AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL POWER ENGINEERING

"EXPERIMENTAL AND THEORETICAL INVESTIGATION ON THE PERFORMANCE OF CENTRIFUGAL PUMP IN CONJUNTION WITH INDUCER"

By

Eng. / MAMDOH ABOUL – FITOH MOSTAFA

M.Sc in mechanical Engineering

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STATEMENT

This thesis is Submitted as Partial fulfillment of ph.D.degree in mechanical engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

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ABSTRACT

**** The First approach (WATER):**

An experimental & Theoretical investigations on the performance of centrifugal pump in conjunction with inducers, are studied for this purpose, a test rig is specially designed with a pump to suit the investigation of the parameters under consideration.

A Series of experiments is carried out to investigate the effect of introducing a helical and axial inducers with changing the following parameters:

(a) For Helical Inducers:

(1) Pitch (2) Angle (3) Length (4) Depth

(b) For Axial Inducers:

(1) In – Line Axial Inducers. (2) Cascade Axial Inducers.

(3) Pitch of stages. (4) Angle of blades.

The Helical Inducers are selected with different number of turns, (2,3 &4)turn, with different Angles(12º-15º-17º) for 2- turns helical inducers also (8º- 9.5º-12 º) for 3- turns helical inducers and (9º) for 4- turns helical inducer.

The Axial Inducers are selected with number of Blades (3, 4 , 5) with inlet and outlet blade angles ($\beta 1, \beta 2$) of (11.5º, 29.5º) and (18.5º, 34.5º) degrees, respectively. The cascade Inducers have 3- blades with inlet and outlet blade angles ($\beta 1, \beta 2$) of (11.5º, 29.5º) and (18.5º, 34.5º) degrees respectively with different pitch of stages.

Tests, for every inducer, (Helical – Axial), are repeated for eight different speeds (500- 750- 1000- 1250- 1500- 1750- 2000-2150 rpm). For a certain inducer, a complete set of readings is taken at different discharges from shut off to fully open delivery valve. Suction head delivery head, discharge, speed and pump input torque are measured at different selected points.

The performance of the pump with & without inducer are studied in regard to the results of tested (Helical-Axial) Inducers, It was found that: Test for all helical inducers are made, the best performance of the pump (maximum efficiency, maximum head and minimum brake-power) was obtained by using (3)-turns helical inducer with angle (12 º) at 750 rpm.

Same procedure of tests are made for all axial inducers, the best performance of the pump was obtained by using (3-Bladed) axial inducer with angles

($\beta 1 = 11.5^{\circ} - \beta 2 = 29.5^{\circ}$) at 750 rpm Tests of remaining inducers (Helical-Axial) show that variations in (rpm) gives different cases of pump performance according to the tested inducer. The dimensions of the tested inducers are chosen randomly. A fair agreement was found when comparing the present work results with other investigators.

**Results of first approach (water):

From the experimental work and discussions, the following conclusions can be drawn :

1- when selecting the inducer (helical-axial), we must have the best performance (maximum efficiency, maximum head and minimum brake power)for having the best performance when operating with centrifugal pumps.

2-maximum efficiency and maximum value of NPSH of the centrifugal pump are obtained by using helical inducer

(2-turns, (17°)),shaft diameter 25 mm in all case studies of inducers (helical-axial) and it is preferable to be used for having the best performance of the centrifugal pump.

3- When operating the centrifugal pump with axial inducers, the best performance is obtained by using (3) bladed and (5)bladed axial inducers at low rpm with different angles.

4- Comparison of max. efficiency: for helical inducers the max. efficiencies obtained by using (2,turns,17) shaft diameter 25 , for axial inducers, the max efficiency is obtained by using (4) bladed, ($\beta 1 = 11.5^{\circ} - \beta 2 = 29.5^{\circ}$) axial inducer

5- Comparison of NPSH : the maximum value of (NPSH) of a centrifugal pump is obtained by using (2-turns,(17°)) helical inducer and minimum value of (NPSH) is obtained when operating the centrifugal pump without inducer.

6- The experimental work show that it is preferable for the users of the inducers with centrifugal pump, that helical inducers give the best performance of the centrifugal pump than axial inducers, also, the head of the high-speed centrifugal pump is the highest with the two turn helical inducer than three or four turns helical inducers.

**** The Second approach (SLURRY):**

An inducer is an axial flow impeller with blades that wrap in a helix around a

central hub. An Inducer Serves as a small booster pump for the main impellers. Usually inducers have between (2) and (4) vanes, although they may be more, the inducer imparts sufficient head to the liquid so that the NPSH requirement of the adjacent main impeller is satisfied.

Although the inducer usually has a lower NPSH requirement than the main impeller ,it can , and often does, cavitate during normal operation, the key is that there is so little horse power involved with an inducer that there is virtually no noise, vibration, or resulting mechanical problems. Meanwhile, the higher horsepower main impeller sees sufficient head to operate without cavitation.

An inducer invariably has higher suction specific Speed (S) than an adjacent impeller. (S) is a dimensionless term that describes the inlet characteristics of a pump. For a constant RPM and flow, a lower NPSH requirement means a higher suction specific speed. Inducers commonly have suction specific speeds of between (15.000) and (25.000).

Effect of slurry properties on the performance of centrifugal slurry pumps in conjunction with inducers has been experimentally studied.

For this purpose, a test rig is specially designed with a pump to suit the investigation of the parameters under consideration.

Measurements have been made using three solid concentrations, (0.1%,0.5%.1% by weight) of sand glass on pump performance with and without inducers was studied to investigate the effect of having a helical and axial inducers with changing the different parameters.

The present work is concerned with the evaluation the performance of a centrifugal slurry pump in conjunction with inducers. To achieve the above objectives, the performance of the centrifugal slurry pump with and without inducers has been evaluated at different speeds (750- 1000- 1250- 1500- 1750- 2000rpm). With clear water and with sand glass at different solid concentrations (by weight). For a certain inducer, a complete set of readings is taken at different discharges from fully open to shut of delivery valve. The head, discharge, speed and pump input torque have been measured at different selected points.

Performance curves are used to show the slurry pump performance with and without inducer with clear water and with sand glass (grain size 300 micron) at different solid concentrations (0.1%, 0.5%, 1%) by weight, for different number of

ABSTRACT

speeds (500 -750 – 1000 – 1250 – 1500 – 1750 – 2000) rpm, for different parameters for helical and axial inducers and the performance curves were plotted and compared with those of clear water.

Results show that at all the speed, the head developed and efficiency of the pump is found to reduce with increase in solid concentrations. The power input to the pump is also found to increase almost linearly with increase in specific gravity of slurry.

****Results of second approach (Slurry):**

1. The maximum efficiency is obtained for all concentrations (0.1%, 0.5%, 1%) at 1000 rpm.

2. The best performance (maximum efficiency, maximum head and minimum brake power) is obtained for the (2-turns) helical inducers with different angles for all concentrations, at different rpm, also is obtained for (3-bladed) axial inducers with different angles, different rpm for all concentrations (0.1%, 0.5%, 1%).

3. Comparison of max efficiency: for helical inducers, the max efficiency is obtained by using (2-turns, 17 º) shaft diameter (25 mm) helical inducer for axial inducers, the max efficiency is obtained by using (4)- bladed ($\beta 1 = 11.5$ º - $\beta 2 = 29.5$º) axial inducer for all speeds and all concentrations.

4. Comparison of (NPSH) : the maximum value of (NPSH) of the centrifugal slurry pump is obtained when operating without inducer at concentration (1%) also the minimum value of (NPSH) is obtained by using (4)- bladed ($\beta 1 = 11.5$ º-$\beta 2 = 29.5$º) axial inducer at concentration (0.1%).

Keywords:

Inducers, Helical, Axial, Pump, Slurry, Pitch, Angle

LIST OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES