A Study on Radial flow turbine in Centrifugal pump using Bernoulli's Principle

S.Bhuvaneswari[1], M.Dhivya[2]
[1]Head of the Department Mathematics,
[2]M.Phil Research Scholar, Department of Mathematics,
Kamban College of arts and science for women,
Tiruvannamalai, India.

Abstract : This paper performs a study on radial turbulent flow in centrifugal pump. We have investigated the enhancement of centrifugal pump with flow of liquid through the suction pipe to the discharge level. We observed that transfer of liquid enhanced significantly with the increase of pressure in suction pipe when the velocity at low and transfer to radial flow turbine in impeller where the pressure decreases due to loss of friction and increases the velocity in turbine flow. Therefore, we have suggested the calculation of pressure requirement in the impeller.

***IndexTerms* -** Bernoulli's theory, centrifugal pump(impeller).

I. INTRODUCTION

Bernoulli's principle can be applied to various types of fluid flow, resulting in various forms of Bernoulli's equation. The principle states that " an increase in the speed of a fluid occurs simultaneously with a decrease in the fluid's potential energy"[4]. A centrifugal pump works by the conversion of the rotational kinetic energy, typically from an electric motor or turbine, to an increased static fluid pressure. It is used to lift water or any other liquid from lower head to higher head. If we know the power W_{out} that is delivered by a pump, then it is possible to calculate the pressure P_p.

II. BERNOULLI'S THEORY

According to law of conservation of energy, $P + \left(\frac{1}{2}\right)\rho v^2 + \rho g h = constant.$

Consider a tube AB varying cross section at different heights h_1 and h_2 liquid is flowing from A to B. when the fluid flowing through a section of pipe with one end having a smaller cross sectional area than the pipe at the other end. The velocity of fluid in the constructed end must be greater than the velocity at the larger end. So, $P_1 > P_2$

Here, $A_1 > A_2$ and $V_1 < V_2$. The fast on the liquid at $A = P_1V_1$ and $B = P_2V_2$. The network done per second is equals $P_1V - P_2V$. Hence, the workdone per second equals increases the potential energy and kinetic energy per second from A to B.

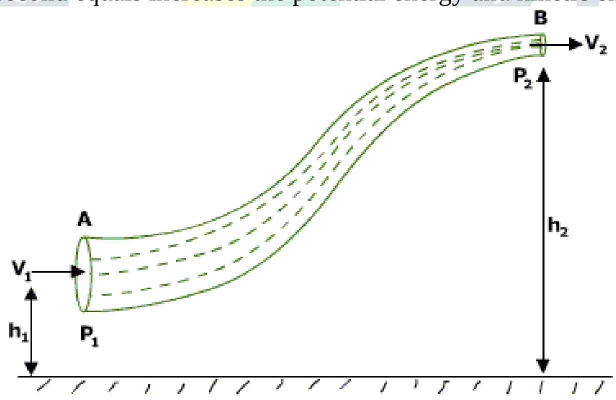

Figure1. Bernoulli's Principle

A. *Equation of continuity*

Now, consider pipes of different areas A_1 and A_2 then the volumetric flow rate Q must be the same for both pipes i.e. $Q = A_1V_1 = A_2V_2$.

B. *Flow equation*

Consider an incompressible fluid flowing along a pipe as in fig2. Its volume(V) is given by, $V = A.L$. then the volume passing per second and the flow rate Q is given by, $Q = A.L$

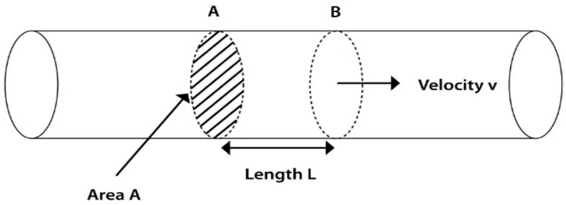

Figure2. Flow Equation

III. DESIGN METHODOLOGY OF CENTRIFUGAL PUMP

Centrifugal pumps are most commonly used turbo machinery devices which are used to raise pressure or induce flow in the control volume they are radial flow devices. The reverse function of the centrifugal pumps is a water turbine converting potential energy of water pressure into mechanical rotational energy. Like most pumps, a centrifugal pump converts rotational energy often from a motor, to energy in a moving fluid. A portion of the energy goes into kinetic energy of the casing, is caught up in the impeller blades and is whirled tangentially and radially outward until it leaves through all circumferential parts of the impeller into the diffuser part of the casing. The fluid gains both velocity and pressure while passing through the impeller as shown in fig.3

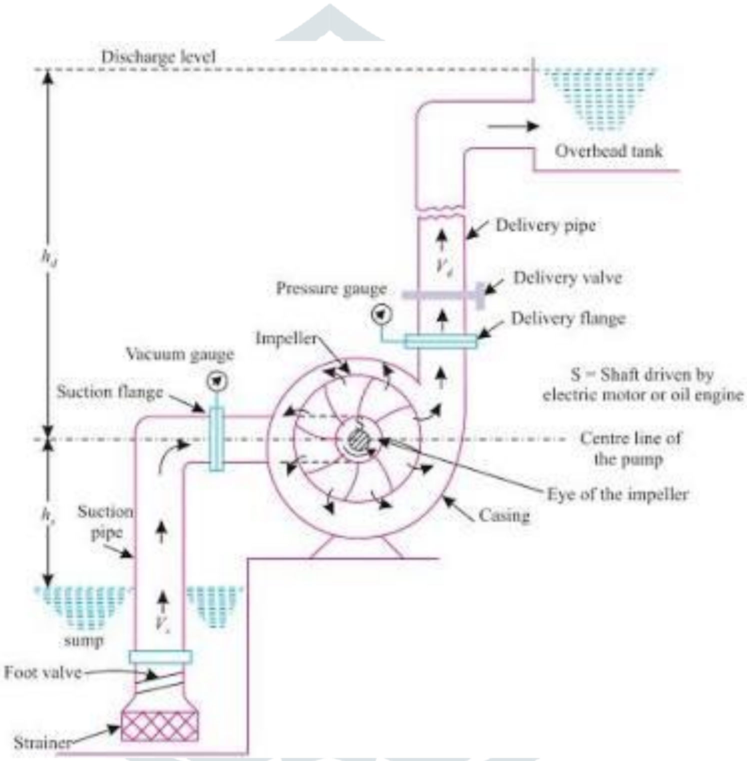

Figure3. Centrifugal Pump

The doughnut-shaped diffuse or scroll section of the casing decelerates the flow and further increases the pressure[1] as shown in fig3. Here, the fluid increases from inlet and outlet due to energy addition to fluid then the work required for changing inlet velocity condition to outlet . For a centrifugal pump inlet velocity will be parallel to radius so tangential component at inlet is zero. So from here we can find the body (head)of the pump rises and the outlet blade can be derived in terms of velocities. If we want to scale up the flow rate the pressure rise generated or the head rise generated by the dynamics in the pump. Also, the flow rate in impeller is given as,

$$Q \propto DN$$
$$H \propto D^2N^2$$

Where, D – size of the pump, H – head of the pump, N – speed of the fluid, ρ −density, and g −gravity of the system.

Hence, the power $W_{out} = \rho gHQ$ when the valve is closed the flow rate Q = 0 where the velocity increases and the valve is cracked open then the flow rate Q = small where the velocity similarly increases. At the section of the impeller the flow rate slightly increases where the pressure decreases due to loss of friction.

IV. PUMP AND TURBINE

Essentially a pump adds energy to a system and a turbine takes it away. Therefore typically in the Bernoulli's equation the pump pressureP_p and the turbine pressure P_t is added. So, for a system containing a pump and a radial flow turbine the Bernoulli's equation can be written as, $P_1 + \left(\frac{1}{2}\right)\rho v_1{}^2 + \rho g h_1 + P_p = P_1 + \left(\frac{1}{2}\right)\rho v_2{}^2 + \rho g h_2 + f_h \rho g + P_t$.

Typically pumps have an efficiency(γ) which is the ratio of the power out $W_{out}$to the power in W_{in}. It represents losses in the pump due to loss of friction and electrical efficiency.

$$W_{out} = W_{in}\,\gamma$$

Here, the requirement of pressure is $P_p = W_{in}\,\gamma/Q$. Hence, it allows the determination of the power requirement or alternatively the flow rate in a system for a given power[2].

V. RADIAL TURBINE FOW IN IMPELLER

The radial turbines consists in the way the fluid flows through the components of the impeller whereas for a radial turbine the flow is smoothly oriented perpendicular to the rotation axis[3]. Here, the fluid accelerating from the centre of rotation and the moving fluids acts on the blades so that they move and impart rotational energy. Hence, the rotating component equipped with vanes or blades used in turbo-machinery as shown in fig4. The deflection of flow at the impeller vanes allows mechanical power to be converted into pump power output W_{out}.

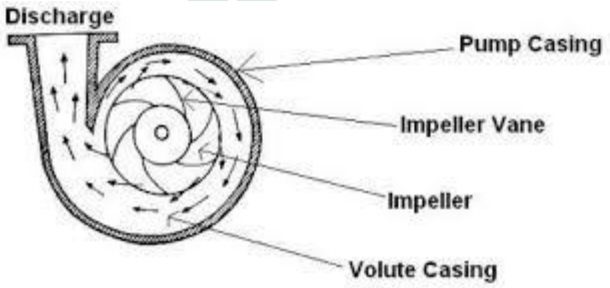

Figure4. Volute type impeller

Since, the work required for changing inlet velocity condition to outlet be given by,

$$w = \rho Q\left(u_2 v_{\theta_2} - u_1 v_{\theta_1}\right)$$

At tangential component inlet to be 0 then, $v_{\theta_1} = 0$. We have, $w = \rho Q\left(u_2 v_{\theta_2}\right)$

A. Advantages of centrifugal pump

- Centrifugal pumps are fairly simple in nature. An engine is attached to the axis, which then rotates the pump impeller, which is reminiscent of an old ships "water wheel"[3].
- Low cost and easily transport.
- Less frictional losses.
- Almost no noise.
- No drive seal so there is no leakage in pump.

VI. CONCLUSION

Applying Bernoulli's principle, a study on radial turbine flow in centrifugal pump has been studied and enhanced significantly with the increase of pressure and flow rate in the centrifugal pump and also suggested the radial flow in the impeller.

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