Energy Scenario of a Centrifugal Pump by varying Tip Clearance

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Abstract –*Centrifugal Pumps play a major role in household as well as industrial applications. The energy consumption of the centrifugal depends upon its load, type of application and also on the type of impeller used. The energy scenario in centrifugal pumps remains eventful. In an attempt to evaluate the energy performance with the varying tip clearance of the Centrifugal Pump fitted with a semi-open impeller, an experimental analysis has been done and the performance has been observed. The performance test was conducted with varying the discharge of flow as well as the tip clearance of the pump. This pump has been designed with an annular casing. Experimental analysis has been concluded with a thought of the right tip clearance and its effect on the energy scenario of the chose centrifugal pump. The energy scenario was described as a measure of calculating the input and output power.*

Key Words:Semi-open impeller, Tip Clearance.

1. INTRODUCTION

Centrifugal pumps is of inevitable nature as they are being deployed in household, processing industries, agriculture, cleaning and a lot more activities. Parameters of the pump have to be designed in such a way that it should consider the internal flow of the pump. For instance, designing of the impeller of the pump must involve the selection of type of flow [1] and also on the flow characteristics. Centrifugal dynamically moves fluid from one section to another section by the principal of momentum creation [2]. Several researchers have tested the flow through pumps using CFD Analysis [1],[3] but researches for energy consumption remains limited.

Any Centrifugal pump would generally have the following main components (a) Impeller, (b) Casing, (c) Foot Valve, (d) Connecting Shaft, (e) Electrical Motor, (f) Suction and discharge pipes. Tip clearance is the distance between the impeller and the casing body. Several researchers [4-7], have tested the effect of tip clearance effects in compressors but the tip clearance research work on pumps remains limited. This research work has tested the energy performance of the pump by varying tip clearance.

Energy conservation in pumps will definitely lead to an efficient and sustainable environment in industries [8]. Hence it is to utmost importance to operate pumps in an energy efficient way. Energy efficiency will directly involve the performance of the centrifugal pump.

2. DESIGN OF THE CENTRIFUGAL PUMP

2.1Design of the Impeller

Impellers for pumps can be categorized into three types based on the physical configuration.

1. Closed Impeller
2. Semi-Open Impeller
3. Fully Open Impeller

Closed impellers are characterized by front and back shrouds, Semi-open by its back shroud and Fully open impeller by no-shroud. The impellers are shown in Fig.1

(a) (b) (c)

Fig -1: (a) Closed Impeller, (b) Semi-open Impeller, (c) Fully Open Impeller

In this research work, semi-open impeller has been designed by multiple arc method. The major specifications of the designed impeller include:

- Number of Blades = 6
- Blade inlet angle = $24^0 29'$
- Blade outlet angle = 27^0
- Shaft diameter for impeller = 25mm

A Solid stepped shaft was used to connect the impeller with the motor coupling. The solid shaft assembly consisted of the following components:

1. Solid Stepped shaft of 550mm length.
2. Bearings (ISI25BC03)
3. Plummer Block (MASTA)
4. Motor Couplings (Couplings mating Φ25mm shaft and Φ28mm motor shaft were chosen)

The designed impeller was casted and then machined by Vertical milling for to contour out the impeller blades. The model of designed impeller is show in Fig.2

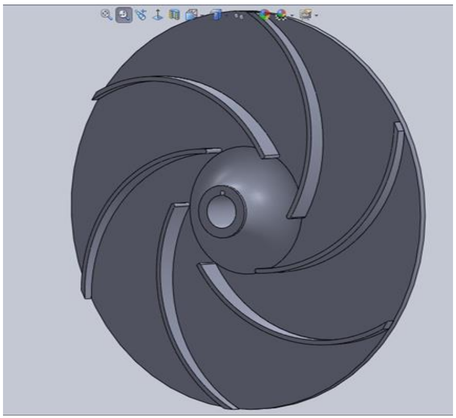

Fig -2: Model of the impeller.

2.2 Design of Casing

Annular configuration was chosen for the pump casing such that a constant flow volume can be obtained between the impeller and the casing inner circumference. For the ease of assembly, the annular casing was designed to be of three compartments:

1. Front transparent compartment (PMMA) (Plexiglas)
2. Middle compartment (Cast Iron)
3. Rear closed compartment (Cast Iron)

Fig -3(a): Rear Compartment of Annular Casing

Fig -3(b): Middle Compartment of Annular Casing

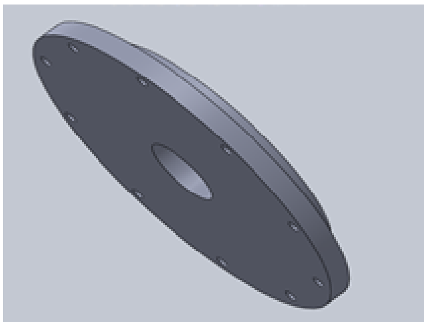

Fig -3(c): Front Compartment of Annular Casing

The entire assembly is as shown in Fig.4

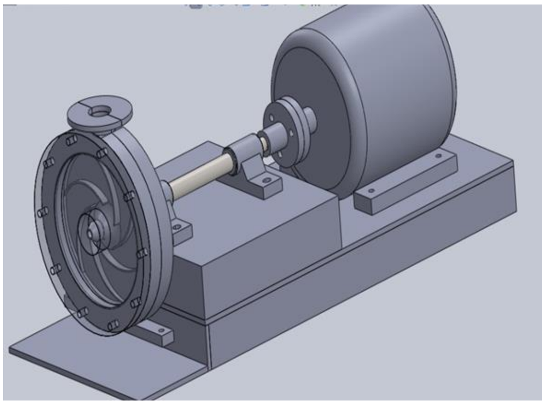

Fig -4: Designed Pump Assembly

4. EXPERIMENTAL ANALYSIS ON THE CENTRIFUGAL PUMP

A Performance test on the centrifugal pump was conducted with varying tip clearances of 1.5mm, 3mm and 4.5mm. Provisions were provided at the seat of the impeller on shaft for to adjust the tip clearances and to perform the test. The performance of the pump was tested by varying the discharge of the pump by the delivery valve provided. The experimental results are shown in Fig.5, Fig.6, and Fig.7

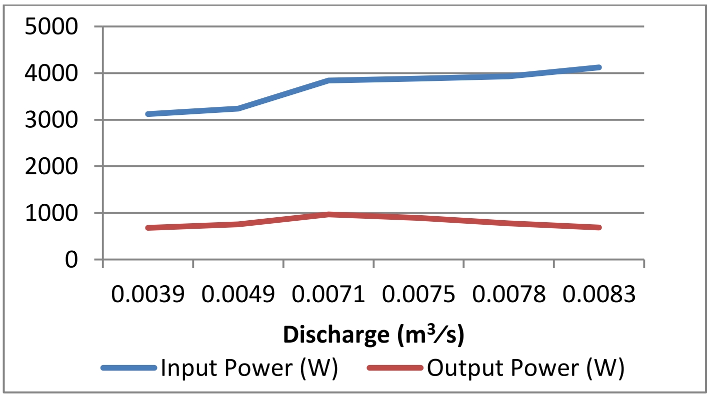

Chart -1: Performance Characteristics of Pump at 1.5mm Tip Clearance

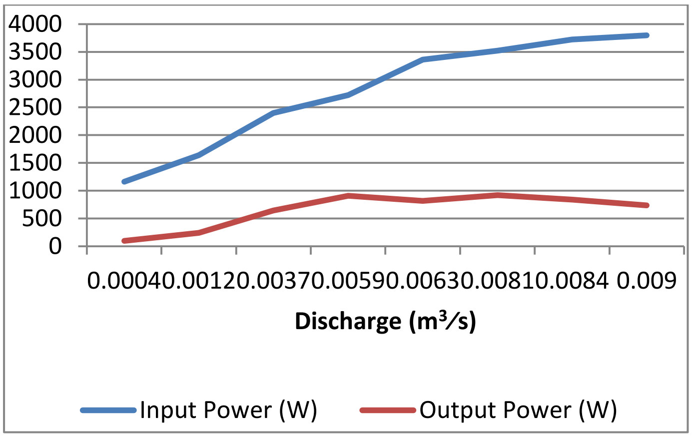

Chart -2: Performance Characteristics of Pump at 3mm Tip Clearance

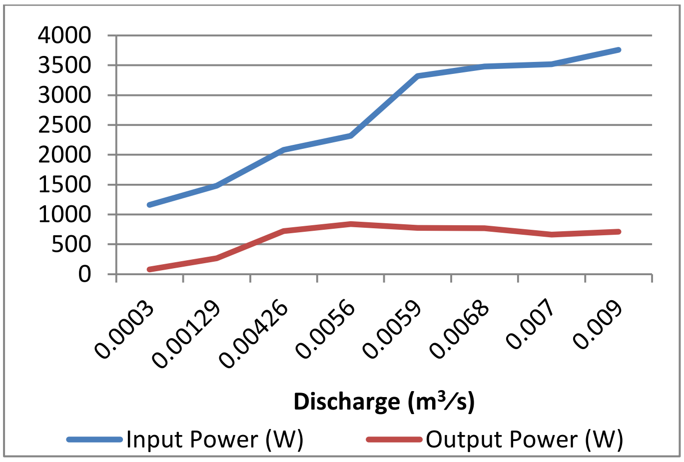

Chart -3: Performance Characteristics of Pump at 4.5mm Tip Clearance

5. POWER CONSUMPTION IN THE CENTRIFUGAL PUMP

The scenario input power to the pump varies different from the output power which is basically hydraulic power. When considering the case of tip clearance of 1.5mm (Chart -1), the input power increases with increase in discharge. The entire power consumption domain lies between 3000W to 4000W. For tip clearances of 3mm (Chart-2) and 4.5 mm (Chart-3) the scenario for input power seems similar in variation with a domain between 1000W to 3700W. Hence it can be concluded that tip clearance of 1.5mm if found to consume higher power and hence is found not suitable when considering the input power alone

The scenario of output power is different from the input power. Taking into consideration the system efficiency, we can find that 1.5 mm tip clearance is also found not suitable. The output power seems fluctuating with discharge and the range of output power is also very low comparatively. Also the performance of 3mm tip clearance configuration is much more efficient than 4.5mm taking into consideration the input power also.

6. CONCLUSIONS

Major conclusions that can be rendered from the experimental analysis are as:

1. The performance of the pump with respect to power consumption is not satisfied when operated at 1.5mm tip clearance. The Input Power consumed by the pump is high in this case.
2. Regarding input power 3 mm and 4.5mm tip clearances show a similar trend.
3. Comparing with the output power of the centrifugal pump, it can be concluded that 3mm tip clearance will be best suited for best energy efficiency of the centrifugal pump.

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BIOGRAPHIES

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