Prediction of Critical Speed and Natural Frequency of Shaft by Effect of Campbell Diagram in Different Materials: A Review

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Abstract— A shaft is a mechanical component which is used for power transmission in automobiles and also used in industrial purpose like power houses, in turbines, compressors, shafts are used to transmit power from source to system it is a rotating member. It has mostly replaced the older version of shafts. The reciprocating piston engine consists crank shaft which is used to convert reciprocating motion into rotary motion with the help of the web mounted on a shaft for more power and torque transmission shaft has greater used on various purpose of power transmission and industrial applications.

Key words: Campbell Diagram, Shaft, Critical Speed, Natural Frequency, Wavelet Transform and Optimization Technique

I. INTRODUCTION

Shafts take on many different configurations are used for several different purposes, many different definitions are in commonly use, as listed below. The nomenclature isn't always clear cut and there is often an overlap of function and therefore of definition. Shaft In general, a rotating member used for the transmission of power one part from another part. Axle generally a stationary member used as a support to the rotating members such as shaft, bearing, wheels, idler gears, etc. Stub shaft a shaft which is integral with an engine, motor or prime mover and is of suitable size, shape and projection to allowed easy connection to other shafts.

II. TYPES

- Transmission shafts are used to transmit power between one part from other part and the source and the machine absorbing power.
- Machine shafts are the integral part of the machine itself.

III. CASING OR SHAFT ARRANGEMENTS

These arrangements consists single casing, tandem compound and cross compound shaft. One casing units are the most common style where a single casing and shaft are attached to a generator. Tandem compound are utilized where more than one casings are directly attached together to operate a single generator

IV. MATERIALS USED

- Most of shaft is made from steel, either low- or medium-carbon. However, high
- Quality alloy steel, usually heat treated, may be chosen for critical applications.
- Other metals, like brass, stainless steel or aluminum, may be used where
- Corrosion is a problem or lightness is required.
- Small, light-duty shafts, like in household appliances, may be injection molded
- In a plastic material such as nylon or delrin.

V. MODAL TESTS

The shaft test setup is shown in Figure 1. Thirteen accelerometers were attached to the surface of the shaft, and it was impacted with an instrumented hammer at three locations – at each end and in the middle. The attempted were simultaneously measured at 13 locations using a high-precision 16-channel data acquisition system. The thirteen accelerometer locations are indicated in diagram. During impact testing, time domain records of 64,000 samples each were acquired from the impact hammer and the accelerometers. Each record contained data from eight consecutive impacts. 3 sets of data were taken by impacting in the middle and at each end of the shaft.

Fig. 1: Shaft Test Setup

VI. COMPOSITES

Composite is any material made of more than one component. There are a lot of composites around you. Concrete is a composite. It's made of cement, gravel, and sand, and often has steel rods inside to reinforce it. These shiny balloons you get in the hospital when you're sick are made of a composite, which consists of a polyester sheet and an aluminum foil sheet, made into a sandwich. The polymer composites made from polymers, or from polymers along with other type of materials. But specifically the fiber-reinforced composites are materials in which a fiber made of one material is embedded in another material.

VII. MODULUS

In the elastomers are need the high elastic elongation. But for some other kinds of materials, e.g. plastics, it is usually they not stretch or deform so easily. If we know that how well a material resists total deformation, we measurement something called modulus. To measurement tensile modulus, we do the same thing as we did to measure

strength and ultimate elongation. That time we measure the stress we're exerting on the material, just like we did when we were measuring tensile strength. Firstly is slowly increasing the amount of stress, and then we measure the elongation the sample undergoes at each stress level. We keep doing this until the sample divided into several parts. This plot is a called stress strain curve. The height of the curve when the sample divided into several parts is the tensile strength, of course and the tensile modulus is the slope of this plot. If the slope is steep, the sample has a high tensile modulus, which means it resists deformation. If the slope is gentle, then the example has a low tensile modulus, which means it is easy all deformed. There are many times when the stress-strain curve is not nice and straight, like we saw above. The slope isn't constant as stress increases. The slope, this is the modulus, is changing with stress. In this paper like this we usually, the initial slope change as the modulus change. In general, materials have the highest tensile moduli, and elastomers have the lowest, and plastics have tensile moduli somewhere in between fibers and elastomers.

VIII. REVIEW OF LITERATURE

A. Numerical and Experimental Investigation

1) Nicoara Dumitru

The aim of this paper is that of developing a computational technique of the Campbell diagram of rotors. This paper deal with bending in the field of mono-rotors, such as in compressors and turbines. The presentation is concerns the use of the Campbell diagram and highlights some specific cases of its use.

2) H. D. Nelson (1976)

this analysis is presented for dynamic modeling of rotor bearing system which consist of rigid disk distributed parameter finite rotor elements and descrete bearings. The formation is presented in both of fixed rotating frame of prefrence. The finite element model consist a effect of rotatory inertia, gyroscopic moments and axial load is developed using the include matrix aproch. A reduction of coordinate procedure is utilized the model elements with variable cross section properties. The bearing may be nonlinear, however, only the linear stiffness and viscous damping is consider. the natural whril speeds and unbalanced response of typical overhung system is presente for two set of shaft parameters : (1) undamped isotropic, (2) undamped orthotropic. A comparison results is made with an independent lumped mass analysis.

3) Victor j. [1982]

this paper present is involves two major parts. The first part present is to develop the procedure for the general interactive analysis of machine shaft. This case both deflection and stress measure with consideration of stress and concentration for arbitrary cross section. The procedure is programed used to graphics to help the engineer visualizes the problem and result as they are determined. The method is based on the linear transfer matrix methods using the fundamental question of motion for the bending of a beam. The second major part present in this paper is to develop an automobile design procedure for round, stepped shafts.

4) Chun-Ping Zou (2002)

Rigid coupling and flexible connection made up of elastic coupling units are widely applied to rotor-bearing system with multi-branched shafting system. This paper presented a modal synthesis method of lateral vibration analysis for such type of rotor-bearing system. When the proposed approach is developed, the elastic coupling unit is defined as ''flexible substructure'' which is treated individually and the other parts are partitioned into some substructures which are analyzed by finite element method. The lower-frequency normal modes of the substructures are retained, where the higher-frequency normal modes are neglecting by a frequency truncation criterion and the residual flexibility of those omitted modes is optimized. The lower-frequency normal modes and residual flexibility are considered to the assumed modes of Rayleigh–Ritz method of whole structure. The approach to the treatment of higher-frequency modes leads to a great reduction in the calculation time and a significant improvement in the efficiency of modal synthesis.

5) S.P. Harsha (2003)

The paper presented with the structural dynamic modeling response of rotor supported by ball bearings. This method model takes into account the sources of nonlinearity such as Hertzian contact force, surface waviness, varying compliance and internal radial clearance resulting transition from no contact to contact state between rolling elements and races. In the case of the feature that the nonlinear bearing forces act on the system, a new reduction method and corresponding integration technique is used to increase the numerical stability and decrease computer time for system analysis. The effects of speed of balanced rotor in which ball bearings show periodic, quasi-periodic and chaotic behavior are analyzed. The results are presented in the form of time displacement responses, frequency spectra and Poincar2e maps.

6) Erik Swanson (2005)

This paper is to present a practical understanding terminology and behavior based a visualizing how a shaft vibrates and examining issue that effect vibration. Hope this presentation will help the non-specialist better understand what is going on the machinery, and that the specialist may gain a different view and some new examples.

7) F. C. Nelson (2007)

The analysis is presented of the lateral and torsional motion of spinning rotors is replete with applications of Newton's and Euler's equations method. Sometimes the intricacies of these equations overshadow their simpler physical meaning.

8) Keyu Qi (2007)

A novel method is analyzed for operational modal analysis OMA of linear rotor systems, combined with correction technique of spectrum analysis (CTSA), harmonic wavelet filtering (HWF), random decrement technique (RDT) and Hilbert transform (HT) method. With CTSA method, operational frequency component is reconstructed and subtracted from rotor vibration signal. The residual signal is presented by harmonics of operational frequency and several model responses. The single mode responses can be fined by HWF and then RDT method is employed to process these responses, respectively, to extract single mode free responses of the rotor systems. Finally, HT analysis is

applied to fined modal parameters of the rotor systems from these single mode free responses.

9) R. Whalley (2008)

The dynamics modeling of shaft–rotor systems, where the shaft profiles are contoured and considered. Shafts with diameters which are functions of the shaft length are considered. Analysis enabling the finding of the deflection, slope, bending moment and shear force at the extremities of the shaft is employed. Resonance, critical speed or whirling frequency conditions are computed using simple harmonic response methods. The analyzed of the system for particular shaft–rotor dimensions and rotational speeds is determined, establishing the dynamic characteristics in the vicinity of the whirling speed. A cantilevered shaft–rotor system with an exponential – sinusoidal profile is investigated for purposes of illustration.

10) S.A.A. Hosseini (2009)

Using the analysis of harmonic balance, combination resonances of in-extensional simply supported rotating shafts with nonlinearities in curvature and inertia are present. The frequency– response curves are plotted for the first two modes. The effects of mass moment of inertia, eccentricity and external damping coefficient are investigated on the steady state response of the rotating shaft.

11) O. N. KIRILLOV (2009)

This paper deal with an axis-symmetric flexible rotor perturbed by dissipative, conservative and non-conservative positional forces originated at the contact with the anisotropic stator. The Campbell diagram of the unperturbed system is a mesh-like structure in the frequency–speed plane with double Eigen frequencies at the nodes.

12) Mohammad Hadi Jalali (2014)

The High speed rotors are vulnerable to vibrations resulting in the failure of the all operating system. To avoid all resonant conditions at operating speeds, modal analysis of such rotors is very important in the design and development of the system. Full rotor dynamic analysis during operating conditions is also mandatory to investigate the dynamic behavior of the rotating structure. This presentation is full dynamic analysis of a high speed rotor with certain geometrical and mechanical properties is carried out using 3D finite element model, one-dimensional beam-type model and experimental modal test. Good deal between the theoretical and experimental results indicates the accuracy of the finite element models. The Campbell diagram, critical speeds, operational deflection shapes, and Unbalance analysis of the rotor are obtained in order to completely investigate the dynamic behavior of the rotating system.

13) Ma Jing-min1 and Ren Yong-sheng2 (2015)

A dynamic model of composite shaft with variable cross section is analysis. Free vibration equations of the variable cross section thin-walled composite shaft considering the effect of shear deformation are established based on a refined variation asymptotic method and Hamilton's principle. The numerical results determined by Galerkin method are analyzed to indicate the effects of ply angle, taper ratio, and transverse shear total deformation on the first natural frequency and critical rotating speed.

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