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Efficiency Enhancement of Centrifugal Water Pump by Using Inlet Guided Vanes

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ABSTRACT

The demand of national economy is energy. Centrifugal water pumps are being used in several applications from household usage to the industrial operations so efficiency enhancement is the major concern in the developing research. The efficiency of the centrifugal water pump is enhanced by using inlet guided vanes (IGV) in its suction pipe which generates the pre-whirling of water before entering into the centrifugal pump. Numerically and experimentally examined its performance at different angles of (IGV) and done experiments having a variety of flow rates. The results obtained from experiments evinced that head can be altered by using (IGV). Efficiencies are observed at different angles 0°, 30°, 45°, 60°of pre-whirling of water. The performance curves were obtained at different conditions of operations. Experimental results revealed that (IGV) decline the cavitation in centrifugal water pump and augment the efficiency of centrifugal water pump at the 30° best angle of pre-whirling.

Keywords: Centrifugal pump, IGV, Inlet guided vanes section IGVS, Pre-whirl regulation

INTRODUCTION

The fortune of national economy based on energy. Energy saving and efficient technologies are becoming important due to the developing of economy. As centrifugal pumps have higher consumption so they are having higher capability towards less saving of energy. Inlet guided vanes are used in centrifugal compressors to control the mass flow and pressure ratio at constant rpm. From several decades the centrifugal compressors having (IGV) are being examined sufficiently. The review of literature of (IGV) for compressors lie in categories of impact of inlet guided vanes on centrifugal compressors, [1-2] interpretation of energy [3-4]; methods of design and parameters of structure of (IGV) [5-6]. Comparing with the centrifugal pumps it seems to be uncommon for centrifugal pump but installation of IGV reduces the losses being generated due to the sudden impact of water on impellers eye and pre-whirling tends to reduce the cavitation. Cavitation tends to fluctuate pressure and irregular distribution of load which minimizes the efficiency of the centrifugal pump and makes it unstable. Many researchers performed their work on the problem of cavitation [7]. There is also some research on the pre-whirling effect in pumps [8]. 3D design of IGV and introductory study of pre-whirl regulation mechanism in centrifugal pumps is proposed. Their conclusions show that IGV has an impact on the efficiency and head of centrifugal water pump. This paper examines the impact of different pre-whirling angles on the efficiency and head of the pump and the performance curves were obtained at different conditions of operations as to nurture study of the work by Tan et al [9].

EXPERIMENTAL APPARATUS

The parameters of centrifugal water pump are shown in Table -1. In Inlet guided vanes section (IGVS) the installed guided vanes which had 3D shape were designed having the method given by Tan *et al* [8]. The arrangement of guided vanes was uniform along the circumference as shown in the fig 1. The movement of guided vanes were aided with planetary hypoid bevel gears. The sun gear installed on the inlet pipe rotates the planetary gears which rotates the vanes inside the pipe. Thus pre-whirling is controlled by the angle adjuster which moves on the angle scale from 0 ° to 90°. The most suited axial distance was maintained at 101.6 mm according to tan et al [9]. The angles of guided vanes with the reference axis are shown in the fig. 2 where different angle planes are shown to ease the understanding. The (IGVS) shown is having a reference plane and all the angle planes that were calibrated from this plane. The impact of (IGV) on centrifugal water pump is examined by the test apparatus shown in the fig 3. The apparatus consisted of components such as centrifugal pump, inlet pipe, outlet pipe, pressure gauge, vacuum gauge, storage tank, regulating ball valve, drain valve, IGVS (inlet guided vanes section), flow meter is shown in the fig. 3.

Table -1 Parts of Centrifugal Water Pump

Item	Value
Volumetric flow rate Q (m^3/h)	37
Head H(m)	20
Rotational speed n(r/min)	1200
Blade numbers	5
Diameter of suction pipe(mm)	50.8

Table -2 Parameters of Guided Vane

Item	Value
Hub of guide vane (mm)	10.16
Blade numbers	5
Shroud of vanes (mm)	50.8

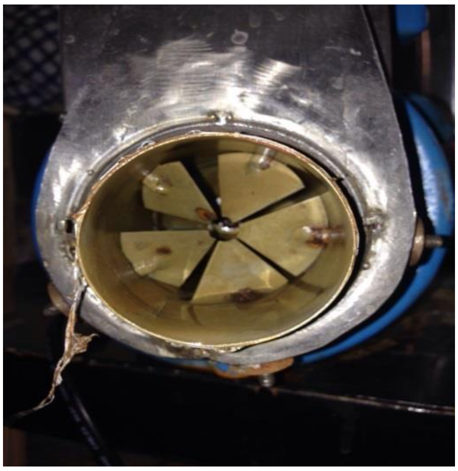

Fig 1 Guided vanes

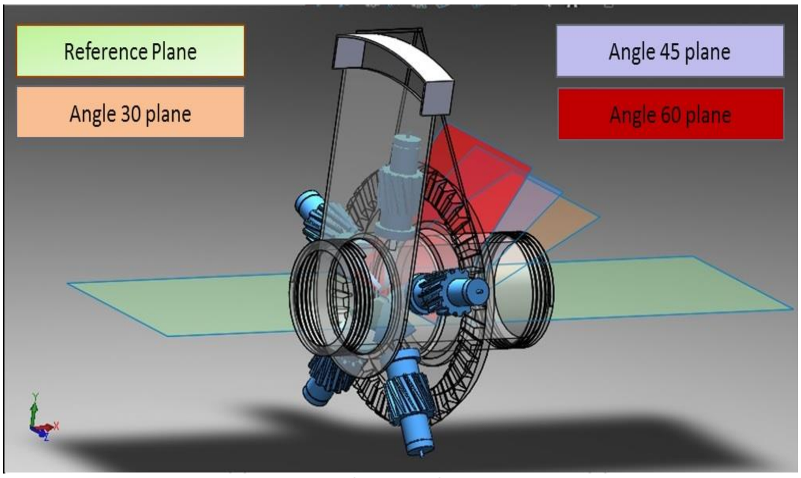

Fig 2 Planes of angles of guided vanes

Fig 3 Centrifugal pump with guided vanes

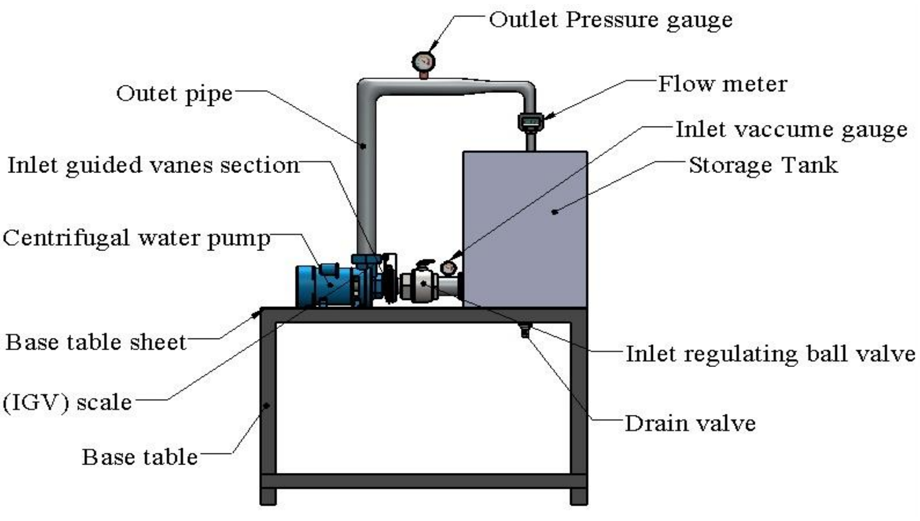

Fig .3 Components of the apparatus for testing impact of guided vanes on centrifugal pump

Head of our experimental apparatus was calculated as

$$H = \frac{\Delta P}{\rho g} \quad (1)$$

Whereas ΔP is differential pressure and ρg is specific weight. Then efficiency was calculated as

$$\eta = \frac{P_w}{P_{BHP}} \quad (2)$$

Where P_{BHP} is the brake horsepower of the shaft of centrifugal water pump and P_w is the power of water which is

$$P_w = \frac{\rho g H Q}{3.6 \times 10^6} \text{ Kwatt}$$

Then suction head of our experimental apparatus was calculated as

$$h_s = \text{static head} + \text{velocity head}$$

$$h_s = p_s / \gamma_{liquid} + v_s^2 / 2g \quad (3)$$

Whereas P_s is the suction pressure and γ_{liquid} is the specific weight of water and V_s is the Suction velocity. Whereas net positive suction head required was calculate as

$$NPSH_r = h_s - h_v \quad (4)$$

Whereas h_s is suction head whereas h_v is vapor head. The net positive suction head available was calculated as

$$NPSH_a = h_s + h_e - h_v \quad (5)$$

RESULTS AND DISCUSSIONS

From the fig 4 it is clearly visible that increase in head results in increase in NPSHa. As NPSHa is related to the cavitation in the centrifugal water pump. Maximum NPSHa is at an angle of 30° and it decreases with an increase in further angle. Without (IGV) which means that at an angle of 30° the cavitation is degraded. In the fig 5 when the flow rate increases the head tends to decrease. The maximum flow rate attained by the pump is at an angle 30 °of IGV and decreases by further increase in the (IGV) angles. As shown in the fig 6 the efficiency is maximum at an angle 30 and decreases by increasing the angle of (IGV).Without (IGV) the experimental results show lower efficiency while at an angle 30 ° centrifugal pump efficiency is enhanced by 2%.

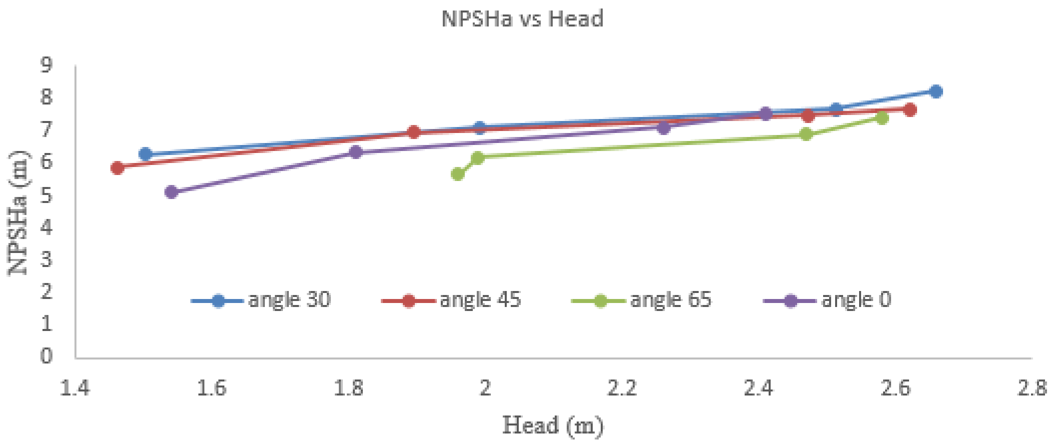

Fig. 4 Experimental results of NPSHa at different (IGV) angles

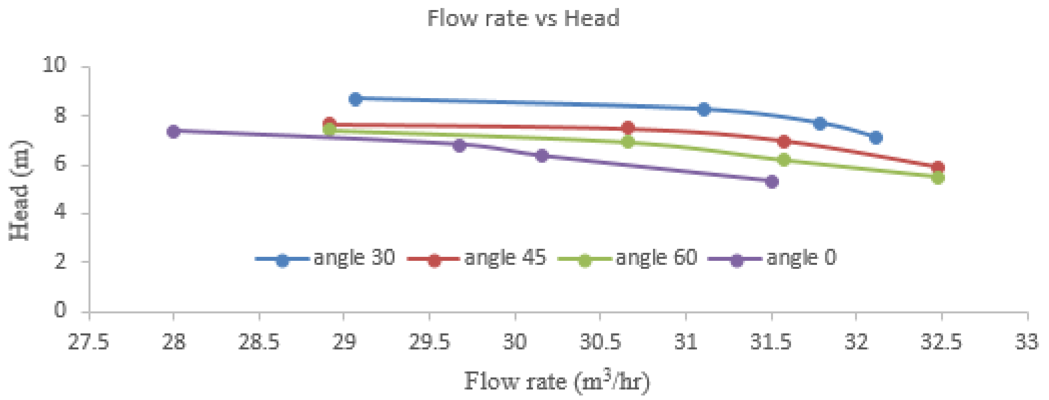

Fig. 5 Experimental results of Flow rate and Head at different (IGV) angles

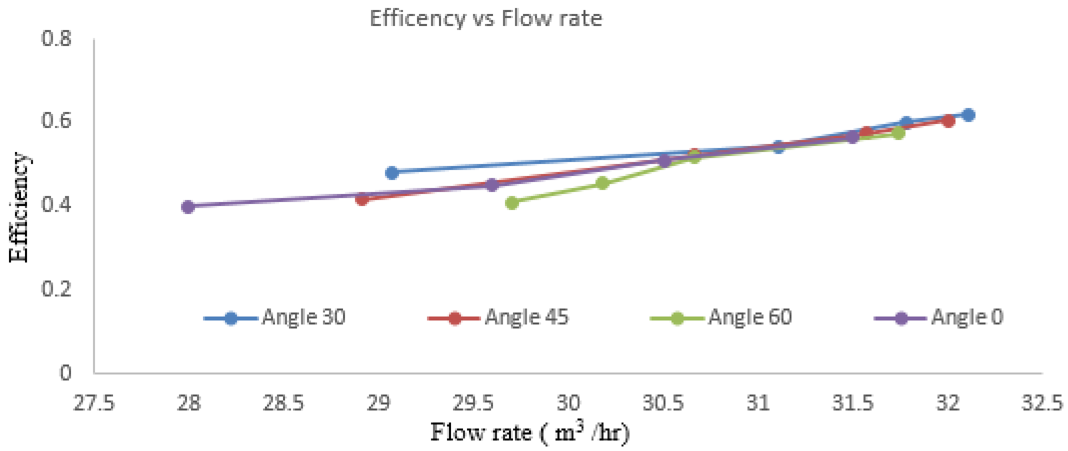

Fig.6 Efficiency flow curves at different (IGV) angle

CONCLUSIONS

Pre-whirl regulation effect was experimentally determined on head and efficiency of the centrifugal water pump. According to results the centrifugal pump having (IGV) has more efficiency than not having (IGV).Enhancement in efficiency is about 2 % according to the conditions of design. The results also show the degradation of cavitation. The range of pre-whirl angle from 0° to 60° the pre-whirl regulation of IGVs can increase or decrease the centrifugal pump head and gave the best efficiency at an angle of 30° pre-whirling , and bring circumscribed negative effect on the cavitation performance.

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