Simulation of rotor supported by bearing on a shaft

Swati Kulkarni[1], Prof. Yogita Potdar[2]

[1] *Student, Dept. of Mechanical Engineering, KLSGIT College of Engineering, Belagavi, Karnataka, India*
[2]*Prof, Dept. of Mechanical Engineering, KLSGIT College of Engineering, Belagavi, Karnataka, India*

---***---

Abstract - *Rotors and bearings are widely used in all the different engineering fields. Rotor rotation mainly depends on the dynamic characteristics of the system. These dynamic characteristics are basically the force and stiffness. The stiffness considered is the torsional stiffness as the rotor is rotating. The results were obtained with the ansys. The model basically consists of a rotor on a shaft supported by bearing. The CAD model was designed on SOLID WOKS software.*

The model consists of a rotor supported by bearing on a shaft at uniform distance and mass on the rotor was also uniform so that efficiency is equal at both the ends of the shaft. The work is carried to study the dynamic characteristics. This study was carried out on Ansys software to understand the stability of the system at a range of rpm, for which solid model was created using solid works software and further worked on ansys software.

***Key Words*: Rotor, dynamic characteristics, journal bearing, shaft rotation, etc .**

1. INTRODUCTION

Rotating machine such as compressors, turbochargers, jet engines, pumps all are subjected to vibrations. Vibrations are of two types synchronous or nonsynchronous caused by rotor whrilling.[1] The major concern area is on rotor critical speed , system stability and unbalance response. The main components of a rotor-dynamic system are the shaft , rotor with disk and the bearing with seals. Vibration of a turbo machinery affect the function of any industrial plants. High level of vibrations reduces the output and efficiency of a system .In simple terms the turbo machine consists of rotor supported on bearings. There are three forms of vibration torsional, lateral and axial vibrations. Torsional vibration specifies about the angular/rotational motion of the shaft. Lateral vibration as name species the vibration of rotor in lateral direction. Axial vibration specifies dynamics of rotor in axial direction. Rotating shaft are used in industrial machines such as turbo-generators, combustion engine, turbine for power transmission. On demand of such system in industries, the rotors of these machine are made flexible, which leads to detail study of vibration and dynamic characteristics of the system. These machines are subjected to torsional and bending vibrations. .

1.1 Operating Principle

Considering a three- phase induction motor to understand the working principle of the power transmitted through rotor. [4] In a three phase induction motor, the major parts are the stator & the rotor systems supported by the bearings on the end frames/shields. The stator is stationary part & rotor is the rotating pert of the system, the stator has a uniformly distributed windings in the form of coils across the slots in the stator. The magnetic field is created in the stator, the rotor on the other hand has a squirrel cage construction comprising of slots which are usually filled with brass or aluminum damper bars with end rings short circuiting creating close loop internally.

When the electric power (alternating current) that is supplied to the stator windings. This energizes the stator to create the magnetic flux in the system. This flux generated in the stator links across the rotor through the air gap between rotor and stator which in turn leads to induce the voltage and hence further produces current through the rotor bars. The output of the rotating flux and current produces force that generates torque to start the system.

Due to the relative speed between the rotating flux & stationary conductors, an emf is induced in the rotor, the emf induced is the same as that of the supply frequency. Its magnitude is proportional to the relative velocity between the flux & the conductors. Since the rotor bars form a closed circuit (squirrel cage construction), the rotor current direction is such as to the cause producing it (Lenz's law).

The cause which produces the rotor current is the relative velocity between the rotating flux of the stator & stationary rotor conductors. Hence, to reduce the relative speed, the rotor starts to rotate in the same direction as that of the flux & tries to catch up with the rotating flux. The rotor is set into rotation in the same direction as that of the stator flux or field.

In practicality, the rotor does not rotate at the synchronous rpm, the difference between the actual speed & the stator field, this is termed as slip. As the rotor slips back from the synchronisms, if the rotor would run at the synchronous speed then there would be no relative speed between the stator filed flux & the rotation of rotor, hence no emf would be induced in the rotor.as a result of which there would be rotor emf & no rotor current. As an end result there would be no torque to maintain the rotation.

1.2 Principle used in designing the model.

Primarily the model used incorporates the assembly with a unit comprising of a simply support structure with 2 bearings, the rotor mass is a single unit. But the modified model intends to uniformly distribute mass in 2 sections. Supported by 3 bearings yielding a very efficient & balanced unit optimizing the unit.

The shaft defection in the earlier model is a unit with mass concentrated at a particular location, usually compensated by a higher shaft diameter & bearing sizes leading to higher costs of the unit. The proposed unit due to the intermediate support bearing will no doubt give a better support reducing the defection & also uniformly distribute the mass & optimize the entire the assembly.

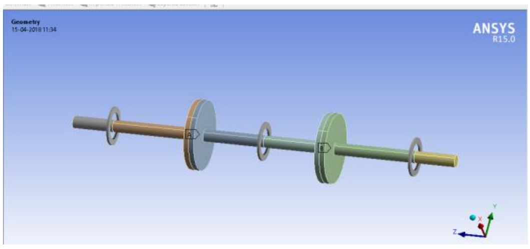

Fig-1 Rotor supported by bearing.

Table-1: Parameters Considered for designing.

Parameters	Value
Diameter of the rotor	70mm
Mass of the rotor	20kg and 30kg
Thickness of the rotor	10mm
Speed of the rotor	Upto 30,000 rpm
Length of the shaft	1200mm
Force	280N
Stiffness	10^6 N/mm

Fig 2 : Representing mode Shapes at different rpm values

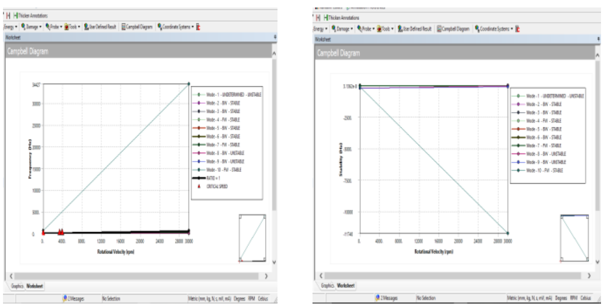

Fig 3: Results obtained showing the stability and critical speed of the system for 20kg

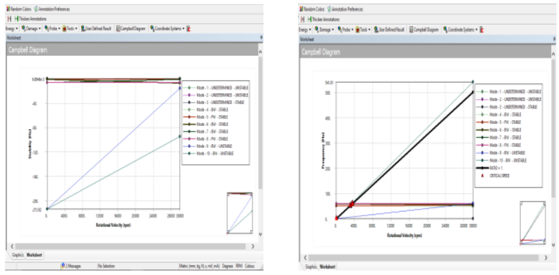

Fig 4 . Representing graph for stability at rpm which also shows the critical speed

1.3 RESULTS

From the above graph it is clear the stability of the system is linear i.e as the speed of the system increases from 0 to 4000 rpm the graph varies linearly. The stability of the system increases as the speed increases. The critical speed is the point at which both the stability and speed intersect, which is found to be at 3800 rpm in case of 20 kg mass of the rotor., and the critical speed is 3400 rpm in case of rotor with mass of 30kg . From the graph above we could see the logarithmic decrement of system is linear.

3. CONCLUSION

As looking into the above results we could check the stability of the system. From the literature survey it was observed that stability of a rotor depends on the mass and speed . Hence the work was performed by varying the mass of the rotor and was observed that varying loads and mass on the rotor the stability of the system also varies. Dynamic characters like force and stiffness are studied at different rpm.

ACKNOWLEDGEMENT

In this work performed was successful because of the huge support of Prof: Yogita potdar who guide me in all respect in order to understand the basic concepts of the work done.

REFERENCES

[1] Robert Y text book on Introduction to Rotor Dynamics Basics".

[2] Electrical Therrja ," A text book on introduction of Electrical Engineering. "To unserstand the working principle of a rotor".

[3]. Robert L Norton " A tecxt book on machine design " Second addition.

[4] Xiao- Hua Cao *et.al* " Effects of length of rotor wafters on rotor temperature rise for permanent magnet synchronous motor"

[5] Praveen Kumar N "Electromagnetic Field Analysis of 3-phase Induction Motor Drive under broken rotor bar fault condition using FEM".

[6]. Jiri Klima, *et.al* "The influence of rotor Slits on the performance of High- Speed Solid –Rotor Induction Machine.

[7] Sarumol. G "Minimization of Losses in Permanent Magnet Synchronous Generator for High Speed Applications".

[8].Chao Feng "Application of an improved discretization method for the rotor bearing assembly in the radiated noise analysis using Riccati transfer matrix method"

[9] Robert L Norton " A text book on machine design"

[10] Mário J. M. Gonçalves1, Renato C. Creppe2, Emanuel G. Marques1, Sérgio M. A. Cruz1" Diagnosis of Bearing Faults in Induction Motors By Vibration Signals – Comparison of Multiple Signal Processing Approaches" 2015s

[11] Ritesh Figade *et.al* "Unbalanced response of rotor using ansys Parametric design for bearings"

[12] Mr. Sandeep Tiwari, Dr Shak bahadur " Dynamic analysis between rotor bearing system for flexible bearing condition " 2017.

[13] Arvind katyayn, Praveen kumar Agarwal," Comparitive analysis of conical and conventional active magnetic bearing for complete support of rotor system" 2017

[14] Gao Dianrong, Du Shiyuan " Numerical calculation and analysis of suspension force of permanent magnetic bearing in conical spiral blood pump

[15] K T Shrreekumar *et.all* "Locality constrained linear coding for fault diagnosis of rotating machines using vibration analysis"

[16] Anirudhha Roy, et.all "Performance comparison of nonlinear hydro dynamic journal bearing with rotor internal damping using optimal and fractional order controllers

[17] Rami Levy, *et.all* "Inertial centering approach for high fkexible rotor system supported by AMBS"

[18] Yoshihiro Kai"Dvelopment f walking support roto with vrlocity and torque based mechanicals safety devuces."

[19] GAO Dianrong . *et.all* " Numerical calculation and analysis of suspension force of Permanent Magnetic Bearing.

[20] Jiqiang Tang " Simulative Analyses of the rotor for Magnetically suspended flywheel with Vernier capavity"

BIOGRAPHIES

Prof: Yogita Potdar
Asst Professor (Mechanical Dept)
Completed M.Tech in Machine Design at KLS Gogte Institute of technology and currently pursuing PhD in Rotor dynamics filed.

Swati Kulkarni
Mtech (Machine Design Student)
Completed Bachelor of Engineering in Industrial production and currently in final year of M .Tech in Machine Design.