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Analysis and design of impeller using carbon fiber reinforced fibreglass composite material

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ABSTRACT

This project addresses the need for advanced materials in the design of impellers for fluid machinery by exploring the integration of carbon fibre and fiberglass composites. Impellers, critical components in various applications, demand materials with superior strength, corrosion resistance, and reduced weight. In response, this study undertakes a thorough examination of the mechanical properties of carbon fibre and fiberglass composites, aiming to leverage their unique characteristics for enhanced impeller performance. The project entails a detailed methodology encompassing layup design, curing processes, and quality control measures to fabricate a composite impeller. Evaluation methods include structural analysis, fatigue testing, and fluid dynamics simulations.Anticipated outcomes involve the creation of a lightweight impeller demonstrating improved mechanical properties, contributing to heightened efficiency and extended service life in fluid machinery applications. Beyond the immediate application, the study aligns with broader goals of sustainable engineering by presenting a potential solution to reduce environmental impact during manufacturing while maintaining or improving performance. The successful implementation of a composite impeller has far-reaching implications for industries reliant on fluid machinery, promising advancements in both performance and environmental responsibility. This research seeks to bridge the gap between traditional materials and cutting-edge composite solutions, paving the way for innovative approaches in engineering and design.

KEYWORDS: composite material, carbon Fiber Reinforced polymer, Glass Epoxy

I.INTRODUCTION :

The mechanical properties of a polycarbonate matrix composite with glass fiber reinforcements used for the manufacture of a multistage centrifugal pump impeller are researched in this article. The material properties are modelled using Solid work and to determine the strain resistance of the composite with different proportions of reinforcements in ANSYS. The results have been verified by physical testing to determine the influence of the shape and mass proportion of reinforcements on its mechanical properties. The strength of the manufactured part is correlated to technological factors using the ANSYS 16.2, and the most and the least favorable combinations of these factors are determined.

The centrifugal pump creates an increase in pressure by transferring mechanical energy from the motor to the fluid through the rotating impeller. The fluid flows from the inlet to the impeller center and out along its blades. The centrifugal force hereby increases the fluid velocity and consequently also the kinetic energy is transformed to pressure.

Principle of the centrifugal pump

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BASIC COMPONENTS

Volute, casing, body or Diffuser

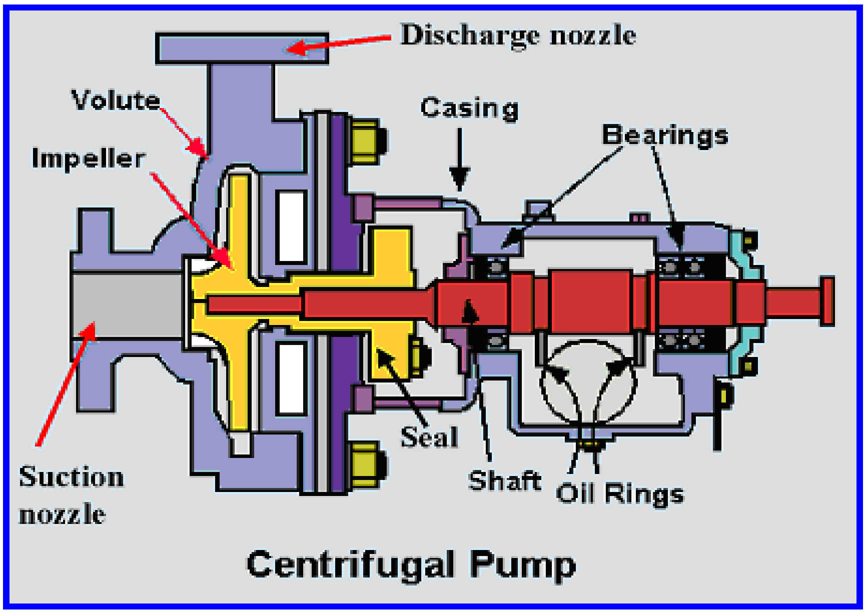
Impeller or impellers

Driver (motor)

Casing

The pump's casing houses the whole assembly and protects it from harm as well as forces the fluid to discharge from the pump and convert into pressure. The casings design does not influence TDH but is important to reduce friction losses. It supports the shaft bearings and takes the centrifugal forces of the rotating impeller and axial loads caused by pressure thrust imbalance.

Pump Impeller



The impeller is the essential part of a centrifugal pump. Its performance depends on the impeller diameters and its design. The pump's TDH is basically defined by the impeller's inner and outer diameter and the pump's capacity is defined by the width of the impeller vanes. In general, there are three possible types of impellers, open, enclosed and semi open impellers, each suitable for a specific application. Impellers are made of cast iron or carbon steel, while impeller for aggressive fluids and slurries to require high end materials to ensure a long pump.

OBJECTIVE

- Optimizing Weight-to-Strength Ratio: Utilizing the high tensile strength of carbon fiber to create a lightweight impeller without compromising structural robustness.
- Enhancing Corrosion Resistance: Incorporating fiberglass to provide enhanced corrosion resistance, particularly crucial in applications involving aggressive fluids.
- Advanced Manufacturing Techniques: Exploring advanced layup design and curing procedures to ensure precise material distribution and maximize the composite impeller's performance.
- Fluid Dynamics Optimization: Conducting fluid dynamics simulations to analyze and optimize the impeller's design for improved fluid flow patterns and efficiency

OPTIMIZATION OF DESIGN

The practice in industry to improve the performance of a pump is to redesign it based on the feedback gained from field experience. Though this method is reliable, it is tedious and time consuming. The optimization techniques are helpful to overcome the difficulty.

Impeller Design

D_O -The diameter of the impeller eye is dependent on the shaft diameter, D_S, which must initially approximated. The hub diameter, D_H, is made 5/16 to ½ inch larger than Ds. After calculating D_S and D_H, D_O is based on the known flow rate. The inlet vane edge diameter, D_1, made equal to D_O in order to ensure smooth flow.

Required head: h_V = 150 ft Required flow rate: Q=2000 gpmRequired speed: N = 2820 rpm

Dynamic Pressure Head:-

Applying Bernoulli principle: The first force cause the absolute velocity of the object as circumferential speed which means Dynamic Pressure Head. The equation of Dynamic pressure Head is,

Hd= U^2/2g = 14.26 mStatic Pressure Head:-

The second force creates the static pressure. If a mass moves radially outward along a vane of the impeller its orbit will be a spiral-shaped curve. We can easily calculate its angular speed. In two dimensions the angular velocity ω is given by

ω =2π*2960/60 =309.37 rpm

To identified the optimum results

To fabricate the optimum result impeller andfind the efficiency

OPTIMIZATION OF DESIGN

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Impeller Design

Do -The diameter of the impeller eye is dependent on the shaft diameter, Ds, which must initially approximated. The hub diameter, DH, is made 5/16 to ½ inch larger than Ds. After calculating Ds and DH, DO is based on the known flow rate. The inlet vane edge diameter, D1, made equal to DO in order to ensure smooth flow.

Required head: hv = 150 ft Required flow rate: Q=2000 gpm Required speed: N = 2820 rpm

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So during it movement the centrifugal force Fc always present as

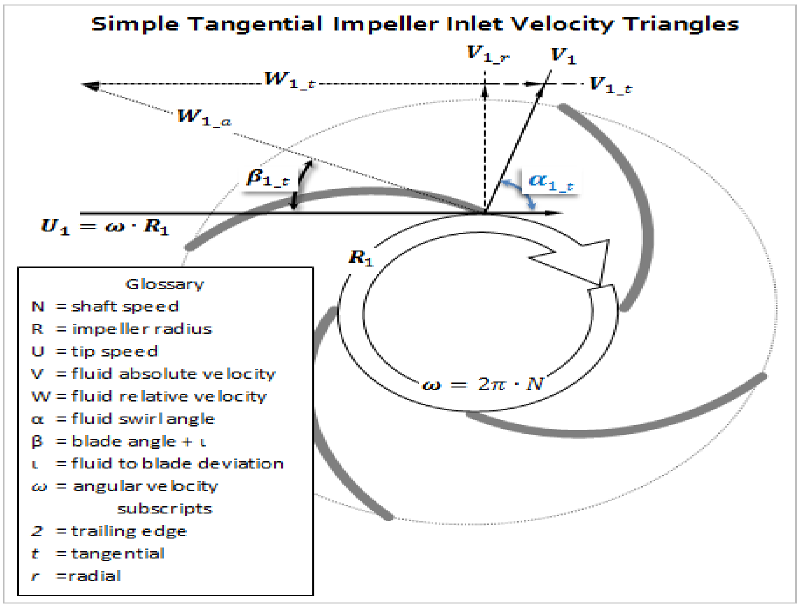
Fc=mrw2=1132.3N

The centrifugal acceleration increase linearity on the radius R (variable). In constant gravitational acceleration g, static pressure of a column of water h is

Hs = gh = 96.76 m

Velocity diagram and work done by impeller:-The velocity diagram and work done by impeller of centrifugal pump on the liquid may be derived same way as for a turbine, since radial flow centrifugal pump acts as a reversed of an inward radial flow reaction turbine

.II.RELATED WORKS



Generally, centrifugal pump impellers are made of cast iron, cast steel, stainless steel, alloy steel,carbon structural steel, and non-metallic materials and the common material used for water pump impeller is cast iron. This results in the high weight of pump and also high corrosion and less fatigue strength. In the given context for ever-increasing need anddemand for higher and better pumping efficiencies, pump designers and manufacturers are seeking out for new and better ways of increasing the performance characteristics of pumps. Many factors affect centrifugal pump performance which includes cavitation, flow rate,static pressure head, dynamic pressure head,specific speed, poweretc.

III.PROPOSED SYSTEM

The dimensions for modelling the pump impeller are chosen as the following:

Source	DF	SeqSS	Contribution %	AdjSS	AdjMS	F-Value	P-Value
Material	2	3.45	16.06	3.45	1.72	2.83	0.261

Angle	2	1.41	10.03	1.41	0.71	1.16	0.463
No ofblade	2	28.23	70.89	28.2	64.11	45.47	0.120
Error	2	1.22	3.02	1.22	0.61		
Total	8	34.31	100.0				

The static analysis results of mean effects plot for means and for S/N ratio is shown in show Fig.. In these results, the number of blades influences the most on static pressure while the blade angle influences the least. Since the aim is get the maximum stress value, Larger is better has chosen. Table 4 represents the maximum affecting parameters from analysis. In modal analysis we can observe the natural frequencies and totaldeformationbecause ofvibrations producedatdifferentnodes. Results of this simulation are compared among themselves to choose a suitablematerial

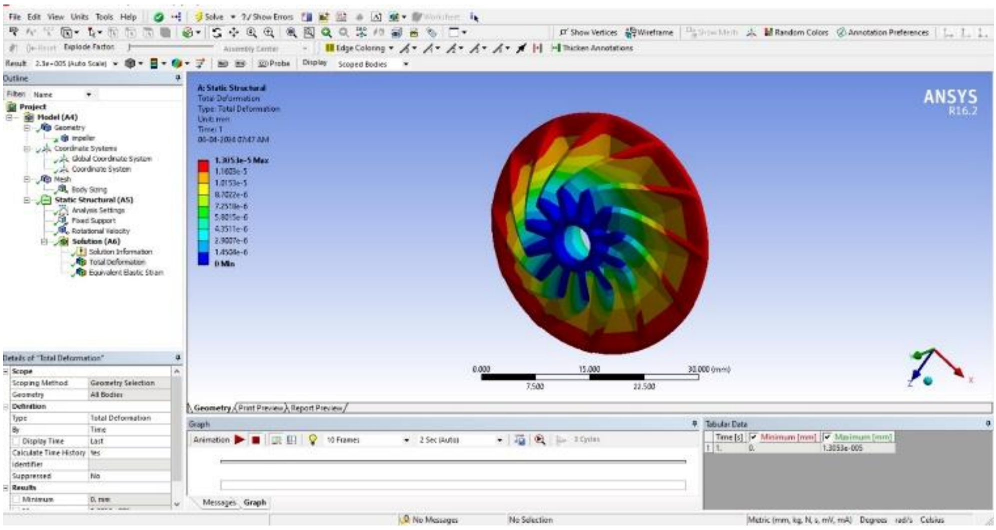
IV ANALYSIS

BOUNDARY CONDITIONS OF DOOR IN ANSYS WORKBENCH

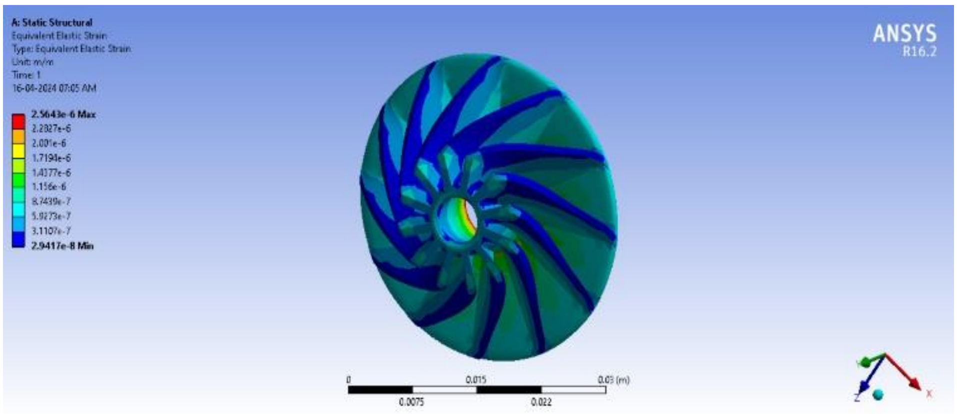
A software model is accomplished by using proportions of shell, tubes and baffles in ANSYS 16.2. Workbench design modeler is used to construct Heat exchanger geometry and for further analysis. Geometry is made easy by making an allowance for the plane symmetry. This heat exchanger is counter flow type and the tube side consists of one inlet and one outlet representing of 36 complete tubes and taking into consideration the symmetry. After model is generated, run thermal simulation of heat exchanger. The outcomes prevailed were moderately well- known with general circumstance. The parts independently as well as in congregation are as shown below

EXPERIMENTAL WORK

1.Total deformation



2.Structural Analysis



V.RESULT

It can be noted in the diagrams shown in Figure , that junction lines are formed at the places where the orientation of the fiber strings changes. It is also necessary to note the location of the junction lines, as stress concentration occurs at the junction lines, mesh openings and mounting positions. The numerical calculation shows that the highest intensity of stress concentration occurs with two injection points along two long junction lines.

The static analysis results of mean effects plot for means and for S/N ratio is shown in Fig. 10. In these results, the number of blades influences the most on static pressure while the blade angle influences the least. Since the aim is get the maximum stress value, Larger is better has chosen. Table represents the maximum affecting parameters from analysis.

Experiment num	ber X 1	$X2$	y	$X1$ $X2$	X^2	X^2 X^2	X X^3	$X1$ $X2$y	X^4	X^2 y 2
1	270	3	1.41	810	9	656100	7290	1142.1	81	12.69
2	260	3	1.51	780	9	608400	7020	1177.8	81	13.59
3	270	1	1.56	270	1	72900	270	421.2	1	1.56
4	260	1	1.49	260	1	67600	260	387.4	1	1.49
Σ	1060	8	5.97	2120	20	1405000	14840	3128.5	164	29.33

VI.CONCLUSION

The detailed methodology for numerical simulation of a composite material based on polycarbonate with chopped fibers to produce impellers of a multistage pump was presented in this article. Numerical analysis was performed to determine the stress- strain curve and the failure criterion at the microlevel, making it possible to predict the strength of the composite and reduce the number of full-scale experiments. The results of numerical analysis and full-scale experiments decided the composition of polycarbonate and chopped fibers. The tensile strength of the material reaches 150 MPa, with the difference between numerical and full-scale experiments occurred as 7% in stress-strain and 20% in engineering data, the difference being conditioned by the influence of technological factors of the injection molding process**..**

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