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Design and Implementation of Two Stage Centrifugal Pump

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ABSTRACT: The design and construction of a two stage centrifugal pump is presented in this project work, electric motor drives the centrifugal pump, which draws fluid (water) from a water storage wall and delivers same through a flow control valve to a tank. The experimental results obtained shows that the tested pump can develop a head, (H) of 25m, volumetric discharge, (Q) 2050 in LPH and the speed of 2800 rpm for an input power of 1.0HP. The operation of the pump was observed to be very smooth with low vibration and noise level on the pump and motor respectively, this guarantee the reliability of the pump in service.

KEYWORDS: Centrifugal Pump, Impeller Design, Shaft Design.

LIST OF SYMBOLS

Q Volumetric capacity m3/s
N Power J/S, W, KW
P fluid pressure Pa
d_{hp} Impeller Hub Diameter
L Length of the coupling
$U1$ Impeller Entry and Discharge Parameters Peripheral Velocity
Co Fluid Velocity at Impeller Eye
H Head, Height m
η Efficiency of machines
Z Number of vane
D1 The normalized inlet diameter
b2 Impeller Discharge Vane Width

I. INTRODUCTION

The jet pump is a device for pumping fluids by means of a high velocity jet of the same or another kind of fluid. The principle phenomenon involved is the transfer of some momentum from the high velocity fluid to the low velocity fluid during the mixing process, with the result that all fluid leaving the mixing tube has about the same velocity. The general type of pump operating on this principle is classified as a momentum pump. Special names have been developed for jet pumps applied to specific services, the names being ejector, injector, hydraulic compressor, etc.,.

The jet pump is applied to many pumping problems due to its low first cost, simplicity in operation and ability to mix thoroughly two fluids. On the other hand, the usual installation is limited to small power inputs since the efficiency of the pump is inherently low. Development of theory has been slow because the fluid flow equations are complicated particularly in case of compressible fluids. High velocity jets of steam are used to pump air. Or sometimes, the jets of high velocity air are used to pump air. As was pointed out earlier, the general class includes injectors and steam jet air pumps, as well as water jet pumps, but the latter possesses the decided advantage of not involving either compressibility or heat transfer.

The water jet pump was first used by James Thomson about 1852, and the theory of pumping by jet action was developed in 1870 by Rankine. The low efficiency of this pump has limited the field of application to conditions in which the absence of valves or working parts and the small size of the unit are sufficient to offset the greater power requirement of this than of other possible types. This unfavorable circumstance has caused the water jet pump to

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receive less attention than it deserves. A number of writers including Jesse (1904), Lorenz (1910), Gibson (1924), LeConte (1926), and Bergeron (1928) have developed theoretical equations, but almost no experimental data for checking these equations were available. This report has been designed to summarize particularly the operation, theory, design characteristics and the application of "water jet pumps" in which the water is used as a primary as well as secondary fluid. Optimum design parameters, the jet pump system characteristics and their use in design" have been reported and discussed. Various advantages of jet pumps have been mentioned. Experimental verification was made and the results reported.

1.1 Overview of Two Stages Centrifugal Jet Pump

The basic principle of the jet pump is the transfer of momentum from one stream of fluid to another. The water jet pumps possess a special advantage of not involving either compressibility of fluid or any heat transfer as in the case of steam jet air pumps. The theory presented here is specifically applicable only to an incompressible fluid of small viscosity such as water. One treatment involves an energy balance with the computation of friction losses in the pipe lines, the impact loss and the pressure change in the mixing chamber. A second treatment involves the conservation of momentum theory and force balance. Both methods of analysis lead to basic relationship of head and capacity and the overall efficiency.

1.2 Existing Method

Design and construction of a single stage centrifugal jet pump using only one impeller and it is able to produce a head of about 15m, volumetric discharge, (Q) 1960 in LPH and the speed of 2800 rpm for an input power of 1.0HP. The performance of a pump is however better evaluated if tested at the design speed and power with all necessary parameters ready by direct measurement.

1.3 Proposed Method

Design and construction of a two stage centrifugal jet pump using two impeller and it is able to produce a head of about 25m,volumetric discharge, (Q) 2050 in LPH and the speed of 2800 rpm for an input power of 1.0HP. There are using closed type and also Semi-open type of impellers. The performance of a pump is better evaluated if tested at the design speed and power with all necessary parameters ready by direct measurement. The pump operated was observed to be very smooth with low vibration and noise level on the pump and motor respectively, this will guarantee the reliability of the pump in service.

1.4 Block Diagram of Two Stages Centrifugal Jet Pump

The basic block diagram of two stage centrifugal jet pump is shown in above figure it contains induction type motor, two types of impeller and single phase power supply.

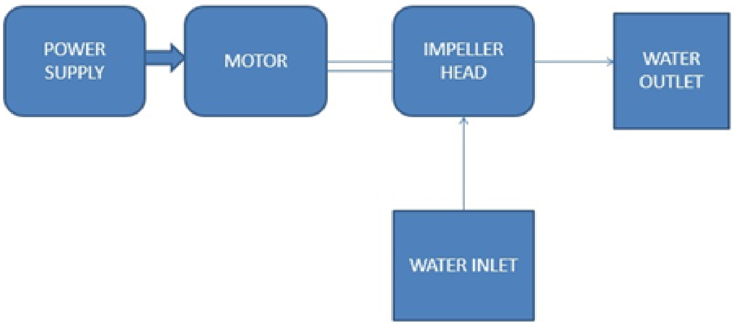

Fig 1.4 Block diagram of two stage centrifugal jet pump

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II. OPERATING PRINCIPLE OF TWO STAGE CENTRIFUGAL JET PUMP

A centrifugal pump converts mechanical energy from a motor to energy of a moving fluid. Centrifugal pumps include a shaft driven impeller that rotates inside a casing. Energy conversion is due to the outward force that curved impeller blades impart on the fluid. When the impeller rotates, the fluid surrounding it also rotates. This imparts centrifugal force to the water particles, and water moves out. Pressure and kinetic energy of the fluid rises due to rotational mechanical energy transferred to the fluid. A negative pressure is induced at the eye because water is displaced at the suction side.

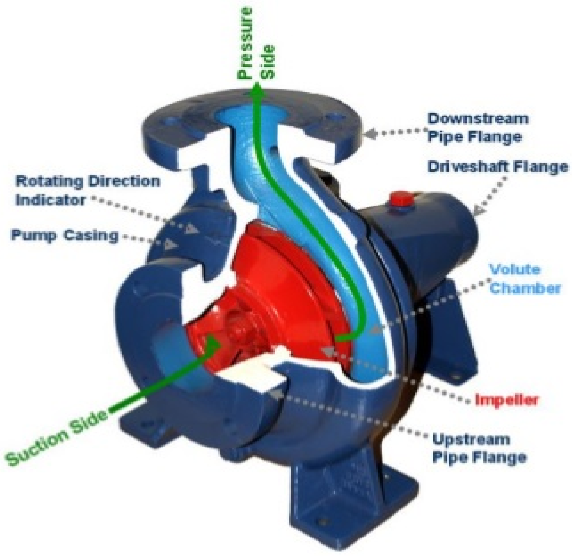

Fig 2.0 Centrifugal pumps

III. EJECTOR THEORY

The jet pump is a centrifugal pump with two impeller and diffuser with the addition of a jet ejector. A JET EJECTOR consists of a matched nozzle and venturi. The nozzle receives water at high pressure. As the water passes through the jet, water speed (velocity) is greatly increased, but the pressure drops. This action is the same as the squirting action you get with a garden hose as when you start to close the nozzle. The greatly increased water speed plus the low pressure around the nozzle tip, is what causes suction to develop around the jet nozzle. Water around a jet nozzle is drawn into the water stream and carried along with it. For a jet nozzle to be effective it must be combined with a venturi. The venturi changes the high-speed jet stream back to a high-pressure for delivery to the centrifugal pump. The jet and venturi are simple in appearance but they have to be well engineered and carefully matched to be efficient for various pumping conditions.

The jet nozzle and venturi are also known as ejectors/ejector kits. On a shallow-well jet pump the ejector kit (jet nozzle and venturi) is located in the pump housing in front of the impeller. A portion of the suction water is recirculated through the ejector with the rest going to the pressure tank. With the ejector located on the suction side of the pump, the suction is increased considerably. This enables a centrifugal pump to increase its effective suction lift from about 20 feet to as much as 28 feet. But, the amount of water delivered to the storage tank becomes less as the distance from the pump to the water increases... more water has to be recirculated to operate the ejector. The difference between a deep-well jet pump and a shallow-well jet pump is the location of the ejector. The deep-well ejector is located in the well below the water level. The deep-well ejector works in the same way as the shallow-well ejector. Water is supplied to it

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under pressure from the pump. The ejector then returns the water plus an additional supply from the well, to a level where the centrifugal pump can lift it the rest of the way by suction.

IV. BASICS ELEMENTS OF TWO STAGE CENTRIFUGAL JET PUMP

The main component of centrifugal pump are (i) An impeller (ii) A shaft complete with parts to attach the impeller and safe guard against wear at stuffing boxes (iii) Bearings (iv) coupling (v) casing (vi) stuffing boxes (vii)suction and discharge nozzles (viii) others such as pump basement (skid and bolts).Impeller Types are categorized into three types.

4.1 Closed impellers require wear rings and these wear rings present another maintenance problem.

4.2 Open impellers are less likely to clog, but need manual adjustment to the volute or back-plate to get the proper impeller setting and prevent internal re-circulation.

4.3 Semi-open pump impellers are great for solids and "stringy" materials but they are up to 50% less efficient than conventional designs.

The number of impellers determines the number of stages of the pump. A single stage pump has one impeller only and is best for low head service. A two-stage pump has two impellers in series for medium head service. A multi-stage pump has three or more impellers in series for high head service.

V. TWO STAGE CENTRIFUGAL JET PUMP PERFORMANCE CURVES

The capacity and pressure needs of any system can be defined with the help of a graph called a system curve. Similarly the capacity vs. pressure variation graph for a particular pump defines its characteristic pump performance curve. The pump suppliers try to match the system curve supplied by the user with a pump curve that satisfies these needs as closely as possible. A pumping system operates where the pump curve and the system resistance curve intersect. The intersection of the two curves defines the operating point of both pump and process. However, it is impossible for one operating point to meet all desired operating conditions. For example, when the discharge valve is throttled, the system resistance curve shift left and so does the operating point.

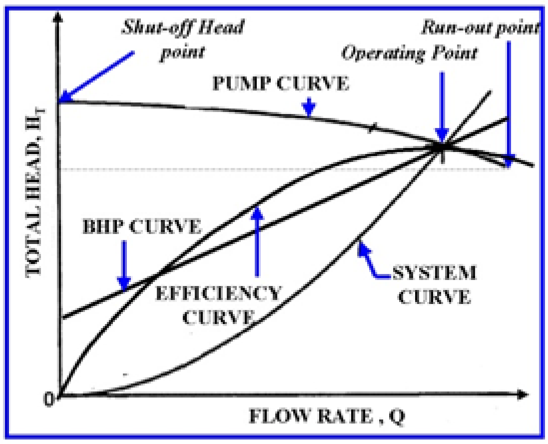

Fig 5.0 Typical system and pump performance curve

5.1 Developing a system curve

The system resistance or system head curve is the change in flow with respect to head of the system. It must be developed by the user based upon the conditions of service. These include physical layout, process conditions, and

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fluid characteristics. It represents the relationship between flow and hydraulic losses in a system in a graphic form and, since friction losses vary as a square of the flow rate, the system curve is parabolic in shape. Hydraulic losses in piping systems are composed of pipe friction losses, valves, elbows and other fittings, entrance and exit losses, and losses from changes in pipe size by enlargement or reduction in diameter.

5.2 Developing a Pump performance Curve

A pump's performance is shown in its characteristics performance curve where its capacity i.e. flow rate is plotted against its developed head. The pump performance curve also shows its efficiency (BEP), required input power (in BHP), NPSHr, speed (in RPM), and other information such as pump size and type, impeller size, etc. This curve is plotted for a constant speed (rpm) and a given impeller diameter (or series of diameters). It is generated by tests performed by the pump manufacturer. Pump curves are based on a specific gravity of 1.0. Other specific gravities must be considered by the user.

5.3 Normal Operating Range

A typical performance curve (Figure D.01) is a plot of Total Head vs. Flow rate for a specific impeller diameter. The plot starts at zero flow. The head at this point corresponds to the shut-off head point of the pump. The curve then decreases to a point where the flow is maximum and the head minimum. This point is sometimes called the run-out point. The pump curve is relatively flat and the head decreases gradually as the flow increases. This pattern is common for radial flow pumps. Beyond the run-out point, the pump cannot operate. The pump's range of operation is from the shut-off head point to the run-out point. Trying to run a pump off the right end of the curve will result in pump cavitations and eventually destroy the pump.

VI. CONCLUSION

Centrifugal Pumps transfer rotational kinetic energy to increase the hydrodynamic energy and head of fluid flow. Centrifugal Pumps have been used since the 1400's, and remain a popular choice in applications across multiple industries. Centrifugal Pumps can handle high hydraulic heads, with variable flows. When designing a Centrifugal Pump, Blade Angle, Rotations per Minute, and the number of impeller blades all impact the efficiency and discharge of a pump.

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