THE ADVANTAGES OF IMPLEMENTING A PREDICTIVE MANAGEMENT WITHIN THE MAINTAINIG AND EQUIPMENT REPAIR AT AN ENTERPRISE WHICH PRODUCES COMPONENTS FOR THE AUTOMOTIVE INDUSTRY INCLUDING TECHNICAL ASSISTANCE AND SERVICES

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Abstract:

Economic efficiency within enterprises is represented by how maintenance and repair activities are organised and operated, the under repairing equipment's immobilization time because, by diminishing this factor significant reserve resources can be achieved by increasing production volume. The management activity shall be responsible to organise cars' and equipments' maintenance and repair activities, to apply rules of organisational structure and human resources, established and approved in the company's organisational chart, measures to improve the information system and relationships between departments and sectors, to improve tracking system and movement of documents and to permanently expand data processing sector.

Predictive maintenance is based on monitoring wearing parameters of the key elements or subparts of the fixed assets, by some specific instruments (wearing, vibration, oil analysers) in order for the maintenance interventions to be accomplished before the flaw appears.

Keywords*: maintenance, repairing, predictive maintenance, reduced cost*

1. Introduction

In the current economic context, the machine industry remains one of the main sectors of the national economy, with an impact on all areas of the economic and social activity, with an important contribution to the accomplishment of economic growth in Romania.

In order to achieve the company's fundamental objectives regarding the supply with products and services in certain conditions, human resources, material and technical, established by experts as necessary, are not enough.

The company's management have to permanently know the maintenance and repair costs and, according to this, the cost for fulfilling the production activity, thus being able to determine its activity's economic efficiency in order to determine

responsibilities and provide the employees with material incentives. Moreover, information regarding the size of repair and production expenses is very important to the company's management since it offers it the possibility to know how much of the product's value is the value of the production means used for that product's manufacturing and sale and how much is the newly-created value.

Maintenance and repair of production machinery and equipment has a particular importance and necessity for the company. Therefore, by carrying out these activities in optimal conditions, the normal operation of equipment is ensured, according to the production schedules, thus avoiding decommission, making a contribution to the achievement of a rhythmic activity.

Since the maintenance and repair activity implies significant costs, the main objective is the development of activities in terms of minimizing the total cost of interventions and repairs and reducing losses caused by failures.

The management of an industrial unit, taking into consideration the interruptions registered in the functioning of equipment within a production division, sets as objective the increase of equipment's availability within this division, requiring the maintenance department to establish a maintenance policy for the achievement of this objective.

The maintenance strategy shall be applied both at the level of the entire company, and at each machinery in part, it shall allow to redirect efforts on the critical departments to add some quality to the final result by doing this. We may conclude that the ultimate objective is the increase of machinery's and equipment's availability within the production divisions, thus forcing the maintenance department to establish an adequate maintenance policy with the purpose of eliminating losses.

2. The necessity of equipment's maintenance and repair activity and aspects related to their management

We must not forget that, after some time, the equipment wears out, recording a progressive degradation, unless an adequate maintenance and repair is ensured. With the physical wear of the equipment also comes a moral one, which is a process of quality depreciation of the equipment due to the technological progress, having more technically-efficient and more economical work means (Unguru, L.,1998).

The existence of the physical wear process requires the introduction of a series of activities that would reduce their effects and provide the maintenance of the equipment's functional characteristics throughout the entire operation period.

By analysing the equipment's behaviour in the wear process, there can be noticed that the wear of different parts takes place in a different way. This requires taking some extensive maintenance and repair decisions, in order to prevent the equipment's premature decommission. In order to prevent this, the permanent checking of machinery, the mandatory performance of maintenance and cleaning activities, the lubrication of moving mechanisms, the permanent monitoring of its

maintenance, the operation of works with a well-trained maintenance team and the operation of repairs in due time are required. It is also requested that periodically the accessories that form the equipment are checked, although they are used more rarely.

Using the production equipment under proper conditions requires some preventive maintenance works, which would prevent premature wear and some control and revision operations that would allow the discovery of possible failures (Borza, A., 1995).

Due to the equipment's peculiarities to wear inconsistently, resulting in the fact that while some parts are completely worn-out, others may still be used for a particular period of time, lasting longer, it is economically requested that an adequate maintenance and repair system is adopted.

Therefore, carrying out such activities ensures the normal operation of production equipment, according to the production schedules, avoiding decommission and thus contributing to the accomplishment of a rhythmic activity.

With the major changes that have been happening in the recent years on a global and national level, the introduction of some modern maintenance and repair methods has become a necessity, in order to increase economic efficiency and also to make high quality products.

Providing a high quality of requested products and a high economic efficiency can be achieved by maintaining the equipment's and installations' functioning at proper parameters, without interruptions or accidental pauses.

Under these circumstances, there are only three conditions to become efficient:

- Refurbishment, which also includes the existing equipment's modernisation;
- Using at full capacity the already existing production capacities;
- The implementation of some new managerial methods that would lead to a maximum increase of company's performances.

Maintenance is a relatively new term that defines activities that belong to the most common and best known category, employed on a regular basis in the industrial environment since the earliest of times. Although maintenance is known as "the maintenance and repair of equipment", it represents not only a notion but a higher approach of the specific activities, which have as purpose to maintain the performances of the used good, completed by specific and integrated methods in a systemic conception with logistics, administrative and managerial activities, so that economic efficiency is permanently improved (Unguru, L., 1998).

The main objectives of the maintenance activity within companies are:

- minimising economic losses due to interruptions and optimising maintenance and repair expenses;
- maximising performances obtained with the existing equipment, by increasing the equipment's operation time, either by increasing the time between two technical interventions, or by decreasing the time of its maintenance in repair;
- preventing accidental interruptions and their consequences on the rhythm and continuity of productive activities;

- ensuring the maintenance of the equipment running for a longer period of time;

- avoiding excessive wear and accidental decommission of the equipment;

- carrying out maintenance and repair activities with the lowest costs and the highest quality, by increasing productivity of the workers who are operating these activities;

- modernisation of obsolete machinery.

In the strategy of improving the economic activity, it is up to the manager to plan a series of specific activities in order to make the maintenance and repair activity a key factor of improving the usage of production capacities, both extensively and intensively by:

- providing growth opportunities of checking the equipment and of the slight change of wear parts from the design stage;

- proper placement of equipment so that maintenance and repair can be done without problems;

- organising the productive process so that intermediary stocks that would provide production continuity during interruptions are forecasted;

- optimisation of the maintenance and repair technology, so that the intervention time is the smallest possible, reducing the interruption times of the working equipment;

- carrying out a preventive maintenance programme that, by a planned inspections system and by changing some critical, wear elements, may reduce the probability of accidental interruptions (Borza, A., 1995).

Maintenance works have as purpose to provide the equipment's maintenance in perfect state of functioning, to avoid excessive wear and to accidentally, or before time remove it from usage, to increase the equipment's functioning time, both by increasing the time between two operations and by reducing the necessary time to carry out repairs, to make repairs with minimal costs and of the highest quality (Badea, F., 2007).

For the small and medium-seized enterprises, which use machineries and equipment, maintenance and repair works are provided by the workers and mechanical engineers within the enterprise, and this provides a number of major advantages:

- the possibility to intervene immediately in case of accidental failures;

- increased flexibility in carrying out repair works;

- reducing costs by carrying out maintenance and repair works which are a facility and are part of the company's general costs (Barbulescu, C., Bigu, C., 2001).

At the beginning of maintenance and repair activity of equipment, this was done in an empiric way, meaning that the repair activity of equipment was done only when the equipment broke down due to wear. To avoid excessive wear of equipment and prevent accidental decommission, maintenance and repair systems have been developed, whose main objectives are:

- knowing the date of the equipment's decommission for repair:

- establishing the way repairs should be done and the execution time, in order to get ready the materials, equipment and labour force necessary for their enforcement;

- determining financial resources necessary for the repairs.

Based on these requirements, two maintenance and repair systems were developed, namely:

- the repair system based on findings;

- the preventive-planned repair system.

The repair system based on findings consists of establishing the pause dates of the equipment for entering into repairs, as well as their content, after a close monitoring of how the equipment works by the specialised employees, based on which their functionality condition is determined.

The preventive-planned system aimed to provide a double character to the entire set of maintenance and repair measures, namely:

- prophylactic character;

- planned character.

The prophylactic character comes from the fact that this system requires the implementation of certain maintenance and control measures that would prevent the possibility of a premature failure, due to which the equipment is put out of use before the normal time of functioning expires. The planned character is given by the fact that the different maintenance and repair works included in the system are carried out at dates established in advance, with the corresponding motivation (Badea, F., 2007).

These two features of the preventive-planned system give the system an obvious superiority as against the system based on findings, having a positive influence on the quality of repairs, of their operation and of the production costs.

The preventive-planned repair system can be implemented in two ways:

- the standard way;

- after revision method.

The standard method consists of the fact that each equipment or installation enters for repairs at pre-established intervals, for each of them in part. The repairs' type, volume and content have a standard character, according to a technical documentation, regardless of the equipment's state of functionality at the moment of entry on repair.

This method has a number of advantages, such as: it allows carrying out repairs based on a well-prepared documentation, it is easy to be applied and it has high efficiency for the enterprises with a large number of machineries and equipment. The disadvantages of using this method would be the fact that it requires a large amount of work to prepare the documentation necessary for the implementation of the method, which unnecessarily increases the cost of repairs for the equipment for which repairs are made, although their technical state does not require it.

The after revision method consists of the fact that the amount and content of repairs is determined after a technical revision. To establish how repairs shall be done, a first cycle of repairs of each type of equipment in part is made.

The advantage of the method is that it allows finding the level of wear of the equipment, at the time of the technical revision, avoiding repairs for the equipment where their technical state does not require it. The preventive-planned repair system contains the following categories of technical interventions:

a) maintenance and daily supervision of the equipment carried out by workers who operate the equipment in the production divisions, or by the workers specialised in carrying out these operations, which aim the elimination of the equipment's small failures, without replacing parts;

b) the technical revision *R* which includes operations that are carried out before a current or capital repair. By doing a technical revision, one aims to determine the equipments' technical state and establish the operations that should be made within current or capital repairs. During the technical revision, adjustment and consolidation operations of certain parts and subassemblies can be also made, to provide a normal functioning until the first repair;

c) current repair, level I and II *R1* and *R2* are the ones in which repairs are done periodically, in order to eliminate physical wear, by replacing certain parts or used subassemblies, the difference between the two types of repairs depending on the time interval between two successive current repairs and the amount of repaired or replaced parts and subassemblies;

d) the capital repair R K is a technical intervention made after the expiration of a functioning cycle of the equipment, whose size is stipulated in its operating regulations and which has as a purpose to keep the equipment running until the end of its normal life. Capital repair is the most complex technical intervention; it has a general character, because a wide range of parts and subassemblies that form the equipment are subject to the maintenance, control and repair process. It is carried out when performance, accuracy and safety of the equipment is no longer provided (Barbuescu, C., Bigu, C., 2001).

In addition to the technical interventions included in the preventive-planned system, other types of technical interventions are carried out within the enterprise.

These are:

- accidental repairs which are carried out at undetermined time intervals, caused by unpredicted decommissions due to accidental failures;
- restoration repairs are carried out for the equipment that has gone through several capital repairs and have a high level of physical wear. Due to these repairs, it also recommended to have some modernisation works of the equipment;
- failure repairs are carried out each time equipment breaks down due to either bad handling or maintenance, or because of natural disasters: earthquakes, fires, floods, etc.

In conclusion, the preventive-planned maintenance and repair system is a set of maintenance, control and repair measures which:

- is carried out periodically, at well-established intervals;
- aims to prevent excessive wear and the occurrence of failures;
- aims to maintain the equipment running for a longer period of time.

The qualitative growth of repair works and the decrease of their operation duration heavily depend on the method used to carry out the equipment's maintenance and repair activity. Among the most efficient methods used in organising the maintenance and repair works, the most used ones are:

- the repair method on subassemblies;
- the repair method based on the principle of production flow lines.

The repair method on subassemblies is characterised in that, in the enterprises with a large number of equipment of the same category, a stock of functioning subassemblies are created.

These subassemblies shall replace the used subassemblies within the equipment that are to be repaired, and then the trouble failures shall be repaired and shall become part of the stock of functional subassemblies. This method reduces very much the equipment's time of repair and thus the equipment's operating time increases, with all the favourable consequences deriving from here.

The method based on the principle of production flow lines is used for the equipment that requires demounting from foundations and transporting them to the repair workshops (for the capital repairs). In this warehouse, in order to carry out the repairs, those possibilities offered by the production flow lines shall be used, from the enterprise's basic divisions.

To implement repairs through the preventive-planned repair system, the industrial production companies prepare a repair plan. This activity involves solving two problems:

a) drawing the repair cycle structure of an equipment;

b) determining the dates on which each technical intervention on the considered equipment shall take place.

The repair cycle is the time between two capital repairs, including the duration between them, usually the last one.

Preventive maintenance has worked well for the continuity and safe operation of the equipment but was not a long term economic solution, because maintenance works were carried out to the equipment that did not requested it. Experience has proven that machinery and equipment do not break down all of a sudden; they break down gradually, after a period of weeks, months or years. During all this time they give us various warnings and signals over time. These signals, for example, small changes of temperature, run-outs, vibrations or sounds can be discovered through predictive maintenance.

As a result, predictive maintenance gives us time to plan, programme, and make repairs before the equipment breaks down (see figure 1.1).

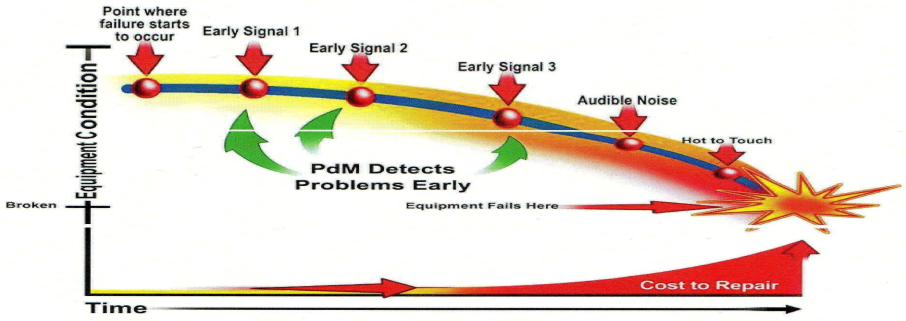

Figure 1. The graph of signals in time up to the break-down of equipment

Predictive maintenance requires permanent control at given time intervals of certain manifestation modes of equipment's operation in the operating process or of some working parameters (Barbulescu, C., Bigu, C., 2001).

Off al types of maintenance, the predictive maintenance gives you the most time to plan and programme the maintenance and repair activities and that is why it should be number one in planning maintenance.

Advantages of predictive maintenance:

- Maintenance is carried out only in case of necessity.
- Smaller stocks of spare parts.
- Stops are shorter and lass frequent than in the preventive maintenance.
- It increases the life of the spare parts.
- It requires less maintenance personnel.
- Low costs.
- Accuracy of the machinery's operation is guaranteed by measurements.

Disadvantages of predictive maintenance:

- It requires expensive equipment (for example: the analysis of vibration sphere).
- It requires highly-trained personnel, for measurements and the implementation of results.

Benefits of predictive maintenance:

- maintenance costs fall by 50%;
- unexpected failures reduce by 55%;
- general repair and revisions reduce by60%;
- the inventory of spare parts reduce by 30%.

Hidden benefits of predictive maintenance:

- less stress;
- more calm;
- an easier work;
- more free time.

Preventive maintenance has worked well for the continuity and safe operation of the equipment but was not a long term economic solution, because maintenance works were carried out to the equipment that did not requested it (Badea, F., 2007).

Beginning with the '90s, the obligation to carry out preventive and planned maintenance and repair activities ahs disappeared, commercial companies implementing intervention measures according to necessities, when the accidental break down occurs. The reason for choosing this method is the carrying out of technological processes without interruptions, with the purpose of accomplishing the proposed plans and the finished products on time. But in time, with the technological development, a competitive information system and an increased tendency to diminish production costs and increase competitiveness on the market, the necessity to implement some new maintenance methods – preventive maintenance emerged.

3. The advantages of implementing a predictive management within the maintainig and equipment repair at an enterprise which produces components for the automotive industry including technical assistance and services

For the case study, there was chosen an enterprise whose object of activity is the manufacturing of components for cars, but also the performance of a wide range of services, and has as a main purpose to meet current and future requirements of customers and business partners.

Beginning with 2009, the predictive maintenance system was introduced to the machinery and equipment of the company.

The employees in the manufacturing division have the obligation to write on the evaluation charts of the equipment data on the possible deviations from the nominal operating parameters, easy vibrations, run-downs of the equipment, organoleptic oil checking, and to announce them immediately. The personnel in the chief mechanic's workshop has the obligation to carry out periodical measurements of the mobile elements movements, to detect possible wears of the moving bodies, to determine viscosity, to monitor the maintenance and repair activity. The chief engineer shall centralize the information provided by the machinists and mechanics in order to create a database and monitor the replaced parts, by establishing the proper intervention moment on the machineries.

Based on the information collected during the analysed period, the following accidental failures of the equipment in the company were noticed.

Table 1. Table of the equipment's accidental break-downs

Current no.	Name of equipment	Number of accidental break downs		
		2007	2008	2009
1	SN 400 turner	8	11	7
2	Flat adjusting machine	2	5	3
3	Tin plate discharging guillotine	3	6	3
4	250 tf Hydraulic press	2	4	2
5	Round adjusting machine	1	3	1
6	Semi-automatic wire processing machine	3	7	4
7	6.3 tf Mechanical press	1	5	3
Total		**20**	**41**	**23**

Graphic representation of the number of accidental break-downs is shown below:

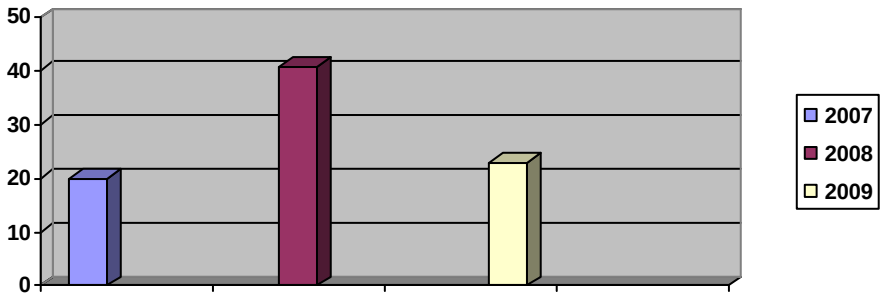

Figure 2. Evidence of accidental failures of equipment

This shows that in 2008 there was an increase of accidental failures as compared to 2007, the motivation being the increase of operation duration and implicitly increased wear of parts. After implementing the predictive maintenance, there was a decrease in the number of accidental interruptions in 2009 as compared to 2008 in a percentage of approximately 50%. By comparing 2009 with 2007, the implementation of the principle led to a regression of accidental failures almost like that from 2007, which indicates the high performance of predictive maintenance.

Looking at the maintenance and repair activity for 2007, the company has replaced 13039 lei worth of parts for equipment, in 2008 the replaced parts 21.274 lei worth, and in 2009 the value of replaced parts was worth 11.232 lei. For the analysed period 2007-2009, the company has had total expenses with parts worth of 43.093 lei. The study proves that implementing the predictive maintenance led to the decrease of expenses for the year 2009 as compared to 2008 that had a significant increase as

against 2007, which means that the company replaces parts rationally and scientifically. With regard to the value of work, in 2007 it was worth 13.039 lei, while in 2008 the value was of 43.091 lei, and in 2009 it was of 11.753 lei. During 2007-2009, an increase of the value of work can be noticed by almost 300%, but in 2009 it falls below the level registered in 2007, which reflects an increase of the value of work costs according to the technical time units to replace the worn parts.

4. Conclusions

The analysis of the company's incomes and expenses outlines a decrease of profit in 2008 by 52,37% due to the increase of operation expenses, but in 2009 there is a significant profit as related to 2008, with a percentage of 142,66% by giving an increased importance to incomes and judicious usage of operating expenses.

If during 2007-2009, there was an increase of the equipment's maintenance and repair operations, by implementing the predictive maintenance, after carrying out the measurements and operations specific to this type of maintenance, a decrease of failures and accidental stops was noticed, which allowed the significant increase of the turnover and also of the profit in 2009.

The analysis shows that the implementation of predictive maintenance caused the decrease of expenses for the year 2009 as compared to 2008, which registered a significant increase as against 2007, which means that the company replaces the parts rationally and scientifically. With regard to the value of work, in 2007 it was worth 13.039 lei, while in 2008 the value was of 43.091 lei, and in 2009 it was of 11.753 lei. During 2007-2009, an increase of the value of work can be noticed by almost 300%, but in 2009 it falls below the level registered in 2007, which reflects an increase of the value of work costs according to the technical time units to replace the worn parts.

It can be concluded that the introduction of predictive maintenance led to a decrease of expenses related to maintenance and repair works, of expenses of supply of spare parts and materials and indirectly reducing intercession time for problems and an increase of productivity.

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