International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET

Rotor Dynamic Analysis of Multi-Disc System with Viscoelastic Support

Sagar N[1], Manjunath S B[2]
[1]Postgraduate Student, Department of Mechanical Engineering, Dayananda Sagar College of Engineering, Bangalore, India
[2]Assistant Professor, Department of Mechanical Engineering, Dayananda Sagar College of Engineering, Bangalore, India

Article Info
Volume 9, Issue 4

Page Number : 335-344

Publication Issue :
July-August-2022

Article History
Accepted : 05 August 2022
Published: 16 August 2022

ABSTRACT

The detailed study of rotor dynamic aspects of a rotating system is very much essential before the start of manufacturing process. In different types of rotating machines like compressor, turbine, turbo-pumps and so on the different types of bearings and support system have been used to obtain desired performance. A detailed analysis on critical speed estimation and frequency response of the system has been carried out in this work. To avoid resonant condition at operating speeds, modal analysis of such systems is much important in the initial stages of design. Full rotor dynamics analysis during operating conditions is also mandatory to investigate the dynamic behaviour of the rotating structures. In this work modal analysis, critical speed and harmonic analysis of frequency response of high speed multi disc system supported with viscoelastic support has been carried out using 3D finite element analysis software named Ansys workbench. The critical speed and mode shapes of the multi disc system supported with viscoelastic support are obtained through Campbell diagram in order to investigate the dynamic behaviour of the rotating system. The effect of change of critical speed due to change in stiffness values of the support is been studied. Further, harmonic analysis is been carried out in order to determine the frequency response of the system.

Keywords: Rotor Dynamic, Critical Speed, Campbell Diagram, Natural Frequencies, Unbalanced Response.

I. INTRODUCTION

Rotodynamic is an area of applied mechanics that focuses on the behavior and diagnostics of rotating system. It also known as rotor dynamics, it is frequently used to analyze the behavior of various types of constructions including computer hard drives, steam turbines and jet engines. The use of foil journal bearing for high speed rotor systems is a growing popularity [15]. Due to shaft’s high flexibility, it is prime important to do the dynamic modelling and also the vibrational analysis for design and operations of multistage rotating system [12]. Multi-disc systems are widely used around the domain as a dependable, flexible and efficient power generation option. This adds to the workhorse that has been unparalleled in aircraft engines for eras. The more progressive the technology, the lower the vibration of the turbine, thus increasing rated power, reducing weight and improving efficiency. This requires the use of progressive materials, so a deeper understanding of rotor dynamics analysis becomes essential. In this paper a viscoelastic support has been given around the bearing to study how the viscoelastic support around the bearing will make changes in the performance of the multi-disc system about the critical speeds which are obtained from the Campbell diagram and also the frequency response of the multi-disc system with viscoelastic support. Amor Zapanta [1] Viscoelastic material characterization was carried out using Dynamic Mechanical Analyzer (DMA). A rectangular curved specimen for the mold compound material characterization was used, at the test temperature range from 300 C to 3000 C with 100 C increment and a frequency sweep from 0.1 Hz to 100 Hz with 5 points per decade spaced accordingly to a log scale. DMA output showed that the relationship between the storage modulus and temperature for all the frequencies applied, the they see that the modulus becomes lower at higher temperature as heat softens the mold material. Jing Wang, Yongfeng Yang [2] A rotor system having dual disc with uncertain parameters was analyzed with Chebyshev convex method of non-probabilistic type, for the dual disc rotor system the dynamic equations was derived with the help of finite element method and Chebyshev convex method was used to get the uncertain transient response. The dual disc rotor experiment findings confirmed the precision and effectiveness of the Chebyshev convex approach, their future work will be on optimization of Chebyshev convex method, that will provide effective help to rotor dynamics designer. Qinwu Xu [3] To enhance the current model, they created a material that is non-linear viscoelastic with mathematical and physical exponential. Here the non-linear strain hardening is taken into account as the relaxation modulus transient from the glassy stage to the rubbery stage through a time-dependent viscosity in a continuous spectrum. The model is numerically stable and does not slow down computational speed. I I Ivanov [4] They provided the proper strategy, which combines the usage of non-linear support models with rotor finite element models. The hertz contact theory was used to determine the non-linear exponential dependencies of forces on displacement that were used to simulate rolling bearing. Mehmet Parlak [5] A compact steam turbine rotor was subjected to rotor dynamic analysis and by applying a finite element approach based on dynort software, critical speed, modal shapes and Campbell diagram of the system were derived. Vasanth Kumar S [6] He used rotor bearing system of small gas turbine to study the dynamic analysis, an equivalent mass model was designed to carry out the study of rotor bearing to examine the response in an effective way. He used various bearing stiffness values in order to find critical speed, stability limit and unbalanced response of a rotor bearing system. He explains how we can use bearing stiffness and control the vibration parameters. Number of stages of the multi disc system is specified in the design program by considering the factors specified for working condition and overall efficiency and size of the system. As the steps in the system increases, there will be increase in the efficiency because the heat loss of each step is optimized in the next step, but still the weight, cost and size of the system increases.

II. METHODS AND MATERIAL

Design of a multi-disc system is a difficult task although the working principal is same as that of single stage systems. The analysis is carried out for multi-disc system, in this study we can carry out the model analysis and unbalanced response. There are no systems which are vibrations free, this is due to the external and internal forces, the primary aim is to bring the vibration levels within the acceptable limits. The standard procedure followed in the designing of these rotor system is to perform the finite element analysis on various rotor configuration for the fabrication. For this work the commercially available finite element package, ANSYS Workbench is used.

2.1 Finite Element Method

A finite element method can be done using computers to predict the effects of a wider range of physical structures. FEM software is a very standard tool used by engineers and physicists because it can accurately flexibly and practically apply the laws of physics to real world scenarios. FEM is a scientific technique used to imprecise answers to differential equations, which can now be answered by the computer multiple times. Differential equations are important and exists for many technical problems since they characterized the linguistic in which the laws of physical are conveyed. They combine alterations in internal variables such as displacement, temperature and pressure with the geometry, physical properties of things, and external influences that act on them.

2.2 Catia V5 Software

Catia is a computer assisted drawing software developed by French company Dassault Systems. Catia is an aggressive application that helps you to create difficult design. The purpose of Catia process shoes how to calculate a part or assembly in Catia and how to create a simple drawing of that part or assembly. Using Catia software, 3D parts from 2D sketching are possible, sheet metal parts, composite materials can be designed with minimal errors.

2.3 ANSYS Workbench Software

ANSYS Workbench is a well-known analysis software. This consist of pre-processing and post-processing steps. It takes CAD model to carry out the finite element analysis steps for structural, thermal and electromagnetic problems. Ansys workbench consist of several steps to be followed like importing a geometry, meshing the geometry, applying the boundary conditions and extracting the results and reviewing the analysis in the software.

Initially the model from the Catia software should be saved in stp file format, then the stp file should be imported in the Ansys workbench software. The imported model is meshed first by providing the material properties and then various constraints and application of different types of loads by providing all these in Ansys software we are going to extract the results.

III. Multi-Disc System Model

A multi-disc rotor bearing system is shown in the Fig. 2 and same system with three disc is taken for the purpose of analysis. The rotor bearing system supported with viscoelastic support is made of axial turbine, bearing and shaft. The material properties are taken from the reference [6], the material properties are shown in Table 1.

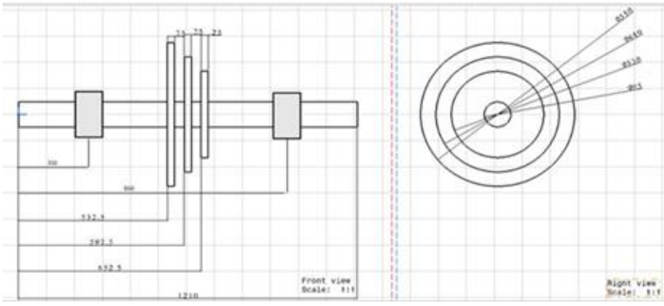

Fig. 1. 2-Dimensional view of Multi-Disc System.

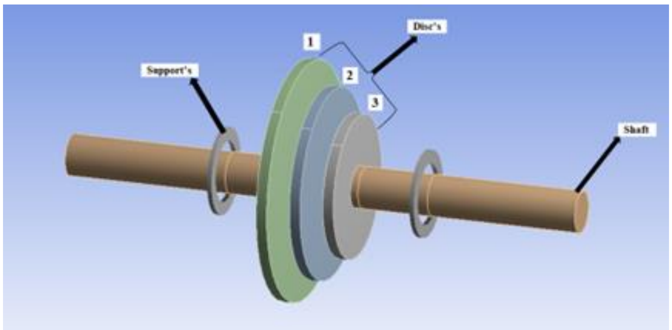

Fig. 2. Components of Multi-Disc System with Viscoelastic Support.

Table 1. Material Properties of Multi-Disc System.

Component	Material	Young's Modulus (GPa)	Poisson's Ratio	Density (Kg/m^3)
Disc's	CM-247	209	0.3	8500
Shaft	C-15	235	0.24	7850

Each component is being modelled by Catia V5 software and all the components are being assembled for further analysis. The Ansys workbench software is used to do the analysis after assembling the model is imported in the Ansys workbench. In the analysis we have considered two cases, Case 1 is the assembly with only bearing support and the other one is Case 2 is the assembly with bearing support along with the viscoelastic support, for these two cases the analysis is done. After proper meshing and proper application of the boundary condition's the results are extracted along with the frequency response curve.

IV. ROTOR DYNAMIC ANALYSIS

Rotor dynamic is a sub division of applied mechanics, which helps to study the behavior changes of rotating system. Rotor dynamic study is done for analyzing the turbines, jet engines, auto engines and so on. Rotor dynamic analysis is concentrated on rotational velocity and the supports to the system. There will be vibrations in the system due to the unbalance present in the rotor, when these vibrations exceed the limit, the component fails. Depending on the types of bearing and support used the magnitude of these vibrations varies. The maximum vibration takes place when the system's natural frequency will be equal to frequency of rotation and that speed value is called as critical speed. The first critical speed is the lowest speed on which the resonance occurs. Likewise, within the operating speed a single system can have many critical speeds. To avoid working near critical speeds of the system it is important to analyze the unbalanced forces which produces high vibrations. Neglecting these aspects might results in loss or wear of machine component and even the loss of equipment and also the catastrophic failure of the component can occur.

The equation of motion in its generalized matrix form is written as:

$$\mathbf{[M]\ddot{u} + \Omega[(C + G)]\dot{u} + [K]u = f(t)} \qquad (1)$$

Where:

- [M] is the Mass matrix.
- [C] is the Damping coefficient in matrix form.
- [G] is the Gyroscopic matrix.
- [K] is the Stiffness matrix.
- U is the Generalized coordinates of the rotor.
- f (t) is the unbalanced forces.
- Ω is the spin speed.

The above equation (1)'s generalized solution involves complex eigen vectors which are spin speed dependent. To understand these solutions, one depends on the Campbell diagram, the Campbell diagram is the diagram which gives all the necessary information's like critical speed, whirl direction and stability values.

Fourier Transformation is used to write the solution vector u to solve the equation (1).

$$\mathbf{u = Ue^{j\omega t}}$$

$$\mathbf{\dot{u} = j\omega Ue^{j\omega t}}$$

$$\mathbf{\ddot{u} = -\omega^2 Ue^{j\omega t}}$$

Substituting the above in equation (1) and reducing it to standard form we get,

$$\mathbf{\left[\omega^2[I] - A\right]U = 0} \qquad (2)$$

Where A = $[M - j\ G]^{-1}[K]$. The critical speed is calculated using the above equation (2).
The critical speed is defined either backward or forward whirl subjected to the rotation mode generated with respect to the axis of rotation. The critical speed map is then extracted using this data in the form of Campbell diagram.

V. FE Analysis of Multi-Disc System

We have used equivalent mass representation for all the disc's, each of these components is designed modelled by means of Catia software and all the component are assembled for the further study as shown in the Fig 3. The assembled model is then imported in Ansys workbench. After proper meshing as shown in Fig 4 and application of boundary condition results are extracted for both the cases as mentioned above. The extracted results contain critical speed values and its frequencies with their whirl direction.

For the model there were totally 4544 elements and 24580 nodes were created with an edge length of 17.50 mm

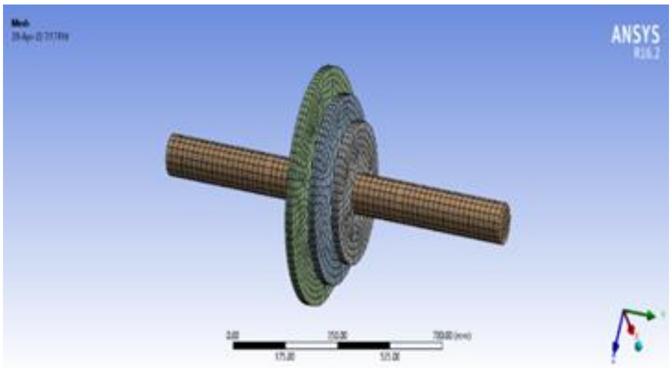

Fig. 3. Multi-Disc Model in Catia Software.

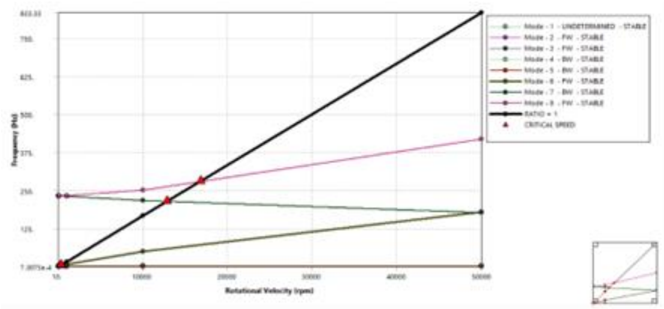

Fig. 4. Meshed Model in Ansys Workbench

After meshing the model, the model is analyzed by applying all the oprational boundary condition, along with suitable bearing stiffness values. For rotor dynamic analysis the Coriolis effect is turned on so that the campbell diagram can be extracted. After that the frequency response are exteacted for both thr cases as mentioned above.

5.1. Case 1: Multi-Disc System Supported with only Bearing

The modal analysis for the multi-disc system supported with only bearing is carried out with the bearing stiffness of 50 N/mm. The application of constraints is shown as in the Fig. 5(a) and the output containing Campbell diagram is shown as in the Fig. 5(b) which includes critical speeds, whirl direction and mode stability as shown in Table 2.

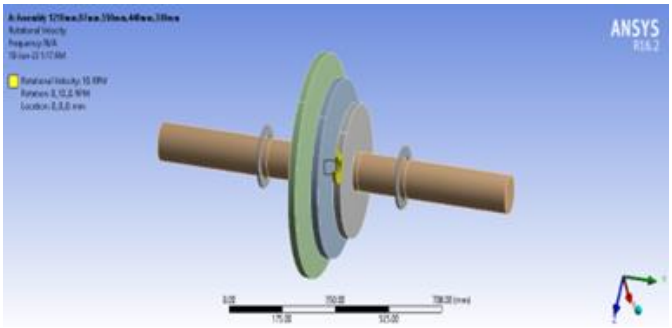

Fig. 5(a). Constrained Model.

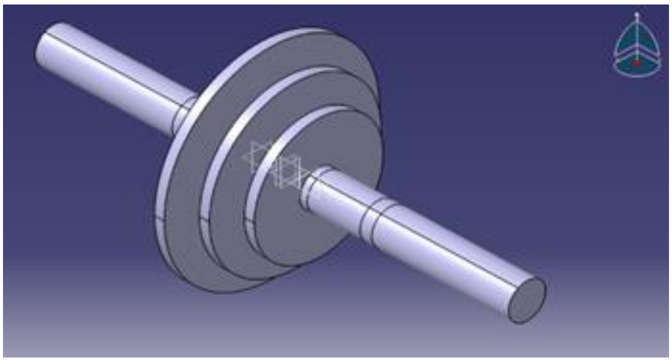

Fig. 5(b). Campbell Diagram for Multi-Disc System with only Bearing Support.

Table 2. Critical speed and Stability

Mode	Whirl Direction	Mode Stability	Critical Speed
1	UNDETERMINED	STABLE	NONE
2	FW	STABLE	NONE
3	FW	STABLE	234.58 rpm
4	BW	STABLE	240.17 rpm
5	BW	STABLE	234.86 rpm
6	FW	STABLE	319.02 rpm
7	BW	STABLE	12860 rpm
8	FW	STABLE	16845 rpm

The harmonic analysis is also carried out on this case to extract the frequency response of the system for the unbalanced mass of 0.01 Kg with rotating radius of 2 mm i.e., Unbalanced force of 2×10^{-2} Kg-mm, these unbalanced forces are given on all the three discs as shown in the Fig 6. After applying the unbalanced mass at a radius, the analysis is done and the frequency response of each disc is extracted as shown in the Fig. 7, Fig. 8, Fig. 9.

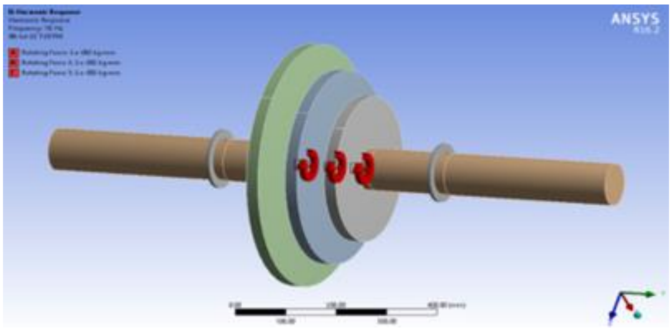

Fig. 6. System with Unbalanced Force with only Bearing Support.

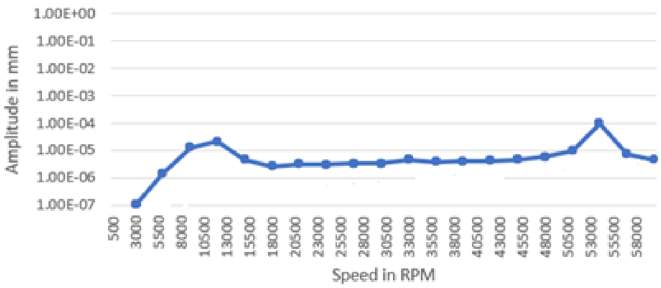

Fig. 7. Frequency Response of Disc 1 for only Bearing Support.

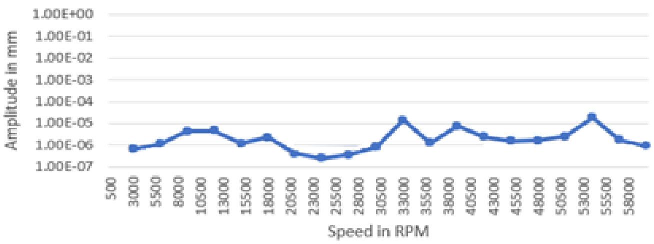

Fig. 8. Frequency Response of Disc 2 for only Bearing Support.

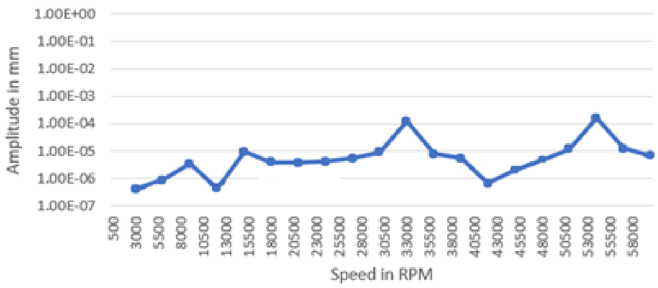

Fig. 9. Frequency Response of Disc 3 for only Bearing Support

5.1 Case 2: Multi-Disc System Support with Bearing along with Viscoelastic Support

The modal analysis for the multi-disc system supported with bearing along with the viscoelastic support is carried out with the equivalent stiffness of 49.2362 N/mm. The application of constraints is shown as in the Fig. 14(a) and the output containing Campbell diagram is shown as in the Fig. 14(b) which includes critical speeds, whirl direction and mode stability as shown in the Table 4.

The calculation of equivalent stiffness by considering the bearing stiffness is as shown below

- $$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \text{ in N/mm}^2 \qquad (3)$$

Force = 50N

$$\text{Area} = \text{Length of Arc} \times \text{Width}$$

$$\text{Area} = 2 \times \pi \times \text{radius} \times \left(\frac{\theta}{360}\right) \times \text{Width}$$

$$\text{Area} = 2 \times \pi \times 85 \times \left(\frac{70}{360}\right) \times 30$$

$$\text{Area} = 3115.4127 \text{ mm}^2$$

$$\text{Pressure} = \frac{50}{3115.4127}$$

Pressure = 0.01604 N/mm².

- Bearing Stiffness, K_b =50 N/mm.
- Viscoelastic Support Stiffness, $K_s = \frac{\text{Pressure}}{\text{Deflection}}$ (4)

The deflection of the viscoelastic support is found by analyzing the viscoelastic support in the Ansys workbench software.

5.2.1 Viscoelastic Support Analysis

The viscoelastic Support is given around the bearing. The model of viscoelastic support is done using Catia software and analyzed in Ansys workbench. The inner diameter of the viscoelastic support will be the external diameter of bearing which is 170 mm and also the outer diameter of the viscoelastic support is taken from design data handbook which is 310 mm. The 2D representation of the quarter part of viscoelastic support is as shown in the Fig 10. And the Catia model is as shown in the Fig 11 and the material properties given for the viscoelastic support is as shown in the Table 3 (a) and (b).

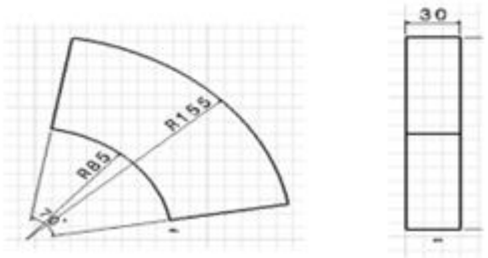

Fig. 10. 2-Dimentional View of Quarter Part of Viscoelastic Support

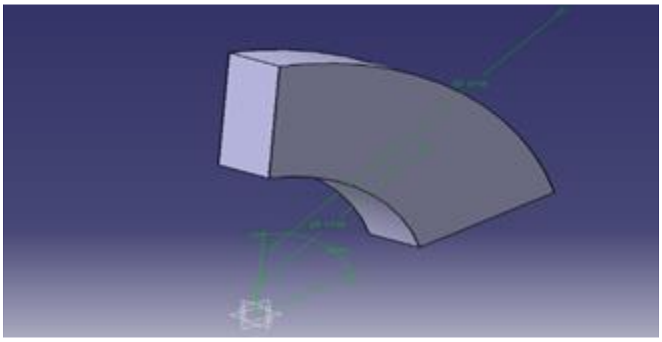

Fig. 11. Viscoelastic Support Model in Catia Software.

Table 3(a). Material Properties for Viscoelastic Support.

Component	Young's Modulus (GPa)	Poisson's Ratio	Density (Kg/m^3)
Viscoelastic Support	200	0.3	2300

Table 3(b). Prony Shear Relaxation Table for Viscoelastic Support.

Index	Relative Moduli	Relaxation Time in s
1	0.5	1
2	0.2	10
3	0.2	100

The fixed support is applied on the outer surface of the viscoelastic support and a pressure of 0.001604 N/mm^2 is applied in the internal surface of viscoelastic support the same has been shown as in the Fig. 12. After applying the boundary condition. The total deformation is extracted which is needed to calculate the viscoelastic support stiffness.

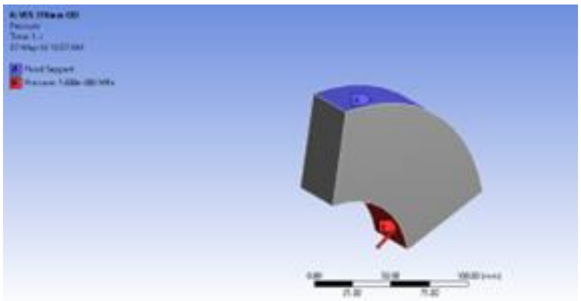

Fig. 12. Constrained Viscoelastic Support Model

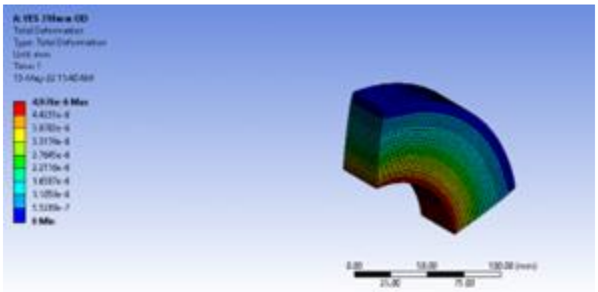

Fig. 13. Total Deformation of Viscoelastic Support.

The total deformation obtained for the viscoelastic support is obtained as 4.976×10-6. The further calculation of the stiffness of viscoelastic support and for the calculation of equivalent stiffness we are considering the bearing stiffness along with the viscoelastic support stiffness and with having the equation (4) we can write the viscoelastic support stiffness as shown below.

- From equation (4), Viscoelastic Support Stiffness, $K_s = \frac{\text{Pressure}}{\text{Deflection}}$
- $K_s = \frac{0.01604}{4.976\times10-6}$ => K_s = 3223.4726 N/mm.
- Equivalent stiffness, $K_e = \frac{Kb\times Ks}{Kb+Ks}$ (5)

$K_e = \frac{50\times3223.4726}{50+3223.4726}$ => K_e = 49.2362 N/mm.

The multi-disc system support with bearing along with the viscoelastic support subjected to constraints is as shown in in the Fig 14 (a) and the output containing the Campbell diagram shown as in the Fig. 14(b) and the whirl direction, critical speeds, mode stability is shown in the Table 4.

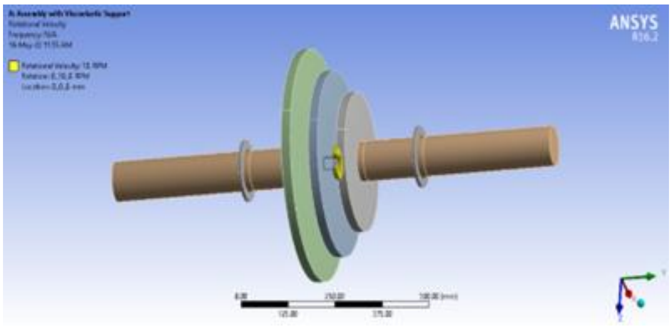

Fig. 14(a). Constrained Model.

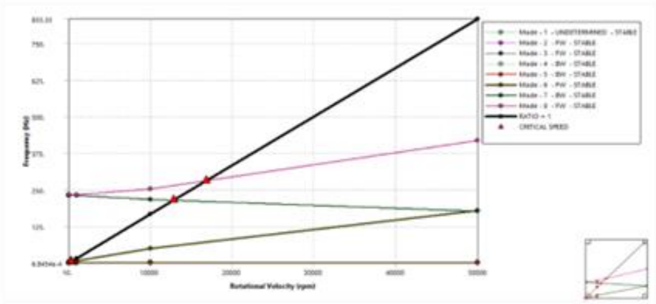

Fig. 14(b). Campbell Diagram for Multi-Disc System with Bearing and Viscoelastic Support.

Table 4. Critical speed and Stability.

Mode	Whirl Direction	Mode Stability	Critical Speed
1	UNDETERMINED	STABLE	NONE
2	FW	STABLE	NONE
3	FW	STABLE	232.82 rpm
4	BW	STABLE	238.40 rpm
5	BW	STABLE	233.41 rpm
6	FW	STABLE	317.14 rpm
7	BW	STABLE	12860 rpm
8	FW	STABLE	16840 rpm

The harmonic analysis is also carried out on this case to extract the frequency response of the system for the unbalanced mass of 0.01 Kg with a rotating radius of 2mm i.e., Unbalanced force of 2×10^{-2} Kg-mm, After applying the unbalanced mass at a radius on all discs, the analysis is done and the frequency response of each disc is extracted as shown in the Fig 16, Fig 17, Fig 18.

Fig. 15. System with Unbalanced Forces with Bearing and Viscoelastic Support.

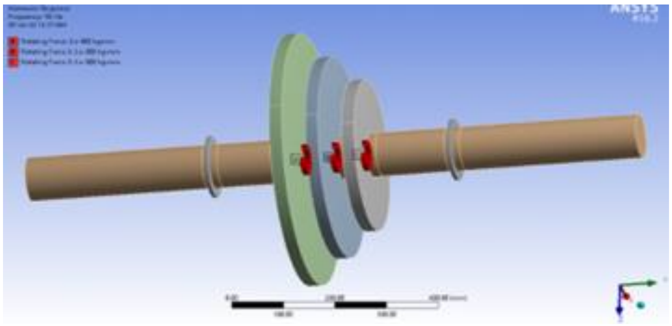

Fig. 16. Frequency Response of Disc 1 for Bearing Support along with Viscoelastic Support.

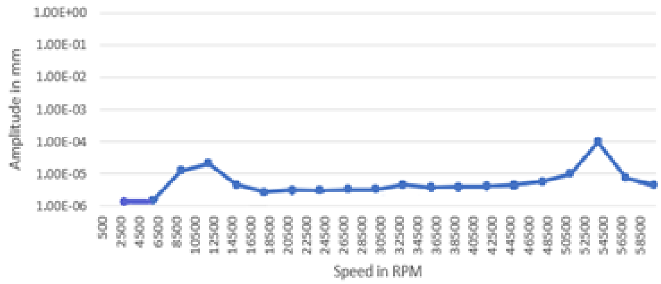

Fig. 17. Frequency Response of Disc 2 for Bearing Support along with Viscoelastic Support.

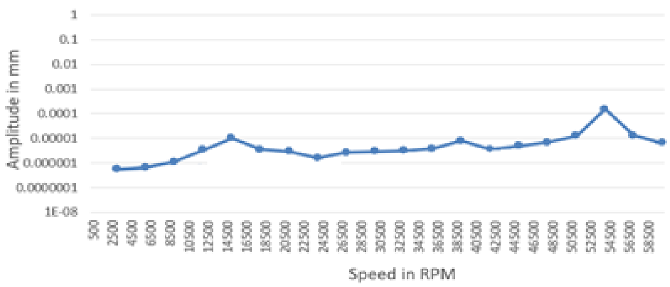

Fig. 18. Frequency Response of Disc 3 for Bearing Support along with Viscoelastic Support.

VI. RESULTS AND DISCUSSION

The analysis carried out for two cases one is the multi-disc system supported with only bearing another one is the multi-disc system with bearing support along with viscoelastic support. The analysis carried out so far are done to see the changes in the critical speeds, mode stability and frequency response so that the suitable support stiffness can be proposed. Based on the response obtained, system with viscoelastic support configuration was proposed to be analyzed for an equivalent stiffness value of 49.2362 N/mm. From this we have obtained all the modes as stable along with their critical speeds and also the frequency response of each disc is obtained and compared between the two cases.

Table 5. Comparison of Critical Speed for Stiffness 50 N/mm and 49.2362 N/mm.

Mode	Mode Stability	Critical Speed for Stiffness 50 N/mm	Critical Speed for Stiffness 49.2362 N/mm
1	STABLE	NONE	NONE
2	STABLE	NONE	NONE
3	STABLE	234.58 rpm	232.82 rpm
4	STABLE	240.17 rpm	238.40 rpm
5	STABLE	234.86 rpm	233.41 rpm
6	STABLE	319.02 rpm	317.14 rpm
7	STABLE	12860 rpm	12860 rpm
8	STABLE	16845 rpm	16840 rpm

The summary of the above comparison Table 5 is, first we analyzed the system with only bearing support with a stiffness of 50 N/mm after that we analyzed the system with bearing along with the viscoelastic support with an equivalent stiffness of 49.2362 N/mm. On comparing the above two analysis the critical speed of the system reduced slightly by providing a viscoelastic support compared to the system with only bearing support.

The harmonic analysis is also done to know the frequency response for the two cases, the frequency response comparison of each disc is as shown in the Fig 19, Fig 20, Fig 21 and discussed the same.

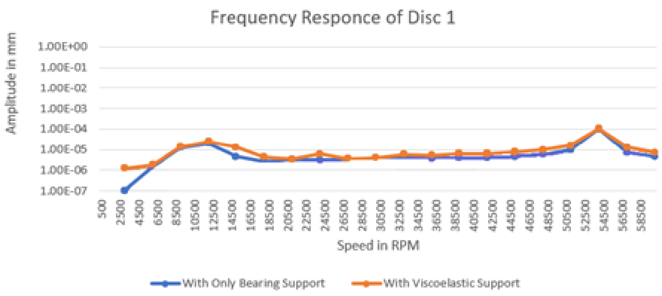

Fig. 19. Comparison of Frequency Response of Disc 1.

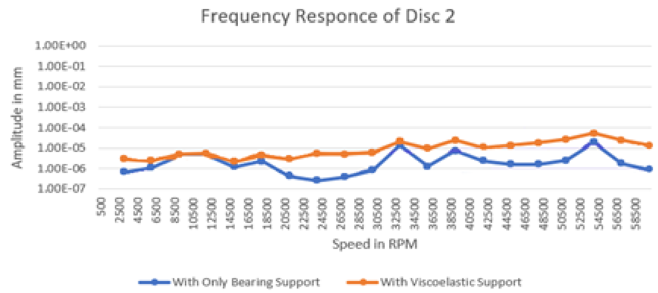

Fig. 20. Comparison of Frequency Response of Disc 2.

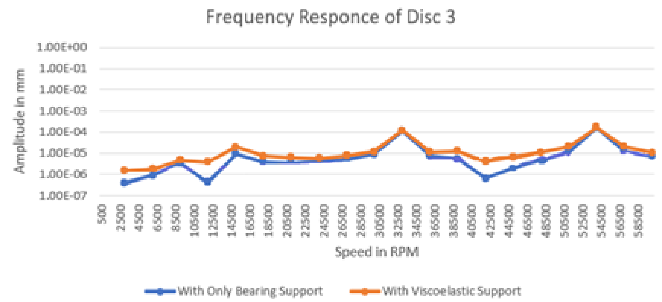

Fig. 21. Comparison of Frequency Response of Disc 3.

The summary of the above three comparison graphs is, the three graphs says that the amplitude variation in the system with only bearing support is quite greater than the amplitude variation in the system with bearing along with the viscoelastic support, so from the above three comparison graphs we can say that frequency response of the multi-disc system model with bearing along with the viscoelastic support is greater than the frequency response of the system with only bearing support. Therefore, the multi-disc system with viscoelastic support is proposed to be analyzed.

VII. CONCLUSION

In this paper, the multi-disc system is used to study the model and harmonic analysis of the system in two conditions one is multi-disc system with only bearing support and the other one is multi-disc system with bearing along with viscoelastic support for these two conditions the analysis was done. Based on the above analysis results, following conclusions are drawn.

- The analysis of critical speed helped us to study the parameters responsible for changing the rotor dynamic performance of the system.
- Through Ansys workbench software FE analysis can be employed for the effective analysis of critical speed and frequency response of the rotor dynamic system.
- The stability of the multi-disc system mainly relies upon the stiffness of the bearing used and also on the stiffness of the viscoelastic support used.
- Harmonic analysis shows that any vibrations in the system will lead to the failure of the component or the entire system. The source of this vibration will be due to the unbalanced mass present on the rotor system. These vibrations are reduced by adding or by reducing masses at specific location.
- The additional viscoelastic support configuration to the multi-disc system with bearings helps in reducing the overall unbalanced response and provides a better frequency response.

VIII. REFERENCES

[1]. Amor Zapanta and Jefferson Talledo ,"Viscoelastic material characterization: A realistic approach to stress analysis", Journal of engineering research and reports, July 2021. DOI-10.9734/jerr/2021/v20i917381

[2]. Jing Wang, Yongfeng Yang, Qingyang Zheng, Wangqun Deng, Desheng Zhang and Chao Fu, "Dynamic response of dual-disc rotor system with uncertainties based on Chebyshev convex method", Applied Sciences, October 2021. DOI-https://doi.org/10.3390/app11199146

[3]. Qinwu Xu, Bjorn Engquist, Mansour Solaimanian and Kezhen Yan, "A new non linear viscoelastic model and mathematical solutions of solids for improving predictions accuracy", Scientific Reports, Nature research, 2020. DOI-https://doi.org/10.1038/s41598-020-58240-y

[4]. I I Ivanov, V V Belousov, V Y Myasnikov, N N Serebriakov and D V Shadrin, "Study of Rotor Dynamics Considering a Fluid Film Bearing", Material Science and Engineering, 2020. DOI-https://doi.org/10.1088/1757-899X/747/1/012050

[5]. Mehmet Parlak and Hamdi Taplak, "Rotor dynamics analysis of a small steam turbine using finite element method", International Information and Engineering Technology Association Vol.7, No.1, March 2020. DOI-https://doi.org/10.18280/mmep.070108

[6]. Vasanth Kumar S, "Rotor Dynamics Analysis of Flexible Gas Turbine Engine", Journal of Modern Thermodynamics in Mechanical System Vol 2, 2020.

[7]. Kashyap Krishna P, "Fatigue Analysis of a Multi stage Gas Turbine", International Journal of Scientific Research and Review, Volume 10, Issue 8, 2021.

[8]. Isadora R Henriques, Lavinia A Borges, and Daniel A Castello, "The Mechanical Behavior of Viscoelastic Materials in the Frequencies Domain", Springer International Publishing AG, 2019. 10.1007/978-3-319-91217-2_5

[9]. Hao Deng, Xi Fang, Huachun Wu, Yiming Ding, Jinghu Yu, Xiaoyu Zhang, Hong Li and Chenwei Liu, "Dynamic Analysis of Flexible Rotor Bases on Transfer Symplectic Matrix", Hindawi Shock and Vibration, Volume 2019. DOI-https://doi.org/10.1155/2019/9154272

[10]. Stefan Diebels, Tobias Scheffer, Thomas Schuster and Aron Wewior, "Identifying Elastic and Viscoelastic Material Parameters by means of a Tikhonov Regularization", Hindawi, Mathematical Problems in Engineering, Volume

2018. DOI- https://doi.org/10.1155/2018/1895208

[11]. Andre Lab, Matti Schilling, Jitendar Kumar and Frank Hendrik Wurm, “Rotor dynamic analysis of a tidal turbine considering fluid structure interactions under shear flow and waves”, International Journal of Naval Architecture and Ocean Engineering, March 2018. DOI- https://doi.org/10.1016/j.ijnaoe.2018.03.002

[12]. Shibing Liu and Bingen Yang, “Vibration of flexible multistage rotor system supported by water lubricated rubber bearing”, Journal of Vibration and Acoustic, Vol 139, April 2017. DOI- 10.1115/1.4035136

[13]. Junli Liu, Zongrui Hao, Juan Xu and Qingming Meng, “The analysis of critical speed and unbalanced response in rotor system”, Applied Mechanics and Materials, Vol 607 July 2014. DOI- https://doi.org/10.4028/www.scientific.net/AMM.607.515

[14]. Hamdi Taplak and Mehmet Parlak, “Evaluation of gas turbine rotor dynamics analysis using FEM”, Measurement January 2012. DOI- https://doi.org/10.1016/j.measurement.2012.01.032

[15]. J P Peng and M Carpino, “Calculation of stiffness and damping coefficient for elastically supported gas foil bearing”, ASME, Vol 115, January 1993. DOI- https://doi.org/10.1115/1.2920982

Cite this article as :

Sagar N, Manjunath S B, "Rotor Dynamic Analysis of Multi-Disc System with Viscoelastic Support", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 4, pp. 335-344, July-August 2022.
Journal URL : https://ijsrset.com/IJSRSET229456