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# THE AUTONOMOUS MAINTENANCE IMPLEMENTATION DIRECTORY AS A STEP TOWARD THE INTELLIGENT QUALITY MANAGEMENT SYSTEM

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**Abstract**:
The article describes the effects of the improvement of the production process which one of the industrial enterprises obtained by implementing the method of Autonomous Maintenance (AM), which is one of the pillars of the concept of Total Productive Maintenance (TPM). AM method was presented as an aid to the formation of intelligent, self-improving procesess of the quality management system (QMS). The main part of this article is to present results of studies that have been conducted in one of the large industrial enterprises in Poland, manufacturing for the automotive industry. The aim of the study was to evaluate the effectiveness of the implementation of the AM method as a tool for self-improvement of industrial processes in the following company. The study was conducted in 2015. The gathering and comparison of data from the period of two years, ie. the year before and the year after the implementation of AM, helped to determine the effectiveness of AM in building intelligent quality management system.

***Key words**: Autonomous Maintenance, Intelligent quality management system, TPM*

## INTRODUCTION

The quality management system is a system, which only function is the continuous improvement of the organization. This manifests itself constantly, correcting the efficiency and effectiveness of the organization processes. One of the key processes that should be improved in industrial companies is the process of production. This process should be as efficient and effective, as it is both the main generator of value, and the generator of expanses for the company. These expances are closely linked to the operation and maintenance of the basic resources of the production process which is the machinery. Therefore, improving the efficiency of the production process should be, in the first place, related to the reduction of costs of maintenance and operation of machinery and equipment. Given the costs associated with unplanned exclusion of equipment operation and the cost of repair, it is not surprising that the maintenance of the machinery is found in the sphere of interest of scientists and practitioners in order to improve the organization. Improving the functioning of the organization is also one of the primary purposes for which implemented quality management systems, especially those based on general (ISO9001) [1, 2], or industrial (ISO/TS 16949) international standards. A special case of the quality management system is the QMS focused on the improvement of the intelligent quality management system [3]. The system, which basic features are self-improving mechanisms, is based on the concept of knowledge management and the concept of a learning organization. The inteligent system also requires management responsible for the results of improvement and the full involvement of employees in the improvement. In the area of manufacturing processes and maintainance of their technical resources, intelligent quality management system can be supported by the method of Autonomous Maintenance, which is one of the pillars of the concept of Total Productive Maintenance (TPM).

The article describes the effects of improvement, which was achieved in one of the industrial companies by implementing AM at one of its production divisions. AM method was presented as an aid to the formation of intelligent quality management system (QMS). The main part of this article is to present results of studies that have been conducted in one of the large industrial enterprises in Poland, producing products for the automotive industry. The aim of the study was to evaluate the effectiveness of the implementation of the method AM as a tool for self-improvement of industrial processes. The study was conducted in 2015. Collection and collation of data from the period of two years, ie. The year before and the year after implementation of the implementation of AM helped determine the effectiveness of AM in building intelligent quality management system.

## THE ESSENCE OF TPM AUTONOMOUS MAINTENANCE

One of the complex concepts of organizational improvement in the maintenance of technical resources such as machines is known and proven concept of TPM [4, 5]. It is a comprehensive set of effective methods and tools to support managers in maintainance of continuous and efficient operation of the machines [6, 7, 8]. With TPM, it is possible to sucessfully minimize the risk of unplanned disruption of industrial processes [9, 10].

TPM concept is a complex approach to the maintenance of the machinery. The complexity of this concept manifests itself in a broad approach to the problem of maintainance of movement. The concept includes production facilities throughout their life cycle in the company. In addition, TPM requires the participation of a broad spectrum of the company's employees, which is associated with the operation of a team, it includes various levels in the organizational structure. It is worth noting that a key role in this concept, not as expected, do not play maintenance services and machine operators who directly support them. It can be argued that they are the main element of efficient preventive maintenance. Autonomous Maintenance (from Japanese Jishu Hozen) is a key pillar of TPM [4]. In this approach, the responsibility for maintaining the machine park rests equally on machine operators and maintenance department employees [11]. The operators in their daily work with the machines gain experience and knowledge related to the operation and diagnostics of machines. Therefore, this machine operators are the first line of defense against unplanned downtime of production equipment. It is no supprise that the essence of Autonomous Maintenance is to eliminate the classical roles at the service of production and services responsible for the enumerated actions of maintenance, which unstress machine operators by incorporating a system of maintenance of the machinery and perform simple maintenance procedures [11].

Implementation of Autonomous Maintenance has been divided into 7 stages shown in Table 1. Dividing the process into phases facilitates and organizes the implementation process and allows to focus on the objectives set for each stage. A characteristic feature of the Autonomous Maintenance is also carrying out audits of each stage of implementation. Audits allow to assess progress and identify problem areas requiring adjustments [11]. Effective implementation of Autonomous Maintenance in the company based on the work of permanent teams "caring" to machines. These teams have the appropriate qualifications and skills to create autonomously functioning and effective system for maintainance of the machinery.

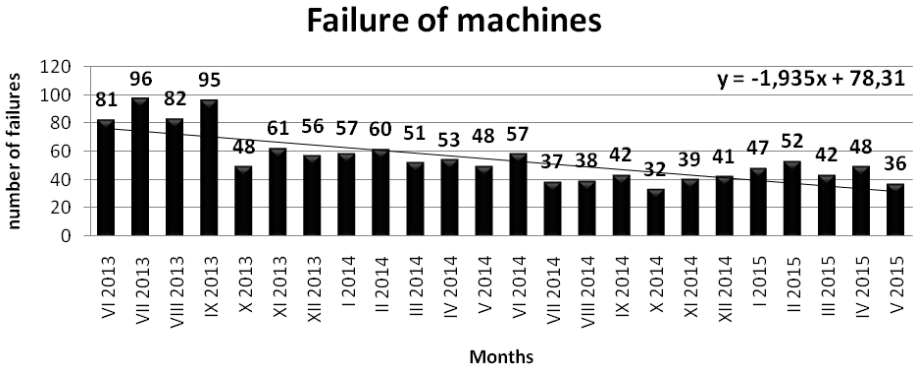


***Fig. 1 Failure of machines in each month during the period***
*Source: Own calculations based on [12].*

***Table 1***
***Stages of implementation AM***

| 7 stages of implementation of Autonomous Maintenance | |
|---|---|
| **No.** | **Brief characteristics** |
| Stage 1. | Initial cleaning machines. The aim of the step is to thoroughly clean the equipment inside and outside. |
| Stage 2. | Removal of sources of pollution and difficult to reach places. The purpose of this stage is to detect and remove or reduce sources of pollution and difficult to reach places, which make it difficult to clean the machine and access to critical areas. The result will shorten the time for cleaning, lubrication and tightening backlash. At this stage we achieved success will also be irrational: to better understand the philosophy of TPM solution to small problems, and the first benefits of the improvements. |
| Stage 3. | Standards cleaning, lubrication and tightening backlash. The purpose of this step is the introduction of visual standards, cleaning, lubrication, tightening and loosening. This results in facilitating the inspection of these operations through immediate feedback about the current state of affairs. |
| Stage 4. | General overview of the machine. At this stage, operators will learn how to perform inspection of the basic mechanisms of the machine. Knowledge transfer requires the creation of manuals, on the basis of which maintenance workers will train operators (often requires a deeper knowledge by themselves). The result will be the establishment phase of the initial schedule a check and the time needed for its implementation. |
| Stage 5. | Authomatic check-up. This stage combines the standards of cleaning and lubrication developed stage 3 standards and inspection machines developed stage 4 in one general standard inspection equipment. Samoinspekcji The aim is to make it as soon as possible. |
| Stage 6. | Quality assurance. At this stage, the past actions are enhanced with operations to ensure the quality of products (eg. Construction and installation of equipment Poka-Yoke, preventing an error or to detect defects before they can reach the next stage of the process). The role of management is to improve the standards and verification of their application. |
| Stage 7. | Continuous improvement. Step 7 is a step in improving the systems that have been developed on the previous stages. Operators continue to acquire new skills and working in teams, using the data to analyze problems, detect root causes and process improvement. |

*Source: [11].*

## THE EFFECTS OF IMPLEMENTATION AM IN THE AUDITED COMPANY

In order to illustrate the effects of the implementation of the Autonomous Maintenance for the company examined in the study, which involved gathering of data from the period from June 2013 to May 2015 on the failure of the machinery covered by the AM. Completion of the implementation of AM was exactly half of that period, ie., in June 2014. The level of failure rate during the given period is shown in Figure 1. The graph is generated basing on data contained in Table 2.

During the whole period one can notice visible reduction in the number of failures in each month. Over two years, significant improvement was observed. The trend line failure on the basis of the gathered data has been determined by the Excel spreadsheet function: y = 78.31 + -1.935x.

In order to eliminate the effect of seasonal changes in the volume production of machinery failure, Figure 2 shows the number of failures for each month exactly one year after the implementation of AM. In each comparable number of month breakdown it was lower in the period where the AM function method.

Downtime of machines that have been failures in the period shown in Figure 3. generated by the spreadsheet Excel trend line shown in Figure 3 takes the form of the function: y = - 25.94 + 1357, which shows a gradual reduction of downtime during the period considered reveals possible potential for further improvement.

Table 3 shows the comparative data of each month in the period before and after implementation of AM. After analysis of the data in Table 3, one can conclude that the implementation of AM largly influenced a total of 3.763 minutes reduction of machine failure time duration. This represents a reduction of over 26% compared to the period before implementation. The figure number 4 presents data on the duration of failures in comparable months in terms of workload production.

***Table 2***
***Comparison of the number of failures in each month***

| No. | Months | | Number of failures | | Effect | Effekct [%] |
|---|---|---|---|---|---|---|
| | | | without AM [year] | with AM [year] | | |
| 1. | June | VI | 81 [2013] | 57 [2014] | -24 | -30% |
| 2. | July | VII | 96 [2013] | 37 [2014] | -59 | -61% |
| 3. | August | VIII | 82 [2013] | 38 [2014] | -44 | -54% |
| 4. | September | IX | 95 [2013] | 42 [2014] | -53 | -56% |
| 5. | October | X | 48 [2013] | 32 [2014] | -16 | -33% |
| 6. | November | XI | 61 [2013] | 39 [2014] | -22 | -36% |
| 7. | December | XII | 56 [2013] | 41 [2014] | -15 | -27% |
| 8. | January | I | 57 [2014] | 47 [2015] | -10 | -18% |
| 9. | February | II | 60 [2014] | 52 [2015] | -8 | -13% |
| 10. | March | III | 51 [2014] | 42 [2015] | -9 | -18% |
| 11. | April | IV | 53 [2014] | 48 [2015] | -5 | -9% |
| 12. | May | V | 48 [2014] | 36 [2015] | -12 | -25% |
| **Total** | | | **788** | **511** | **- 277** | **- 35.2%** |

*Source: Own calculations based on [12].*

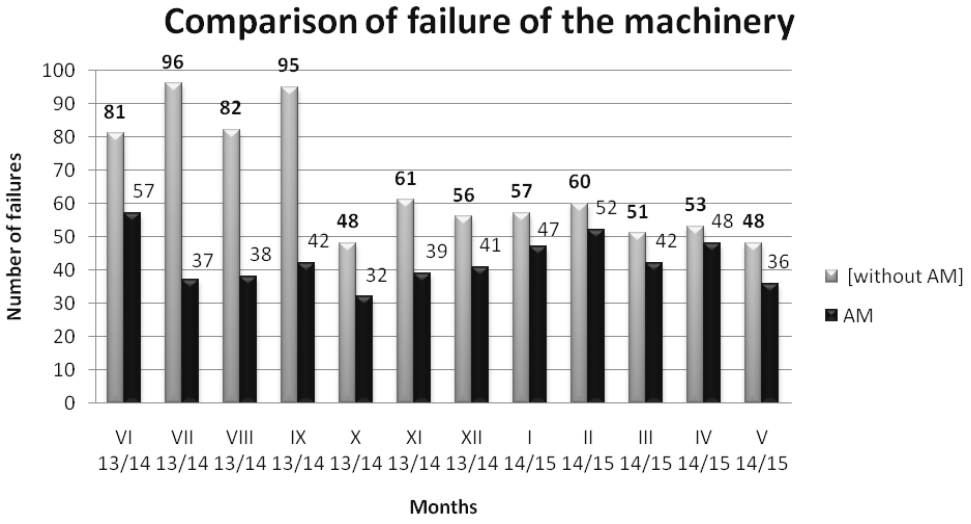


***Fig. 2 Comparison of failure of the machinery in the corresponding months***
*Source: Own calculations based on [12].*

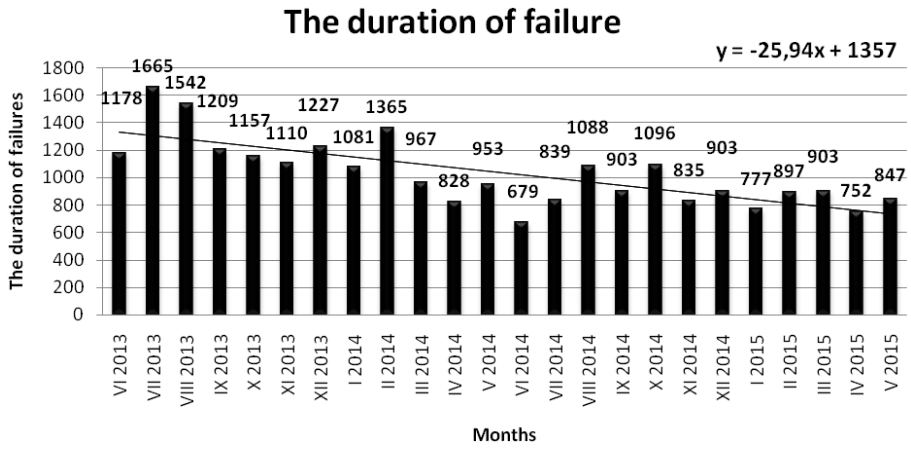


***Fig. 3 The duration of failure in individual months***
*Source: Own study based on [12].*

***Table 3***
***Comparison of the duration time in machine failure in each month***

| No. | Months | | Duration time of failures [minutes] | | Effect | Effekct [%] |
|---|---|---|---|---|---|---|
| | | | without AM [year] | with AM [year] | | |
| 1. | June | VI | 1178 [2013] | 679 [2014] | -499 | -42% |
| 2. | July | VII | 1665 [2013] | 839 [2014] | -826 | -50% |
| 3. | August | VIII | 1542 [2013] | 1088 [2014] | -454 | -29% |
| 4. | September | IX | 1209 [2013] | 903 [2014] | -306 | -25% |
| 5. | October | X | 1157 [2013] | 1096 [2014] | -61 | -5% |
| 6. | November | XI | 1110 [2013] | 835 [2014] | -275 | -25% |
| 7. | December | XII | 1227 [2013] | 903 [2014] | -324 | -26% |
| 8. | January | I | 1081 [2014] | 777 [2015] | -304 | -28% |
| 9. | February | II | 1365 [2014] | 897 [2015] | -468 | -34% |
| 10. | March | III | 967 [2014] | 903 [2015] | -64 | -7% |
| 11. | April | IV | 828 [2014] | 752 [2015] | -76 | -9% |
| 12. | May | V | 953 [2014] | 847 [2015] | -106 | -11% |
| Total | | | 14282 | 10519 | - 3763 | -26.3% |

*Source: Own calculations based on [12].*

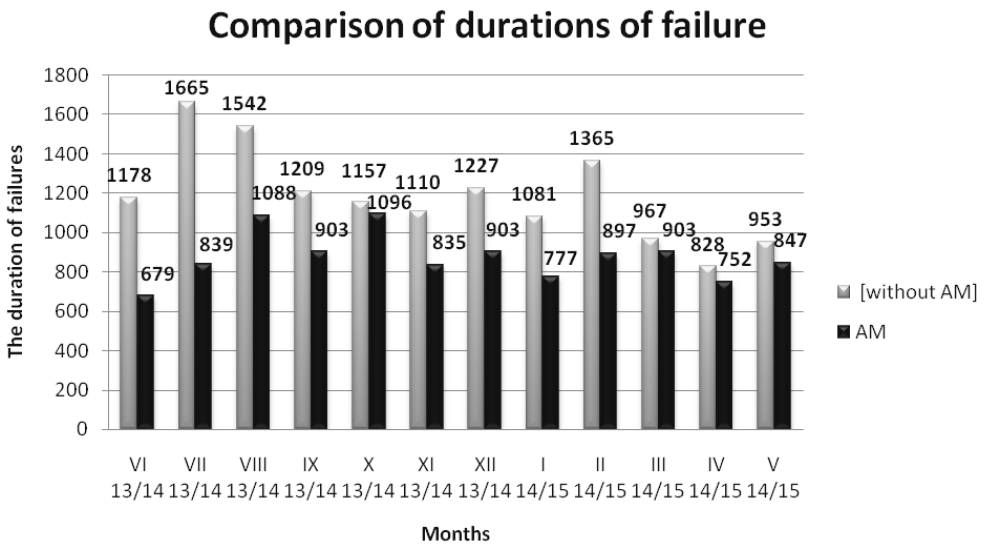


***Fig. 4 Comparison of durations of failure in the corresponding months***
*Source: Own calculations based on [12].*

In any text compared to the life of the AM preferably falls, which clearly demonstrates the effectiveness of the implementation of the method.

The research results prove as effective in improving the functioning of the organization is introduced method. With AM, the number of failures was considerably reduced from 788 in the period before the implementation of the 511. Similar conclusions are obtained from the analysis of time troubleshooting. Reducing the number of failures during the year of implementation of AM decreased by over 26% compared to the year before implementation. Consider this to be the unquestionable success of the implemented method, which is very effective in supporting the QMS in the field of self-improvement.

## CONDITIONS OF BUILDING INTELLIGENT QUALITY MANAGEMENT SYSTEM

To effectively implement the Autonomous Maintenance, based on the intelligent system of quality management in the organization [3], you must meet some basic conditions. First, conditions should include the organization of effective transfer of knowledge in the company about the machine maintenance and improvement of methods [10] and procedures. The basic condition is to share the maintenance knowledge of operators of machines on the methods and techniques of machine maintainance. The best solution here is the formalization of knowledge and its preservation. Intelligent self-improving QMS is based on the concept of knowledge management and the learning organization.

Another condition of effectiveness in building intelligent quality management system is to ensure the appropriate qualifications of all involved in the change process. Change of work organization, new roles and responsibilities often require formal qualifications and/or rights. Implementation of AM often requires the presence of specialized training. Intelligent quality management system is based on qualifications and precisely defined competencies within the organization. Senior management should expand the responsibilities for maintenance as much as possible. In particular, this applies to broaden the scope of decision-making by the machine operators and maintenance staff. Only then, the status of a smart, self-improving quality management system based on "autonomous decisions and proceedings" can be reached.

Another, although obvious, condition for the successful implementation of AM and building intelligent QMS is suitable motivation. It is extremely important to create an incentive system in which the employee would have been rewarded for ideas and creative approach to the improvement of the organization, in particular as regards the maintenance of generation resources. Employee evaluation system deserves much attention. Implementation of AM often requires remodeling of such a system. Implementation of AM cause that operator in the production department can not be measured simply in terms of quantitative production standards. Categories related to the maintenance and improvement of the production process, such as reducing maintenance costs, and the size and the time of the accident should be included as one of the basic criteria for the evaluation of the operator.

Building intelligent system is not an easy task, especially in the area of maintenance. The process of implementation of Autonomous Maintanance, can be seen as a classic multi -purpose approach to the implementation of organizational changes. In the audited company, as was to be expected during the implementation of AM, the main obstacle was overcome fears of operators connected with applying a wider range of duties and responsibilities. Therefore, it is necessary to reduce negative attitudes through full participation of operators in the implementation of changes. This will increase employee awareness of the principles of operation and maintenance of machines and create the conditions for a personal commitment to maintaining operated machines in good condition.

## SUMMARY

A strong focus on knowledge management and improvement through organizational learning in the area of maintenance, poses with AM method, which can become a key element of intelligent quality management system. The results of the implementation of the Autonomous Maintenance in the audited company is primarily a gradual reduction of failures and time to remove them. The obvious consequence of this is a more efficient use of machinery and reducing the cost of repairs. AM made it possible to reduce the failure rate of machines with 788 crashes in the first test of the year to 511 the following year. In addition, the introduction of mandatory preventive measures made possible to reduce time troubleshooting in the comparable periods of more than 26%. Implementation of AM is an addition to these tangible benefits, which allowed to improve security and improve comfort.

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