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Lean Manufacturing – results of selected implementation projects

Abstract: Lean Manufacturing is a structured program whose objective is to maximize the effectiveness of the company. It is based on the practices and methods of KAIZEN / LEAN applied by the world's best companies. The experiences from the Author led us to the conclusion that the Lean Manufacturing is based , among others, on the following concepts:
– Total Productive Maintenance TPM
– Single Minute Exchange Die SMED
The Lean Manufacturing focuses on the systematic pursuit and elimination of waste and losses. The losses identified are analyzed, evaluated in adequate manner to the attribute processes. The result of the analysis determines where and how to intervene.
In the paper has been presented the bases of Lean Manufacturing. The results of the implementation of Lean Manufacturing in different companies have been described. The main issues of Lean Manufacturing implementation have been characterized.
Keywords: Lean Manufacturing, continuous improvement, KAIZEN, implementation case study.

The Lean Manufacturing bases

The times we live in are a period of transformation [Bednarek M. et al. 2012]. We witness everyday rapid changes and it seems to us that we control them, although we actually tend to adapt to them. The rhythm of changes used to be measured in intervals of more or less fifty years. Now it is measured in monthly or yearly periods. It has been caused by the following trends we can observe in the contemporary world economy:

– scientific and technical progress, particularly in the field of information technology,

– scientific and technical progress which requires the economy to be restructured, thus causing that enterprises operate in an environment forcing them to act under conditions of ongoing uncertainty, characterised by unexpected emergence of new competitors which, in turn, forces them to seek further outlet markets.

It strengthens the position of countries and regions whose markets, along with their scientific and technical surrounding and a strong private sector, facilitate the flow of capital triggering even stronger dynamics of changes.

It requires entrepreneurs to:

1. Attain and maintain condition enabling their enterprises to respond to both foreseeable and unforeseeable changes in the surrounding;
2. Obtain customer satisfaction under dynamically changing market conditions;
3. Manage their operations in a lean, agile and smart manner;
4. Hire employees working based on their knowledge;
5. Satisfy interests of all the company stakeholders (shareholders, employees, suppliers etc.).

The lean enterprise concept was born in Japan when Eiji Toyota along with his partner Taiidzi Ohno came to a conclusion that mass production of cars was lacking raison *d'être* in their country. This is how a production model known as Toyota Production System (TPS) came into being, only to be subsequently transformed into a concept of lean manufacturing, a described by J. Womack et al. in "La maquina que cambio el mundo" published in 1992.

The Lean Manufacturing implementation

The main point of TPS was to manufacture economically sound products in short batchs, adjusting their characteristics to requirements of various groups of customers. When this concept was developed, the market was far less globalised and more stable, and it was not obvious to all companies that different clients groups represented different requirements. The main feature of TPS was seeking and minimising (or eliminating) all kinds of waste and introducing automation primarily based on numerically controlled machines. What it practically meant was such a design and performance of production processes as to make it possible to manufacture more on smaller and smaller quantities of human, material, time and territorial resources consumed. Hence the concept was referred to as *Lean Manufacturing*. The model of production according to the Lean Manufacturing concept is focused on systematic search and elimination of loss and waste in production processes. The waste thus identified is analysed and appropriately assessed. What is also defined is a set of ways applied to eliminate or minimise the waste. One is to determine where

teams must interfere in order to eliminate the waste and how to measure the outcomes attained in the given process. For the sake of the Lean Manufacturing concept implementation, KAIZEN is applied. Lean Manufacturing is based on the following grounds:

1. The very basis of management is the added value generated in the process of creating a product or a service;
2. For the sake of efficient management, one needs to define a chain of values composed of three basic links:
   – product (service) designing process,
   – production planning and programming process,
   – production or service performance process.
3. The main goal of the management is to eliminate all waste which may emerge in each of the three basic links in the chain of values as well as continuous improvement of the actions undertaken in the given link.

In order to be able to put the ideas of lean manufacturing and management into practice, one must apply a number of methods in the enterprise, only to mention TPM (Total Productive Maintenance) or SMED (Single Minute Exchange of Die) chosen according to the company's individual characteristics. The author believes that all such methods are of major importance for the implementation of Lean Manufacturing in Polish enterprises, especially small and medium-size ones.

The ultimate goal of Lean Manufacturing is to attain a zero waste status in the enterprise, meaning:

– no scraps,
– no stocks,
– no unplanned downtimes,
– no changeovers.

Production machinery and equipment changeover is assumed to prepare them for new production, whereas unplanned downtimes result to a large extent from inefficiency of maintenance and repair works. Finding ways to reduce the time of changeover and unplanned downtimes is the goal managers responsible for production processes pursue. Quick changeovers and planned downtimes do not only stand for cost saving and efficiency increase, but also enable elimination of the existing bottlenecks in the process. Following the author's observations made in the course of research and implementation efforts undertaken in industrial facilities, long changeover times are predominantly due to:

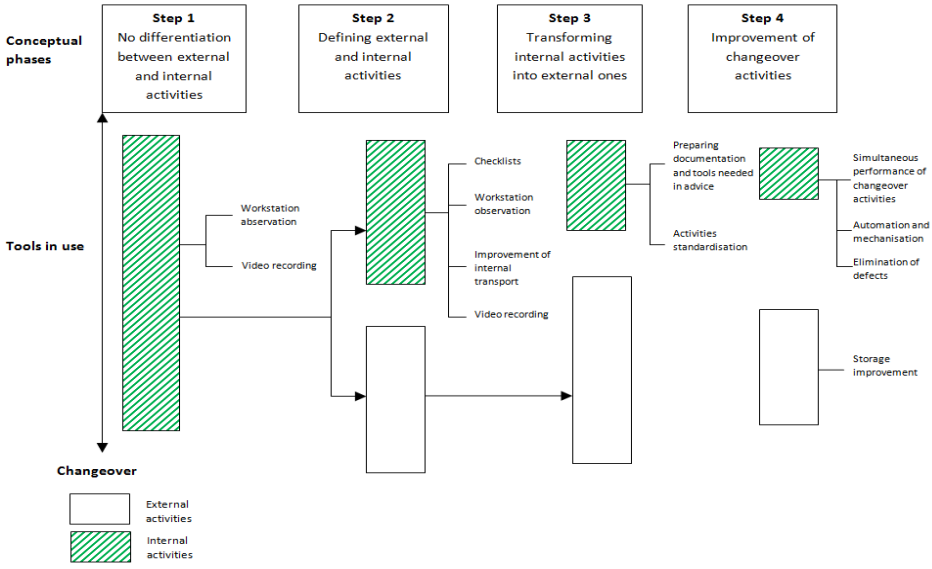
– organisational disorder at the production department (lack of documentation, appropriate tooling or action procedures),
– inconsistent implementation of the principles of Autonomous Maintenance or 5S,

– putting machines out of the process no only for the sake of the changeover and what it requires, but also while conducting actions necessary to overcome the existing organisational disorder.

SMED – Single Minute Exchange of Die

Reducing changeover time is never the ultimate purpose itself, since the related projects are usually involved in implementation of *Just-in-time* (JiT) schemes or Group Technologies. Decreasing the time required for machinery changeover is the fundamental goal of the Single Minute Exchange of Die (SMED) method originally proposed in 1985 in a book entitled "A Revolution in Manufacturing. The SMED System". Its author, Shigeo Shingo [Shingo 1990], is a Japanese consultant of worldwide renown who wrote a number of books on the ways to improve manufacturing systems. Shingo noticed that the changeover process can be divided into external activities, i.e. those which do not require the machinery to be stopped, and the internal ones, when some downtime is necessary. This observation had led him to develop conceptual assumptions of the SMED method. They have been depicted in Figure 1.

Figure 1. SMED concept – stages of machinery and equipment changeover



Source: author's own study based on: Shingo S., op. cit.

The above diagram comprises the following activities, being components of the SMED method:

Step 1 – Persons responsible for the changeover operations do not distinguish between internal and external activities. A machine is stopped for

the entire time required to perform the changeover, regardless of the whether the person performing the operation is actually searching for drawings or the necessary tool (external activities), or replaces one tool or jig with another (internal activity).

Step 2 – Machines are only stopped for a period of time needed to perform internal activities. Before proceeding with the changeover operation, one must prepare the relevant documentation, tools and instruments next to the station, and only then is the machine stopped.

Step 3 – The number of internal activities is reduced by transforming them into external ones. This can be achieved through the tooling optimisation, by performing such activities as mounting, inspection or measurements without interference with the machine, and by using auxiliary devices. This conversion is fully achieved through application of checklists of the activities performed, monitoring stations or analysing the activities undertaken by video recording them.

Step 4 – Improvement of the changeover works. The main point in this respect is to eliminate all unnecessary activities, to introduce automation techniques, e.g. setting operations, or to improve the ways in which transport operations are performed.

While implementing the SMED methodology, the author noticed the following regularities to exist in the process:

– by following the sequence of actions shown in Figure 1, one can reduce the setup time by ca. 50%. Attaining such an effect is initially fairly easy. The problem is to make this time reduction repeatable. This goal is only achieved after several months of intense team efforts supported by those of managers, enabling the existing habits and deeply rooted operational customs to be altered;
– what matters particularly in the SMED implementation is the inclusion of machinery and equipment operators in the project.

TPM – Total Productive Maintenance

The assumptions of the Total Productive Maintenance (TPM) system were originally defined by Seiichi Nakajima representing the Japan Institute of Plant Engineers (JIPE) [Nakajima 1988]. The main purpose of TPM is the continuous improvement of operating efficiency of machinery and equipment with active participation of all the enterprise employees in maintenance and repair processes. It takes 12 basic steps [Suzuki 1992] to implement TPM, including the following ones:

1. Top management's obligation to implement TPM.
2. Establishing organisational structures required in TPM implementation process.

3. Establishing basic TPM policies and goals.
4. Formulating the TPM implementation master plan.
5. Implementing an autonomous maintenance programme.
6. Implementing a preventive maintenance programme for machinery and equipment.
7. Implementing an office work efficiency system.
8. Implementing an occupational safety and environment management system.
9. Implementing an early equipment management programme.

Like in TQM, so in TPM, the word *Total* is attached special importance. This is because the gist of the problem is:

– to attain comprehensive efficiency and profitability through elimination of all kinds of machinery and equipment downtime,
– to introduce a comprehensive system of preventive maintenance,
– to ensure comprehensive participation of the enterprise personnel in the TPM programmes.

Lean Manufacturing implementation – selected outcomes

Figure 2 illustrates a sequence of steps developed and applied by the author while implementing the Lean Manufacturing methodology. A detailed description of the activities performed in individual steps has been provided below.

An audit is envisaged to define the degree to which Lean principles have been implemented in the enterprise, and it consists in:

– identifying and describing the existing waste and inefficiency,
– identifying elements of visual communication,
– analysing the method and means applied to solve problems,
– analysing the ways to supply materials,
– analysing the arrangement of workstations and storage areas,
– analysing the organisation of workstations.

Based on the audit results, one is to determine the scope of works necessary to be performed further on in the process.

Step 1 is the implementation preparation comprising:

– training of top management and selected managers in the scope of Lean,
– promotion of the Lean agenda among employees,
– explanatory meetings with employees and trade unions,
– Lean team appointment and training.

Steps 2 and 3 are pilot implementations of the Lean Manufacturing scheme. They comprise the following works:

– choice of the pilot implementation area,

- mapping of the production process and developing detailed definitions of the existing waste and inefficiency,
- defining success indicators (i.e. the expected level of waste reduction owing to the implementation) and means to measure them,
- training courses and workshops for the Lean team and selected employees,
- implementation kick-off,
- developing and implementing the suggestion scheme,
- summarising and closing the pilot Lean implementation project,
- assessment of the success indicators attained and stabilised.

Having completed steps 2 and 3, one usually obtains the following outcomes:

- improvement of the workplace organisation,
- improvement of machinery management,
- implementation of a pull system using Kanban or Supermarkets, necessary layout and organisational structure changes,
- utilisation of the personnel's potential and skills,
- Lean culture building,
- attaining initial tangible savings in the processes performed within the framework of the pilot implementation.

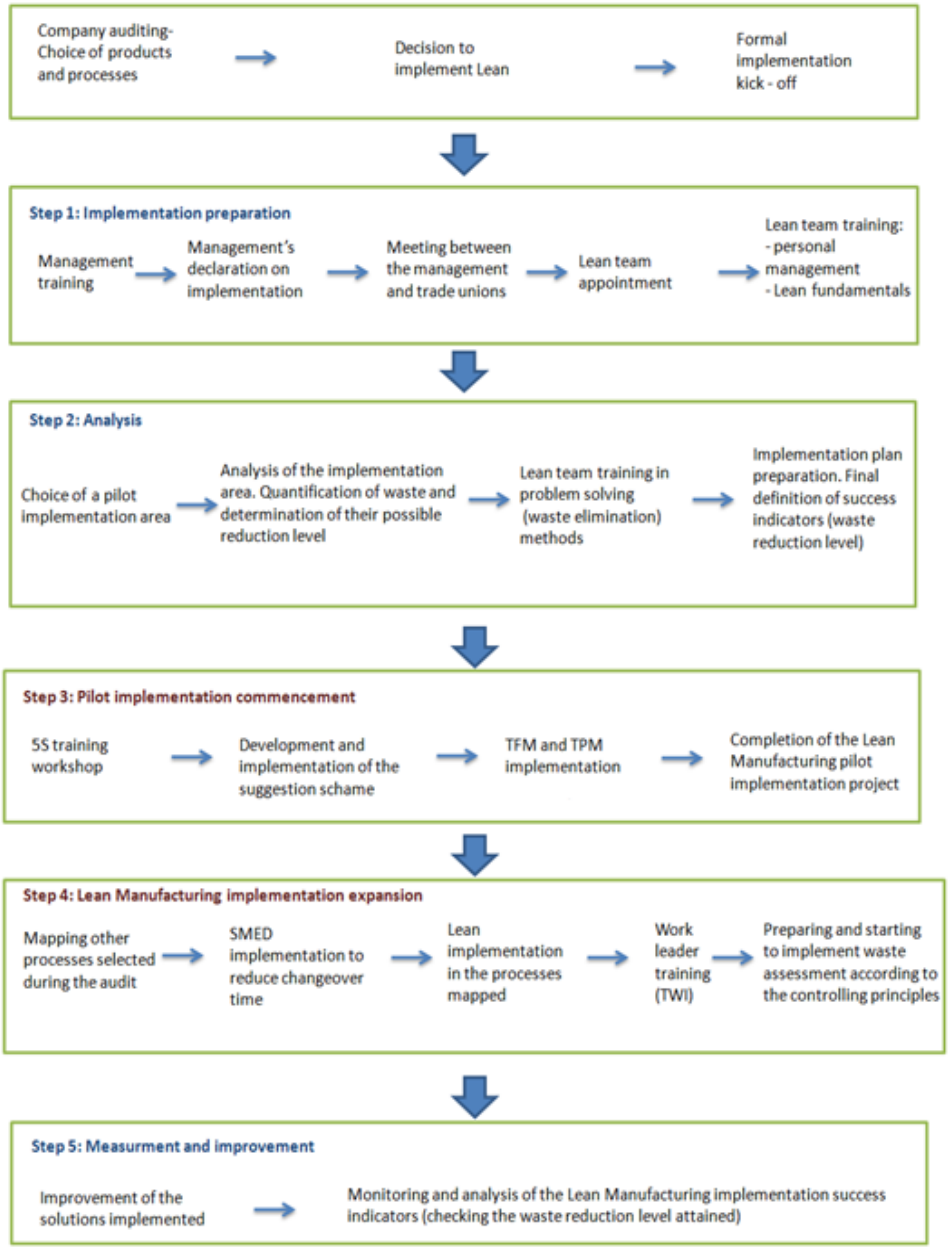
Step 4 is expansion of the Lean Manufacturing methodology implementation in the remaining parts of the enterprise. The following works are conducted at this step:

- mapping of other production processes,
- repeating, depending on the mapping outcomes, the selected scope of implementation works described under steps 2 and 3,
- specialised training for work leaders, known as Training Within Industry (TWI),
- continued assessment of tangible savings attained in the scope of the implementation processes performed.

The following outcomes are usually obtained as a result of step 4:

- reduction of the level of waste in the operation of machinery and equipment,
- spreading the Lean culture among employees across other enterprise areas,
- improvement of practical implementation of Lean tools and methods,
- completion of the Lean team preparation to unassisted continuation of the Lean Manufacturing methodology implementation.

Figure 2. Sequence of steps in the Lean manufacturing implementation



Source: authors' own study.

Step 5 entails measurements and improvements of implementation works, which consists in the enterprise monitoring and improving the Lean implementation on its own.

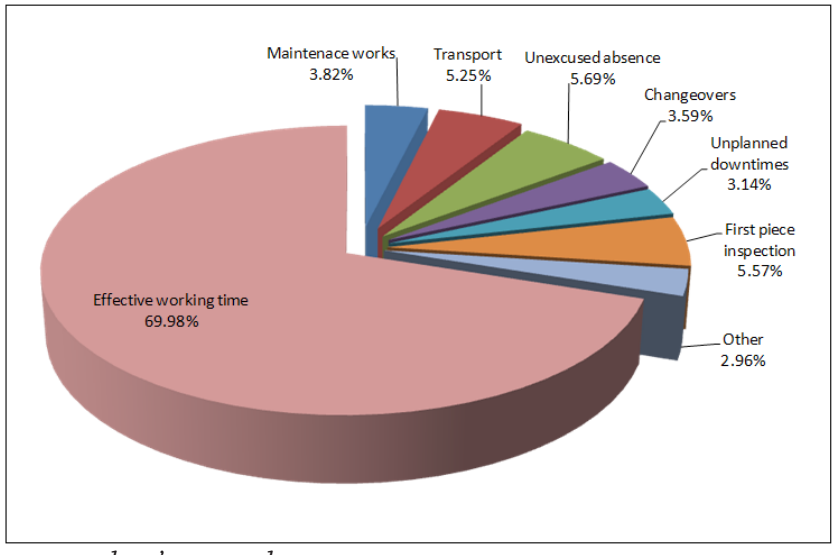
Implementing TPM and SMED methodologies in industrial enterprises has brought the outcomes illustrated in several exemplary drawings. Figures 3 and 4 show how working outcomes (success indicators) change in a group of machinery and equipment items owing to a similar TPM and SMED implementation project completed at one of manufacturing divisions of an automotive company. Figure 3 is based on data obtained while measuring machinery downtimes during an audit, whereas Figure 4 shows values of the same indicators in the course of the TPM and SMED implementation.

Comparing both diagrams, one may notice the following implementation outcomes (ca.):

- 15% increase in the effective operating time of machinery and equipment,
- 36% decrease in changeover time,
- 58% decrease in downtime related to maintenance of machinery and equipment,
- 63% decrease in unplanned downtime caused by various defects of maintenance of machinery and equipment.

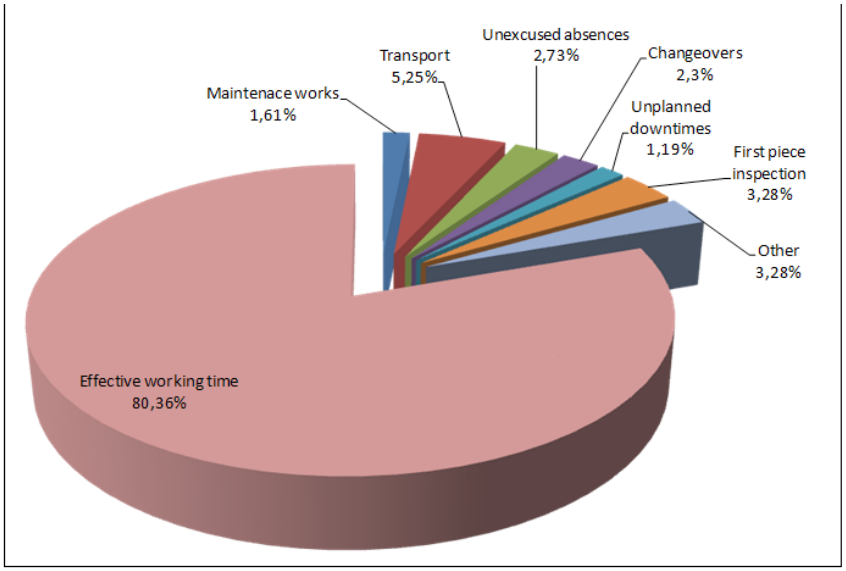
The outcomes shown are average waste values measured in the course of the operations described as steps 2, 3 and 4 (compare Figure 1) of the Lean Manufacturing concept implementation.

Figure 3. TPM and SMED implementation – status as of the audit time



Source: authors' own study.

Figure 4. TPM and SMED implementation – values of indicators after the implementation completion



Source: authors' own study.

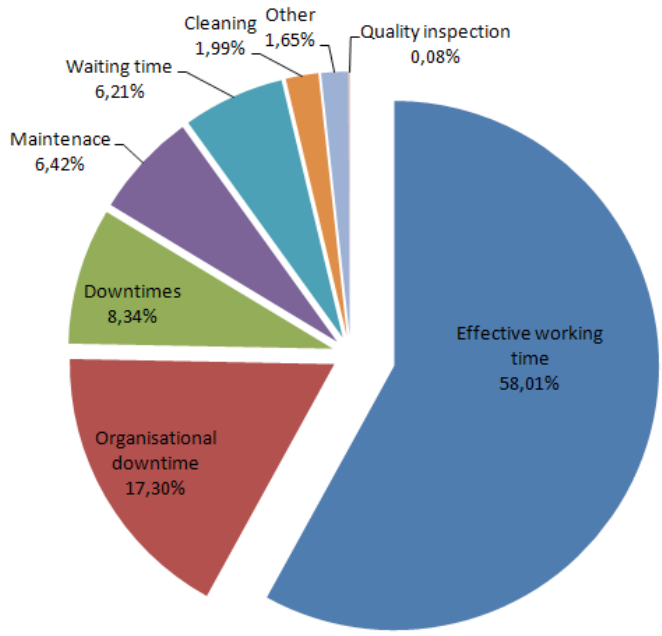
Figures 5 and 6 show how working outcomes (success indicators) change in a group of machinery and equipment items owing to the TPM method implementation at one of manufacturing divisions of a furniture company. Figure 5 is based on data obtained while measuring machinery downtimes during an audit, whereas Figure 6 shows values of the same indicators in the course of the TPM implementation.

Comparing both diagrams, one may notice the following implementation outcomes (ca.):

- 32% increase in the effective operating time of machinery and equipment,
- 72% decrease in maintenance time,
- 64% decrease in downtimes,
- 97% decrease in cleaning time.

The outcomes shown are average waste values measured in the course of the operations described as steps 2, 3 and 4 (compare Figure 1) of the Lean Manufacturing concept implementation. The clear reduction in the times of defect processing, maintenance and cleaning is mainly due to the fact that emphasis was put in this project on implementation of the 5S and autonomous maintenance principles in the enterprise.

Figure 5. TPM implementation – status as of the audit time

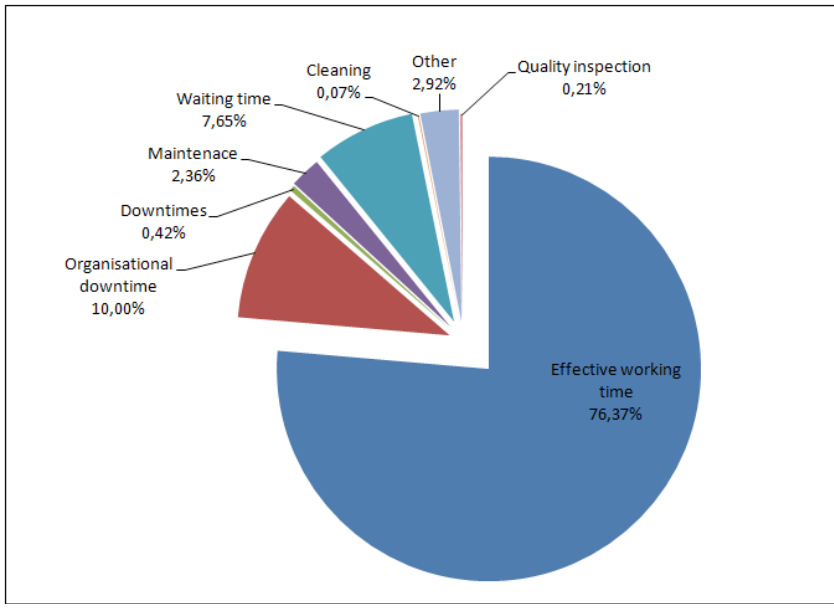


Source: authors' own study.

Conclusions

Lean Manufacturing, once it has been implemented, is an ample source of benefits for the entire enterprise. It triggers a considerable increase of manufacturing flexibility, puts order into the workstation arrangement and reduces downtimes. Production is handled according to the customers' demand and deliveries are faster. The standardisation being an outcome of the 5S principle implementation improves work organisation and stabilised production. Making organisational structures more flat owing to the Lean Management principles and improved information transfer between the management and employees exerts a positive influence on mutual communication. Training is a means to improve professional qualifications among employees. In other words, implementation of the Lean Manufacturing concept is a shift from a traditional production scheme to a modern manufacturing systems, rapidly responding to market changes and varying demands of final recipients. It also stands for reduction of the amount of operating resources involved in the production process.

Figure 6. TPM implementation – values of indicators after the implementation completion



Source: authors' own study.

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