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ANALYSIS AND PERFORMANCE ENHANCEMENT OF REGENERATIVE TURBINE PUMP

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Abstract— **Pumps are used for lifting and transporting of liquids since industrial revolution. The different types of pumps were developed for the purpose of specific applications. One among them is Regenerative pump for getting high lift and also with self priming capability. Regenerative turbine pumps are used for clean nonabrasive fluids with relatively high head and low flow requirements. The impeller is generally a solid disk with impulse type buckets cut around its periphery or radial blades on the upper part of the walls near the periphery. The latter is referred to as the side entry type. The flow is acted upon by a chain of impulse turbine type pulses as each vane imparts energy to the fluid being pumped. The energy imparted by these impulses from the impeller blade increases as the liquid makes its way along the casing passage. The pressure at zero flow can be several times than at the full load rating or the best efficiency point of the pump. The casings are concentric (equal cross-sectional area), as opposed to the volute type. The regenerative turbine pump follows the affinity laws of centrifugal pumps with capacity being proportional to the speed and head proportional to the square of the speed. In order to enhance the efficiency of the regenerative turbine pump an effort is exercised by modification of impeller blade profile.**

Key words **- ANSYS Fluent, CFD, Impeller blade profile, Regenerative Turbine Pump.**

I. INTRODUCTION

Pumps are used for lifting and transporting liquids in industries, and domestic purposes. Generally pumps are classified in two major categories i.e., 1. Positive displacement and 2.Dynamic pumps. The most important one is Centrifugal pump of dynamic category, which lifts and circulates the fluid by imparting kinetic energy to the fluid being pumped.

Regenerative pumps are the kind of Dynamic or Kinetic pumps which can develop high heads at low flow rates with a single impeller. At low specific speeds the pump also shares characteristics with positive displacement pumps and centrifugal pumps. The head rise is achieved through an exchange in momentum between the impeller and the fluid. In spite of low efficiency, usually less than 50%, regenerative pumps can offer a more efficient alternative to other (centrifugal) pumps in specific applications.

A regenerative pump is also called a turbine pump or peripheral pump. The impeller has vanes on both sides of the rim that rotate in a ring like channel in the pump's casing. The fluid does not discharge freely from the tip of the impeller but is re-circulated back to a lower point on the impeller diameter and given additional energy. The design of the pump includes for a special impeller with a large number of radial blades. The fluid heads developed in this type of pump can be very high and the pump should not be used without a close coupled relief valve in the system.

In a regenerative pump, liquid being pumped enters and exits repeatedly through pump impeller blades during each revolution of the impeller. The velocity and pressure increases of the liquid are therefore gradual compared to the centrifugal pump. Liquid entering the pump near its vapor pressure is less likely to experience the pressure change that can cause cavitations due to the smaller pressure gradient. Therefore, regenerative pumps, typically, require lower net positive suction heads than centrifugal pumps.

This pump is generally made from special materials to combat the corrosive conditions resulting from the high degree of turbulence experienced within the casing. This design uses peripheral or side channel vanes or buckets that are manufactured integral with a rotating impeller to impart energy to the pumped liquid. Through shearing action, the liquid acquires a spiral rotation as it passes into the buckets of the rotating impeller. Fig.1 indicates a regenerative turbine pump with impeller and casing while Fig.2 indicates how pressure builds up continuously from suction to discharge side.

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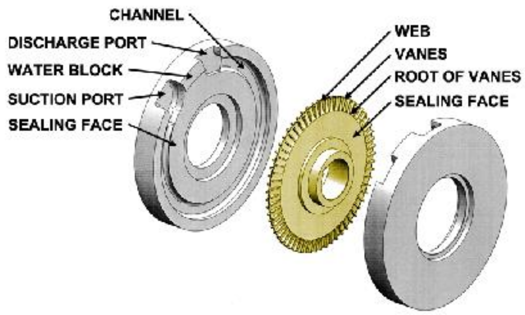

Fig 1: Regenerative turbine pump impeller showing radial vanes on each side of its rim

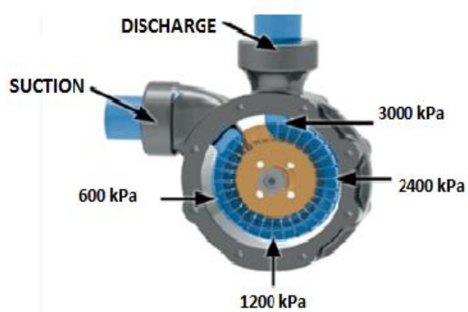

Fig.2 Pressure produced by a regenerative turbine pump increases continuously from suction to discharge

A. Pump Specifications

The following image in Fig.3 shows the existing regenerative turbine pump as available in the market and Table-I indicates the specification.

Fig.3 Image of existing regenerative turbine pump

TABLE -I: SPECIFICATION OF THE PUMP UNDER STUDY

Pump kW/HP	0.37/0.5
Maximum Current	3.5 A
Frequency	50Hz
Speed	2880 RPM
Voltage	240 V
Discharge	850 lph
Size	25 x 25 mm
Total Head	15 / 25 m
No. of vanes	36 vanes
Thickness of Vane	1.2mm
Diameter of Impeller	65mm

II. ANALYSIS OF THE PUMP

The meshing of the model is done in ANSYS workbench. Interface surfaces are created so as to separate the fluid regions into stationery and rotating surfaces before meshing. Fig.4 and 5, indicate the three dimensional mesh of the pump fluid region for Existing and Modified impeller with Casing Assembly.Fig.6 and 7 indicate the model of the Existing and Modified impeller.

TABLE- II MESHING OF EXISTING, MODIFIED IMPELLER WITH CASING ASSEMBLY

Parameters	Existing	Modified
Meshing Type	3D	3D
No.of Nodes	3857668	4084180
No.of Elements	19614899	20874124

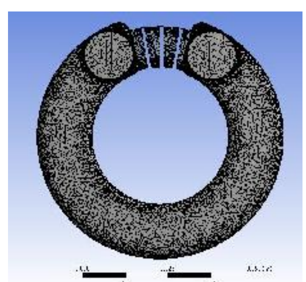

Fig.4 Three dimensional mesh of fluid region for existing Impeller

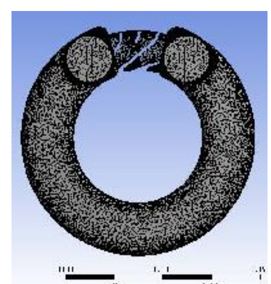

Fig.5 Three dimensional mesh of fluid region for modified Impeller

Fig.6 Model of Existing Impeller

Fig.7 Model of Impeller with Modified blade profile

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TABLE- III GEOMETRIC STUDY OF IMPELLERS

Parameters	Existing	Modified
Number of Blades	36	36
Full length Blade	36	18
Intermediate Half Blades	-	18

By modifying the Blade profile and geometry, the turbulence losses were kept lesser than the existing Impeller.

Boundary Conditions

A regenerative turbine pump impeller domain is considered as the rotating frame of reference with a rotational speed of 2880 RPM. The working fluid through the pump is water. K-omega viscous turbulence model with turbulence intensity of 5% is considered. The casing and impeller domain chosen for analysis which is symmetric about vertical axis. Hence half of the domain is taken for analysis.

III. RESULTS:

a) Velocity Stream lines of the existing impeller

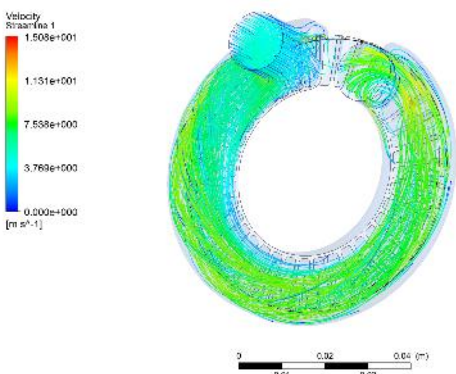

Fig.8 Image of stream lines of the existing impeller

b) Velocity Stream lines of the modified impeller

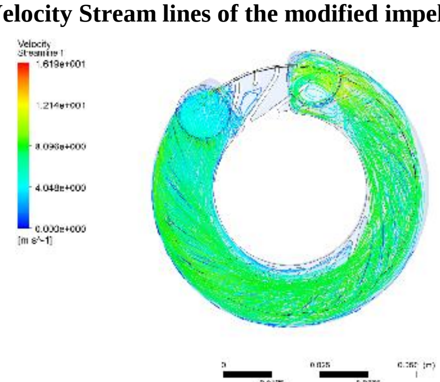

Fig.9 Image of stream lines of the modified impeller

c) Pressure Contour of Existing Impeller

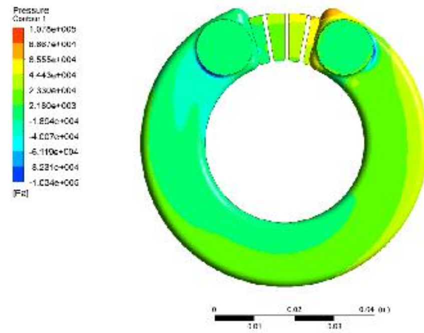

Fig.10 Pressure contour of existing impeller

d) Pressure Contour of Modified Impeller

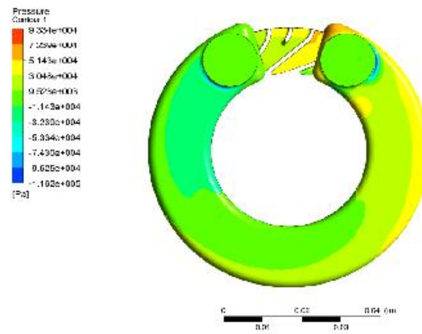

Fig.11 Pressure contour of modified impeller

TABLE- IV RESULTS BASED ON CFD ANALYSIS

Parameters	Existing Impeller	Modified Impeller
Pressure at inlet – gauge	0	0
Pressure at outlet - gauge	40 kPa	42.6 kPa
Mass flow at outlet	0.679 kg/s	0.682 kg/s
Improvement % on pressure	---	6.5%

IV. CONCLUSION

ANSYS fluent CFD is a vital tool which helps in visualizing the complex flow phenomena that exists in a regenerative pump.

From the above Table - IV, it is evident that performance of the regenerative turbine pump is enhanced to 6.5% on outlet pressure for the same mass flow.

APPENDIX

ANSYS - Analysis System
CFD - Computational Fluid Dynamics
RPM - Revolution per minute
kPa - Kilo Pascal
Kg/s - Kilogram per second
Lph - Litre per hour
CVRDE - Combat Vehicles Research and Development Establishment.
DRDO - Defence Research and Development

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Organisation.

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BIOGRAPHIES

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