Review paper on Pump shaft failures

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Abstract : **In this explore, we are going to understand different ways of shaft failure and there reasons. researchers worked on different pump shaft failures to know reasons that why shaft failure occurs. They conducted different test to identify regions where most of the pump shaft failure occurs. Tests like Chemical analysis, micro structural characterization fractography hardness measurement tensile and Chirpy impact tests were used for the analysis. most of the failure occurs due to corrosion, torsion load & erosion. These problems are identified and can be solved by means of changing material, by providing radius at sharp edges, by avoiding stress concentration on weaker regions, change in design.**

IndexTerms **- Pump shaft, Reasons of failure , analysis of pump shaft.**

I. INTRODUCTION

A shaft is a metal bar usually cylindrical in shape (solid or hollow) used to support rotating components or to transmit power or motion by rotary or axial movement[Shafts operate under a broad range of service conditions including various corrosive environments and a wide temperature range[Shafts may be subjected to a variety of loads such as tension\ torsion\ compression\ bending or a combination of these[Shafts are also sometimes subjected to vibratory stress . Shafts are made of various materials according to their applications and requirements

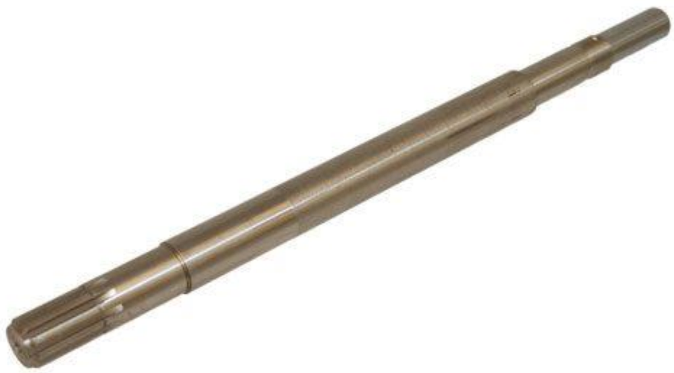

FIG.PUMP SHAFT

II. FAILURE OF PUMPSHAFT

Many pumps have the problem of shaft breaking. There are several reasons behind this breaking of shafts. During operation shaft ofl pump may bend or twist which will lead it to failure. Also the shaft of pump wears out with the usage due to erosion. As pumps are used for liquid transfer with water being widely transferred or lifted, the shafts are prone to corrosion. To overcome these problems the shaft must optimized through hardening or change of material.

FIG.PUMP SHAFT FAILURE DUE TO CORROSION

III. RESEARCH METHODOLOGY

In this section, contribution of different researchers is discussed

G Das[1] An analysis of the premature failure of two counter shafts used in centrifugal pumps for lifting slurry has been carried out. Chemical analysis, microstructural characterization fractography hardness measurement tensile and Chirpy impact tests were used for the analysis. The chemical compositions for the shafts were as per recommendation. The microstructure of one of the shafts was ferritic-pearlite and its mechanical properties were inferior to the recommended values. For the other shaft the microstructure was tempered binate; although the impact energy satisfied the specification, the other properties(hardness\ UTS) were inferior. It was concluded that the improper heat treatment was the prime cause for the premature failure of the shafts.

Niculai PASCA, Liviu MARSAVINA, Sebastian MUNTEAN[2] The shaft is an important component in hydraulic pumps used to transmit power from electrical motor to the pump impeller. The paper presents failure analysis of a shaft, from a double suction hydraulic pump in operation of approximately 30 years, in a storage station. The shaft material is a Romanian steel, equivalent after their chemical composition and mechanical characteristics with American SAE 4340 steel for which in literature are available necessary data for failure analysis. The paper is structured in two parts: finite element analysis of the pump shaft and an analytical failure analysis for a circumferential crack type, using the failure assessment diagram (FAD). In a modeling program for stress and strain analysis the 3D shaft was loaded in torsion. The numerical results show the maximum stress zones, the stress concentration effect, and the possibility of crack occurrence. For circumferential crack type the failure assessment diagram for Mode III loading were plotted using the stress intensity factor solution. The results indicate the unsafe zone respectively the critical circumferential crack depth, where the shaft cannot operate with defects. This study presents an opportunity related to safe operation condition and remaining life estimation for a storage pump

PramodJ,Bachche,R.M.Tayade[3] Centrifugal pump is world one of the oldest water pumping devises. The current work deals study Shaft of centrifugal pump for static and dynamic analysis. As we know rot dynamic machineries are designed keenly as there is lot of fluctuation in the loads and speeds. The shaft is analyzed by using finite element analysis technique for stresses and deflections. The total work is carried out in two stages first stage is static analysis. In this stage pump shaft is analyzed for stresses and deflection and same results are verified using graphical integration method. And second for dynamic analysis, in this stage result obtained by static analysis are used to calculate dynamic forces coming in pump shaft. Again shaft is analyzed in dynamic input condition and results are verified by using graphical integration method. The software used for the finite element meshing is HYPERMESH and solver used is RADIOSS. Result values obtained for deflection and stresses are compared in both cases. Result obtained by graphical method and FEA are nearly similar and are in acceptable limits. Keywords: Centrifugal pump shaft, linear static analysis, dynamic analysis, graphical integration method.

Wali Muhammad • KashifMairajDeen[4] A number of shaft failures were encountered in water recirculation pumps of an industrial setup. The shafts were made of martensitic stainless steel. A detailed study was carried out to determine the cause of the pump shaft failures. In this connection, the analyses performed include chemical analysis, microstructural characterization, fractography, tensile, shear, and hardness measurement. The chemical composition of the shafts was as per standard, however, hardness was very low. It was concluded that the material was used without heat treatment, causing inferior properties (hardness, tensile, and shear). Experimental heat treatments were done to improve the properties of the shaft material.

Maki M. Onari[5] Two multistage barrel type pumps were installed in a nuclear power plant in reactor charge application. The pumps are driven by a 600 HP (447 kW) four-pole induction motor through double helical gear increasers. The overall vibration amplitude of the pump casing and the shaft were determined to be acceptable. However, one of the pumps was found with shaft repetitive cracking failures (MTBF = 7.3 years) initiated away from the key-way stress concentration area, under the later stage impellers, in a zone where fretting was occurring. Several attempts pursued by the plant and their supplier, over the years, did not find the root cause of this shaft cracking problem, in spite of the good troubleshooting procedures and careful installation practices pursued. Therefore, an exceptionally comprehensive root cause investigation was implemented, with specialty vibration testing at its core.Thorough vibration testing combining spectral and time- transient vibration testing on the pump casing and shaft, Experimental Modal Analysis (EMA) testing of the impeller and pump casing, and Operating Deflection Shape (ODS) testing revealed the dynamic behavior of the pump rotor and the entire pump system. The results identified unsuspected excessive axial shuttling of the pump shaft at the motor running speed frequency due to axial run-out of the helical gear set. Based on the test results and supported by non-linear FEA analysis, the authors identified the root cause of the crack initiation phase of the shaft failure. An additional transient FEA based fracture mechanics analysis approach was able to predict that the stresses in the shaft, underneath the impeller, were able to encourage initiation and propagation of the crack.
This lecture demonstrates the effectiveness in machinery root cause investigations of thorough vibration testing including ODS, EMA, and FEA rather than traditional troubleshooting approaches, which had not detected a gear/pump inter-related problem, and would not have provided such clear visual Evidence for decision makers.

B.Sajjan, A.Santhosh[6] This work deals with design of an Impeller type Centrifugal pump and do analysis using ansys work bench . The primary goal is to apply pre load in the belt and to check deflections and stresses developed in impeller and pump housing. Different materials will be applied to pump and compared for internal induced stresses which should not exceed the elastic limit. The variation of von-misses stress, von-misses strain, deformation factor, natural frequencies, mode shapes for different materials can be taken into consideration. Ansys design modeler is used for modeling the parts and analysis is done in ansys workbench.Ansys is dedicated finite element package used for determining the variation of stresses, strains and deformation across profile of the impeller. A structural analysis is has been carried out to investigate the s tresses, strains and displacements of the impeller.

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LucjanWiteka*, Feliks Stachowicza, ArkadiuszZałęskib [5] Main objective of investigations is explanation of failure reasons of the crankshaft of diesel engine. An additional aim of this work is determination the stress distributions in crankshaft during the work of the engine. In this study the modes, frequencies and stress states were also obtained for the crankshaft subjected to resonant vibrations Performed visual examination indicated that on crankshaft fracture the beach marks typical for fatigue failure were observed. Observation of crack initiation zone showed that the crack origin was not covered by corrosion products. The local surface corrosion on the fracture occurred because the crankshaft after failure was stored for a long time in a humid air. In next step of analysis the crankshaft was subjected to the material investigations. In order to check the real material properties the shaft segment was cut on 3 mm thick specimens. In this operation the wire- cut machine was used. The geometrical (3D) model of crankshaft was made using the Catia software. In next step the model was exported to the Abaqus program and divided onto finite elements. The nonlinear stress analysis of the crankshaft was made with the use of Abaqus program. As a result the stress distributions for crankshaft subjected to the operational loads were obtained Based on results of performed investigations it was concluded that the main reasons of premature failure are resonant vibrations of the crankshaft.

Mohammad JamalkhaniKhameneh, Mohammad Azadi[6] has studied Evaluation of high-cycle bending fatigue and fracture behaviors in EN-GJS700-2 ductile cast iron of crankshafts finding A high-cycle bending fatigue and fracture behavior of the EN-GJS700-2 ductile cast Iron, which has been widely utilized for crankshafts in engines, was experimentally evaluated The studied material in this research was a ductile cast iron, entitled EN-GJS-700-2. Such material has been used for manufacturing engine crankshafts in automotive industries. The chemical composition of this material (standard specimens were extracted from crankshaft webs) was measured, comparing to standards. Obtained quantometric results showed that unless the copper element, other element percents have a good agreement with those values, mentioned in standards. The microstructure of the studied material can be seen in Fig. 1, for etched and un-etched samples. As known, mechanical properties of ductile cast irons have been directly related to their microstructure. The as-cast matrix microstructure of ductile cast irons may be entirely ferritic, entirely pearlitic, or a combination of ferrite and pearlite, with the spheroidal graphite distributed in the matrix. Besides, bainite and martensite were not found in the as-cast structure, since they were formed by the heat treatment process. The optical microscopy image from the studied material (considered from the pin journal of the crankshaft), was included ferrite-pearlite and nodular graphite phases. Ferrite halos (in regions) could be observed around nodular graphites. It should be mentioned that to obtain the material microstructure was etched by the 2% Nital conditi

Khin Cho Thin, Mya MyaKhaing[7] This paper deals with the design and performance analysis of centrifugal pump. In this paper, centrifugal pump is analyzed by using a single-stage end suction centrifugal pump. Two main components of a centrifugal pump are the impeller and the casing. The impeller is a rotating component and the casing is a stationary component. In centrifugal pump, water enters axially through the impeller eyes and water exits radially. The pump casing is to guide the liquid to the impeller, converts into pressure the high velocity kinetic energy of the flow from the impeller discharge and leads liquid away of the energy having imparted to the liquid comes from the volute casing. A design of centrifugal pump is carried out and analyzed to get the best performance point. The design and performance analysis of centrifugal pump are chosen because it is the most useful mechanical rotodynamic machine in fluid works which widely used in domestic, irrigation, industry, large plants and river water pumping system. Moreover, centrifugal pumps are produced by manufacturing processes in Myanmar. In this paper, the pump is driven by one horse power electric motor and the design is based on Berman Method. The head and flow rate of this pump are 10 m and 0.179m3/s and the motor speed is 2900 rpm. The low specific speed is chosen because the value of specific speed is 100. The number of impeller blade is 9 blades. The performance analysis of centrifugal pump is carried out after designing the dimensions of centrifugal pump. So, shock losses, impeller friction losses, volute friction losses, disk friction losses and recirculation losses of centrifugal pump are also considered in performance analysis of centrifugal pump.

Mohd Nasir Tamin and Mohammad ArifHamzah [8] This chapter deliberates on the systematic processes in failure investigation of engineering components and structures. The procedures are demonstrated in performing failure analysis of a centrifugal pump shaft. The chemical, microstructural, and fractographic analyses provide information on the material science aspects of the failure. The mechanical design analyses establish the cause of failure based on the stress calculations using the strength-of-materials approach. Fatigue analysis using the modified Goodman criterion is employed with consideration of yielding, under the fluctuating load. It is concluded that fatigue crack nucleated in the localized plastic zone at the threaded root region and propagated to cause the premature fatigue failure of the rotor shaft.

Ghanshyam G. Iratkar[9] In general the Efficiency of a centrifugal pump (ηo) = Mechanical efficiency (ηm) × Volumetric efficiency (ηv). Most of the study has been done in the improvement of Hydraulic efficiency but overall efficiency depends on both factors Hydraulic and Mechanical. Mechanical components – for example, impeller weight and structure produce a mechanical loss that reduces the power transferred from the motor shaft to the pump or fan impeller. Also, the strength of the pump reduces due to stress corrosion problems in impeller which can be minimized using an alternate material having same/more strength. The modelling of the impeller will be done by using solid modelling software, CATIA. The meshing and boundary condition application will be carried using Hypermesh, it is also used to produce good and optimal meshing of the impeller to obtain accurate results and analysis has been done by using ANSYS. A static analysis on 3HP pump impeller has been carried out to examine the stresses and displacements of the centrifugal impeller. Conventional MS material is replaced with glass fiber composite material. After getting safe results from the analysis, the model will be fabricated and testing will be done on UTM.

VI. **DISCUSSION**

The strength and efficiency of the pump shaft has a certain relation with general weight. so far as per literature review researchers considered change of material and thickness to increase strength and overcome corrosion and erosion effects. But, without making any changes in design, change of material overcoming all these problems is a highly desirable goal, if it can be achieved without increase in cost and decrease in quality and reliability. It is possible to do so through surface treatment processes of the pump shaft considerably by optimizing the surface treatment parameters by satisfying the all constraints. In the research work the main focus in towards increase strength; and if provided an attempt is made to reduce weight without compromising in strength and functionality. Typically, the finite element software like Hypermesh is utilized to achieve this purpose. For analysis Ansys could also be utilized.

V. **CONCLUSION**

After studying the pump shaft geometry and structure and its static and dynamic loading parameters, we may be able to find out different failure regions at stress concentration areas .so geometry of shaft is such that it will reduce stress concentration on different regions of pump shaft. secondly to avoid shaft failure we have to improve properties like toughness , hardness either by change of material or by providing some heat treatment. This can be achieved by means of use of analysis software like Ansys or Hypermesh to know results of change in properties or change in material or heat treatment processes like hardening.

VI. **REFERENCES**

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