|| Volume 6 || Issue 4 || April 2021 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH
AND ENGINEERING TRENDS

DESIGN AND STATIC DYNAMIC ANALYSIS OF CENTRIFUGAL IMPELLER WITH CONVENTIONAL AND COMPOSITE MATERIAL USING VARIOUS MATERIALS

SHAIK BASHA[1], Mr. J. NAGARAJU M.Tech.[2]

M.Tech., Machine Design, Department of Mechanical Engineering Nova College of Engineering &Technology Jangareddygudem-534447, West Godavari District[1]

Associate Professor, Department of Mechanical Engineering Nova College of Engineering &Technology Jangareddygudem-534447, West Godavari District[2]

Abstract: - Centrifugal pumps are used to transport liquids/fluids by the conversion of the rotational kinetic energy to the hydro dynamics energy of the liquid flow. The rotational energy typically comes from an engine or electric motor or turbine. In the typical simple case, the fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits. Pumps are widely used for water supply plants, steam power plants, sewage, oil refineries, chemical plants, hydraulic power service, food processing factories and mines, because of their suitability in practically any service. Therefore it is necessary to find out the design parameter, working conditions and maximum efficiency with lowest power consumption, The aim of the project is Design modification and static dynamic analysis of centrifugal impeller using various materials generally using materials are conventional material .In this project taken composite materials because of composite materials have high strength and non corrosion material. non metallic component so, the chattering noise will be low compared to other materials during the functioning process. Find out the best material on these materials(CFRP ,GFRP, Al 1060,Inconel 625,Inconel 740) to decrease the weight and increase the efficiency by using the design software is catia and analysis using the Ansys software. finally find out the stresses, strains, deformations in static analysis and Deformations are find out at different frequencies in modal analysis .

I INTRODUCTION

PUMP

A **pump** is a machine used to move liquid through a piping system and to raise the pressure of the liquid. A pump can be further defined as a machine that uses several energy transformations to increase the pressure of a liquid.

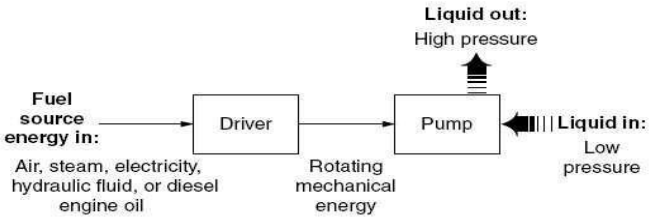

Figure 1 Working principle of Pump

TYPES OF PUMP1.2.1 RECIPROCATING PUMP

In reciprocating pumps the mechanical energy is converted into hydraulic energy by sucking the liquid into a cylinder in which a piston is reciprocating(moving backwards and forwards)which exerts the thrust on the liquid and increases its hydraulic energy(pressure energy),the pump is known as reciprocating pump. Reciprocating pumps are used where a precise amount of liquid is required to be delivered, also where the delivery pressure required is higher than that can be achieved with other types. Figure 1.2 shows line diagram of reciprocating pump.

ROTARY PUMP

Rotary pump is used to move heavy or very viscous fluids. These employ mechanical means such as gear, cam and screw to move the liquid.

CENTRIFUGAL PUMPS

It is the rotodynamic machine. By rotating action develop the pressure able to lifting of liquid lower level to higher level. Centrifugal pump is explained with the following headings:

W ORKING PRINCIPLE OF CENTRIFUGAL PUMP

Centrifugal pumps works on the basis of second law of Newton. Due to the rotation of the runner, called impeller the fluid at the inner radius moves to the outer radius & gain the Centrifugal head. Suction is created at the inlet to the pump which is called the eye. Continuous lifting of fluid thus takes place from sump to the pump while passing through the impeller the fluid take the energy from vane sin pressure &

kinetic energy. A large amount of impeller outlet therefore made to convert the kinetic energy of fluid into pressure energy before the fluid enters the developing pipe.

CENTRIFUGAL PUMP APPLICATIONS

Pumps are used wherever any quantity of liquid must be moved from one place to another. Pumps are found in such services as steam power plants; water supply plants; sewage; drainage or irrigation; oil refineries, chemical plants and steel mills; food processing factories and mines; dredging or jetting operations; hydraulic power services and almost every ship whether driven by diesel or steam engine. While these pumps have much in common, they are varied to meet special requirements and particular needs of each service.

- ¬ Petroleum Industry
- ¬ Chemical Industry
- ¬ Textile Industries
- ¬ Paper Industry

II LITERATURE SURVEY

[1]. A Syam Prasad, BVVV Lakshmipathi Rao, A Babji, Dr P Kumar Babu , "Static and Dynamic Analysis of a Centrifugal Pump Impeller" Alloys are playing major role in many engineering applications. They offer outstanding mechanical properties, flexibility in design capabilities, and ease of fabrication. Additional advantages include light weight and corrosion resistance, impact resistance, and excellent fatigue strength. In this paper study of static and modal analysis of a centrifugal pump impeller which is made of three different alloy materials. (viz., Inconel alloy 740, Incoloy alloy 803, Warpaloy) The best material for design of impeller is Inconel 740. Specific modulus of Inconel 740 obtained in static analysis is 10 % higher than other material. The natural frequency in modal analysis is 6% higher than other material. The deformation of Inconel 740 in static analysis is reduce by 12%.

[2] Karthik Matta, Kode Srividya, Inturi Prakash , "Static and Dynamic Response of an Impeller at Varying Effects" An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic. The modeling of the impeller was done by using solid modeling software, CATIA V5 R18. It is proposed to design a blower with composite material, analyze its strength and deformation using FEM software. In order to evaluate the effectiveness of composites and metal blower and impeller using FEA packaged (ANSYS). Modal analysis is performed on both Aluminum and composite centrifugal blower impeller to find out first 5 natural frequencies. If number of blade and outer diameter increases stresses and deformation also increases all are allowable limit. Total analysis result compares and found that composite materials are having less deformation and stresses.

[3]. G. Kalyan, K.L.N. Murty. "Design and Optimization of Centrifugal Pump Guide Vanes" In this paper an impeller of a centrifugal pump is designed and modeled in 3D modeling software Pro/Engineer.. Materials used are steel and aluminum. The optimization of the impeller design is done by observing the results obtained from the analysis performed. The results considered are stress frequency velocity pressure flow rates. Analysis is done in ANSYS.

By observing the structural analysis result the stresses by increasing number of blades andincreasing the angle of blade. When Aluminum material is used the stresses are less than that of steel. By observing modal analysis results the frequencies are reducing by increasing the number of blade .

[4]. Pramod J. Bachche1, R.M.Tayade "Finite Element Analysis of Shaft of Centrifugal Pump" Centrifugal pump is world one of the oldest water pumping devises. In this paper study Shaft of centrifugal pump for static and dynamic analysis. The shaft is analyzed by using finite element analysis technique for stresses and deflections. The total work is carried out in two stages first stage is static analysis. In this stage pump shaft is analyzed for stresses and deflection and same results are verified using graphical integration method. And second for dynamic analysis, in this stage result obtained by static analysis are used to calculate dynamic forces coming in pump shaft. Again shaft is analyzed in dynamic input condition and results are verified by using graphical integration method. Maximum deflection and stress are generated to minimum flow condition. Maximum dynamic deflection is obtained 11% less than allowable deflection and Maximum stresses for dynamic is obtained 18% less than allowable tensile strength.

[5] S.Rajendran and Dr. K Purushothaman "Analysis of centrifugal pump impeller using ANSYS-CFX" In this paper analysis of centrifugal pump impeller design is carried out using ANSYS-CFX. It is most common pump used in industries and domestic application. The complex internal flow in centrifugal pump impeller can predicted by ANSYS-CFX. A centrifugal pump is kinetic device. Liquid entering the pump receives kinetic energy from the rotating impeller. The centrifugal action of impeller accelerates the liquid to high velocity, transferring mechanical (rotational) energy to the liquid. The flow pattern, pressure distribution in blade passage and blade loading of centrifugal pump impeller are discussed in this paper. Centrifugal pump impeller without volute casing is solved at designed mass flow rate is high. Total efficiency of pump is 30% increases.

III MATERIAL DESCRIPTION

CFPR MATERIAL

CFRPs can be expensive to produce but are commonly used wherever high strength-to-weight ratio and rigidity are required,

such as aerospace, automotive, civil engineering, sports goods and an increasing number of other consumer and technical applications.

Gfrp material composition

Glass fiber concretes are mainly used in exterior building façade panels and as architectural precast concrete. Somewhat similar materials are fiber cement siding and cement boards.

Properties	GFRP (E-glass/epoxy)	CFRP (Carbon/epoxy)
V_f	0.60	0.60
Density (g/cm³)	1.95	1.58
E_1 (GPa)	44.60	142
E_2 (GPa)	12.46	10.30
G_{12} (GPa)	4.85	7.20
ν_{12}	0.24	0.27
F_1^{tu} (MPa)	1300	2280
F_1^{cu} (MPa)	691	1440
F_2^{tu} (MPa)	47	57
F_2^{cu} (MPa)	130	228
F^{su} (MPa)	44	71

Table 1 CFRP AND GFRP MATERIAL PROPERTIES

STAINLESS STEEL

Stainless steel is notable for its corrosion resistance, and it is widely used for food handling and cutlery among many other applications.

Stainless steel does not readily corrode, rust or stain with water as ordinary steel does. However, it is not fully stain-proof in low-oxygen, high-salinity, or poor air-circulation environments.[2] There are various grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required.

MATERIAL	Stain less steel
Density	7.60 g/cm^3
Yield stress	170%
Modulus of Elasticity	193 Gpa
Poissons Ratio	0.32
Ultimate tensile strength	505 Mpa

Table 2 Material properties of STAINLESS STEEL

MATERIAL PROPERTIES OF INCONEL :

Table 3 INCONEL MATERIAL PROPERTIES

MATERIAL	Inconel alloy 740
DENSITY (*1000 kg/m^3)	7.7-8.03
Poissions ratio	027-0.30
Elastic modulus(GPa)	190-210
Tensile strength(Mpa)	1158
Yield strength (Mpa)	1034
Elongation (%)	15
Reduction in area (%)	53
Hardness (HB)	335

Inconel is a family of austenitic nickel-chromium-based superalloys. Inconel alloys are oxidation- and corrosion-resistant materials well suited for service in extreme environments subjected to pressure and heat. When heated, Inconel forms a thick, stable, passivating oxide layer protecting the surface from further attack.

AL 6061 MARTERIAL

6061 is a precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties, exhibits good weldability, and is very commonly extruded (second in popularity only to 6063). It is one of the most common alloys of aluminium for general-purpose use.

Table 4 AL 6061 MATERIAL PROPERTES

MATERIAL	AL 6061
Density	2.7 g/cm^3
Melting Point	580
Modulus of Elasticity	75 Gpa
Poissons Ratio	0.33
Ultimate tensile strength	135

OBJECTIVES OF STUDY:

[1] To check strength of pump by static analysis using various material like CFRP,GFRP ,INCONEL ,STAINLESS STEEL,AL-6061

[2] To reduce weight of pump by using different material.

[3] To determine static analysis of CFRP , ,GFRP INCONEL, STAINLESS STEEL,AL-6061

[4] Observe the stresses ,strains, deformations.

[5] Finally conclude the suitable material for impeller.

Methodology

Step 1: Collecting information and data related to CENTRIFUGAL IMPELLER PUMP

Step 2: A fully parametric model of the CENTRIFUGAL IMPELLER PUMP is created in catia software.

Step 3: Model obtained in igs. analyzed using ANSYS 14.(workbench), to obtain stresses , deformation, strain etc.

Step 4: Taking boundary conditons.

Step 5: Finally, we compare the results obtained from ANSYS and compared geometry with different materials.

Table 5 Design parameters of impeller

1	Specific Speed, Ns=46.48 RPM
2	Impeller Eye Diameter, D0=69.97mm
3	Impeller inlet Diameter, D1=79.77mm
4	Impeller Outlet Diameter, D2=125.1mm
5	Number of vanes, Z=6
6	Inlet vane angle, β1=10.21o
7	Outlet vane angle, β2=15.670
8	Tangential velocity at inlet, U1=12.0275 m/s
9	Tangential velocity at outlet, U2=18.8767 m/s
10	Flow velocity at inlet, Vf1= 2.1675m/s
11	Flow velocity at outlet, Vf1=2.8550 m/s
12	Relative velocity at inlet, Vr1=12.2212 m/s
13	Relative velocity at outlet, Vr2=12.2212m/s
14	Hydraulic efficiency, ηHy=76.15%
15	Overall efficiency, ηoverall= 56.96%

DESIGNING OF THE MODEL: DESIGN PROCEDURE IN CATIA WORK BENCH:

DESIGN PROCEDURE IN CATIA : Create the circle as per dimensions in sketcher workbench after go to part design apply pad again go to sketcher workbench and create the vanes go to partdesign apply padding as per dimensions after go to sketcher create the small circle and apply pocket in part design workbench.

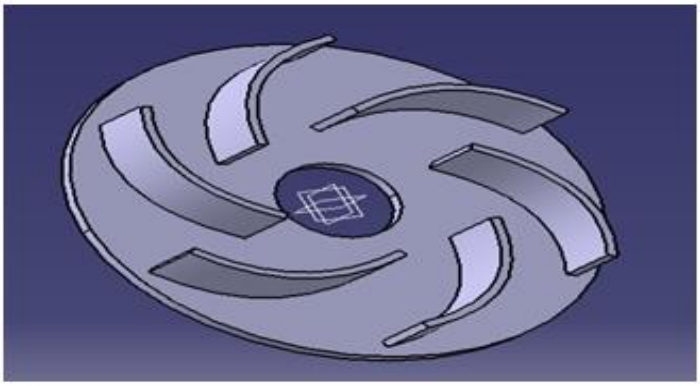

Figure 2 Centrifugal impeller in catia software

IV INTRODUCTION TO ANSYS

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics**.**

PROGRAM ORGANIZATION:

The ANSYS program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

The Begin level acts as a gateway into and out of the ANSYS program. It is also used for certain global program controls such as changing the job name, clearing (zeroing out) the database, and copying binary files. When you first enter the program, you are at the Begin level.

At the Processor level, several processors are available. Each processor is a set of functions that perform a specific analysis task. For example, the general pre-processor (PREP7) is where you build the model, the solution processor (SOLUTION) is where you apply loads and obtain the solution, and the general postprocessor (POST1) is where you evaluate the results of a solution. An additional postprocessor, POST26, enables you to evaluate solution results at specific points in the model as a function of time.

V FINITE ELEMENT METHOD

INTRODUCTION

The Basic concept in FEA is that the body or structure may be divided into smaller elements of finite dimensions called “Finite Elements”. The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called “Nodes” or “Nodal Points”. Simple functions are chosen to approximate the displacements over each finite element. Such assumed functions are called “shape functions”. This will represent the displacement with in the element in terms of the displacement at the nodes of the element.

The Finite Element Method is a mathematical tool for solving ordinary and partial differential equations. Because it is a numerical tool, it has the ability to solve the complex problems that can be represented in differential equations form. The applications of FEM are limitless as regards the solution of practical design problems.

Due to high cost of computing power of years gone by, FEA has a history of being used to solve complex and cost critical problems. Classical methods alone usually cannot provide adequate information to determine the safe working limits of a major civil engineering construction or an automobile or an aircraft. In the recent years, FEA has been universally used to solve structural engineering problems. The departments, which are heavily relied on this technology, are the automotive and aerospace industry. Due to the need to meet

the extreme demands for faster, stronger, efficient and lightweight automobiles and aircraft, manufacturers have to rely on this technique to stay competitive.

FEA has been used routinely in high volume production and manufacturing industries for many years, as to get a product design wrong would be detrimental. For example, if a large manufacturer had to recall one model alone due to a hand brake design fault, they would end up having to replace up to few millions of hand brakes. This will cause a heavier loss to the company.

The finite element method is a very important tool for those involved in engineering design; it is now used routinely to solve problems in the following areas.

- Structural analysis
- Thermal analysis
- Vibrations and Dynamics
- Buckling analysis
- Acoustics
- Fluid flow simulations
- Crash simulations
- Mold flow simulations

Nowadays, even the most simple of products rely on the finite element method for design evaluation. This is because contemporary design problems usually can not be solved as accurately & cheaply using any other method that is currently available. Physical testing was the norm in the years gone by, but now it is simply too expensive and time consuming also.

STRUCTURAL STATIC ANALYSIS:

A static analysis calculates the effects of study loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can however include steady inertia loads and time varying loads that can be approximated as static equivalent loads. Static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed, i.e. the loads and the structure's responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis include:

- Externally applied forces and pressures.
- Steady state inertial forces
- Imposed displacement
- Temperatures

Fluences (for nuclear swelling)

- Imposed displacement

PROCEDURE OF STATIC ANALYSIS ANALYSIS:

Create the geomentry in catia workbench and save the file in igs format and open ansys workbench apply engineering data(material properties), create or import the geomentry, apply model(meshing),applyboundaryconditions(setup)shown the results(stress,deformation,strain).

MESHING AND BOUNDARY CONDITIONS:

Meshing of the impeller for coupled field analysis first the impeller is imported to ansys workbench for meshing in the static analysis and the impeller is meshed with the tetrahedron or quadrilateral meshing is done on the whole 3D model to define and refinement is done on the impeller and the meshing style is free or Default meshing. the statics denied after meshing the model is divided into 1319 element s and the number of nodes formed are 2968 and fixed top side and apply moment 459N.m as shown below figures.

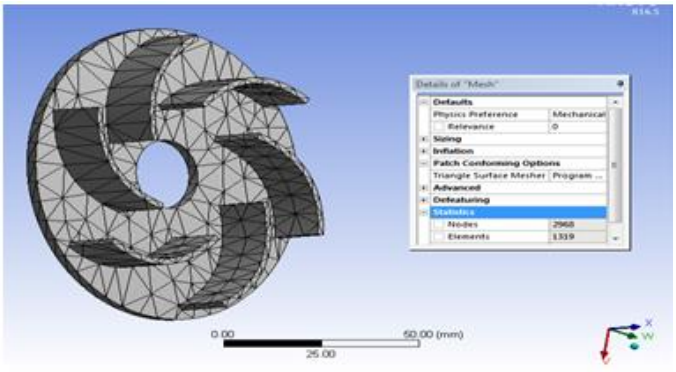

Figure 3 Mesh body

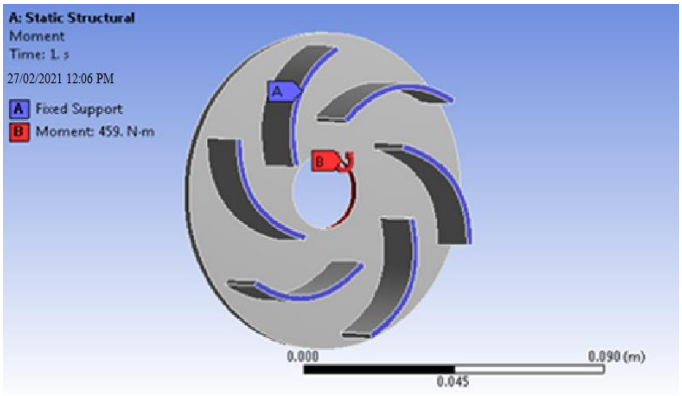

Figure 4 Boundary conditions

VI RESULTS AND DISCUSSION

The constructed impeller in catia is analyzed using ANSYS 14. and the results are as shown in below.

6.1 CFRP MATERIAL:

Here the stresses, strains, deformations are obtained by analyzing the impeller by using cfrp material, as shown in below figures

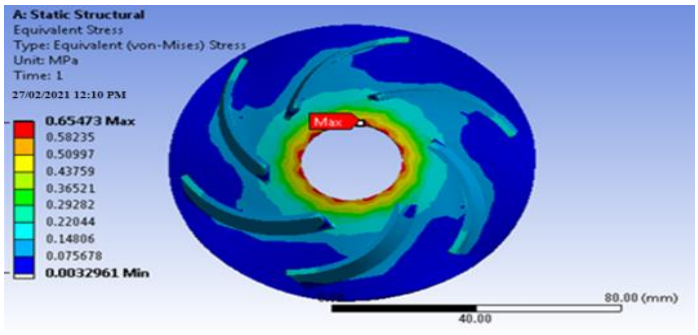

Figure 5 Von-mises stress of CFRP material

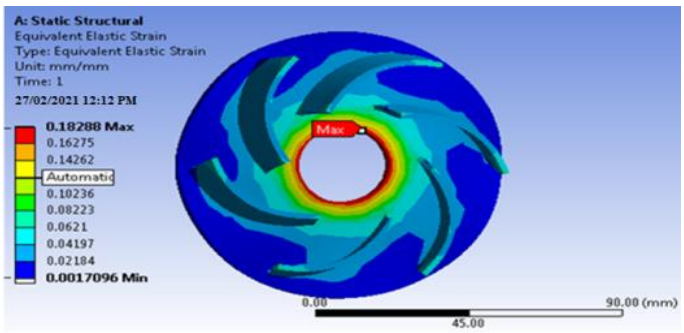

Figure 6 Strain of CFRP material

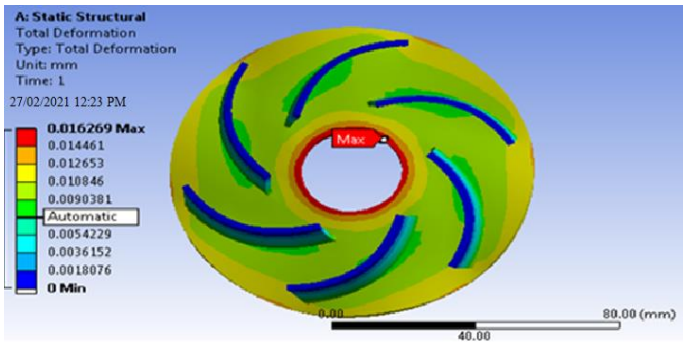

Figure 7 Total deformation of CFRP material

GRAPHS

Graph between von-mises stresses :

This graph shows the different stress values in different materials, GFRP,CFRP materials have least stress values compared to another three materials as shown below graph

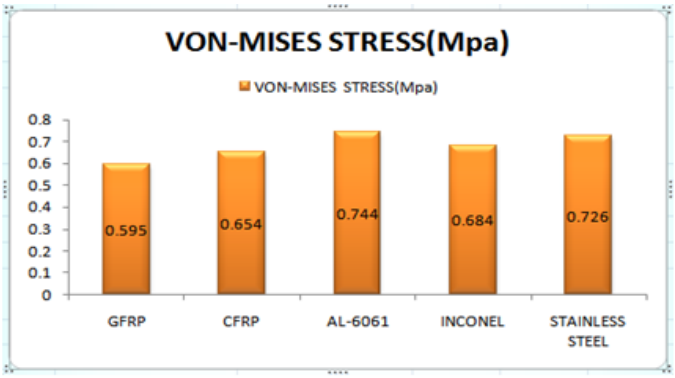

Figure 8 Von-misses stress graph

GRAPH BETWEEN STRAINS:

This graph shows the different stress values in different materials, GFRP,CFRP materials have least strain values compared to another three materials as shown below graph

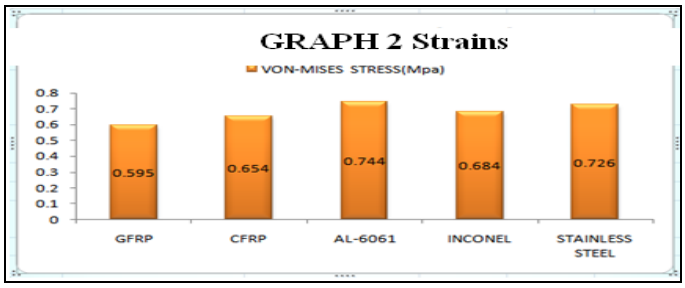

Figure 9 strain graph

Graph between total deformations :

This graph shows the different stress values in different materials, GFRP,CFRP materials have least Total deformation values compared to another three materials as shown below graph

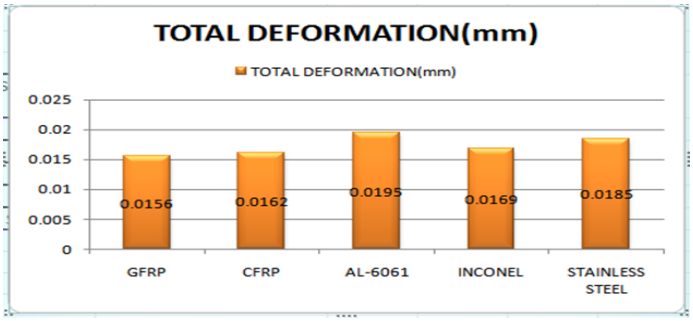

Figure 10 Total deformation graph

VII CONCLUSION:

Modeling and simulation of centrifugal blower fan has done using catia software. After observing the static analysis values we can conclude that GFRP, CFRP, better stress bearing capacity compared with the other materials and its showing better strength values when loads are applied . On doing static analysis of pump impeller it is clear that, the maximum Stress, strains and deformations are induced in Stainless steel , Al-6061, inconel materials compared to other materials(composites). If we compare stress, strain corresponding deformations of the material composites (GFRP,CFRP,) above result finally GFRP and CFRP is concluded as suitable material For centrifugal impeller and manufacturing the centrifugal blower impeller we can proceed with GFRP,CFRP materials because it has high stress bearing capacity and reasonable manufacturing cost.

REFERENCES:

(1) A Syam Prasad, BVVV Lakshmipathi Rao, A Babji, Dr P Kumar Babu , “Static and Dynamic Analysis of a Centrifugal Pump Impeller” International Journal of Scientific &

Engineering Research, Volume 4, Issue 10, October-2013, pp966-971

(2) Karthik Matta, Kode Srividya, Inturi Prakash , "Static and Dynamic Response of an Impeller at Varying Effects" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 1 Ver. III pp 101-106 (Jan. 2014),

(3) Pramod J. Bachche1, R.M.Tayade " Finite Element Analysis of Shaft of Centrifugal Pump" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 7, Issue 3 (Jul. - Aug. 2013), pp 37-42

(4) Amit Bhuptani, Prof. Ravi K. Patel, K. M.Bhuptani, "Design and Analysis of Centrifugal Pump", Journal of Information, Knowledge and Research in Mechanical Engineering, Vol.-2, Nov. 12-13, PP:196- 201.

(5) Ashish J. Patel, Bhaumik B. Patel, "A Survey of CFD Analysis of Centrifugal Pump Impeller", IJSRD, Vol.-2, 2014, PP. 911-914.

(6)Gundale V.A., Joshi G.R., "A Simplified 3d Model Approach in Constructing the Plain Vane Profile of A Radial Type Submersible Pump Impeller", Research Journal ofEngineering Sciences, Vol. 4, July 2013, PP. 33-37.

(7) Khin Cho Thin, Mya Mya Khaing and Khin Moung Aye,"Design and Performance

Analysis of Centrifugal Pump", World Academy of Science, Engineering andTechnology, Vol.-2, 2008-10-22, PP. 366- 373.

(8) Mehul P. Mehta, "Performance Analysis of Mixed Flow Pump Impeller using CFD",International Journal of Emerging Trends and Development, Vol.1, Jan 2013, PP: 647-661.

(9) Shardul Sunil Kulkarni, "Parametric Study of Centrifugal Pump and its Performance Analysis using CFD", International Journal of Emerging Technology and Advanced Engineering, Vol. 4, July 2014, PP: 155-161.

(10) Shyam Karanth, V. K. Havanur, " Design, Modeling & Analysis of a Submersible Pump and to improve the Pump Efficiency", International Journal of Latest Trends in

Engineering and Technology (IJLTET), Vol. 4, July 2014, PP. 178-190.

(11) Prof. V. M. Patil, Prof. D. M. Patil, Prof. V. K. Otari, Prof. U. N. Jawale, "Fluid Power" Nirali Publication, Third Edition, Pp. No.7.1-7.14.