drag or field properties as pressures and velocities are obtained. Fluid dynamics is involved with physical laws in the form of partial differential equations.

CFD analyses have a great potential to save time in the design process and are therefore cheaper and faster compared to conventional testing for data acquisition. Furthermore, in real life tests a limited amount of quantities is measured at a time, while in a CFD analysis all desired quantities can be measured at once, and with a high resolution in space and time.

CFD technique is used for the flow rate and pressure rate analysis of the centrifugal pump impeller through the ANSYS analysis software for which the 3-D model of the centrifugal impeller was made in the SOLID WORKS modeling software and then the impeller model made was converted into IGES format so that it can be supported by the ANSYS software and then model is opened in ANSYS fluid dynamics.

4.2 Materials Selection:

4.2.1 Cast Iron properties:

The impeller material is made up of cast iron material. Cast iron is having many properties of which some of them are given in the below table.

Properties	**Gray Cast iron**	**Ductile Cast iron**
Tensile strength(Mpa)	**250**	**750**
Young's Modulus(Gpa)	**105**	**160**
Fatigue Resistance(Mpa)	**110**	**250**
Hardness(HB)	**179-202**	**217-255**

TABLE 1: CAST IRON PROPERTIES

4.2.2. Water Properties: Water is taken as the fluid medium inside the centrifugal pump. The properties of water are discussed below:

Properties of Water	Values
Viscosity	0.001003(kg/m.s)
Specific heat capacity	4182(J/Kg K)
Density	997(Kg/m^3)
Thermal Conductivity	0.6069(W/m K)

TABLE 2: WATER PROPERTIES

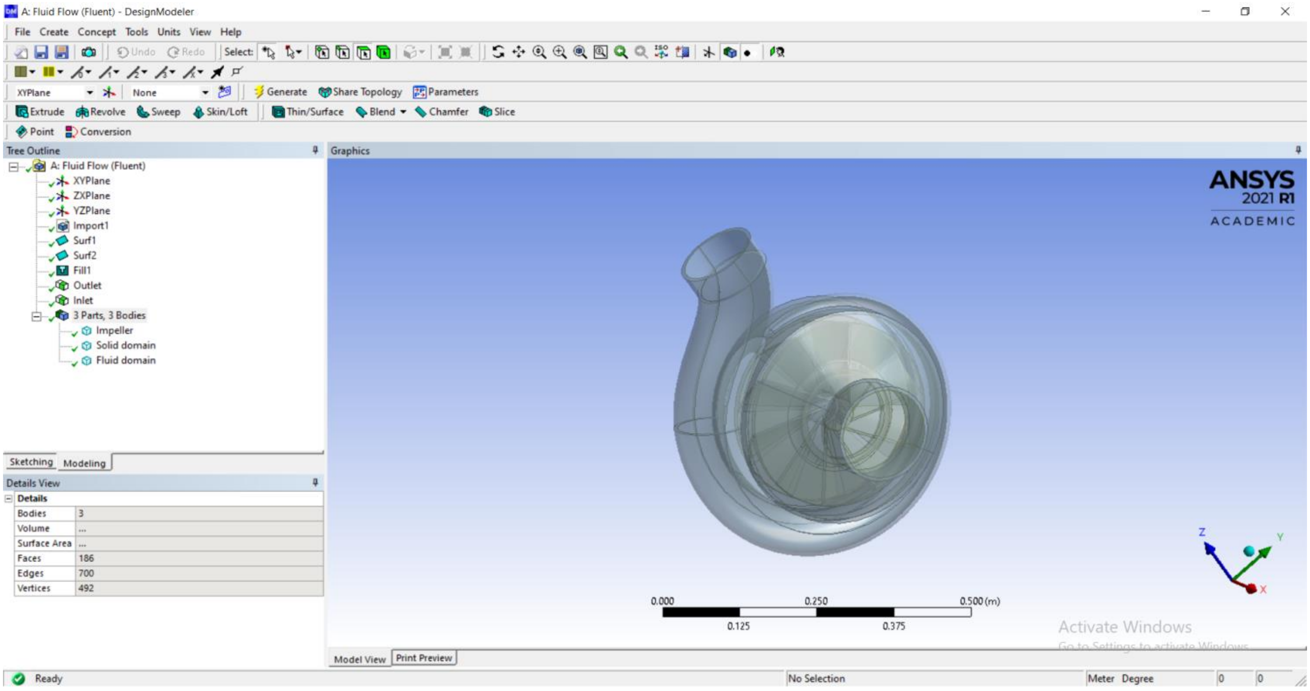
4.2.3 Design specifications of Impeller:

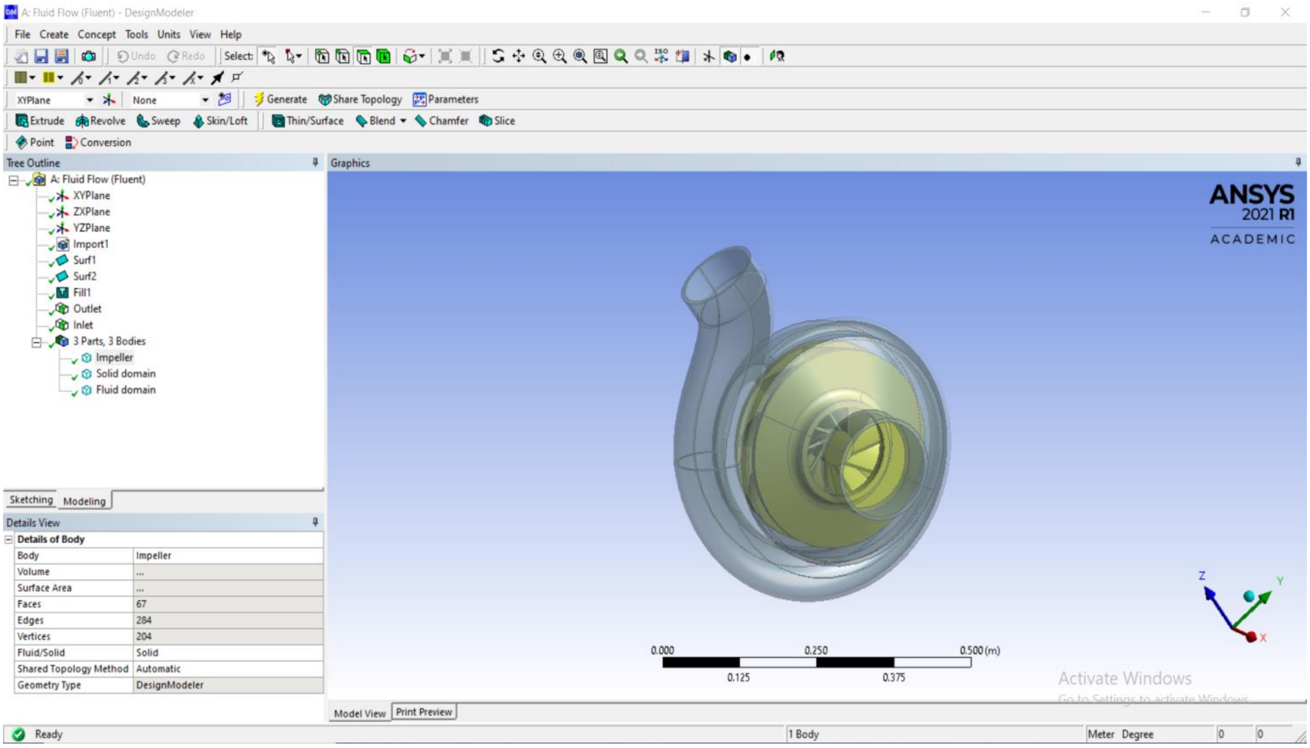
Input Parameter	Values
Rotational Speed	1250,1350,1440RPM
Inlet velocity	2,4,6(m/sec)
Pump Head	24m
Inlet Blade angle	20 degrees
Exit Blade angle	24 degrees
No. of .Vanes	9,10,11

TABLE 3: DESIGN SPECIFICATIONS OF IMPELLER

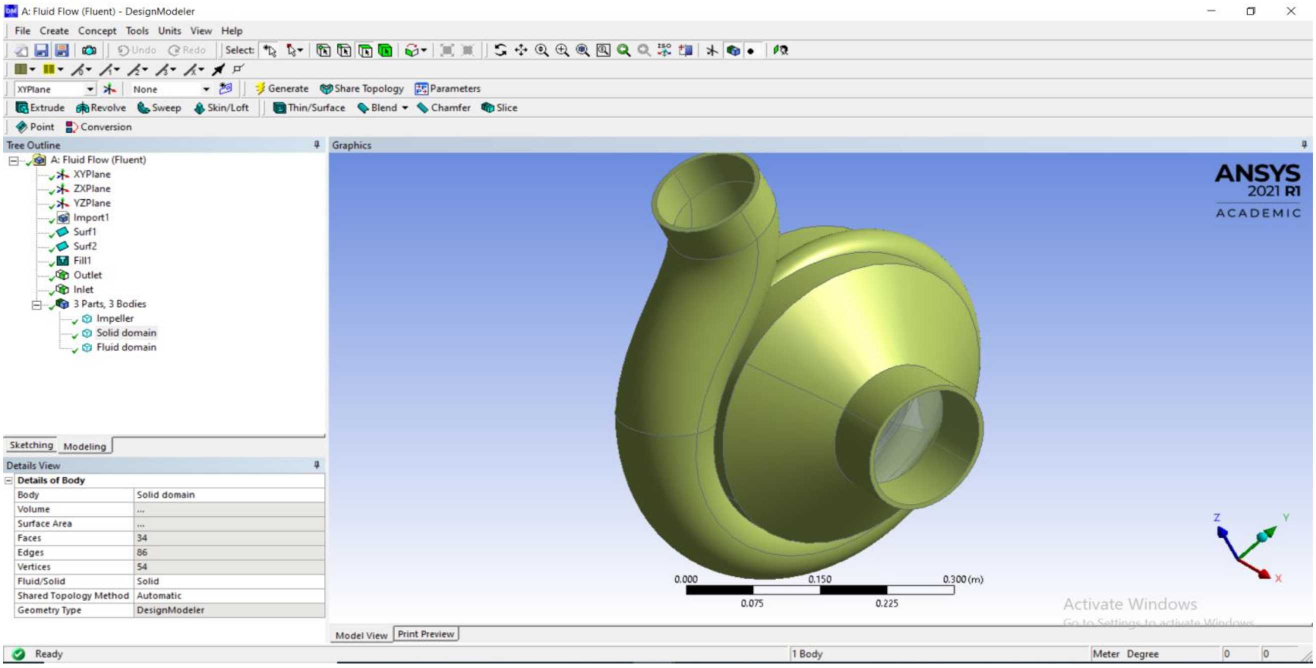
4.3 CFD ANALSIS STEP BY STEP PROCEDURE:

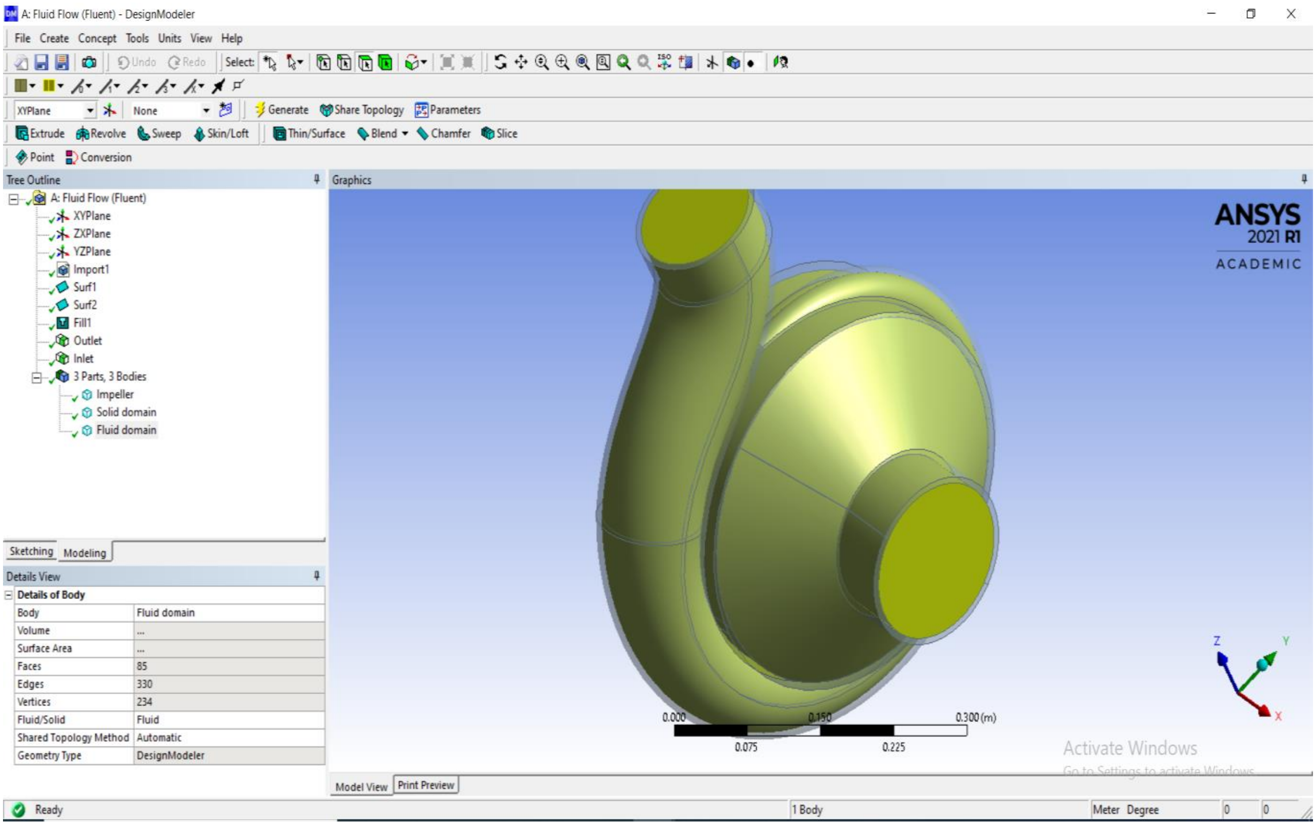
1) Importing the catia file into the ansys fluent software.



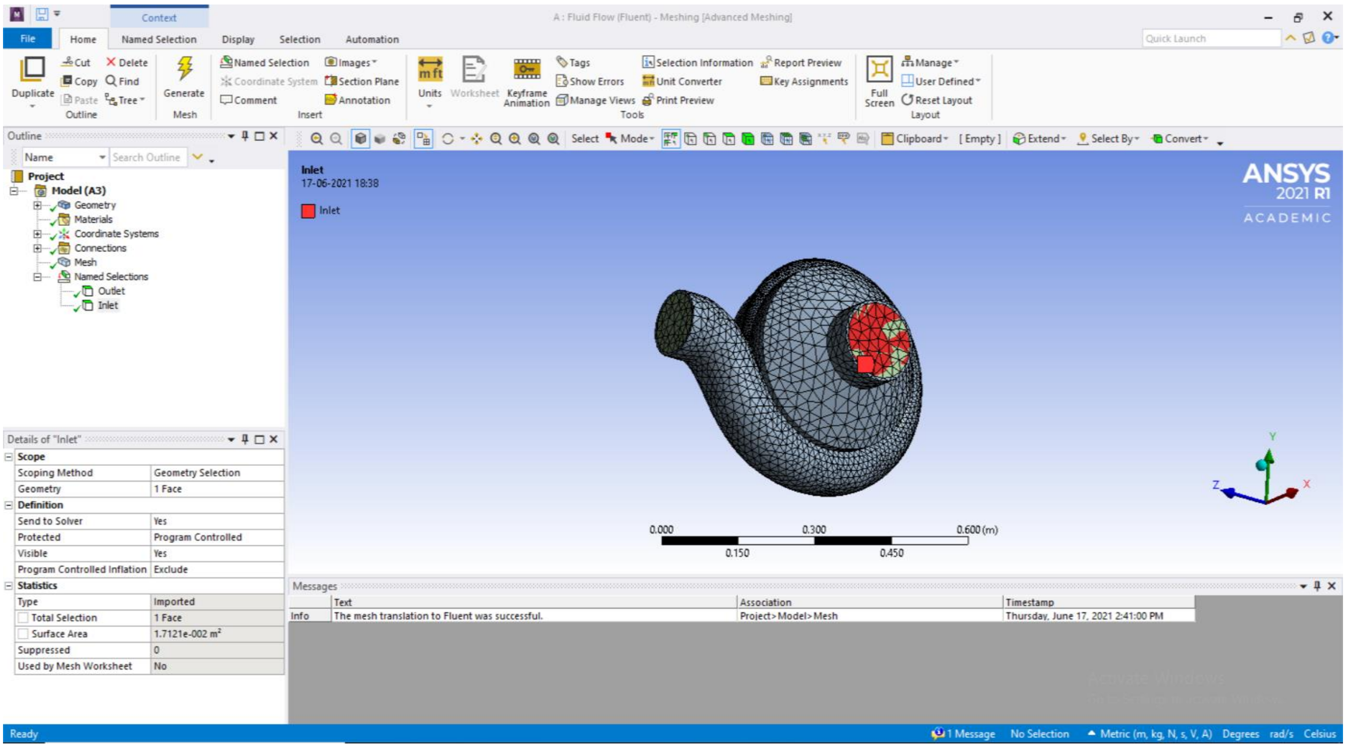


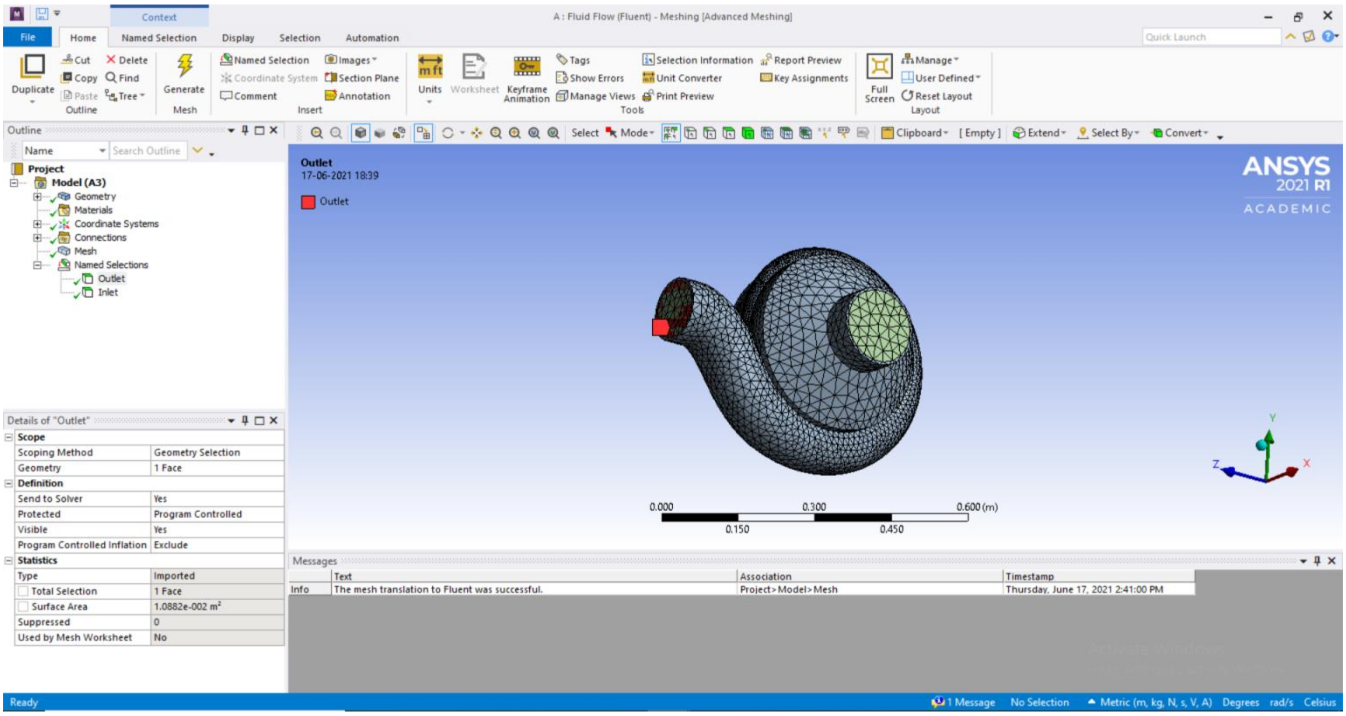
2) Creating solid domain for impeller and fluid domain for fluid flow along the impeller.



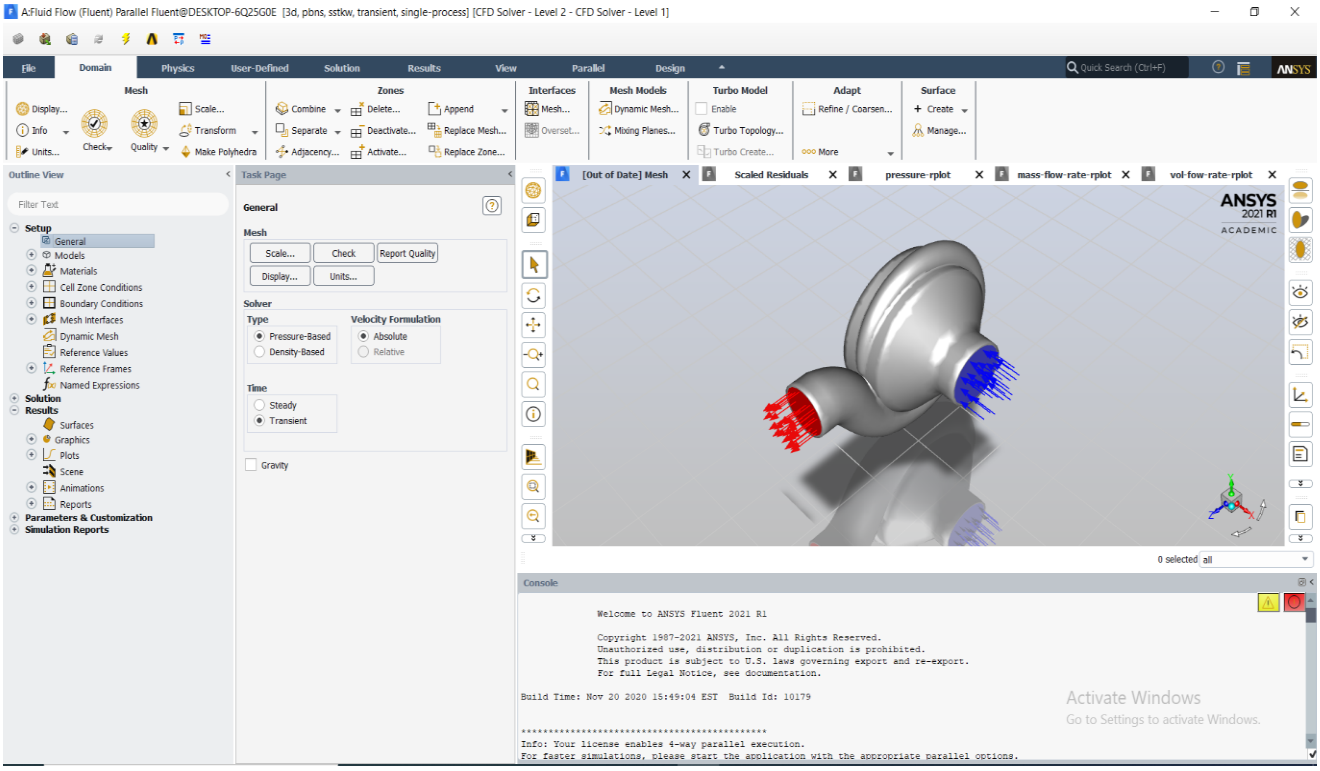


3) Generation of mesh: Creating a mesh in the imported geometry is an important step in Ansys analysis as the size of the finite element is decided by the mesh properties. Finer the mesh is, more accurate are the results.

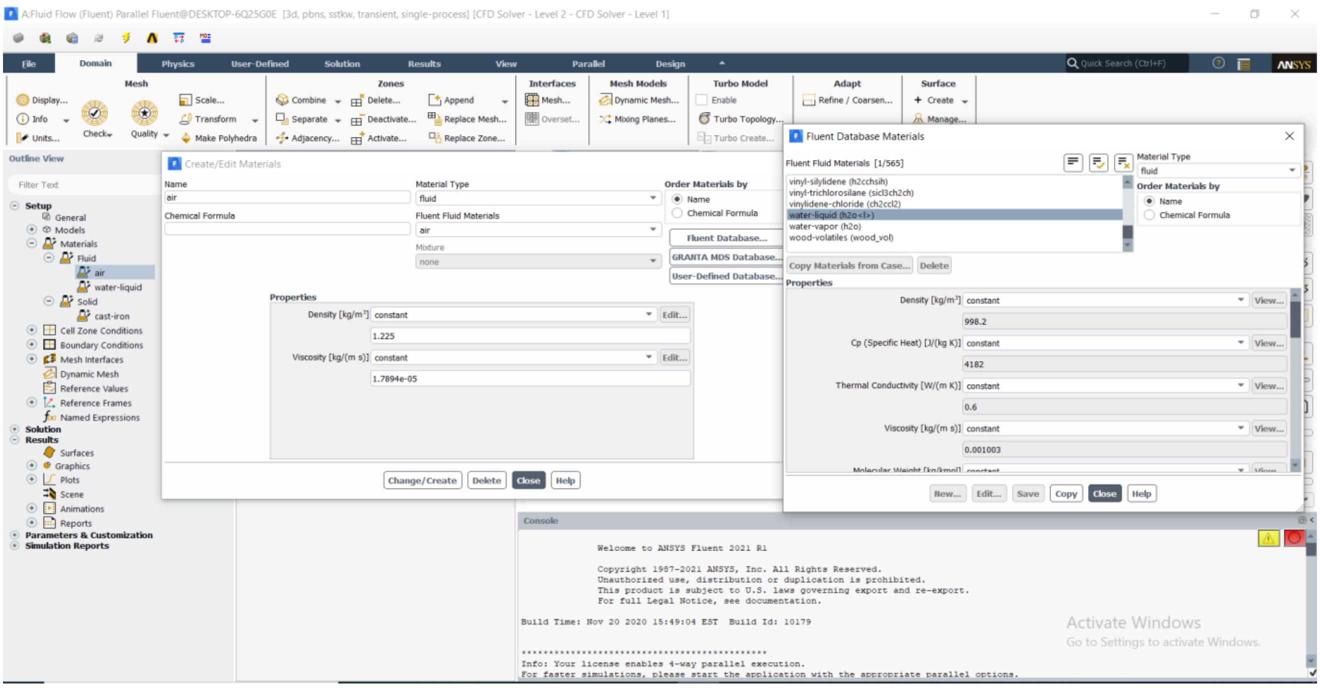




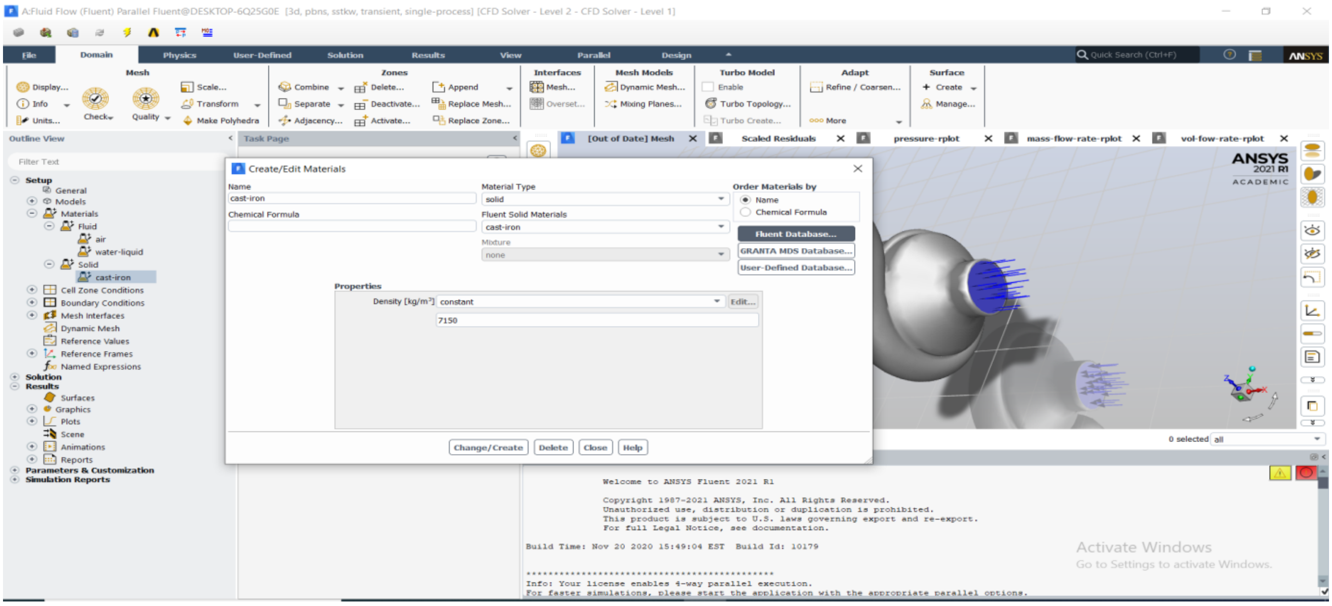
4) Now we go to set up ,and set up the analysis to pressure based and transient type.



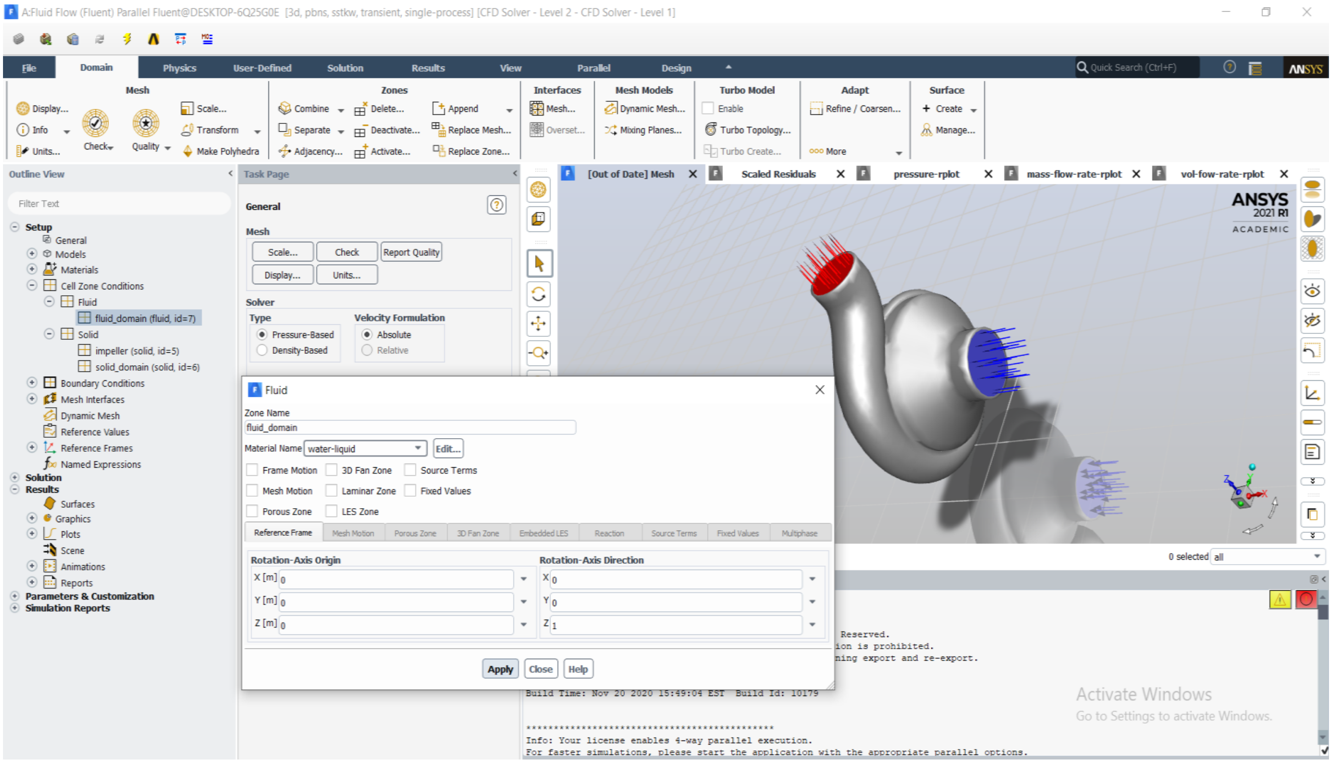
5)Now we go to materials and select the fluid as water and give the desired properties of water for fluid domain.



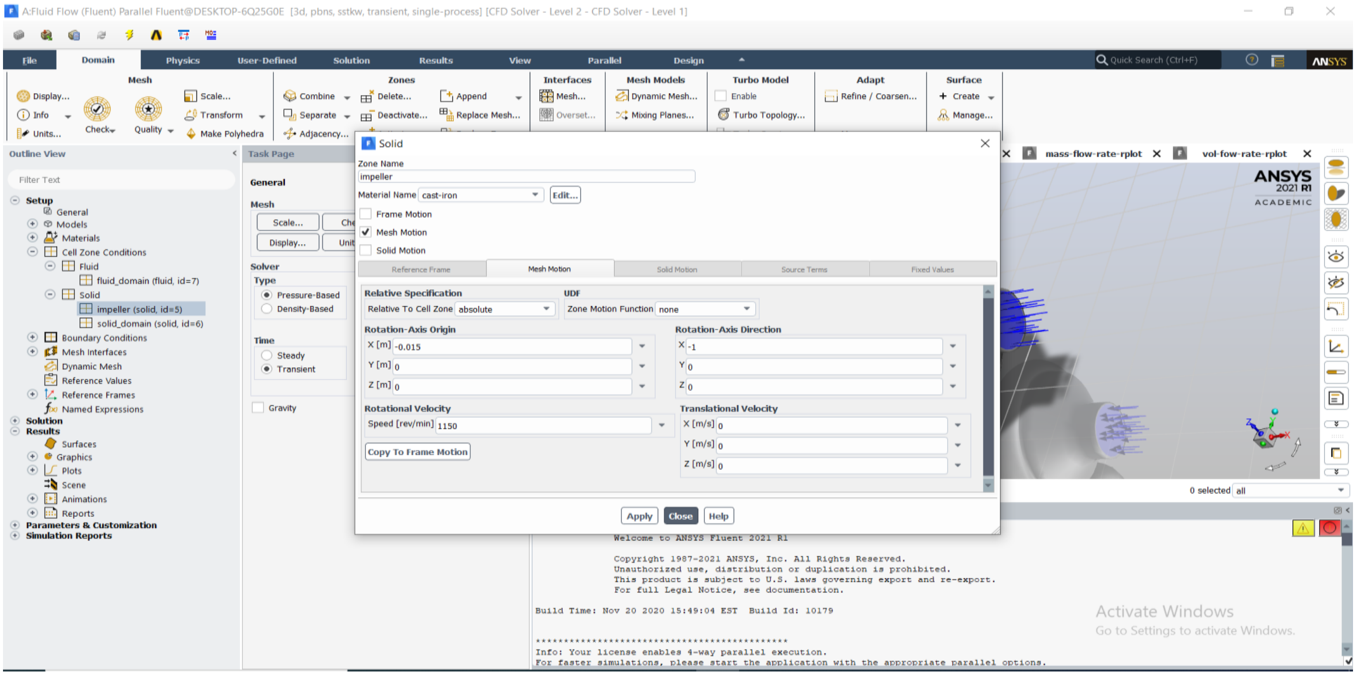
6) Now we go to materials and select the material cast iron for impeller and give the desired properties of cast iron for solid domain.



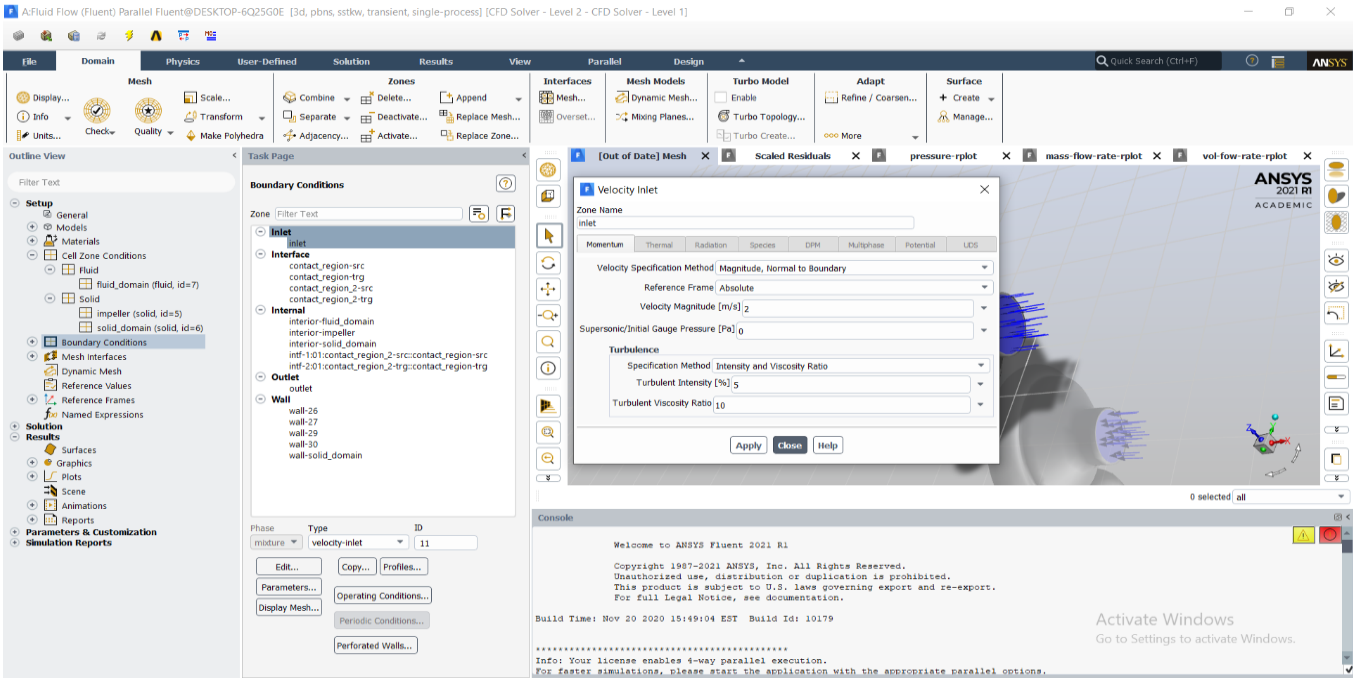
7)Now we change the rotation axiz to Z –axis ,1 indicates the impeller rotate in the anticlockwise direction.



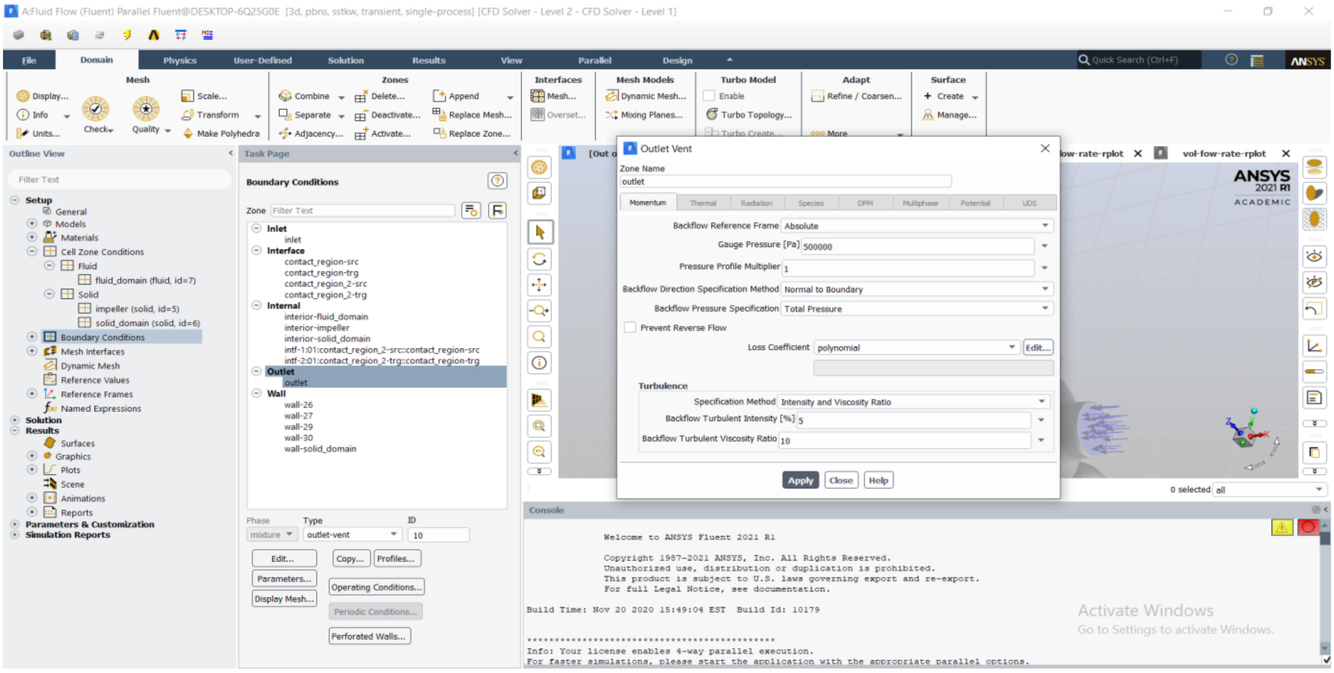
8)Now we give the roational speed of the impeller as 1250,1350 and 1440 RPM as input speeds.



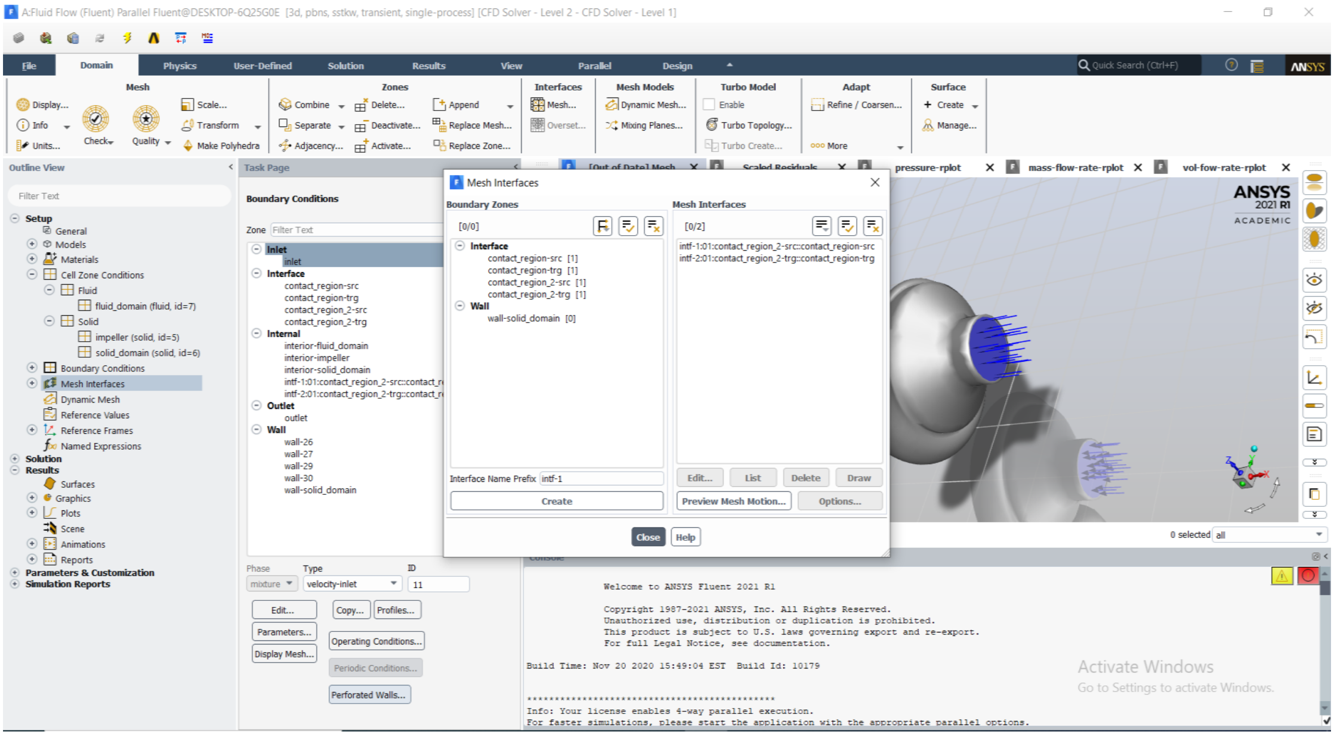
9) Now we go to boundary conditions and give the inlet mass flow rate as 2,4,6 m/sec.



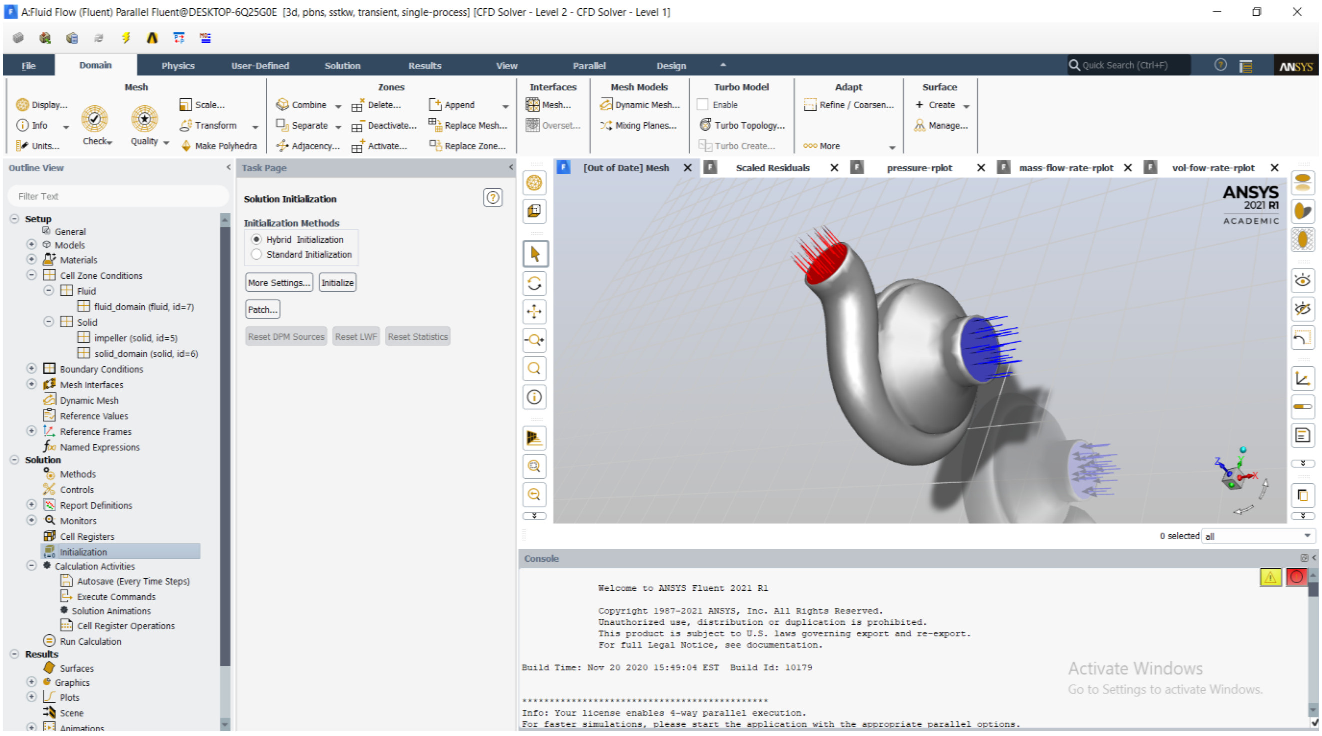
10)Now we go to boundary conditions and give the inlet pressure equal to atmospheric pressure.



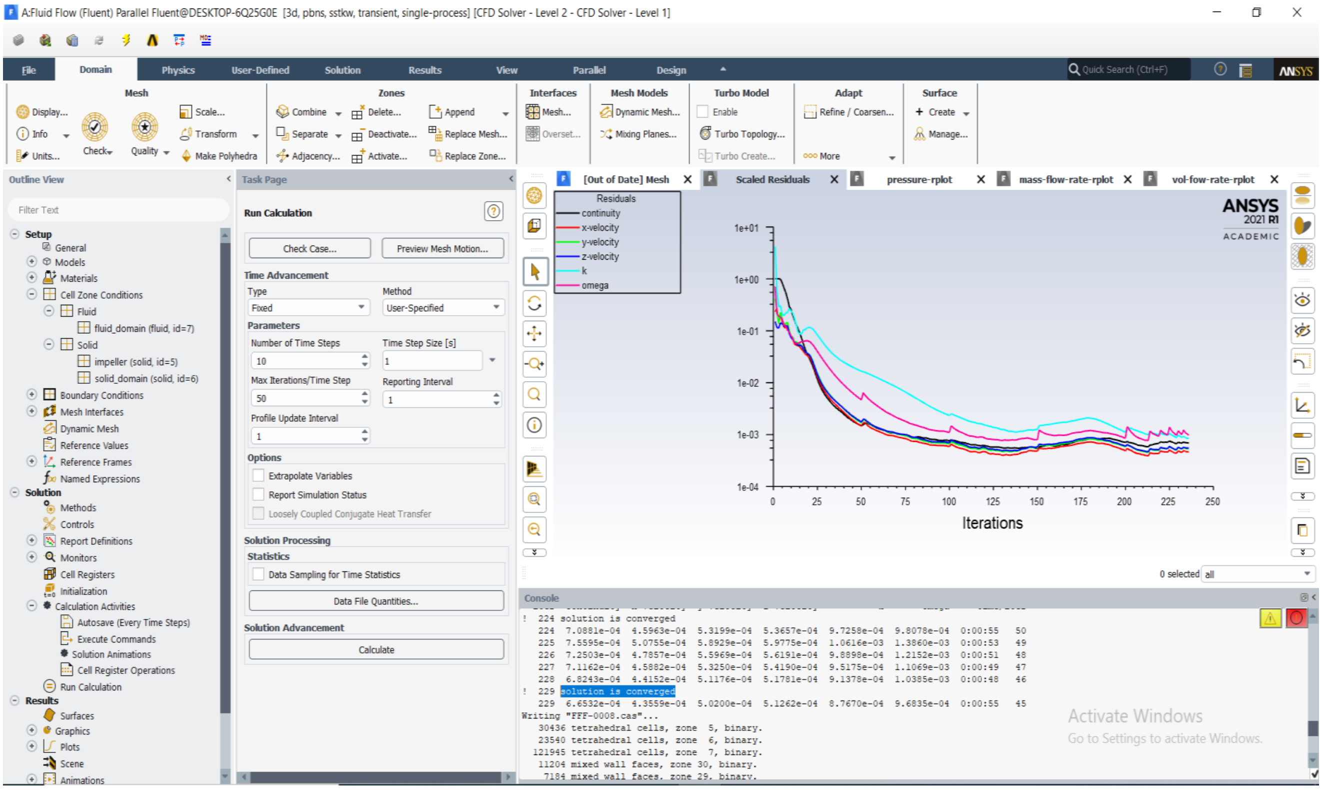
11)Now we create a mesh interface between solid and fluid domains.



12) Now we go to solution and start the hybrid initialization.



13)Now we go to run calculation and plot the convergence plot between residuals and iterations.



CHAPTER-5

RESULTS AND DISCUSSIONS

5.1) Pressure and velocity distribution of closed impeller of 9 impeller blades

5.1.1) Pressure distribution of closed impeller at 1250rpm

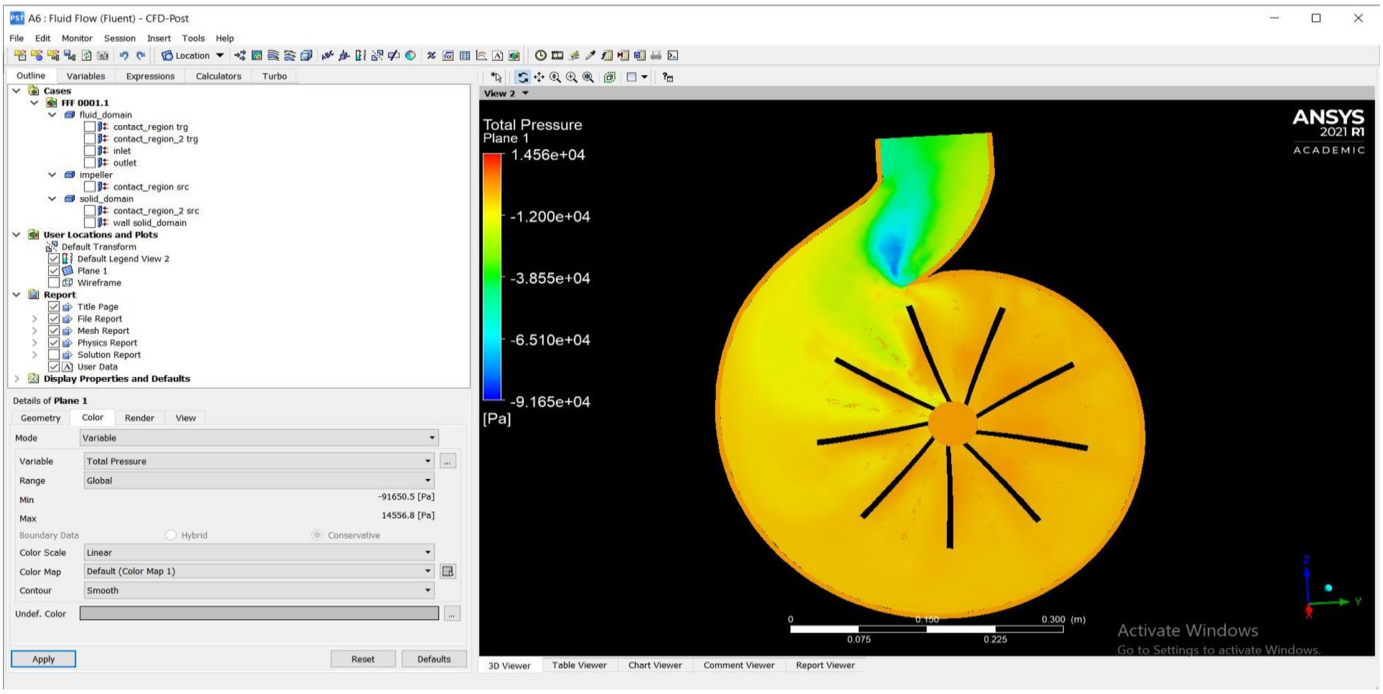


Fig. 10

5.1.2) Velocity distribution of closed impeller at 1250rpm

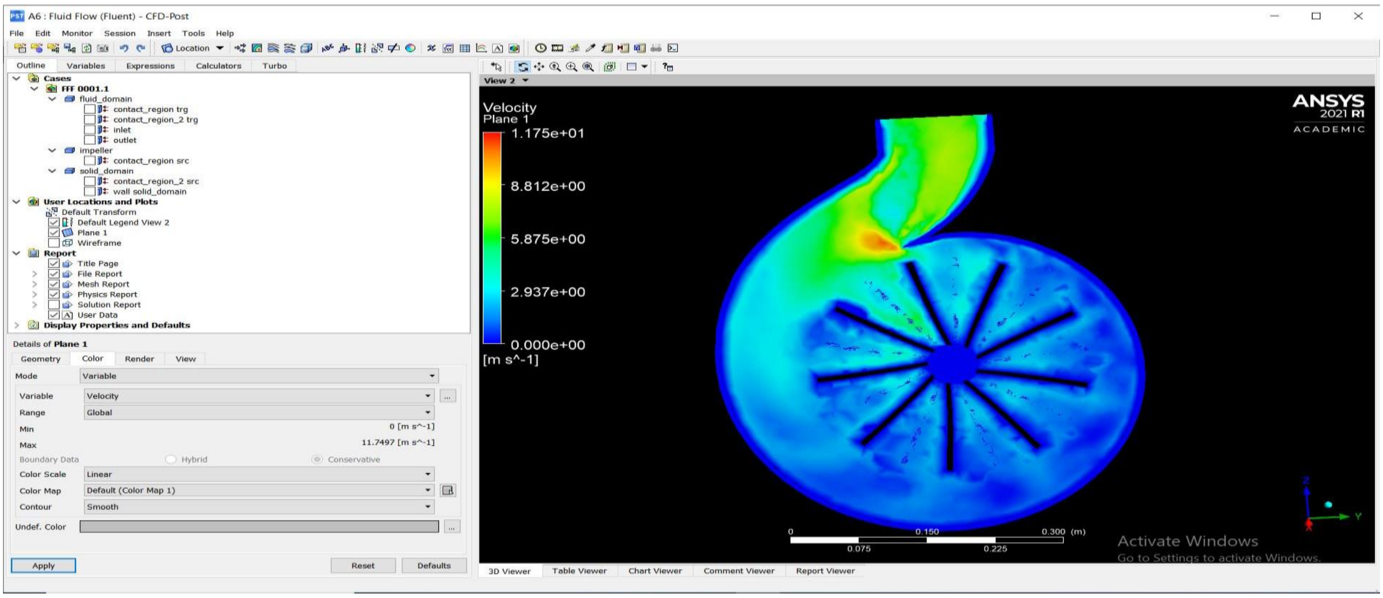


Fig. 11

5.1.3) Pressure distribution of closed impeller at 1350rpm

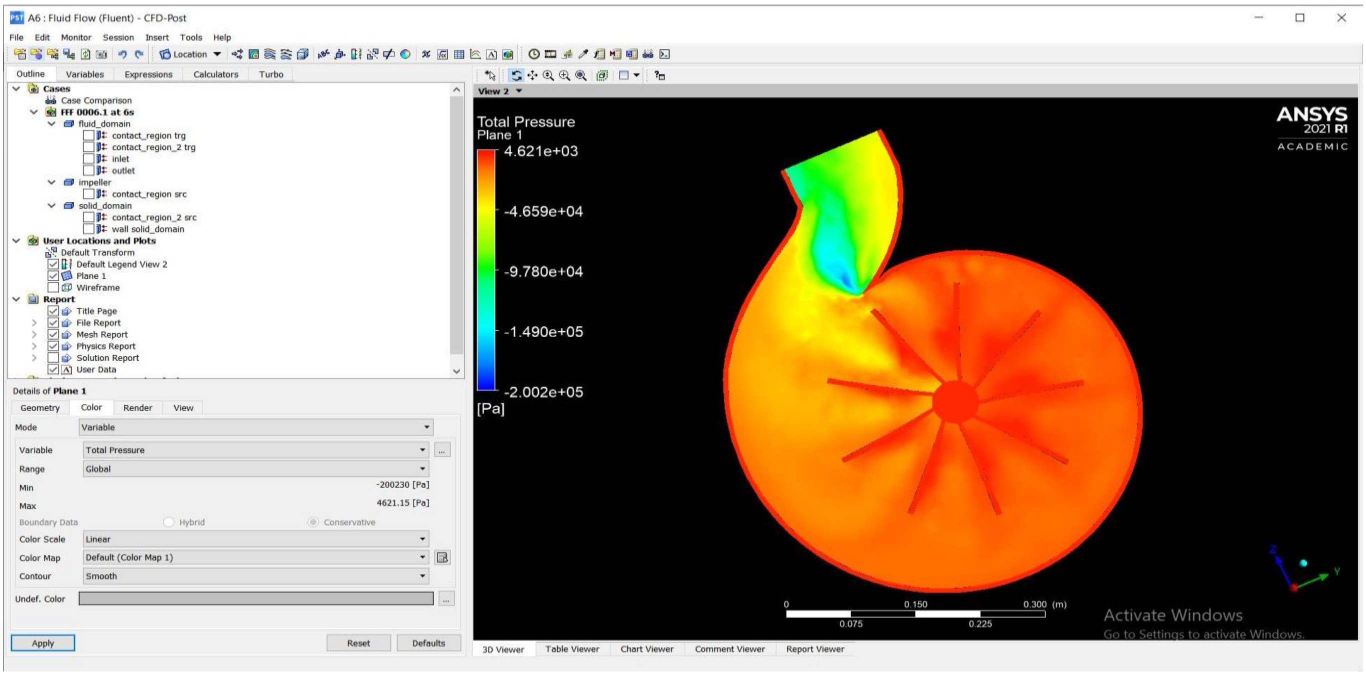


Fig .12

5.1.4) Velocity distribution of closed impeller at 1350rpm

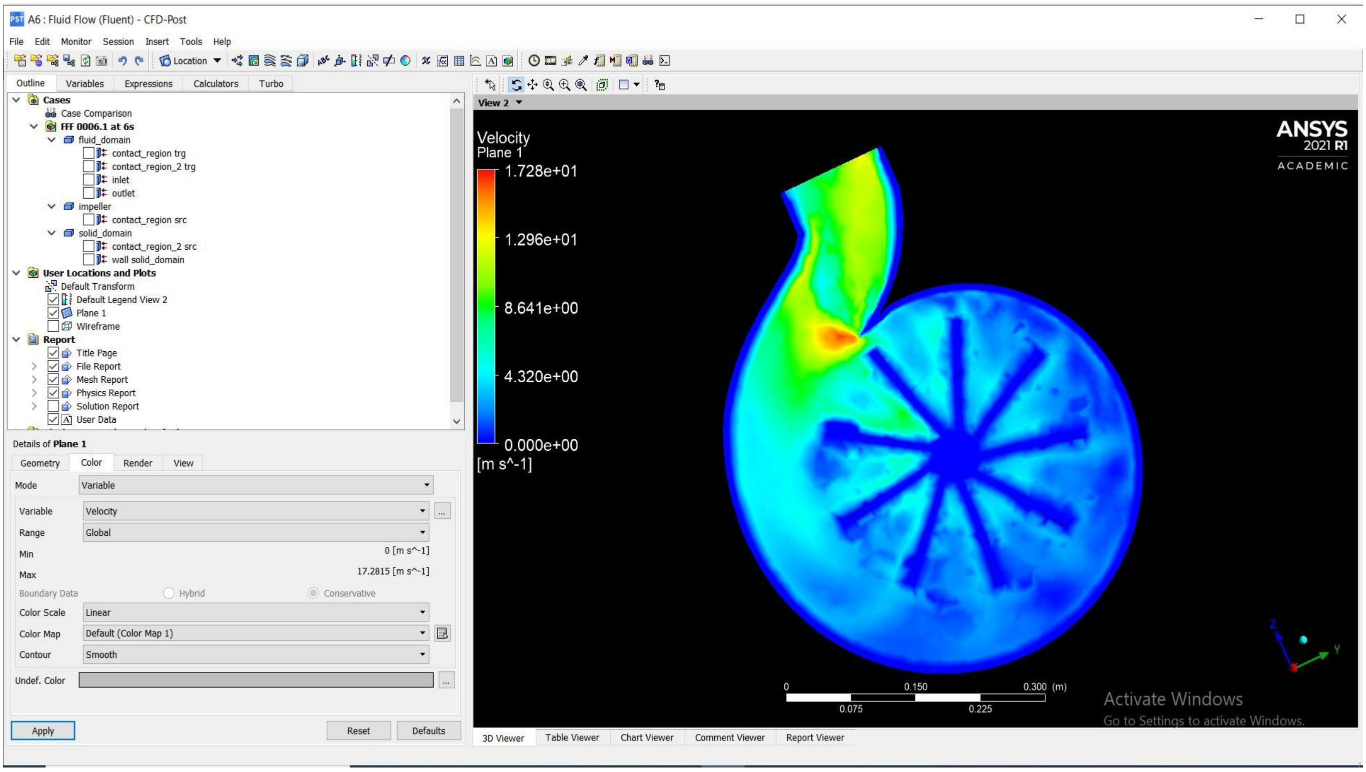


Fig .13

5.1.5) Pressure distribution of closed impeller at 1440rpm

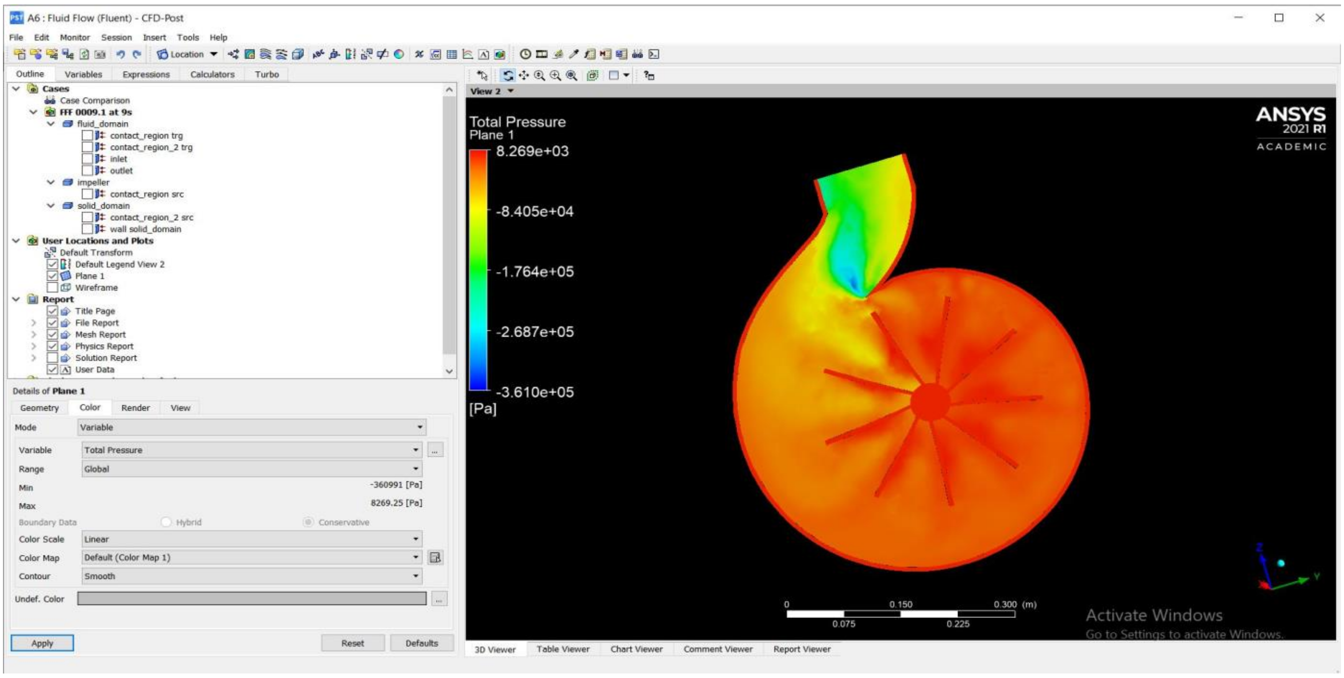


Fig .14

5.1.6) Velocity distribution of closed impeller at 1440rpm

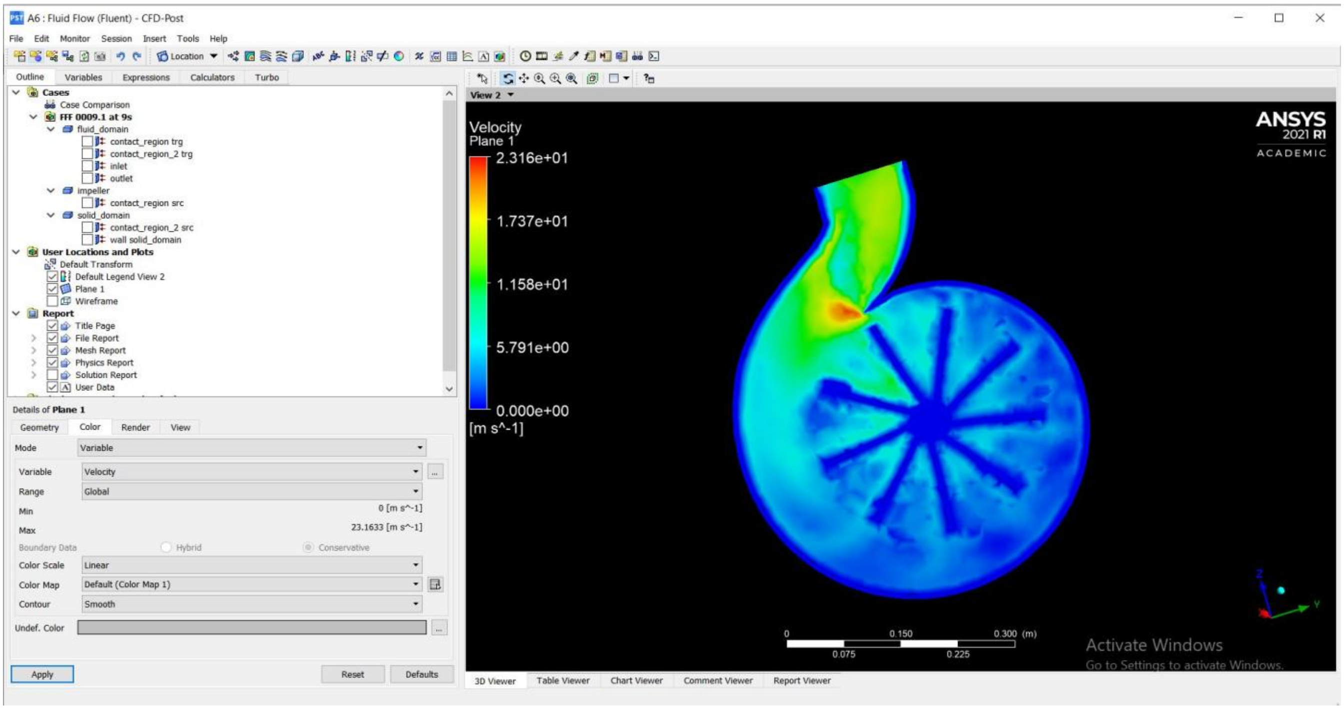


Fig.15

5.2) Pressure and velocity distribution of closed impeller of 10 impeller blades

5.2.1) Pressure distribution of closed impeller at 1250rpm

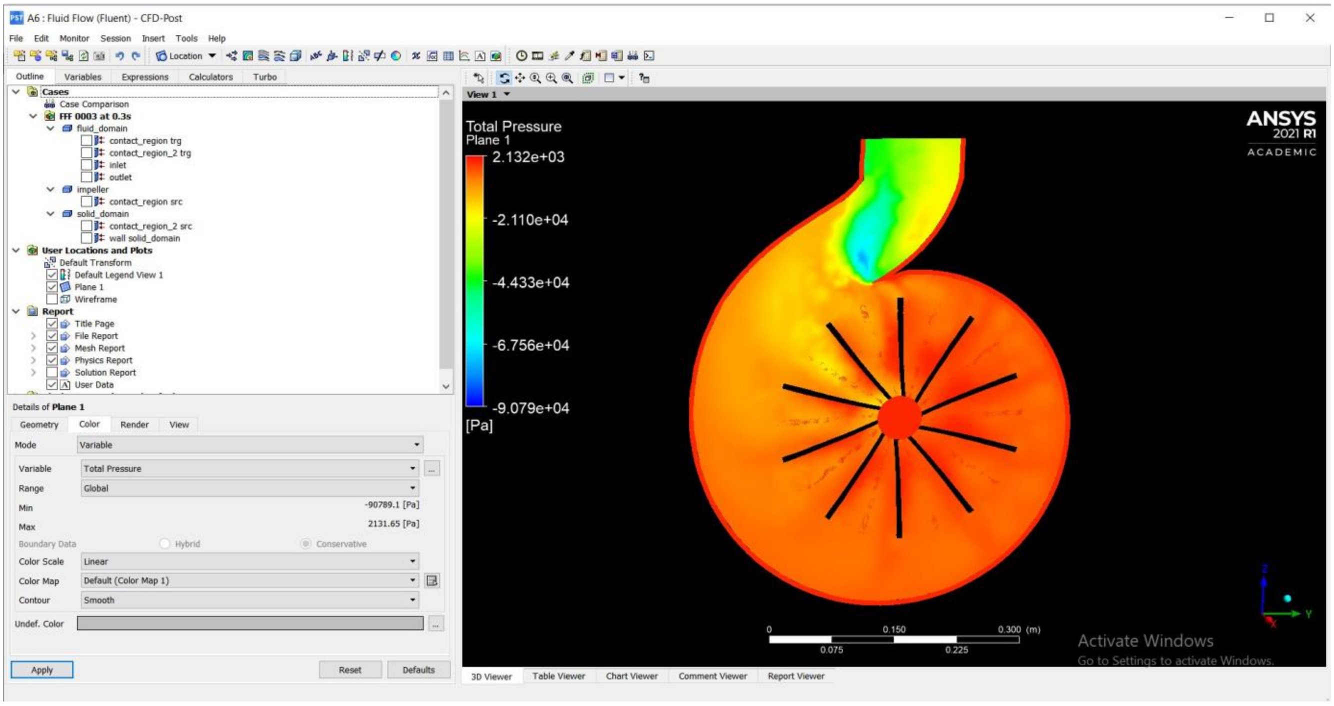


Fig .16

5.2.2) Velocity distribution of closed impeller at 1250rpm

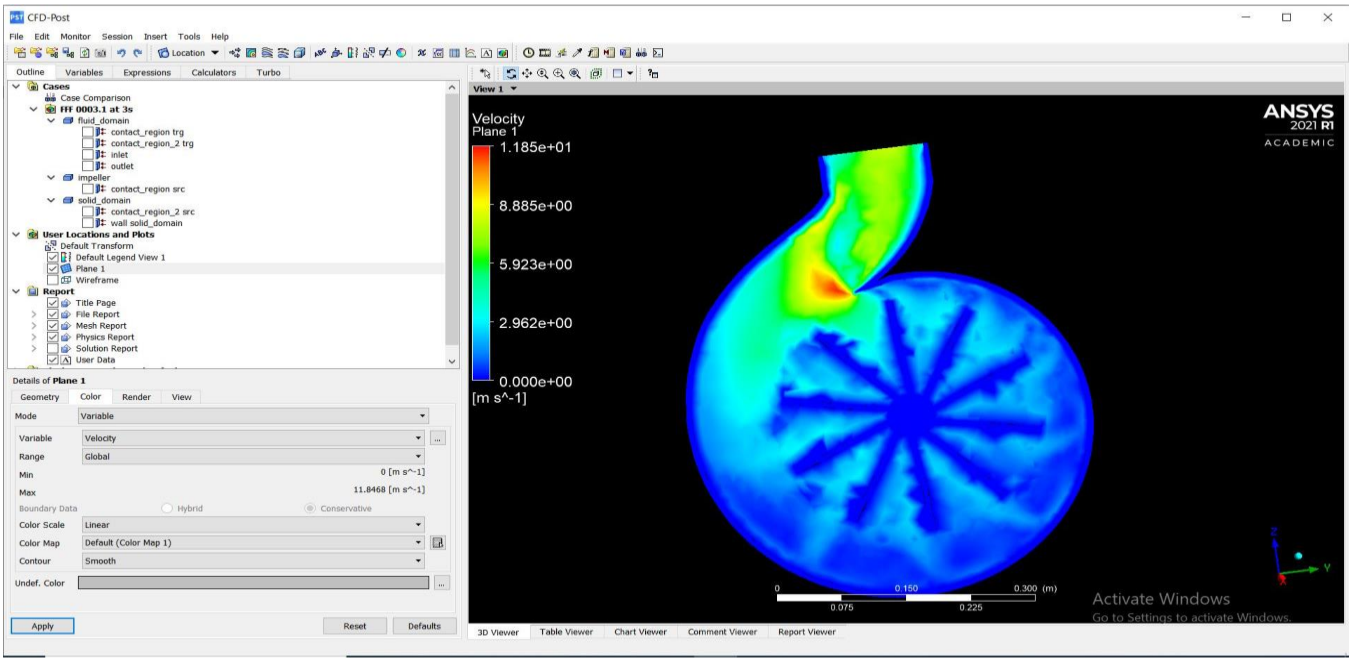


Fig.17

5.2.3) Pressure distribution of closed impeller at 1350rpm

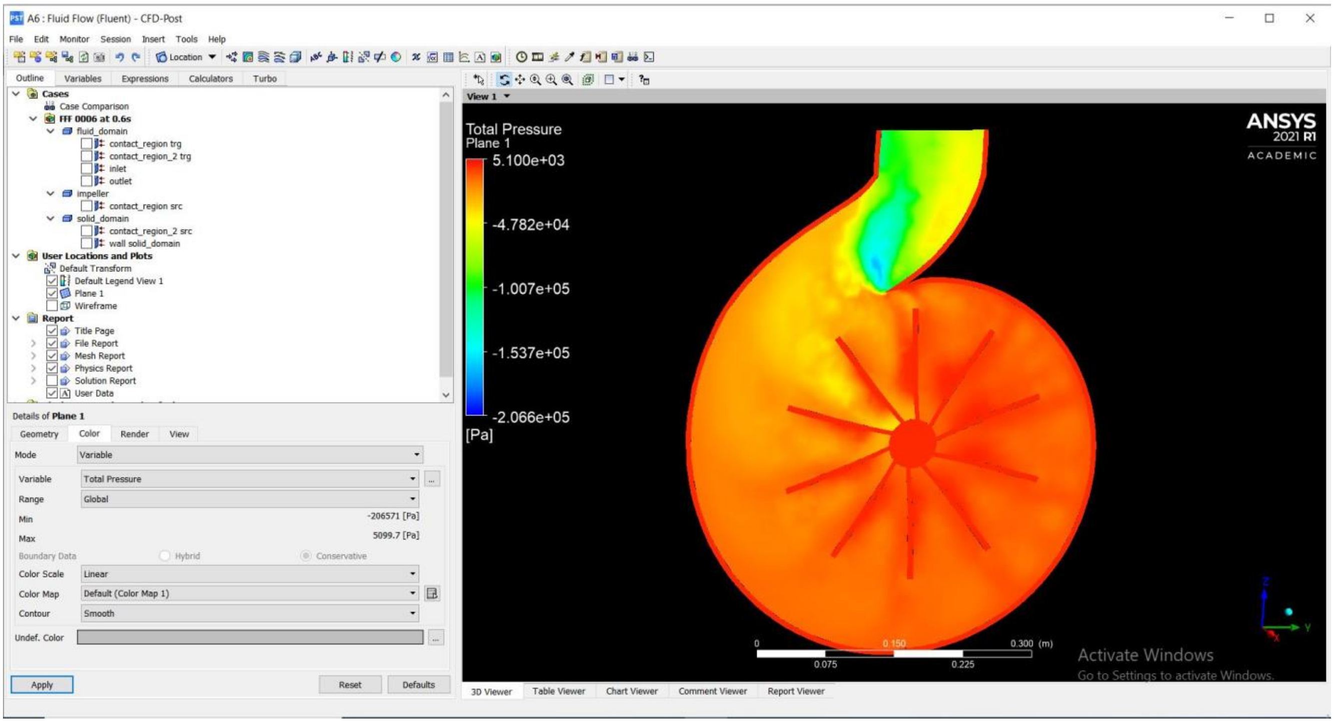


Fig .18

5.2.4) Velocity distribution of closed impeller at 1350rpm

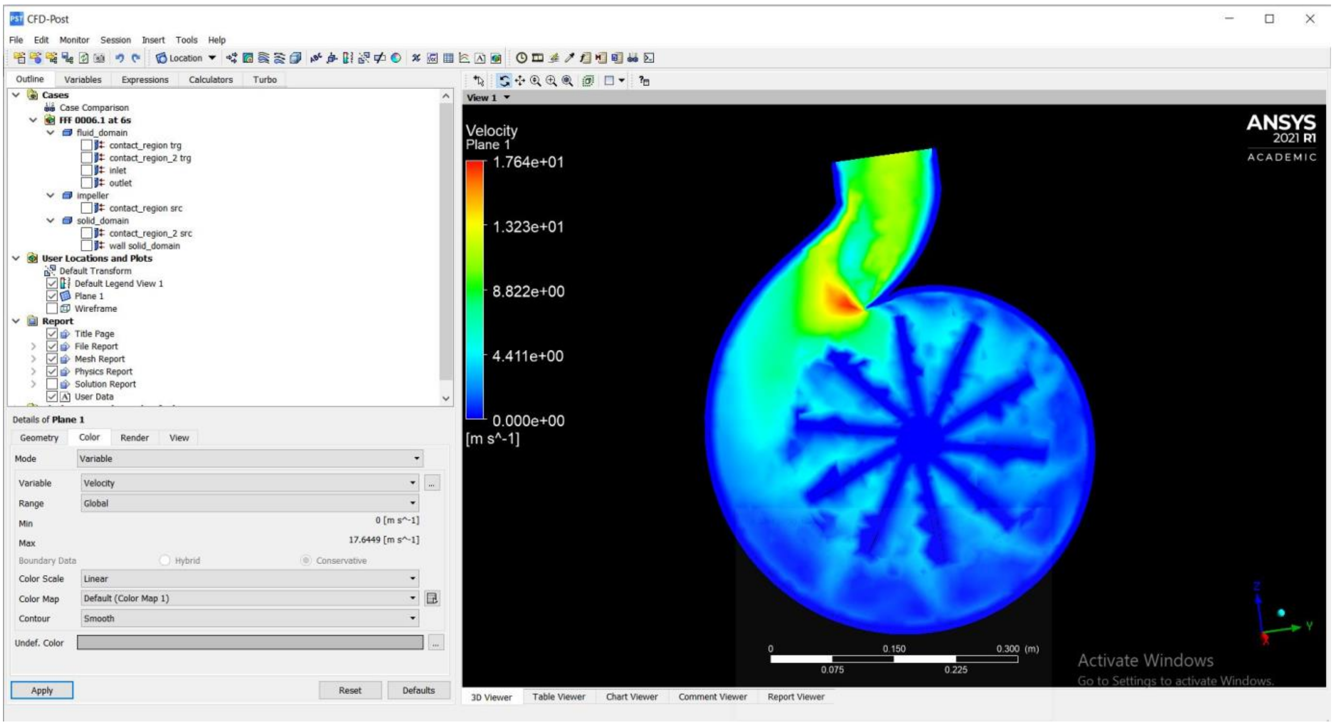


Fig.19

5.2.5) Pressure distribution of closed impeller at 1440rpm

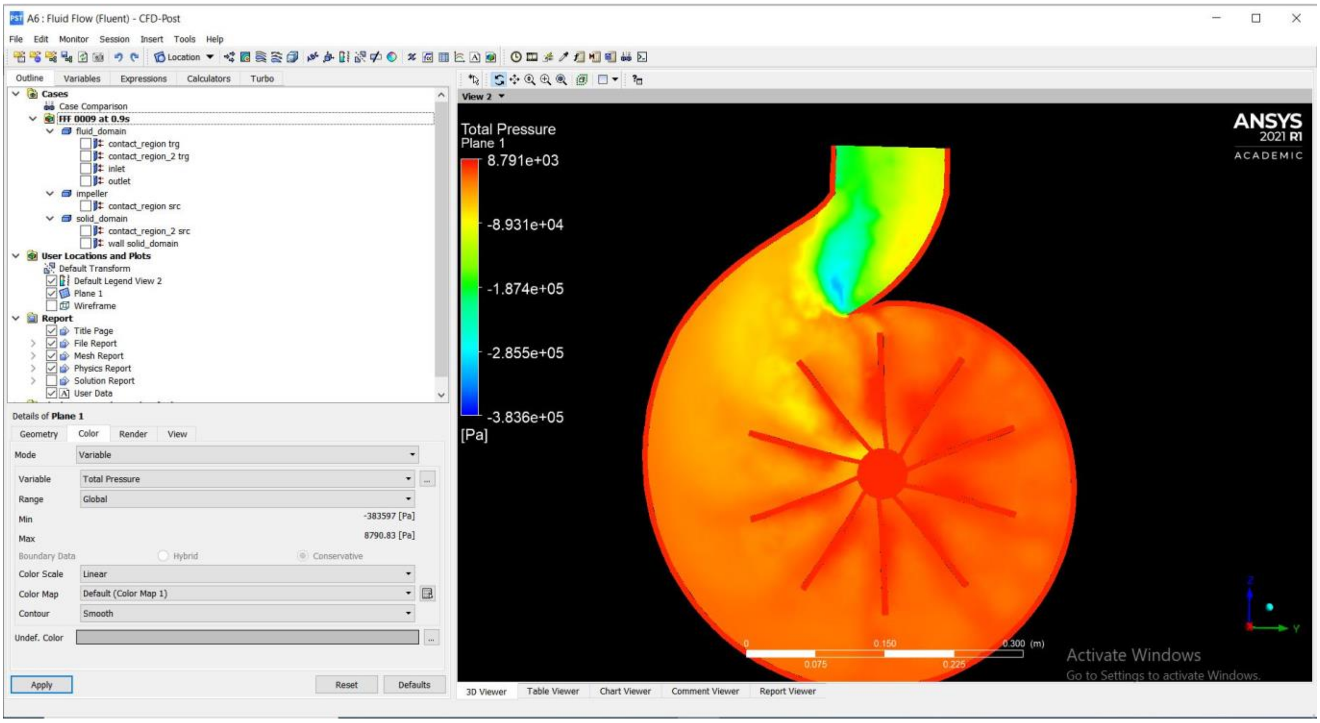


Fig.20

5.2.6) Velocity distribution of closed impeller at 1440rpm

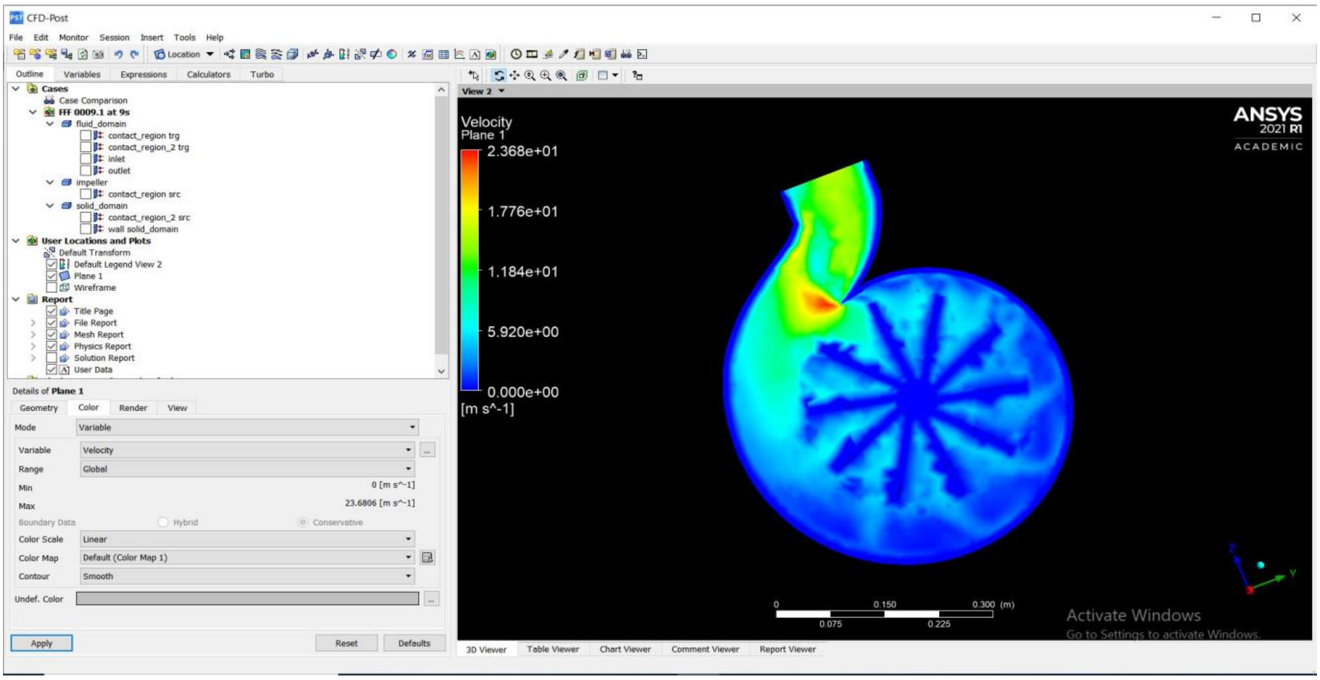


Fig.21

5.3) Pressure and velocity distribution of closed impeller of 11 impeller blades

5.3.1) Pressure distribution of closed impeller at 1250rpm

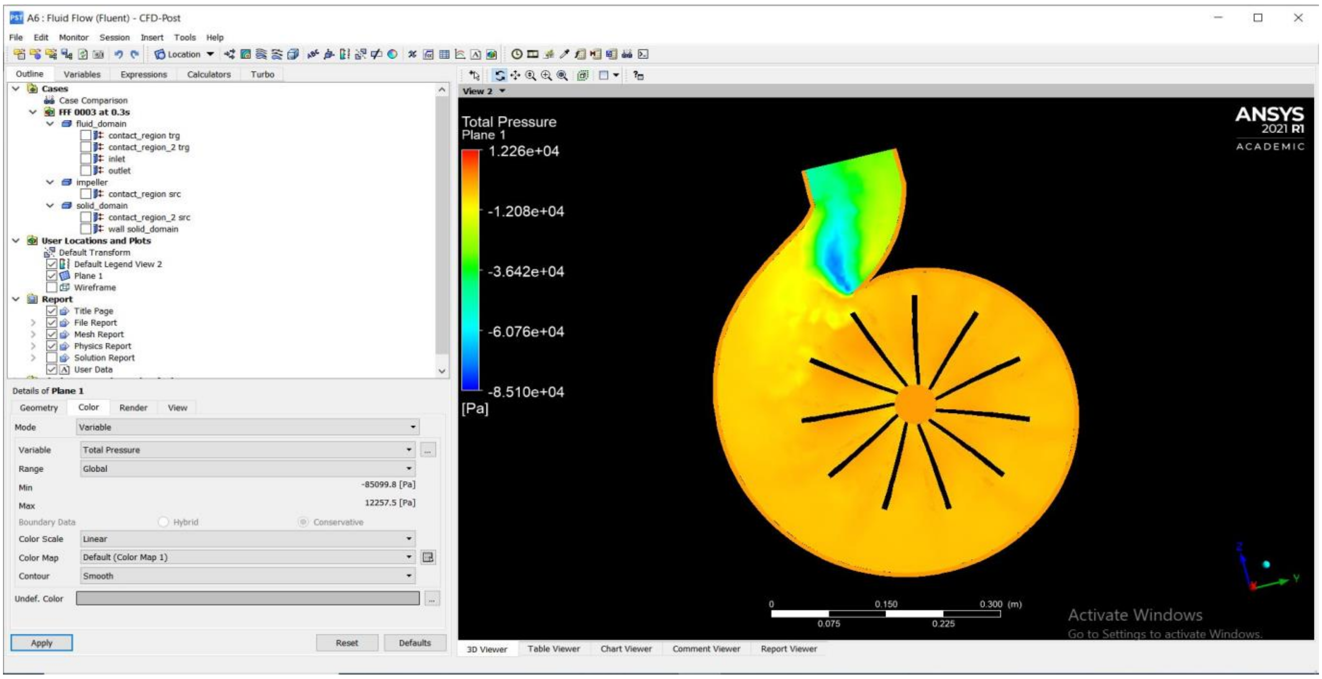


Fig.22

5.3.2) Velocity distribution of closed impeller at 1250rpm

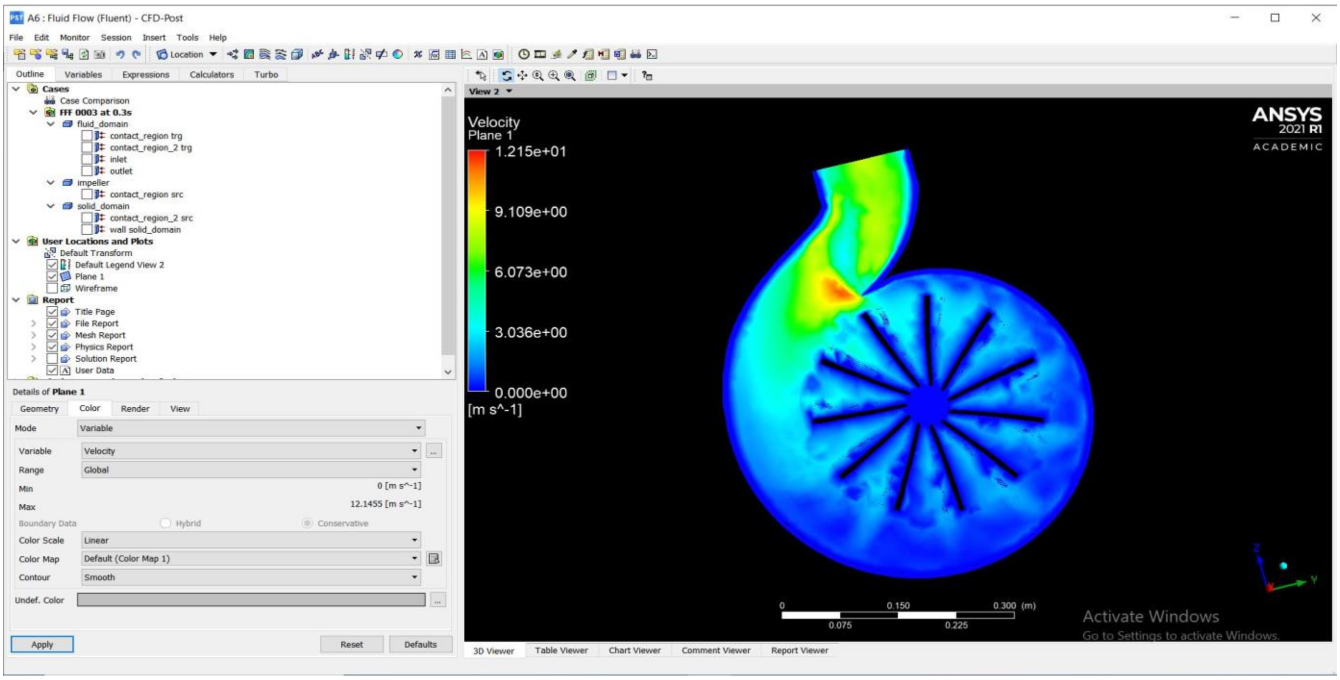


Fig.23

5.3.3) Pressure distribution of closed impeller at 1350rpm

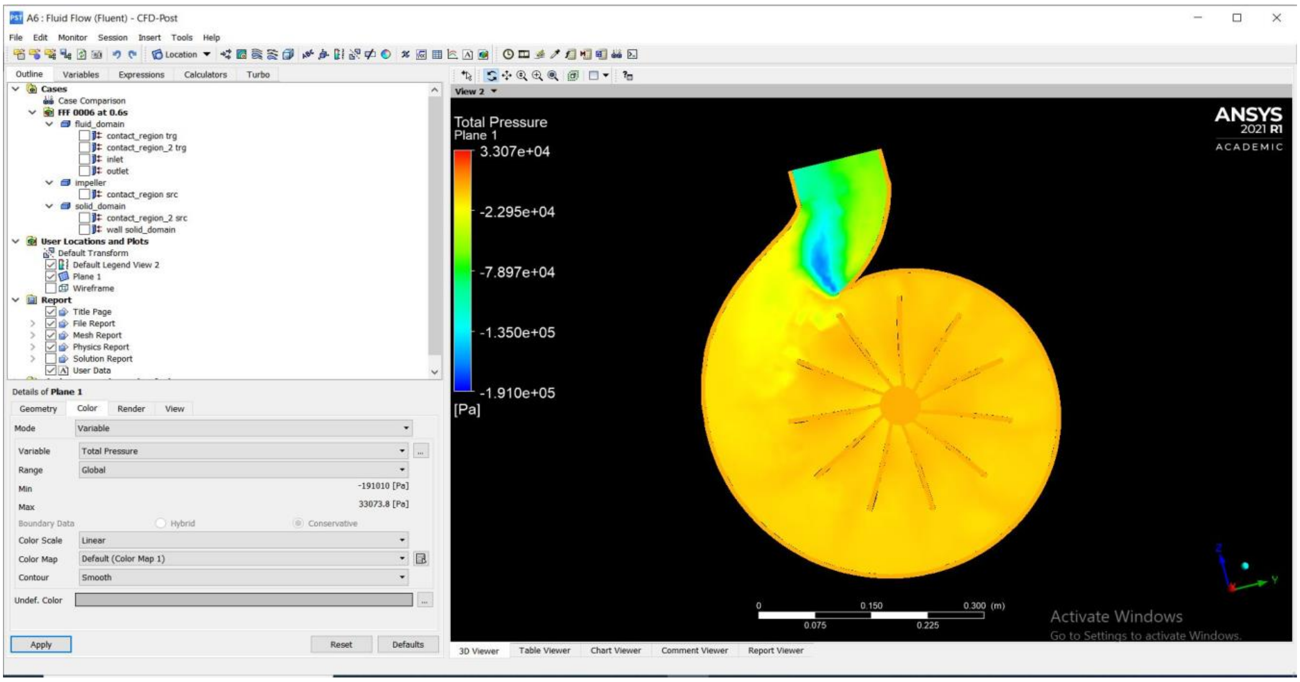


Fig.24

5.3.4) Velocity distribution of closed impeller at 1350rpm

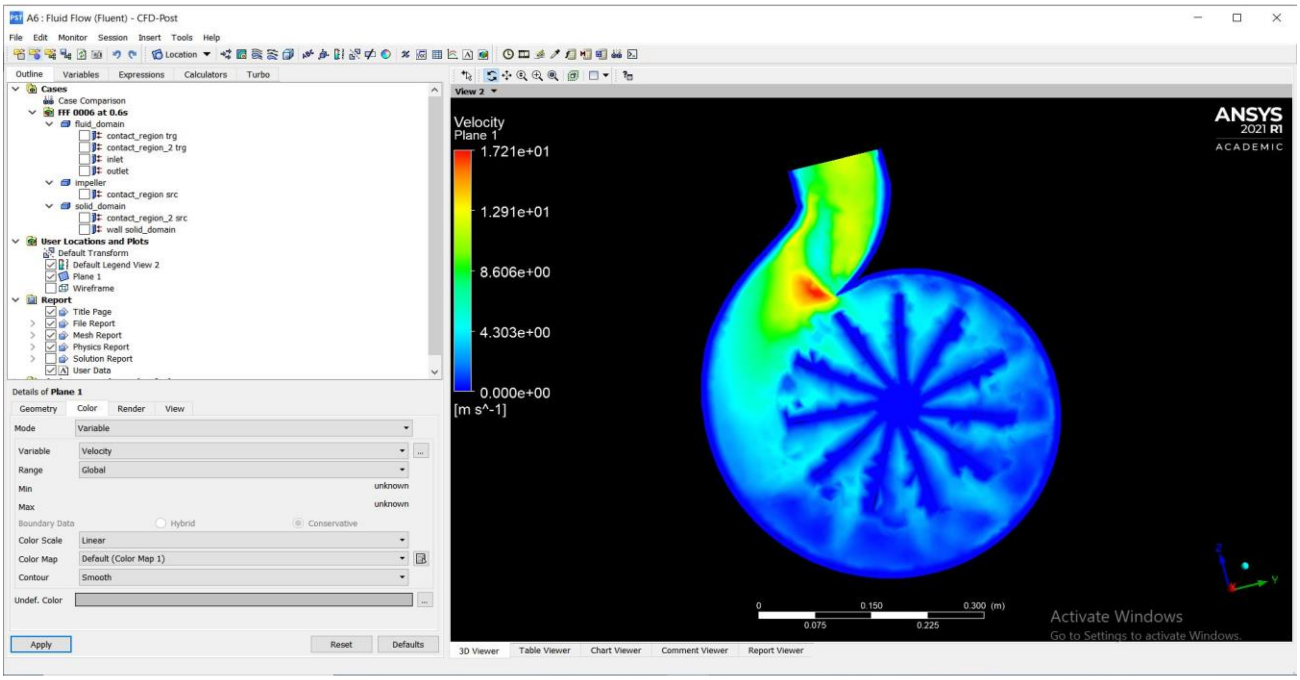


Fig.25

5.3.5) Pressure distribution of closed impeller at 1440rpm

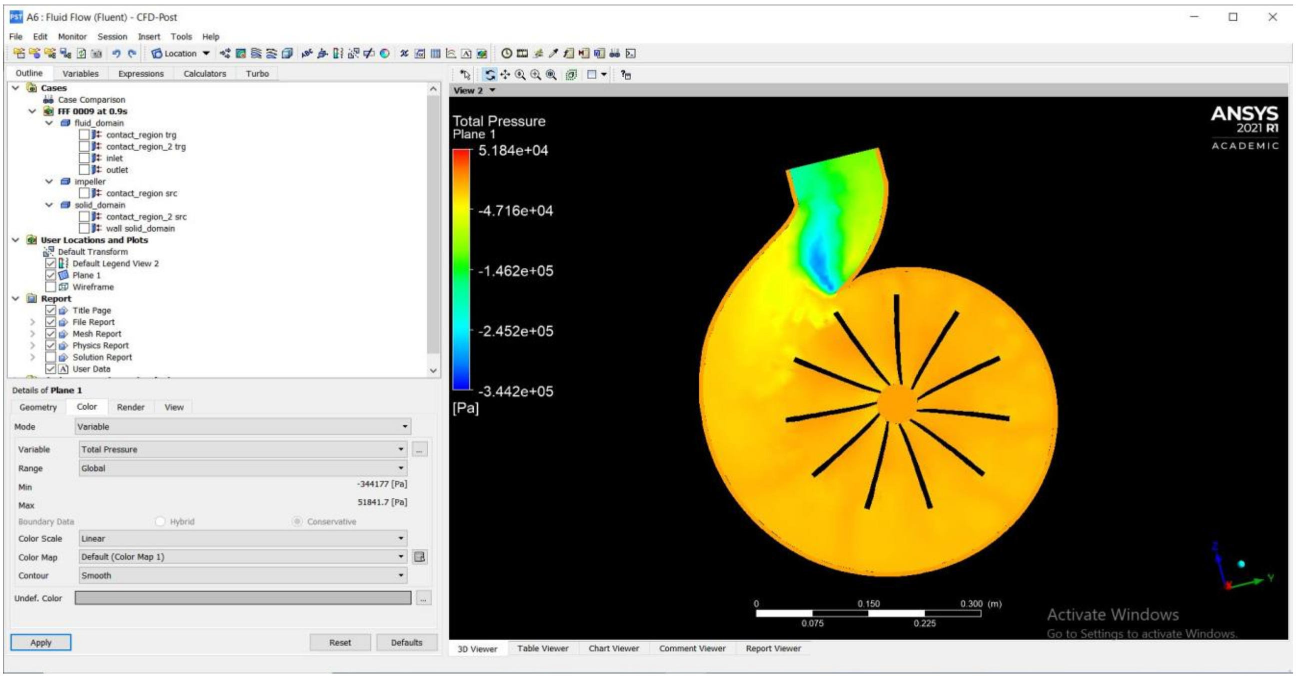


Fig.26

5.3.6) Velocity distribution of closed impeller at 1440rpm

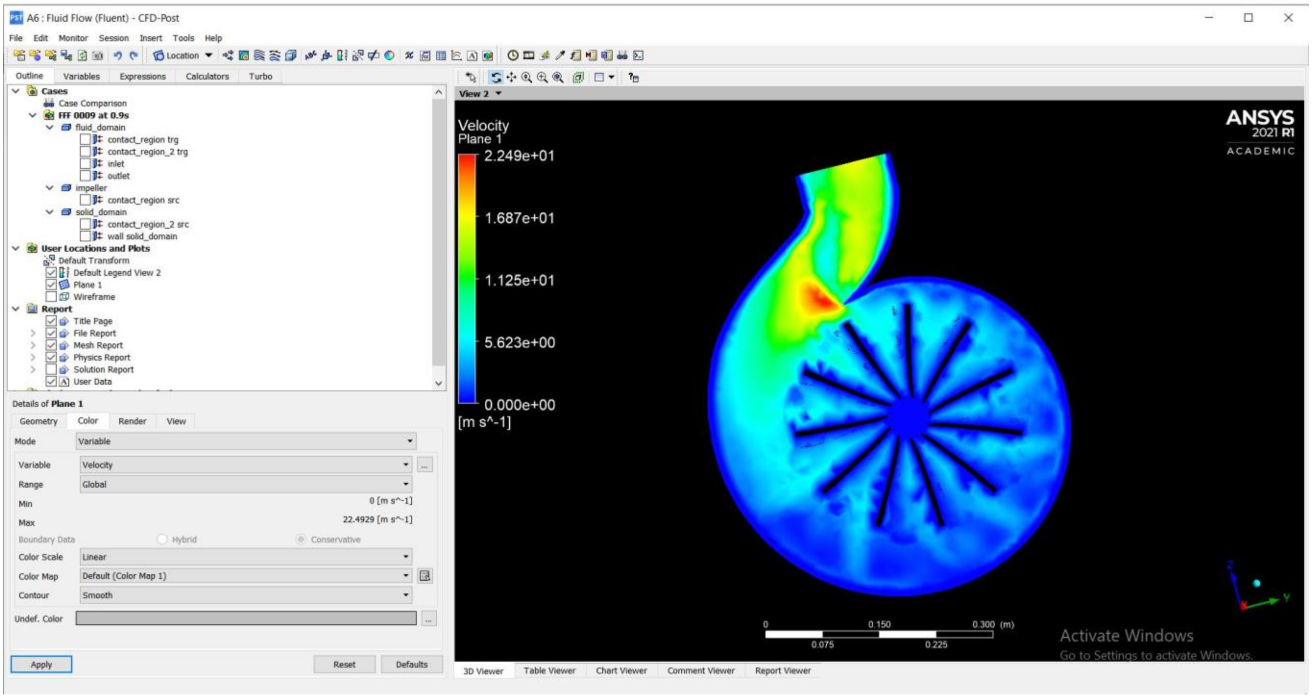


Fig.27

5.4) Pressure and velocity distribution of Semi open impeller of 9 impeller blades

5.4.1) Pressure distribution of Semi open impeller at 1250rpm

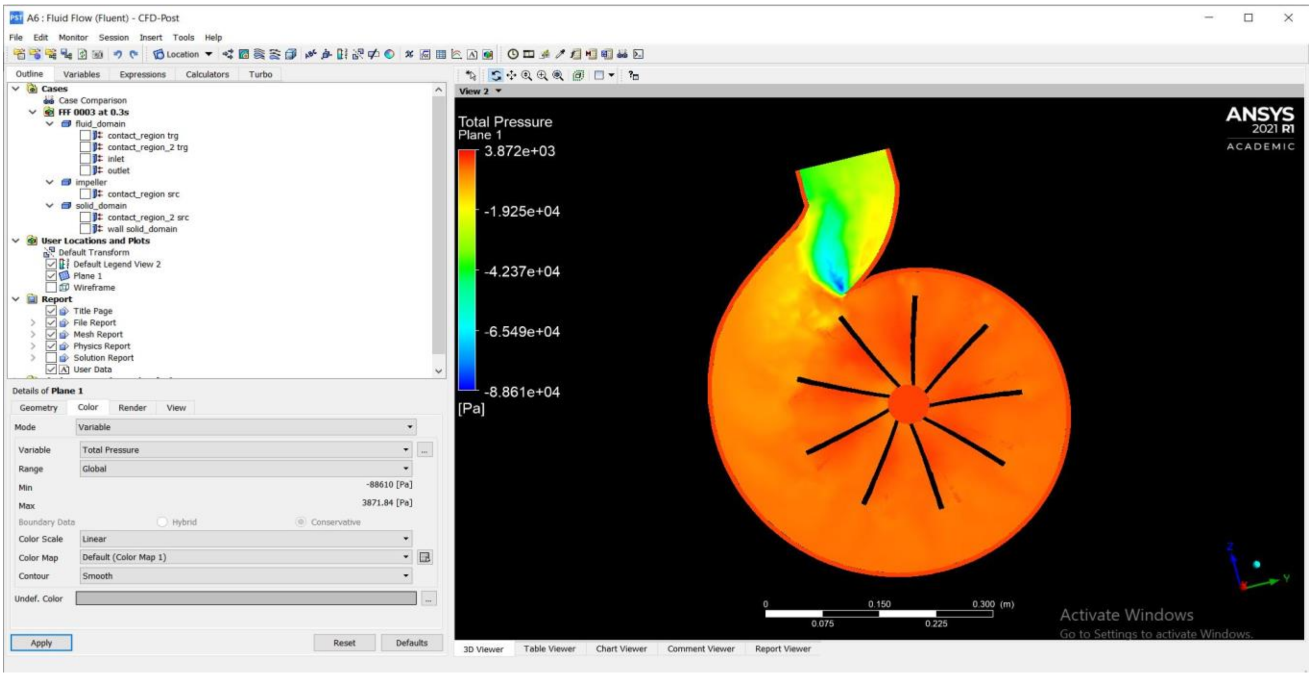


Fig.28

5.4.2) Velocity distribution of Semi open impeller at 1250rpm

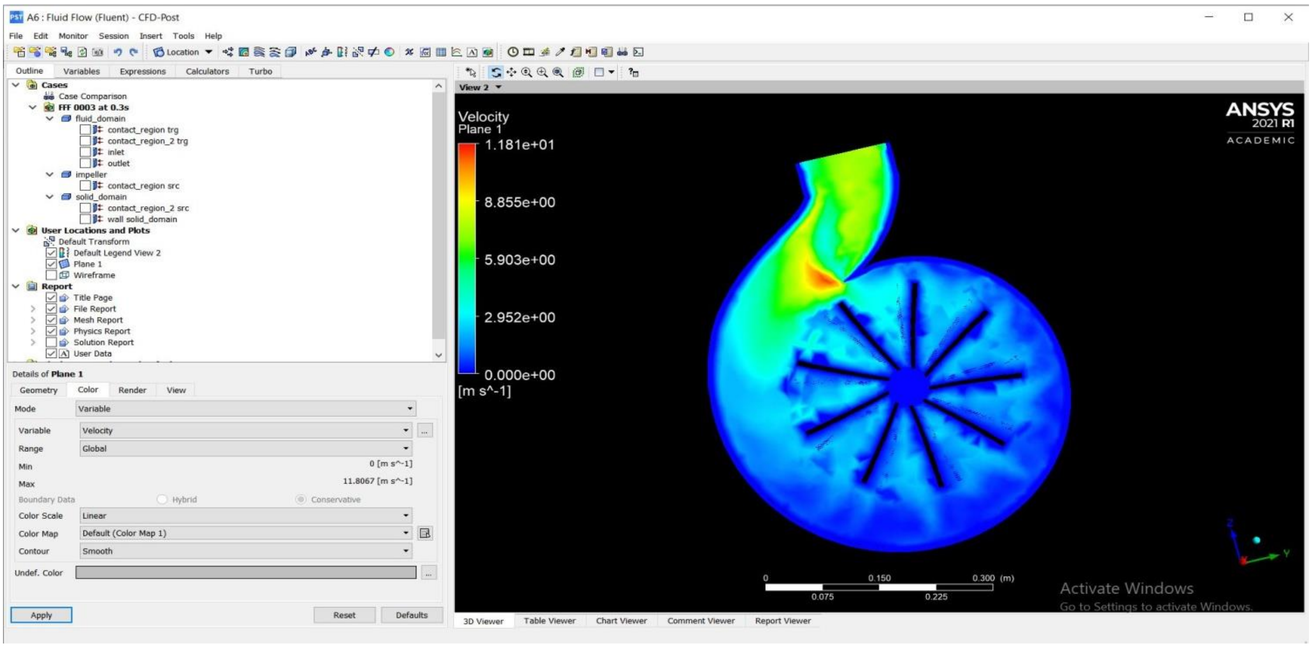


Fig.29

5.4.3) Pressure distribution of Semi open impeller at 1350rpm

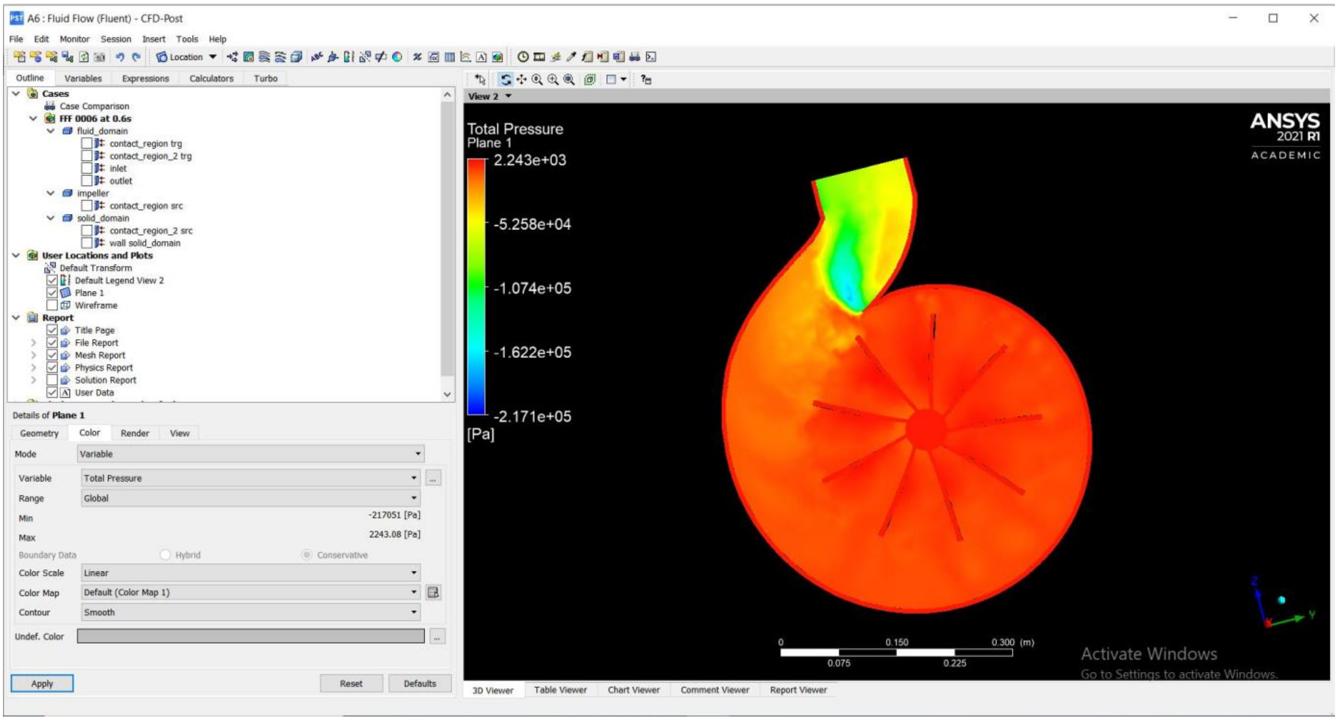


Fig.30

5.4.4) Velocity distribution of Semi open impeller at 1350rpm

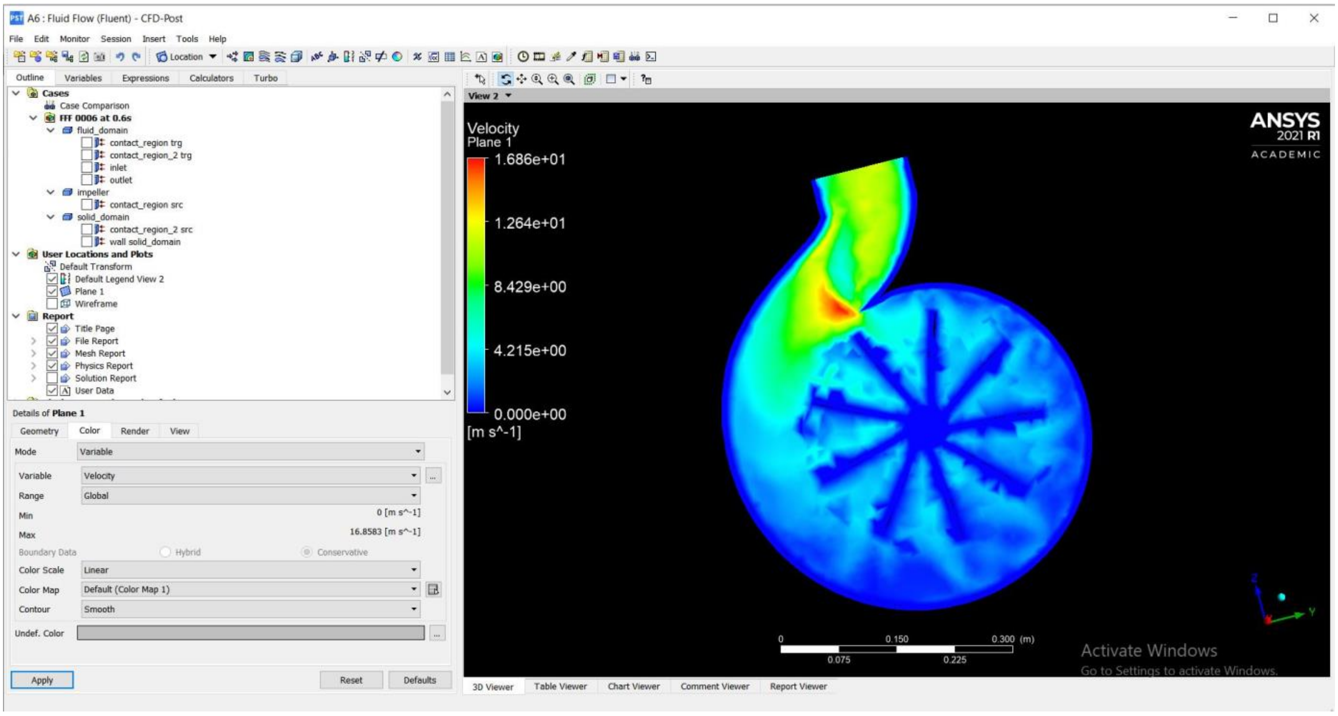


Fig.31

5.4.5) Pressure distribution of Semi open impeller at 1440rpm

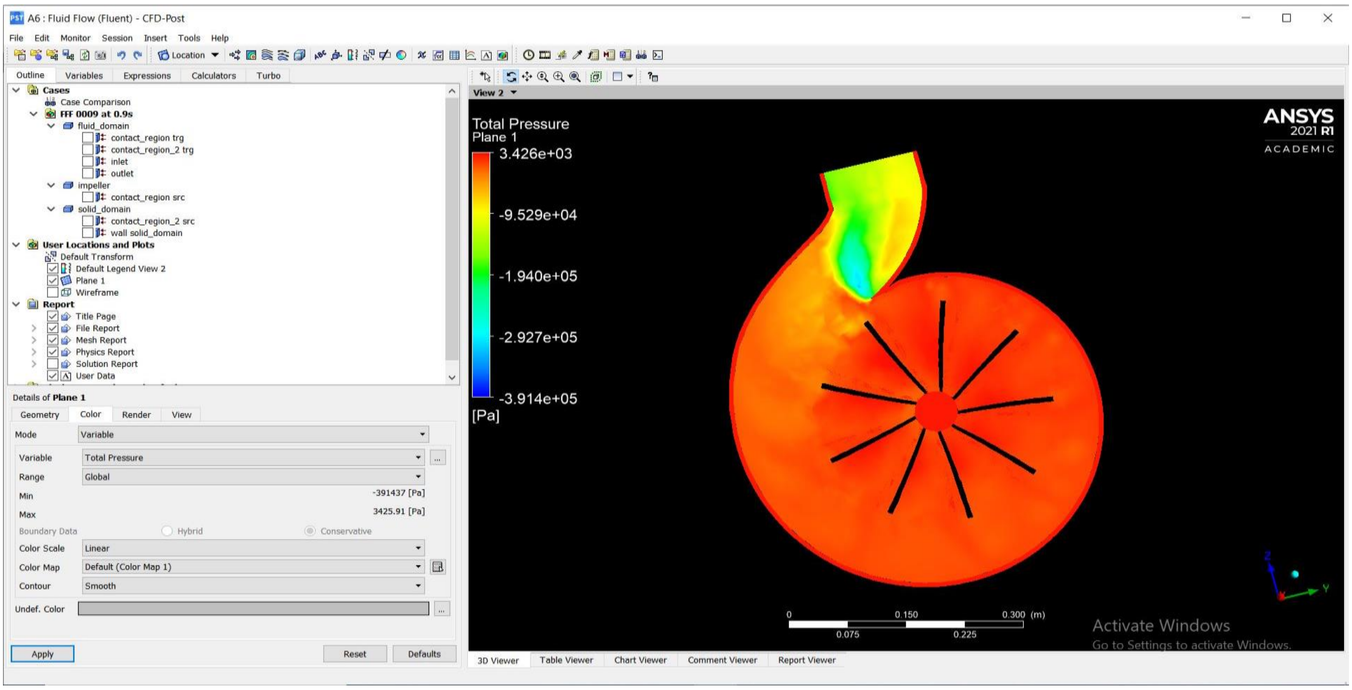


Fig.32

5.4.6) Velocity distribution of Semi open impeller at 1440rpm

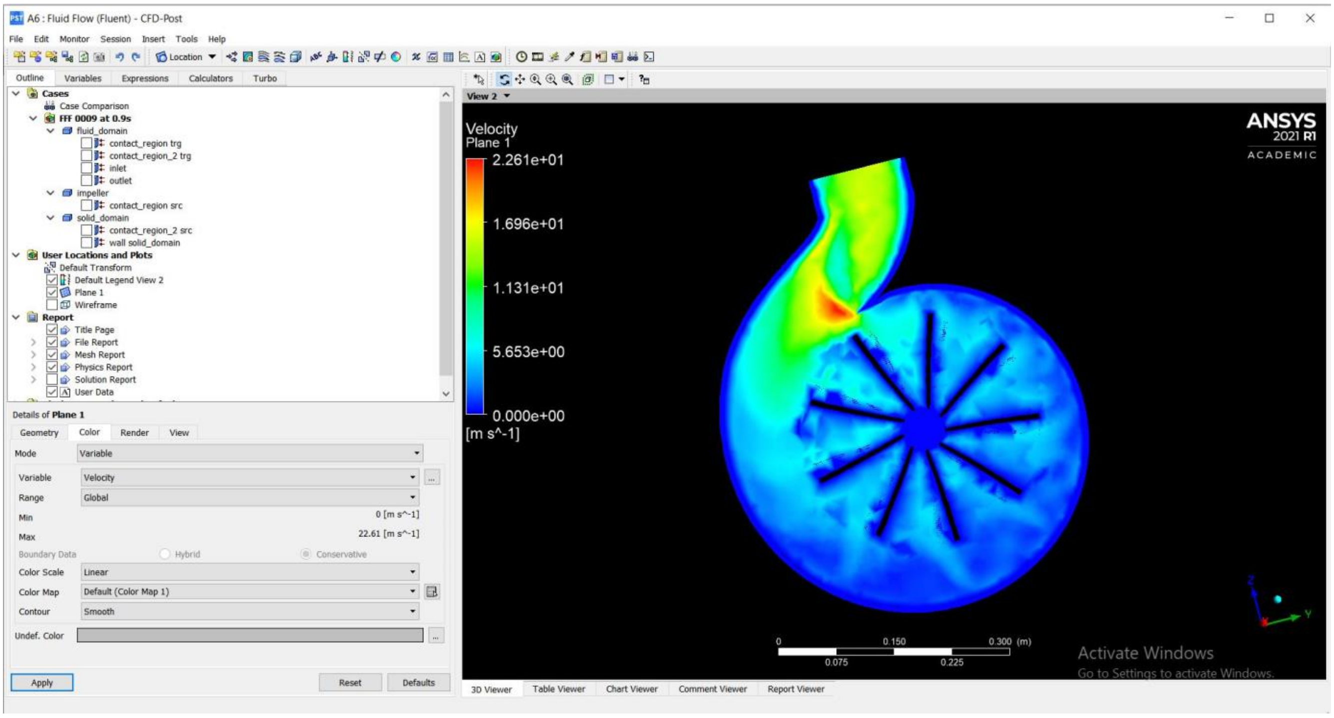


Fig.33

5.5) Pressure and velocity distribution of Semi open impeller of 10 impeller blades

5.5.1) Pressure distribution of Semi open impeller at 1250rpm

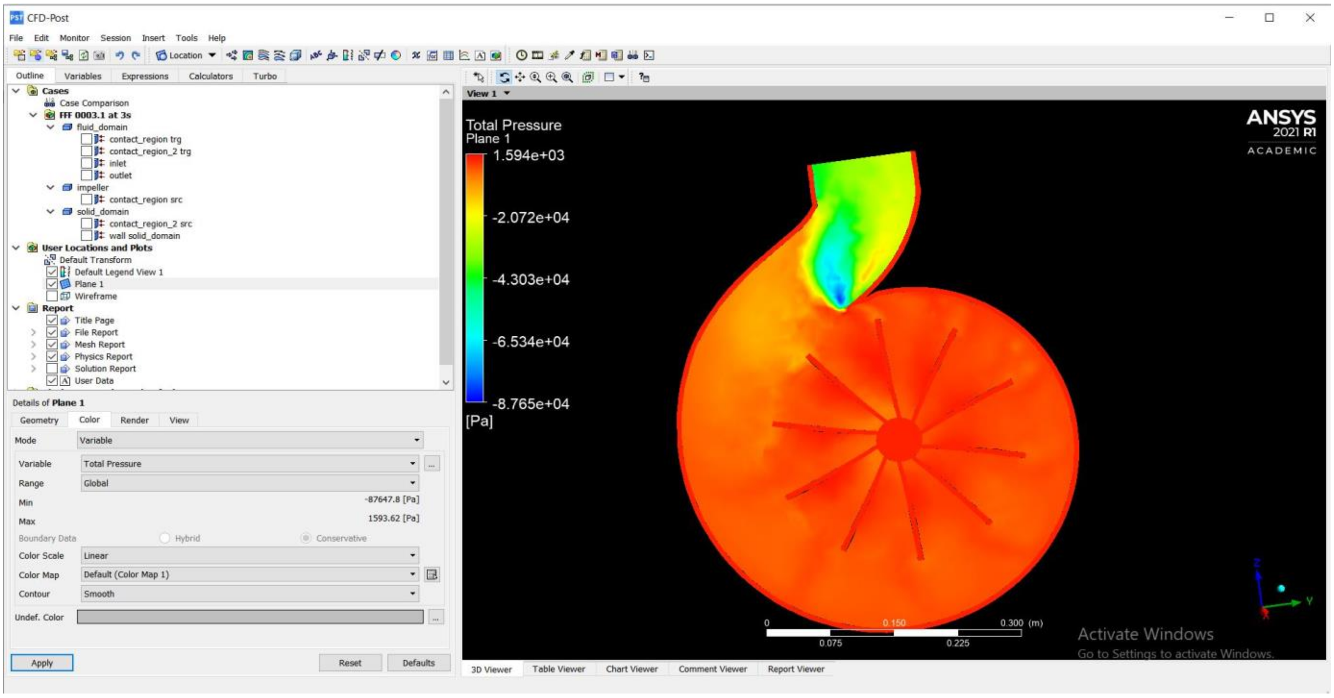


Fig.34

5.5.2) Velocity distribution of Semi open impeller at 1250rpm

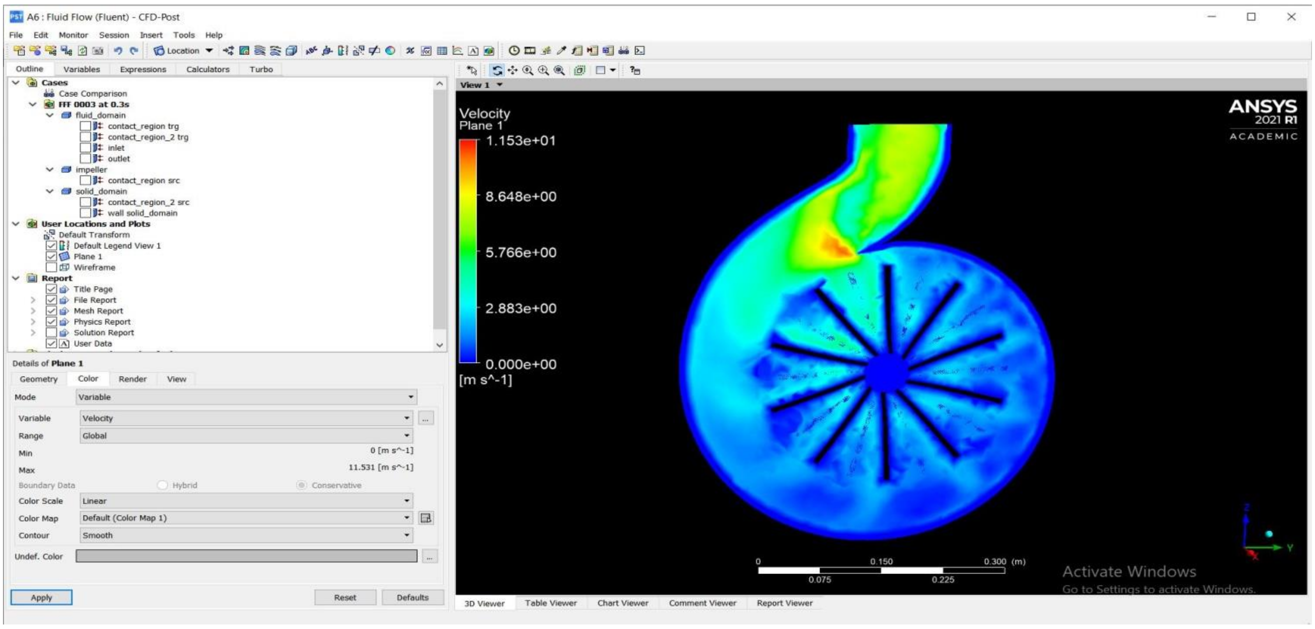


Fig.35

5.5.3) Pressure distribution of Semi open impeller at 1350rpm

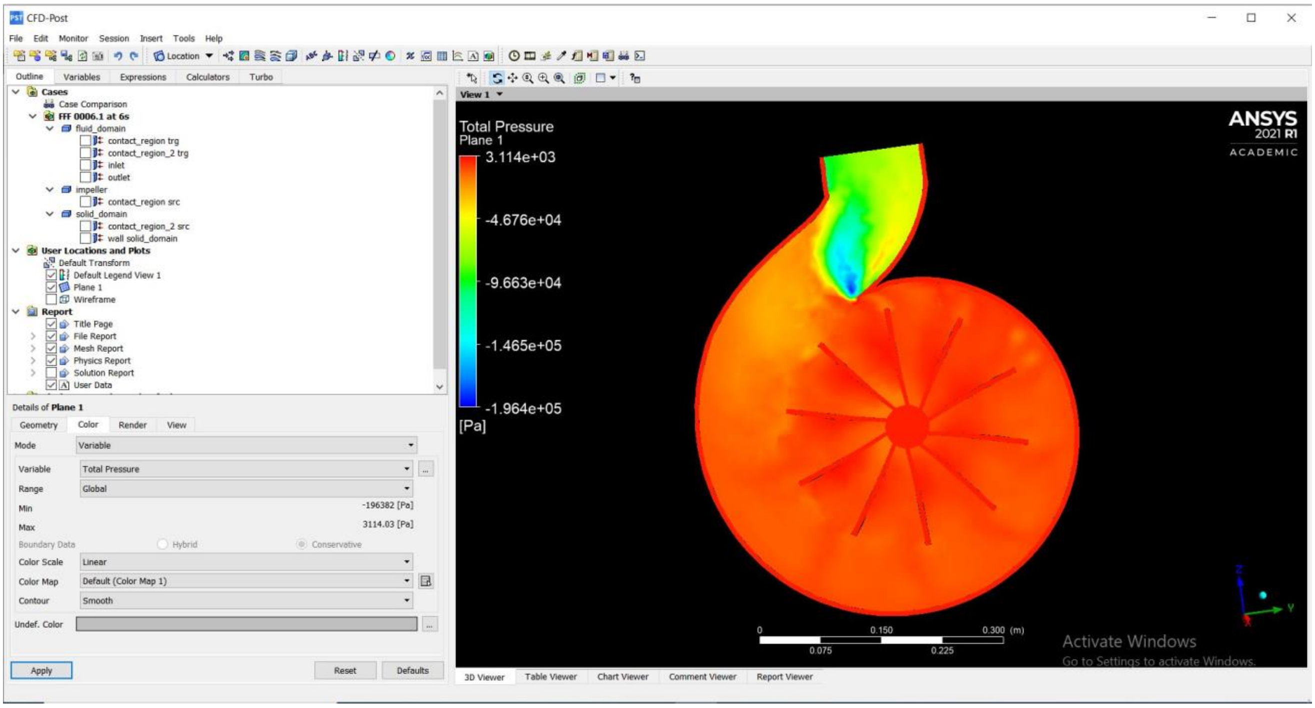


Fig.36

5.5.4) Velocity distribution of Semi open impeller at 1350rpm

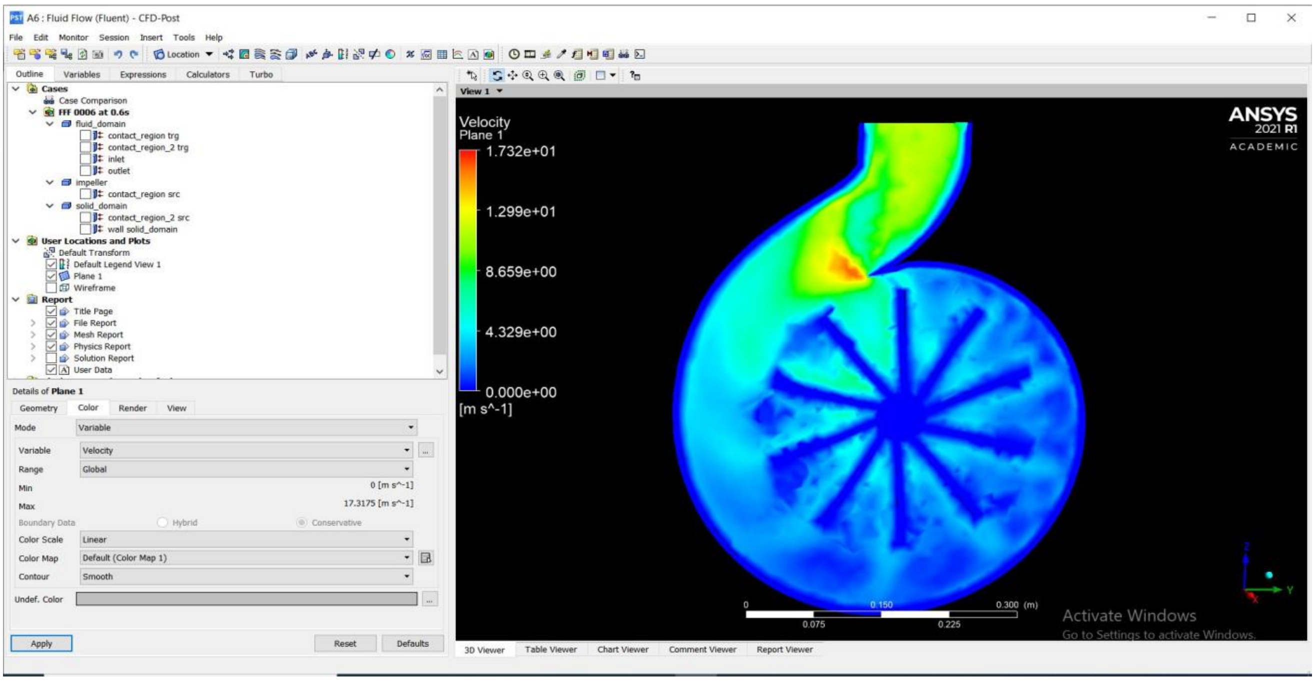


Fig.37

5.5.5) Pressure distribution of Semi open impeller at 1440rpm

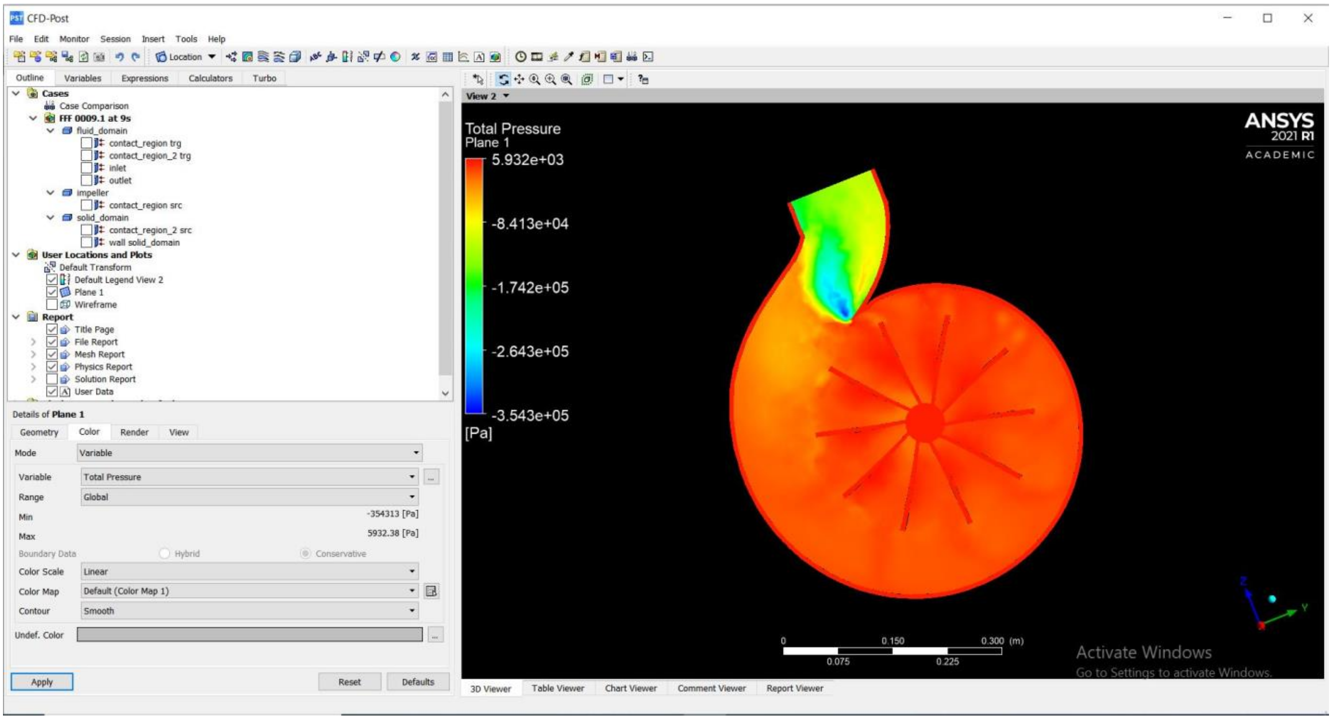


Fig.38

5.5.6) Velocity distribution of Semi open impeller at 1440rpm

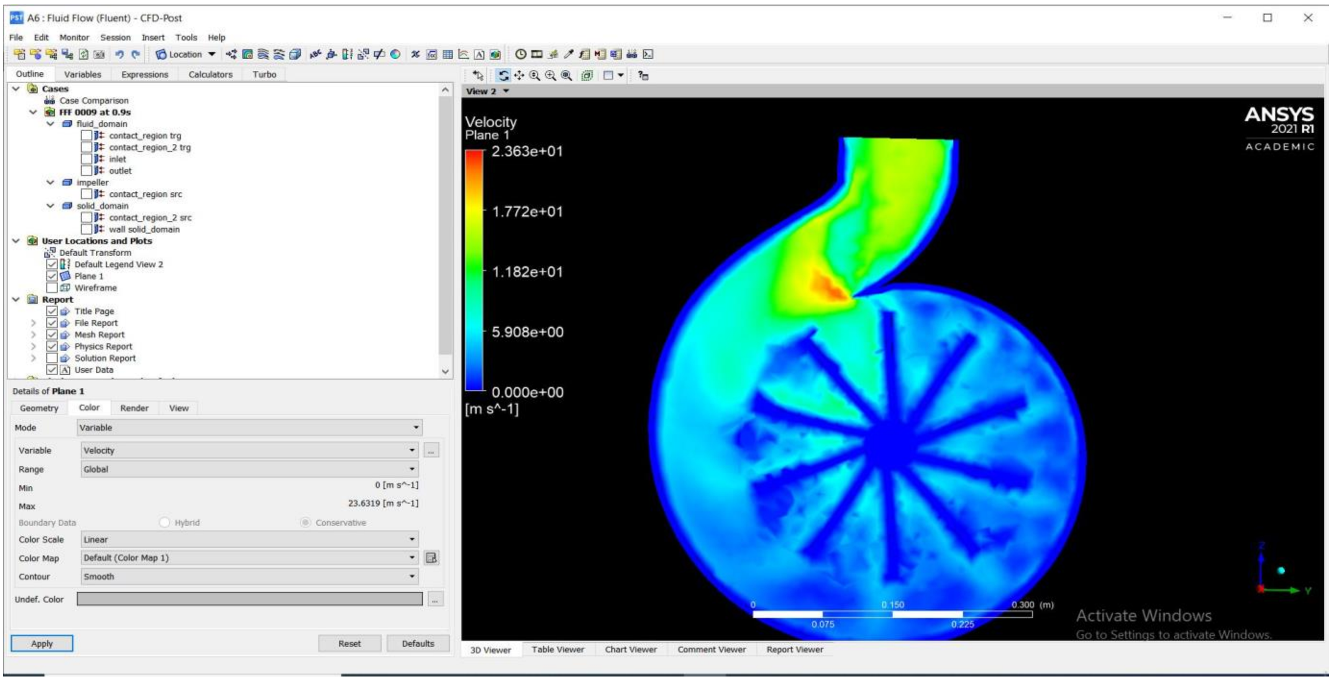


Fig.39

5.6) Pressure and velocity distribution of Semi open impeller of 11 impeller blades

5.6.1) Pressure distribution of Semi open impeller at 1250rpm

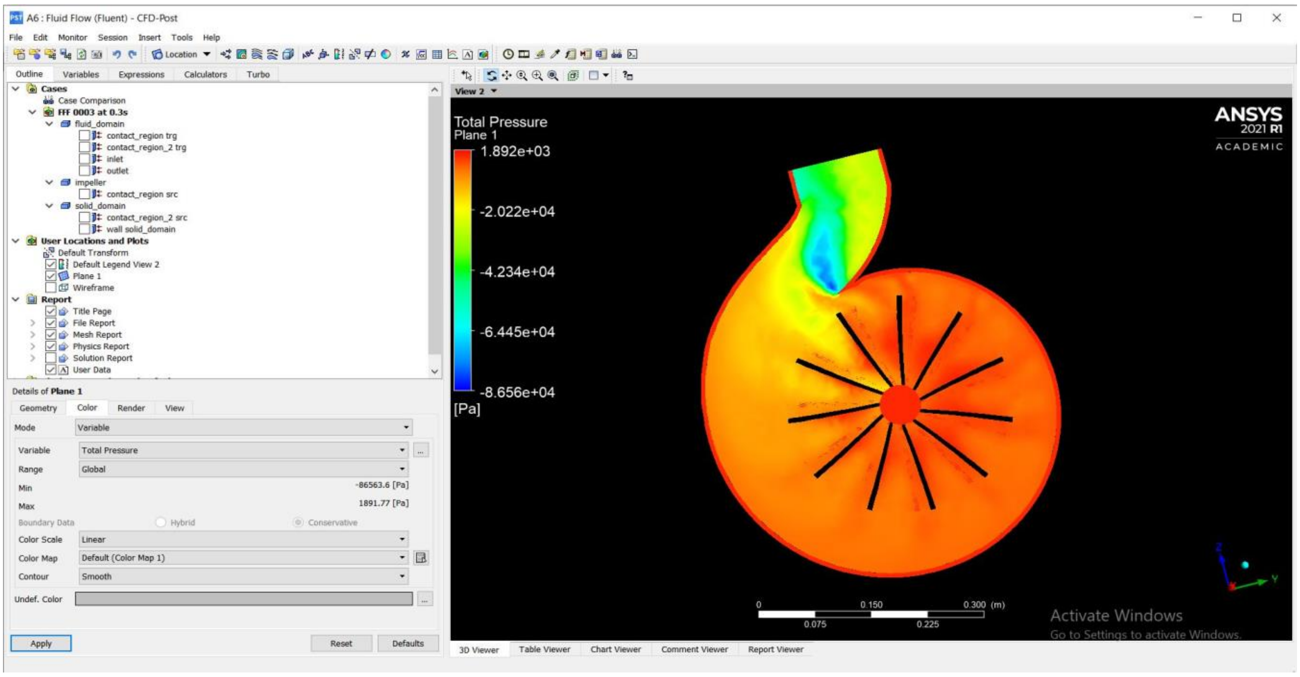


Fig.40

5.6.1) Velocity distribution of Semi open impeller at 1250rpm

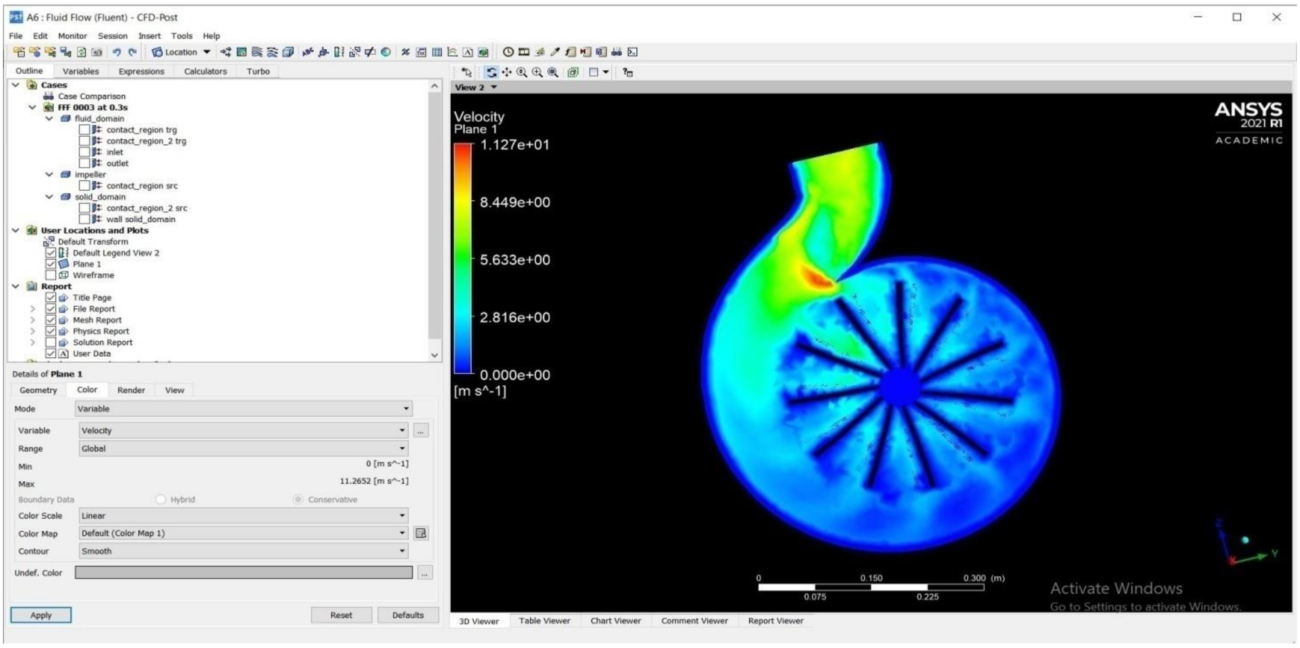


Fig.41

5.6.3) Pressure distribution of Semi open impeller at 1350rpm

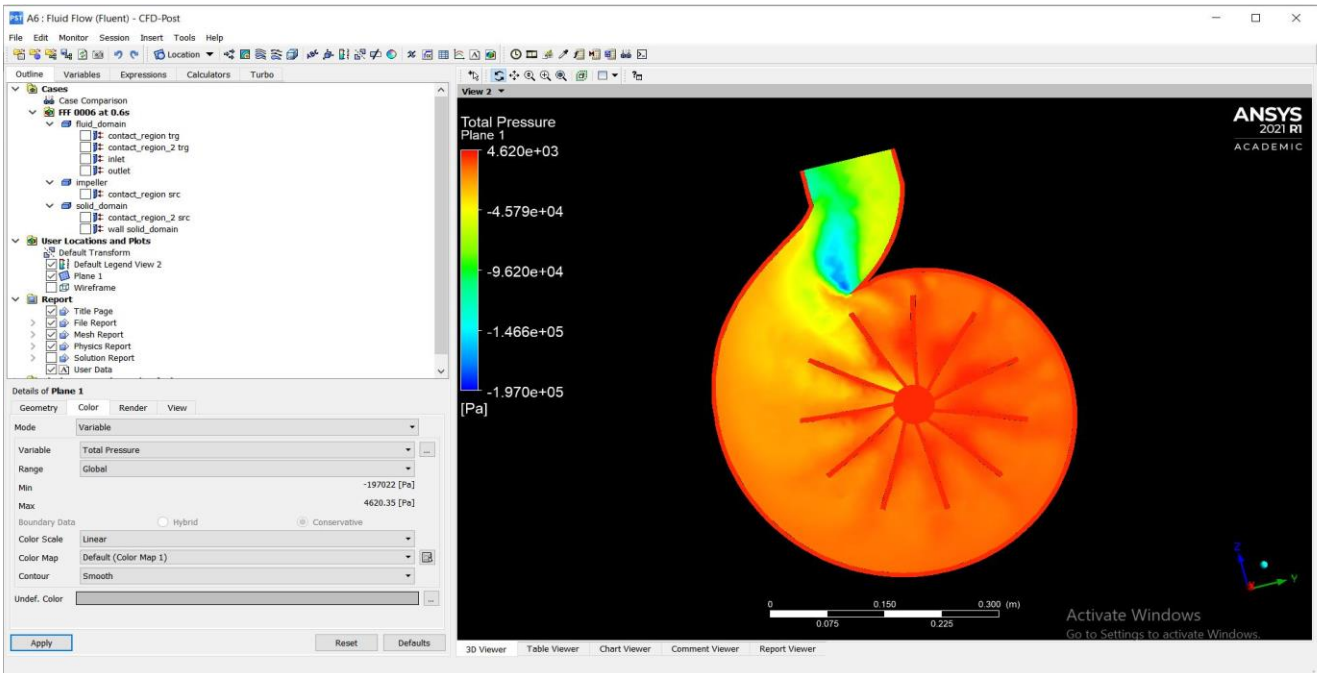


Fig.42

5.6.4) Velocity distribution of Semi open impeller at 1350rpm

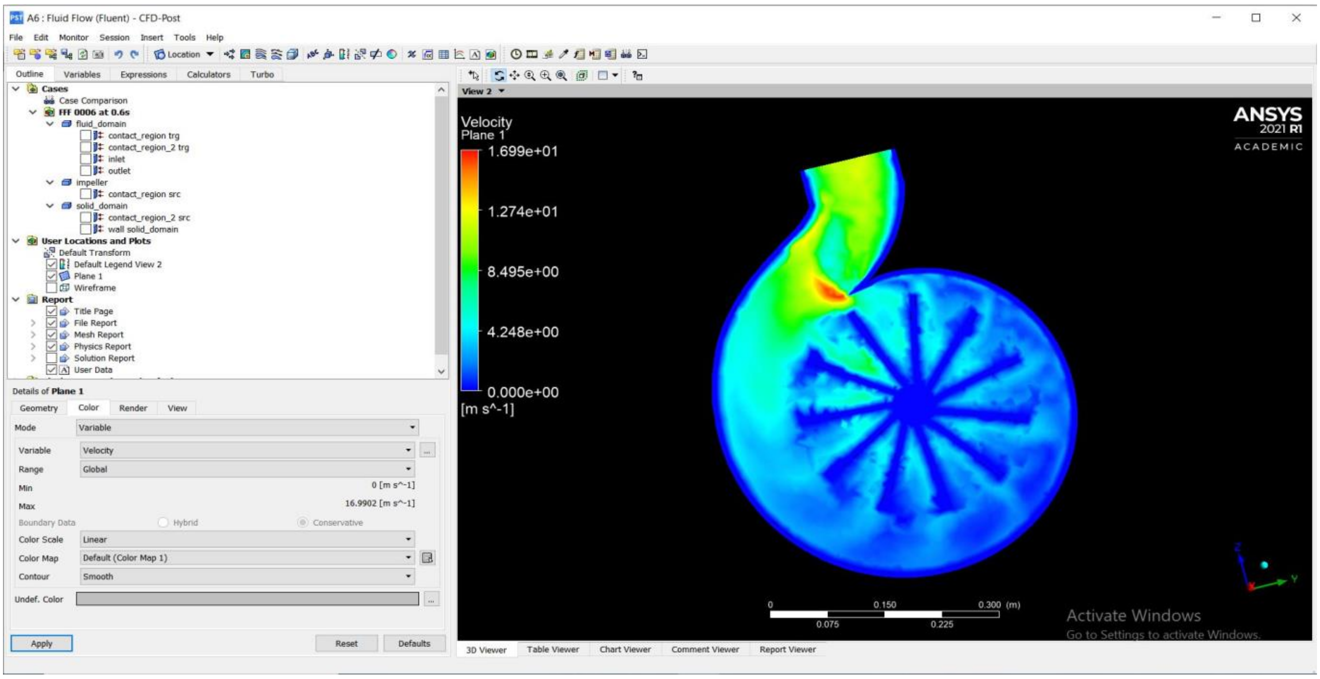


Fig.43

5.6.5) Pressure distribution of Semi open impeller at 1440rpm

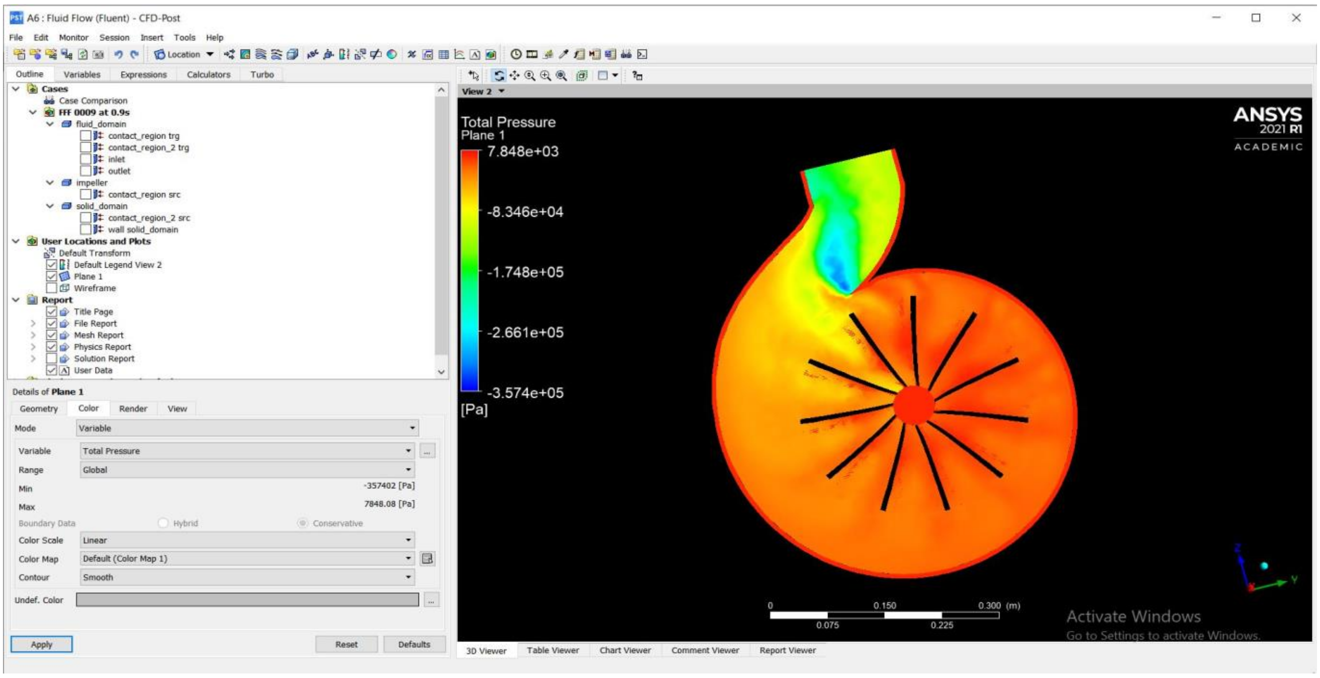


Fig.44

5.6.6) Velocity distribution of Semi open impeller at 1440rpm

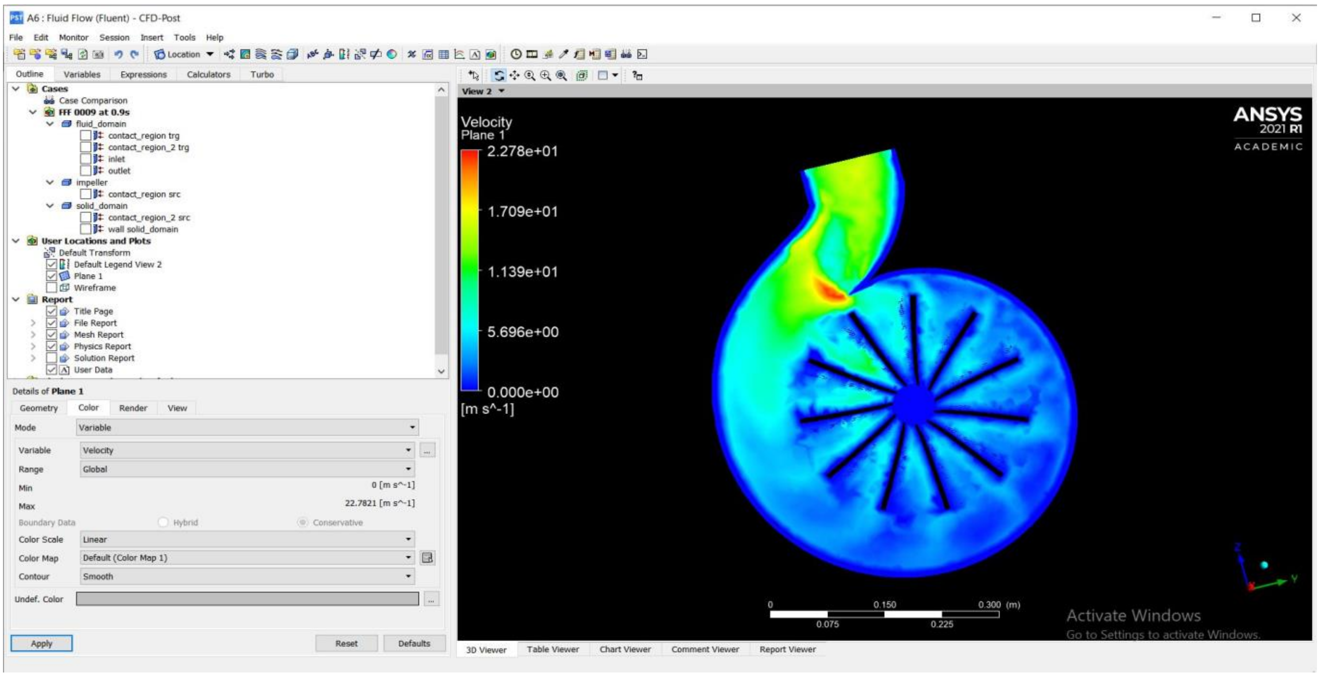


Fig.45

Table-4: Pressure and Velocity variation of closed impeller

Serial No.	No. of. Impeller blades	Rotational Speed(Rpm)	Maximum Pressure(Pa)	Maximum Velocity(m/sec)
1	9	1250	1.456e+04	1.175e+01
2	9	1350	4.621e+03	1.728e+01
3	9	1440	8.269e+03	2.316e+01
4	10	1250	2.132e+03	1.185e+01
5	10	1350	5.100e+03	1.764e+01
6	10	1440	8.791e+03	2.368e+01
7	11	1250	1.226e+04	1.215e+01
8	11	1350	3.307e+04	1.721e+01
9	11	1440	5.184e+04	2.249e+01

Table-5: Pressure and Velocity variation of Semi open impeller

Serial No.	No. of. Impeller blades	Rotational Speed(Rpm)	Maximum Pressure(Pa)	Maximum Velocity(m/sec)
1	9	1250	3.872e+03	1.161e+01
2	9	1350	2.243e+03	1.686e+01
3	9	1440	3.426e+03	2.261e+01
4	10	1250	1.594e+03	1.153e+01
5	10	1350	3.114e+03	1.732e+01
6	10	1440	5.932e+03	2.363e+01
7	11	1250	1.892e+03	1.127e+01
8	11	1350	4.620e+03	1.699e+01
9	11	1440	7.848e+03	2.238e+01

- From the above results, we can observe that for closed impeller we are getting maximum velocity distribution as 23.68m/sec at a rotational speed of 1440rpm and impeller blade number 10.
- Also, we can observe that for closed impeller we are getting maximum pressure distribution as 5.184e+04 Pa at a rotational speed of 1440rpm and impeller blade number 11.
- From the above results, we can observe that for Semi open impeller we are getting maximum velocity distribution as 23.63m/sec at a rotational speed of 1440rpm and impeller blade number 10.
- Also, we can observe that for Semi open impeller we are getting maximum pressure distribution as 7.848e+03 Pa at a rotational speed of 1440rpm and impeller blade number 11.
- The rise in pressure and velocity from inlet to outlet is observed for both the closed and semi open impellers.
- With the increase in rotational speed of the impellers, the pressure and velocity distribution also increases.

CHAPTER-6

CONCLUSIONS

- The rise in pressure and velocity from inlet to outlet is observed for both the closed and semi open impellers.
- With the increase in rotational speed of the impellers, the pressure and velocity distribution also increases.
- With the increase of the impeller blade number, the pressure distribution also increases from inlet to outlet for both closed and semi open impeller.
- The maximum pressure is observed for closed impeller at rotational speed of 1440rpm of impeller blade number 11.
- The maximum velocity is observed for closed impeller at rotational speed of 1440rpm of impeller blade number 10.
- The maximum pressure of 5.184e+04 Pa and maximum velocity of 23.68m/sec both are observed for closed impeller only.
- From this we can conclude that closed impeller is showing more efficiency than the semi open impeller.

CHAPTER-7

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