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"REVIEW OF PERFORMANCE CAVITATIONS AUGMENTATION IN CENTRIFUGAL PUMP IMPELLER"

***Md Qaied Azam* [1], *Prof. Rohit Kumar Choudhary* [2], *Dr. Suresh Kumar Badholiya* [3]**

[1] *Research Scholar, Department of Mechanical Engineering, Bhopal Institute of Technology & Science. Bhopal, India*
[2] *Associate Professor, Department of Mechanical Engineering, Bhopal Institute of Technology & Science. Bhopal, India*
[3] *Assistant Professor, Department of Mechanical Engineering, Bhopal Institute of Technology & Science. Bhopal, India*

ABSTRACT

Cavitation is one of the most challenging fluid flow abnormalities leading to detrimental effects on both the centrifugal pump flow behaviors and physical characteristics. Centrifugal pumps' most low pressure zones are the first cavitation victims, where cavitation manifests itself in form of pitting on the pump internal solid walls, accompanied by noise and vibration, all leading to the pump hydraulic performance degradation. In the present article, a general description of centrifugal pump performance and related parameters is presented. Based on the literature survey, some light were shed on fundamental cavitation features; where different aspects relating to cavitation in centrifugal pumps were briefly discussed.

Key Words: *Centrifugal pump performance, cavitations, hydraulic machine, CFD Analysis , Mechanical energy.*

I. INTRODUCTION

Cavitations occur in a centrifugal pump when the temperature and pressure of the working fluid, such as the water entering the impeller, is equal to the vapour pressure. Cavitations occur at very low pressures at normal operating temperature. During cavitation, the aqueous liquid is transformed into steam and generates very high temperatures and pressures. Centrifugal pumps: A hydraulic machine that converts mechanical energy into hydraulic energy is called pumping. When mechanical energy is converted into pressure energy by centrifugal force acting on the fluid, the hydraulic machine is called a centrifugal pump.

Cavitations :-

Cavitation is an abnormal condition that can lead to loss of production, material damage and, in the worst case, cavitation, which derives from the Latin word cavus, which means a hollow space or cavities. In the context of centrifugal pumps, the term cavitation involves a dynamic process of bubble formation in the liquid, its growth and subsequent subsidence when the liquid flows through the pump.

Type of Cavitations:

In the context of centrifugal pumps, the term cavitation involves a dynamic process of bubble formation in the liquid, its growth and subsequent subsidence when the liquid flows through the pump. In general, the bubbles that form in the liquid are of two types: vapour bubbles or gas bubbles.

Vapour bubbles are created by the evaporation of a pumped process fluid. The cavitation state induced by the

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formation and collapse of the vapour bubbles is commonly called Vaporous Cavitation.

Fig. 1 Traveling Bubble Cavitation on the Hydrofoil Suction Side

Gas bubbles are formed due to the presence of gases dissolved in the liquid, which is usually the pumped air, but it can also be any gas in the system. The cavitation state induced by the formation and collapse of gas bubbles is commonly called gas cavitation. Both types of bubbles are formed in a position in the pump in which the local static pressure is lower than the vapour pressure of the cavitation of liquid or vapour or the saturation pressure of the gas cavitation.

Cavitation Model: Cavitation is the process of the formation of vapour bubbles in low pressure regions within a flow.

Different cavitation patterns are here down presented.

A. Traveling cavitation

In this type of cavitation, the micro bubbles otherwise called cavitation nuclei are curried along the flow field until they get to the flow's lower pressure zones, where they become macroscopic cavitation bubbles before collapsing at pressure recovery zones. The developed bubbles are usually in complex shapes mainly from their interactions with neighboring walls .

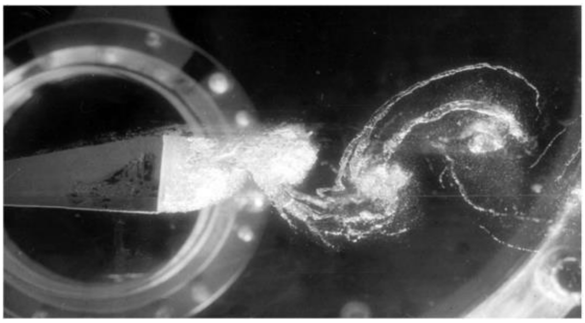

Fig. 2. Cavitation in the Wake of a Bluff Body

Attached cavitation Contrary to the above presented travelling cavitation, the attachedcavitation stays at the same location attached on a wall. This does not mean that the flow is steady. Actually, cavitation is almost always the source of unsteadiness which may be quite strong.

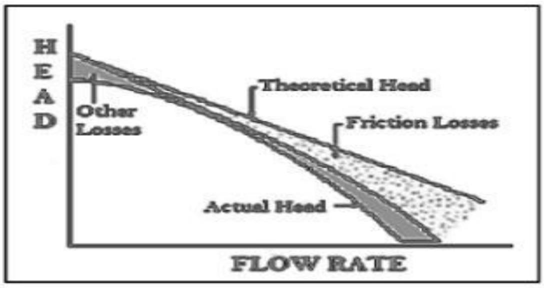

Fig. 3 Head Loss in Centrifugal pump

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Vortex Cavitation

This type of cavitation is the mostly found in marine propellers. It is found at the vortex core generated by the secondary flow at the blade tip. The blade tip second flow is a result of the pressure difference between the vane pressure and suction side. The pressure at the generated tip vortex is much lower than pressure far away in the same fluid making it vulnerable to cavitation phenomenon.

Cavitations Augmentation:-

The Centrifugal pump is used to transfer the fluid from one point to another in a system, by simply adding momentum. There is no rigorous procedure for designing a pump; Various manufacturers have developed their own approaches, involving thumb rules and proportions. The design is normally based upon desired head and capacity. Type of drive system may also be specified. To achieve better performance for a centrifugal pump, design parameters are

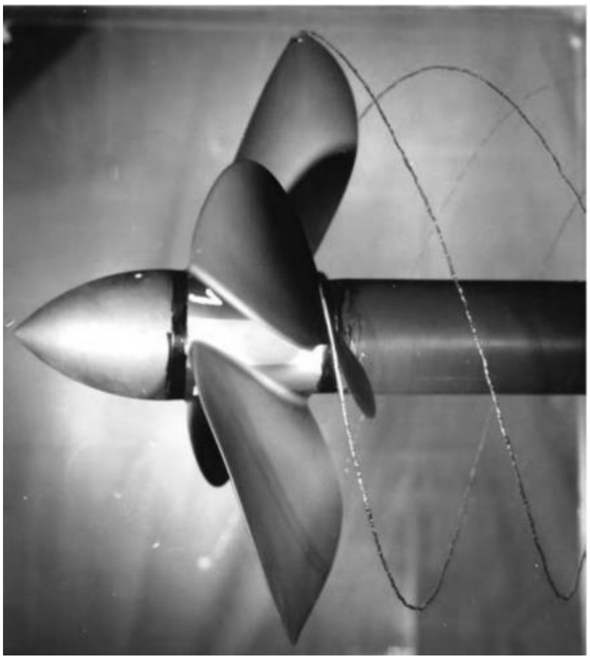

Fig. 4 Vortex Cavitation Generated by a Propeller

- Impeller Speed
- Pipe Connections and Velocities Impeller Inlet Dimensions Impeller Outlet Dimensions Impeller Vane Shape
- Design of Volute Design of Diffuser.

Liquid flow is quite complex due to its three dimensional behavior and turbulence. Hence the parameters governing the behavior fluid flow through impeller and affects its performance must be accurately determined.

The pressure rise in the impeller is more than or equal to manometric head the centrifugal pump will start delivering water. Otherwise the pump will not discharge any water through the rotating impeller. When impeller is rotating the water in contact with the impeller is also rotating.

[1] Hybrid multiple optimization technique to concurrently enhance hydraulic efficiency and decrease unsteady radial forces resulting from fluid-induced vibration of a single-channel pump for wastewater treatment. [2]Hexahedral meshes were used in the computational domain. The numerical results for performance curves showed good agreement with experimental data. The results showed that the steady and unsteady performance characteristics were dependent on both the IGV and blade pitch angles. Adjusting these angles affected the total pressure rise and thus caused variation in the efficiency in overload conditions. [3]Three-dimensional Reynolds -averaged Navier–Stokes equations was used to predict the pump performance, and the optimized design was validated by an external characteristic test. [4] Yuxing Bai et. al.,To meet the emergency relief needs associated with the flooding of the coal mine, a high capacity, high capacity and low flow submersible pump has been developed [5] Centrifugal pumps are widely used due to their suitability in almost all services for water supply systems. [6] The turbine for a centrifugal lixiviation pump to increase its performance and efficiency and take advantage of the design parameters (six-blade turbine, wheel design changes) compared to the old Turbine [7] It is very important that the centrifugal pump works effectively thanks to its great application. Pump performance is influenced by the speed triangle, depending on the input or output angle of the blade. [8] Centrifugal pumps are widely used in the oil and gas industry and pump performance decreases with higher viscosity and greater roughness of the pump wheel surface, and wheel design parameters have a significant impact on

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pump performance.[9] steam turbines, etc. Centrifugal pumps can be single or multi-stage. It depends on the number of wheels used in the pump.

III. CFD ANALYSIS

Methodology for obtaining a discrete solution of real world fluid flow problems. Simulation- based design instead of "build & test"

- More cost effective and more rapid than EFD
- CFD provides high-fidelity database for diagnosing flow field
- Simulation of physical fluid phenomena that are difficult for experiments
- Full scale simulations (e.g., ships and airplanes)
- Environmental effects (wind, weather, etc.)
- Hazards (e.g., explosions, radiation, pollution)
- Physics (e.g., planetary boundary layer, stellar evolution)

ANSYS BladeGen: A geometry creation tool designed specifically for turbo- machinery blades.
Vista CPD: Vista CPD is a program that uses a 1D approach for preliminary pump design. Vista CPD is able to produce projects for a wide range of pumps, from mixed flow (Ns ~ 5500) to Francis type with radial head (Ns ~ 500). It is integrated with ANSYS Workbench, so it can be used to create an optimized wheel design before quickly switching to a complete 3D geometry model, using flow analysis and CFD.

ANSYS Design Modeler: A general tool for preparing the geometry integrated in ANSYS Workbench. This CAD-type program is mainly used to prepare CAD geometry models for analysis with other ANSYS Workbench-based tools.
ANSYS TurboGrid: A mesh instrument specialized in CFD analysis of turbo- machinery blade ranks.
ANSYS CFX-Pre: A general-purpose CFD preprocessor with a turbo-machinery driven configuration that facilitates the deployment of turbo-machinery CFD simulations.
ANSYS CFD-Post: A general-purpose CFD post-processor with functionality to facilitate post-processing of CFD simulations of turbo- machinery.

- Phonetic, supernic and supersonic flow
- Heat transfer and heat radiation
- Buoyancy
- Non-Newtonian streams
- Transport components of inactive scales
- Multiphase flow
- The combustion
- Flow in some reference frames
- Particle tracking

[10] Computational Fluid Dynamics approach was proposed to study the centrifugal pump impeller flow with Ansys Fluent.. [11] Various parameters influence the performance of the pump. The wheel exit diameter, blade angle, blade number and housing are the most critical. In this study, experimental and numerical investigations are performed on two turbines of different diameter and of the same shell.[12] After optimization, the velocity gradients on the suction surface are more uniform and the flow separations on the input portion of the blade are eliminated. [13] Phase change is carried out at constant temperature and the local fall pressure generated by the flow conditions. Turbomachines, like centrifugal pumps, suffer from loss of power. [14] Centrifugal pumps are widely used for their suitability for almost all irrigation services, water supply, steam plants, wastewater, oil refineries, chemical plants, hydropower plants, food processing plants and mines. Therefore, it is necessary to determine the design and working conditions of settings that enable optimal performance and maximum efficiency with the lowest power consumption. A study shows that the dynamic analysis of computational fluid dynamics is increasingly used in the design of centrifugal pumps.

[15] CFD approach was proposed to study the flow in the centrifugal pump impeller with Solid Workflow Simulation.

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[16] Vibration optimization of the centrifugal pump taking into account the fluid-structure interaction . [17] Water over a short to medium distance through the pipeline, where moderate height and discharge are required. To ensure optimal pump performance, the blades must be designed accordingly. [18] Performance of the deep well centrifugal pump with four different wheel output widths and studied numerical, theoretical and experimental methods. [19] Flow inside the centrifugal pump is very complex, mainly because of the structure of the 3D flow that includes turbulence, secondary flow [20] Taguchi method to optimize the design parameters in fan operation. The optimization of the design parameters using this technique is directly subject to an economic solution for the turbo-machinery industry. [21] The relationship between the diameter of the wheel, the angle of output of the blade and the width of the blade at the outlet. [22] The different performance parameters of the centrifugal pump have been calculated, such as overall efficiency, cavitation, slip factor, losses, etc. [23] Wheel repair and voltage design are undertaken to improve the performance of the centrifugal pump. Design limitations related to the development of planetary aircraft options.

III. Mixture of Refrigerants

Because of the complex nature of cavitation, it's always not very straight forward to know the exact cause of its occurrence. But one can at least mention about some of the most seen cavitation cases in pumps. Cavitation in centrifugal pumps may have different reasons, some may be related to the pump design, others to the operating conditions such as the insufficient head at the inlet from different losses in the inlet pipe or faulty liquid depth estimation above the inlet, faulty system configuration leading to higher pump speeds, and pump developed head overestimation beyond the design values.

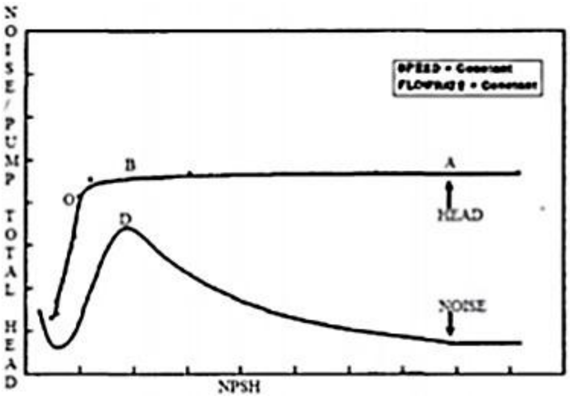

Fig.5 Cavitation development

[24] Evaluated the performance of the wheels with the same outlet diameter with different numbers of blades for centrifugal pumps. [25] A high- speed impeller pump with a free wheel centrifugal wheel. They found that the pump had a large high pressure exhaust head, because the blade angle at the wheel exit was important, the liquid coming out of the wheel had a high absolute speed and the dynamic distribution head of the wheel it was great. The kinetic energy of the liquid was converted into pressure in the volute and in the diffuser [26] On the influence of the number of blades on the internal volume capacity and on the properties of the centrifugal pump. Numerical simulations and experimental [27] Performance and energy consumption, such as wheel outlet diameter, blade angle and blade number, and evaluated wheel performance with the same outlet diameter. [28] The simulation of three- dimensional turbulent flow in turbo-machinery is currently based on the resolution of Reynolds' average Navier-Stokes equations.

IV. Conclusion

Cavitation phenomenon is globally understood like formation of vapor bubbles in the fluid flow from a pressure drop below its vapor pressure. Due to its speedy and complex nature, cavitation detection requires sophisticated methods; otherwise it can only be noticed by its effects on the equipment like unusual noise, vibrations and material damage. In fluid machinery, based on the system physical and working conditions, Cavitation can appear under different forms, which after getting to its full development, present almost similar effects on the system characteristics. In centrifugal

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pumps, cavitation performance mostly depends on the impeller geometrical design such that, any geometry modification can result in a totally different performance. Therefore, the design process requires a more careful control, such that, through experimental and numerical methods, the centrifugal pump's performance can be well predicted where cavitation can be decreased to acceptable levels if not completely eliminated.

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