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Eliminating Muda (Waste) in Lean Management by Working Time Standardization

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Abstract

Process improvement is a constant search for opportunities to improve the processes in the daily operations of the company, and to enhance the relationships between processes. One of the concepts of continuous improvement is the Lean Management approach. Lean management is the way to achieve the perfect level of the organization through the gradual and ongoing, which is characteristic for continuous improvement approach, elimination of waste ("muda" in Japanese) and losses in all the aspects of business, and the integration of activities connected with the stream creating customer value. The approach to classification of wastes dominating in the literature comprises seven groups. The authors focused on just the last type of waste that is on the under-utilization of the potential of employees. However, according to the author's interpretation, thinking of "muda" is not using the available working time of employees. In the opinion of the authors, this loss is due to a lack of standardization of working time of employees In order to eliminate wasted time at the workplace, the authors suggest using the techniques of work analysis and standardization. The purpose of this article is to present the methods mentioned and focus on the possibility of their inclusion in the concept of Lean Management, in the context of elimination of waste in the form of under-utilized potential of employees. The above approach combines the Japanese approach in terms of improvement of processes and European approach in the context of research on work.

Keywords: Working study methods; Building process flow; Lean management; Working time; Standardization; Elimination of waste

Introduction

Karol Adamiecki - the founder of management science in Poland - at the beginning of the twentieth century wrote that "although we manage an inexhaustible supply of time, which itself costs nothing, it is one of the most expensive "materials", which we use when manufacturing industrial products. It would seem that anyone, anyone who is engaged in productive work, should feel and understand its value, but if we look closer at technical-industrial economy, we will see that with none kind of material or energy we deal as uneconomically as with time" [1]. How currently-unfortunately-these words sound today, as over 100 years little has changed for the better in the management of the most valuable "material", which is the time.

Process improvement is a constant search for opportunities to improve the processes in the daily operations of the company, and to enhance the relationships between processes. The idea of continuous improvement (Kaizen) lies in the fact that the majority of the members of each organization on every day basis reveals opportunities to improve processes in which it participates, and find and implement solutions to increase productivity and quality of activities and products. As a result, process improvement is to lead to increase of the quality and/or productivity, cost reduction, and in the final assessment to contribute to the efficiency of the entire organization. In the method of continuous improvement, the efficiency increase is achieved by a gradual, continuous actions aimed at improvement. One of the concepts of continuous improvement is the Lean Management approach. In many studies [2-5] Lean concept is presented as the one that provides efficient use of resources by eliminating losses. Lean management is the way to achieve the perfect level of the organization through the gradual and ongoing, which is characteristic for continuous improvement approach, elimination of waste ("muda" in Japanese) and losses in all the aspects of business, and the integration of activities connected with the stream creating customer value [6]. The approach to classification of wastes dominating in the literature comprises seven groups. They were first categorized by Taiichi Ohno for Toyota Motor Company. In addition to the traditional seven kinds of muda, i.e., excessive inventory, defects and their repairs, improper processing, waiting, the eighth category is more and more often analyzed - under-utilization of the potential of employees [7,8].

The authors focused on just the last type of waste that is on the under-utilization of the potential of employees. However, according to the authors' interpretation, thinking of "muda" is not using the available working time of employees. In the opinion of the authors, this loss is due to a lack of standardization of working time of employees. In order to eliminate wasted time at the workplace, the authors suggest using the techniques of work analysis and standardization, including in particular the MTM method [9,10]. The purpose of this article is to present the methods mentioned and focus on the possibility of their inclusion in the concept of Lean Management, in the context of elimination of waste in the form of under-utilized potential of employees. The above approach combines the Japanese approach in terms of improvement of processes and European approach in the context of research on work.

Lean Management

The idea and principles of Lean Management

The original concept of "Lean" is older than its name and dates back to the 50's, when Taiichi Ohno employed by Eiji Toyoda introduced the system known today as the concept of "Just in Time" in the automotive

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industry. However, the term "Lean Production" was used for the first time - only in 1988 - by John Krafcik - one of the researchers at the International Motor Vehicle Program, and was popularized in the book "The Machine That Changed the World", written by J.P. Womack, D. Jonesand D. Roos. Hence, Lean Management is a management concept, creating such a work culture at a company that makes all employees strive to continuously reduce costs, improve the quality and shorten delivery cycle to maximally meet customers' expectations and adapt to the environment by eliminating any waste identified [11].

The concept of Lean Management is based on certain assumptions that Polish author Z. Martyniak [12] called principles, and German authors F. Gendoand and R. Konschaka [13] refer to as components. The following chapter is a brief description of the basic principles of Lean approach.

Teamwork stems from the conviction that the performance of the team is better than the performance of individual employees (because of synergy effect). The tasks and responsibilities are delegated to the team, together with the decision-making autonomy. The result is a limitation of the direct control by the supervisor for self-control. These assumptions relate to the activities aimed at the humanization of work and the autonomy of the group, because the greater autonomy of the group, the greater the motivation and willingness to work represented by group members.

Personal responsibility is mainly reflected in the fact that the goal is the transfer of responsibility to direct tasks performers, there by resulting in increasing the autonomy, responsibility for the team and self-control. When the goal is achieved, decisions are taken at the lowest level of the organizational structure. A prerequisite for the implementation of this principle is to raise the level of qualification of contractors to allow for making effective and efficient decisions. With a flat organizational structure it is easier to coordinate activities, communication runs smoothly and interest in the client is growing.

Feedback on Lean Management assumes that even in the conditions of the continuous work (production lines) the creative potential of workers can be unleashed. The starting point of this transformation is to bring diverse information to the executive level. Detailed information on the results achieved by the individual employee reaches the recipients in the spectacular way, and thanks to a feedback benefits in perfection of the tasks performance.

Pro-customer orientation should be the idea, all the employees of the company live for: from management to employees at the production line. In order to tie the customer with products of the company, it is necessary to be sensitive to customers' wishes and listen to their comments. Meeting the desires of the client begins with the supplier, so the suppliers should also be convinced of the importance of the client.

Priority of the value added is created not only by the time taken to manufacture the product, technical knowledge used during the construction or the materials from which the component parts were made of, but also the demands of the market resulting from the needs of potential customers. Value of the product in general depends on the subjective assessment of the customer and the market conditions in which it is distributed. Less emphasis is placed on quality control of already complete do semi-finished products while error-free performance of their manufacturing process is essential.

Work standardization is a tool for keeping work productivity, quality and safety at a high level and it covers the following three aspects: working time, the sequence of work and work in progress (WIP) inventory. Job Rotation is typical for Lean Management: employees take a kind of journey through various workstations associated with the manufacturing of the product. To facilitate this move from one station to the other, standardization of the operation is used.

Continuous Improvement is to avoid extravagance and waste (in Japanese referred to as "muda"). Activities that do not bring the value added are considered wasteful. Among all the concepts and methods used in Lean Management, without doubt the most frequently cited is the concept of "Kaizen" which is the process of continuous improvement. Each process can be further improved, so that waste-often unnoticed - was eliminated.

Rapid elimination of the causes of errors (at source) lies in the fact that one should not settle for superficial reasons for finding defects, poor quality, shortages, etc. Detecting and eliminating errors costs least when done at the place of origin, and is the most expensive and the client. That is why, all the employees should be involved in detecting and eliminating. The tool commonly used in this area is the method of "5 times ask "why?"".

Predicting in the concept of Lean Management is manifested by the fact that much care is taken to ensure that the employees counted for operational level staff take part in planning of future activities (decentralization of decision). Preparation of decisions implies not only the use of the knowledge contained in the written word and figures, but also the experience of operators and lower management, which often takes the form of "emotional arguments".

Gradual (simultaneous) improvement lies in the fact that the traditional product development process is replaced with simultaneous process (concurrent), so that at the same time the concept is being developed, product planned, production planned and manufacturing process performed. This saves time, which is an important factor in competitiveness.

Importance of Lean Management in a contemporary company

In order to see how the concept of Lean Management is seen in practice, the research was conducted to see the importance of this management concept for the company. The research was conducted with use of a questionnaire. The population analyzed consisted of employees in the Wielkopolska region (Poland). The sample size was 1200 people, and the results obtained from 1050 respondents were analyzed. The sampling method was random, and the study was conducted in March and April of 2015. The first question concerned the assessment of the significance of the above listed principles of Lean Management for the modern enterprise. The results are shown in the diagram (Figure 1).

According to the results of the research, the respondents identified rapid elimination of errors (84.95% of responses is important) as the most important principle of Lean Management for contemporary company, continuous improvement (75.71%) and customer orientation (72.81%) were also at the top of the list. The research confirm the importance that companies nowadays attach to the relationship with the client on the one hand, and improving internal business processes on the other. It is interesting, however, that the respondents indicated the three principles of Lean Management as those which are not relevant or their importance is small. These are: the priority value added (46.57% believe that it has small importance, and 21.52% - that does it is not relevant at all), standardization (respectively 36.19% and 16.19%) and feedback (43.90 % and 10.57%). These responses can be caused by respondents' lack of understanding of importance of these concepts for contemporary company.

The second question was based on the identification of the most important principles of Lean Management for the company, which employs the respondent. The results are shown in the graph (Figure 2).

Analysis of the results obtained leads to the conclusion that the views of the respondents are consistent. As the most important principle of Lean Management for a company in which the employee works, they indicated pro-customer orientation (23.81% of responses). Among the least important principles the employees indicated: feedback (2.83%), the priority of the value added (3.81%) and prediction (3.81%).

During the analysis of the data, the results were divided with the hierarchy criterion, into two groups, the ones obtained from respondents who work in management positions and the ones coming from operational positions. The results are shown on the next two graphs (Figures 3 and 4).

The results obtained from the employees at operational level confirm earlier results of the research. The vast majority of employees are deemed that the most important principle of Lean Management, is now-a-days rapid elimination of errors (84.38% of responses indicating the highest importance) remembering that detecting and eliminating errors costs least in the place of origin, while is the most expensive at the client's. In the case of three principles: the priority of the value added, the feedback and the standardization, the results of the survey were split almost in half: 40-45% of respondents believe that they have large importance and 40-43% that it is of little importance for contemporary companies.

The analysis of results of survey among employees working at managerial level is far more interesting. They, as the most important nowadays, recognize the following principles of Lean Management: continuous improvement (91.82% of respondents think that is important) and the rapid elimination of errors (86.82% respectively). The study therefore confirms managers awareness that each process can be further improved, and thus waste and resulting errors at the source - often invisible - can be eliminated. It is worth noting that none of the respondents indicated the principles of Lean Management, which would be completely irrelevant, which may prove the awareness of managers as to the value and importance of this conception a contemporary company.

Kaizen

The Kaizen idea and types of wastes

In Japanese "Kaizen" means continuous improvement, improvement, which applies to all, both managers and employees. Kaizen is a philosophy of management, in the centre of which is a continuous, systematic and implemented step by step improvement that takes place with the involvement of all employees [14]. It is also a tool for individual workers to organize and manage their own work. Leading to standardization which introduces reproducibility and order in the

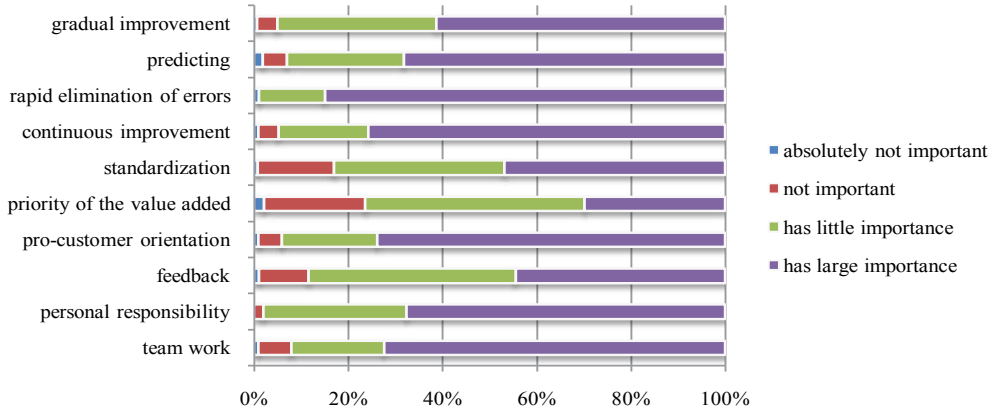


Figure 1: Importance of Lean Management principles according to employees (N = 1050).

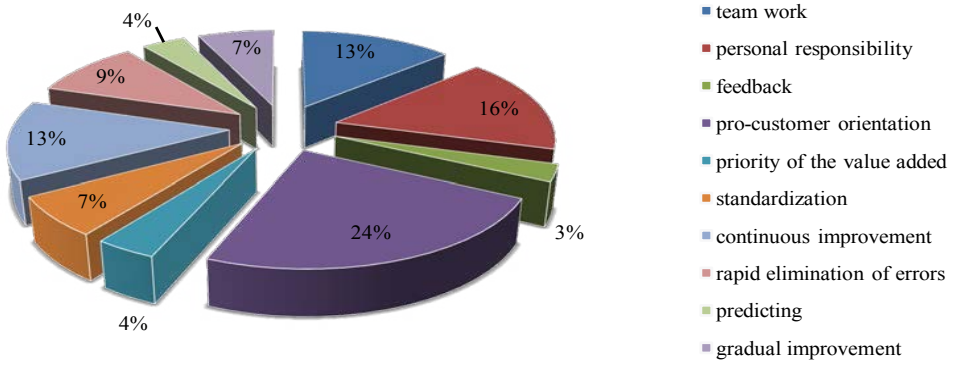


Figure 2: The most important Lean Management principle according to employees (N = 1050).

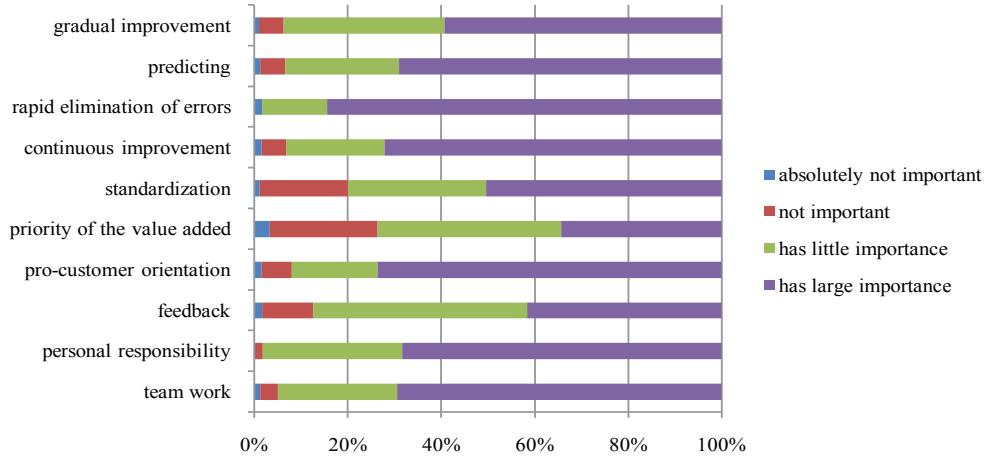


Figure 3: Importance of Lean Management principles according to employees at operational level (N = 640).

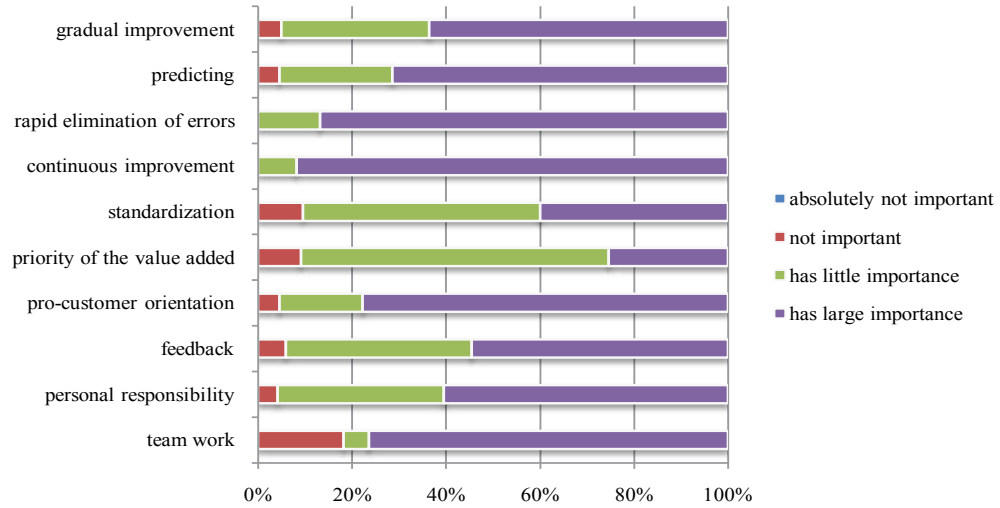


Figure 4: Importance of Lean Management principles according to employees at managerial level (N = 220).

work performed. This allows employees to identify problems easily and develop appropriate solutions [11].

According to the concept of Lean Management, company's objective is to seek to identify and completely eliminate or at least minimize any activities that do not add value to the product or service. According to P. Drucker, "there is nothing more senseless than the smooth implementation of the operations, which should not be performed at all" [15]. Activities generating value added for the customer are those for which the customer is willing to pay, and any action non-value adding from the point of view of the customer and operations absorbing too much of the resources in relation to the effects and the values they generate, are treated as waste [16]. Taiichi Ohno (1988) lists seven types of waste (in Japanese "muda") [16].

Unnecessary transport is due to too long distances between the various stages of the production process. Thus, movement of materials, WIP and finished goods requires the involvement of means of transport, which is associated with additional costs, loss of time and generating damage during transport process.

Waiting times are associated with the occurrence of "bottlenecks". In this case, employees are not doing their work, as they are unproductively waiting for the components coming from the previous production phase, and waiting does not bring added value.

Overproduction is the result of production planning that predicting the level of defects, absence of employees or equipment malfunctions, programs the level of production higher than what the market demands.

Improper processing is the result of poor design of production lines or incorrect selection of the technologies used, and also extends the working time required to produce a particular finished product. Production and repair of defects are associated with advanced automation of production processes and are the result of producing the batch of defective products. Repairing such products generates high costs, employs people without adding value to the customer.

Surplus inventories are closely linked with the problem of overproduction. Finished goods, work in progress or materials remaining in the company as inventories do not provide any value, what is more - generate high storage costs, as well as cause the funds freezing (cost of capital).

Unnecessary movements are due to poor organization of production and jobs. Workers producing in such conditions carry unnecessary movements and needlessly move parts or components, without adding any value with these activities.

In addition to these seven types of waste, the eighth category is incorporated more and more often, namely the one relating to the human factor - under-utilization of the potential of employees [6,17].

Elimination of waste in a contemporary company

The research discussed earlier (see. Section 2.2) was not only on Lean Management concept, but also on the different types of waste in the enterprise and the need to eliminate them in a contemporary company. The third question concerned the assessment of the significance of the types of waste above listed for a contemporary company. The results are shown in the graph (Figure 5).

According to the results of the research, the respondents believe that the most important type of waste that needs to be eliminated in contemporary companies is unnecessary transport (84.57% of responses "necessary to eliminate"), as well as improper processing (84.48%) and under-utilization of the potential of people (82.19%), followed by: unnecessary movements and waiting times. The fact that such a large percentage of respondents (almost 40%) indicates the types of waste that are not relevant to contemporary companies, and they are: overproduction (39.81% of responses "does not matter", and 9.90% "do not have to eliminate"), excessive inventories (38.38% and 21.24%) and defects and their repair (29.04% and 13.81%) is worth noticing. This may indicate either a lack of awareness of the hidden type of waste or the fact that many companies have eliminated these losses, using the principles of JIT and TQM.

The fourth question was the identification of the type of waste, elimination of which is the most important for the company, which employs the respondent. The results are shown in the chart (Figure 6).

Analysis of the results of obtained leads to the conclusion that the most important type of waste to be eliminated in the enterprise is under-utilization of the potential of employees (16% of respondents indicated that type). The research therefore confirms the thesis so important these days when so much attention is paid to the qualifications and competences of employees. In the coming years learning organization will be gaining its importance, resulting in greater attention of managers paid to the use of the capacities and knowledge of workers.

The data analyzed was divided according to the function criterion. The following groups were identified: the results which were obtained from respondents who work in production, trade and service and administrative units. The results are shown on the next three graphs (Figures 7,8 and 9).

Analyzing the detail data obtained on the basis of research on various fields of activities of the surveyed companies, the consequence is noticed. Namely, according to employees of manufacturing companies, the most important type of waste that must be eliminated is unnecessary transport (96.41% of responses) and under-utilization of the potential of employees (83.87%), followed by unnecessary movements (79.57% of responses), and improper processing (79.57%). Research suggests, therefore, the need for working routines optimization. And here comes the huge field of possibilities for improving the work - and

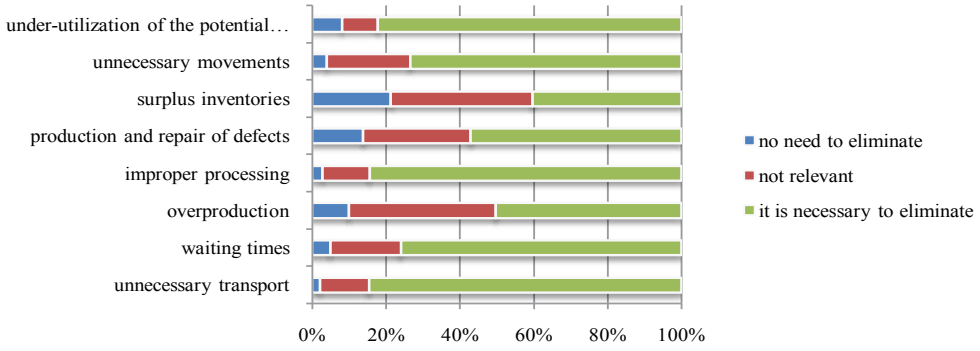


Figure 5: Importance of waste types for employees (N = 1050).

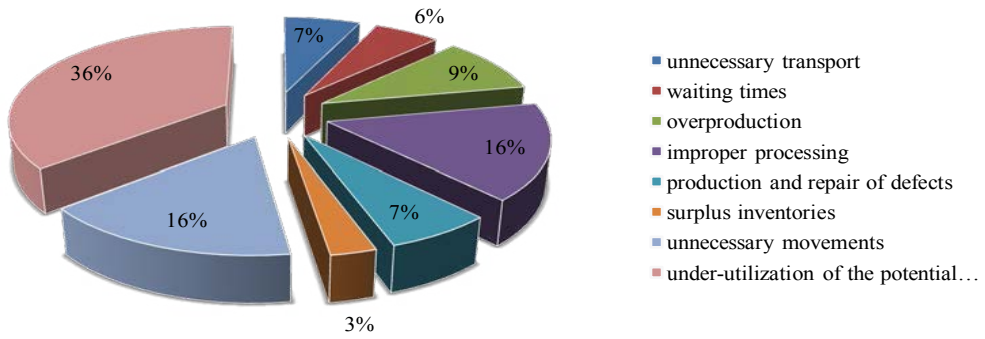


Figure 6: The most important type of waste according to employees (N = 1050).

thereby eliminating waste - with the use of methods of testing and standardization of work.

The same research conducted among employees of trading and service companies also indicates that the most important type of waste to be eliminated is the under-utilization of the potential of employees (83.45% of indications that it is necessary to eliminate), unnecessary transport (83.10%) and improper processing (81.03%). In the opinion of respondents for three following factors: excessive inventories (25.86% of responses), defects and their repair (21.89%) and over-production (13.38%) do not have to be eliminated, which results from the nature of the trade and service companies surveyed.

The results of the survey conducted among employees of administrative units show that the most important type of waste, which is necessary to eliminate is the improper processing (90.00% of responses), unnecessary transport (86.88%) and waiting times (79.38%). Hence, the conclusion is that not only in manufacturing but also in administrative units and trading and service companies measures must be taken to analyze the organization of human labor and the use of working time, probably because there are enormous reserves hidden, where waste can be transformed into the value added. In the opinion of respondents the three following factors: the overproduction (50.00% of responses), excessive inventory (43.75%) and defects and their repair (36.25%) do not matter, because of the nature of administrative operations.

Analysis and standardization of work

Analysis and standardization of work as a work organization improvement factor

One of the key factors to improve the organization of work is technical standardization of work, i.e., the determination of the optimal effort to perform a working task in certain organizational and technical conditions. Practically speaking, the standardization work is a set of actions leading to the determination of labor standards, which is the amount of time necessary and sufficient so that a specified operation was performed by the employee (or a team) [18]. This is done by analyzing the relationship between the various components of working time and work organization and working methods, the characteristics of the technological process and workstations equipment, as well as taking into account the principles of ergonomic design of workplaces. At the same time standardization of work provides an output data necessary to [18]:

- proper assessment of the level of organization of work,
- determining the conditions and possibilities for further improvement of labor efficiency,
- assessing the level of costs of production,
- improving the management organization,
- improving working conditions,

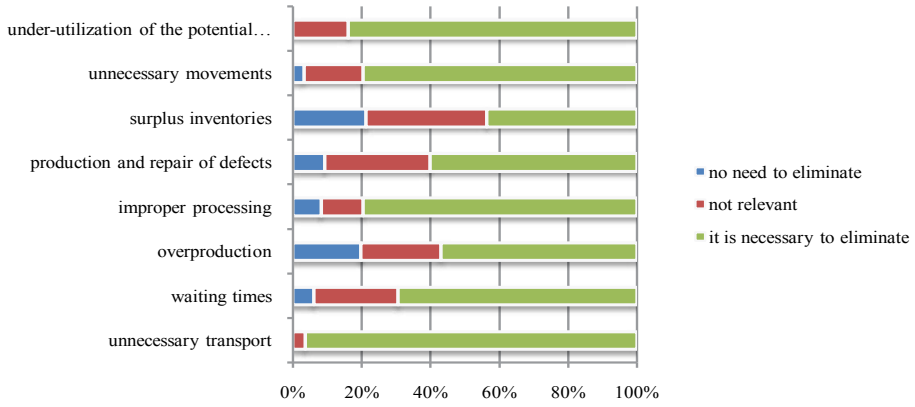


Figure 7: Importance of waste types according to respondents employed in production companies (N = 279).

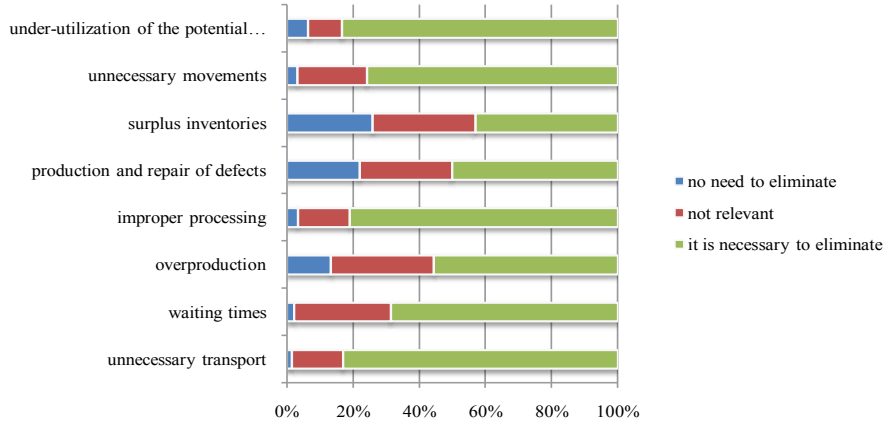


Figure 8: Importance of waste types according to respondents employed in trade and services companies (N = 533).

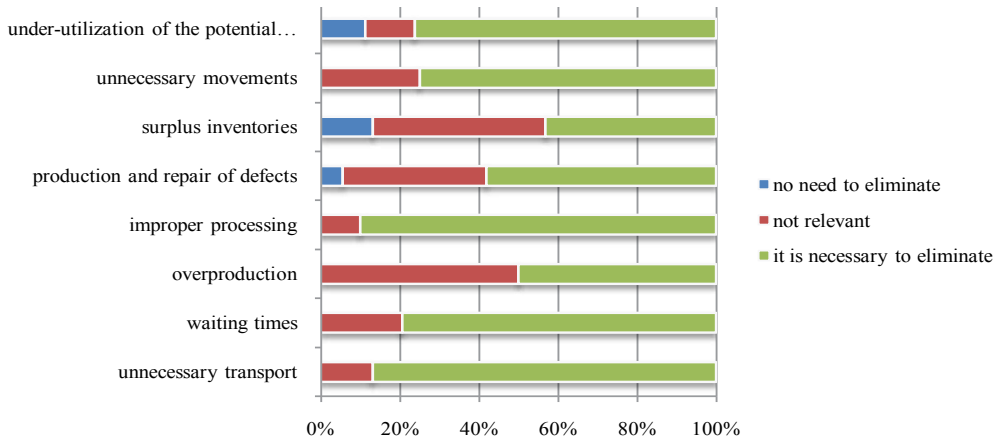


Figure 9: Importance of waste types according to respondents employed in administrative units (N = 160).

- developing and applying appropriate motivation employees.

The standard technically justified does not mean subordination humans to technical requirements of a job. On the contrary: the process of normalization takes into account the biological and psychological possibilities of a man and the social objectives of the production company. The condition for the establishment and implementation of appropriate labor standards is the optimization of the operating conditions in terms of organization, technics and ergonomics on individual workstations. Introduction of labor standards is reasonable only on the basis of the completed improvements. The introduction of appropriate labor standards does not mean the end of the process of improving the organization of work and production. Analysis of time standards meeting in terms of technical and organizational progress and the growth of qualification paves the way for further improvements of organizational, technical and ergonomic character for individual workstations [18].

The essence of work examination

Attempts to improve the human labor, to reduce expenditures per unit of product or service, is always associated with the necessity of the study, which covers many aspects already done or planned work. Man has always sought to minimize the effort to work, so first create the appropriate conditions for it, strive to improve the technical side of work. Later, with the development of mechanization and automation, along with the progressive division of labor and making the process more complex, there is a need for the organization, planning, motivation and control of, the measure [19]. There are three different areas of research work (Figure 10).

Job evaluation, as a field of research work is a process of systematic analysis and assessment of objective difficulties typical for specific work to establish their hierarchy. It should be noted that the hierarchy is the assumption basic salaries relativization is based on. Job evaluation requires proper standardization of work [20].

Measurement and standardization of working time is defined as the systematic determination of the current run-time movements, activities, operations, and implementation of certain administrative and office procedures and determination of the structure of time consumption at each workstation with the use of techniques for measuring time [20].

Work measuring: Testing and standardization of work methods used in practice can be classified according to the standards of the final size and the degree of detail required by the standards for the determination of elements. Depending on the method of determining the amount of standard distinguishes [21]:

- statistical method, according to which the value of the standard is based on statistical data on the actual usage time for the operation in the past,
- an estimation method by which the value of the standard is determined by an expert (from standardization, or master, or technologist) on the basis of their own experience,
- comparative method by which the value of the standard is determined by comparing the operation (or part of) the operation (part of) is very similar to the conditions of their implementation,
- standard research (experimental), according to which the value is determined by standard measurements of time in the workplace,
- calculation method by which normal value is obtained by calculating on the basis of certain mathematical formulas.

Due to the level of detail required by the standard components of its findings, standardization methods can be divided into [19-22]:

- summary method, which is characterized by the fact that the time allowed to complete the work shall be defined without separating it into its constituent parts,
- analytical methods that differ from those totals with the approach to planning, the work planned is divided into its constituent parts, sometimes down to the basic movements, and then the duration of these elements is determined, to get the execution time under specific conditions (i.e., standard), the times are subject to aggregation.

In addition to the methods listed above there are methods used which are a combination of the previously mentioned [23,24].

Work examination methods: Technical standard of working time, based on calculations, are an important factor in motivating contractors to streamline work, allowing the best employees to be better than the standards. Contemporary theory and practice of work standardization refers to the number of test methods for assessing use of the working time. However, the most popular are the four following methods.

Methods for elementary times and movements are based on pre-determined time standards. These standards are derived from the study of movement of limbs and eyes, and are made up of elements of ongoing fraction of a second. With these elements, as with the building blocks, string actions - operations are built. This is an analytical standard, very labor intensive [22]. The approach of time and methods of basic movements is based on the following assumptions: each job consists of a variety, repetitive elementary movements, each of which has a fixed value of time and the time of all elementary movements are accurately measured and set the tables. Thus, the use of these methods is to identify basic movements used by the job, and then determine their time using the time-tables of the movements and eventually sum them up. Among the family of elementary norms of methods won the most popular method of MTM, which is the acronym of: Methods-Time Measurement, which can translate this as: time measurement method. The assumption underlying this approach is that the time needed to carry out a particular job depends on the method chosen for the service. In short, the method chosen determines the time [9].

Timing is to determine the time required for an operation (operations) at a normal pace of work, based on a certain number of measurements [1,19]. For this purpose a number of measurements carried out using a stopwatch and recording the results of measurements on special forms, so that the results obtained were as accurate as possible [19]. According to the definition of the British Office of Standards, the timing is a technique for measuring work, aiming to record the duration and rate of the components of specific work performed under certain conditions in order to analyze the current time and determine the time required to perform the work of a certain level of performance [24]. Therefore, the timing is about determining predetermined time (normative) based on analyzing and measuring the real time. Measurements are made using an outside expert – a specialist in the field of research and standardization of work. Timing is used to determine the time charged to the man in the tasks in which the person has an impact on labor productivity [23].

Photography of working time is measurements which are carried out during the period of a certain time, usually during the entire shift. They are designed to either determine the frequency and the length of time and factors recurring rarely and irregularly, or check the current standards of the time [4]. The essence of this observation is the continuous tracking of continuous human work on one or more workstations and recording the order of the elements tested to work with simultaneous registration of the timing of the initial or final points of the listed facts [21]. Photography of a working day, though very labor intensive, is a valuable source of information, not only about the observed workload operations, but also about the level of organization of work. The purpose of photography is to capture the working day and all the wasted time and define the relationship between working time and breaks time.

Ciliary observation is a random examination of time in which people (and related equipment) remain in a particular state of activity. The test is cheap and easy, it can be carried out by the direct supervision staff, and even the respondents [19]. The method of observation is a snapshot of the quantitative analysis of working people, of machines or a designated state or activity. The research is based on the theory of probability and statistics, and more specifically on the study of a representative sample [23]. The essence of the method consists in recording workstations at random times, and on that basis determining the proportion of break time intervals with respect to work time. To ensure the representativeness of the study it should be remembered that the number of observations is a function of the desired accuracy of the results. On the basis of the study the percentage of time devoted to work is determined, and what percentage of the observations were wasting time, taking into account reasons of work breaks [19].

Work evaluation: The third family of techniques inherent in the study of methods and measuring work, regarded as an important element of the organization of work, is to determine the eligibility of work or used interchangeably – job evaluation. This close relationship is clearly underlined by Martyniak Z. [12], "between the three parts of work examination every feedback is possible. Thus, job evaluation can inspire improvement actions within the work examination and the influence correcting the organizational workflow, defined as the measurement of work".

Workstation evaluation is not to be confused with job evaluation. The first of them – the valuation of the workstation – it is a process which aims to set a price for a specific job performed at a predefined workstation. Its criteria determine the type, quantity and nature of the activities resulting from the mission and role of the job, and the skills and the time necessary to provide the functions of that position. Job evaluation is a process which aims to assess the quality of work of a particular employee in his position, and the criteria relate to the quality of activities performed in the process of working through the employee being evaluated. The value of what an employee gives to his company with his attitude and way of working is specified. Hence, these additional personal values should be rewarded, rewarded and reinforced to enhance the level of motivation. Meanwhile, job valuation determines what -and more specifically-how the company can or should give the employee the skills, time and activity (work) that are required and necessary for a given position. Determining these values

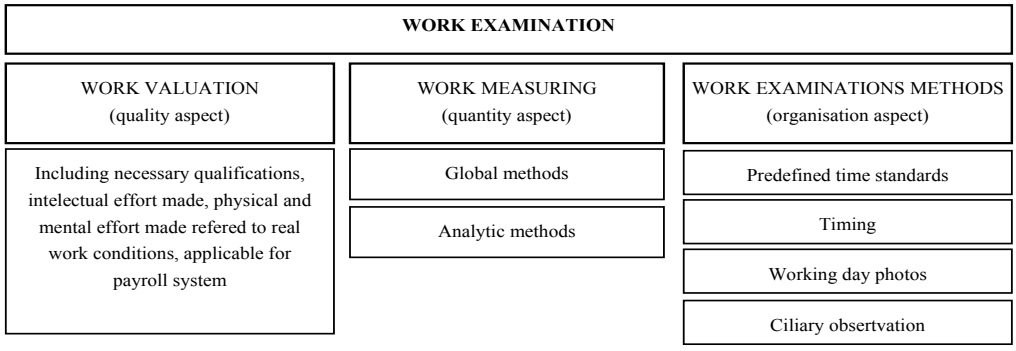


Figure 10: Work examinations areas.

is a function of job evaluation system, and they are a starting point for determining the base salary in the company [25].

Due to the importance of job evaluation system in the process of organizing the company and later in its keeping, an important step is to select the method of valuation methods for ensuring a proper fit to the specifics of the analyzed company. The whole set of methods of work can be distinguished two basic methods: summary and analysis [26].

Elimination of wastes with MTM method

The MTM method introduction: Methods of times and elementary movements management are based on the standards to be fixed in advance. These standards are derived from the study of movement of limbs and eyes, and are made up of the elements lasting a fraction of a second. With these elements operations are built as with the building blocks. This is the analytical standard, which is very labor intensive. Methods of elementary times and movements can be applied to research on and plan an appropriate workplace organization and the organization of the implementation of the work itself. These methods are united in an element of movement and time. They are based on the finding that, when considering manual work, there are some specific elementary movements which combined in various way create every job. The division of work movements into elementary movements is just a starting point for these methods. Working movement is a short, introverted motion sequence, which in typical form occurs frequently, and directly affects the course of work, or any action. Whereas the elementary movement is isolated part of the movement, which independently of the work is the result of the mechanics of the human body. F.B. Gilbreth on the basis of his experience established 17 elementary movements called - from an anagram of his name - therbligs [25,27].

Among the family of methods of elementary standards, the MTM method, which is the acronym from: Methods-Time measurement, has gained the greatest popularity. This approach is based on the assumption that the time required to carry out a particular job depends on the method chosen for the implementation of activities. In short: the chosen method determines the time. MTM method was applied for the first time in 1948, and later modified several times. Its authors took as a basis [9]:

- 8 elementary hand movements: reaching, grasping, moving, combining and bleeding (elementary and the most common movements, representing 70-80% of the entire course of work) and pressing, separating and rotating,
- 2 visual functions: visual shifting and controlling,
- 9 movements of the body (legs and trunk), including the movement of the feet and legs, body movements with shifting and tilting the axis of the body.

Time values determined on the basis of the movement analysis with the movie in the specific production conditions. The unit is TMU (Time Measurement Unit) which is equal to 1/100 000 part of an hour (0.036 seconds).

Work processes are, with the use of the MTM method, decomposed into elementary movements necessary for its implementation. For each elementary movement there are, depending on the input, the times set (units of time), from which it is possible to make a working method. Determinants for each elementary movement give specific attachment points for the development of methods of work and work processes, as well as jobs. Through a detailed analysis of the work tasks MTM method specifies the time, manner and quality of the work, thus giving a complete picture of the method of execution, together with a careful determination of the value generating activities, showing its bottlenecks, and an indicating the direction of optimization. By making the planning analysis it is possible to accurately determine the potential of the area. Using the MTM method it is possible to identify and realize opportunities to develop the entire value chain. MTM tools allow to determine the best methods of execution, which allows for maximizing productivity by simplifying or eliminating elementary movements which do not generate added value [25,27].

Elementary movement's time and its shortening with MTM method

An important element of the elimination of waste in the workplace (and thus in the whole enterprise) is designing the correct spatial relations at the workplace, or to provide working man in convenient reach of the work (work area) and in a convenient position of the body so that he/she can traverse freely and without undue effort, and thus without fatigue, safely and efficiently [28]. In the method of elementary movements the goal of shaping the course of movement is to find their simpler counterparts, i.e., less aggravating and tiring, and to dense the movements by switching to two-handed operation, which is perceived by the employees as a more rhythmic and more enjoyable. A characteristic feature of the use of MTM in enterprises is a growing trend to non-investment rationalization, or improving the conditions of work systems at relatively low costs of investment for application of equipment, tools and other means of production, which is designed to reduce the burden of worker [9].

Taking movements (reaching, grasping and letting go) in the method of elementary movements depend primarily on the length of the movement, case of the movement and the type of course of the movement. A simplification of these movements is achieved by reducing the size of influence, which means that movements taking more time are to be converted into less time consuming.

Movement length reduction is achieved by pulling up (reducing the distance) to the objects of labor and tools to the site of action. For example, reaching a distance of 65 cm to the subject lying separately (traffic code R65B) requires 22.6 TMU time, and reaching for the same object lying at a distance of 30 cm (R30B) requires only 12.8 TMU. The reduction here is almost by half. Length of movements should be reduced enough to keep their natural rhythm. Too short movements lead to one-sided burdening and early fatigue of an employee.

Analyzing the impact of a case of a movement, which is attention needed (concentration) during movement, the opportunities to simplify the movement are also sought for. In case of a stretching movement at the same distance (e.g. 30 cm) there are five options of movement with the following time relation:

- "A" case - slight intensity of attention, the object is always in the well-defined place (code motion R30A) - 9,5 TMU time, taken as the base (100%),
- "B" case - moderate intensity of attention, the subject is separated (R30B) - 12.8 TMU time (135%),
- "C" and "D" cases - required attention, item mixed with some other objects (R30C) or small object (R30D) - 14.1 TMU time (148%),
- "E" - low intensity of attention, moving hand in the unmarked position (R30E) - 11.7 TMU time (123%).

The simplifying the stretching movements is by transforming the movements C and D into the B or A. This can be done by making use

of the forwarding mechanisms or defined location of the parts. The case "D" concerns the movement for very small or difficult to handle objects, thus suitable configuration of an object could be helpful. A similar situation exists in the case of capture movement. A significant factor influencing the elementary movement of capture is the way of grasping, which results in the time required for movement (Figure 11).

Selective grip of the object mixed with other objects (G4) is four times more time-consuming than grabbing separately lying object (G1A grip). Grips G4 can be converted into G1A and G1B cases through the use of gripper containers. Time saved is particularly evident when eliminating selective grip while doing ambidextrous activities. Sometimes grips G1 or G4 can be converted into the G5 (touching grip) by depositing parts and configuration of delivery device, allowing the ejection of individual items. The attention should also be paid to the correct location of the clamshell containers including the reach zones and the principles of economics of working movements.

In the case of placing movement (moving, combining) a method of elementary movements the movements simplifying can be achieved by similar methods as in the case of taking movements. Moving movements are affected by the size of force necessary, that must be reduced/eliminated especially in those cases where it leads to static load of an employee and occurs repeatedly. This can be accomplished by the use of cargo supporting equipment and the transport equipment.

Values that affect the elementary joining movement are: fitness class, symmetry conditions and manipulation. Simplifying this type of movement is always bound with the product shaping. Switching accuracy can be reduced by larger tolerance (clearance between the joined objects), the use of chamfer, restriction of movement (the guide rail, the use of the stop), or even elimination of the joining movement. The possibility of reducing the time by the symmetry conditions is to change the structure of the items to be combined. For example, combining objects with square profile (traffic code P2SSE) takes time of 19.7 TMU, and the same movement for the items of circular profile (P2SE) requires only 5.6 TMU (time savings of nearly 75%).

Principles of movement's economics and their influence on elimination of wastes with MTM method : Principle of movements made by a man economics can be reduced to such an organization of work in order to avoid unnecessary movements so that the path of necessary movement was as short as possible and that the movements followed each other in an optimal way in terms of the order, certainty and difficulties. These principles were formulated in 1911 by F. and L. Gilbreths and developed by R.M. Barnes. They can be divided into three groups [21]:

- rules on human work (selection of movements), based on maximum utilization of potential of the human body,
- rules on the workstation,
- rules for the selection of tools and equipment.

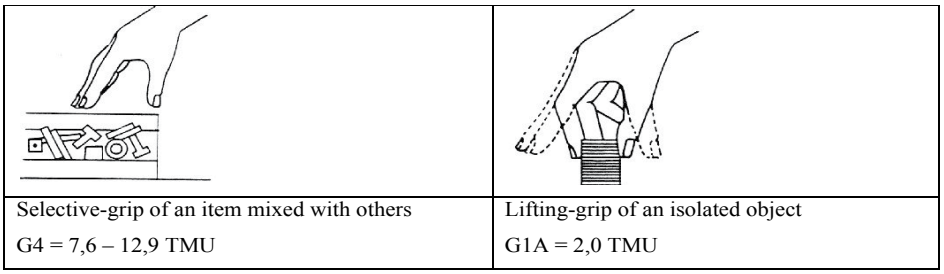
Standardization of work methods consistent with the principles of elementary movement economics is focused on the execution of a task with a minimum number of moves, the least time-consuming, carried out simultaneously with both hands. These rules apply to the organization of work using the MTM method and are based on the following assumptions:

- simultaneity of movements - developing working methods in such a way that the work was carried out with both hands at the same time taking into account all the principles of ergonomics,
- simplification of movements - seeking to ensure that the necessary elementary movements were the least time-consuming to make,
- reduction of unnecessary movements - is to eliminate unnecessary movements that do not add value to the process; repeated move of taking and hanging up the same part can be the example,
- shortening the distance for movements of grabbing and moving - by creating the optimal position and working methods, combined with the principles of ergonomic design of work.

Conclusion

"Time is money," Benjamin Franklin said. However, time is worth a lot more than money, because it is a scarce commodity, time cannot be bought, nor stored or reproduced or translated, or transferred [29]. Time is running constantly and irrevocably [30].

In this article, the authors focused on the specific type of waste, which is the under-utilization of the potential of employees, and the authors interpret this as a kind of muda as not using the available time of workers in a company. In the opinion of the authors, this loss is due to a lack of standardization of working time of employees. In order to eliminate wasted time at the workplace proper research method and standardization of work should be applied. Objectively established time standards are essential to the proper division of labor within the entity, and the rational organization of work. Only with the help of labor standards objective criteria for the planning, organization and control of all activities can be developed for a particular production process. Standardization of work therefore plays a vital role in management of the whole enterprise, as well as of work of man. Attempts to improve the human labor, to reduce expenditures per unit of product or service, always involve the necessity of its analysis, which covers many aspects of work already done or just planned.



Selective-grip of an item mixed with others	Lifting-grip of an isolated object
G4 = 7,6 – 12,9 TMU	G1A = 2,0 TMU

Figure 11: Comparison of Times required for grasping movement.

To ensure the optimum configuration of workstations and in consequence a better use of the potential of employees, the below listed principles should be followed [31]:

- workstation must provide convenient and safe access for its operators,
- location for materials and tools should be predefined and fixed,
- materials and tools should be placed in the employee's functional field, heavy objects, and most commonly used should be placed in the optimal field and at the height of the working surface,
- materials and tools must be arranged in such a way as to provide a fixed sequence of moves,
- distances between objects on the workstation should be as small as possible,
- position of the object should allow quick and easily capture,
- the table containers, conveyors, gravity conveyors, handles, etc. should be used in order to facilitate the work and relieve the hands,
- work pieces should fall through the hole in the table, or be placed in a container that is set so that the required hand movement was minimal.

The final remark is that attention should be paid to another aspect, namely the use of solutions within the concept of Lean Management. The combination of research and standardization of methods of work with the principles of Lean Management allows in the process of work optimization and standardization for the precise definition of the activities that add value or are a waste. Determination of value-adding activities at the level of elementary movements allows for better development of optimal methods of work and as a result reduction of the manufacturing cost. It is also important to standardize the working method with 5S method. This allows getting the unique effect of the optimization process, which is to increase productivity while reducing workload.

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