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"A REVIEW ON EFFECT OF VIBRATION ON SHAFT UNDER DIFFERENT LOADING CONDITION IN STEAM TURBINE"

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ABSTRACT

Steam turbines that includes a control stage often show significant changes of the vibration levels correlated with changes of megawatt load. This can be due to changes of magnitude and direction of the journal bearings loads which cause variations of oil-film geometry and dynamic stiffness coefficients. A suitable choice of the bearing geometry can reduce the severity of these phenomena. Anyhow, load rises and decreases can generate additional dynamic forces, transmitted to the turbine shaft through the blades of the first stage, which cause further changes of the machine vibrations. As a consequence, the eigenvalues and eigenmodes of the mathematical model of the machine change. The real part of the eigenvalue associated with the first flexural normal mode of the turbine shaft may become positive causing the conditions for unstable vibrations. The original contribution of the paper is the application of a model-based analysis of the dynamic behavior of a large power unit, affected by steam-whirl instability phenomena. The model proposed by the authors allows studying successfully the experimental case. The threshold level of the steam flow that causes instability conditions is analyzed and used to define the stability margin of the power unit.

Key Words: *Rotordynamics, steam-whirl, steam-whip, instability, model based analysis.*

I. INTRODUCTION

Changes of the shaft-train alignment caused by changes of the machine thermal state as well as changes of the forces transmitted to the shaft of steam turbines that include a control stage, in consequence of megawatt loadings, can cause significant changes of magnitude and phase of the vectors associated with the loads acting on the turbine journal bearings. Owing to this the oil-film geometry and the corresponding dynamic stiffness can be affected by important changes. This can cause significant changes of the machine vibrations. Moreover, the static and dynamic forces transmitted to the rotor by the steam that flows through the control stage and possible further forces induced by excessive thermal expansions of pipes linked to the machine case can be additional causes of changes of the machine vibrations in operating conditions. Tilting-pad journal bearings can reduce the risk of the occurrence of high vibrations of steam turbines due to considerable changes of magnitude and phase of the bearing load vectors. Nevertheless, elliptical journal bearings are often mounted instead of tilting-pad journal bearings owing to their minor cost and the underestimation of the consequence of the rotor system excitations generated by some critical The results of detailed analyses of monitoring data integrated by those obtained by means of model-based
methods provide significant diagnostic information that can explain the reasons of the occurrences of abnormal vibrations that sometimes affect the steam turbines. The method proposed in this paper can be used to study corrective actions that can reduce the sensitivity of the turbine vibrations to the excitations generated by the phenomena.

Shaft vibration imposes additional load on bearings and coupling components. For turbine generators in the 4–10 MW

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size range, a test stand limit of 2 mils is readily achievable for manufacturers that use up-to-date rotor balancing and equipment design methods. There is thus no reason to compromise at this stage and a prudent user would usually insist on full compliance. Once the turbine generator is operating and has perhaps done so for years, stable vibratory performance is more important than absolute values. In other words, operation at a constant 4 mils over the past four years should be of less concern than operation at 2.9 mils for four years and a jump to 3.9 mils that occurred yesterday. An alarm value of 4.7 mils seems quite reasonable. It would alert the operators that the limit for unrestricted long-term operation is being approached in the ISO case and has been exceeded in the case of typical US practice. A "danger" setting of 6.9 mils, indicating advice to shut down at the earliest opportunity, will incur at least some risk of failure before a safe shutdown is triggered. In contrast, shutting down when 5.5 mils are exceeded would virtually eliminate the risk of catastrophic failure. In an obvious compromise, we would use a shutdown value of 6.5 mils for these 3600 constant-speed turbine generators. Remembering our first trigonometry lesson in school, we might even realize that 6.5 mils observed by a shaft displacement monitoring probe mounted at a 45-degree angle may, occasionally, relate to a true and actual shaft displacement that will have to be multiplied by the square root of 2. That would then turn 6.5 mils into 9.1 mils. How's that for reconciling the various discrepancies. Perhaps of even greater importance is the difference in risk tolerance. A repair-focused user will consider himself shielded by compliance with the ISO standard. Conversely, a reliability-focused, risk-averse user will stay closer to the limits indicated in our US practices column.

II. LITERATURE REVIEW

Chun-Ping Zouet al. (2002) [1] - This paper proposes a modal synthesis method of lateral vibration analysis for such type of rotor-bearing device. When the proposed method is evolved, the elastic coupling unit is defined as ''flexible substructure'' that's handled for my part and the alternative parts are partitioned into some substructures which are analyzed by finite element method.

S.P. Harsha et al. (2003) [2] - The paper offers with the structural dynamic response of rotor supported by ball bearings. The mathematical model takes into account the assets of nonlinearity together with Hertzian touch pressure, surface waviness, varying compliance and internal radial clearance resulting transition from no contact to touch state among rolling elements and races. In phrases of the function that the nonlinear bearing forces act on the machine, a brand new discount method and corresponding integration method is used to increase the numerical stability and lower laptop time for system analysis.

Erik Swanson (2005) [3] - The purpose of this article is to present a sensible understanding of terminology and conduct based in visualizing how a shaft vibrates, and examining problems that affect vibration. It is hoping that this presentation will assist the non specialist better apprehend what goes on within the machinery, and that the specialist may gain a unique view and/or a few new examples.

F. C. Nelson et al. (2007) [4] - The analysis of the lateral and tensional motion of spinning rotors is replete with packages of Newton's and Euler's equations. Sometimes the intricacies of these equations overshadow their less difficult bodily meaning. This paper tries to make amends for this by means of explaining the dynamic conduct of spinning rotors without writing any equations.

Keyu Qi et al. (2008) [5] - The single mode responses can be obtained via HWF and then RDT technique is employed to manner those responses, respectively, to extract single mode free responses of the rotor structures. Finally, HT approach is implemented to attain modal parameters of the rotor systems from those unmarried mode loose responses. The experimental effects of the proposed technique are close to those of the finite element method which suggests that the proposed method is effective in practical programs.

Keyu Qi et al. (2009) [6] - this investigation disturb relate degree pivot symmetric flexible rotor worked up by dissipative, moderate and non-preservationist point powers started at the contact with the aeolotropic stator loop. The Campbell graph of the unruffled framework could be a work like structure inside the frequency speed plane with twofold physicist frequencies at the hubs.

R. Whalley et al. (2009) [7] - The response of the device for precise shaft–rotor dimensions and rotational speeds is determined, establishing the dynamic traits inside the place of the whirling pace. A cantilevered shaft–rotor machine

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with an exponential – sinusoidal profile is investigated for purposes of illustration. The flexibility of the method and the general applicability of the method proposed are emphasized.

R. Whalley et al. (2009) [8] - The multivariable irrational, hyperbolic and circular characteristic, input–output dating for the system, is derived. Arbitrary, geometrical shaft profiling may be accommodated within the analytical strategies mentioned. Conventional frequency response methods are employed in the dedication of the critical speed condition. Specific studies, incorporating cantilevered rotors with non-linear shaft duration–diameter configurations are exact. The widespread applicability of the procedures outlined is emphasized.

S.A.A. Hosseini et al. (2009) [9] - The outcomes of mass second of inertia, eccentricity and outside damping coefficient are investigated on the constant nation reaction of the rotating shaft. The loci of saddle node bifurcation points are plotted as features of damping coefficient and eccentricity. Results of perturbation method are demonstrated with numerical simulations.

Mohammad Hadi Jalali et al. (2014)[10] - In this paper, full dynamic evaluation of a high velocity rotor with certain geometrical and mechanical houses is carried out the use of 3D finite detail model, one-dimensional beam-kind model and experimental modal take a look at. Good agreement among the theoretical and experimental effects shows the accuracy of the finite element method. The Campbell diagram, essential speeds, operational deflection shapes, and unbalance response of the rotor are acquired that allows you to completely look into the dynamic conduct of the rotating system.

Ma Jing-min et al. (2015) [11] - The numerical results calculated by Galerkin method are analyzed to indicate the consequences of ply perspective, taper ratio, and transverse shear deformation on the first herbal frequency and essential rotating pace. The outcomes are in comparison with those received by means of the use of finite element package ANSYS and to be had within the literature the usage of different method.

Rohit Tamrakar et al. (2015) [12] - This paper offers with the study of whirling of shaft with 3 rotors. Natural frequency of the system is found with the aid of effect hammer take a look at accompanied by way of figuring out the speed at which whirling happens in the gadget. Experimental consequences had been demonstrated through using Dunkerley's method for natural frequency. Rayleigh-Ritz equation is used to find out the essential velocity of the shaft and for this reason to validate with experimental result.

Piotret al. (2015) [13] - The fundamental intention of this paper is to show dynamic conduct of carbon fiber power shaft. In the paper, authors confirmed the impact of passing shaft resonance (1st critical speed). The effect of a shaft passage thru crucial kingdom underneath conditions of acceleration and deceleration was shown. The fundamental conclusion of the research is the need of considering an influence of adjustments rate on the traits of the composite shape elasticity.

O. N. KIRILLOV (2015) [14] – The singularities join the issues of wave propagation within the rotating continua with that of electromagnetic and acoustic wave propagation in non-rotating anisotropic chiral media. As mechanical examples a model of a rotating shaft with two ranges of freedom and a continuous version of a rotating circular string passing through the eyelet are studied in detail.

Xujun Lyu et al. (2016) [15] - In this paper to emulate the operation of such flywheels on a rotor-AMB take a look at rig we recently constructed. Specifically, the 2 AMBs placed at the 2 ends of the rotor are used as supporting bearings, while the other two placed at the rotor mid span and quarter span are used to emulate the generator negative stiffness and gyroscopic results on the rotor dynamics caused by the flywheel disk. Simulation and experimental outcomes are supplied to expose the effectiveness of the proposed emulation method.

I Crâștiu et al. (2017) [16] - The purpose of this paper is the development and validation of an impulse excitation method to determine flexural important speeds of a single rotor shaft and multy-rotor shaft. The experimental size of the vibroacoustic response is done through the use of a condenser microphone as a transducer.

I Geonea et al. (2018) [17] - In this paper it's presented the theoretical, experimental and numerical simulation of important pace for proper shafts. For this reason, its miles designed a digital version of a test bench for shaft essential

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speed analysis. The studied shaft is established on bearings and on the middle it has set up a heavy disc.

Suhas S. Jadhav et al. (2019) [17] - Present paper deals with theoretical study of crucial pace of shaft wearing single rotor. Every item has its very own frequency, known as as natural frequency. The measurement of this vital velocity and related whirling movement is one of the critical troubles to be addressed with the aid of a layout and protection engineer.

A. M. A. Wahab et al. (2019) [18] - It was found that the effect of torsional degree of freedom on the whirling frequency behaviour is significant especially for shaft at high speed where at the spin speed of 20000 RPM, the difference between the whirling frequencies corresponds to FEM model that considers tensional degree of freedom and model that does not consider can be as high as 45.3%.

2.2 Conclusion -The above literatures represents an investigation of experimental and simulation of shaft this shows a critical speed is a major issue for failure of shaft thus in our present analysis critical speed is analyzed for different material and profiles of shaft to determine and to optimize the effect of critical speed of shaft and its vibration at working condition.

III. PROBLEM STATEMENT

In present analysis study of shaft is done on critical speed and their natural frequency from above literature we found that on solid shaft types of vibration analysis were performed by analytically, numerically as well as experimental approach, we found that vibration and amplitude occurred during rotation of shaft is major issue by selecting the research paper of Dumitru et.al. We generated finite element model in ANSYS and solved on same parameter as per base paper values of damped natural frequency and spin speed for validation, after validation of base paper we optimized shaft by using stepped shaft in place of solid shaft used in base paper as well as four types of material were also used on optimized shaft on ANSYS simulation and critical speed was determined by simulating on these optimized parameters we found that gray cast iron gives less critical speed on stepped shaft and different masses mounted on it, Hence gray cast iron shaft could be used on gear shaft.

IV. OBJECTIVE OF THE WORK

The main objective of the current work is

1. Validation of the ANSYS models by comparing the present simulated results with the experimental result.
2. To predict natural frequency and critical speed effects for different shaft diameter (70-100 and 80-100 mm diameter) on the shaft.
3. To simulate the shaft of the different material having different diameter for variable modes and same RPM.
4. To define natural frequency effects and critical speed effects for the shaft of different diameter profile and different material and constant angular velocity of 3000rad/s.
5. To predict frequency distribution along the shaft.

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