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METHODICAL APPROACH TO DESIGNING WORKPLACES AND INCREASING PRODUCTIVITY BASED ON VALUE STREAM MAPPING AND METHODS-TIME MEASUREMENT

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Summary

The introduced methodical approach connects value stream mapping (VSM) and methods-time measurement (MTM) and offers new distinct advantages to reducing lead time and increasing productivity based on lean principles and standardised processes. The mutually aligned design and improvement of assembly and (production) logistic processes take workplaces, their surroundings and the supply areas as well as the overall value chain into account.

The principle, benefits and the procedure of application are described in the paper. A practical example highlights the redesign of assembly workplaces and the redesign of (production) logistic processes to reduce inventory/lead time.

Key words: *value stream mapping, MTM, productivity, lead time reduction, ergonomic workplace design*

1. Introduction

Increasing productivity in a defined time frame (e.g. one day, one shift), among other things, causes an increase in overall added value within this defined time frame. A short lead time through a process chain (a value stream) results in a higher output and therefore in higher productivity, thus increasing the overall added value within this given period of time. On the other hand, the same overall added value can be achieved in a shorter period of time. Lead time reduction in a value chain arises from reducing lead times (operating times, idle times, transportation times…) of subprocesses in this value chain. The target for designing a process is therefore to create its added value as fast as possible. Based on these "faster" processes "more" time is available in this given period of time to "produce" more output (see Figure 1).

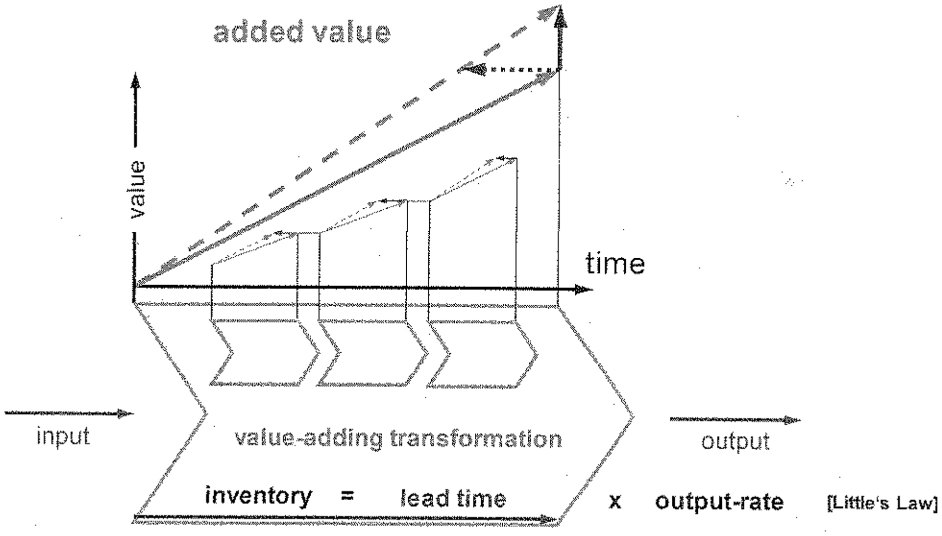

Fig. 1 Optimisation of added value by lead time reduction

2. Value stream mapping and methods-time measurement at a glance

A value stream includes all activities, i.e. value-adding, non-value-adding and supporting activities that are necessary to create a product (or to render a service) and to make this available to the customer. This includes operational processes, the flow of material between the processes, all control and steering activities as well as the flow of information. Taking the value stream view means considering the general picture of an organisation and not just individual aspects. Value stream mapping was originally developed as a method within the Toyota Production System and is an essential element of lean management. In order to assess the potential for improvement, value stream mapping considers particularly the entire operating time compared with the overall lead time. The greater the distinction between operating and lead time the higher the potential for improvement [1].

MTM is the abbreviation for methods-time measurement, meaning that the time required to execute a particular activity depends on the method performed for this activity. It is a modern instrument for describing, structuring, designing and planning work systems by means of defined process building blocks. MTM exhibits an internationally valid performance standard for manual tasks. Today, MTM is the most common predetermined time system in the world [2], thus establishing a worldwide uniform standard of planning and performance for a global business.

A process building block represents a process step with a defined work content and a distinct purpose to which a standard time applies. A system of process building blocks consists of a defined amount of process building blocks. The MTM system of process building blocks [3] was developed for a specific, clearly defined process typology, a specific complexity of processes and defined process characteristics. MTM process building block systems are assigned to clearly defined fields of application, such as mass production, batch production or job shop production.

A value stream analysis provides a very fast overview of the whole value stream from the supplier to the customer, with the focus on lead time and linkage between the processes. MTM is a tool based on a uniform process language to describe and standardise processes. In addition, it provides the time (basic time) of single processes in the value stream.

Value stream mapping and MTM aim at identifying, evaluating, reducing and eliminating waste within the value stream in terms of lean management.

3. Productivity

Productivity is the expression of the quantitative productiveness of an economic activity (of the product realisation process) and allows conclusions to be considered how well the deployed production factors are used. Productivity is defined as output divided by the input factors. Basically, productivity is categorized according to the individual production factors (workforce/manpower, machinery, material).

On the one hand, an increase in productivity results from increases in effectiveness by eliminating what is wrong and/or from doing what is right and, on the other hand, from increases in efficiency, through accurate assessment and the achievement of levels of capacity and performance. The consideration of the different dimensions of productivity provides a profound understanding of this relationship and a basis for implementing measures for increasing productivity [4].

The dimension "method" describes "how" a work assignment or work content in a specified work system is fulfilled and refers to the whole process chain (overall processes) as well as to single processes or executions. The dimension of "utilisation" considers aspects of the degree to which resources are utilised. The "performance" dimension considers aspects of performance level (willingness to perform, potential for achievement).

4. Increasing productivity using value stream mapping and MTM

The design of (work) methods is the most important dimension to influencing productivity [4, 5]. Planning and implementing "well" designed, i.e. efficient and effective methods have come into the very focus of projects to increase productivity (see Figure 2).

These projects can lead to investment. The achievement of high employee utilisation, however, does not often require investment. Obstacles, such as fluctuations in customer or order frequency, without flexible employee assignments lead to utilisation losses. This can frequently be recognised in service processes (e.g. trade, administration). The time determination of processes, e.g. in production areas to evaluate the performance level opposes these obstacles efficiently. In particular, a neutral and valid base to evaluate performance is required to achieve increases in productivity.

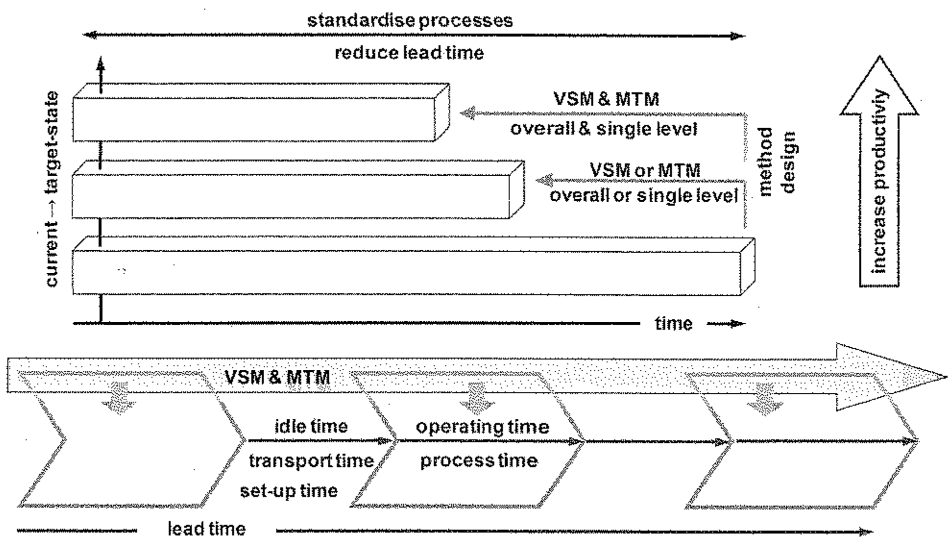

Fig. 2 Method design by VSM and MTM [6]

Table 1 provides an overview of the different design areas for the dimension (work) method, performance and utilisation.

Value stream mapping does not just contribute to reducing lead times by reducing and avoiding waste, it also contributes to increasing effectiveness and efficiency by improving work methods and the organisation of work, thereby raising productivity.

The focus of optimisation is the alignment and combination of individual processes to form a continuous, efficient value stream throughout the organisation (consideration of overall processes). Through its well-grounded time determination and with its systematic analysis of processes, MTM contributes to evaluation and productivity improvement. The focuses of optimisation are the individual activities and the work places (consideration of single processes). MTM contributes to the correct determination and assessment of the performance level. Capacity utilisation is influenced by both MTM and value stream mapping. The two tools complement each other perfectly in contributing to raising productivity as the combined application of value stream mapping and MTM affects the design of all three dimensions of productivity.

When looking at the dimensions and their design areas (see Table 1) it becomes obvious that the increase in productivity is achieved by designing smarter processes combined with reduced investment and low cost automation. The focus is set on designing methods (processes) and standardising work. The different aspects of the design areas indicate possible potentials for improvement.

Table 1 Dimensions of productivity – design areas [6,7]

Method / process design	
„Single processes" **(individual task orientation) - MTM** • layout - workplace design (tools, fixtures, machines…) • added value, complimentary work, waste • handling expenditures • expenditures for controlling and supervision • ease of assembly / disassembly • ease of grasp / operability • manual material handling	**„Overall processes"** **(flow orientation) - VSM** • process organization / work organization • production systems • layout - workplace alignment layout (factory, floor, assembly line, cell…) • material flow
Information flow and control VSM+MTM • production planning and control • control principles	• product design • design of information flow
Performance	**Utilisation**
MTM • performance standards (performance rate, actual / target-time ratio, standard time, normal performance, …) • personal performance • labour standards • training, routine • motivation / disposition • target orientation / monitoring • competences, skills, education • support / instructions, coaching	**VSM+MTM** • net man-hours worked, total amount of hours available • fluctuations in order-frequency and work content • balancing (static, dynamic) • work in progress / inventory • stock (amount) • idle times / breakdowns • scrap (quality of work) • setup times / change over efficiency • maintenance • machine utilization • material utilization • area utilization

Table 2 Benefits of the combined application of value stream mapping and MTM

	VSM	MTM
Exact determination and assessment of		
• operating, transport and set-up times		X
• performance and utilisation		X
Reduction of lead time through		
• minimising and eliminating **idle times**	X	
• improvement and redesign of **methods** and reduction in operating and transport times	X	X
Increase in productivity through		
• design of **methods** (increased effectiveness)		
flow-oriented consideration (overall processes)	X	
task-oriented consideration (individual processes)		X
• improvement in **performance** and **utilisation** (increased efficiency)		X
• **standardising processes**		X
Reduction in inventory in form of	X	
• raw materials, work in progress and finished goods		
Improvement in delivery reliability through	X	
• lead time reduction and batch size reduction		
• smoothing out fluctuations		
Evaluation and planning of flow of material		X
• based on standardised logistics process building blocs		
Reduction in control overhead through	X	
• simplification of information flow		
• application of the principles of self-regulation (supermarket,...)		
Reduction in required shop floor areas through		
• material flow optimisation improved workplace layout	X	
• improved workplace design		X
• lower stock quantities (inventory)	X	
Comparability and evaluation of current and target status		X
• internationally applied, standard performance benchmarks for human work		
Simulation capability	X	X
• planning, design, assessment and optimisation of "virtual" methods (flow- and task-oriented) in current and target states		
Simple and comprehensible documentation of methods	X	X
• simple and easily understood documentation of the processes and work procedures and transferability of results		

Table 2 provides an overview of the most important benefits from the joint application of VSM and MTM.

5. Areas of application

Once MTM has been successfully deployed in an organisation, value stream mapping is a valuable extension in order to analyse the whole process chain. Conversely, if an organisation already uses value stream mapping as a tool, the application of MTM is a useful addition. The following practical areas of application and possibilities for use result from the interplay of the combination of value stream mapping and MTM (see Figure 3):

- *assessment of added value rates*
- *ergonomic design of workplaces*
- *current/target state comparisons*
- *balancing*
- *layout design (overall and single level)*
- *assessment of logistic processes*

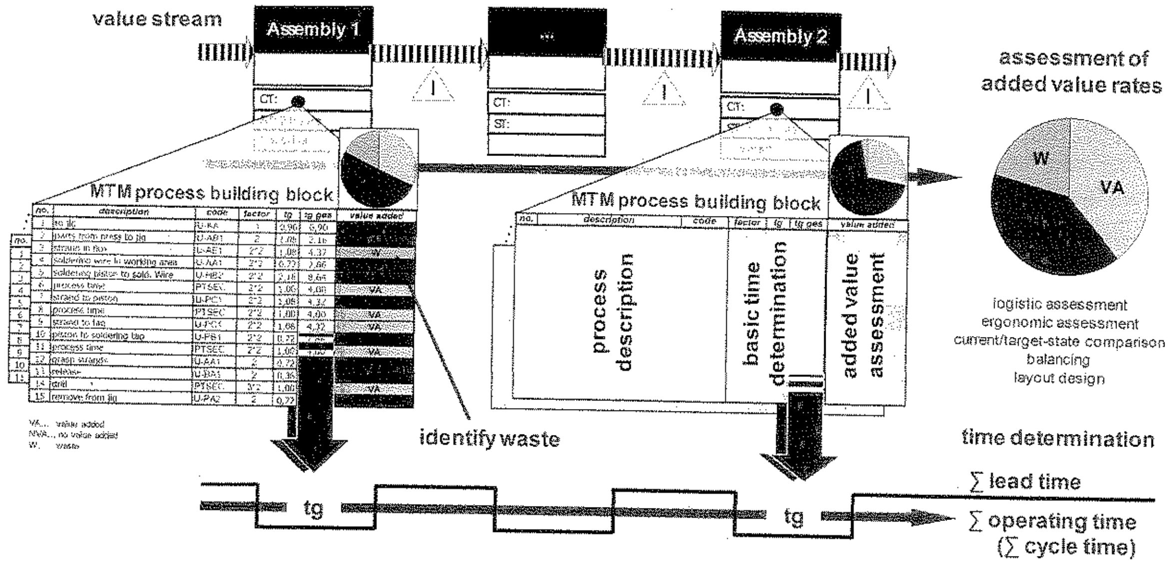

Fig. 3 Principle of the application of VSM and MTM [6]

5.1 Assessment of added value rates

The systematic identification of waste is the precondition for avoiding wasteful activities through the design of target processes. The use of MTM ensures that the time with respect to the percentage of waste is assessed. A fundamental concept of lean management and the continuous improvement process (CIP) that is decisively responsible for raising productivity is the search for the identification and the elimination of waste. This ensures that e.g. movement, transport, rework and other wasteful or non-value-enhancing aspects are removed from or at least minimized within the processes. It is necessary to assess the amount of waste (see Figure 1) in order to sustainably and retraceably prove the results of improvement measures. MTM process building blocks meet this requirement particularly well as every simulated or actual change to an operating procedure is immediately quantifiable in terms of time – and subsequently in terms of cost – in the form of the MTM performance norm intrinsic to every process building block.

5.2 Ergonomic design of workplaces

The design of processes from the point of view of raising productivity must be balanced with designing work with people in mind. Risk analyses are used to ensure the ergonomic quality of design. These evaluate stresses on the body, such as posture, movement, strain as well as influencing forces, sensomotoric functions and psychological pressures. For this purpose the application of the EAWS (European Assembly Worksheet) is suggested. Among other things, process descriptions based on MTM process building block systems are the basis for the risk analysis. Ergonomic design measures are important particularly in early product and process planning stages as they can often be taken into account in this phase without incurring great additional overheads.

5.3 Current/target state comparisons

The rapid deployment intrinsic to value stream mapping usually leads to less importance often being attached to the current state. It is therefore often hardly possible to compare the planned with the implemented target states. This is especially true in the current value stream for the determination of cycle times (operating times). The simple and rapid application of the concentrated MTM process building block systems provides an accurate assessment of the processes of the current value stream. This creates the basis for the comparability of the target state achieved with the current state under consideration and for the assessment of the realised potential for improvement.

5.4 Balancing

Design principles, such as e.g. orientation to customer demand (customer tact time) or the design of one-piece flow production, present particular challenges for coordinating the cycles of workplaces and workstations. During balancing, the "circle times" of serially connected work stations are coordinated with one another taking account of technical circumstances. Work content must be assigned and aligned across the individual work stations in such a way that no substantial idle times occur at individual work stations and no staff or equipment is overloaded. Balancing losses and the effectiveness of the line are used as assessment criteria. Using the granularity MTM process building blocks facilitates the even distribution of work content across work stations.

5.5 Layout design (overall and single level)

The interaction of value stream mapping and MTM as tools for the design of methods at the single and the overall process level provides valuable information for the planning and design of layouts for workplace arrangement and workplace configuration.

5.6 Assessment of logistic processes

By applying the MTM process building block "logistics" essential pieces of information can be indentified/calculated on a reliable, standardised and retraceable base in the current status as well as in the target status. During planning future processes in particular, quantitative evidence about the target logistic efforts (such as transportation times, utilisation of internal logistic staff) can be estimated.

Applying MTM valuably contributes to the organisation, the design and the evaluation of logistic processes. Logistic issues in different areas of companies are characterised by comparable procedures with a significant level of repetitiveness.

Typical logistical procedures have been standardised and condensed into a process block system. It provides standards for the following logistical processes [8]:

- Transportation (procedures with different transportation vehicles such as forklifts, electric forklifts, manual lift trucks, trolleys)
- Manual handling (of cardboard boxes, containers, barrels of boxes, opening and closing of wrappings/packings, information processing (orders/receipts))
- Process blocks are also available for commissioning tasks.

Due to the arising necessity in a VSM analysis to evaluate the required logistic efforts it is highly recommended to enlarge the classical VSM by including additional logistical aspects.

From a logistical point of view MTM expands VSM by including the aspect of established time assessment. Special attention must be drawn to the fact that the logistic planning of transportation using different means of transport between stock and workplace can be achieved in both the current and the target status. MTM process blocks assume special importance in calculating box handling between means of transportation and supply areas (e.g. supermarket racks, flow racks) and further onto the workplaces.

6. Practical application: assembly workplace

In the initial situation, plastic jacks and their components are assembled in three assembly workplaces (pre-assembly, main assembly and packing). The target of this improvement project was to increase the output (to increase different aspects of productivity such as increased output, reduced inventory, increased area productivity) and to redesign the assembly workplaces based on lean and ergonomic principles (by applying VSM and MTM). This practical example also underlines the benefits presented in Table 2.

Based on combining VSM and MTM the proposed improvements, corrective actions and changes in the assembly workplaces and processes increased the productivity.

Reliable and evaluated figures of the improvement are the number of pieces (jacks and components) produced per shift and the reduction in the operating time (basic time) per piece.

The implemented layout of the assembly workplaces, the surroundings, the supply areas and the transportation flow is presented in Figure 4.

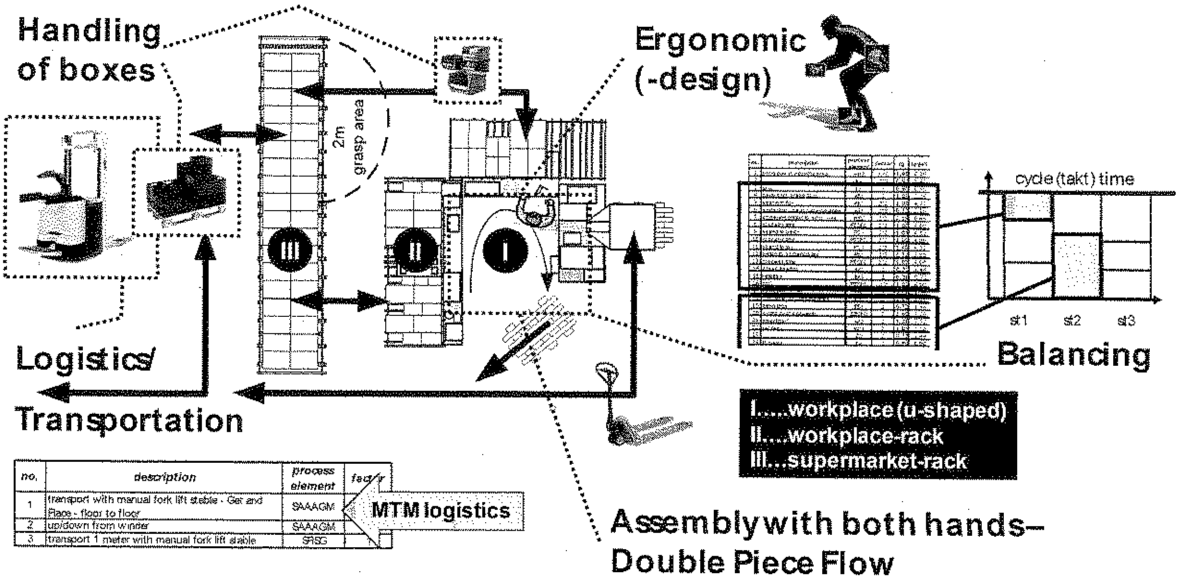

Fig. 4 Layout of a workplace, surroundings, supply areas and transportation flow considering the new design ideas

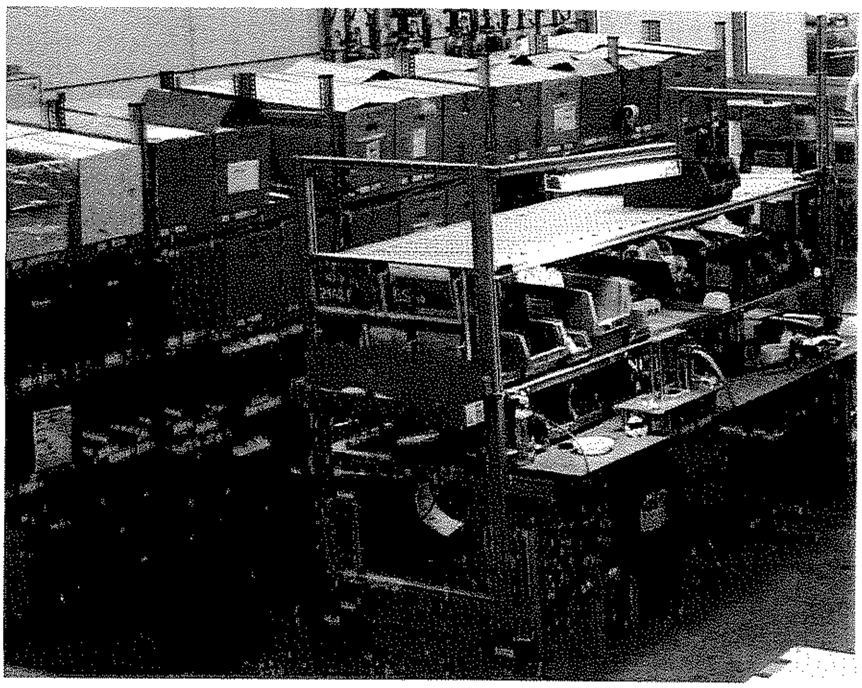

Fig. 5 Practical realisation of a workplace based on the joint application of VSM and MTM (e.g. supermarket rack and workplace)

7. Summary

The interaction of value stream mapping and MTM at different levels of detail consideration contributes to the identification, elimination and avoidance of waste, thus leading to the design of efficient and effective processes. The joint mutual benefit of the combined application arises from the increase in productivity, the standardisation of processes, the reduction in lead time/inventory and from the accurately determined times; it also enables and ensures the predictability and the capability to assess the target status.

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