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METHODS FOR DESIGN, ANALYSIS AND IMPROVEMENT OF LOGISTICAL PROCESSES

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Abstract: There are lot of tools and sophisticated methods for design, analysis and improvement of logistical processes. The author introduces the two most often applied methods, which are the lean– and the simulation methods. The paper summarizes the advantages of the lean philosophy which is a performance–based process used in manufacturing organizations to increase competitive advantage. The author defines the most typical wastes and emphasizes the importance of application of lean manufacturing, lean techniques and tools. Main steps of a lean project completed in an industrial environment are also introduced. The essence, the typical application fields and the main steps of a simulation process is also details and finally the advantages and disadvantages of simulation method are also introduced.
Keywords: lean tools, lean process improvement, simulation method, simulation process

INTRODUCTION

The world around us is a very complex and multi–parametric system, like the weather, traffic, operation of machines, production processes, etc. Understanding of the characteristics, operation and behaviour of these systems and processes is not easy due to their complexity. The design of optimal production procedures is an essential task for planners. The target is the increasing of the efficiency of the production and analysis of the effect of parameter changing. There are lot of tools and sophisticated methods for design, analysis and improvement of logistical processes. The author introduces the two most often applied methods, which are the lean– and the simulation methods.

LEAN BASED PROCESS IMPROVEMENT

Lean manufacturing is a performance–based process used in manufacturing organizations to increase competitive advantage in an increasingly global market. Nowadays this philosophy is applied in many sectors including automotive, electronics, white goods, and consumer products manufacturing, etc.

The focus of the approach is on cost reduction by eliminating non–value added activities. Originating from the Toyota Production System, many of the tools and techniques of lean manufacturing (e.g., just–in–time (JIT), cellular manufacturing, total productive maintenance, single–minute exchange of dies (SMED), production smoothing etc.) have been widely used in manufacturing [1,2].

In today's increasingly global marketplace, many manufacturers are adopting lean manufacturing practices in order to optimize quality and costs, thereby gaining a competitive advantage. The challenge to organizations utilizing lean manufacturing is to create a culture that will create and sustain long–term commitment from top management through the entire workforce. There are many literatures in topic of lean production principles and application of it [3,4,5].

Lean manufacturing techniques are based on the application of five principles to guide management's actions toward success [6,7,8]:

1. Value: The foundation for the value stream that defines what the customer is willing to pay for.
2. The value stream: The mapping and identifying of all the specific actions required to eliminate the non–value added activities from design concept to customer usage.
   2.1. Identification of wastes
   2.2. 5 Why
   2.3. Value stream mapping

3. Flow: The elimination of all process stoppages to make the value stream "flow" without interruptions.
   3.1. JIT
   3.2. One piece flow
   3.3. Takt time design
   3.4. Heijunka
   3.5. SMED
   3.6. Jidoka
4. Pull: The ability to streamline products and processes from concept through customer usage.
   4.1. Pull system
   4.2. Kanban
   4.3. Supermarket
5. Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.
   5.1. Standardization
   5.2. Kaizen
   5.3. 5S

Figure 1. The five principles to guide management's actions toward success [6,7,8]

All of processes can be categorized into three groups:
- » value added activities (e.g. manufacturing, assembly, …),
- » required but non–value added activities (e.g. exchange of die),
- » wastes are "any element that does not add value, or that the customer is not prepared to pay for" (e.g. over–production, transportation, …).

Several types of wastes can be identified in processes [6,7]:
1. Over production – Producing more final products than is needed or before it is needed for the customer is a fundamental waste in lean manufacturing.
2. Waiting – Worker or machine is waiting for material or information. Material waiting is not material flowing through value–added operations.
3. Motion – Any unnecessary motion that does not add value to the product is waste.
4. Transportation – Moving material does not enhance the value of the product to the customer.
5. Inventories – Material sits taking up space, costing money, and potentially being damaged. Due to stocks problems are not visible.
6. Over– processing – Extra processing not essential to value–added from the customer point of view is waste.
7. Producing defective products – Defective products impede material flow and lead to wasteful handling, time, and effort.
8. Other additional wastes – Underutilized worker creativity and resource, application of non-adequate equipments and systems, wasted energy and water, damage of environment.

Figure 2. Several types of wastes can be identified in processes [6,7]

These wastes are readily apparent in every manufacturing facility in the business world. Companies who identify, manage, and minimize these wastes are able to succeed the best in the very competitive marketplace.
A central element of the Lean philosophy is the relentless and systematic elimination of unneeded resources, or waste.
The basics of lean manufacturing employ continuous improvement processes to focus on the elimination of waste or non–value added steps within an organization and production.
The main tools and techniques of lean manufacturing are for example Value Stream Mapping, JIT, One–piece flow, Takt–time analysis, Heijunka, Single Minute Exchange of Dies (SMED), Jidoka, Pull system, Kanban, Supermarket, Kaizen, Standardized processes, 5S, Total Productive Maintenance (TPM), 6σ, Cell design and layout for flow (Cellular production, U–shaped cells), Flexible manufacturing system [9], Work group team error proofing, Zero defects (ZD), Station and operation process control, Error proofing (poke–yoke), Balanced flow–, Synchronous flow, Mixed flow lines, etc. .

Each of these tools and techniques focuses on certain aspects and areas of the manufacturing process in order to help improve costs and efficiencies at the company.
The lean manufacturing and a lean enterprise or business mean that the company is focused on supplying exactly what the customer wants, in the form they want it in, free of defects, at the exact time that they want it, with minimal waste in the process.

MAIN STEPS OF A LEAN PROJECT IN AN INDUSTRIAL ENVIRONMENT

The main steps of a lean project generally are the followings [10]:

» STEP 1: Determination of goals and objectives of the project, identification of obvious problems with the management

At first the most important KPIs (key process indicators) should be defined which should be measured at the beginning and which should be improved at the end of the lean project. The measurement of processes and activities by KPIs provides a basis for understanding performance capabilities and improvement opportunities [6].

» STEP 2: Choose the pilot pick an important product, product family, or customer

Pareto Analysis has to perform by volume (qty.), or by sales value in Euros, or by volume of scrap, by costs, by strategical customer, etc. Based on Pareto analysis 1 item should be chosen for study.

» STEP 3: Study and evaluate the pilot process

Value Stream Mapping (VSM) is a very efficient tool of lean philosophy for visually representing where wastes occur in the process [3]. Value Stream Map helps to visualize the flow of information and product, helps to see wastes, shows the relationship between information and material flow, and forms the basis for prioritizing lean actions.
The first step in creating a Current State Map (CSM) is to group and identify product families. The next step is to walk the process, collect data relating to the all of the manufacturing processes. The data relating to the different manufacturing processes should be collected and written into the map, inventory levels and process cycle times, along with changeover times also should be documented. Interview could be made by key people to identify key assumptions. The following engineering studies can be performed: capacity analysis, labor analysis, takt–time analysis, methods analysis, handling analysis, space analysis and value engineering analysis.
Based on analysis of CSM bottlenecks and wastes can be identified in the process. After it brainstorm can be realized with key personnel, short and long–term improvements should be documented, recommendations can be made and savings and benefits can be quantified. The suggestions should be presented to management for approval.
A Future State Map is then developed for the system with lean tools. The process of defining and describing the future state map starts while developing the current state map, where target areas for improvement start to show up.

» STEP 4: Operator training

Adequate key persons should be exposed to techniques of lean manufacturing. Expected savings and benefits should be emphasized.

» STEP 5: Pilot implementation, establishment of core project team for implementation

Project team and team leader should be selected, the project should be scheduled.

» STEP 6: Run pilot and refine

Pilot project should be run for process validation, personnel should be trained, suggestions and changes should be achieved. Adjustments should be refined and made if it is necessary. Opportunities can be identified for full implementation. Results of the project can be measured by the improvement of defined KPIs.

» STEP 7: Full implementation

Pilot project should be integrated into the total Lean Program. Goals and objectives of the total Lean Program should be defined, improvement and study areas should be identified. Expected savings and benefits should be defined and detailed engineering studies and analysis to include savings, benefits, costs and ROI (Return On Investment) should be performed. Current conditions and areas for improvement to eliminate "waste" should be documented, and the Project Team should be established and trained in the techniques and principles of Lean Manufacturing. Executive plan for each project should be developed, each project should be scheduled, monitored and measured after implementation. Necessary revisions and adjustment should be made to ensure success.
Advantages of lean based process improvement:

» Lean tools are easy to use due to their simplicity.

» Lean tools provide the possibility to gain a better understanding of the current production processes and to point out potential for improvement.
» Bottlenecks and wastes can be found easily.
» Most of lean tools and methods require only a pen and a single sheet, nothing more expensive equipment. (The value stream with the most important production parameters are sketched on–site by hand.)
» Use excellent visualization techniques, which support the transparency of the process and the optimal production design.
» The examined process can be visualized in the current state map and in the future state map.
» Lean method requires very little time effort.

Disadvantages of lean based process improvement:

» The examined process includes simplifications of the real process in order to manage the complexity of the real system.
» The whole system cannot be analyzed only a part of it.

SIMULATION METHOD FOR ANALYSIS OF LOGISTICAL PROCESSES

Analysis of complex systems can be carried out by the application of models. A model is a simplified representation of a complex real–world system and process in a mathematical system.

More and more information can be gained about the characteristics, operation and behaviours of a real system or process by analyzing and studying a model.

The simulation model "simulates" the analyzed complex system, in order to imitate its real behaviour. The model is able to take into consideration only the most important elements of the complex real–world system, so it is a little bit simpler compared to the real system. This simplification makes it possible to examine complex systems.

Simulation is an analysis tool for the imitation of existing or non–existing systems by the help of a model. The behaviour of the real system can be understood by the examination of the model. It is the most widely used tool for decision making. [11–13] VDI (Verein Deutscher Ingenieure, Association of German Engineers) Guideline 3633 [14] defines simulation as the emulation of a system, including its dynamic processes, in a model one can experiment with. It aims at achieving results that can be transferred to a real world installation. In addition, simulation defines the preparation, execution and evaluation of carefully directed experiments within a simulation model. [15]

Typical application fields of simulation are the followings:

» design and analysis of production systems,
» optimization of supply chains,
» design and analysis of traffic systems,
» analysis of military processes,
» examination of structures and structural elements, etc.

The most common application field of simulation software is the analysis of production processes. This is because of the following tendencies:

» production activities are very complex stochastic processes,
» customer demands are changing extremely fast, which results in
    Ξ changing of production volume,
    Ξ changing of product variety, or
    Ξ modification of the production process,
» the pressure of continuous cost reduction and efficiency improvement requires optimization and improvement of production activities.

Simulation can be applied, for example, when we have to…

» plan a new facility, or
» optimize an existing facility.

Simulation analysis of production processes is required in case of:

» deterministic processes of complex and big systems and processes;
» stochastic processes of systems and processes in which influencing events occur randomly [16].

Random events can be, for example: operational problems of machines, breakdown of material flow machines, lack of equipment or human resources, lack of component supply (supplier or transport problems), defects of control systems, etc.

Aims of simulation in the analysis of production or logistical processes:

» elimination of mistakes during the design of new complex production systems or material flow systems,

» comparisons of system variations,
» analysis of deterministic and stochastic processes,
» providing the possibility of bottleneck analysis,
» optimization of parameters of machines, processes and systems to increase efficiency,
» comparison of operation strategies,
» simulation of occurrence and elimination of abnormal system operation,
» examination of system parameters and influencing parameters, etc.

The main steps of a simulation process are the followings:

STEP 1: Preparation of the simulation analysis

» Identification and formulation of problems, determination of objectives of the simulation analysis

The first step of preparation of the simulation analysis is the identification and formulation of problems. After this, the objectives of the simulation analysis and the Key Process Indicators (KPI) to be improved should be determined. The most frequently used KPIs are: reduction of lead times, reduction of machine set–up times, reduction of stock, optimization of production areas, improvement of product quality and improvement of productivity.

» Process analysis, determination of parameters to be examined

Analysts have to define the parameters to be examined and their influencing factors should also be determined. During the process analysis the relation and functionality degree of parameters need to be examined and influencing factors should be determined.

» Determination of input data required for simulation, collection of real system data

The reliability of simulation results depends on the accuracy and reliability of data collected from the real–world system (e.g. production cycle times, volume of stock, distance of machines, etc.) [17]. These data are the input data required for the simulation.

» Formulation and development of a model

The next task is the formulation and development of a model that is appropriate to simulate the complex real process to be examined. The simulation model includes simplifications compared to the real process in order to manage the complexity of the real system. Finally model testing and validation will be completed or, if required, the original model will be modified.

» Working out operation algorithms

Operation algorithms of the production system should be elaborated and the appropriate subroutines should be developed.

STEP 2: Run simulation

The simulation run should be performed – several times, if required – by the application of different operation strategies, or different input data or system parameters. Results of the simulation run are the output data.

STEP 3: Evaluation of results

Results of simulation runs should be evaluated and analyzed. The conclusions drawn after the evaluation will be used for forming suggestions.

STEP 4: Making suggestions

Required system modifications should be defined based on the results of simulation runs in order to improve the values of selected key process indicators. Suggestions for real system modification should be formulated in the form of action plans. These plans should be implemented in the real system to achieve the improvement goals.

Advantages of simulation:

» Simulation can help to understand how the complex real–world processes operate.
» Simulation is the only appropriate investigation tool when traditional mathematical analysis methods are not available.
» It offers a good solution for examining complex systems and processes.
» The effects of modifying system parameters can be tested virtually, without disruption of a real ongoing process, so costs can be lowered or the chances of system failure can be reduced.
» The modification of an existing model or its parameters is easy, and a lot of newer model or system variations or operation strategies can be tested.
» Time can be compressed or expanded to allow for a speed–up or slow–down of the phenomenon, and long and short–term effects can be predicted.
» Bottleneck analyses can be performed.
» The examined system operation can be visualized with animated simulation.

Disadvantages of simulation:

» The usage of simulation software requires special expertise and competences.
» It is often expensive and time consuming to develop a simulation model.
» The simulation model includes simplifications of the real process in order to manage the complexity of the real system.
» An invalid model may result in incorrect results and conclusions.

CONCLUSIONS

Two often used methods for logistical process design and improvement were introduced in this paper, which are the lean and the simulation methods.

The paper summarized the essence and the 5 principles of the lean philosophy. Lean manufacturing techniques and typical wastes were also detailed. The author described the main general steps of a lean project completed in an industrial environment and after it the advantages and disadvantages of the lean method were introduced. The essence, the typical application fields, the main steps of a simulation process, advantages and disadvantages of simulation methods were also introduced.

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