ANALYSIS OF MAINTENANCE PRACTICES ADOPTED BY THE ROMANIAN PRODUCTION SYTEMS

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Abstract: In the present globalization stage, there are a lot of constraints of productive systems (costs, complying with terms, quality, health and environmental security, etc) which became sharper. By its specific and complexity, the maintenance activity of technical equipment has a significant influence on the efficiency of production system. Various studies and researches carried out in different countries, point this out. With this respect, this paper proposes to ground designing of a questionnaire, intended to carry out a research of maintenance practices existing within Romanian production systems, especially IMM-s (Small and medium sized companies). Among the objectives of the questionnaire are: to identify and check variables, their interconnection having as aim the formulation of some improvement proposals.

Keywords: maintenance, maintenance system

1. INTRODUCTION

In the present globalization stage on world and national level, a special attention is paid to increase competitiveness of small and medium sized production systems (IMM) representing the engine of economic and social development [6]. According to the provisions of *Law no. 346/2004* completed by *Ordinance no. 27 of 26/01/2006* concerning grounding and development of small and medium sized companies, criteria of framing companies within these categories are fixed. Accordingly, company framing in size classes is made both according to the average number of employees and the turnover criteria, according to Table 1.

Company-types .Table 1

Company type	Average no. of employees	Net yearly turnover
Micro-companies	Less than 9	less than 2 million €
Small companies	between 10 an 49	less than 10 million €
Medium sized companies	between 50 an 249	less than 50 million €
Big companies	between 250 and 999	more than 50 million €
Very big companies	1000 and more	

Within the EU and Romania, IMM-s are representing 99% of the total number of companies. At 2004's level within the Romanian industry 54.675 IMM have been operating. Out of these, 73% represent micro-companies, 19,1% small companies and 7,9% medium sized ones.

Productivity of Romanian IMM-s, generally is more than 19 times reduced than productivity on EU level, calculated as a ration between added value, expressed in Euro and employee number of the IMM-sector, for a yearly average rate of exchange of 3.6027 lei / Euro, according to Table 2 [7].

Productivity within Romanian and EU IMM-s. Table 2

Zone	Productivity (Euro/employee)			
	Total	Micro	Small	Medium sized
UE	65.000	40.000	75.000	105.000
Romania	3.278	2.688	3.688	3.542

Performance increases of Romanian IMM-s and of their structural, dimensional, functional, contextual consistence to the European ones represent a necessity in the present globalization stage.

2. MAINTENANCE SYSTEM

Maintenance has to be defined as an ensemble of technical, administrative and managing activities with regard to provide keeping or restoring of the technical equipment operating state, under secure operating conditions.

Achievement of the objectives designed by the definition, of keeping (maintaining) and restoring of the operating conditions of equipment, has to be approached:

- *correctively* – by changing components after the failure appeared;
- *preventively* – by systematic change of the component(s) at regular laps of time, before failure occurs.

Fixing the laps of time may be grounded on different methods, such as:

- recommendation of the manufacturer;
- experience of the maintenance staff;
- statistic models based on the collected historical data.

- *conditionally (predictive*) – by changing components just before failure occurs.

Fixing the components replacing moment is based on monitoring items condition by using specific techniques and equipment.

Maintenance activity of devices is imposed by the fact that during their productive use, they are submitted to physical and moral wear. For maintaining functional features of the equipment and operating under conditions near to the initial ones, within the company a maintenance system of production device is managed.

The present paper has as aim to use the concept of maintenance system having two meanings. On the one hand maintenance system represents the managing manner of maintenance, which, according to the allotted sources and objectives pursued, provides an optimal availability of technical equipment [4]. In a more detailed formulation [1], the maintenance system represents a managing manner of maintenance, specific to the technical equipment, which presumes knowing previously the type of intervention, moment of execution, for allowing its technical and organizational preparing.

On the other hand, it is grounded on the concepts of: „system on the whole – production system – maintenance system. Thus, the *maintenance system* is to be understood by analogy, as the production system, as the entity of a company, realizing the maintenance function of all equipment.

According to [8] practices represent: method, proceeding applied for and effective checked during the people's activity within the process of material production. In the case of maintenance activity, identifying processes and methods applied by the Romanian companies with regard to provide the functional state of their own equipment is to be pursuit.

Selection of variables used in estimation of maintenance practices is based on the specialty literature and experience of their authors, accumulated on this field.

In identifying maintenance practices following are referred to:

- maintenance policy applied to;
- selecting manners of maintenance policy;
- maintenance management: centralized, decentralized, or mixed;
- organizational bedding of maintenance;

- qualification of the maintenance staff;
- informational system of maintenance (technical documentation, intervention history records, existence of data bases);
- using specialized IT programs;
- planning level and factors being on the base of maintenance planning;
- outsourcing grades of maintenance activities.

3. INTERCONNECTION PRODUCTION SYSTEM – MAINTENANCE SYSTEM

Estimation of maintenance practices used within the Romanian productive systems is made by having in view following features of production systems:

- type of production;
- size of the production system;
- complexity of production.

3.1.1. Type of production

The organizational manner of the production activity depends on the production volume, size and complexity. Specialty literature [5] designates 4 types of production: sole exemplar production, serial production, mass production and continuous flow production (Fig.2):

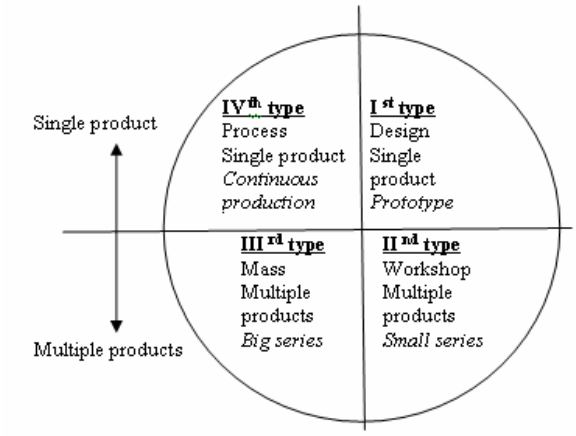

Fig. 2. Types of production

Each type of production presents specific features representing entering variables in designing the maintenance system adequate for the used equipment. Among these complexity and equipment type, qualifying level of production operators may be counted. While individual production is achieved on universal equipments, serial production may be achieved on universal or specialized equipment, for the mass and flow production, specialized tool-machines, automates or even automate lines are required. As devices became more complex and more automate, providing their maintenance presumes a high qualification level of maintenance operators and a higher variety of skills.

On the other hand, individual production needs high qualified operators while mass or flow production their qualification is has to be lower. Qualification level of operators has impact on the maintenance system. High qualification represents a warranty of corresponding use of equipment, pursuing their working, identifying and fixing causes of failures. Meanwhile, highly qualified operators may involve themselves in them maintenance activity of equipment.

Also in designing maintenance system it is necessary that maintenance priorities to be recorded among the production type priorities. According to [9], specific priorities of the four production types are presented within Table 2.

Priorities of production types. Table 2

Production type / Priorities	I	II	III	IV
Minimal Cost	**	*	***	***
Supply term	**	**	**	**
Performance level of the product	***	*	**	**
Production flexibility	*	***	*	*

*** Essential criterion ** Important criterion * Criterion without importance for the client

In fixing production type influence on the maintenance system it is to have in view also the working schedule (number of shifts) of the production system and the equipment critical state.

3.1.2. Size of the production system

Maintenance system is different from an industrial unit to other, according to several factors, such as the size of the production system. Big production systems have at their disposal enough material and human resources for providing equipment maintenance by their own, specialized departments. According to the size of production system, maintenance departments may be organized independent or within the production department. Production size determines also the organization manner of the maintenance department. This may have a centralized, decentralized or mixed organization.
Comparing to big production systems, the IMM size grants them some advantages (decisional flexibility, fast adaptation to the market needs, etc.), but meanwhile disadvantages due to limited resources (financial and human) disposing for. These are determining changes with regard to providing equipment maintenance, which is carried out partly or totally by the production operators, or specialized companies.

3.1.3. Production complexity

Production complexity is given by its following features: used technologies and technological diversity of equipment. Paper [2] scores that the number of employees in a company is influenced by the investment in technology. This means that investment in technology contributes to reducing the total number of employees. But, on the other hand, investment in technology influences the ratio between the number of production operators and maintenance operators. The more important is the investment, the more reduced is the number of production operators, while the number of operators providing maintenance of equipment is increased. Advanced technology also imposes a high diversity and a high level concerning the maintenance operator's qualification.

Technologies used in production systems, represented by equipment having to be kept in function, have influence on the qualification level and diversity of maintenance operators, on the manner they achieve maintenance (correctively, preventively, conditionally) as well as on maintenance organization and on the used working means.

Diversity of devices represented by the different types of equipment, adding also diversity of suppliers contributes to increasing complexity of maintenance activity. The high diversity of equipment and suppliers needs to increase the number of the maintenance staff's qualification (mechanic, hydraulic, electric, electronic operators, fitters, etc), of spare parts types, of equipment and spare parts suppliers.

With regard to overtake interconnection between the productive system (SP) features and maintenance practices used, the following aspects have to be in view:
- size and structure of the production system;
- size of the maintenance department;

- working schedule (number of shifts);
- company configuration (one or more locations);
- advanced production technologies;
- equipment diversity.

4. EFFICIENCY OF MAINTENANCE ACTIVITY

Selection of one of the maintenance types (corrective, preventive, conditional) or their combination, with regard to obtain an optimal maintenance system, is made according to the objectives of the productive system, because it has direct implications on its efficiency, concerning:
- availability of equipment;
- maintenance costs;
- implementing costs of the maintenance type;
- products quality.

4.1. Availability of equipment

$$D = \frac{MTBF}{MTBF + MTSR} \tag{1}$$

Where: *MTBF* – average time of good function;
MTSR – average repairing staying time.
It is to notice that in providing availability of equipment it is needed that repairing staying time to be as reduced as possible. This size in influenced by different factors: manpower (qualification, experience, grounding, skills, training), existence of spare parts, needed working means, working methods and proceedings.

4.2. Maintenance costs

Maintenance costs include two component parts: a direct one, including salary costs, spare parts, lubricants costs, etc., costs involved in re-putting into function of equipment and unavailability cost.
Unavailability cost is generated by [3], [4]:
- production losses and downgraded products, penalties for failures of supplying terms, (*Pp*);
- losses generated by raw materials and consumed materials but not transformed into final products (*Pm)*;
- fixed costs, consisting of redemptions and interests (*Pa*);
- costs generated by unexpected events and with law appearing probability, such as: accidents [4], (*Px*) .

$$C_d = P_p + P_m + P_a + P_x \tag{2}$$

4.3. Implementing cost of the maintenance type

For implementing a certain maintenance type, following costs have to be taken into consideration:
- material resources (equipment, tools, verifying tools and devices, intervention means);
- human resources (number, qualification, skills, experience, training);
- IT methods, proceedings, instructions, documents, systems.

Choosing and implementing maintenance type is according also to the laps of time planned to apply, or, with other words, the duration of investment recovery (ROI). For example, implementing of a conditional maintenance system (predictive system) is expensive therefore the analysis cost-profit related to the duration of investment recovery has to be taken into consideration.

4.4. Product quality

Although specialty literature doesn't offers methods, theories, proceedings for investigating interconnections between the quality of achieved products and the maintenance activity, implementing ISO 9000 quality standards presumes surveillance of products quality, with regard to identify nonconformities and causes generating them. Thus, practically, by processing quality records, the impact of maintenance on products quality may be determined.

5. CONCLUSIONS

By its specific and complexity, maintenance of technical equipment has a significant influence on the performance of production system. With this regard to carry out an analysis of maintenance practices used by the Romanian production systems and especially by IMM-s. With this regard, the present paper has as aim to ground the project of a questionnaire of data, specific to the local industrial reality, following that in a subsequent stage, a technical, economical and managerial integrative analysis of the maintenance activity shall be carried out.

The said questionnaire is structured on 3 parties. The first one refers to the features of productive system: company size, production type, technological complexity of equipment, their diversity. The influence of the company size on the production type, technological complexity and diversity of equipment on the maintenance system shall be studied.

The second part is centered on the evaluation of maintenance practices, identifying general and specific features of the activity related to the features of the productive system. Specific correlations between the implied factors shall be settled.

The third part of the questionnaire regards the impact of maintenance on productivity, performance, efficiency, complexity of the company. Equipment availability, maintenances costs, law cost products quality shall be analyzed, for identifying maintenance variables with impact on competitiveness.

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