PRACTICAL RESULTS OF PREDICTIVE MAINTENANCE PROCEDURE INTRODUCTION IN ROMANIAN PAPER INDUSTRY

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Abstract: This paper presents applicative studies related to the implementation of the supervisor system and predictive maintenance in the paper industry. Bank data content is presented regarding the unexpected functioning interruptions and reconditioning technologies. The constructive and technological aspects regarding the maintenance of this unit are presented using one case study, proving the real advantages of this concept as compared to the classical concept of maintenance.
After a detailed analyze of the construction and the behavior in exploitation of the paper manufacturing complex equipments there has been established a clear evidence of the different sources of failures. Based on this it was elaborated a repair program which follows the predictive maintenance methodology. Also, in this paper there are presented different characteristic aspects of the defects appeared during exploitation.
Key words: predictive maintenance, paper industry.

1. INTRODUCTION

The industrial development of the last decades – globalization, the increasing concurrency and the high qualitative claim requirements – has made the role of maintenance to be a very important issue. It is very well known that the industrial installations are in a continuous way exposed to a very complex degradation (erosion processes of wears), which leads after a period to severe break–down of the equipment and the abruption of the entire manufacturing process.
These critical abruptions are less and less accepted by the industry because they could cause accidents, production-looses and important financial looses, too.
In order to increase the durability and to improve the functionality of the pumps from the paper manufacturing equipment the assurance of a correct exploitation and service based on the predictive maintenance methodology is compulsory needed.
According to the statistics, currently in the hard industry field of the petrol refinement, metallurgy, metallurgy of iron, the paper and pulp industry, the costs of the maintenance of the equipments reach almost 40 % of the total manufacturing costs (Gramescu & Chirila, 2001).
The practical researches made at S.C. SOMES Dej Company revealed the fact that in most cases the pumps are working in improper conditions, leading to unexpected interruptions. The production of this company is over 20.000 tons of paper and over 25.000 tons of cellulose.
The repairs are made usually during the interruptions without being assured an optimal durability of the pumps. The made repairs leads to technological lines braked-down and productivity loses (Ionut et al., 2003).
The research developed by our team was oriented mainly to create an intervention program to eliminate the disadvantages that were presented.
The predictive maintenance concept is based on the idea of including some particular sensors in the system in order to analyze the technical recorded data for establishing the right maintenance solutions when the performances of the parts starts to decrease and the chance of the process to be breaked down becomes high (Guide, 1996).
The damages are repaired in a programmed and in an organized way, avoiding severe losses to be recorded.
The predictive maintenance objectives used by us are:
▪ to establish the optimum repair schedule in order to have a good maintenance of the equipment;
▪ to prevent accidental droppings;
▪ to reduce the costs regarding maintenance;
▪ to improve the quality of the maintenance and the quality of the products (Rimap, 2004).
The predictive maintenance tools were:
▪ recording of vibrations (such as the frequency, the amplitude, e.g.);
▪ load problems detection, such as abnormally pressures
▪ distinguish of the wear near limits during the process;
▪ analysis of the corrosion and erosion problems during equipment exploitation.
The parameters referring to the normal run out of the equipment (such as operating velocity, temperature, lubrication, e.g.) must be recorded in a continuous way, evaluated and than post processed, by correctly

interpreting the technical and the functional conditions whenever needed.Diagnostic techniques based on the vibrations analysis, spectroscopy, sonic analyze, e.g. can also be used.

Damages will be solved in the next period by replacing only those parts that presents deviations from normal behavior, leading finally to significant supplementary costs in order to make repairs and for the maintenance of the equipment.

2. APPLICATIVE AND EXPERIMENTAL STUDYS

In order to identify and efficiently avoid the process interruptions, a rigorous investigation analysis is needed. When speaking about the classical maintenance, the investigations are made at least one time per year, when planning repairs are scheduled or on every time when a pump is brake-down and needs to be replaced (Kovacs, 2009).

The trace, which are referring to an improper work out, are: the presence of the oil flows or the consistent grease present on the base plate, increased temperature of the engine box, the presence of an important quantity of rubber dust under the electric coupling, the misalignments between the electric engine and the pump, etc. For example, because of the misalignments between the electric engine and the pump in the range of 0.52 mm and for a period of 4 months of pump functioning, important damages are caused.

In conclusion an efficient predictive maintenance program needs to be created in order to predict the evolution of the misalignments in time (Fulop at al. 2008, Fulop at al. 2007).

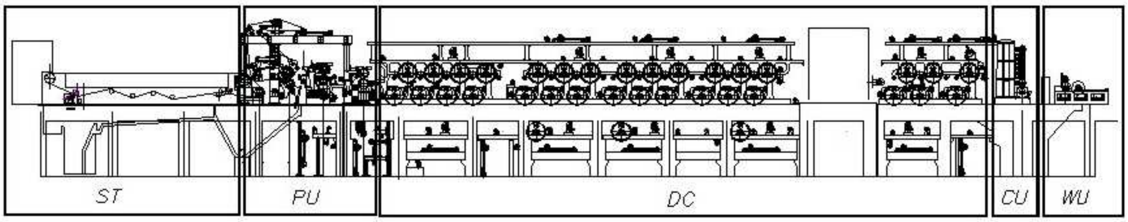
The predictive maintenance program is based on a detailed analyze of each damage in order to establish exactly what caused the problem. Meantime some changes are needed to be maked out in order to prevent the future damages repetability.

Sometime none of the demarches presented above indicates the existence of a problem, but in most cases, if multiple investigations are made, the source of the defects could be discovered in time and could be used in order to avoid similar defects in the future.

Even the time needed for the investigations seems sometimes too long, in the final, it could be concluded that the time dedicated for this purpose was not lost.

2.1. Description of the paper manufacturing aggregate

The practical research was made at S.C. SOMES Dej Company for a paper manufacturing aggregate. The utilized aggregate is composed by the following components (figure 1):



ST - the table of the sieve; PU - press unit; DC - drying cylinders; CU – calender unit; WU – wrapping unit

Fig.1. The basic scheme of the paper aggregate

- The raw material (the cellulose fiber + water +bounding agent + colouring agent+ filling materials) launched on the sieve and in the unit **ST** where the paper is formed as sheets and a big part of the water is being removed.
- The sequel in the press unit **PU,** for pressing the sheet paper, in order to remove the remaining water. (For this purpose the paper sheet is passing through the drying cylinders that are heated with steam).
- The calender unit **CU** that presses the paper in order to obtain a good gloss.
- The roller that ends the manufacturing process of the paper and the wrapping unit **WU** (Gyenge at al., 2007, Costea et al., 2008).

2.2. The supervising of the inadvertent interruptions of the equipments

Beginning with year2003, there has been pointed out some inadvertent interruptions of the equipment that were caused by different factors, such as the ones presented in Table 1, (Costea et. al., 2008).

Table 1. The inadvertent interruptions (unexpected) of the paper machine in hours

Year	Technological	Electrical	Mechanical	Total stops
2003	175	87	96	358
2004	164	94	94	352
2005	142	115	88	345
2006	152	26	65	243
2007	74	14	20	108

Using the recorded data presented in Table 1, a diagram could be draw in order to presents better the different types of unexpected functioning interruptions of the equipment (figure 2).

From figure 3 it could be noticed that over 50% of the annual total functioning interruption were caused by the mechanical and the electrical defects. From the figure 4 it could be observed that a positive evolution was recorded only in year 2006 towards the decreasing of the functioning interruption time, obtained by a series of technical-management solutions that were performed, such as predictive maintenance method that has been applied.

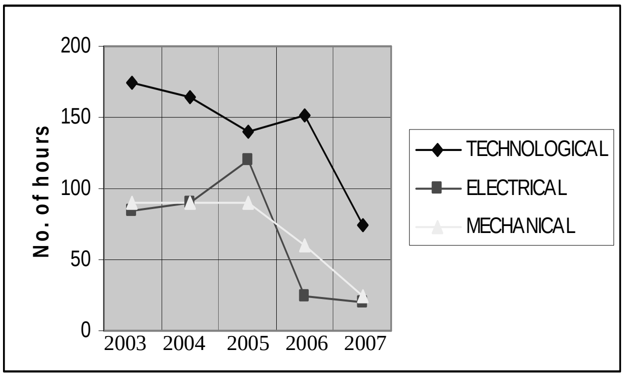


Fig.2. The diagram of the unexpected functioning interruptions, caused by different factors

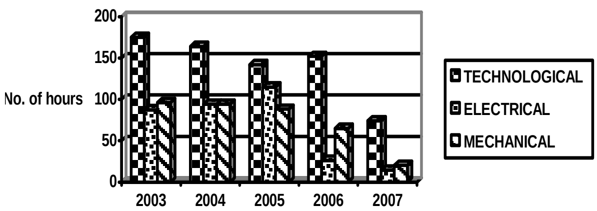


Fig.3 The diagram of the unexpected functioning interruptions, caused by different factors

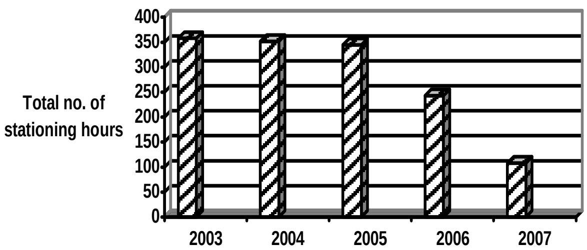


Fig.4. The diagram of the total functioning interruption

2.3. Case study: the black lye pump of regeneration boiler

The regeneration boiler is a continuous feed with concentrated lye pump type ABS NB-125-100, driven by 22 kW/1500 rot/min electric engine.

By analyzing the historic of the black lye pump, the total duration of the unexpected breakdowns was 280 hours and the main causes were identified, as presented below:

- pump bearing deterioration - 54%;
- the burning of the electric engine, because of the excess load, caused by the restriction of the pump tubing, according to the lye pump debit adjusted, which entered into the boiler: - 28%;
- sealing up problems caused by worm sealing destruction from the shell and the axle pump - 14%;
- the breaking of the pump hold down screw, due to the high vibrations caused by the non-adequate base of the electric engine and the pump in the base structure - 7%;
- other causes: impropriete lubrication, breaking of the rubber blades from the couple, the disequilibrium of the rotor - 3%.

The black lye pump, illustrated in figure 5, is equipped with NU 312ECP bearing, on the rotor side, and a tow 6313NR bearing on the electric engine side (Fulop et al., 2008).

Fig.5. Black lye pump

The breake down of the pump was caused mainly because of the deterioration of the 6313 NR bearing that is placed on the electric engine side. Possible causes of the bearing deterioration were identified, as following:

▪ a wrong technical solution for fixing the axle of the pump on the bearings;
▪ a high level of vibrations caused by a wrong equilibrium of the rotor, sever misalignments, “soft foot” phenomena and high stresses of the tubes;
▪ sealing problems between the case of the pump and the axle of the pump, that leads to a lye penetration into the body of the pump.

By analyzing all these causes, a sample pump has been prepared. Some amendments were made, as presented below:

▪ the radial roller bearing 6313 NR was replaced with two radial-axial roller bearings assembled in set from 7313 BECBP series;
▪ the dynamic balancing of the rotor was made for a relative velocity of 1500 rot/min;
▪ the soft consolidation between the case of the pump and its axle was replaced with a mechanical consolidation. For this purpose, the wear sleeve was taken out and the axle of the pump was modified in order to realize the optimal assembly of the mechanical consolidation;
▪ the manufacturing of the base plate of the pump has been made in one fixing direction.

In order to eliminate the erosion phenomena of the pump rotor, the wear of the case pump and the wear of the fixing flanges from the admission pump side equipment, which separate the sand and the lye has been also manufactured.

The proposed solution in order to reduce the deterioration of pump bearing was to replace the radial roller bearing 6313 NR with the radial-axial roller bearings 7313 BECBP.

Meantime we have replaced the C2 black lye pump worm sealing with a mechanical sealing, A new pump base was fixed in the structure by a casting process, proceeding with one fixing pump for mounting the shoe, then the alignment of the pump electrical engine and with the laser center device that was made, and the replacement of the manual valve from pump delivery with an automatic one.

For protecting the electrical engine from the additional load of the solution we have found was to assembly one frequency converter that adjusts the electrical engine velicity by the black lye capacity, barred from operator monitoring board.

It is important to notice the fact that, during the analyzed period, the total costs of the made repairs were around 180.000 euro/year.

As could be observed, the main cause of the unexpected breake downs of the manufacturing process was the pump bearing deterioration.

Meantime a new solution has been proposed in order to realize the couple between the electric engine and the pump, by replacing the toothed clutch with an elastic plate coupling, which has the propriety of taking an important percent of the existing misalignments from the system.

The equipment, which separates the sand and the lye, has been mounted on the circuit of the black lye pump.

By analyzing the run of the black lye pump over a period of 6 months, some advantages were compared to the old version of the black lye pump, such as:

▪ the decreasing of the unexpected break downs caused by - the damage of the pump bearings with 80%; - the wear of the rotor and the case of the pump with 73%; - the sealing up problems of the pump with 78%; - the couple break down with 64%;

▪ the decreasing of the planning repairs costs with 40%;

▪ the decreasing of the unexpected breake down manufacturing process time with 67 %.

The run period of the new black lye pump version as compared to the old version of the pump was increased from 1,5 months to 6 months. After using the pump since January 2008, were noticed that the the unexpected break down have been decreased with 88%.

The costs regarding the developing of the new version of the pump and the build-assembly additional costs that were needed were amortized after a period of 4 months of black lye pump using, from the economies made with the maintenance, without taking into account the product-looses, caused by the unexpected break downs.

2.4. The methodology of supervising the equipment's state

One of the efficient supervising methods of the functioning state of the equipment is the measurement of the vibrations (Gyenge, 2007).

For this purpose, we have used the Microlog CMVA60, (figure 6), and Martin-Condition Detector device, in order to measure the period of the vibrations in the following directions: H – horizontal, V – vertical and A – axial.

Fig. 6. Microlog CMVA60

In figure 7 is presented the evolution diagram of the horizontal vibrations period at one of the aggregate's pump.

As it can be observed from figure 6, in the first months of using the pump, the amplitudes were in the normal limits. In 2008 these started to be increased suddenly. After some solutions that were applied, we noticed that these amplitudes were finaly brought back to the normal limits.

The results obtained in the made research revealed the fact that the unexpected break downs of the pump electric engine were caused by the damages of the electric engine components, such as the rotor, the stator or the bearing, figure 8.

In order to find out what are the possible damages of the electric engine, a vibration detector was used in order to collect data about vibrations, which are present in the manufacturing process during the normal run out of the engine.

The data were processed afterwards and some conclusions about the working state and possible damages of the electric engine were made. These presented damages were detected by using the vibration detector.

The collected data were analyzed and some suggestions were made in order to avoid the possible damages of the engine in the future.

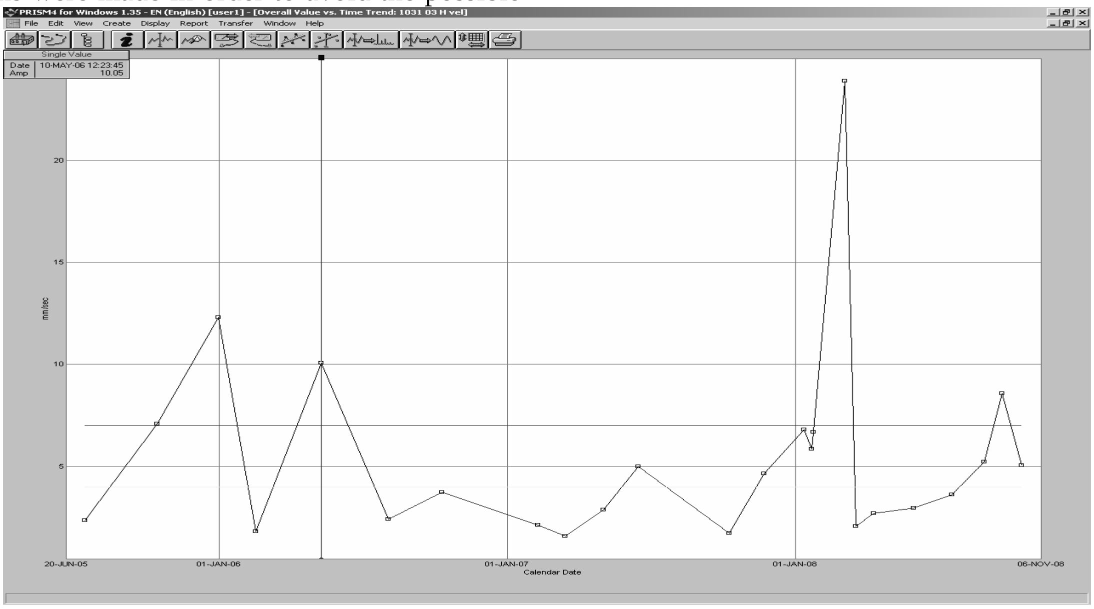


Fig.7. The diagram of the evolution of the horizontal vibrations of the pump

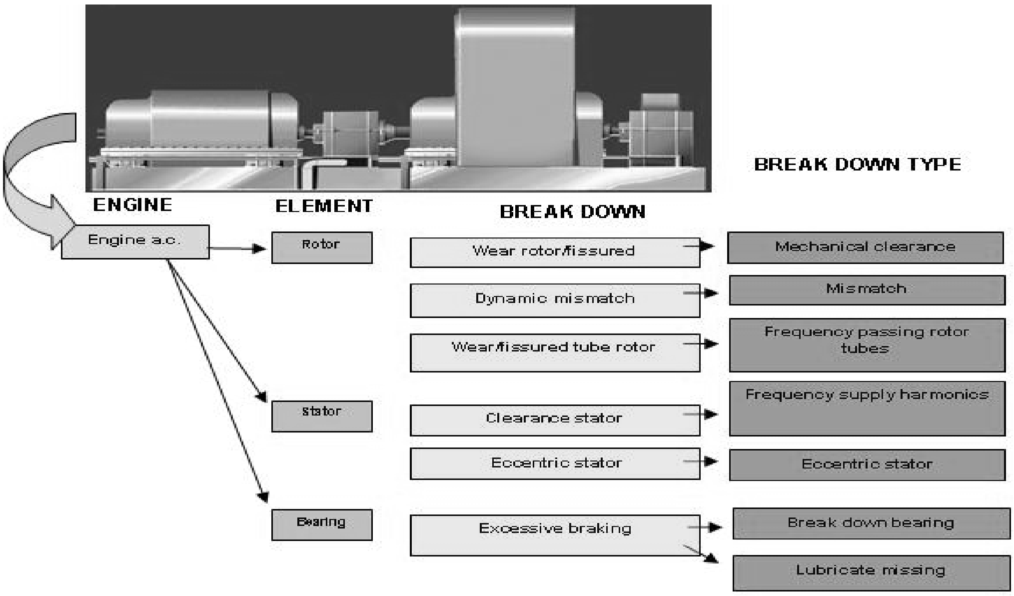


Fig.8. Possible damages of the electric engine

The results obtained in the made research revealed the fact that the unexpected break downs of the pump electric engine were caused by the damages of the electric engine components, such as the rotor, the stator or the bearing, (figure 8).

In order to find out what are the possible damages of the electric engine, a vibration detector was used in order to collect data about vibrations, which are present in the manufacturing process during the normal run out of the engine (Fulop, 2008). The data were processed afterwards and some conclusions about the working state and possible damages of the electric engine were made. These presented damages were detected by using the vibration detector. The collected data were analyzed and some suggestions were made in order to avoid the possible damages of the engine in the future.

Some improvements were made regarding the retrieve and replace of the engine, in order to avoid a capital break down of the engine. By analyzing the technical state of the company, different type of equipment and by using the vibrations detector, it is possible to classify the equipment that needs to be repaired or replaced.

The maximum vibrations are caused by the misalignments during dissasembling process and not by the prominent vibrations from the electrical damages, (figure 9).

The bearings damages leads to vibrations with high frequency and variable amplitudes.

As illustrated in figure 10, it is possible to observe the fact that the machine frame resonance caused by the dynamic disequilibrium has the auto-amortization tendency.

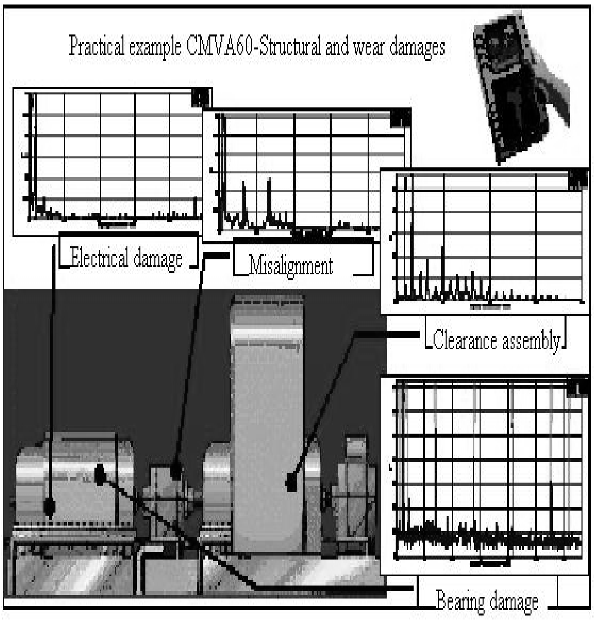


Fig. 9. Structural and technological damages

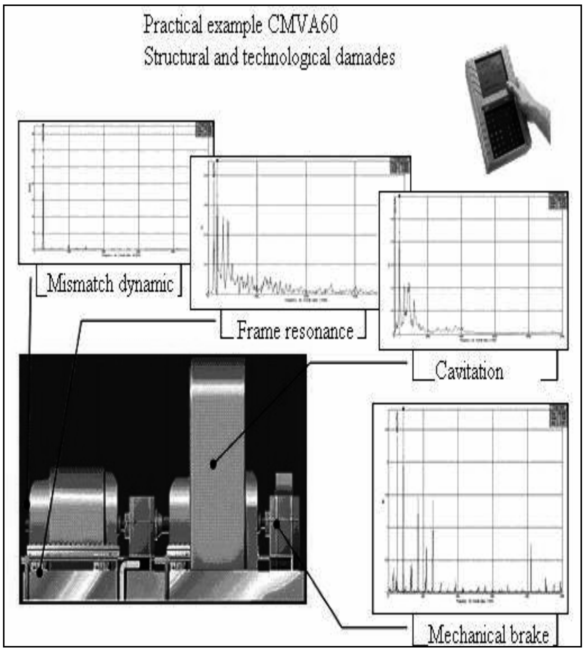


Fig. 10. Structural and technological damages

3. CONCLUSIONS

In order to realize an efficient exploitation of the equipment used within the paper industry the followings solutions are necessary to be taken in consideration:

► the continuous and careful supervising of the behavior of each equipment;

► the elaboration of a maintenance program;

► the elaboration of some adequate reconditioning technologies.

By applying the predictive maintenance method it is possible to record and analyze the evolution regarding the working state of the equipments and the process evolution of different types of damages in time. Based on this remarks, it is possible finally to conclude that an efficient predictive maintenance concept that is applied (as it was made by out team) in S.C. SOMES Dej Company case study, leads to a significant decrease of the additional costs and to a significant increase of the run out capability and operational reliability of the equipment in time.

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