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Full Length Research Paper

A practical approach to electromotor fault diagnosis of Imam Khomaynei silo by vibration condition monitoring

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Practical experience has shown that vibration technique in a machine condition monitoring program provides useful reliable information, bringing significant cost benefits to industry. The objective of this research was to investigate the correlation between vibration analysis and electromotor fault diagnosis. This was achieved by vibration analysis of an electromotor in Imam Khomaynei silo. The vibration analysis was initially run under regular interval during machine life. A series of tests were then conducted under the operating hours of electromotor. Vibration data was regularly collected. Overall vibration data produced by vibration analysis was compared with previous data. Numerical data produced by vibration analysis were compared with vibration spectra in standard condition of healthy electromotor, in order to quantify the effectiveness of the vibration condition monitoring technique. The results of this paper have given more understanding on the dependent roles of vibration analysis in predicting and diagnosing of electromotor faults.

Key words: Vibration analysis, vibration condition monitoring, electromotor, predicting and diagnosing electromotor faults.

INTRODUCTION

Machine condition monitoring has long been accepted as one of the most effective and cost-efficient approaches to avoid catastrophic failures of machines. It has been known for many years that the mechanical integrity of a machine can be evaluated by detailed analysis of the vibratory motion (Eisenmann, 1998; Peng and Kessissoglou, 2003). Vibration signals carry information about exciting forces and the structural path through which they propagate to vibration transducers. A machine generates vibrations of specific character, when in a healthy state and the degradation of a component within it may result in a change in the character of the vibration signals (Williams, 1994). The most effective and cost-efficient group of condition monitoring techniques is vibration analysis (Barron, 1996). Recent evidence shows that vibration condition monitoring techniques provides greater and more reliable information, thereby resulting in a more effective maintenance program with large cost benefits to industry (Mathew and Stecki, 1987; Maxwell and Johnson, 1997; Troyer and Williamson, 1999). Vibration analysis in particular has been used for some time as a predictive maintenance procedure and as a support for machinery maintenance decisions (Barron, 1996; Want et al., 1996; Luo et al., 2000; Smith, 1989; Wowk, 1991). In this paper, investigate the correlation between vibration analysis and electromotor fault diagnosis. This was achieved by vibration analysis of an electromotor in Imam Khomaynei silo. A series of tests were conducted under the operating hours of electromotor. Vibration data was regularly collected. Overall vibration data produced by vibration analysis was compared with previous data. Numerical data produced by vibration analysis were compared with vibration spectra in standard of healthy electromotor, in order to quantify the effectiveness of the vibration condition monitoring technique. The results from this paper have given more understanding on the dependent roles of vibration condition monitoring in predicting and diagnosing of electromotor faults.

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Experimentation and testing

The test rig used for the experimentation was a transmission electromotor in Imam Khomaynei silo. Details of the electromotor give in Table 1. Figure 1 shows a photograph of the electromotor.

Vibration data was collected on a regular basis after the run in period. The experimental procedure for the vibration analysis consisted of taking vibration readings at two select locations over

Table 1. Detail of silo electromotor.

Electromotor	Description
Electromotor capacity (kW)	112 (150 HP)
Motor driving speed (rpm)	1480
Voltage	380 v
Phase	Three phase
Ambient air temperature (℃)	≈25
Non driven end bearing	FAG 6317
Driven end bearing	FAG NU319

Figure 1. Photograph of the electromotor.

the electromotor. There were taken on drive end (DE) and non-drive end (NDE) of electromotor. Vibration measurements were taken by vibration analyzer, its commercial name is X-Viber (VMI is the manufacturer).

RESULTS AND DISCUSSION

Standard ISO 10816-1 has been used for testing. According to results, the overall vibrations of NDE of electromotor that shows in Figure 1 were higher than those of standard values. Root mean square (RMS) of vibration velocity (mm/sec) in three measurements was higher than standard value (Figure 2).

The results showed that the overall vibration values of NDE of electromotor were on warning status but bearing condition values were on acceptable condition. Mean of overall vibration was 12.50 and standard deviation of that was 1.46. The warning overall vibration recommend value in ISO 10816-1 for this electromotor was 7.1 mm/sec but overall vibration values and mean of them were higher than standard value. It showed that more vibration indicated a problem. Mean of bearing condition of NDE of electromotor was 1.05 and standard deviation was 0.44 (Table 2). According to the results, the bearing of NDE of electromotor had a problem but the problem was in initially stage. In the frequency 50 and 100 Hz two peaks (Figure 3) indicates that there was a bearing defect developing. Those frequencies were related to the ball spin frequencies of driven end bearing (FAG 6317). A developing bearing defect was consistent with inadequate lubrication, resulting in an increase in metal-to-metal contact.

The velocity frequency spectrum of the NDE of electromotor showed a dominant frequency corresponding to the shaft speed (24.6 Hz). The peak at shaft speed frequency could represent an unbalance fault (Figure 4). Examination of both the time and frequency domain plots recorded over the duration of test indicated that the bearing of NDE of electromotor was operating in bad condition and had a little probles 3 and 4 show the frequency spectrum results of NDE of electromotor before repair.

According to Figures 5 and 6, the overall vibrations of DE of electromotor and vibration values of Bearing Condition of DE of electromotor were respectively higher and lower than standard values. RMS of vibration velocity in three measurements in overall vibrations of DE of electromotor was higher than standard value and that points were on critical area of diagram (Figure 5).

The results of Table 3 shows that the overall vibration values were on critical status and bearing condition values were near warning status. It showed that more vibration indicated a serious problem. According to the results (Figure 7) the velocity frequency spectrum of DE of electromotor before repair showed a dominant frequency corresponding to the shaft speed (24.6 Hz) and its harmonics. The peak at shaft speed frequency and its harmonics could represent a misalignment fault.

Both bearing and fixed unbalance and misalignment of electromotor have been changed and tested again. The results show in Figures 8, 9, and Tables 4 and 5. Results show that the overall vibration and bearing condition of DE and NDE of electromotor have been on good condition after the repair.

Conclusions

Results showed that vibration condition monitoring technique has detected fault diagnosis of transmission storage bines electromotor. Vibration analysis has provided quick and reliable information on the condition of the bearings. Integration of this condition monitoring technique with another condition technique resulted in a comprehensive diagnosis of the machinery condition.

ACKNOWLEDGMENT

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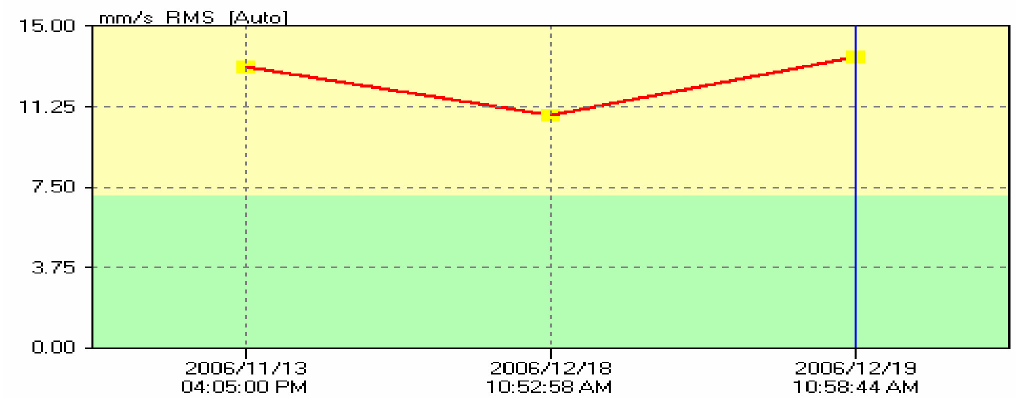

Figure 2. Overall vibrations of non-driven end (NDE) of electromotor before repair

Table 2. Measuring date, RMS of vibration velocity, alarm status, and BC of non-driven end (NDE) of electromotor before repair.

Test	Measuring date	RMS of vibration velocity (mm/s)	Alarm status	BC	Alarm status
1	13-11-2006	13.09	Warning	0.57	Ok
2	18-12-2006	10.84	Warning	1.44	Ok
3	19-12-2006	13.58	Warning	1.15	Ok
Mean		12.50		1.05	
Standard Deviation		1.46		0.44	

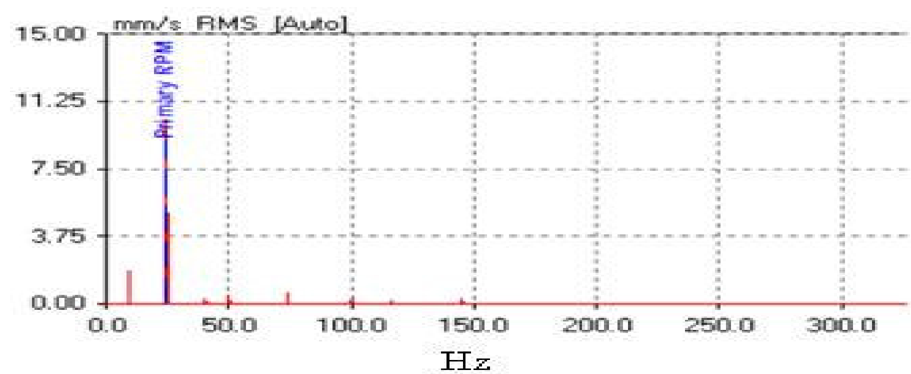

Figure 3. Frequency spectrum result of NDE of electromotor before repair.

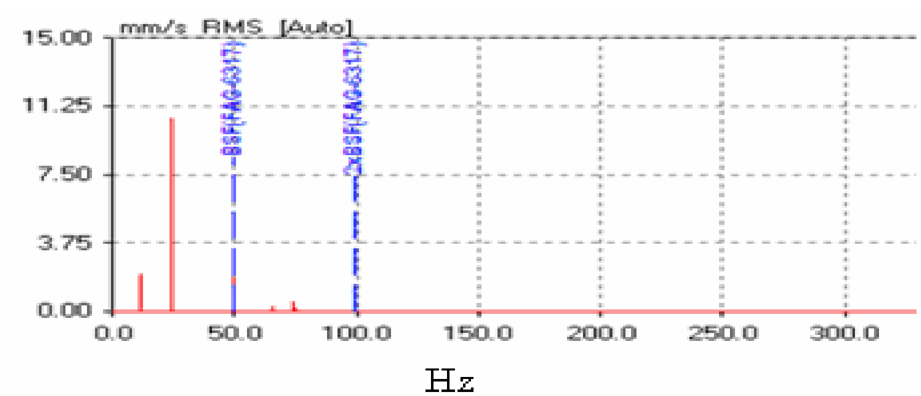

Figure 4. Frequency spectrum result of NDE of electromotor before repair.

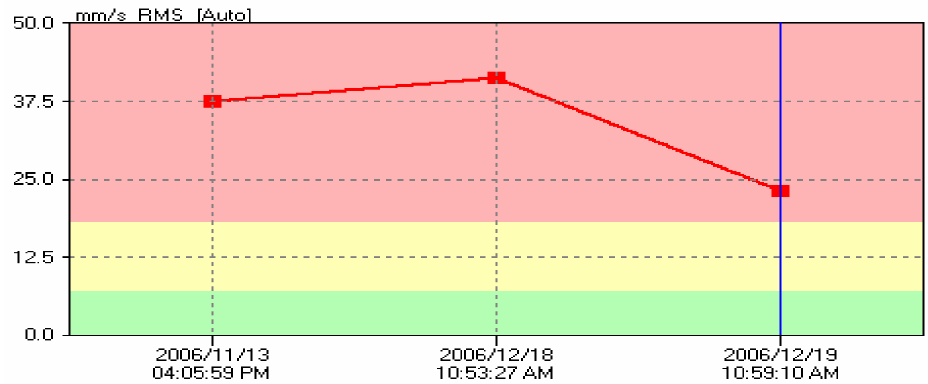

Figure 5. Overall vibrations of driven end (DE) of electromotor before repair.

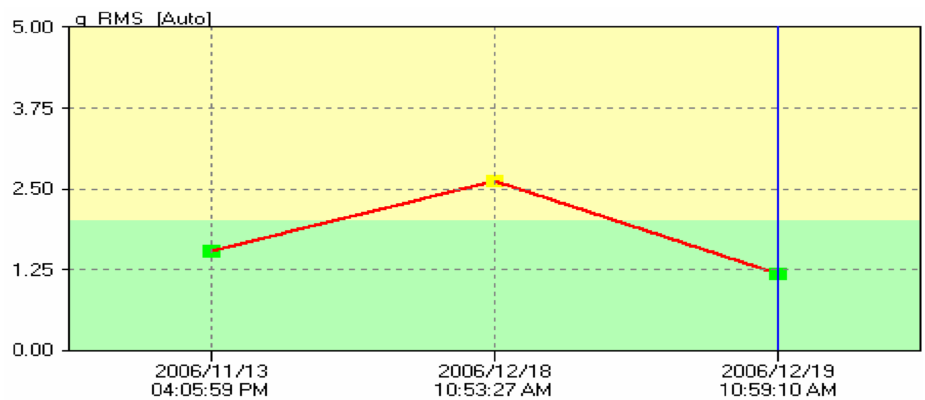

Figure 6. Bearing Condition of driven end (DE) of electromotor before repair.

Table 3. Measuring date, RMS of vibration velocity, alarm status, and BC of driven end (DE) of electromotor before repair.

Test	Measuring date	RMS of vibration velocity (mm/s)	Alarm status	BC	Alarm status
1	13-11-2006	37.48	Danger	1.56	Ok
2	18-12-2006	41.21	Danger	2.62	Warning
3	19-12-2006	23.23	Danger	1.2	Ok
Mean		33.97		1.79	
Standard Deviation		9.49		0.74	

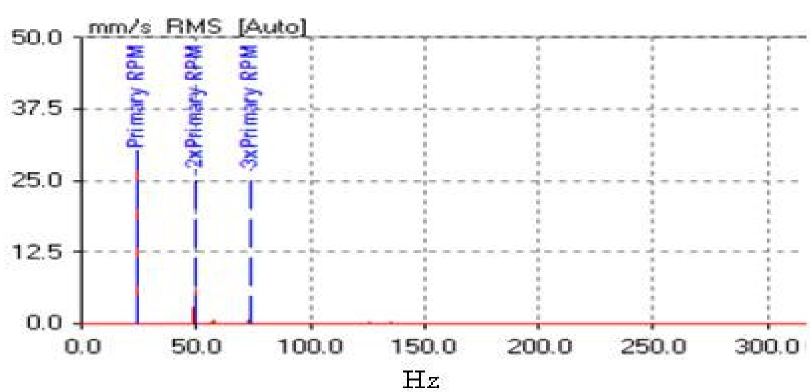

Figure 7. Frequency spectrum result of DE of electromotor before repair.

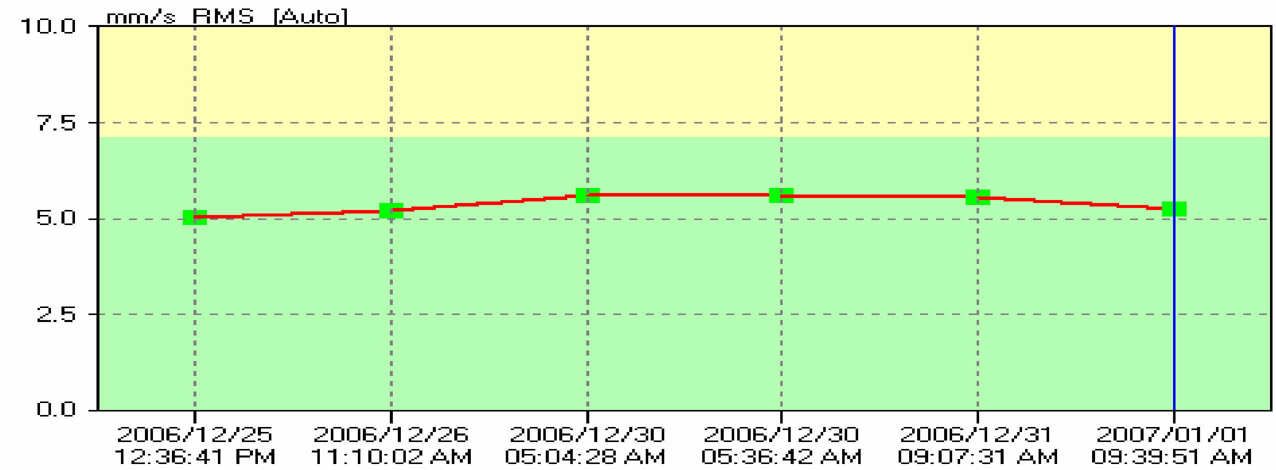

Figure 8. Overall vibrations of non-driven end (NDE) of electromotor after repair

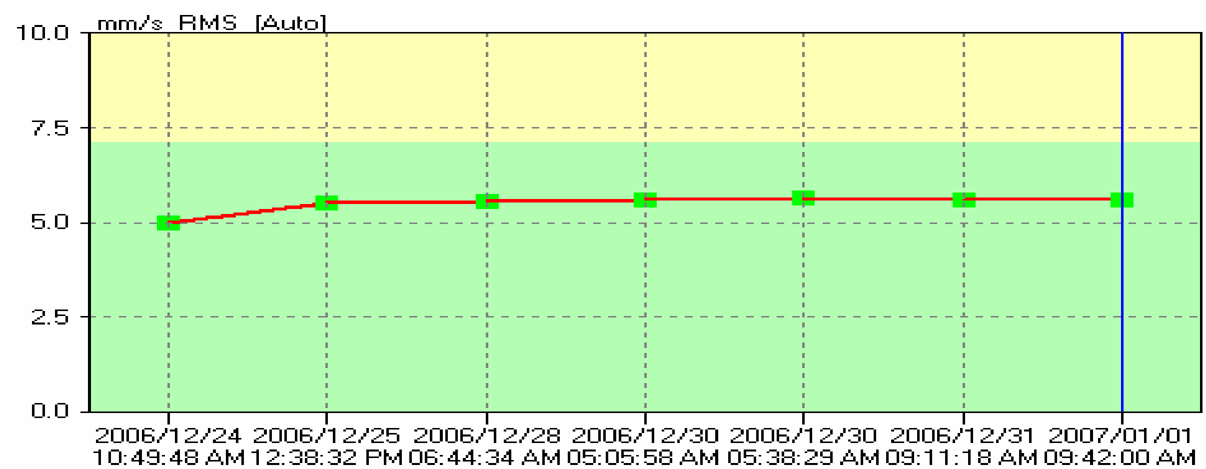

Figure 9. Overall vibrations of driven end (DE) of electromotor after repair.

Table 4. Measuring date, RMS of vibration velocity, alarm status, and BC of non driven end (NDE) of electromotor after repair.

Test	Measuring date	RMS of vibration velocity (mm/s)	Alarm status	BC	Alarm status
1	25-12-2006	5.03	Ok	0.08	Ok
2	26-12-2006	5.23	Ok	0.07	Ok
3	30-12-2006	5.61	Ok	0.09	Ok
4	30-12-2006	5.61	Ok	0.2	Ok
5	31-12-2006	5.55	Ok	0.16	Ok
6	01-1-2007	5.26	Ok	0.09	Ok
Mean		5.38		0.12	
Standard Deviation		0.24		0.05	

Table 5. Measuring date, RMS of vibration velocity, alarm status, and BC of driven end (DE) of electromotor after repair.

Test	Measuring date	RMS of vibration velocity (mm/s)	Alarm status	BC	Alarm status
1	24-12-2006	4.98	Ok	0.14	Ok
2	25-12-2006	5.52	Ok	0.12	Ok
3	28-12-2006	5.56	Ok	0.1	Ok
4	30-12-2006	5.61	Ok	0.08	Ok
5	30-12-2006	5.65	Ok	0.09	Ok
6	31-12-2006	5.6	Ok	0.1	Ok
7	01-01-2007	5.61	Ok	0.09	Ok
Mean		5.50		0.10	
Standard Deviation		0.23		0.02	

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