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Optimum Design and Analysis of Centrifugal Pump Impeller

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***Abstract*--- Centrifugal pump is very essential equipment and very useful for water pumping for domestic as well as agriculture purpose. Impeller is heart of centrifugal pump. This paper revolves around the concept of optimize and efficient design of centrifugal pump impeller using simulation software ANSYS and other suitable software. Performance parameter like head, rotational speed, pressure distribution, pump efficiency will compare by analysis.**

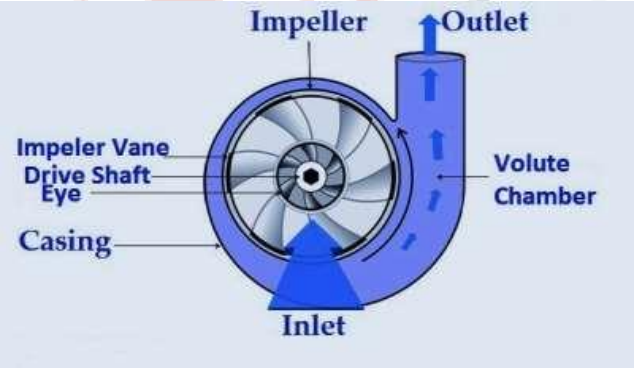
***Index Terms*— Centrifugal pump, impeller, analysis, ANSYS**

I. INTRODUCTION

Centrifugal pump comes under category of mechanical pumps. Pump is used for transporting fluid from one place to other. It is useful for daily usage like domestic, agriculture and industrial applications. Basically pumps are classified as positive displacement pump and non-positive displacement pump (Hydrodynamic). Centrifugal pump is hydrodynamic type pump. Centrifugal pump is power consuming device we have to supply power in order to operate pump. In pump energy conversion takes place and fluid is pressurized due to centrifugal action. Centrifugal pump creates vaccum at entrance and fluid sucked in the eye, impeller increases pressure of fluid by means of conversion of kinetic energy into pressure energy.

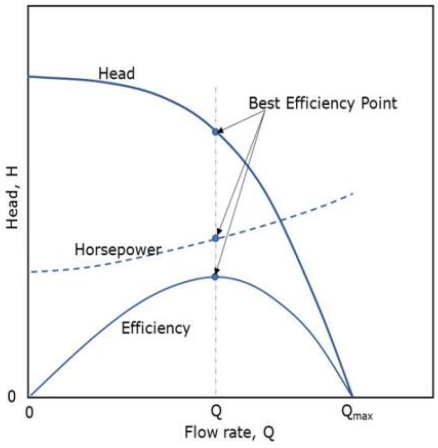
II. WORKING AND METHODOLOGY

Figure shows constructional details of centrifugal pump and impeller working.



The basic working of centrifugal pump is when an external torque is applied on a certain mass and it results velocity energy conversion into pressure energy and finally it results in rise in pressure head. The main difference between positive displacement pump and dynamic pump is positive displacement is used for fixed volume of fluid, high pressure whereas dynamic pumps are used for high flow rate. Centrifugal pumps are category of dynamic pump. Centrifugal force acting on the fluid that makes it to flow within the casing. The rise in the pressure head of the rotating liquid at any point is directly proportional to the square of tangential velocity of the rotating liquid. Pressure head is inversely proportional to flow rate.

Rise in pressure head =v^2/2g



A pump performance curve indicates how a pump will perform in regards to pressure head and flow. Typical centrifugal pumps will show an increased flow rate as head pressure.

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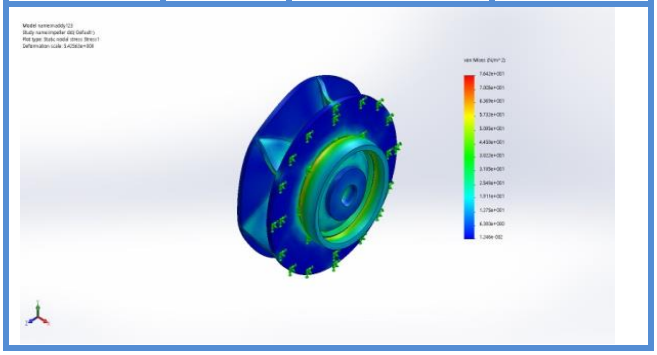
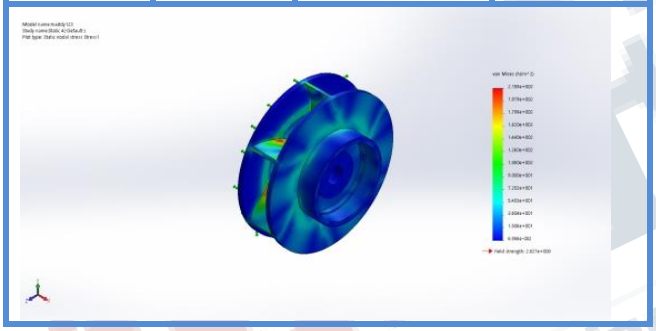
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.0124616 N/m^2 Node: 16175	76.4203 N/m^2 Node: 9591



Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.0698576 N/m^2 Node: 16028	215.912 N/m^2 Node: 7619



Model construction-

ANSYS is used as a design tool. It is an engineering analysis software widely used for structural analysis, computational Fluid Dynamics methods.

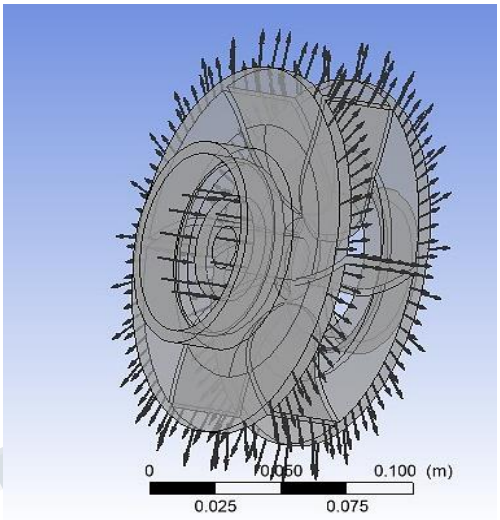
Pump Specifications –

Pump specifications are studied before the impeller can be designed because the performance is affected by impeller geometry. Following table shows pump specifications

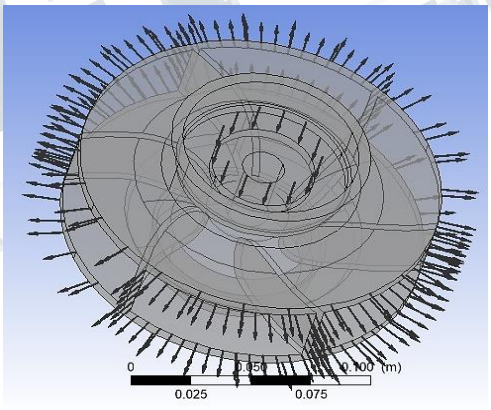
Table 1:- Description Of Pump parameters

Parameters	Dimensions
Pump Head	10 m
Flow Rate	250 GPM
Motor Speed	1440 RPM
Outlet Mass Flow Rate	20 Kg/s
Number Of Blades	6

Model Construction- Solid modeling software is used for three-dimensional model. Number of blades for impeller is six. Figure below the isometric view of the impeller.



Meshing- The meshing is used combination of quadrilateral and triangle mesh.



Isometric view of rotational boundary condition

III. RESULTS

CFD Analysis- Area Weighted Average

Static Pressure	(Pascal)
inlet	-391006.2
Velocity Magnitude	(m/s)
inlet	27.943021
outlet	10.151361
Turbulent Kinetic Energy (k)	(m2/s2)
inlet	2.9373731
outlet	2.9499495
blades	4.4154296

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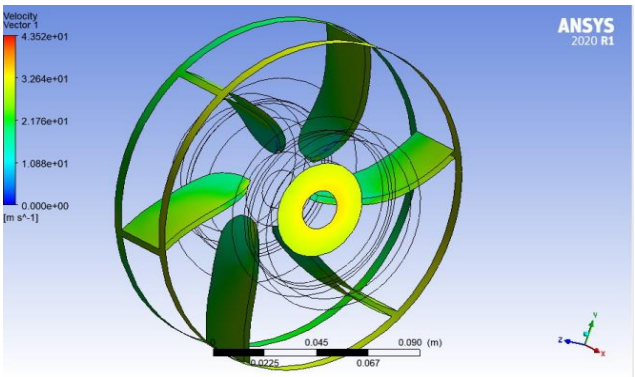


Mass Weighted Average –

Static Pressure	(Pascal)
impeller- free parts	-573405.42
Mass Flow Rate	(kg/s)
inlet	35.125929
outlet	35.126732

Sample calculation –

Inlet power = $2\pi NT$/ 1000 * 60 = 2π*1440*50 /60000 = **7.53 KW**

Outlet power = (Po - P1)Q/1000 = (327000-32000)*0.016 /100 = **4.44 KW**

Efficiency = **0.5896**

Pressure to head conversion at different pressure

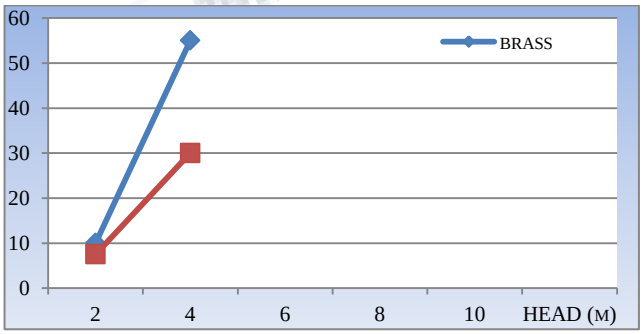
H = 10.197 *p / specific gravity

= 10.197*1 / 1= **10.19 m of liquid**

H = 10.197*1.35/ 1 = **7.5 m of liquid**

IV. RESULTS AND DISCUSSION –

Impeller Material	Head (m)	Flow rate (m^3/hr)*10^-2
Brass	10	55
Cast Iron	7.5	30



Comparison graph of Head (m) Vs Discharge (m^3/hr)*10^-2 Of CI and Brass impeller

The following conclusions are drawn from this work -

1. Brass impeller is most efficient impeller from observation with greater discharge and head with comparison to cast iron impeller
2. From material properties analysis in solid modeling tensile strength and shear modulus of Brass impeller is better than Cast Iron impeller.
3. From CFD analysis values of fluid pressure, velocity and mass flow rate were got is used for determining Head of fluid by doing calculations.

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