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Practical Approach to Maintenance of Integrated Management Systems

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***Abstract*—This study presents the theoretical and practical approach to the TPM method used in corrective-preventive maintenance. Considering the advantages of this method, namely the practical utility for increasing the performance of industrial equipment, the authors have proposed that the objective of presenting the way of maintaining maintenance. In this respect, we present the methodology and the stages of the maintenance process for the analyzed case, namely the actual results obtained during the inspection of the activities carried out by the TPM team.**

Keywords— Maintenance; Method, Corrective, Predictive

I.INTRODUCTION

By applying this concept at an orgazational level, better equipment maintenance is ensured, leading to improved technical and economic indicators, maintenance of machine functionality parameters under prescribed conditions.

The way of organizing the activity ensures an efficient participation in the collective work of the teams of workers, which leads to an increase of their professional training level.

Considering that the T.P.M. aims to improve the efficiency and effectiveness of the production system and maintenance of equipment, it is considered that the guidelines of this method are directed to diminish the influence of the following aspects, highlighted in industrial practice [1,8]:

- the diminution of productive workplaces, due to the failure of working equipment and due to their unexpected failure, the low level of operational management and the reduction of productivity caused by the decrease of the working speeds;
- failure of equipment due to accidental defects caused by the unfavorable influence of most disturbing factors, such as wear of parts of machinery components, shocks, vibrations, working temperature, etc.

The theoretical and practical approach of T.P.M. has been the subject of worldwide research [2,5,6,7], which has resulted in great technical and economic benefits for organizations interested in applying the method. It is worth mentioning that in its evolution from Nakajima (1970s).

In Japan to the present, the concept and practice T.P.M. went along with the quality management concepts developed by ISO 9000 family standards.

II. GENERAL PRESENTATION OF THE EVOLUTION OF APPROACHES FOR INTEGRATED MANAGEMENT SYSTEMS (QUALITY, ENVIRONMENT, HEALTH AND EMPLOYMENT SECURITY)

The increase of the trade links, in the conditions of the intensification of the competitive phenomenon, constituted, for all organizations, a reason for thinking about the ways to stay in the market.

Each organization has sought to improve its position and develop its business through the quality of its products / services, as well as the processes developed both internally and externally (by strengthening partnership relations).

The concern for product quality dates from the period of the Industrial Revolution when the first concepts crystallized within the specific relationships of that period:

• the manufacturer and the direct user of the product are identical;

• The manufacturer and the direct user of the product being made are in direct contact with an exchange relationship.

It can be said that the quality aspects have arisen with the concern for things well done, for beauty and for the better since the oldest times. The first information we find in Hammurabi's code: "a mason builds a house, and the house breaks down by killing the occupants, the mason will also be killed", following the 5th century BC, in China, where there were departments whose concern was to follow produce and control the quality of silk.

In the field of quality it is mentioned in the specialized literature the following stages are known:

The first period of scientific management is characterized by the detection of defects through inspection that has been developed based on the models applied by Federich Winslow Taylor (1865-1915) within US industrial organizations, the primary objective being to effectively increase the organization by scientifically designing tasks of all employees. Taylor's most important contribution to the development of scientific management is the idea of separating the planning function from the execution function.

Another personality was Henry L. Gantt, who sought to improve systems in orgazations by innovating task planning and rewarding innovation by introducing the GANTT Chart (today used under a software program called Microsoft Project), providing managers with all the information about their activities planned and achieved and the responsibilities of the persons carrying out these activities.

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The second period called "Quality Control" is between 1930-1950.

Ford Motor Co. has been highlighted by implementing innovations in mass production, in the automotive industry, by introducing conveyor belt assembly lines and conveyor lines, increasing productivity. The new management methods implemented (the mechanization of production flows, the placement of machinery and equipment, the design of the car to be manufactured in the conveyor belt system, the standardization of vehicle components, the final inspection) have led to improved quality and productivity, reducing manufacturing costs. At first the control was done piece by piece. At the time of mass production, inspection techniques and procedures were developed, laying the foundations for quality control.

Mathematician W.A. Shewhart introduced the statistics in 1931 as a means of quality verification, this method taking shape in the Second World War due to the large amount of control that had to be applied to different categories of weaponry.

In 1945, Dr. A.V. Feigenbaum published the work "Quality as a Method of Leadership." During this period, the American Society for Quality Control (ASQ) was created and qualitative engineers are in charge of statistical and metrological techniques, and was created in 1952 by the Institute of Statistics of the University of Paris.

The third period titled "Quality Assurance" from 1950-1970 begins with the creation of the French Association for Quality Industrial Control, which, together with the German, Italian, Dutch and British Associations, establishes the "European Organization for Quality Control".

After the Second World War, the diversification of the industry has created the premises for the development of quality problems. The Japanese miracle led (through the exchanges of ideas between Ishikawa and JUSE on the one hand and Deming, Juran and Feigenbaum on the other side) to the implementation of new quality techniques in the Japanese industry.

In 1951, Juran pointed out that, in terms of quality, it is imperative to separate the avoidable costs (scrap, expense, trade, etc.) from the inevitable costs (costs of preventing them). Reliability and cost analysis, in other words "Quality Assurance", has led to the identification of preventive actions in the form of quality control procedures at all stages of the manufacturing process at all stages of product realization.

Total Feeder Precursor, Feigenbaum, wrote in 1956 the "Total Quality Control" work, marking the transition to the fourth period, and is an effective system for integrating efforts across all departments of the enterprise (marketing, design, development, production and service) on the realization, maintenance and improvement of the quality in order to satisfy the customer in an efficient manner. "For the implementation of this concept, Feigenbaum considers the so-called subsystems presented in Fig.

Feigenbaum identified 3 important aspects in the quality approach: consumer requirements (determines quality), product quality responsibilities (from top management to the last employee) and quality is done by all departments of the organization. Another important contribution brought by the great quality analyst is the clarification of quality-related costs.

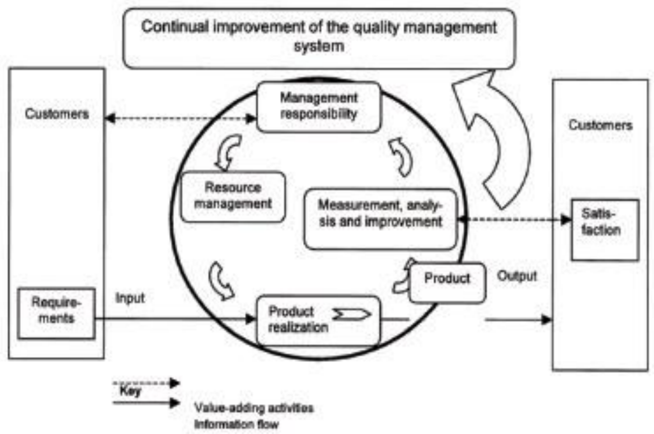

Fig. 1 Deming cycle within TQM (source CSN EN ISO 9001)

The introduction of the "zero defects" concept in 1961 to the Martin Company (supplier of the US Army) assumed consideration of the economic aspect along with the motivation of the staff.

The initiator of this concept, Philip B. Crosby, asserts that the following four basic principles must be taken into account in achieving quality:

• ensuring compliance with requirements;
• quality assurance through prevention "quality must not be controlled, it must be done";
• promoting the "zero defects" concept;
• The quality measure is the costs due to the non-fulfillment of the requirements (quality does not cost "free").

The fourth period, ranging between 1970-1980, called "Total Quality", is characterized by the global leadership of the quality of processes and products and has an excellent "Excellent" concept.

Since 1968, Ishikawa has defined its own concept of "Company Wide Quality Control (CWQC)," which is based on three components: quality assurance, quality control, and control of costs, quantities and delivery times.

The evolution of the "Quality Assurance" concept was the transition from achieving the quality of the finished product to "ensuring the quality of all activities and processes" in such a way that only products are made, while taking into account the costs, quantities requested, delivery deadlines .

Process monitoring and improvement can only be accomplished through the four steps of the PDCA cycle (Plan-Do-Check-Act).

In this way Ishikawa gives an internal dimension to the customer orientation principle. It separates customers into two categories: internal customers (those involved in the process of making products from different compartments of the enterprise) and external customers (the final beneficiaries of the products).

Ensuring the quality of the basic processes on the idea of a personal commitment of all employees for research on quality improvement and leading to the formation of a problem solving group Table 1.

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TABLE 1 The main stages, quality objectives responsibilities

Stages	Object	Responsibility
1.	Product quality	Quality control technicians (on production and at the end)
2.	Sectoral quality	All people participating in the product (workers and CTC)
3.	System quality	All persons involved in product design, execution, verification and approval
4.	Preventive quality	All the staff of the organization is responsible for meeting customer requirements

Genichi Taguchi defines the quality of the product during its exploitation stage as "the loss induced by the organization at the time of delivery of the product" as a consequence of the failure to properly apply the abilities to use [1].

Interpreting the non-quality of a loss to be avoided, Taguchi defines the concept of quality improvement based on seven principles:

• The loss caused to the organization is a product quality dimension - failure to meet product quality requirements translates into subsequent costs that are only intended to maintain the reputation of the organization;

• Continuous improvement of quality and cost reduction are necessary to achieve continuity of activities - losses due to qualitatively non-compliant products lead to reduced benefits, wastage of resources and depletion of producer reserves;

• The quality of products can be improved by reducing the variability of the quality characteristics in relation to their optimal value - actually setting the optimal value of the product characteristics;

Induced loss of performance variation debt is proportional to the square of the deviation from the target value. Taguchi - minimizing losses involves achieving the quality characteristics as close to their optimal value as the objective value.

Taguchi proposes here a function of losses (Figure 2) and described in relation (1).

$$P = k(x - M)^2 \quad (1)$$

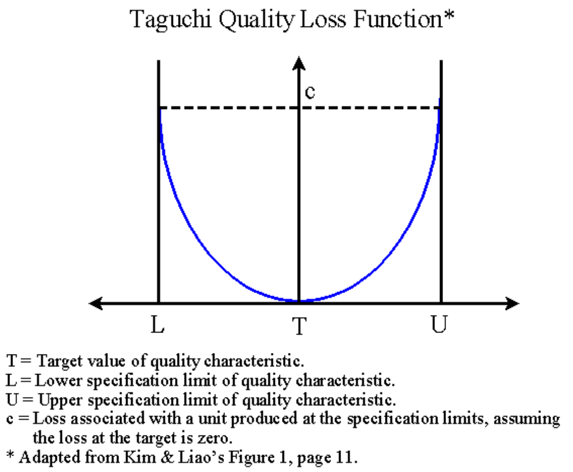

Fig. 2 Management And Accounting Web
http://maaw.info/ArticleSummaries/ArtSumKimLiao94.htm

III. TOTAL PRODUCTION MENTENANCE (TPM) AND TOTAL QUALITY MANAGEMENT (TQM).

Total production mentenance is a global and complete equipment management technique, used in the KAIZEN strategy (permanent improvement) to increase the use and life of the machinery, with the participation of all workers.

The principles of this method were first known in Japan in the 1980s, as a result of research conducted by a team of specialists from the Japanese Institute of Industrial Maintenance, and while observing the benefits of this method, it has begun to be applied all over the world. The purpose of the TPM concept is to continuously improve the equipment and manufacturing process, as well as reducing the number of scrapping to increase productivity and production quality. This concept aims to achieve the following goals: -that finished products have ZERO defects-The equipment has ZERO failureand ZERO work accidents-capacity of producing different patterns on the same line.

The safest way to achieve our goals is to understand the problems we face and to contribute to solving them all. In the field of production with equipment or products throughout the period of use of the equipment it tends to be achieved through maintenance activities to zero scrap and zero defects.

The TPM addresses all departmental categories and from the maintenance departments to marketing, people have to be fully involved. This rightly applied philosophy can create a working environment where employees can work out their best conditions to be able to produce the highest quality products at low cost.

Applied in a correct form over the activities in a plant, it can help increase production by 50% to 100%.Principles for correct TPM implementation: • You are the main actor• Do not hesitate to uncover your ideas• Ask everything you do not understand• Be without doubt about your status• Be sure to be successful• Grow together.

• Respect the ideas• Remember that we are all people

• Autonomy maintenance is important• Our duty is not just to produce

• By joining efforts we can achieve great results•

Trust your factory and act as you go. Why do we need TPM?

This is the highest level of planned maintenance and has already been applied in various factories around the world where it has brought major improvements and one of the best ways to drive the factory as much as possible and to offer quality services and products.

In the TPM concept, teamwork is a very important tool in the production process because it is intended that each operator has a well-defined role and actively contributes to solving problems at the site to contribute to the evolution of both the team and the personal .

TPM attempts to focus on the maintenance of work equipment by operators, who are provided the necessary information to be able to specialize so that they are able to repair and maintain the equipment they use over a period of time to use the machine without too many interventions.

TQM, being an innovative concept of T.P.M. plays an important role in the organization's work by stimulating the workers' creativity, changing their mentality, increasing the level of training of the employees, all of which are based on the existence of an efficient management and the existence of a quality oriented organizational culture.

Under the conditions of implementation of the TPPM method in the organization, a new general approach to the structure of TPP activities is appropriate. in which an important role is the way of assigning the responsibilities assigned to the workers in the maintenance teams.

In this context, the professional level of the workers, how they have the skills and resources to work in a team, and how the solving of their tasks is done in a time that will lead to the rapid restoration of the functioning of the equipments .

Effective application of the T.P.M. method must be viewed and evaluated in a unitary way, given that during the production activity there are a number of factors that act on the organizational system, as shown in FIG. 3.

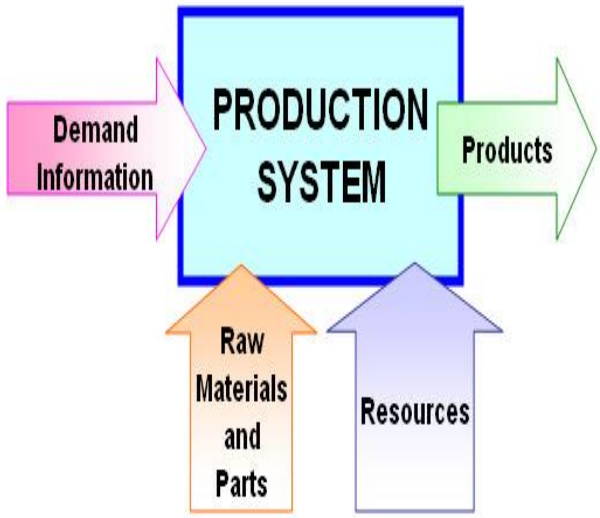

Fig.3. The production system and its compartments [1]

From figure1 it can be noticed that the production system is affected by the influence of disturbing factors that can modify the functioning of different compartments (activities). And within the production activity, parameters derived from the operation of the machinery may occur as a result of the occurrence of wear, vibration, shocks, temperatures, etc.

These influences can be manifested in the production activity by altering the quality characteristics of the manufacturing products.

Therefore, following the corrective maintenance, the values of the parameters were compared with the manufacturer's exact values and the conditions specified in ISO 10618: 2015 Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts.

It is advisable to increase the working life of machines and equipment by monitoring their monitoring on a perennial basis, and in the event of a breakdown, they must be as quickly as possible to restore the equipment to operation.

TABLE 2. Main features of the T.P.M. (adaptation after [3])

Arguments in favor of T.P.M.	1. adopting the lifecycle approach to improve the performance of the production equipment; 2. increasing productivity by increasing the responsibility of the works; 3. Use of small group work activities for the identification of the causes of the faults and their resolution for equipment;
Specific T.P.M.	The major difference between T.P.M. and traditional maintenance activity consists in the fact that some workers with technical skills are involved in the maintenance process. As a result, the concept "I (the operator) I operate and You (the maintenance department) repair" is no longer operational.
Objectives T.P.M.	1. It is required that the following objectives: reaching the zero level defective, zero stops and zero accidents (in all operational processes of the organization); 2. It is appropriate to involve all employees in the departments of the organization; 3. For the practical application of the method it is necessary to form teams T.P.M. to diagnose, repair and commission the equipment;
The main direct benefits of applying the T.P.M.	1. increase the productivity of equipment; 2. Favorable resolution of customer complaints; 3. reducing production costs; 4. Satisfaction of 100% customer requirements; 5. reducing the number of accidents at work; 6. observing the environmental aspects of processing processes;
The main indirect benefits of applying T.P.M.	1. increasing the confidence of workers in their activities; 2. ensuring the working conditions of the workers; 3. The favorable change in the attitude and responsibility of the workers; 4. Achievement of goals through team activity; 5. ensuring the exchange of experience and "socialization" of team members; 6. Increasing the "belonging" of the equipment to the workers operating on it.

In view of the above, T.P.M. can be timely, in which case managerial and operational activities will be carried out consisting of the following [4]:

a. the composition of the personnel teams and support personnel who will participate in the practical application of the TPM method;

b. Developing an array of skills to highlight the level of skills and aspects related to the psychological behavior of workers;

c. Establishing a team of established responsibilities (tasks specifying rotation of team members);

d. compiling a diary covering the day, week, month and quarter of workers;

e. carrying out the work related to the elimination of the detected defect, by taking measures, by which the level of the section specifies the state of the working and non-functioning equipment using record sheets.

At section level mechanical machining, the records related to a-d points are displayed on a task tracking panel accompanied by the workflow diagram.

Therefore, on the basis of the above, the author proposes a model for the development of the TPM maintenance activity, corresponding to the above.

Thus, the table of presence (according to a) is TABLE 4 and in TABLE 5 we pressent the matrix of competence model:

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TABLE 4 TABLE OF PRESENTATION Personal Team

#	Name	Week 1							Week 2							Week 3						
		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
1	D.M.	X	X																			
2	C.A.	X	X																			
3	R.L.	X	X																			
4	P.O.	X	X																			
5	L.P.	X	X																			

D-Detached ■ Present ■ Absent(CO,CM,CFS)A ■ ent groundless

▯ Nr. hours of consent ■ Working days

Given that one of the causes of machine tool failure is the occurrence of vibrations, the practical way to perform corrective maintenance by applying the T.P.M.

When repairing the main shaft (broach) from a C.N.C.

For this, the T.P.M. working team mainly carried out the following operations:

- removing the main shaft assembly (AP);
- assessment of the condition of component parts and bearings;
- cleaning parts and removing traces of wear for: abrasives, nuts, spacer rings, housing;
- Cause-effect diagnosis for the above mentioned parts;
- identification of the condition of the parts: internal play of bearings, rings, caps, shaft, etc.
- machining of parts: grinding of rings, bearings, housing (remediation), etc .;
- measurement of carcass on coordinate measuring machine;
- assembling and final inspection, run-out and balancing, packaging and delivery and final report on the main shaft test.

As a result of the above mentioned activities, an end-of-pipe repair report is prepared which contains the following structure:

TABLE 5 THE MATRIX OF COMPETENCE MODEL

Identification operatory			Competence technical																				Quality			Medium/SSM		
#	Name	Mark	Lock specialist	Certified welding machine	Uncertified welding machine	CNC TIG welding operator	CNC Operator Gaskets	Welding line operator	CNC milling machine	Milling MU classic	Classic MU lathe	Lathe CNC	Oxygen / Plasma CNC cutting operator	CNC Laser Cutting Operator	CNC punching operator	Operator CNC Abkiant	Loader	Forklift	Authorized operator for work at height	painter	Unskilled	Operator CNC CANON	Controls other operations	Autocontrol	Labels conf. And nonconf.	First Aid Officer	It occurs in case of fire	It comes in case of accidental pollution
1	L.A.	M1		■		■	■									■							■	■			■	
2	O.P.	M2	■													■							■	■			■	■
3	E.R.	M3		■			■																■	■			■	
4	T.A.	M4		■				■								■						■	■	■			■	■
5	F.I.	M5		■		■	■																	■	■		■	
6	A.E.	M6		■		■	■																	■			■	

IV. CONCLUSIONS AND RECOMMENDATIONS

The main shaft (AP) has been blocked due to reaching the critical wear level caused by temperature and vibration over time. The bearings have yielded due to severe thermal conditions due to the lack of cooling liquid in the AP. Another probable cause is the earlier incorrect assembly of the shaft.

The lack of vibration and temperature measures associated with periodic monitoring has allowed the development of the defect without identifying, localizing and evaluating it. Thus the accidental stopping of the machine occurred unexpectedly in the production and maintenance activities.

The main shaft has been repaired under appropriate conditions ensuring the precision and rigidity of the whole assembly, replicating technical conditions of operation. The AP was mounted on the car and rolled over 12 hours. During the run of AP, both dynamic (vibration) and thermal monitoring was monitored. Dynamic stiffness AP has been highlighted, the 5000 rpm rpm has intervened to reduce the imbalance, resulting in a total vibration of 0.68 mm / s according to ISO10816 standard. It is recommended to change the drive belt between the engine and AP at the first occasion.

After the maintenance was carried out, it was considered advisable to change the drive belt between the engine and the AP, and to monitor the functioning of the cooling system in the main shaft body in order to increase its operating lifetime.

Also, in order to increase the machine performance, it is recommended to implement activities that include periodic vibration and temperature measurements to provide pertinent information in predictive maintenance. In this way, by performing the above mentioned measurements, it is possible to prevent the occurrence of defects and the wear stage, respectively, predictions regarding the duration of operation and the optimization of the operating conditions of the machine tool can be made.

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