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Importance of early detection of maintenance problems in rotating machines in management of plants: Case studies from wire and tyre plants

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ABSTRACT

In this article, importance of application of predictive maintenance concept with vibration measurement has been discussed. Appreciation of the subject was performed with the help of data collected cases related to maintenance problems from Plants A and B. The first case was examined in aerial conductor manufacturing Plant A. The company does not apply predictive maintenance (PM) in management of the manufacturing activities. The machines used in conductor and similar wire processing plants have very big rotors and their loads on rotors continuously change. Therefore, these types of machines are good examples in checking the health of the machine regularly. The second case was analysed in vehicle tyre plant named as Plant B and it has perfect usage ability of vibration technique of PM methods. The importance of the regular collection of vibration signatures in evaluation of conditions of rotating machines has been analysed in details to indicate the power of the predictive maintenance technique in prevention of losses, which are caused by unbalanced forces, misalignments, improper lubrication of ball bearings, metal fatigue and cracks occurred in welding of constructed parts and locking of the ball bearings due to excessive heating.

The second case observed in Plant B is an example to show detection of a ball bearing failure just in time. Evaluation of second case has been performed using measurements of vibration signatures of the machines with the help of fault indicator graphics.

Results from the cases have been summarised to give useful ideas in management of the plants to the persons responsible with production and maintenance subjects.

1. Introduction

Maintenance strategies are very important in management of the manufacturing process. In the organisation plan of the factories, manufacturing and sales departments are prime importance. Maintenance department is considered as consumer of income of company. It is thought generally that they present always a plan to stop production machines for maintenance aims. To decrease maintenance cost yearly, several strategies have been developed. However, most of them require huge budget to keep the machine in good condition. That is why; companies seek a maintenance technique to spend money just in time. The technique accepted by the most companies is the PM (predictive maintenance).

In our case studies, two companies have been considered. One of them is the "manufacturing plant of aluminium conductor and power cable" indicated here as Plant A. The other one is the "Automobile Tyre Production Plant" indicated here as Plant B. Plant A do not use predictive maintenance technique in the management of the process but Plant B uses it to follow the condition of machines regularly by collecting vibration data from the whole machines run in the production.

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Nomenclature

F_x	resultant force in x-direction
F_y	resultant force in y-direction
m	mass on the rotating axis
$\ddot{x}_c, \ddot{y}_c$	acceleration of the center of the mass in x- and y-directions
x_1,y_1	reaction forces in the support of the rotors in Fig. 1
x_2,y_2	reaction forces in the support of the rotors in Fig. 1
ω	angular velocity
$\dot{\omega}$	angular acceleration
I_{yz},I_{xz}	product inertia moments of the rotating body according to the planes indicated indices
l	distance between of the supports as seen in Fig. 1
FFT	fast Fourier transformation
PM	predictive maintenance
AAC	all aluminium conductor
ACSR	aluminium conductor steel reinforced

The predictive maintenance by vibration analysis is the best tool for checking of the conditions of the machines regularly in the production activities. The vibration analysis is a technique, which is being used to track machine operating condition and trend deterioration in order to reduce maintenance cost and downtime simultaneously.

This technique consists of vibration measurement and its interpretation. Firstly, vibration signal are collected by means of vibration analyser equipped with sensor in the time domain then, these signals are converted into frequency domain by processing FFT, and the information gained from the vibration signals can be used to predict catastrophic failures, to reduce forces outages, to maximize utilisation of available assets, to increase the life of the machinery, and to reduce maintenance costs related to health of machinery. The vibration measurements are taken periodically one time per month in general. Then, vibration signatures are monitored and compared previous measurements.

The vibration monitoring is based on principle that all systems produce vibration. When a machine is operating properly, vibration is small and constant; however, when faults develop and some of the dynamic processes in the machine change, the vibration spectrum is also changes. There are many studies on the vibration monitoring of the rotating machinery. Great amount of them concentrate on ball or cylindrical element bearing vibration monitoring.

However, under conditions of real environment there are many factors that affect the actual running state of the machinery. Thus, these factors must be taken into consideration. Studies related to real operating conditions of machineries were quite few. Gluzman monitored vibration of motor-generator system supported by ball and cylindrical roller bearings to predict impending bearing failures. He successfully identified impending failures of the bearing outer and inner races [1]. Al-Najjar observed many bearing vibration in paper mills for many years to predict remaining bearing life accurately. He also investigated effectiveness of vibration-based maintenance and proposed some findings [2].

Plants established to manufacture aerial or underground cables, telephone cables, bare conductors and fiber optic cables, steel rope manufacturing, pre-stressed steel ropes plants, etc. have similar wire drawing and stranding machines. All stranding machine includes a rotor loaded with bobbins (spools) loaded with drawn wires to strand required construction of conductor. Thus, unbalanced loads force machine bearings in all manufacturing time continuously. This type working conditions may reason failures of ball bearings early and unexpected accidents due to collapse of whole system. Some parts broken from the rotor body with high kinetic energy can destroy every thing by impacting.

2. Machinery park in wire processing plants

The first case study has been analysed in Plant A. Its machinery and processing lines can be separated into three groups. The first group is continuous casting line (CCL), which includes melting and holding furnaces, casting wheel and rolling machine to produce feedstock. Furnaces can be accepted as static machines except huge fan and its driver motor system. Casting wheel runs very low speeds but it is very sensitive to ball bearing faults. Milling machine is generally consists of 8-heads for EC grade aluminium but for production of 6xxx series alloy their construction is changed by increasing number of heads. The rolling head number may be 12 for aluminium alloys. Each head has a set of reduction gearbox and two set rolling mills with their ball bearings. The machine is very sensitive to bearing faults due to very heavy load occurred in rolling of continuous aluminium bar. If the CCL stops, all conductors manufacturing activity must be stopped gradually.

Second group machinery of the plant consists of various types drawing machines with single or double spoolers. These machines do not include big centrifugal forces due to very light mass of wires on rotating disc in the machine when processing of drawing. But centrifugal forces are very high when the spool takes up of the drawn wires. The small capstan mounted in the machine successively performs drawing process. They are turned under oil splash for making reduction of the wires with the help of the drawing die.