FOR A BETTER CONTROL OF THE AVAILABILITY OF THE INDUSTRIAL EQUIPMENTS

Rachid CHAÏB[1], Ahmed BELLAOUAR[1], Mohamed BÉNIDIR[1], Ion VERZEA[2]
[1]Mentouri University, Constantine, Algeria
[2]Technical University Gh. Asachi Iasi, Romania

Abstract. Each one can intuitively understand that maintenance is significant because if equipment breaks down, the production can be stopped. In a system with tended flows or there are few intermediate stocks, such a stop can put in layoff part of the workers and thus to have very expensive consequences. thus, the stoppage or the abnormal operation of the production equipment, and the non-observance of the deadlines which is followed from there, indeed generate costs which the companies are not any more in a position to support: wastes of time, losses of production, thus affect the costs, then losses of credibility near the customers, therefore affect competition and the confidence and finally losses of profitability and competitiveness, even losses of perenniality. This is why; the companies cannot wait any more until the breakdown occurs to cure it but must from now on be organized to proceed to the various operations which make it possible to avoid it. Thus in the company, the function "maintenance" less and less often consists in giving in state the working tool but to more and more frequently anticipate its dysfunctions. So it is not advisable to develop immediately all good practices. Some can be more urgent than others according to priorities' of the company. Indeed, if the maintenance activities are correctly planned, one can better prepare the tools and the necessary parts as well as the team concerned to the various interventions, even a better coordination between maintenance and production. This is why the objective of this work is the early detection of the dysfunctions of the critical machines, even the intervention advisedly, while following the evolution in the time of the symptoms of state drift of the equipment. Thus, one is able to rationally use the mechanical components until complete wear without any risk of sudden breakage and to practice selective maintenance.

Keywords: early detection, vibratory analyzes, rotating machines, maintenance, availability, failure

1. Problems

Today, the majority of the industrial organizations, the improvement of the industrial plants availability are regarded as a means of increasing profitability and competitiveness. The industrial plants disturbed by dysfunction involve losses in every company whatever its size: wastes of time, losses of production, thus affect the costs, then losses of credibility with the customer, thus affect competition and the confidence and finally losses of profitability and competitiveness, even losses of perenniality. However, as the function maintenance is in full evolution. Currently based on the concepts of reliability, of maintainability, of availability and concepts of safety and quality, it is not limited any more to the only vision of the material sits of the failure, but extends to the unit of the company processes [1, 2]. To this end, the company is brought to assess its existing system compared to what it should it be on the one hand and make the priority strategic decisions of maintenance which are essential on the other hand. So it is not advisable to develop immediately all good practices. Some can be more urgent than others according to priorities' of the company. To control such an idea and respond with the requirements of the cement plants, requirements of high safety, reduction of the costs of exploitation and control of the equipment availability, today's industrial world, experienced significant development in the field of the monitoring and the diagnostic of the machines, especially the strategic machines or vital equipment, selected like criticism by their influence on safety, quality and by their impact on the production flow. As a matter of fact, the maintenance of the industrial systems becomes a strategic function in the management of the company and a point of passage obliged of the companies competitiveness when designing the exploitation systems, as well for questions reliability as for questions profitability and quality [3]. It should also be noted that a maintenance badly adapted to a system could also lead to a dangerous critical situation as well for the people for the material or the environment [1, 2, 3, 4]. Moreover, with the very fast evolution of the methods and tools related to maintenance, the industrialists engage in the race towards the zero breakdowns [5], active in the direction of a better control of the availability of the equipment with maximum total output and a reduction of the maintenance costs.

This is why, the objective of this work is the early detection of the dysfunctions of gears in a Symetro reducer, even the intervention advisedly, while following the evolution in the time of the symptoms of drift of the equipment state and in particular the vital equipments which are conditioning the production process while being based on: ***not to fight the effects, but to treat the causes***. Thus, one manages to rationally use the mechanical components until complete wear without any risk of sudden breakage.

2. The technical characteristic of the reducer

The Symetro reducer, figure 1, presents a strategic machine in the production process of cement. The design features are presented in table 1.

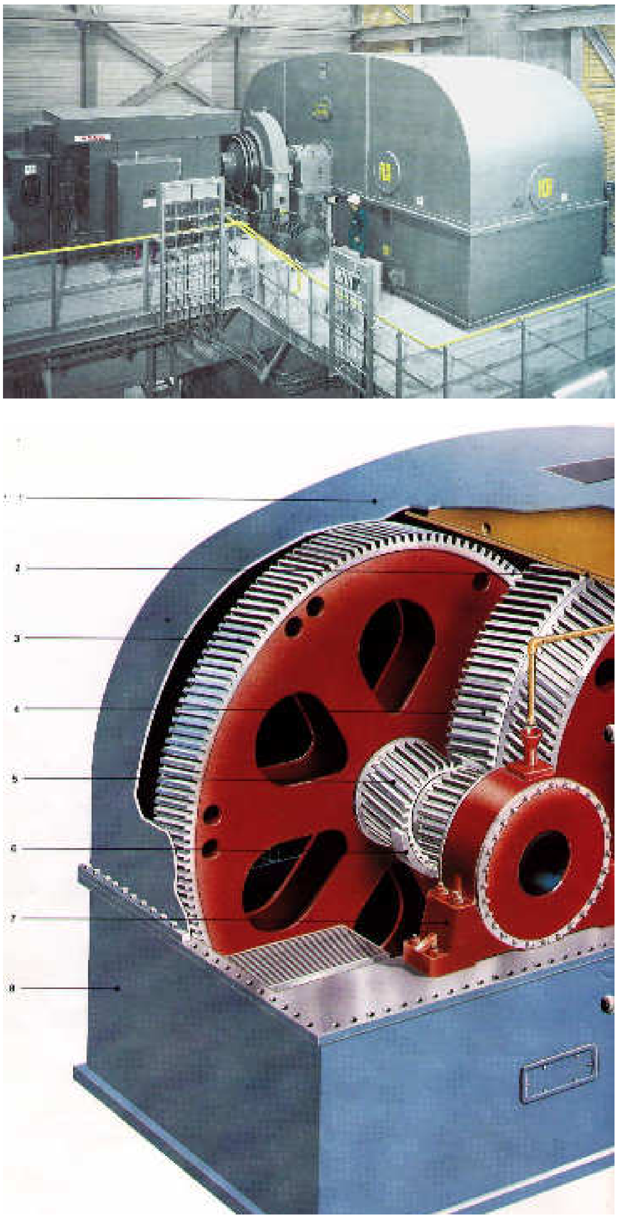


Figure 1. The symetro reducer, order crusher

Table 1. Design features of the Symetro reducer

Designation		Body	No. teeth z	Speed Rotation rev / mn	Frequ * Defect Hz	Frequency * Gearing Hz
Motor			---	495	8.25	------
Réducteur Symetro	1 train	Pinion 1	41	495	8.25	338.25
		Wheel 1	312	65.14	1.08	
	2 train	Pinion 2	44	65.14	1.08	47.5
		Wheel 2	190	15.06	0.25	

2.1. Seeking defects

Points of measurement

According to the workmen who are working on the cement production chain, a monitoring system was adopted. The measurement points were configured with a detailed attention on the choice of the points of measurements carrying indication for an evaluation of the internal reducer behavior, even its damage. This is why a very particular interest is carried to the stages, because they constitute a way of privileged passage for the vibrations. Eight points of measurements were configured to evaluate the behavior of the reducer, figure 2.

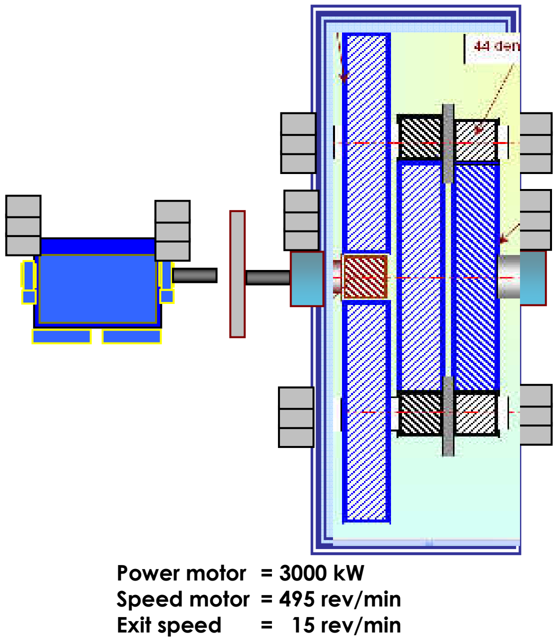


Figure 2. Synoptic and points of measurement

2.2. Overall measurement level

The machine operation at every moment depends on its state. This state can be evaluated by any analysis allowing the quantification of certain symptoms of degradation of the machine elements in the form of overall measurement, figure 3, while referring to known references (former standards, measurements, etc.). By consulting the former measurements history of the reducer, it is noted that the vibratory level is acceptable (lower than the value 2.7 mm/s). On the date of the 26/10/2008, one raises an increase of the total speed level, exceeding the preset threshold (C_4 = 1.21 mm/s). This change in the operation behavior of the equipment supposes that the machine is affected, even modification of the frequencies signs deterioration. To allow the source of the defect, one must pass to the frequency analysis.

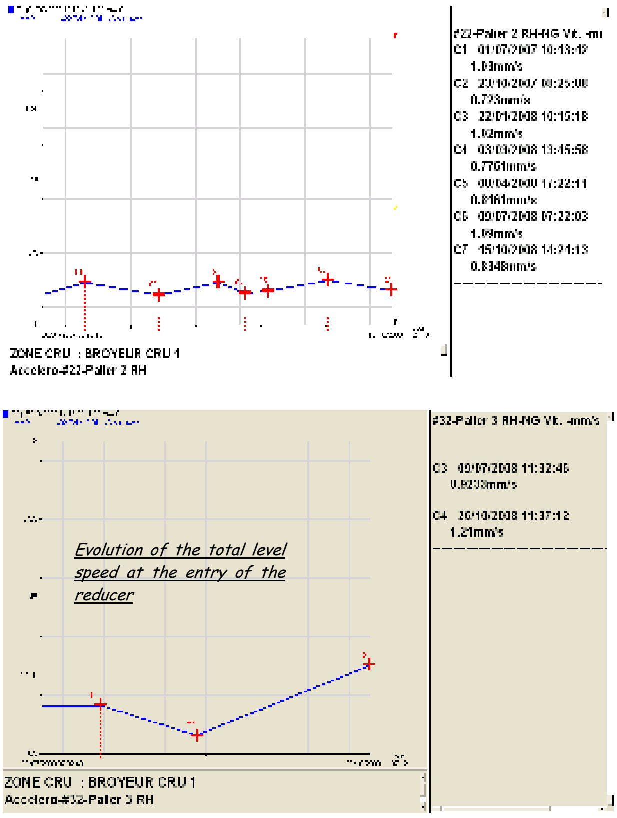


Figure 3. Overall measurement level of the reducer

2.3. Frequency analysis

This type of analysis enables us to locate the failure, to advisedly intervene only and to open the machines only in the condition that is not necessary for it and during programmed stop of the production. However, as the risks of machines degradation are directly related to the observed vibratory levels. The latter describe kinematic signature of the equipment, related to the operating conditions, figure 4. It is necessary to be very attentive with knowing to appreciate at which time the risks become relevant so that the machine can be exploited correctly with the recommended performances. Consequently, one determines the set of priorities of the maintenance actions to be carried out and one directs the procedure of exploitation towards the links more penalizing.

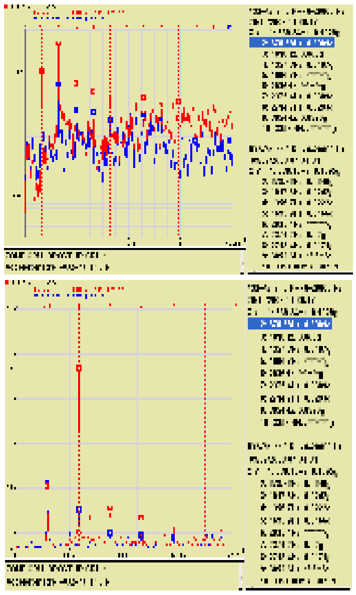


Figure 4. Kinematic signature of the equipment

At the reducer Symetro entry, the spectral analysis of the frequency of engaging high speed and its harmonics show an evolution of the harmonic amplitude of the 2nd of engaging of the 1st stages, figure 4, and blue line. That results in the creation of a play of engaging of the exit wheel. The decision taken to avoid the deterioration of the reducer, it is disassembling. After the disassembling of the reducer, one notices that the wheel of engaging is deteriorated, figure 5.

Figure 5. Disassembling of the reducer and damaged wheel

Considering the economic importance of the cement plant and for lack of spare part in stock and on the national market, the solution recommended by the service of maintenance is the recharging of the broken teeth. After the palliative maintenance action of the wheel toothed by recharge, on 09/07/2008, the amplitude of the 2nd harmonic of the raised engaging frequency at the entry of the reducer was about 0.064g. However, at the exit of the 2nd train, one notes an evolution of this amplitude with 0.3g under the effect of transmission of the vibratory shocks of the exit train, figure 4, red line.

After the loading of the wheel by welding, another problem emerged: they are the periodic shocks with the passage of the charged teeth. The temporal representation below, figure 6, shows the evolution of the amplitudes of the shocks in the temporal signal and that after recharging of teeth.

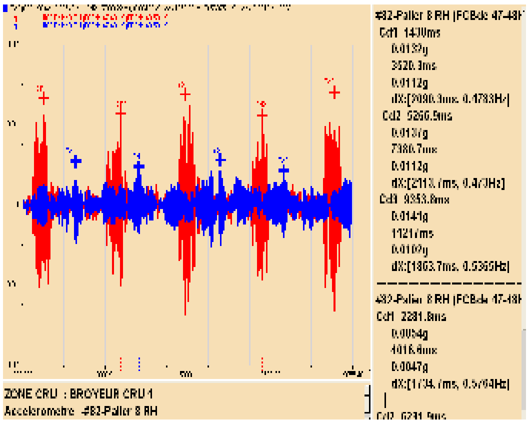
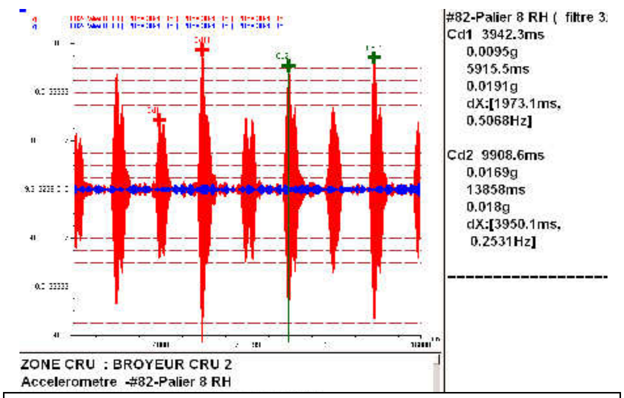


Figure 6.Temporal representation of the signal

Analyzing the figure 6, the following could be noticed:

- evolution of the amplitude of shocks at the frequency of passage of the wheel of exit of the reducer;
- weak amplitude of the shocks at the frequency of passage of the exit wheel of the reducer before the recharging of teeth by welding.

Considering the lack of documentation and the total absence of the installation history file and in order to better determine the problem and to have more information, Cru 2 crusher is used as reference. A comparison between the crusher Cru 2, which is identical to the crusher Cru 1, and work under the same conditions is made. It can be noted that the vibratory level of the reducer is completely different, figure 7.



Temporal signal of the V wheel of the exit reducer Crusher Cru2

Temporal signal after recharging of the teeth with welding of the exit Cru2 reducer V wheel

Figure 7. Comparison of the vibratory levels of the reducers

3. Conclusion and recommendations

The vibratory signal is the identity of the machine [6], at every moment bound to the operating conditions of it. It enables us to envisage the appearance of the dysfunctions while following the evolution in the time of the symptoms which derives from the equipment state and to intervene only advisedly in the presence of defective elements, to even better appreciate the concept of lifespan of a revolving machine (component). To answer the requirements of the cement plant and to rationally use the mechanical components until complete wear without any risk, and avoiding any sudden breakage and a practitioner selective maintenance. The following practices are recommended:

- **For the 1st gearing train G.V.:** Under the effect of the bad engaging of the exit train P.V., we note an evolution of the amplitudes of the engaging frequencies, the latter can be reflected on the state of the teeth of the 1st train: continuous monitoring.
- **For the 2nd gearing train P.V.:** Because of the bad engaging of the exit wheel, after repair by recharging, we note a clear evolution of the shocks amplitude at the frequency of passage of the exit wheel P.V.: need for a rigorous monitoring.

4. References

1. Nakijima, S.: *La maintenance Productive Totale (TPM*). Editions AFNOR gestion, Paris 1987, ISBN 10: 2124651110
2. Stella diagnostic, *la maintenance conditionnelle des machines tournantes*. MVI, technologie, 1999
3. Boulanger, A., Pachaud, C.: *Diagnostic vibratoire en maintenance préventive*. Dunod, Paris 1988
4. Zwengelstein, G.: *Maintenance basée sur la fiabilité, guide pratique d'application de la RCM*. Edition Hermes, Paris 1996
5. Boulanger, A.: *Vers la zéro panne avec la maintenance conditionnelle*. AFNOR 1999
6. Chaib, R., Benretem, A., Teyar, S. and Verzea, I.: *Management of maintenance by vibratory analysis case: a planetary reducer*. World Journal of Engineering, Vol. 4, N°.1 (2007), p. 22-27, Sun Light Publishing, Canada. ISSN: 1708-5284

Received in February 2010