Numerical Analysis of Power Transmission System Components in a Power Loom

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Abstract- Rotating machines driven at higher speeds, placed under more demanding load conditions of higher sensitivity and design of machines tends towards lesser weight. Considering the various factors of accurate alignment methods for rotating machineries is of prime importance. The pertinent information of power transmission system (PTS) in a power loom is observed, displacement, tensions and forces across the larger and smaller pulleys are calculated analytically. With the existing parameters, the entire PTS is modeled and numerical analysis is performed using ANSYS. The existing parameters of the PTS are modified to reduce the stresses at the hot spots based on the amplitudes and nodal frequencies at bearing locations. Based on the inference of numerical results the components of the existing transmission system are modified and is working satisfactorily.

Keywords: Power loom industries, Predictive maintenance, Rotor-bearing system.

A. Introduction

The power loom sector plays a vital role in meeting the clothing needs of the entire country. There were over 19 lakh power looms in the country which is about 47% of the total power looms in the world contributing about 95% of the total cloth production of the country, and provides employment to about 52 lakh persons. The formation of power loom sector in India is because of the conversion of handloom industry to power loom industry. Engineers and researchers develop many areas of innovative advancement and seek to establish and modify methods which meet the ever-widening needs of advancing technology. The objectives are improvements of transmission life, operating efficiency and reliability to increase the power-to-weight ratio and to reduce the noise and vibration of transmissions. Vibration-response analyses yield a great deal of information concerning any faults in a rotating machine. The speed of the shaft together with unavoidable misalignment can be considered as the most important sources of excitation, which may cause critical conditions.

Reference [1] investigated the presence and type of misalignment having significant influence on harmonic content of the excitation forces. The coupling location of rotor FE model using nodal force vector was simulated in [2]. A model based technique was studies and described for fault diagnosis of rotor–bearing system in [3]. The residual forces are compared with the equivalent theoretical forces due to faults. The fault condition and location of faults are successfully detected by the model based technique. The various tests on machinery fault simulator under various operating conditions were performed in [4]. The results of this work provide new perspective machinery for fault detection. The importance of alignment and its problems was studied in [5]. An experimental test rig was constructed to verify the dynamics of a multi-bearing rotor in [6]. The effect of misalignment on the stability of two rotors connected by a flexible mechanical coupling subjected to angular misalignment was investigated [7].

This paper aims at condition monitoring of the various components of the transmission system in a power loom industries by performing the numerical analysis. The power transmission system comprises of shaft, coupling, bearing, motor, and pulley which are used to run the power looms. A finite element model and analysis of the power loom transmission system is performed using ANSYS and it is also validated with the analytical calculations. To support the investigation, the geometrical information of the existing system is modeled using pro-e, various tensions over the pulley is calculated analytically. The critical points are identified and the criticality is minimized by making various changes in the geometry of the PTS, modified PTS is also analyzed and it is found in the safe zone of operation. With the various modifications the actual PTS is modified and it is also in the safe operation.

B. Numerical Analysis

The components (Shaft, Belt, Pulley, Bearing, and Coupling) of the power transmission system (PTS) are modeled using Pro/Engineer with the scale ratio of 1:1 is shown in Figure 1. The modeled PTS is exported to ANSYS software through IGES translator to perform numerical analysis. The specifications of the existing transmission system are tabulated in the Table 1. The tensions across the two pulleys are calculated analytically using the basic principles and the analysis results are shown in the Table 1. The stress raisers, hot spots are identified and modifications have been carried out in the PTS.

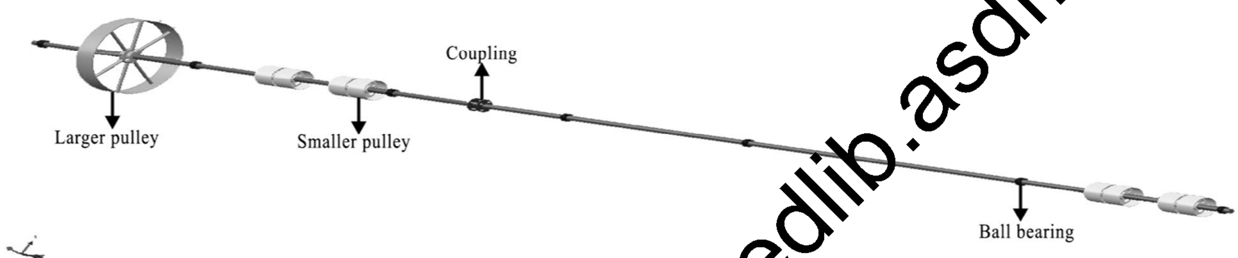

Figure 1. Overall view of the power transmission system

Results and Discussions

During the investigations the hot spots occurs near the vicinity of the motor pulley, drive end bearing and parts of the coupling. Figures 2, 3, 4, 5, 6, 7 show the analysis results of the components of the modified PTS. The deflection plot for the cross pulley and open pulley is shown in the Figures 2 and 3 respectively. The vonmises stress plot for the cross pulley and open pulley is shown in the Figures 4, 5. Plot of the motor pulley deflection is shown in the Figure 6. Figure 7 illustrates the vonmises stress plot for the motor pulley. Due to the various modifications performed in the PTS, there was a significant 43% decrease in displacement. Similarly the vonmises stress was reduced to an amount of 55%. Displacement of the modified / existing system was 0.89/2.03 mm, Von mises stress of the modified / existing system was 0.184×10^8 / 0.33×10^8 Mpa.

Table 1. Specifications of the existing and modified power transmission system

Specifications	Before modification	After modification
Shaft diameter (mm)	38	51
Motor Pulley diameter (mm)	127	127
Larger pulley diameter (mm)	812	762
Loom driving pulley diameter (mm)	178	203
Loom driven pulley diameter (mm)	406	406
Speed at motor pulley (rpm)	1440	1440

Speed at larger pulley (rpm)	225	240
Speed at smaller pulley (rpm)	225	240
Speed at loom pulley (rpm)	99	120

The modal analysis results of the entire PTS are plotted in Figure.8 for before modification and after modification. Before the modification the natural frequency of the system was around 20-45 Hz in all the modes, which has increased to a minimum of 50Hz and maximum of 75Hz. Figure.9 illustrates the comparisons of the harmonic analysis before modification and after modification. Initially the amplitudes at the drive end bearing were around 4mm, which was reduced to 1.5 mm. The bearing stations 3 and 4 represent the coupling zone of the PTS, the amplitude was around 4 mm with 62 % reduction after modification.

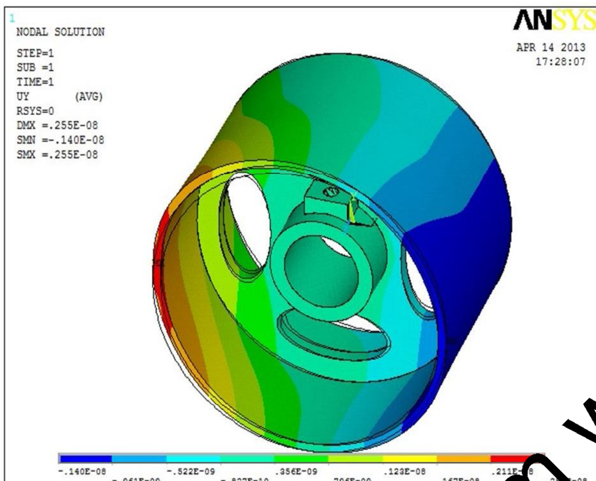

Figure.2 Cross pulley deflection

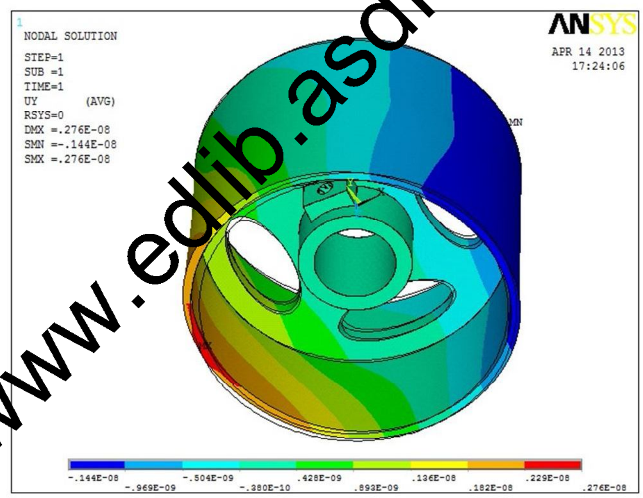

Figure.3 Open pulley deflection

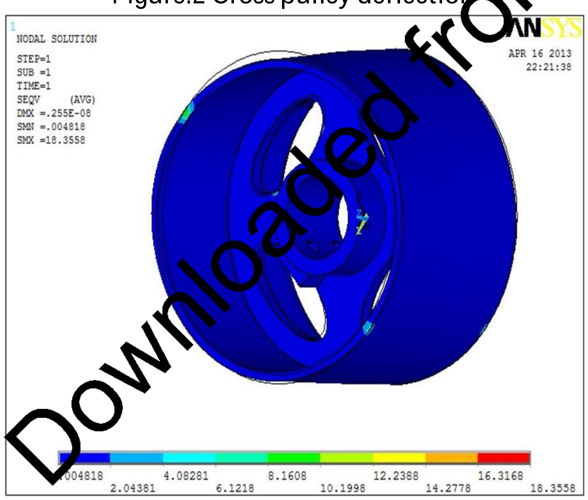

Figure.4 Von mises stress criterion – cross

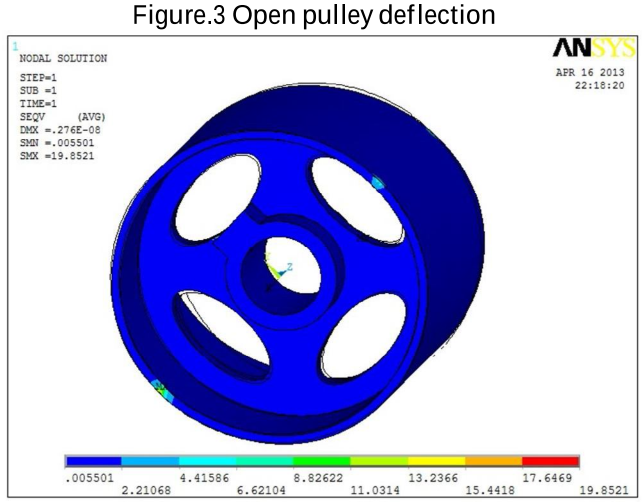

Figure.5 Von mises stress criterion – open

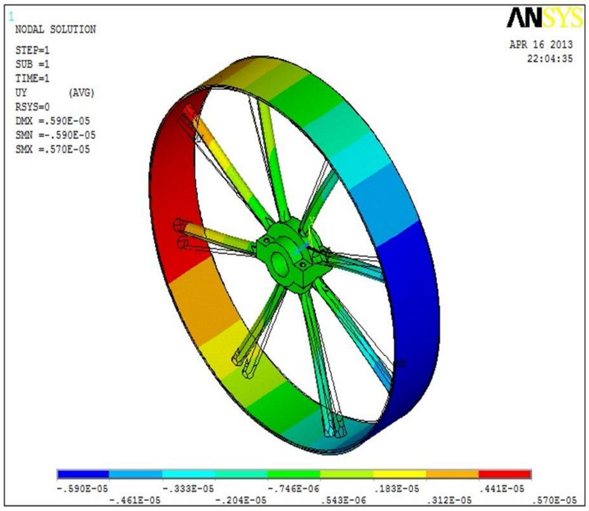

Figure.6. Motor pulley deflection

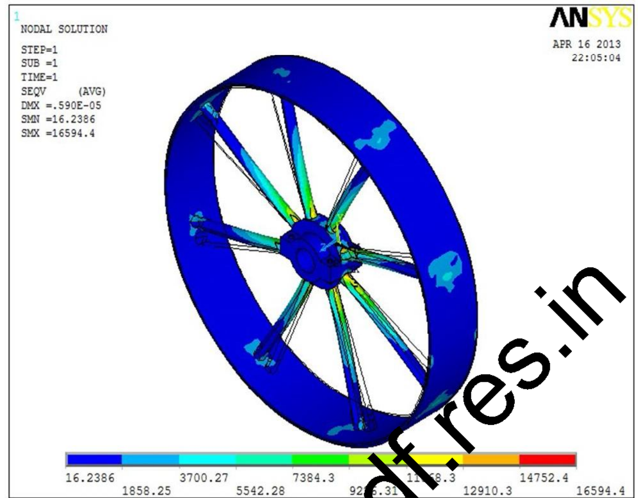

Figure.7 Motor pulley von mises stress

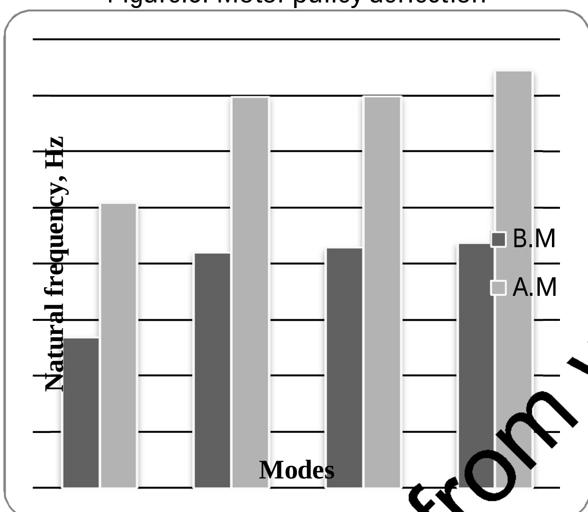

Figure 8. Modal analysis results of PTS.

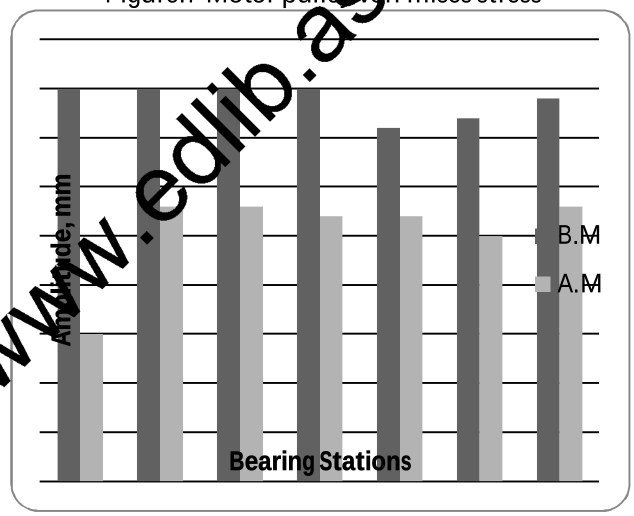

Figure 9. Harmonic analysis results of PTS.

Conclusion

Based on the analytical and numerical results the life of a PTS is predicted. The analytical predictions are in good agreement with the numerical results. From the Fig. 8 it is clear that the natural frequency of the PTS was nearer to the operating speed for all the modes of vibration before the investigation, hence various failures occurred. The predominant natural frequencies have been modified by performing various modifications in the PTS. The amplitude of the PTS at the various bearing stations is depicted graphically in the fig 9. The amplitude of the existing system was higher at all the bearing locations, which has been reduced to a significant value. The result of harmonic response shows the information that the stress level is high due to the application of the load. The result of the simulations, enable to identify the critical parts of the system as well as critical points. By numerical analysis the system safe operation range was determined to run at particular frequencies so that potential dangerous of the system can be avoidable and the reliability of the system can be ensured.

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