Statistical Data Analysis of Preheater Fan in Cement Industry

Saurabh Singh[1], Dr. Manish Vishwakarma[2]

[1]Student, Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, (M.P.) India

[2]Assistant Professor, Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, (M.P.) India

Abstract: *Vibration is a big problem in rotating parts in any machine. Vibrations in one part affect the other parts of machine and also it affects other machines which are connected with the machine generating vibrations. It is required to study the effects of vibration generations in one part over the other parts and machines. Statistic software SPSS is used to study the correlation between the vibrations in fan and the motor which are connected with rigid coupling.*

Keywords: PH fan, vibrations, SPSS, correlation

1. Introduction

Rotating machines are used widely in cement plant. Pre-heater fan is an important machine used in cement plant. Pre-heater fan is associated with the kiln unit. The work of pre-heater fan is to generate draught in kiln and pre-heater tower. This regulates the clinker production by regulating air flow through kiln. The schematic diagram of pre-heater fan is shown in figure 1. The fan is moved by electric motor. There are two bearings each in fan and motor and the rotating shaft is supported on these bearings. There are two bearings one is NDE (non drive end) and second is DE (drive end) on both sides. The electric motor is the prime mover and the fan moves with the help of rigid coupling attached with the shaft of motor. Each rotating machine generates some vibrations during operation. In normal working conditions the vibrations remain at low level. High vibrations occur in the fan and the motor due to different reasons. The reasons may be imbalancing, looseness, misalignment etc [1]. Unbalance in the fan impeller is a major problem and it generates high vibrations in fan. Vibration analysis is the condition monitoring technique which is used to check vibration levels of a part or machine for its health monitoring. The vibration level of fan and motor is checked regularly for health monitoring of pre-heater fan. If any abnormality is found out in the vibrations, the action is taken to prevent the further failure and to prevent the effect of high vibrations of one part over other parts. The vibration data of pre-heater is used for determining correlation of vibration level at different points in fan and motor. It will help in finding the effect of unbalance in fan impeller over other parts of the machine.
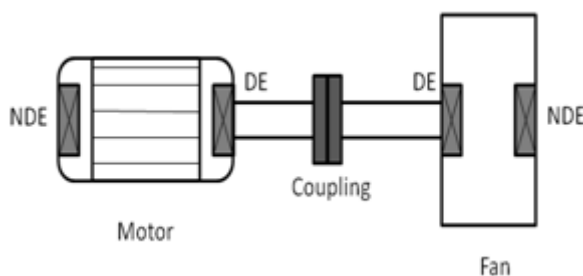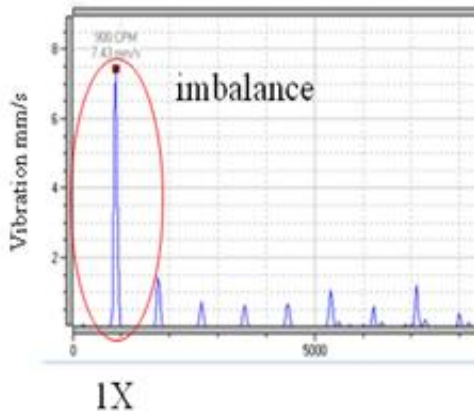

Figure 1: Schematic diagram of PH fan

2. Methodology

This paper studies the effects of unbalance in fan impeller over the parts of motor. The research is based on vibration data collected during the operation of the pre-heater fan. It covers the following key points-
- Collection of vibration data
- Analysis for the causes of vibration
- Analysing collected data for correlation between vibration levels at different points of pre-heater fan unit.

3. Vibration Measurement

Vibration is described as the mechanical oscillation about an equilibrium point. Nearly all machines emit certain amount of noise and vibration. Vibration sources in rotating machines are events that generate forces and notions during machine operations, these sources include imbalance in shaft and impeller, impacts due to faults in bearings, fluctuating forces due to gear mesh etc. These vibration signals are measured through sensors and are plotted on graph. Vibration signals give information about the cause of vibration and through its analysis an emerging fault can be detected. There are four points on pre-heater fan unit, two each on fan and motor i.e., DE (drive end) and NDE (non drive end). At each point three components of vibrations are measured, these are horizontal component, vertical component and axial component. The vibrations are measured with the help of vibration transducers and with the help of analyzer and FFT analysis the spectrum diagram of the vibration is found. The spectrum shown in figure 2 is of horizontal component of vibration at the drive end of fan. The vibration measurement showed the high vibration level in the fan. In the spectrum diagram (figure 2) the vibration was high on 1X of fan rpm which means that vibrations were due to unbalance in the impeller of the fan [2]. The balancing was done and the vibrations were restored to minimum level in the fan. This research is carried out to study how the unbalance in fan impeller affects the vibration level in other parts of the pre-heater fan unit.

Figure 2: Spectrum diagram of fan at DE

4. Statistical Package for Social Science (SPSS) Software

SPSS is a frequently used program for statistical analysis in technology, science, market researchers, government, education researchers, data miners, survey companies etc. In addition to statistical analysis, data management and data documentation are features of the software [5].

Statistics included in the base software:
- Bivariate statistics: Means, t-test, ANOVA, Correlation, Nonparametric test.
- Prediction for numerical outcomes: Linear regression
- Prediction for identifying groups: Factor analysis, cluster analysis Discriminant

5. Hypothesis Formulation

Significance testing is used to help make a judgment about a claim by addressing the question. The first step of hypothesis testing is to convert the research question into null and alterative hypotheses. We start with the null hypothesis (H_0).

The null hypothesis is a claim of "no difference" The opposing hypothesis is the alternative hypothesis (H_1).

Hypotheses	Significance of responses
Null Hypothesis (H_o)	Correlations between vibrations are not significant
Alternate Hypothesis (H_a)	Correlations between vibrations are significant

Table 1: Realibility of data

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.879	.904	12

In statistics, Cronbach's Alpha is used as an estimate of the reliability of a test. Cronbach's Alpha Value Analysis defines internal consistency of collected data. For Reliability, the value of Cronbach's Alpha should not be less than 0.7. Cronbach's alpha coefficient value calculated for the different vibration readings is 0.879, as shown in Table-1. Therefore, above value is greater than 0.7, data are considered to be reliable and can be used for analysis.

6. Hypothesis Testing

Pearson's correlation test was conducted with the significance level of 0.05 to determine the correlation between the different vibration readings. The vibration readings were compared and the correlation of vibration readings of fan and motor at different points was checked.

p value is checked for checking significance of correlation between different vibration levels.

When p value $> 0.10 \rightarrow$ the observed correlation is "not significant"

When p value $\leq 0.10 \rightarrow$ the observed correlation is "marginally significant"

When p value $\leq 0.05 \rightarrow$ the observed correlation is "significant"

When p value $\leq 0.01 \rightarrow$ the observed correlation is "highly significant"

Table 2: Pearson Correlation factor and p-values for different vibration correlations

Correlations							
		Fan H_DE	Fan V_DE	Fan A_DE	Fan H_NDE	Fan V_NDE	Fan A_NDE
Motor H_NDE	Pearson Correlation	0.72	0.688	0.652	0.723	0.624	0.63
	Sig. (2-tailed)	**0**	**0**	**0**	**0**	**0**	**0**
	N	71	71	71	71	71	71
Motor H_DE	Pearson Correlation	0.839	0.764	0.629	0.861	0.803	0.707
	Sig. (2-tailed)	**0**	**0**	**0**	**0**	**0**	**0**
	N	71	71	71	71	71	71
Motor V_NDE	Pearson Correlation	0.057	0.119	0.133	0.038	0.03	0.256
	Sig. (2-tailed)	0.64	0.322	0.269	0.754	0.807	**0.031**
	N	71	71	71	71	71	71
Motor V_NDE	Pearson Correlation	-0.424	-0.317	-0.232	-0.412	-0.366	-0.147
	Sig. (2-tailed)	**0**	**0.007**	0.052	**0**	**0.002**	0.223
	N	71	71	71	71	71	71
Motor A_NDE	Pearson Correlation	0.48	0.499	0.53	0.477	0.403	0.51
	Sig. (2-tailed)	**0**	**0**	**0**	**0**	**0.001**	**0**
	N	71	71	71	71	71	71
Motor A_DE	Pearson Correlation	0.365	0.376	0.291	0.382	0.404	0.371
	Sig. (2-tailed)	**0.002**	**0.001**	**0.014**	**0.001**	**0**	**0.001**
	N	71	71	71	71	71	71

Above readings show in most cases p value is less than 0.05 and in some cases less than 0.01. It means our null hypothesis can be rejected in most cases and we can accept the alternative hypothesis. This means, the vibration levels of different parts of preheater fan unit correlate significantly with one another.

7. Conclusion

From the above observations it can be concluded that high vibrations in fan influence the vibration level in motor significantly. Unbalance in fan vibration also affects the motor parts. Apart from unbalance, other vibration problems in one part will affect the other parts. So it becomes necessary to take corrective actions at early stage of the problem causing high vibrations to prevent deterioration in the other parts of machine.

References

[1] Saurabh Singh, Manish Vishwakarma, "Improvement in machine performance with the help of vibration analysis of rotating machine," International Journal of Science and Research (IJSR), Vol. 4 Issue 7, July-2015.

[2] Kiran Kumar, et, al, 2012, "Determination of Unbalance in Rotating Machine Using Vibration Signature Analysis," International Journal of Modern Engineering Research Vol.2, Issue.5.

[3] Alena Bilosova, Jan Bilos, 2012, " Vibration diagnostics."

[4] Dr. S. J. Lacey, "The Role of Vibration Monitoring in Predictive Maintenance."

[5] https://en.wikipedia.org/wiki/SPSS..

[6] J.K. Nayak, "Data Analysis for Research & Publication" IIT Roorkee, 20-21 December, 2014.