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Thermal Analysis of Steam Turbine Rotor Due to Low Flow of Fluid using Fem Approach

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ABSTRACT

Rotor is an very important part in the machines, especially in the rotating machines like gas and steam turbines. In this paper steam turbine rotor is analysed by using finite elements. In the complex systems, many of the engineering problems, it is difficult to solve the problem by closed form or exact solution method. Then we have to go for some numerical/approximate method for solving the problem. There are lot of numerical/approximate methods available. Finite element technique is an numerical method used for many engineering applications very widely. We have analyzed the rotors acted by different mechanical & thermo-mechanical loads, and analysed to find out the behaviour of the rotors. In the analysis results it is seen that the solid rotor is better than the hollow rotor.

Keywords: Job Satisfaction, Sustainable Development, Policy For Higher Education

1. INTRODUCTION

Power is the main type of vitality which is anything but difficult to deliver, simple to transport, simple to utilize and simple to control. So it is for the most part the terminal type of vitality for transmission and dissemination. Power utilization per capita is the list of the expectation for everyday comforts of individuals of place or nation. Power in mass amounts is delivered in power plant, which can be taking after sort; a) thermal, b) nuclear, c) hydraulic, d) gas turbine, and e) geothermal. Thermal, nuclear, and geothermal power plant work with steam as working liquid and has numerous resemblance in their cycles and structures. Gas control plants are regularly utilized as topping units and it keep running for brief period in day to take care of the pinnacle stack demand.They are, however being increasingly used in conjunction with a bottoming steam plant in the mode of combined cycle power generation. Hydraulic power plants are essentially multipurpose. Besides generating power, they also cater for irrigation etc. they are however, expensive and take long time to build. There is also considerable opposition against their erection due to the ecological imbalance they produce. Geothermal power plant can be built only certain geological location. Steam turbine is a standout amongst the most critical prime movers for creating power. This falls under the classification of energy creating turbo-machines. Single unit of steam turbine can create control going from 1 MW to 1000 MW. All in all, 1 MW, 2.5 MW, 5 MW, 10 MW, 30 MW, 120 MW, 210 MW, 250 MW, 350 MW, 500 MW, 660 MW, 1000 MW is in like manner utilize. The reason for turbine innovation is to extricate the most extreme amount of vitality from the working liquid, to change over it into helpful work with greatest productivity, by methods for a plant having greatest unwavering quality, least cost, least supervision and least beginning time.

Principle of operation of steam turbine

Steam turbines are utilized as a part of the greater part of our significant coal let go power stations to drive the generators or alternators, which create power. The turbines themselves are driven by steam created in "Boilers" or 'Steam Generators' as they are once in a while called. Vitality in the steam after it leaves the heater is changed over into rotational vitality as it extends through the turbine. Figure 1.1 demonstrates the working guideline of steam turbine. The turbine regularly comprises of a few phases with each stage comprising of a stationary cutting edge (or spout) and a turning edge. Stationary sharp edges change over the potential vitality of the steam (temperature and weight) into kinetic vitality (speed) and direct the stream onto the pivoting edges. The pivoting sharp edges change over the kinetic vitality into strengths, caused by weight drop, which brings about the turn of the turbine shaft. The turbine shaft is associated with a generator through the apparatus box.The high magnetic flux cut by shaft rotation which produces electricity in alternator. The rotor is the heart of steam turbine in operation point of view, which can be supported by two types of bearing one is the thrust bearing and another one is tilting pad journal bearing. The thrust bearing is used for reducing the axial motion of the rotor, when the working fluid expand on the rotor blades the rotor starts axailmation, which can reduced by thrust bearing. The tilting cushion diary bearings are utilized for supporting on both side of rotor. The vibration of rotors and rotor frameworks has been a worry of specialists and researchers for an over a century. In 1869, Rankine distributed an article, "On the Centrifugal Force of Rotating Shafts", which is the soonest reference to vibrations of a pivoting framework. From this timeframe, dynamical examination of shaft was started. Present day outlines of rotor-bearing frameworks for the most part go for expanded power yield and change in productivity. The requesting prerequisites set on current pivoting machines, for example, turbines, electric engines, electrical generators, compressors, have presented a requirement for higher speeds and lower vibration levels. Since the innovation of the wheel, rotors have been the most ordinarily utilized parts of machines and systems. Rotational movement is utilized to accomplish interpretation, as from the wheel to the pivot; to store vitality, as in the antiquated sling or present day flywheels; to exchange power starting with one point then onto the next by utilizing belts, cogwheels, or gear trains; to get dynamic vitality from different sorts of vitality, for example, thermal, substance, atomic, or wind vitality. Rotors utilized as a part of machines and instruments give various preferences as respects effectiveness, wear, and simple alterations.

2. LITERATUTR REVIEW

A large portion of the turbo machines working today keep running on or exceptionally close to the second basic speed. Some keep running with no evident vibration issues. Others are marked issue machines, requiring consistent regard for keep the vibration beneath the trek level. A few machines are intentionally intended to work close to the second basic speed on account of the requirement for higher execution necessities and hence higher paces. Others are intended to keep running beneath the second basic speed yet wind up running specifically on the second. It was by and large expected that the second basic was no less than three times the first and, in this manner, of little concern. Real advances have been made over the most recent twenty years in investigative rotor and bearing dynamics that have prompt enhanced basic speed expectations. In the fifties, before the general accessibility of liquid film bearing dynamic examination codes, the rotor basic were anticipated in view of unbending bearing investigations. With the improvement of the fast PC, dynamic bearing projects wound up plainly accessible in the late seventies.

Rotor Dynamics is unique in relation to Structural Dynamics, as we manage a pivoting structure. Fundamentally, all the vibration wonders will be substantial, in any case, there are a few contrasts and we need to set up methodology on dealing with the rotors and their vibratory marvels. Rankine [2] is credited to have said the presence of a basic speed of a rotor in 1869. He characterized this as a farthest point of speed for centrifugal spinning. There were many questions whether a rotor can cross such a basic speed? It was assumed that it will be temperamental in the wake of intersection the basic speed. This is fairly like Speed of sound and whether one can cross this hindrance in flying. We need to sit tight for almost 50 years to have an unmistakable comprehension on this point.

The primary fruitful rotor model was proposed by Foppl in 1895. It comprised of a solitary plate halfway situated on a roundabout shaft, without damping. It exhibited that supercritical operation was steady. Lamentably, Foppl distributed his work in a German structural building diary, which was little perused, if by any means, by the rotor dynamics group of his day.

Jeffcott in 1919[3] regarded the issue as constrained vibration and recognized the essential standards of rotor dynamics.A large portion of the turbo machines working today keep running on or exceptionally close to the second basic speed. Some keep running with no evident vibration issues. Others are marked issue machines, requiring consistent regard for keep the vibration beneath the trek level. A few machines are intentionally intended to work close to the second basic speed on account of the requirement for higher execution necessities and hence higher paces. Others are intended to keep running beneath the second basic speed yet wind up running specifically on the second. It was by and large expected that the second basic was no less than three times the first and, in this manner, of little concern. Real advances have been made over the most recent twenty years in investigative rotor and bearing dynamics that have prompt enhanced basic speed expectations. In the fifties, before the general accessibility of liquid film bearing dynamic examination codes, the rotor basic were anticipated in view of unbending bearing investigations. With the improvement of the fast PC, dynamic bearing projects wound up plainly accessible in the late seventies.

3. OBJECTIVE

Present work involved to configuration of single stage rotor, the base line modal consists of solid type rotor whereas second configuration was with varying cross section disc. The difference in geometry is as shown in sketch

There are several objectives to be fulfilled within a standard rotor dynamic and structural analysis of steam turbine rotors. The following objectives are considered for the present work

- To conduct the static stress analysis of single stage rotor to check the static strength and structural integrity
- To conduct thermal analysis of rotor

Although the aim of the present work is to develop single rotor model and evaluate the rotor dynamic capabilities of Ansys software. Thus, verification of simple model and rotor dynamic analysis method had become one of the dispositions of this work.

4. RESEARCH METHODOLOGY

- Develop an easy-to-use and easy-to-understand analysis procedure for free and forced vibration problems in rotor dynamics.
- To determine the free and forced frequency of a single rotor systems and to understand the concepts of mode shapes
- Develop harmonic frequency response function estimation

5. FINITE ELEMENT ANALYSIS (FEA)

The finite element method is a powerful tool to obtain the numerical solution of wide range of engineering problem. The method is general enough to handle any complex shape or geometry, for any material under different boundary and loading conditions. The generality of the finite element method fits the analysis requirement of today’s complex engineering systems and designs where closed form solutions of governing equilibrium equations are usually not available. In addition, it is an efficient design tool by which designers can perform parametric design studies by considering various design cases, (different shapes, materials, loads, etc.) and analyze them to choose the optimum design. The method originated in the aerospace industry as a tool to study stress in a complex airframe structures. It grows out of what was called the matrix analysis method used in aircraft design. The method has gained increased popularity among both researchers and practitioners. The basic concept of finite element method is that a body or structure may be divided into small elements of finite dimensions called "finite elements". The original body or the structure is then considered, as an assemblage of these elements connected at a finite number of joints called nodes or noda

Solid section

I solid section

A single rotor system is considered which is to be analyzed statically and dynamically to visualize the behavior of stresses and directional deformation of the rotor system. Two types of rotor systems are taken into consideration i.e. (i) solid rotor (ii) I section rotor and comparative analysis is carried out between the two cases of rotor systems.

Preliminary design considerations

The properties of the model are summarized as follows:

Shaft properties

Length of the shaft, L= 1200mm

Diameter of the shaft, D= 40mm

Young's Modulus, E= 210E3 N/mm^2

Poisson ratio = 0.3

Density = 7800 kg/m^3

Speed N = 5000 rpm

6. STEADY-STATE THERMAL ANALYSIS

Steady-state thermal analysis to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. A steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineers often perform a steady-state analysis before performing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis, performed after all transient effects have diminished. A steady-state thermal analysis can be performed using the ANSYS

STATIC ANALYSIS OF SINGLE ROTOR SYSTEM

5.1, GEOMETRY

Fig 5.1, Isometric view of rotor

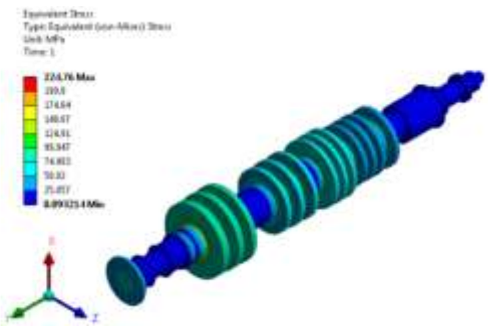
Fig 5.2, View of meshing

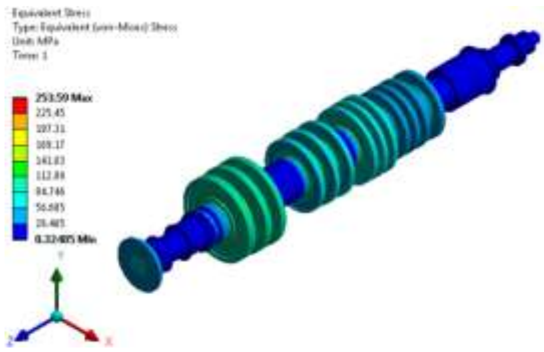
Hex Dominant Meshing Method, where a free hex dominant mesh is created. This option is recommended for bodies that cannot be swept. The mesh contains a combination of tet and pyramid cells with majority of cell being of hex type. Hex dominant meshing reduced element count.

BOUNDARY CONDITION LOAD APPLIED –TEMPERATURE AND ROTATIONAL VELOCITY

The load is in the form of rotational velocity in rad/sec.The load is applied in steps of 0%, 50%, 100%, 121%, 100%, 50%, & 0%.The 100% load is 6920rpm=724.75 rad/s. The load applied is entered in tabular data. The load is applied in the Z-Axis on the Bladed Disc assembly. The figure [4.7] is shown below and with temperature difference

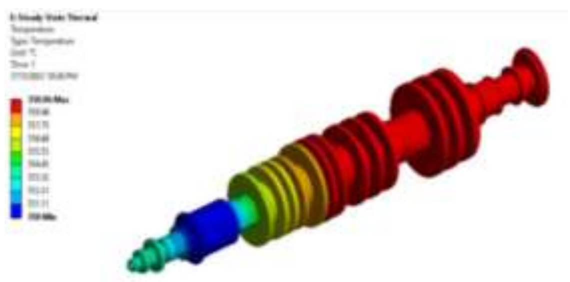
7. Result and observation



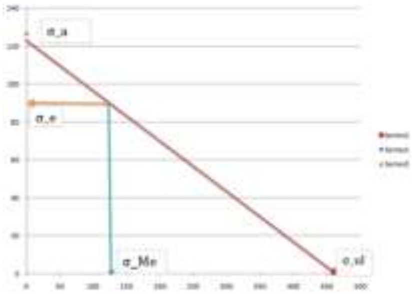


Thermal analysis

After defining all the conditions the FEM analysis was done and the results were plotted. The stress distribution in the rotor is shown in Fig. , and temperature distribution is .



From the stress analysis of the rear fuselage the maximum tensile stress location is identified. A fatigue crack will always initiate from the location of maximum tensile stress. From the stress analysis it is found that such a location is at one of the rivet hole. Atypical flight load spectrum is considered for the fatigue analysis of the vertical tail skin joint. A damage tolerance design criteria and stress-life approach has been adopted for conducting a fatigue analysis. For performing fatigue calculations constant amplitude loading is preferred. In this problem variable amplitude loads will be acting but by converting them to groups of constant amplitude loading in their respective frequency. If loading is constant amplitude, than its represents the numbers of cycles until the part will failure due to fatigue. Calculation of fatigue life to crack initiation is carried out by using Good men . The various correction factors are considered in the calculation of fatigue cycles,



8. CONCLUSION

Linear static structural analysis has been carried out to estimate the maximum stress, strain and deformation at blade, disc and fillet regions. It is found that peak stress of 310.45 Mpa, total deformation of 0.02mm is obtained along in multi stage rotor , hence the design is safe.Fatigue analysis of multistage rotor was carried and the fatigue life estimated obtained more than 100000 cycles Weight of 120.1 kg is reduce in multi stage rotor which is Optimization of in multi stage rotor to increase the life and efficiency We have analyzed the rotors on different mechanical & thermal-mechanical analysis to find out the behaviour of the two rotors. In the analysis result it is seen that the hollow rotor is better than the solid rotor in both case of manufacturing & failure criteria. Till now we have covered steady state thermal analysis of the rotors more analysis could be done by applying transient conditions, as after sometime the temperature distribution changes.

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