An Overview of Disarray in Study and Analysis of Vibration Characteristics of Selected Centrifugal Pump

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Abstract— Vibrations basically are the displacement of a mass back and forth from its static position. In every centrifugal pump, dynamic forces of mechanical and hydraulic origin are present and a certain vibration and noise is therefore inevitable. To ensure the safety of the pump and associated plant components, the vibration and noise must be kept within certain limits. The objective of the paper is to identify the various methods of d analysis of vibration characteristics of centrifugal pump. Effect of vibration on performance of Centrifugal pump will be studied to find out the natural frequency and mode shapes of Centrifugal pump by numerical and experimental methods and also to study method of experimentation.

Key words: Centrifugal Pump, Dynamic, Natural Frequency

I. INTRODUCTION

In every centrifugal pump, dynamic forces of mechanical and hydraulic origin are present and a certain vibration and noise is therefore inevitable. To ensure the safety of the pump and associated plant components, the vibration and noise must be kept within certain limits. If the mechanical state of the pump and its drive are good, the inflow conditions are in order and the duty point is admissible, these limits can be observed without difficulty. Higher vibrations ultimately results in decreased component life due to cyclic loads, lower bearing life, distortion to foundation, frequent seal failures etc. Similarly noise has got huge impact on working environment and comfort conditions of an individual. Exact diagnosis of vibration and noise sources is very difficult in centrifugal pumps as this may be generated due to system or the equipment itself. It has been made to address some general causes of noise and vibrations, its diagnosis and remedies in centrifugal pumps.

Vibrations basically are the displacement of a mass back and forth from its static position. A force will cause a vibration, and that vibration can be described in terms of acceleration, velocity or displacement. The force that will cause the vibration, must overcome the structure's mass, stiffness and damping properties. These properties are inherent to the structure and will depend on the materials and design of the machine. Whereas noise is one of the derivatives of vibrations. Both phenomenon's affect the centrifugal pump performance and its service life adversely. Sources of vibrations and noise are well known but the methods to trace the exact source are still in development stage. The major challenge in diagnosis of vibrations and noise in centrifugal pumps is service of the centrifugal pump itself. When we compare the machine tools or other utility equipment's with centrifugal pumps, diagnosis of the sources of noise and vibrations in machine tools is simpler than pumps as all the components are mechanical and are visible. Whereas in centrifugal pumps, the root of vibrations and noise may lie in mechanical or hydraulic aspects. It is very easy to trace the mechanical causes but it becomes very difficult to trace hydraulic causes. This makes pumps vibration and noise diagnostic very complex.

By considering all above facts, this topic tries to cover literature which deals with Study and analysis of vibration characteristics of selected centrifugal Pump.

II. LITERATURE REVIEW

Many of researchers have contributed in Vibration analysis of Centrifugal Pump.

Ramana Podugu , J.Suresh Kumar, B.V.Ramana murthy, N.Syam Kumar (2011): In this paper the modal analysis of centrifugal pump and its assembly is performed using FEM technology. The mathematical model and FEA model are built for the centrifugal casing and simulation is made to find the pump natural frequencies. First of CAD model of centrifugal pump is prepared in any CAD software then it is simulated and first ten natural frequencies are determined then vibration measurements are taken at the bearings of the pump in axial, horizontal and vertical directions by bump test the data were recorded using spectrum analyzer from the frequency response we can find the resonance condition. To avoid the resonance condition the first natural frequency needs to be increased which is done by providing necessary stiffness. The modified design is tested for FEA analysis the increase of stiffness of pump assembly will increase frequency of centrifugal pump. Thus the dynamic characteristics of the centrifugal pumps are improved.

Ravindra Birajdar, Rajashri Patil, Kedar Khanzode, Kirloskar Brothers Ltd., India (2009): In this paper the focus is on the vibrations and noise in centrifugal pumps, its causes or sources and the diagnosis methods. There are mainly two types of causes of vibration in centrifugal pump that is mechanical causes and hydraulic causes. Once the sources of vibration are known then actual measurement of vibration is done. While taking measurement of vibration location of vibration mount is important. The measured vibration data is analyzed by using vibration spectrum for every sources of vibration spectrum analysis is done .With the appropriate implementation of vibration and noise diagnosis techniques, pumps can operate with higher reliability and efficiency.

A. Albraik , F. Althobiani , F. Gu and A. Ball (2012): This paper investigates the correlations between pump performance parameters including head, flow rate and energy consumption and surface vibration for the purpose of both pump condition monitoring and performance assessment. Using an in-house pump system, a number of experiments have been carried out on a centrifugal pump system using five impellers: one in good condition and four others with different defects, and at different flow rates for the comparison purposes. The results have shown that each defective impeller performance curve showing flow, head,

efficiency and NPSH (Net Positive Suction Head) is different from the benchmark curve showing the performance of the impeller in good condition. The results for all tests show that the vibration level increases with increased of flow rate and with different readings, this is due to a different type of defect on each impeller. The experimental study has shown that data obtained from impellers with different gaps are different, even though the impellers are geometrically similar and for the same pump. This is because impellers 2, 3, 4 and 5 have different faults both the depth of the dents and the number of dents. Further research work will be conducted to extract more data/features from the pump using different techniques. The pump faults may then be identified using these data/features

N.R. Sakthivel, V. Sugumaran, S. Babudevasenapati (2010): This paper deals with vibration based fault diagnosis of monoblock centrifugal pump The main objective of the study is to find whether the monoblock centrifugal pump is in good condition or in faulty condition. If the pump is in faulty condition then the aim is to segregate the faults into bearing fault, seal defect, impeller defect, seal and impeller defect together and cavitation. This paper focuses on the use of decision tree for fault diagnosis of monoblock centrifugal pump. , Piezo-electric type accelerometer is used to measure the vibration signals Two hundred and fifty trials were taken for each monoblock centrifugal pump condition, and vibration signals were stored in the data files the time domain signals taken from monoblock centrifugal pump for different conditions. They show time domain plots of vibration acceleration of pump under normal condition (GOOD) (without any fault), pump with bearing fault (BF), pump with seal fault (SF), pump with impeller fault (IF), pump with both bearing and impeller fault (BFIF), and cavitation (CAV), respectively Set of features have been extracted and classified using C4.5 decision tree algorithm. From the results and discussion it can be concluded that C4.5 algorithm as well as the vibration signals is good candidates for practical applications of fault diagnosis of monoblock centrifugal pump.

P. Thanapandi and Rama Prasad (1995): This paper emphasize on theoretical and experimental stud on the transient characteristics of a centrifugal pump during starting and stopping periods. Experiments have been conducted on a volute pump with different valve openings to study the dynamic behavior of the pump during normal start up and stopping, when a small length of discharge pipe line is connected to discharge flange of the pump. Similar experiments have also been conducted when the test pump was part of a hydraulic system to study the system effect on the transient characteristics. Instantaneous rotational speed, flow rate, and delivery and suction pressures of the pump are recorded and it is observed in all the tested cases It is observed in all the tested cases that the transient head characteristics closely follow the steady-state system head curve and the change of operating point during normal starting and stopping transients is quasi-steady. The dynamic characteristics of the test pump have been analyzed by a numerical model using the method of characteristics. The model predicts well the trend of the dynamic head characteristics during transients. The method can be extended to the analysis of purely unsteady cases, where the pump operation is no more quasi-steady.

W. Diewald , R. Nordmann (1989): This paper presents a finite-element procedure which includes the fluid forces arising from journal bearings, seals, balance pistons and impeller interactions to the dynamic calculations of turbo pumps. The theoretical background is briefly explained and a simple Jeffcott rotor is used to show several effects of these fluid forces. Finally, a real multistage boiler feed pump is calculated and discussed Good performance of rotating machinery is strongly dependent on two types of lateral vibrations. Synchronous motions are mostly caused by unbalance forces. On the other hand, there are non-synchronous vibrations due to self-exciting effects or transient events In order to calculate the dynamic behavior of a centrifugal pump, one has to derive a model from the real system For each type of element, which is used in the model, a force motion relation can be obtained in form of a matrix equation by means of finite-element methods. The orders of these element equations depend on the numbers of degrees of freedom for each element type. Fluid forces, arising from journal bearings, seals, balance pistons and impeller interactions, have a great influence to the lateral vibrations of centrifugal pump rotors.

A.A. Nasser, M.A.Nasser, E.H.T. El-Shirbeeny and S.M.Abdel-Rahman, This project refers experimental modal analysis or modal testing. The technique depends on the developments made m digital signal processing and finite element methods to provide a tool for studying vibration problems of real structures. Modal testing is a controlled test used to obtain the dynamic structural parameters such as natural frequencies, loss factor or damping ratio, and mode shape for each of the modes of interest. A mathematical model for components of a structure can be deducted from such test to be used in structural assembly (sub structuring). Structural measurements can be compared with a finite element model to check the validity of the model and to correlate of the model and the measurement quantitatively. Structural modifications can be done to achieve required dynamic behavior. The results showed that the importance of doing modal testing to obtain the dynamic structural properties of the system to solve the operational and structural problems. The point mobility test gives a good picture of the dynamic behavior of the system and it is enough to some degree to describe the dynamic behavior of the test object. It is important to simulate the actual conditions during modal testing from the view point of supporting, operational conditions, and the frequency range of interest.

Amit Suhane (2012) this paper represents experimental study work carried out on a single stage diffuser type centrifugal pump. The flow-induced pressure pulsations, mechanical vibrations and noise has been monitored during the experimentations for five different flow rates by varying the radial clearance. For each case of radial clearance and flow conditions, overall levels and frequency spectra, in a wide frequency range, have been examined. Experimental results show that by increasing the radial clearance between impeller and diffuser, lower pulsations, vibration and noise levels has been achieved. Pressure pulsations are dominating at fundamental frequency. Vibration is dominating at the fundamental

frequency the overall level is low at low flow rates and high at high flow rates and is minimum at maximum radial clearance. Noise is dominating at impeller vane passing frequency. Small radial clearance may be preferable for pump performance, head and efficiency but it may intimate strong impeller volute interaction resulting in high pressure pulsation inside the pump and consequent higher vibrations and noise. Optimal adjustments of radial clearance in pumps can solve the above problem to greater extent.

Bucher and D. J. Ewins (2001) In this paper, the differences between the mathematical models used for dynamic analysis of non-rotating and rotating structures are clarified. The implications of the model structure, in the latter case, on the application of modal testing are presented, as this is a point of great importance when experimental modal analysis is employed for rotating structures. Models with different degrees of complexity are being used for different types of rotating machines. A classification of such models is outlined in this work and the underlying assumptions and features are described in terms of a hierarchical complexity. Several applications of modal testing are reported here and some experimental evidence to support the validity of the theory is presented. It has been shown that the application of experimental modal testing to rotating structures is a viable option as long as the appropriate models are being used. More progress in the theory and in the experimental procedures should be achieved before experimental modal analysis (EMA) can be routinely applied to any type of rotating machine.

S. M. Abdel-Rahman and Sami A. A. El-Shaikh (2009). In this paper four different case studies related to vibration problem are tested in the field and lab representing the common problems leading to failure and damage for some components of pumping stations. Failure and damage occur for these pumping stations lead to maintenance problems, environmental problems, and water management problems. The results have been shown that vibration level generated from vertically mounted pumps is high, dangerous ant not permissible. Balancing of the unbalanced motor fan enhances dynamic performance greatly as vibration level decreased 92%. Envelope spectrum proves a good tool for diagnosing bearing problems. Replacing the damaged bearing reduces vibration level 95%. Vibration level increases with increasing speed of the variable speed motor and amplitude of vibration increases greatly with increasing excitation forces. Vibration analysis is necessary to detect and diagnose faults of the pumping stations and to avoid any failure or malfunction.

III. Conclusion

From the literature survey it can be seen that the Centrifugal pump has been topic of interest for many researchers. The research started from developing theories related to general behavior of Centrifugal pump and is now moving towards optimizing various Centrifugal pump parameters according to applications. Vibration analysis of centrifugal pump is carried out using various FEM softwres like ANSYS. The modal and harmonic analysis of centrifugal pump is carried out for study of vibration characteristics of centrifugal pump. Ravindra Birajdar from kirloskar brother's ltd mention various experimental techniques to carryout vibration analysis of centrifugal pump. Amit suhane carryout experimental study work on a single stage diffuser type centrifugal pump. They mentioned that optimal adjustments of radial clearance in pumps can solve the vibration and noise problem to greater extent. S. M. Abdel-Rahman mentioned four different case studies related to vibration problem are tested in the field and lab representing the common problems leading to failure and damage for some components of pumping stations.

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