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Wroclaw Centre
for Technology Transfer
Wroclaw University of Technology

UNIDO

Final Report

Subject

Project No. XP/RER/04/009 – High-Tech Regional Programme to increase Industrial E-productivity and Quality in CEE/NIS countries

E4PQ Programme
Area: Lean Manufacturing supported by e-technologies

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Introduction

This report describes the activities conducted by Wroclaw Centre for Technology Transfer WCTT of Wroclaw University of Technology within the programme "E-productivity and qu@lity e4pq" co-financed by UNIDO. The activities included trainings and pilot actions in the enterprises within the area of "Lean Manufacturing supported by e-technologies". The report is divided into seven parts. Part I "Lean Manufacturing supported by e-technologies" includes short description of Lean Manufacturing philosophy and its importance for developing economies. In this part the connections of Lean Manufacturing and e-technologies is clarified. At the end the goal for the project area "Lean Manufacturing supported by e-technologies" is defined.

Part II "Methodology of the project" explains the methodology chosen to realize the project. Part III describes the training "Lean Manufacturing Simulation" performed for 33 managers from several production SMEs. Part IV "Value Stream Mapping analysis in ASSO Filter" reports the analysis performed in ASSO Filter company to estimate the benefits of potential improvements after Lean Manufacturing implementation. Part V "Lean Manufacturing implementation in Inter Mind Wroclaw" describes the implementation actions conducted in Inter Mind company and the achieved results. Part VI "Dissemination actions" presents the activities undertaken to disseminate e4pq programme and achieved results. The last part of the report summarizes achieved results.

Realisation of the planned activities required substantial financial and human resources. Project personnel have been provided by Wroclaw Centre for Technology Transfer WCTT at Wroclaw University of Technology. The core part of the activities have been substantially supported by UNIDO (65% of core activities). The rest of the funds have come from the engaged SMEs. Core activities encompassed Lean Manufacturing Simulation training, Value Stream Mapping analysis in ASSO company and implementation activities in Inter Mind company. Some tasks have been financed by European Commission within the framework of LeanXeur project (survey about lean knowledge and access to e-learning technologies among SMEs in Poland as well as development of software modules for e-learning courses about Lean Manufacturing). Development of software applications necessary for implementation activities in Inter Mind have been financed by Inter Mind company itself.

PART I Lean Manufacturing supported by e-technologies

Lean Manufacturing is a worldwide proven approach for the improvement of production processes through eliminating wastes. The results are better quality, lower costs, and shorter lead-time. It also includes decreasing manufacturing lot sizes, which allow enterprises the ability to reach a higher level of flexibility [Wo96].

"Lean" philosophy is still successfully exploited in industry, although it has been known for 30 years, first in Japan as Toyota Production System [Sh89] and then in '90 in USA and other countries. It does not mean that requirements for production have not changed. On the contrary, nowadays the business environment changes dynamically and forces enterprises to react faster and faster to these changes.

One of the major recent changes is the application of e-business solutions. E-business encompasses a set of ICT solutions, as well the ideas based on extensive exploitation of wide area networks (including *internet*) to support business processes. It includes also activities within the supply chain. Generally "e-business" gives the potential for better flexibility of the production enterprises, and more collaborative way of co-operation, or in broader perspective for managing the whole supply chains.

Most "e" solutions being currently developed for production enterprises base on ERP and SCM schemes and are not applicable for "Lean" value adding chains. Example could be distributed supply chain made of independent organizations. SCM systems provide functions for centralized planning or for paperless order realization. Assumption is that SCM system alone, thanks to intensive information exchange through wide area networks WAN, could improve some crucial performance measures (e.g. inventory levels in Distribution Centre). On the contrary "Lean Manufacturing" focuses on shop floor – to - shop floor communication, and exchanging simple data like "electronic kanbans". It assumes also that only better communication system within supply chain is not enough to improve such measures as total lead time or cost per unit. Firstly the internal production system of companies participating in supply chain have to be changed. Then the logistics system between companies shall to be improved. All the changes will result in the new information flows. In consequence a new "e" business solution for "Lean" supply chain have to follow all the above mentioned changes.

Taking into account the outlined problems the analysis will be performed according to the following questions:

- What are the elements of nowadays environment which decide how production enterprises work?
- Is Lean Manufacturing applicable concept for production value adding chains in such environment?
- Are the available e-business solutions applicable to "Lean" value adding chains ?
- How to create e-business solutions for "Lean" value adding chains ?

This part of the report is based on the experiences from the projects and consulting provided by the Wroclaw Centre for Technology Transfer WCTT to the Polish enterprises and international companies investing in Poland [So02] [Na02] as well as on the other published sources [Jo02] [Fe02].

The business environment of the production enterprises

In Europe, as well as in the whole world, manufacturing enterprises have been suffering from growing pressure to cut the costs and improve flexibility. The first issue is crucial for manufacturing companies, especially if the product is not complex and its market value is easy to evaluate (e.g. suppliers in automotive industry). The flexibility mentioned above could be defined in two ways:

- The narrow sense of flexibility means shorter production lots and bigger variety of products and, in consequence, better reactiveness on the market demand in short term (the key issue here from the shop floor perspective is short lead time).
- The broader sense of flexibility means the ability of fast introducing the new products to the marketplace and, in consequence, better reactiveness on the market demand in long term (it sets the strong requirements for production system as well as for the product development process /including research/, design and production preparation).

Next important issue of today's business is to see production from the perspective of the whole value adding chains, not only the single enterprise. This means optimization of the business processes performed between co-operating enterprises. It could be seen from the simple supplier-customer relation point of view, as well as from the whole value creating stream point of view, beginning at the raw material tier, through components suppliers, to the final assembly and further to the distribution. Anyway the optimization of the supply chain has to be supported by improvement actions in the single enterprises.

In the result production companies have to cut the costs and improve the flexibility. Additionally they have to implement more collaborative business models with their customers and suppliers. The goal is still to lower overall cost and improve flexibility within the whole value adding chain. It could not be forget that quality is also important but it is rather prerequisite to stay in business and not the competitive advantage.

The concept of Lean Manufacturing

The Lean Production expression was first introduced by an M.I.T. international team of researchers, who carried out the International Motor Vehicle Project, which studied world-wide auto production. The findings of these studies were published in 1990 in the book "The Machine that Changed the World". The book gave the following characteristics of Lean Manufacturing:

> *it "uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours, to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site [and] results in ... fewer defects..."*

An important milestone in the understanding of Lean Manufacturing was the publication of the book "Lean thinking" [Wo96], by the same authors. The book stated that Lean Manufacturing principles could be applied to any industrial sector (not only to automotive), and in different cultural environments (not only Japanese). In the book the main principles of Lean Manufacturing were defined:

> *"precisely specify **value** by specific product [from the customer point of view], identify the value **stream** for each product, make value **flow** without interruptions, let the customer **pull** value from the producer, and pursue **perfection**"*

A key issue in Lean Manufacturing is contrasting value added activities with wastes. The activities the customer is willing pay for have value adding characteristics (e.g. machining, painting, designing the product, payroll processing). If an activity adds no value, then it is waste. Taiichi Ohno, the main designer of Toyota Production System identified 7 forms of waste: overproduction, inventory, correcting defects or errors, unnecessary processing, unnecessary movement of material, excess motion, and waiting. This list should be completed with the most dangerous waste: lost of creativity. In conventional plants only about 15-20% of process steps contain any value added activities. In most factories, the value added time is less than 0.2% of the total time material is in the factory. A lot of wastes mean high costs, and also long lead-times, that eventually cause long delivery time. Eliminating waste leads to improvements in both costs and lead-time. So waste elimination is crucial for competitive advantage.

The first step in waste elimination is the understanding of the Value Stream and learning how to apply the method called Value Stream Mapping. The Value Stream is all activities (both value added and non-value added) from raw material through delivery to the customer, involved in the production of product or product family. Value Stream Mapping is a method that helps to see and understand the flow of material and information as a product makes its way through the value stream [Ro99]. Mapping the value stream means following a product's production path from customer to supplier, and carefully drawing a visual representation of every process in the material and information flow (fig.1).

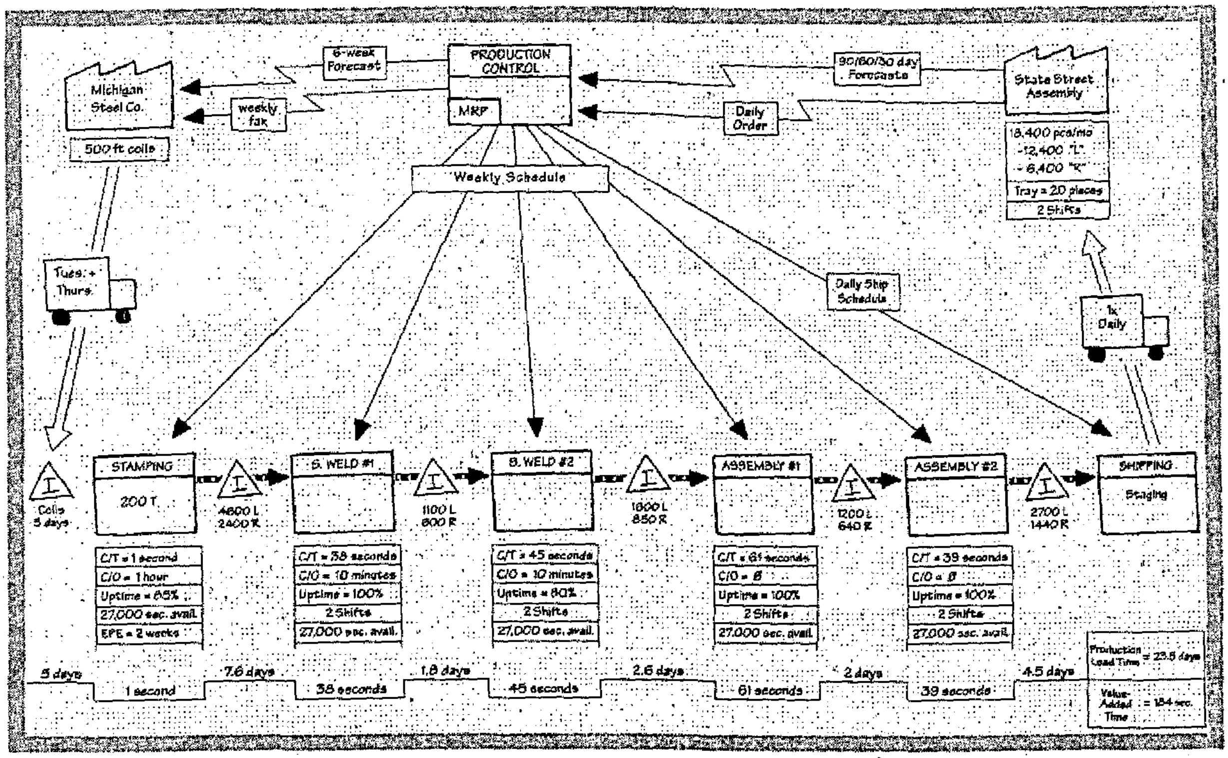

Figure 1. The sample of current Value Stream Map according to [Ro99].

The current value stream map forms a basis to implementing different lean manufacturing methods, tools and approaches (Table 1) as well as to draw the future state map.

Table 1 Lean Manufacturing methods, tools and approaches

Cellular Production / Layout planing	**Quality @ the source**
Total Preventive Maintenance (TPM)	**Andon control**
Visual Control	**5 S**
Continuous flow / One piece flow	**Mistake-proofing (Poke-yoke)**
Pull system	**Continuous Improvement / Kaizen**
Kanban	**Standardised Work**
Takt time / Cycle Time	**Employee empowerment**
Just In Time	**Team work**
Production Levelling / Mixed product	**Internal supplier-customer**
Set-up reduction (SMET)	**Process orientation**

Taking a value stream perspective means analysing and improving the big picture not just individual processes. Many managers trying to implement lean principles, learned that optimising a single part of manufacturing system did not lead necessarily to improving the overall performance of the company.

Several companies who implemented Lean Manufacturing philosophy achieved essential improvements in various performance indexes:

- Decreasing the lead time from weeks to days (70% or more)
- Reducing inventories 50% or more (RM, WIP, & FG) while increasing customer service levels

- Increasing capacity 50% or more in current facility
- Maintaining or increasing throughput.

The Lean Manufacturing can be seen as journey or process of change from traditional manufacturing to highly reactive, customer oriented and therefore competitive manufacturing. This journey goes through waste reduction and continuous improvement guided by value stream mapping. The process of transition should be facilitated and made safer through people empowerment, skilled technical implementation and risk reduction (Table 2).

Table 2 How to facilitate and make safer the transition process toward LEAN

Employee empowerment	Technical implementation	Risk reduction
Extensive training (lean concept, Kaizen, empowerment, ongoing reinforcement) **Kaizen Improvements team** **Improvement: Everyone's Job** **Suggestion/Implementation system** **Workstation/Cell improvement** **Visual/Andon control** **Multiskilled members in Workteams** **Open communication**	**Value Stream Mapping (VSM)** **Continuous product flow** (through: physical rearrangement e.g. cells, Material handling solutions, System structure & control mechanisms) **Single–piece flow/small batches (min. WIP)** (through: set up time reduction, preventive maintenance, orderly, clean work place) **Pull production / JIT inventory control (min. RM & FG)**	**Phased implementation** **Benchmarking against others in Industry** **If consultants support – carefully choice** **Road Map:** **- changes driven by VSM results** **- big hits first** **- save time & capital** **Computer simulation to predict performance before implementation** **Use combination of both employee empowerment and proper method, tools & techniques**

Is "Lean" suitable for nowadays business environment?

The basis of "lean" is to find and eliminate waste. This very simple idea contains several concepts, which built the "lean" strategy (see [Wo96]). The main notion is "takt time". This means the period of time in which (statistically) the customer buys one product. So to react on customer's needs the company should produce one product within every takt time. Again it sounds simple, but to apply this concept to a complex production system could be a challenge. The understanding of the importance of takt time is first step to gain main goals of "Lean" which are:

- short lead time,
- high quality,
- low inventory level,
- large variety of products,
- low cost.

These goals are strongly related one to another. Short lead time usually depends on the level of WIP. Product variety depends on set-up times, but also on lead time (short lead time allows the ability to produce to demand). Finally the costs depend on the quality, inventory level, and lead time (more detailed analysis of these relations is presented in [Sl95]) . This description of "lean" is simplified but gives overall understanding of where to go.

The "Lean" philosophy has to be evaluated from the business environment requirements point of view.

Lower Costs

Reduced costs are a main result of eliminating wastes. In a lot of cases after implementing "Lean" the companies lowered the unit costs by dozens of percent. It is usually the result of reduced inventories (raw materials, WIP as well as finished goods), less machine down times (thanks to Total Productive Maintenance – see [Si92]), shorter lead time, producing "on time", rather than "on forecast", lower quality costs (thanks to the quality at the source rule) and better workers assignment.

Better Flexibility

The growing variety of products generates more inventories in all areas – finished goods, WIP, raw materials (or components). To avoid increased inventories, enterprises have to produce "just-in-time", and/ or to improve forecasting. "Lean Manufacturing" focuses on the first approach. Producing large variety of products on time requires very short lead time, and very effective scheduling and control system for the shop-floor. It encompasses the next key technique of "Lean" – visual control. The known examples from the industry show that inventories could be reduced by up to 80% and the same with lead time [Sh89][Fe02]. Of course it depends on each particular case, but usually the reduction is significant.

Next, the flexibility of production system is related also to the ability of continuous improvement. "Lean" realizes it by team work and exploitation of worker's creativity on each organizational level (Kaizen [Im97]).

Focus on the whole supply chain

Building a close "win-win" relation between partners of supply chain is the base of the "Lean" concepts. But to improve the whole value adding chain, first the participants have to achieve internal readiness. Internal readiness is usually seen as an ability to exchange data between internally integrated IT systems. Actually the main focus of readiness is on the production system and not exclusively on information flows. An example could be a customer that requires frequent deliveries in small transport batches, "just-in-time". The supplier could profit from such requirements, if he had a flexible production system. Otherwise he will need to increase the finished goods inventory and finally to manage the higher costs. Similar situations could be described for the bigger chains of several co-operating partners.

"Lean" is seen today as very useful concept to address key problems which production companies have to manage: lower costs, improved flexibility as well as high quality level.

Are "e" solutions applicable for "Lean" companies and their value adding chains ?

To optimize the whole value stream, one of the key issues is the information flow and processing [Ko01]. It means the flow among the enterprises. This is obvious that exchanged data has to be previously captured and processed inside the enterprises. That is why the performance of the IT system for the supply chain is strongly dependent on the internal IT systems of the companies participating in the chain.

E-business gathers many tools and concepts based on *internet* network or generally on latest ICT solutions. We can enumerate many business processes recognized as reasonable to be supported by *e-business* tools:

- Customer relationship management (advertisement, service, sales, collecting marketing data, pricing),

- Electronic exchange marketplaces (goods exchange between enterprises, searching new business partners, information flow between members, auctions and customer's auctions),
- Product development (concurrent engineering, engineering data exchange, project management in distributed team),
- Supply chain management (collaborative forecasting and planning, forecasts back propagation, paperless order realization, *Available-To-Promise* technique, order realization tracing).

Below some examples will be given that shows the potential of "e" solutions to address the issues of lower cost and improved flexibility.

Lower Cost
Realization of a closer customer-supplier relationship like CPFR (Collaborative Planning, Forecasting and Replenishment [Vi99]) or VMI (Vendor Managed Inventory) has a positive impact on such measures like inventory level, forecasts accuracy, and order realization time. All of them have a positive impact on the product costs, and for e.g. on opportunity loss. Of course the closer collaboration in forecasting, distribution, production planning and control requires "e" solutions to capture appropriate data (e.g. on the inventories in the particular warehouse), aggregate them and exchange within the chain.

Flexibility
ICT technologies and particular *internet* network gives the possibility to build very flexible, re-configurable and relatively cheap applications for supply chains. It means that potentially these applications could follow the changes in the structure of the supply network. It is crucial to create flexible organizational structures like "virtual enterprises" [Mu99] [Me98]. This is also obvious that "e" applications enable organizations to perform product development processes in a distributed environment according to concurrent engineering concepts, which is crucial to reduce "time-to-market" and consequently to improve flexibility in a broader sense.

Software providers offer a lot of e-business applications like SCM systems, CRM systems, ERP systems, "e" marketplaces.
Several of the above listed processes are aided by IT solutions available in the marketplace. Among them most popular are CRM systems, SCM systems, and some functions of the latest ERP systems, and *e-marketplaces*. In the following analysis, only the SCM and ERP systems will be considered from the perspective of the production area. Both solutions derive the MRP or APS (Advanced Planning and Scheduling) planning approach both for single enterprise and supply chain (for examples see [Le02][Ro00]). For distributed (made from independent companies) supply chains, the systems provides the paperless purchase/sale functions which improves purchasing/sale processes between supplier and customer however the process is still performed outside of the shop-floor (through purchase/sales departments) and basing on forecasts and medium-term plans (MRP planning procedure). For distributed production sites of one corporation the centralized planning procedures are implemented which often concentrates on accumulation of production lots according to the EOQ rule.
Lean Manufacturing, as was mentioned in section 1 of this paper, focuses on direct shop floor – to - shop floor communication. The data exchanged are very simple. The single kanban card means that customer needs one bin of particular components in the next several hours (for discussion on "electronic" supplier kanban see [Jo02b], [Lo97]). The optimization of the "Lean" supply chains encompasses making leaner the participants and then the whole value adding chain. It encompasses decreasing the lead time in the companies as well as decreasing the transport batches and increasing the replenishment frequency in the supply chain (e.g.

through implementation of milk run replenishment loops [Jo02b]). It results in decreased overall lead time and improved flexibility of the whole value chain and is in the opposition to the concept of EOQ and accumulated orders.

To recapitulate the e-business gives real potential to implement Lean Manufacturing within value adding chains however the current solutions provided by IT vendors does not suit "Lean" requirements. In the next section the analysis of information flows in "Lean" enterprises will be performed. On this basis the approach to create of e-business solutions for "Lean" value adding chains will be proposed.

Information flows in the "lean" enterprise and value adding chain

To define requirements for information systems in the "lean" value stream it is necessary to analyze the production process, production planning, and control within the single enterprise and the whole value adding chain. The first step is to map the value stream within single enterprise. The main result is the future state map (fig.2).

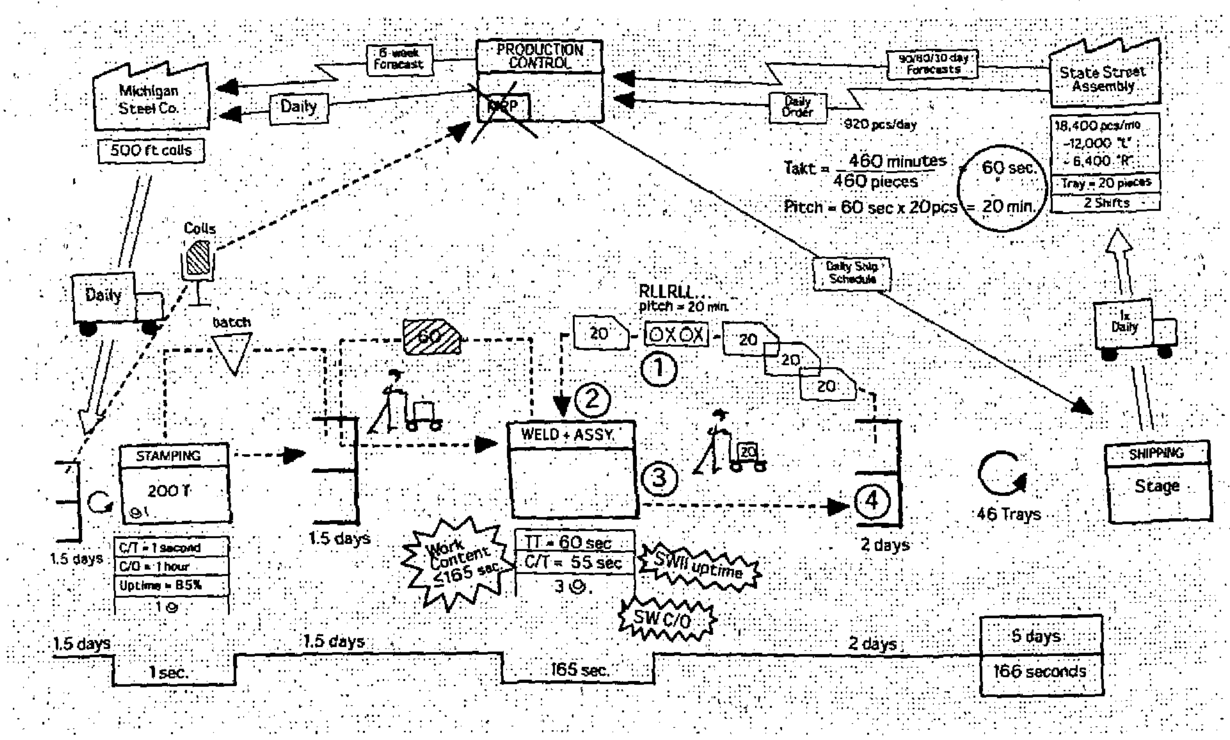

Figure 2 Future state map - example [Ro99].

In the presented example the pace of production is given by shipping area. The production takt time and the sequence depend on the customer's demand, and are set by Production Planning. This is opposite to classical MRP algorithm where the production schedules are made according to forecast, over a longer time period and based on economical order quantity (EOQ). In the system shown on figure 2, the goals for planning and control process are short lead time, low inventories, and increased reactiveness on changing demand. Consequently the planning is oriented on the shipping area. From this point the replenishment signal is propagated back using kanbans and supermarkets. How production control is performed in the system? The material flows between the welding&assembly cell and the stamping is controlled by a supermarket, which has minimal-maximal levels of WIP for components. The average level could be calculated. It represents the component inventory needed for particular

time of production (e.g. an hour). For products sold rarely both levels could be set to zero and special kanban card or visual signal could be used.
The scheme of the material flows and production control through a supermarket is as follows: taking the bin of components is signaling the previous cell to produce them, and after some time the components are replenished in the supermarket (which is also a signal not to produce them in that moment).
In the case of very expensive components, or when the variety is large the broadcasting technique is suggested (fig. 3).

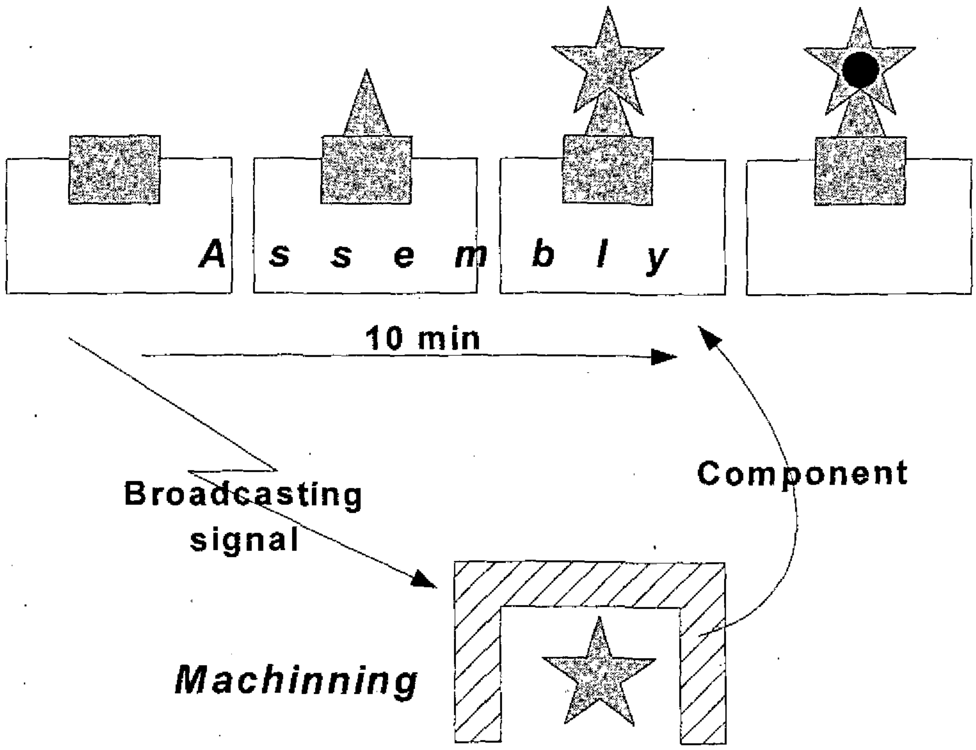

Figure 3 Broadcasting technique in lean manufacturing.

In the areas of production system where continuous flow was implemented the information flow is very simple. All the workplaces within the cell produce one part in the same pace and every event is immediately visible for the operators. Here the big difference between MRP and Lean approaches can be seen. In the "lean" production system the scheduling is really performed in time units like minutes, tens of minutes or hours. In fact as a base scheduling value the processing time of one unit is used. In a MRP driven production system batch processing time is used and it includes also the machine set-up times. However even in such factories operators see the importance of processing time of one unit. This could be noticed when producing the lot of the products taking several weeks, but in some urgent cases producing the short batch of that products is made within several days.
The perspective of the whole value adding chain could be analyzed using Macro Value Stream Mapping. The example shown in figure 4 includes car distributor, producer, and the value adding chain for the car wipers. Like previously, the focus is on the short logistics lead time, low costs (what means also the low level of all the inventories) and high reactiveness on the market demand for the final product.

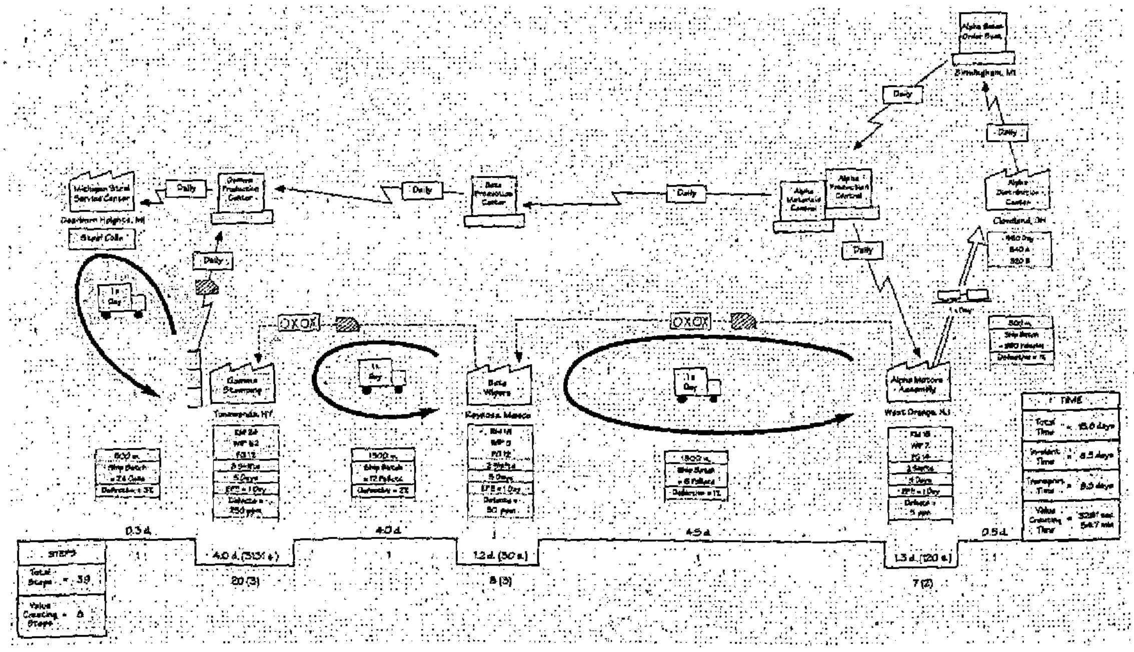

Figure 4 Macro Value Stream Map - example [Jo02b].

In the upper part of the map the information flows are shown. As could be seen on the figure the pace maker for the whole value adding chain is the car assembly company (*Alpha Motors*). It receives the information from the distribution network and defines the daily schedule for its own shipping area. Also the demands are sent to *Beta Wipers* and then upstream to the raw material suppliers. In fact the production scheduling and control in the value adding chain uses the kanban technique. The "electronic kanban" is implemented here. The component bin taken from the inbound area of the customer is electronically scanned, and the signal is sent to the suppliers shipping area via wide area network. There the electronic message could be changed into a paper card put in the heijunka box. Thus the simple information controls the replenishment cycle within the whole value adding chain. Electronic kanban could also initiate the payment between co-operating parties. Unfortunately the offered SCM systems follow rather a different direction. The focus is in the paperless ordering process or logically centralized planning procedures.
It has to be underscored that the structure of the information system in fig.4 is part of the overall optimization strategy focused on shortening of overall lead time, and decreasing production lots in the co-operating factories (e.g. through set-up time reductions) as well as among them (e.g. through milk run replenishment loops in transportation). It should not be forgotten also that the activities on the strategy level are more like a "win-win" orientation in customer-supplier relationship.

The goal for "Lean Manufacturing supported by e-technologies" area of E4PQ project

E4PQ project is focused on Small and Medium Enterprises SMEs. The "Lean Manufacturing supported by e-technologies" area is dedicated to improve internal production processes of SMEs to achieve productivity improvement. The problem is that such companies lack of the knowledge from both Lean Manufacturing and e-technology areas. The latest e-solution for production enterprises are too expensive for most SMEs. But from the other side large companies, like e.g. Toyota (see [Se05]) criticize the usage of advanced IT solutions in production area and implement more effective manual methods for such processes as production control, interruptions management or work-in-process inventory control. Wroclaw

Centre for Technology Transfer proposed to combine lean philosophy with IT solutions to create very simple, cheap but effective production organization methods for SMEs. The general rule is to simplify information exchange procedures instead of automating the existing, but complex and not efficient information flows. The practice proves that in many cases, especially in SMEs, the automation of existing information flows by usage of complex IT systems of ERP or SCM class is too expensive and does not result in radical productivity improvement. On the contrary simplification of the information flows using simple lean techniques and basic office applications (such as MS Excell or MS Access) gives surprisingly good results of productivity increase. Such approach was used in chosen Polish SME - Inter Mind company. The results of implementation actions are described in part V of this report.
The goal of the "Lean Manufacturing supported by e-technologies" area has been defined as below:
"To improve productivity and quality of production SMEs by implementing modern lean manufacturing tools and simple, but effective IT solutions."

Implementation of lean manufacturing concept in SME requires transferring expert knowledge to the company. Usually it is realized through consulting companies. High consulting rates are usually the barrier for SMEs. To eliminate this problem WCTT research team concurrently conducted research on developing effective e-learning courses with interactive content for managers of SMEs about Lean Manufacturing. This works have been financed by European Commission within the framework of "Lean across Europe LeanXeur" project. The second goal of realized activities was:
"To develop effective e-learning tools about Lean Manufacturing for SMEs to minimize the need of consulting services during implementation process."
The result of this part of activities is described in appendix A.

PART II Methodology of the project

The project activities have been divided in 3 parts:

1. Survey about consciousness of Lean Manufacturing and e-learning tools among Polish SMEs.
2. Lean Manufacturing Simulation warkshop for 33 managers of SMEs.
3. Analysis of the chosen enterprise using Value Stream Mapping method.
4. Implementation of the Lean Manufacturing tools in chosen enterprise.

Objective of the first task was to contact 20 Polish SMEs and indetify their needs according to the productivity improvement based on Lean Manufacturing methods (see Appendix A). The goal of the second task was to train a group of managers and owners of Polish SMEs in the area of Lean Manufacturing. From this group of enterprises two companies were chosen for implementation actions. The first company was ASSO Filters in Ostrow Wielkopolski. This company begins the process of lean implementation. That is why the first step there was the analysis of the current state and designing of the future state (after reorganization) using Value Stream Mapping method. Basing on the results of the analysis the lean tools were recommended for implementation. These tasks belonged to the third part of the project. The second company Inter Mind in Wroclaw started lean transformation 2 years ago. During e4pq project the next phases of lean implementation were conducted to gain more benefits from the lean tools. Because ASSO Filter did not decide to implement recommended lean tools the financial resources planned for implementation actions were used to widen the scope of implementation actions in Inter Mind.

PART III Lean Manufacturing Simulation Training

Workshop Overview

Lean Manufacturing Simulation is a licenced version of the training developed within the Centre for Robotics and Manufacturing Systems, University of Kentucky with support of Toyota Georgetown Plant – a major US-based divison of Toyota Motor Corporation. Simulation is a powerful hands-on approach designed to familiarize manufacturers with the concepts and benefits of lean manufacturing, the philosophy of efficiency that, when implemented, shortens the time between customer order and shipment by eliminating waste. The training provides participants with overviews, case examples, in-depth information in key areas, and team interaction make this a powerful, two-day session that gives the participants much more than just theoretical knowledge. Participants will actually feel the effectiveness of lean manufacturing and learn how lean manufacturing elements can be incorporated into their future work environment.

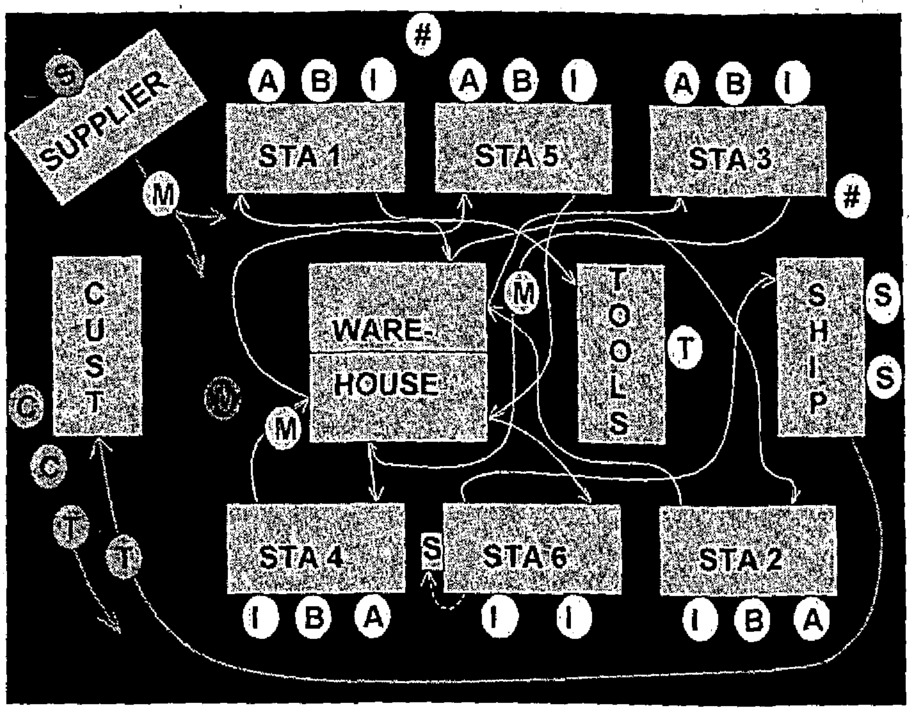

Figure 5 The layout of the simulated factory during first simulation round.

Manufacturing a product on a simulated factory floor in several intensive rounds, they'll be able to see, feel, and measure the effects of different lean manufacturing principles as each is incorporated into the process. These principles include concepts such as built-in quality, visual control, just-in-time, pull system, work levelling, continuous improvement, and teamwork. Following performance indexes will be measured during the simulated work-shift: direct and overhead costs, WIP costs, defects costs, material costs, product cost, lead-time, and customer satisfaction. After completing the simulation, participants will be able to differentiate between a push and a pull system, list the eight wastes that must be eliminated to make the manufacturing process lean; explain how those wastes reduce a company's profits; explain the kaizen process, understand how a kanban works, and make more effective use of the employees that become available through waste elimination.

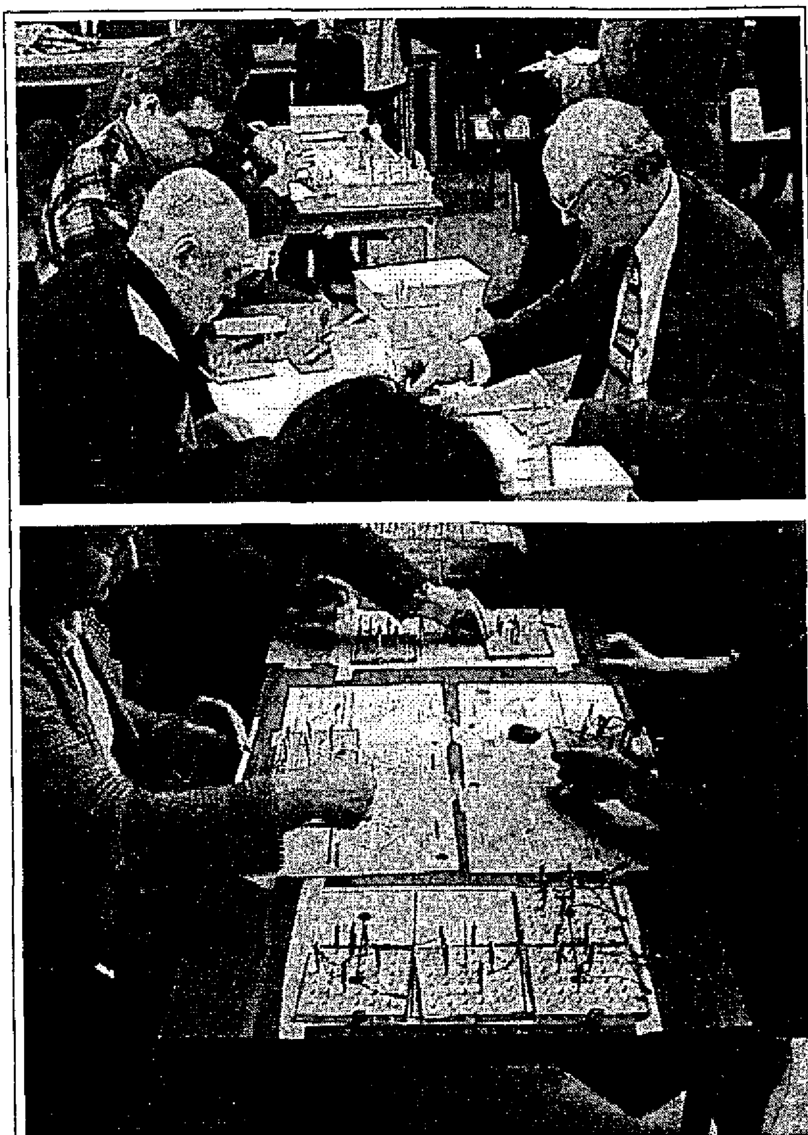

Figure 6 Participants during simulation round.

Lean Manufacturing Simulation is designed for:

- senior manufacturing executives/managers
- operating managers
- manufacturing engineering managers
- materials and/or quality managers
- first level supervisors
- manufacturing or industrial engineers
- training managers
- shop-floor operators

Program

It takes two days to perform Lean Manufacturing Simulation. The following table presents training agenda.

DAY ONE
Round 1
Roots of Lean Manufacturing **Value added activities versus muda (waste)** **Conventional manufacturing system**
Round 2
Kaizen **Visual Control** **Parts flow**
DAY TWO
Round 3
Quality at the source **Standardized work** **Pull system, kanban** **Continuous improvement**
Round 4
One-piece flow **Work balancing** **Built-in quality** **Build-to-order**

Realisation of the Lean Manufacturing Simulation training within e4pq project

Lean Manufacturing Simulation were advertised through the web-pages of Lean Manufacturing Program (www.lean.org.pl), Wroclaw Centre for Technology Transfer (www.wctt.pl) and leaflets sent to 500 companies. The leaflet is shown in appendix B.
The training took place in Wroclaw Centre for Technology Transfer on 18-19 October 2004. Thirty three owners and managers from Polish SMEs took part in the simulation. Appendix C includes the list of participants. During the training representatives of several companies were discussing the possibility of beginning the implementation actions. Two companies decided for further cooperation ASSO Filter and Inter Mind.
The materials provided to the participants during the simulation are presented in Appendix D.

PART IV Value Stream Mapping analysis in ASSO Filter

Overview of Value Stream Mapping tool

Value Stream Mapping VSM is a tool to analyse and improve the production system according to the Lean Production principles. VSM is based on the tool called mapping the material and information flows, used in Toyota company, for continuous improvement on the factory level. VSM has been elaborated as a systematic method for enterprises, to recognize the current state of the production system, identify the wastes and propose the changes. The method was published in 1999 by Lean Enterprise Institute (M.Rother, J.Shook, "Learning to see") and during next years have been used successfully in thousands of the enterprises worldwide.

VSM helps to select the *right* areas to improve, in the *right sequence* and the *right* tools, in the *right sequence*, to achieve the benefits for the production enterprise as a whole.

What is the value stream?

Value Stream encompasses *all the actions (both value added and non-value added)* currently required to bring a product **from raw materials to finished product**. Value Stream perspective is the "big picture" from door (raw materials) to door (finished products), not the single process. The reason is to avoid the risk of optimizing the single process without the benefits for the production system as a whole. The map contains the delivery conditions from the suppliers, all the steps made in the factory to deliver finished product, and the conditions of shipment to the customers. Map includes **both the material and information flows**.

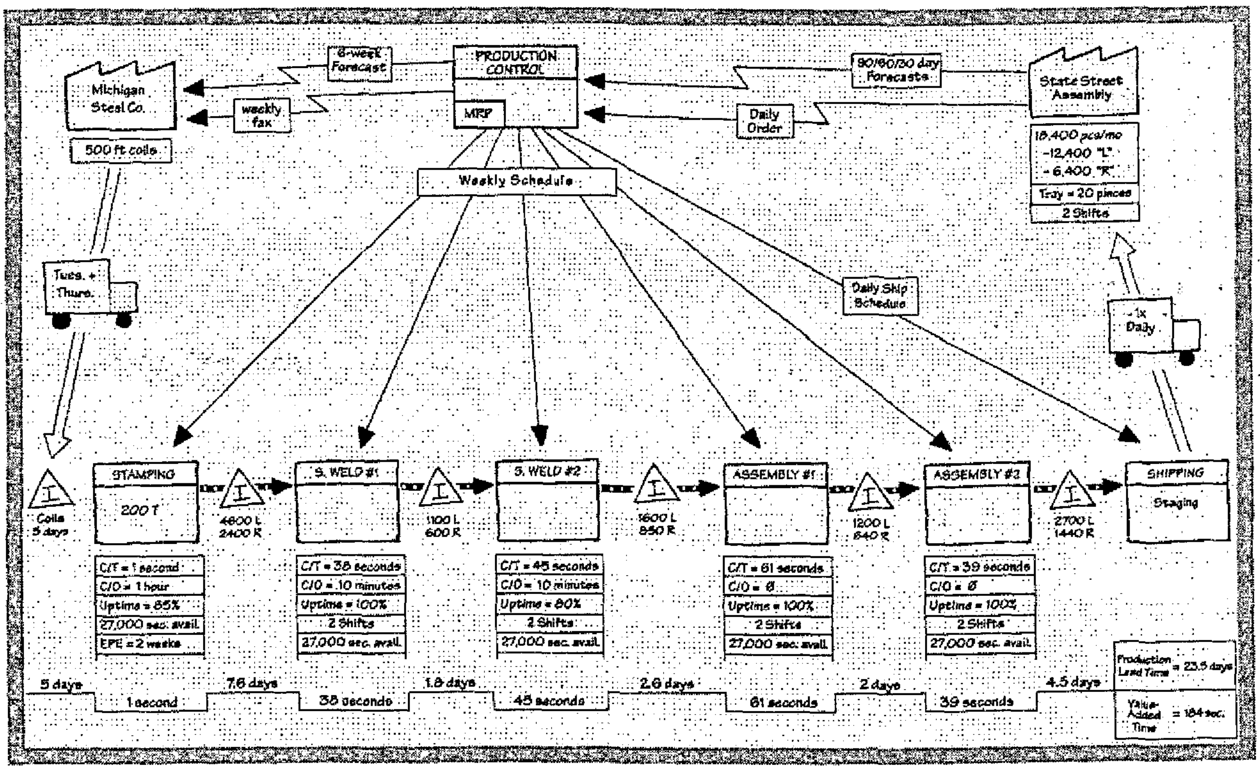

Figure 7 Value Stream Map - the current state map, an example [Ro99].

Value Stream Mapping - A Method

Value Stream Mapping is a pen and pencil tool used directly on the shopfloor, to understand how the flow of production really looks like. The mapping is done by the managers and operators facilitated by the experts. They follow a product's production path from beginning to end, and draw a visual representation of every process in the material & information flow. Creating the first map – Current State Map (see fig.7) – they use as much as possible the data measured directly on the shopfloor not taken from the engineering documentation or ERP system. The next step is the creation the future state map by identification and elimination of the wastes. The future state map is created in systematic way by answering the set of questions and implementing the lean principles – continuous flow and pull system, using the lean tools (production cells, supermarkets, FIFO queues, production leveling, production control at pacemaker, quality at the source, Kaizen, SMED, TPM etc.). The potential benefits are evaluated using such measures as Lead Time, Cycle Times, RM/ WIP/ FG inventories, processing times, batch sizes etc. The example of future state map is presented in the fig.8.

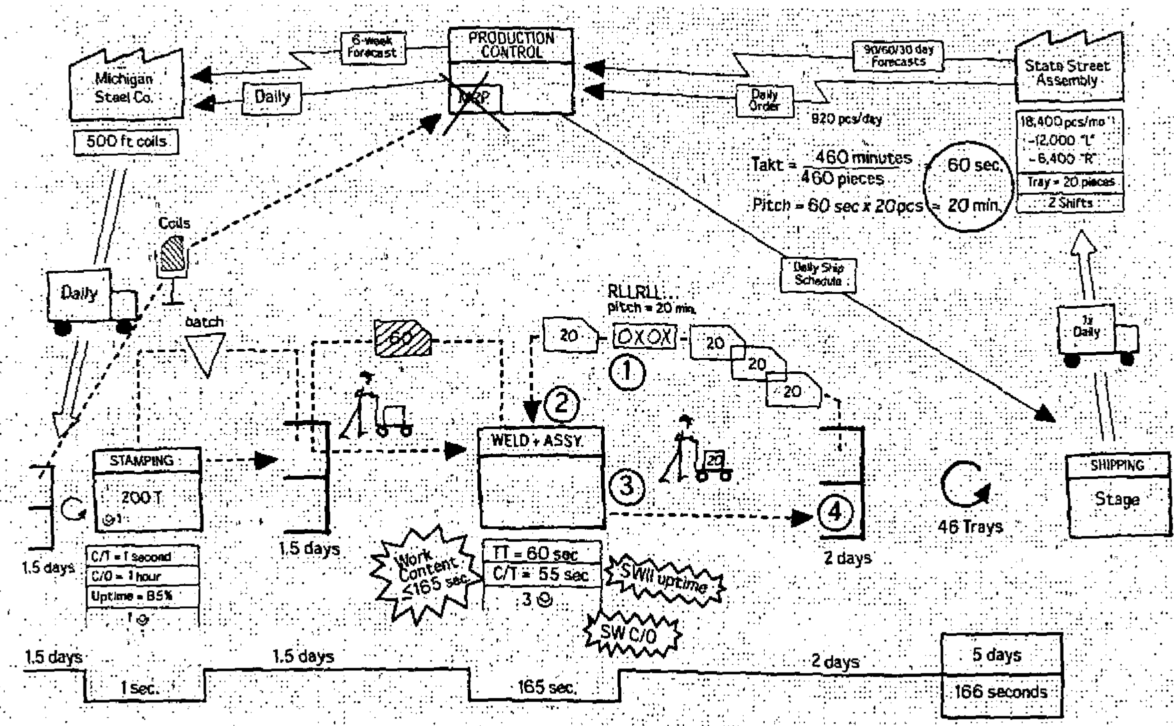

Figure 8 Value Stream Map - the future state map, an example [Ro99].

The mapping process ends with elaboration of the implementation plan and assignment of the responsibilities to the defined tasks.

Value Stream Mapping – a Workshop

Company usually starts using VSM method during 2 days workshop led by experts experienced in this method and in Lean Manufacturing concept. The role of the experts is to teach the participants how to map and to facilitate them during their first mapping in the company. The workshop gathers usually 8-12 staff members mostly from production but also logistics, purchasing and sales departments. The workshop agenda is presented in the table 3.

Table 3 The agenda of the Value Stream Mapping workshop.

DAY 1
Lectures: Introduction and Value Stream Map of the current state.
Exercise: Drawing the current state map for the simple example.
Mapping the current state for the chosen product family within the company.
DAY 2
Lectures: Implementing Lean Manufacturing in the company, creating the future state map of the Value Stream.
Exercise: Drawing future state map for the simple example.
Creating the future state map on the basis of current state map made during DAY 1.
Preparing the implementation plan.
(Optionally: presenting the results to the company director)

VSM in a nutshell:

- Pen and paper method.
- Gives a clear view of the whole value stream - "door-to-door".
- Common language for the employees of different levels and areas to share their knowledge about the production processes.
- First step of introducing "lean" flow of materials and information.
- Easy to learn and use.
- Helps to improve the production system in systematic way.
- Focuses on the elimination of non-value added steps.
- Helps to select the right areas of improvement and the proper tools to gain the benefits for the production system as a whole.

VSM Workshop objectives:

- To learn the concept of the "lean" flow of production and the potential benefits of implementing it.
- To learn the Value Stream Mapping method – lectures and exercises.
- To map the Value Stream in the company for the chosen product family.
- To learn how to see the wastes in the Value Stream, how to eliminate them, and how to create the future state map.
- To design the future state map for the value stream of the chosen product family.
- To recognize problem and obstacles for implementation of the future state, propose the solutions.
- To elaborate the plan of implementation of the future state.

Value Stream Mapping in ASSO

ASSO Filter was founded almost 100 years ago by Spitalniak family in Ostrow Wielkopolski (south-western Poland). At the beginning company produced wheels for carriages. In 70s ASSO begun to produce filters for cars. Now company provides filters as spare parts for different car models for Polish and foreign marketplaces. ASSO employs about 100 workers.

Products made in ASSO are divided into 3 product families: oil filters for cars, air filters for cars, and air filters for paint shops. For Value Stream Mapping analysis the oil filter product family was chosen. Oil filters are fabricated in several production stages: paper bending, sheet metal cutting, threading the bottoms, stamping, painting, and assembly.

The Value Stream Mapping analysis was performed in ASSO in the form of 3-day workshop (22-24 January of 2005). During first day the owners of the company as well as about 15 workers received the lecture about Lean Manufacturing. During second day WCTT consultants provided introduction to Value Stream Mapping method and then the group started to draw the current state map.

The mapping team was divided into two groups. The first one analysed the main value stream. The second one analysed the sub-stream of bottoms. The bottom is one of the three main components of the product beside filter insert and housing.

Drawn maps are shown in the fig. 9 (main stream map) and fig. 10 (sub-stream of bottoms).

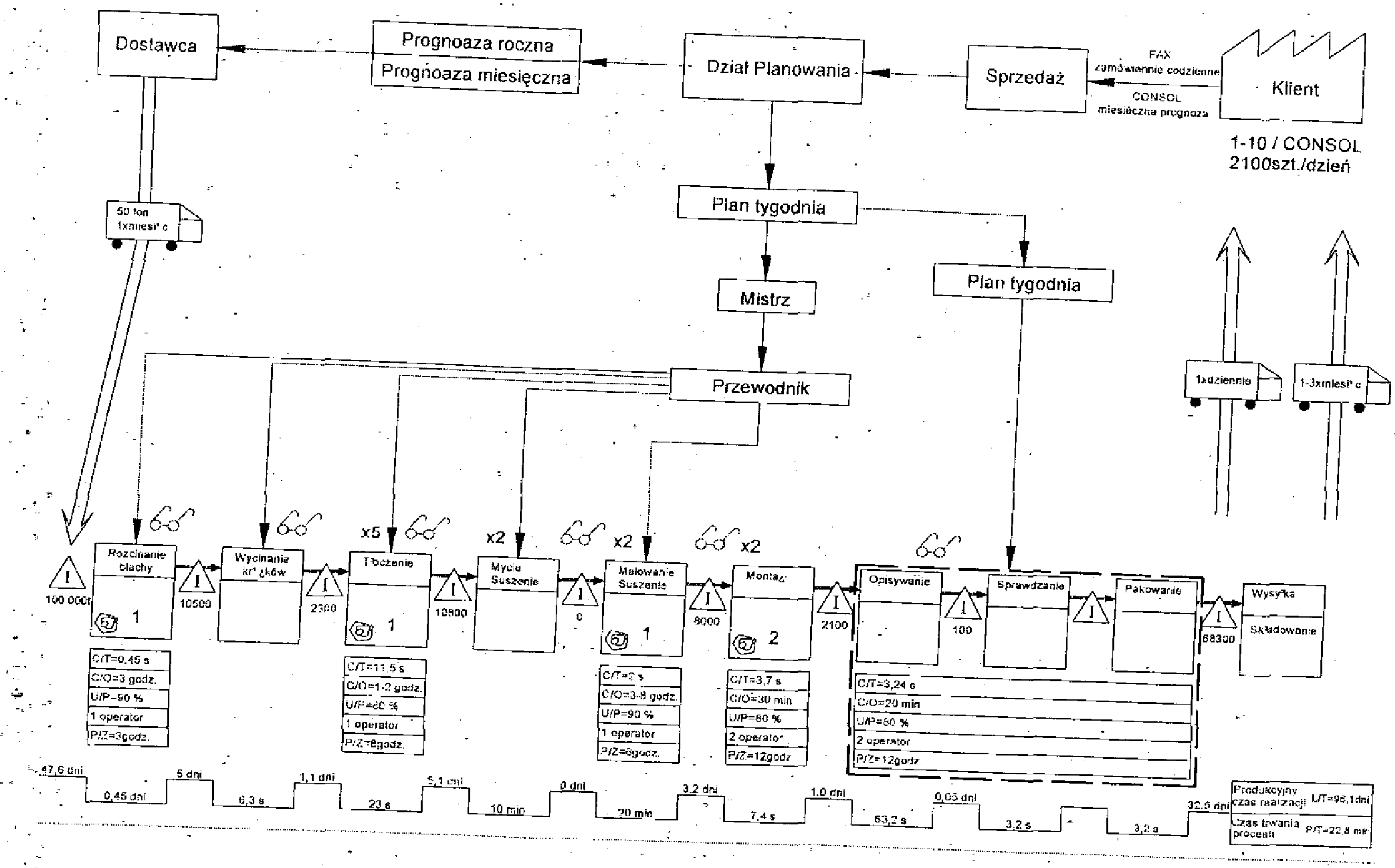

Figure 9. The current state map of main value stream map of oil filters for cars in ASSO Filter.

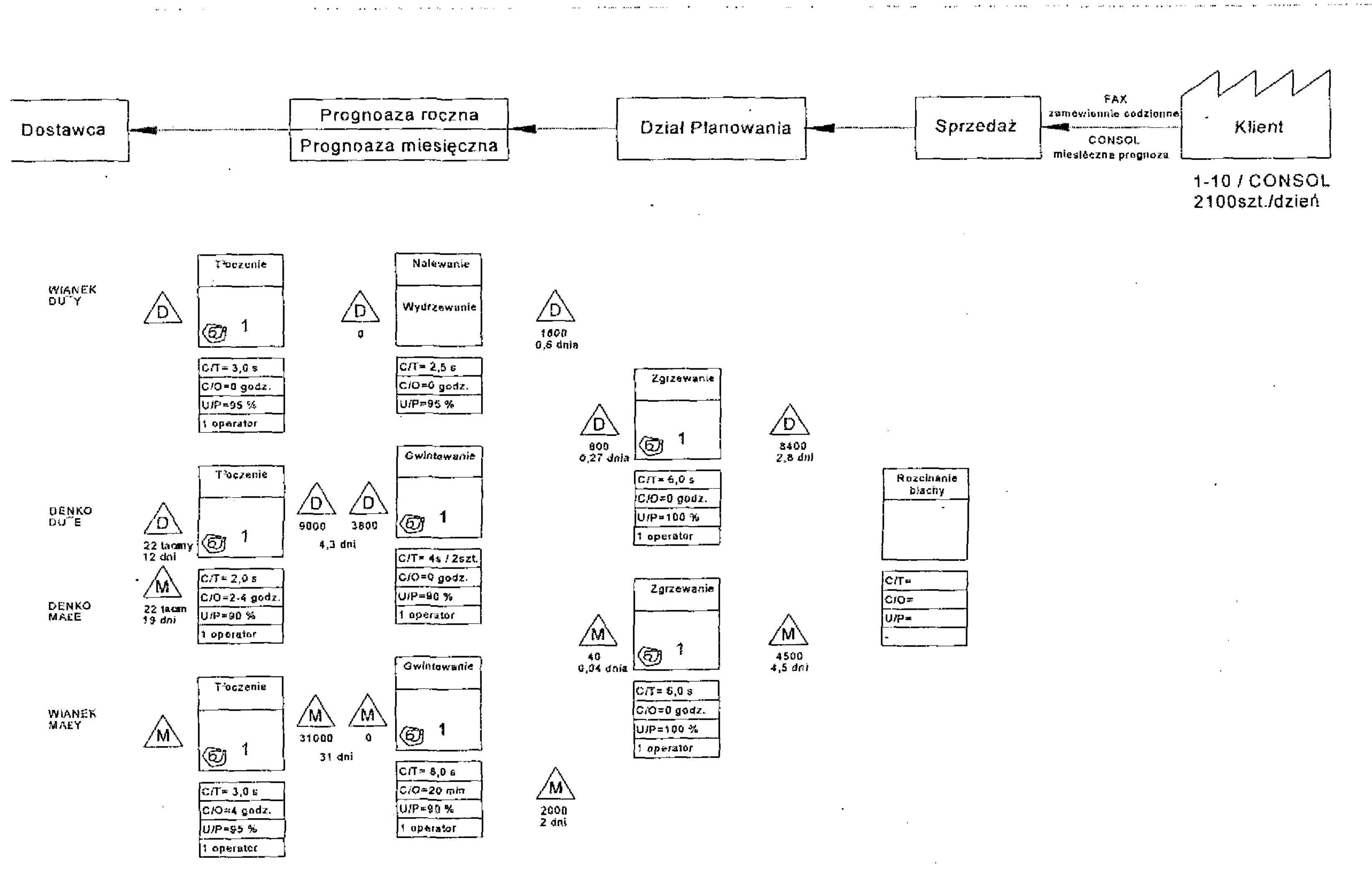

Figure 10. The current state map of sub-stream for bottoms.

The current-state maps exposed several problems of the company. It was measured that total processing time for the main stream (fabrication of housing and assembly) is only 22,8 minutes but the overall lead time L/T=96,1 days. In other words value adding activities constitutes only 0,05% of total time material spends in the factory. The rest 99,95% is waste. Meaningful part of this waste has to be eliminated. The raw material inventories found were very high (47,6) days. Also work-in-process inventory was considerably high, e.g. it was 8,3 days of inventory between stamping and assembly. But surprisingly although inventories are high they do not hold the right components for assembly and often assembly has to change its schedule because of lack of housings needed to realize the original schedule. This situation decreases productivity of the assembly process. Additionally it was found that the work content of the assembly workstations is not balanced. When some stations can not produce on time, the other ones make overproduction. The balancing of the workstations for the whole assembly process could improve productivity of the process significantly.

The third day of the value stream mapping was dedicated for creation of the future state map. This encompasses designing the changes basing on the current state maps and using the lean tools. The team chose the main stream for the first phase of the Lean Manufacturing implementation and future state mapping focused on this area. After introduction provided by consultants form WCTT the team started to design future state according to the future state questions elaborated by John Shook and Mike Rother (see [Ro99]):

1. What is the rate of demand (**Takt Time**) ?
2. How much does demand vary (produce **to buffer or „to order"**) ?
3. Where and how can You combine operations to create the areas of **continuous flow**?
4. Where and how have You to install **„pull mechanisms"** to connect continuous flow areas together ? (use **supermarkets or FIFO**)
5. Which one and only one process will receive the schedule? (chose **pacemaker**)
6. How You will filter orders and **level the production**?
7. How can you increase the frequency of production to make smaller batches of each product in line with demand? (define **the production pitch**)
8. What **improvements** are required to reach the future state, how to implement them?

At the end of the day the mapping team elaborated the future state map for the main stream of oil filters shown in the fig.11.

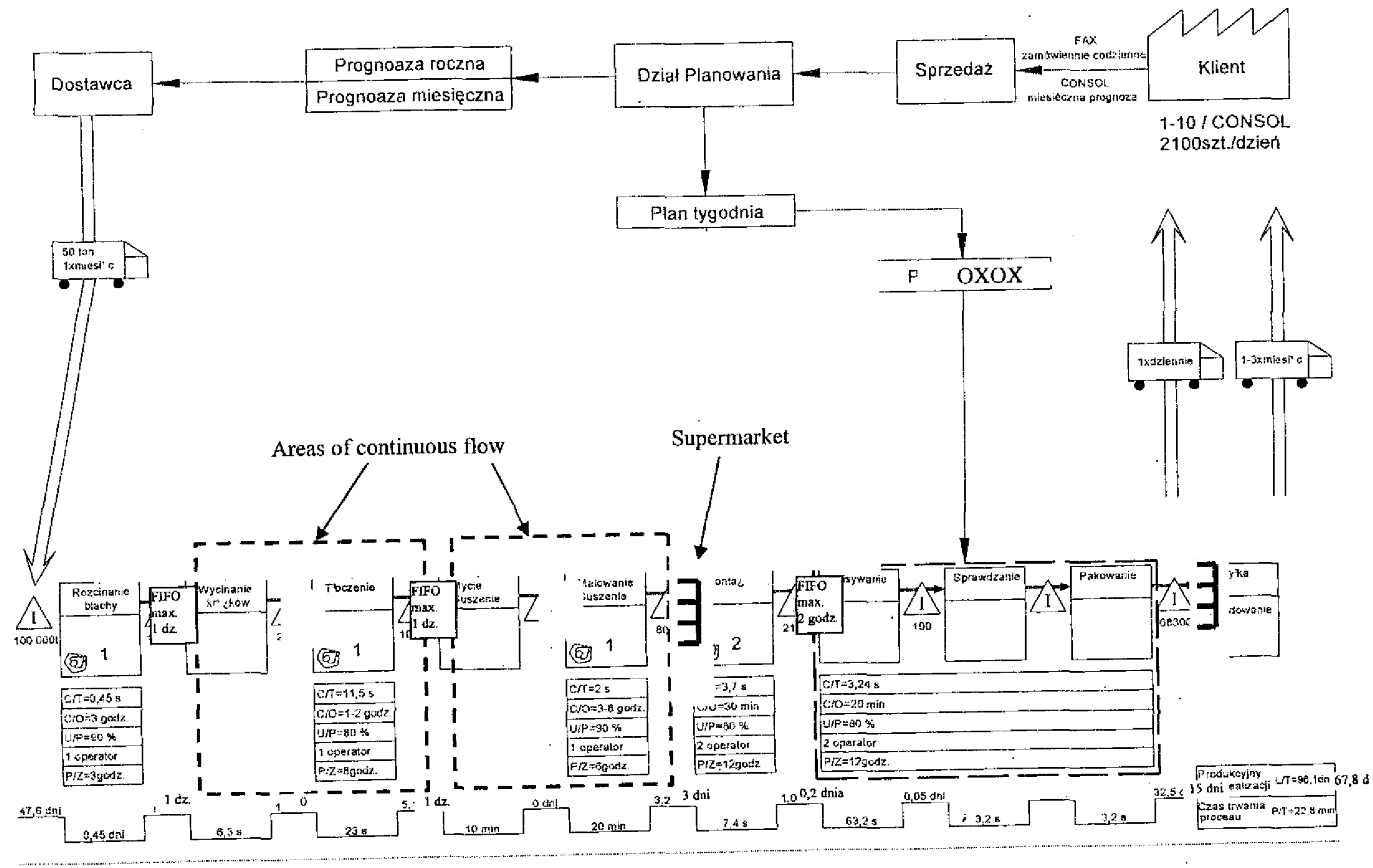

Figure 11. Future state map for main stream of oil filters after proposed changes.

The changes proposed on the future state map encompassed:

- implementation of the new continuous flow areas: cutting+stamping, cleaning+painting,
- implementation of the pull system within the whole stream using supermarkets or FIFO queues,
- implementation of the leveled schedule for assembly, assembly was chosen for a pacemaker, the only point of the value stream which receives the schedule,
- work balancing for the assembly and packaging line.

The potential benefits were estimated basing on the future state map:

- reduction of the lead time L/T from 96,1 to 67,8 days (29% reduction),
- reduction of work-in-process inventory from 15,45 to 5,25 days (66%),
- improvement of assembly line productivity by work balancing and providing components on time using pull system by about 20%.

The materials for VSM Workshop provided to the participants are attached in Appendix E. ASSO Filter after internal discussions among owners and managers did not decide to realize the implementation actions planned after Value Stream Mapping analysis because of lack of the resources (implementation team). The resources available within e4pq project for ASSO project were relocated and used to broaden the scope of project in another company Inter Mind (see next part of this report.)

PART V Lean Manufacturing implementation in Inter Mind Wroclaw

Inter Mind company was founded in 1988 by two Polish entrepreneurs. Currently company employs 110 employees and gains turnover of 40 mln PLN. Company produces cartridges and accessories for computer printers under the trademark BlackPoint and is one of the leader in the Polish marketplace. The vast number of cartridges is produced by utilization of used cartridges, which are de-assembled, cleaned, assembled and packed. Last years company increased its sales in the foreign marketplaces.

Recently company observes growing number of domestic and foreign competitors as well as higher customer expectations according to the product variety, product price and quality as well as service level. To react on these requirements company begun to seek for better production organization methods. The efforts of improving effectiveness undertaken in Inter Mind in last years are shown in the fig.11.

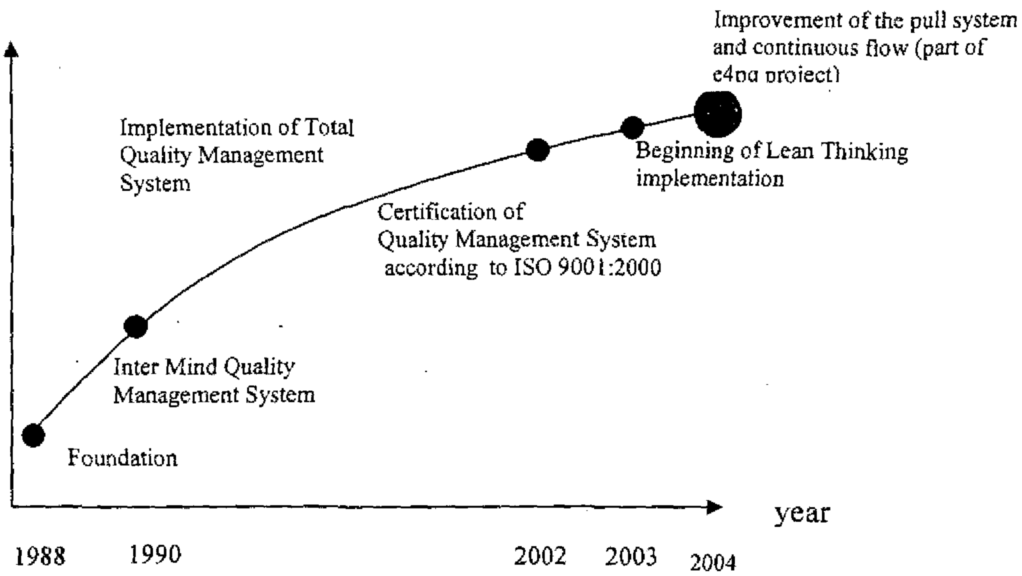

Figure 11. Inter Mind's pathway of organizational improvement.

The first step was the implementation of own, internal rules of quality management for products and processes. This encompassed strict procedures for internal processes as well as standardized methods of cartridge testing according to the standard STMC (Standardized Test Methods Comity). The final step of building the quality management system was certification according to ISO 9001:2000 standard. In 2003 Inter Mind begun implementation of the first elements of Lean Manufacturing System. The company performed Value Stream Mapping analysis and implemented the first version of the pull system for finished goods working with experts from Wroclaw Centre for Technology Transfer. In 2004 company joined e4pq project and started to work on implementation of the other lean tools such as continuous flow, standardized work, visual control, production according to the pitch and improved version of pull system based on kanban cards and demand leveling.

Lean Manufacturing implementation actions before 2004 year

At the beginning of 2003 the management board of the company decided to start implementation of „lean management" philosophy. The first step was to train 33 staff members by the trainers from Wroclaw Centre for Technology Transfer WCTT during the workshop called Lean Manufacturing Simulation. There were representatives of all the functional areas of Inter Mind among the participants of the workshop. The main objective of the training was to familiarize and convince employees to the concept of Lean Management to ensure the engagement of all the departments during the process of implementation. The next step was Value Stream Mapping workshop conducted in Inter Mind to analyse current state of the production processes and design the future state. During mapping process three value streams were identified:

- Laser printer cartridges,
- Ink printer cartridges,
- Ink tapes.

Then for every value stream the current state map was drawn for both material and information flows from „door-to-door" perspective (from raw materials to finished goods). The analysis were performed by Inter Mind's managers and engineers supported by the consultants from WCTT. During analysis main improvement areas were identified, potential benefits were evaluated and future state maps were drawn. These maps became the basis for creation of the implementation plan. The complexion of the planned actions forced the implementation team to divide implementation plan into several projects and start with more important ones, which focused on the laser cartridge value stream (the stream with the biggest sales volume). The main objectives of the implementation actions were:

- Reduction of the finished goods inventory level, reduction of the required storage area, and improvement of the cash flows through the changes of the information flows;
- Reduction of the lead time, product quality improvement, reduction of the required production area, and improvement of the production system flexibility through the changes of the material flows.

The pull system as key element of Lean Manufacturing

Most of the actions undertaken in Inter Mind before year 2004 focused on implementing pull system for finished goods. Pull system differs from traditional system based on Enterprise Resource Planning software (often called push system). In the pull system particular production cell does not receive any production schedule from planning department. Instead it receives the replenishment signal from the next process and produces small batch of products according to this signal. There are two kinds of pull system:

- replenishment pull system (often called supermarket pull system), which is used for repetitive production,
- sequential pull system (often called FIFO queue), which is used for high mix production.

Inter Mind decided to implement supermarket pull system for its finished goods. To implement such kind of system the kanban cards are used. The concept of supermarket pull system and kanban card circulation is shown in the fig. 12.

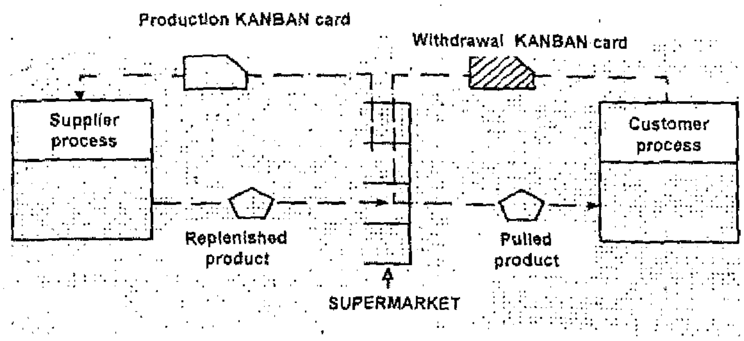

Figure 12. Supermarket pull system.

Customer process maybe internal process, e.g. assembly line, and supplier process maybe e.g. machining cell. When customer process needs a container of particular parts for production it takes the container from the supermarket using withdrawal Kanban. Every container in the supermarket has the production Kanban card attached. Material handler, after receiving withdrawal Kanban from customer process (e.g. from assembly operator) goes to the supermarket at looks for the parts specified on the Kanban card. Then he takes the container from supermarket, takes the production Kanban off the container and places it in the Kanban box. Then he attaches the withdrawal Kanban to the container and moves the container to the customer process. After some time production Kanban cards from the Kanban box are taken by the material handler responsible for moving parts from supplier process to the supermarket. Then production Kanaban card are brought to the supplier process (e.g. machining cell) and becomes the new production order for supplier process. To summarize supermarket works according to 2 rules:

1) Customer process takes from supermarket what he needs and when he needs.

2) Supplier process replenishes only this, what has been taken from supermarket.

In Inter Mind supermarket was implemented between production process (supplier process) and external customers (customer process). Kanban cards were only implemented virtually in the computer system.

Implementation actions

On the basis of the implementation plan the Manager of Laser Printer Cartridges worked out the detailed action schedule. The main tasks and results measured after completion of the tasks are given in the table 4.

Table 4. Main tasks of the implementation and their results.

Task	***Status at the beginning of 2003***	***Status at the beginning of 2004***
Changing the production planning system	Planning performed once per 2 weeks based on the forecast	Planning performed every day using kanban signals according to the real market demand (finished goods inventory reduced)
Changing the production scheduling procedure	Weekly schedule	Daily schedule based on replenishment kanban signals
Reduction of finished goods inventory	18 days	9 days, 50% reduction calculated in money
Shortening time of moving goods from production shop floor to the finished goods warehouse	1 day	4 hours
Elimination of some activities: - material inspection after receiving,	First inspection after receiving in the warehouse, second inspection during material movement to the shop floor and third one before execution of the production order.	Inspection in the warehouse and before execution of the production order.
- foil packing of the cartridges	Foil packing of every product.	New packaging does not require additional foil package for every product.

Changing the layout of the shop floor	Layout not efficient	Implementing of continuous flow for pre-assembly process, implementing FIFO queues between pre-assembly and assembly as well as between assembly and packing. Elimination of the material transport on the shop floor, reduction of work-in-process inventory, simplification of the production process.
Increasing material delivery frequency	Deliveries one per 1-3 weeks	Deliveries one per 1-2 weeks. Improved flexibility, faster replenishment of materials.

In the beginning of the 2004 year all the tasks were completed. The great leap was the implementation of the pull system for finished goods in the form of supermarket. From this time production was not planned according to the weekly forecast but according to the daily replenishment signals from the supermarket. Production started to replenish only what was taken from the supermarket by the shipping department. The time of finished goods movement from the production shop floor to the finished goods warehouse (supermarket) was reduced. The inspection of the raw materials during movement from the warehouse to the shop floor was eliminated. Earlier this activity took the material handlers 2 hours every day. The frequency of material deliveries for the production process was increased after detailed cost-benefits analysis. This improved the availability of the components for the production process.

Product family of laser printer cartridges was carefully analysed to elaborate new procedure of production order executions. In the result the new algorithm of order execution was established to react on real, daily market demand and not, as it was practiced earlier, to follow uncertain weekly forecasts. Also the analysis was performed to determine the possibility to reduce production lots for all the produced types of cartridges. The goal was to minimize production lots because the size of the lot is crucial factor influencing the level of inventories. Then the new system of order scheduling was built based on the kanban system, where one kanban card represents one lot of particular type of products sold. The new system allowed the constant number of kanabn cards for particular type in use. Kanban cards might be in finished goods warehouse or in the production area. The number of kanabn cards determined the maximal work in progress inventory. The system allowed to add or withdraw the kanban cards according to the changing external and internal conditions. The kanban cards were implemented only virtually in the computer system. Every day sales were analysing the number of sold products of particular type. Daily sales was divided by lot size to calculate the number of virtual kanan cards which had to be released for production. This was done by Logistics department. This department additionally had to balance production volume and adjust it to available daily capacities. The result of that changes was the reduction of finished goods inventory by 50% (in value).

Lean Manufacturing implementation actions within e4pq project

In June 2004 representatives of Inter Mind management board met with representatives of UNIDO and WCTT during IV Lean Manufacturing Conference. The sides found out further possibilities of improvements in Inter Mind and the chance that the company could be good example for other SMEs from central and eastern Europe.

At the beginning the results of previous improvement was reviewed and then the next possible improvement areas were defined:

- Planning process based on virtual kanban cards reduced finished goods inventories but still required significant planning effort which increased lead time by 3 days. It was found that planning process might be simplified and shortened.
- The time of assembling the lot differs between different operators because of the lack of standardized work. This affects negatively workcells productivity.
- The production lead time is still too long because of long assembly lead time and too long FIFO queues between deassembly and assembly.
- The production status is controlled every shift which is too rarely to react quickly on the problems. It was recommended to implement hourly production boards and visual control.
- Poor organization of the material delivery process from the warehouse to the production cells. Materials moved in daily lots, material handlers overburden in the morning and underutilized in the afternoon. It was recommended to balance work of material handlers and reduce the quantity of materials provided to the cells by the usage of milk run concept.

Production and planning processes before beginning implementation actions within e4pq project

Production planning process

The level of finished goods inventories is determined for longer period for every type of product to ensure optimal rotation of the products according to the sales and lead time. The production lot size equals to the one kanban card and may be different for different product types. The available workcells capacities are defined. Logistic specialist analyses daily sales recorded in the internal computer system (warehouse management system). Basing on these data specialist moves kanbans on the warehouse-production board (see fig.13).

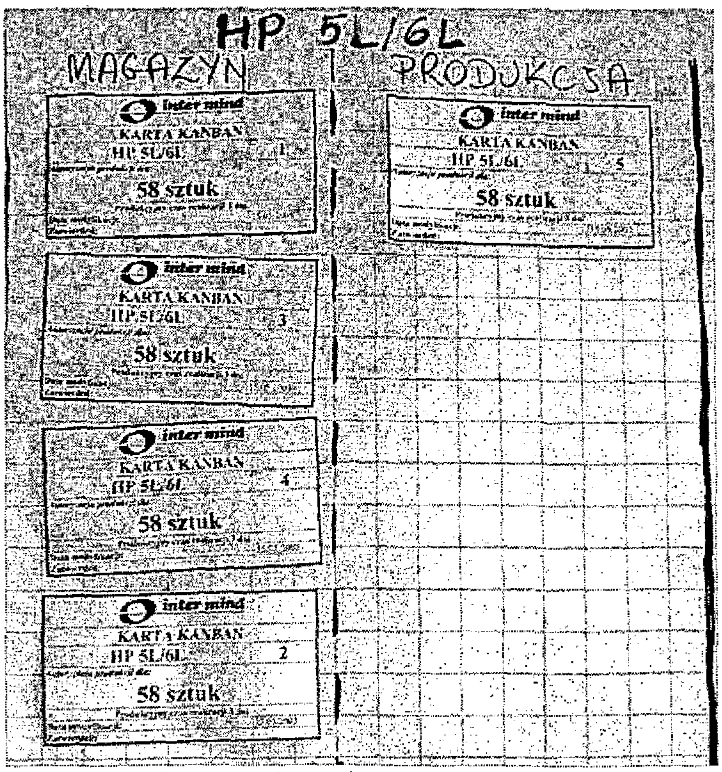

Figure 13. Kanban planning board in logistics department (on the left kanbans located in warehouse, on the right kanbans moved to the production).

Logistics specialist then inputs the production kanbans (located on the right 'production" side of Kanban planning board). After several weeks the planning board was implemented in virtual form in the computer system.
The same day production manager creates production plan on the basis of the production kanbans entered by the logistics specialist. Production plan is created using MS Excell worksheet. The example of the production plan is shown in the table 5.

Table 5. Example of the production plan.

PRODUCTION PLAN: LASERS

Lot no	Type	Qty	Order no	Production phase					Sales date	Hour
				S	D	U	M	P		
59	*HP 1100 ECO	58	5745	X	X	X	X	X	14.10	10.00
60	*HP 2100	32	5747	X	X	X	X		14.10	12.00
61	*HP 1200	51	5746	X	X	X	X	X	14.10	10.00
63	*HP 4200	11	5586	X	X	X	X		14.10	19.00
64	*HP 2100	32	5776	X	X	X	X		15.10	
65	*HP 2100	32	5777	X	X	X			15.10	
66	*HP 1200	51	5773	X	X	X			15.10	
67	*HP 1200	51	5774	X	X	X			15.10	
68	*HP 1300	51	5775	X	X	X			15.10	
69	*HP 4000 A ECO	26	5778	X	X	X			15.10	
70	*HP 1100	60	5772	X	X				15.10	
71	*HP 5L	56	5328*	X	X				18.10	
72	*CANON E 30	49	5531*	X					18.10	
73	HP 5P	40	5820						18.10	
74	HP 1100	60	5823						18.10	
75	HP 1100	60	5824						18.10	
76	HP 1100	60	5825						18.10	
77	HP 1200	51	5826						18.10	
78	HP 1200	51	5827						18.10	
79	HP 1200	51	5829						18.10	
80	KYOCERA TK 17	33	5677*						18.10	
81	HP 4100 X	17	5829						18.10	

LEGEND: S- preparation, D- deassembly, U- steming, M- assembly, P- packing

The plan is sent to the production supervisors between 10.00 – 11.00 a.m.

<u>Process of production order realisation</u>

Production supervisor uses Excell plan to fill out the production cards and material requirement cards (in MS Word files) and prints the cards one time per day. Then he gives the material requirement cards to the material handler. Material handler brings the pallets with materials to the shopfloor in several lots between 12.00 and 18.00. Especially at the beginning (between 12.00 and 13.00) he is overburden.
The lead time for production order realisation from the moment of sending the plan to the production to the moment of moving finished goods to the warehouse is assumed to be 3 days. But after completion of the given order the finished goods wait 4 hours to be moved to the warehouse.

The problems encountered

1. Planning procedure too complex and time consuming.
The lead time of the planning particular production order took 2 days which increased overall lead time meaningfully (from 3 to 5 days). Several persons are engaged in planning process often repeating the same or similar activities (see fig.14).

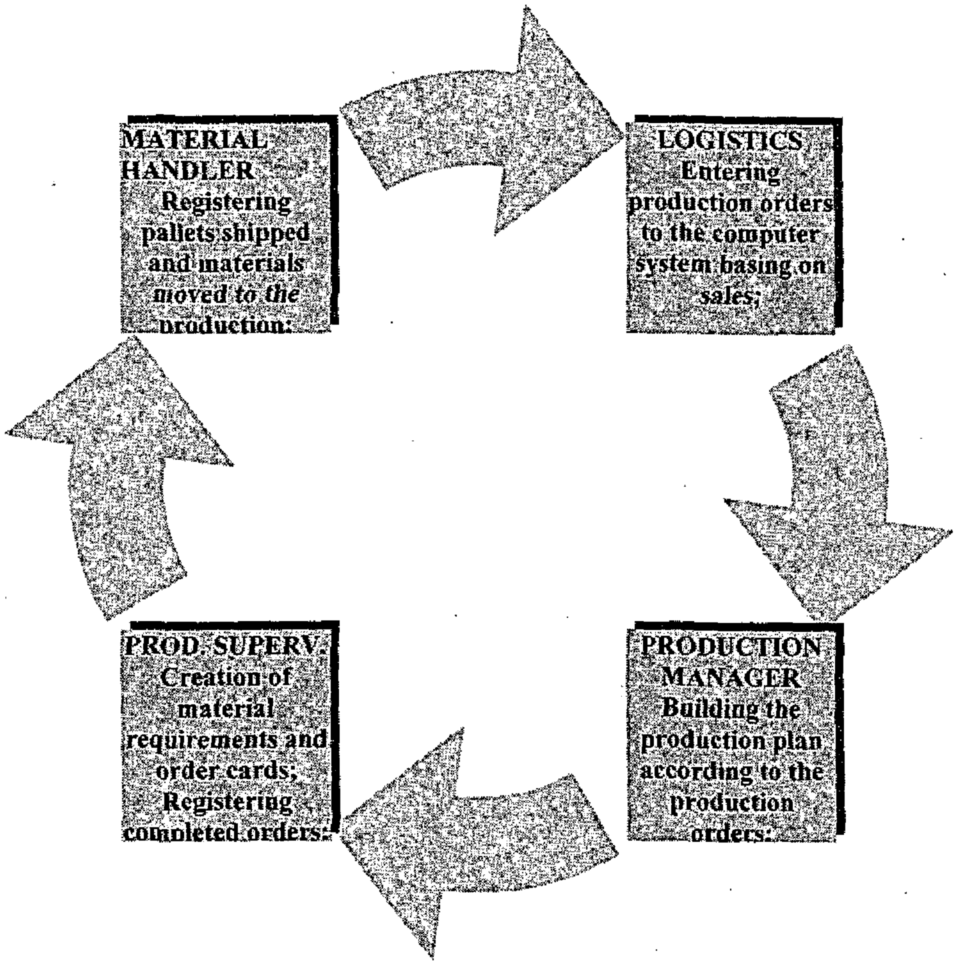

Figure 14. The production planning process.

2. Production order lead time too long.

It was assumed that production order lead time equals to 3 days (from sending production order to the supervisor to moving finished lot to the warehouse). But the real lead time was longer because it encompasses as well planning time (from the moment of shipping lot to the customer to the moment of sending production order to the production supervisor) and the delay between registering movement of finished goods to the warehouse in the computer system and the real movement (which took 4 hours). In result the overall lead time was 5 or more days.

3. Assembly cells and operators not flexible.
In the first phase of lean implementation (before 2004) deassembly line was modified. Thanks to this all deassembly operations are made in one continuous flow line (see fig.15) and all work elements were standardised. The lead time of deassembly was reduced to 120 minutes for the whole lot and is reasonably short.

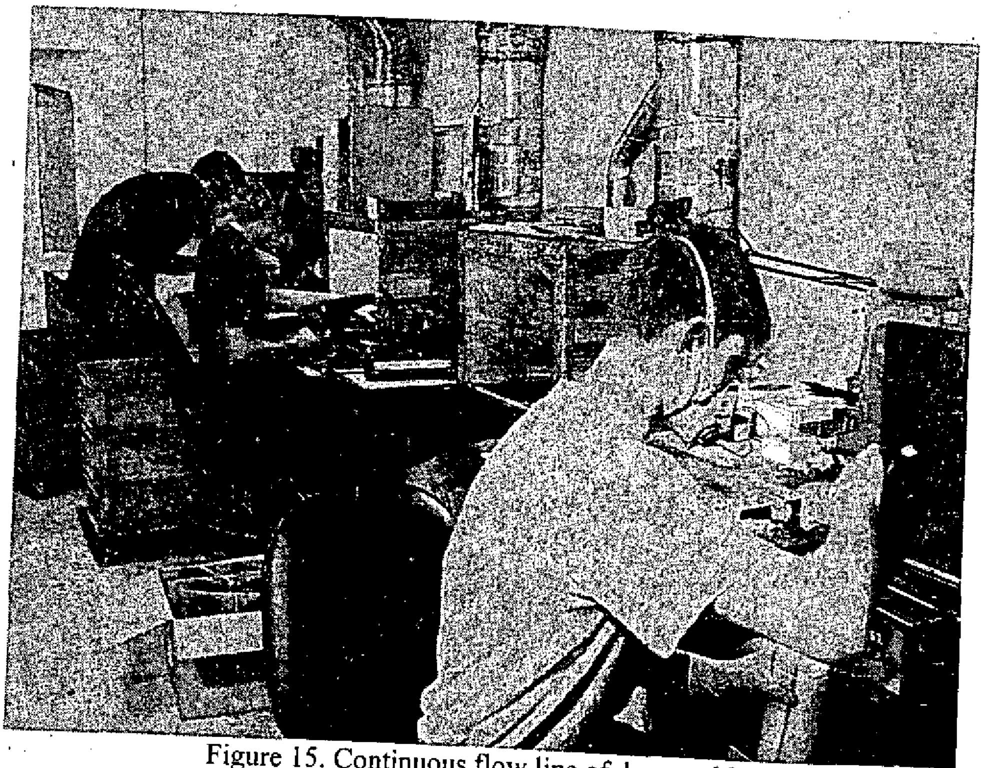

Figure 15. Continuous flow line of deassembly.

But second part of the production process – assembly – was still the group of isolated workstations (see in fig. 16). Because the assembly lead time is much longer and equals to 1000 minutes, the meaningful work-in-process inventory is stored before assembly stations.

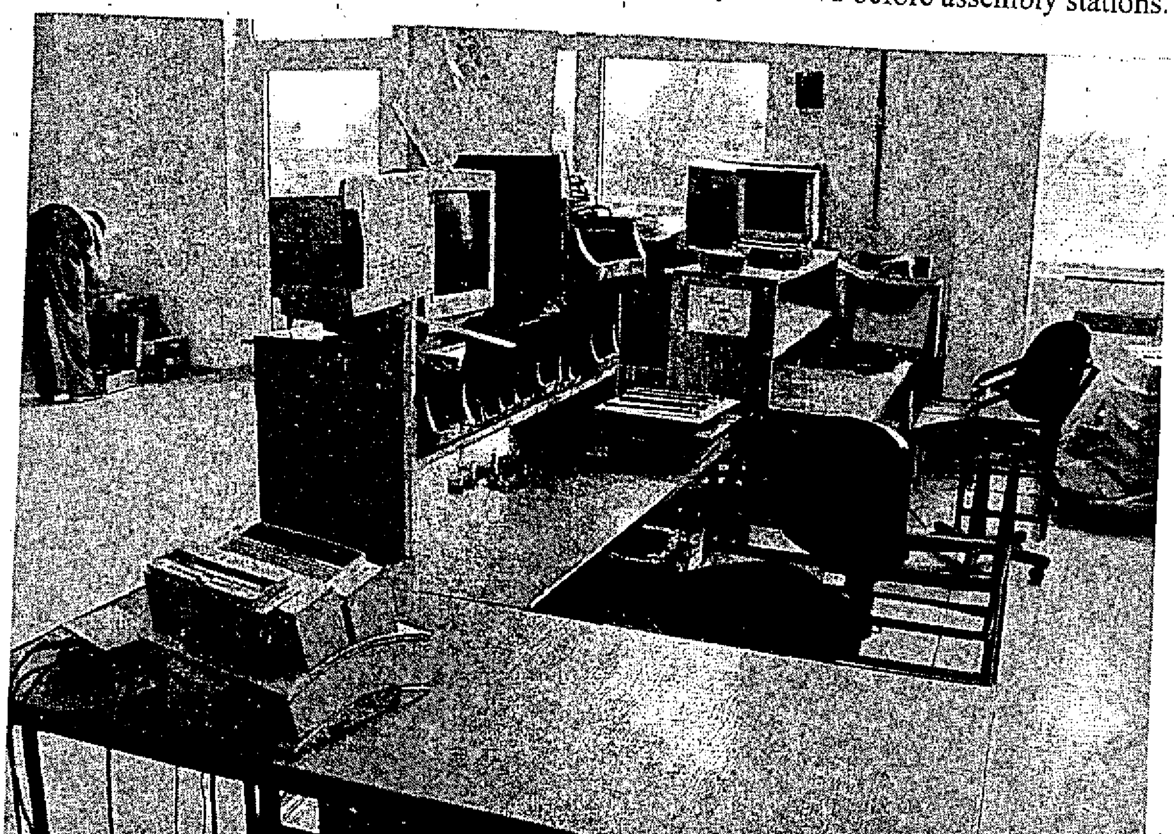

Figure 16. Assembly stations before changes undertaken within e4pq project.

This inventory adds additional waiting time to the production lead time. Figure 17 presents main addends of the production lead time.

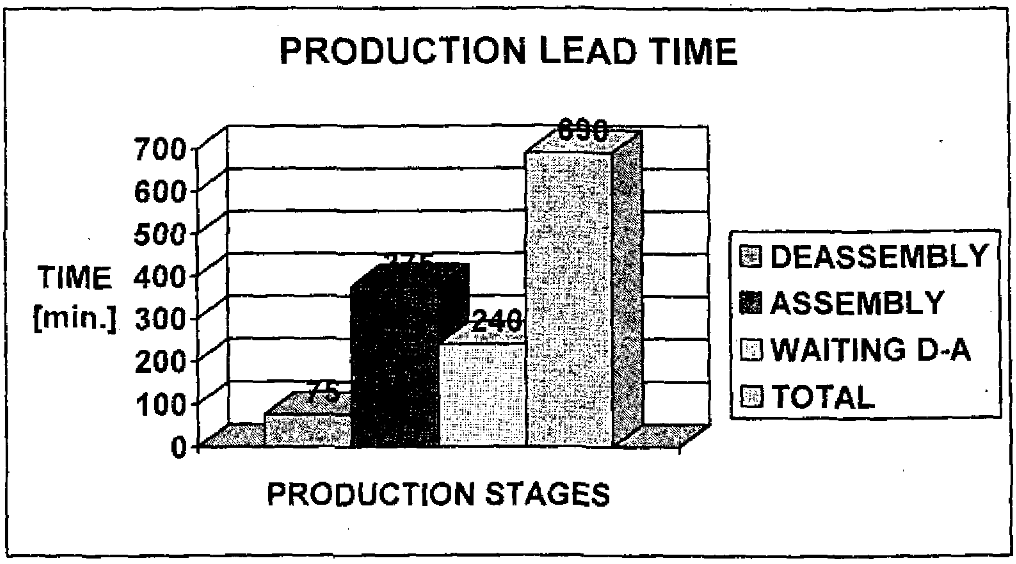

Figure 17.Times of the production stages.

The result is great numbers of kanbans in production. Figure 18 represents the queue of kanabns waiting for production in February and March 2005. The queue longer then 15 kanbans means that order realization lead time is too long to meet marketplace demand.

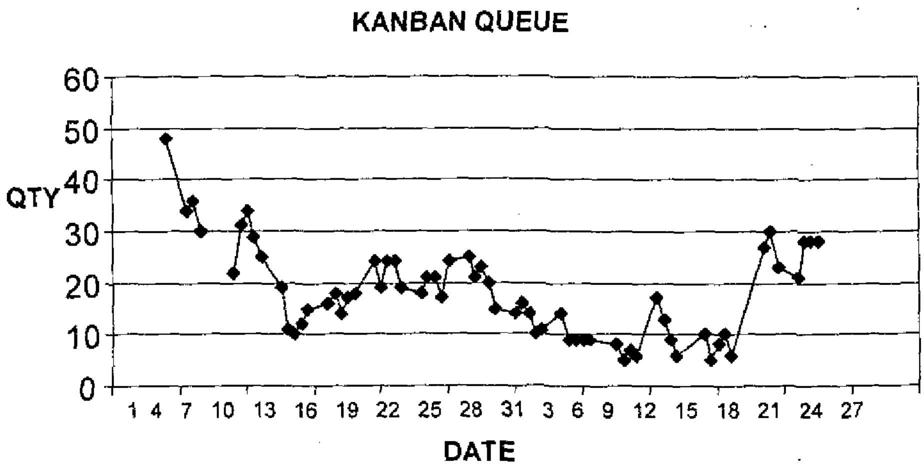

Figure 18.Queue of Kanbans.

4. Lack of work standards for processes between warehouse and production.
The result were too high material inventories on the shop floor.

5. Sales not balanced.
Sales department works according to the traditional (not lean) methods of marketing. Sales representatives have to meet monthly and yearly targets. This results in lower sales at the beginning of years and months and enormously high sales at the end of months and years. The sales is not coordinated with production capacity. Such situation confuses production

department, which can not fully utilize the capacities or is not able to meet the expectations higher then available capacity even using buffer inventories in the finished goods supermarket (see fig. 19).

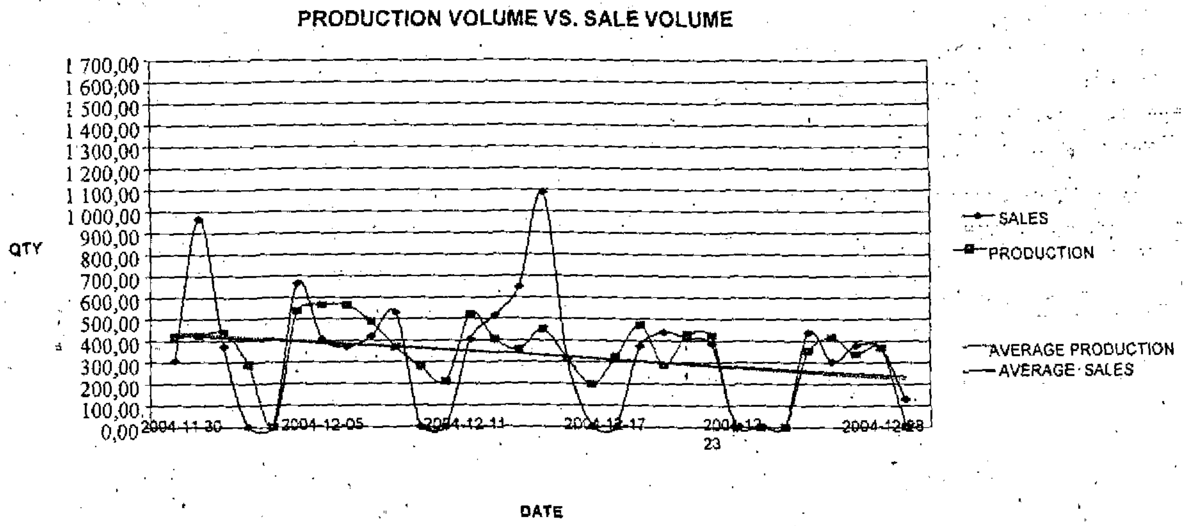

Figure 19. The pikes of sales.

The changes implemented during realisation of e4pq project

After analysis of the complex planning process there were two possible improvement options considered. The first one assumed implementation of modern Enterprise Resources Planning system in hope that it could automate some activities. But after reviewing some large corporations it was stated that even after using complex ERP system the meaningful part of planning activities is still made manually by using customized Excell worksheets. The second option was to eliminate some planning activities at all by implementation of simple, manual Kanban system and automate the rest ones by usage of simple and cheap MS Excell worksheets. The team was encourage to chose the second option because of its low cost and positive effects reported by Toyota corporation (see [Se05]) and leading lean experts (see [Jo02b]).

The manual Kanaban system

The goal of implementing the manual Kanban system was to reduce planning effort, reduce overall lead time and balance work of material handlers. The new system has to integrate the sales process, production planning process, production process and material handling process. The kanban cards previously registered mainly in digital form in computer systems currently are real paper cards which are attached to the every pallet of finished goods. When given pallet of products is shipped the Kanban card is taken off and placed in Kanban postbox. Material handler brings Kanban cards from postboxes directly to the production shop floor to the production supervisors 5 times per day and places them in the supervisor's Kanban box (see fig.20). Kanban cards are not registered in computer planning system at all and work made previously by logistics specialist was completely eliminated.

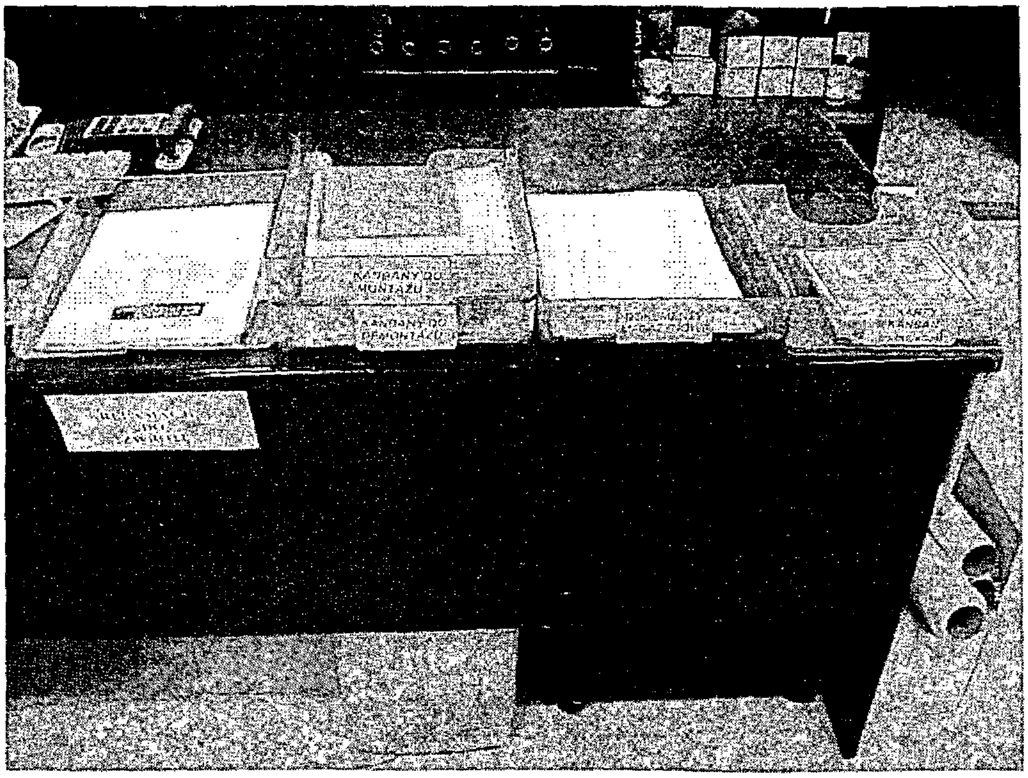

Figure 20. The Kanban box in the production supervisor's desk.

Production supervisor takes Kanban cards and for every card prepares production orders and material Kanbans using templates. The material Kanbans are placed in the material handler scheduling board. The production orders are placed on the production board (see description below). Thanks to that changes the planning work performed previously by production manager was eliminated at all.

The material handler's work organization was changed significantly as well. He works now in the same pace for the whole day according to the material kanbans placed in the material handler scheduling board (see fig.21). This board divides all the material required for production for the whole day into 2 hours periods. Thanks to this material handler's work is balanced into 2 hours intervals. Every 2 hours material handler prepares material required for production for the next 2 hours (and not for the whole day like before), then he transports materials to the workcells, brings kanban cards (from shipped pallets) to the supervisor's kanban box and takes material kanbans for the next two hours from the material handler scheduling board. Material handler repeats this cycle 5 times per day. The result is lower material inventories on the shopfloor and balanced material handler's work for the whole day (no overburdening).

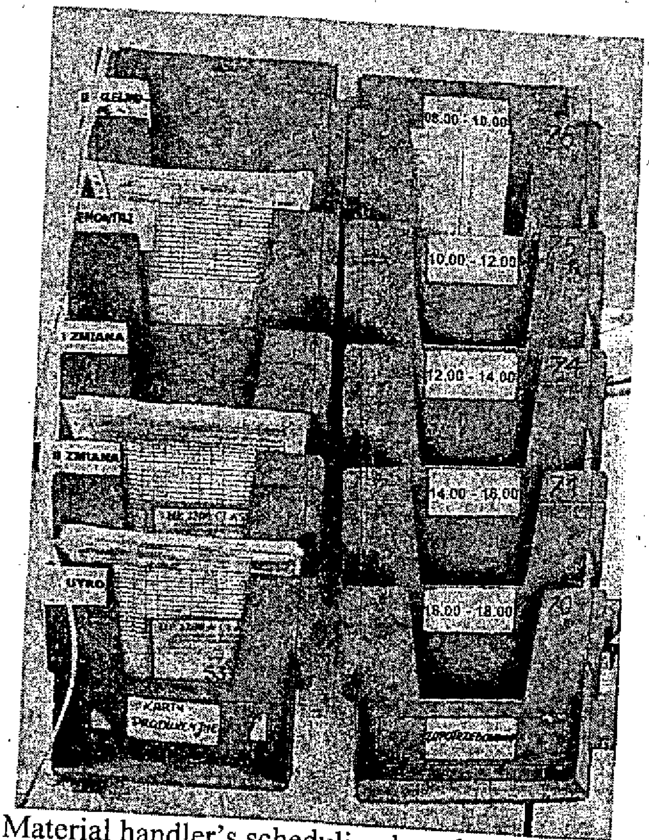

Figure 21. Material handler's scheduling board with material kanbans.

Summarizing the planning process was simplified and human effort was dramatically reduced. The logistic specialist and production manager were eliminated from the process. Manager now only supervises the process to check if it works properly. The only piece of software required for the planning is now capacity analysis worksheet to match capacity with sales volume. This function is realized by the simple MS Excell worksheet prepared by Inter Mind IT specialists. The new planning process is presented in the fig.22.

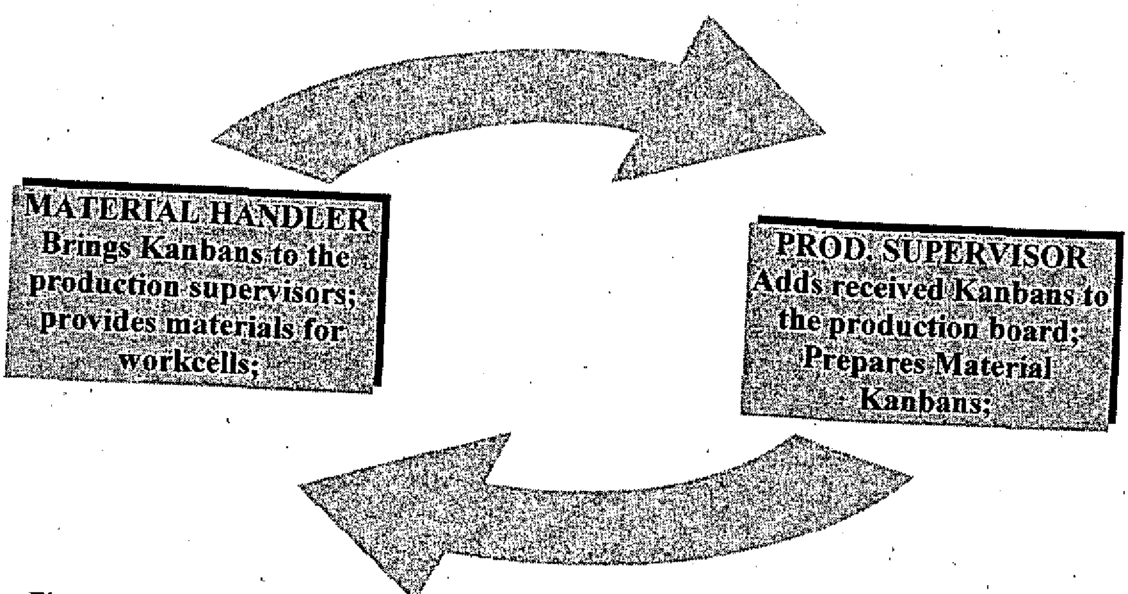

Figure 22. The production planning process after changes (compare to the figure 14).

Work standardization for Kanban system

Work standardisation is powerful lean tool which ensures that work is performed every time in the same and optimal way. Production manager is an owner of Kanban system. All the persons involved in the Kanabn system received their standardized work instructions.

Visual Control

Previously production plans and daily production reports were "hidden" in the computer system. Operators didn't know if the production plan is realized on time or not. Production manager new the production delays after receiving the report from the previous day. Production supervisors undertaken the reaction on delays after receiving the information from production manager. This situation is typical for traditional ERP systems. WCTT consultants suggested to implement hourly production board placed on the shopfloor close to the workcells. Such production boards are the core element of visual control. Because Inter Mind managers were not convinced to such kind of production control they visited nearby Remy plant in Swidnica. Remy is world-wide corporation producing components for automotive industry. Remy is famous as a company advanced in the lean manufacturing production concept. After the visit Inter Mind managers decided to implement visual control system in their own company. Production board in Inter Mind is a paper worksheet (flipchart) with the hourly schedule for assembly and deassembly processes (see fig.23). Operators registers immediately the time of completing the production order and compares it with planned completion time. If order is not completed on time the operator has to note the reason of the delay.

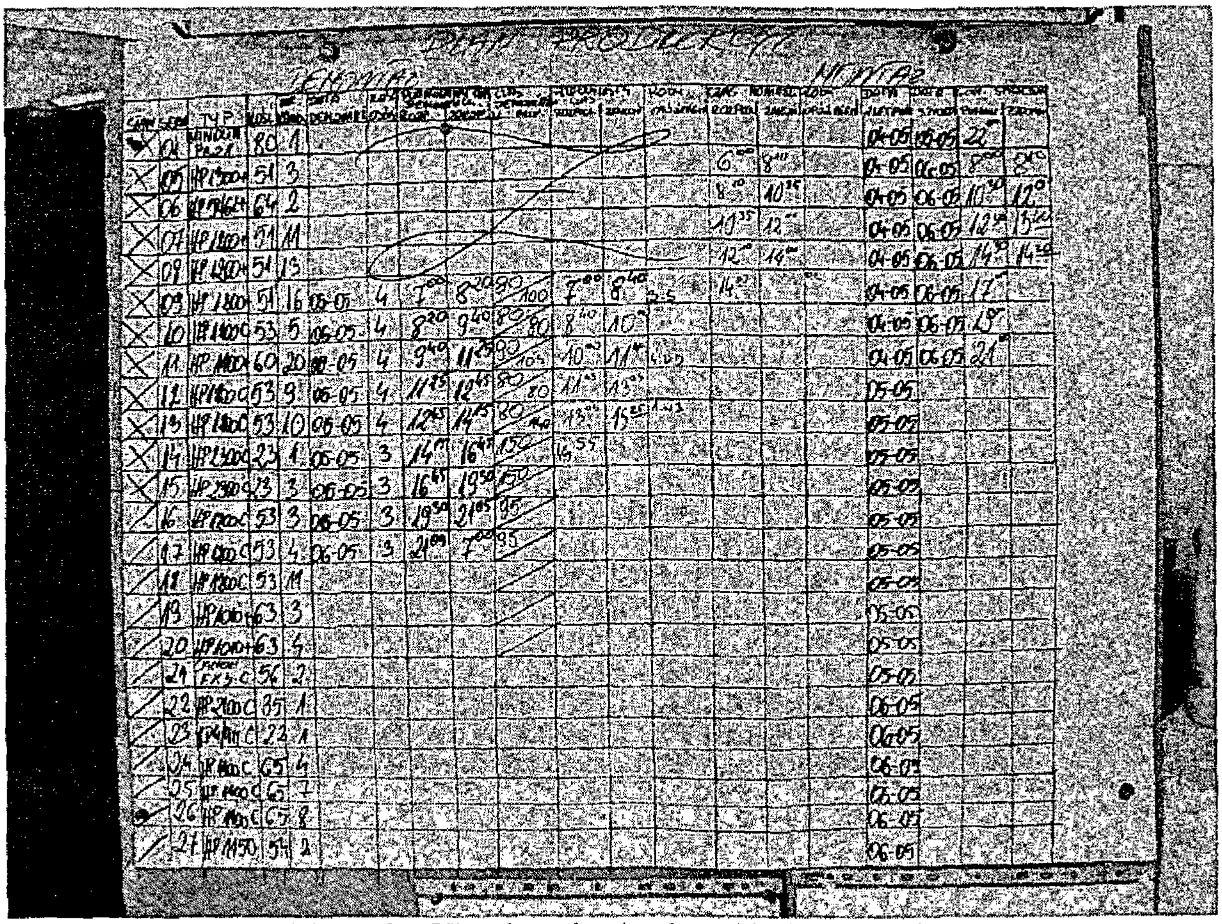

Figure 23. Visual production board in Inter Mind.

After implementing the visual production board every worker on the shopfloor knows exactly if production is on time or not in every moment. Production supervisors undertake the reaction on delays immediately when delay occurs. When they are not able to react (e.g. extra shift on Saturday has to be run) they notify the production manager. Manager finds easily the main problems thanks to the reasons of delays reported by operators on the production board. Thanks to this manager knows what kind of countermeasures have to be undertaken to improve productivity.

Implementation of the flexible and rapid assembly workcells

The assembly workcells created a lot of problems for the production process. They were not flexible, had long lead time and required high work-in-process inventory before assembly process. Also the productivity of the assembly process was not sufficient.

The implementation team decided to implement three important lean methods to improve assembly process:

- Continuous flow flexible workcells to reduce lead time and to change easily the capacity of the given workcell by adding or subtracting the operators. The single workcell has to be designed for 1,2 or 3 operators.
- Standardized work for operators to define optimal way of performing every assembly step to ensure better productivity and quality of the workcell.
- 5S and parts presentation to organize workcells and points of material use in the most efficient way to improve workers' productivity.

<u>**Continuous flow workcells**</u>

Continuous flow is the most efficient method of producing goods and is opposite to producing in batches. Continuous flow cell is created by physical moving several separated workstation into one place. The production between these workplaces is transferred piece by piece (in "one-piece" batches), see in fig. 24.

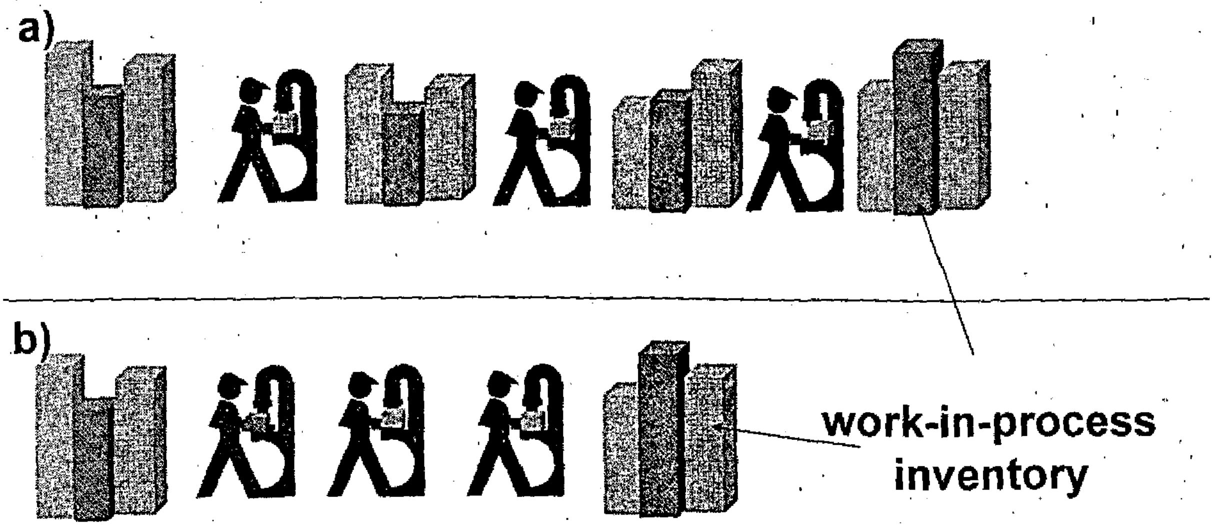

Figure 24. Comparison of a) production in batches and b) continuous flow.

In Inter Mind continuous flow assembly cell was created by connection of three separated workplaces (see figure 25).

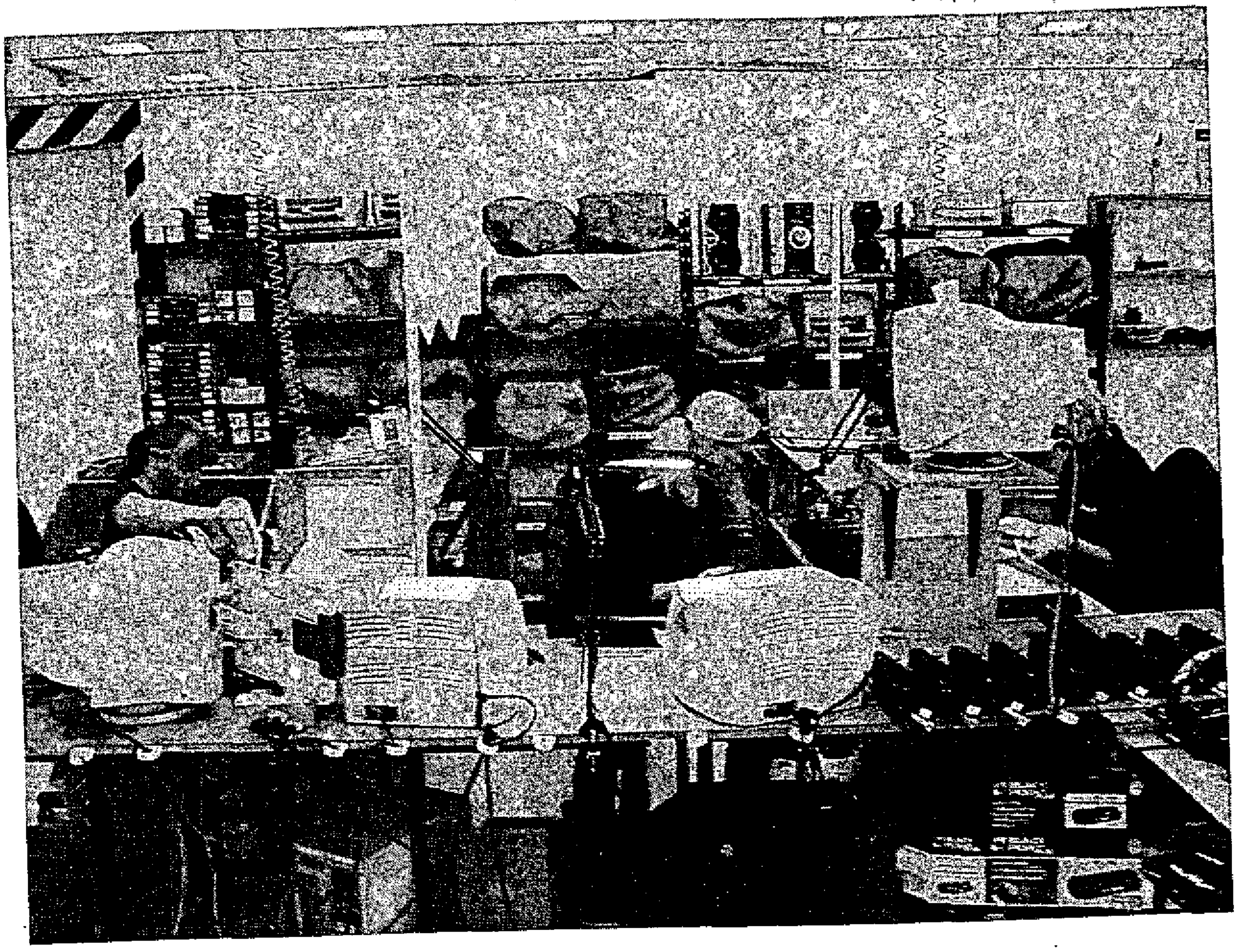

Figure 25. Continuous flow assembly cell in Inter Mind.

To make cell flexible in the sense of capacity it was designed for 1,2 or 3 operators. Cell capacity depends on the number of operators working. In this way production manager may increase or decrease the assembly capacity as needed. There were two flexible assembly workcells created.

Standardised work

One of the basic rules of lean is standardized work. This is an excellent method to increase continuous flow cell capacity and improve quality. Standardised work is a kind of instruction for operators which ensures that production steps are performed every time in the same, optimal way. The procedure of implementation of the standardized work for the workcell is shown in the fig.26.

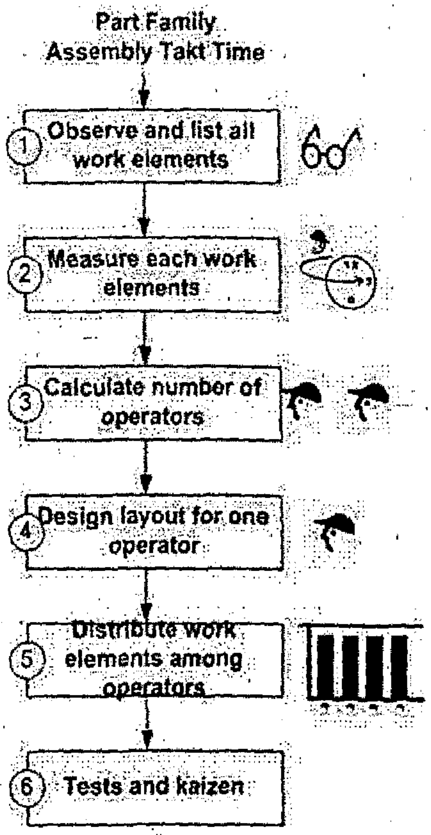

Figure 26. Implementation of standardized work for the workcell [Ro02].

Analysis begins with identification and listing of all work elements needed for producing a product. Next you should time all work element several times and calculate number of operators needed for doing this job. Next step is designing a layout of the cell in such way that one operator could work in the cell efficiently. All work elements (after elimination of these no-value-added) should then be distributed among operator using Operator Balance Chart. The last step is testing new work standard and improving it.
In Inter Mind every work element for most popular products have been analysed. Then three work standards were elaborated for three situations: 3 operators in the cell, 2 operators in the cell, and 1 operator in the cell.

5S and parts presentation
5S is the basic method of visual control. It consist of five simple terms, beginning with an S sound, describing workplace practices conducive to visual control and lean manufacturing. The five terms in Japanese are:

1. SEIRI: Separate needed from unneeded items – tools, parts, materials, paperwork – and discard the unneded.
2. SEITON: Neatly arrange what is left – a place for everything and everything in its place.
3. SEISO: Clean and wash.
4. SEIKETSU: Cleanliness resulting from regular performance of the first three Ss.
5. SHITSUKE: Discipline to perform the first four Ss.

Part of 5S method is proper presentation of parts in the workcell in the way most suitable for operators.

In Inter Mind all the tools and parts required in the continuous flow workcell were analysed and then the area of the cell were divided into fields reserved for particular tools or parts. The workcell after implementation 5S is shown in the figures 27 and 28.

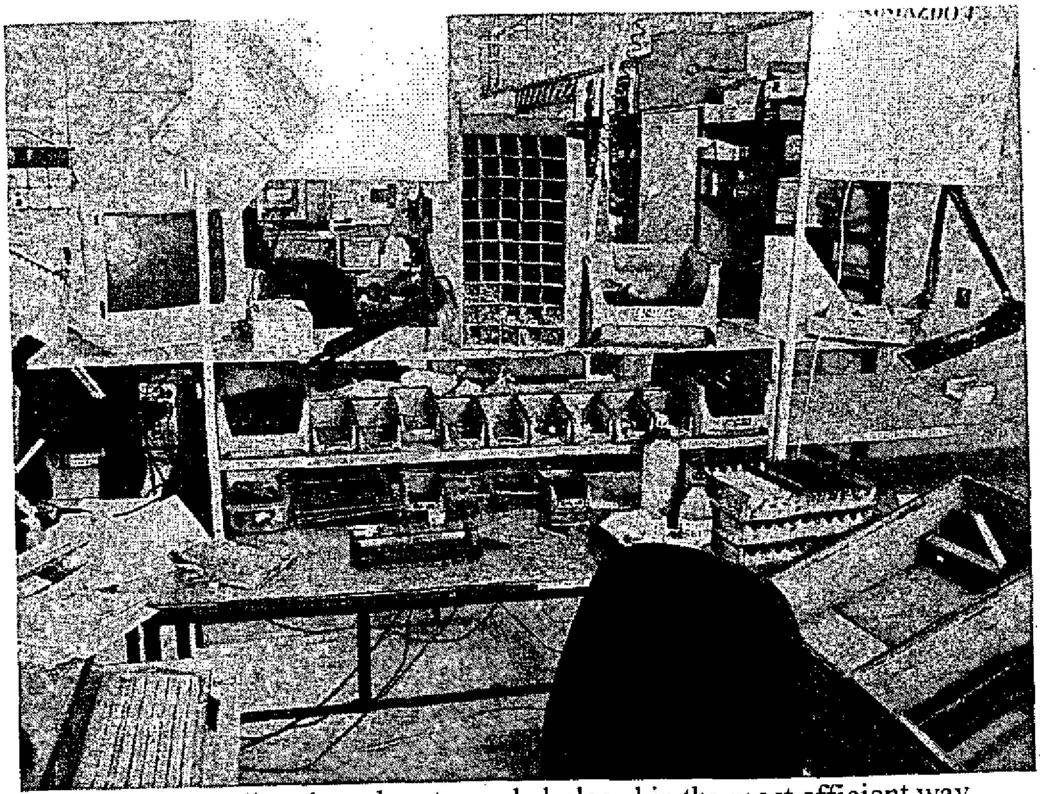

Figure 27. All tools and parts needed placed in the most efficient way.

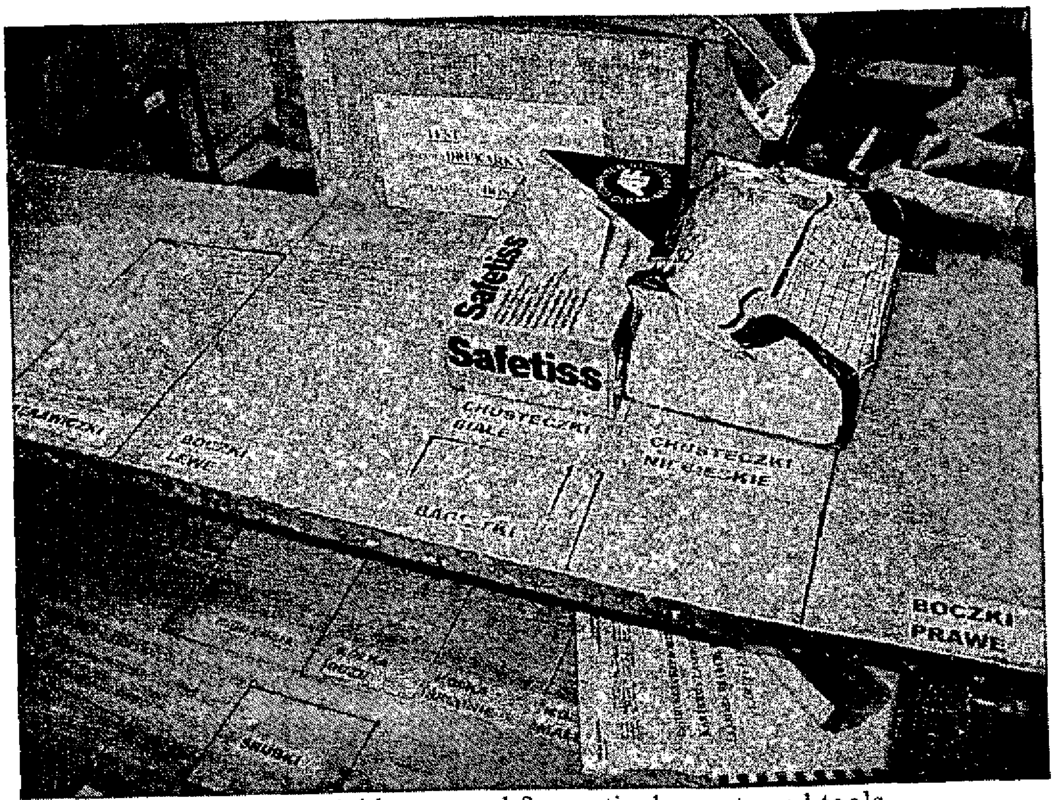

Figure 28. Fields reserved for particular parts and tools.

The results of implementation actions within e4pq project

Implemented lean tools gave very good results and improvement of several key indicators of the production system. Planning process lead time was reduced from 2 days to several hours. Production lead time L/T was dramatically reduced from 690 to 290 minutes (see fig. 29). In many cases overall lead time equals to one day which means that company is very flexible and able to react rapidly to the changing market demand.

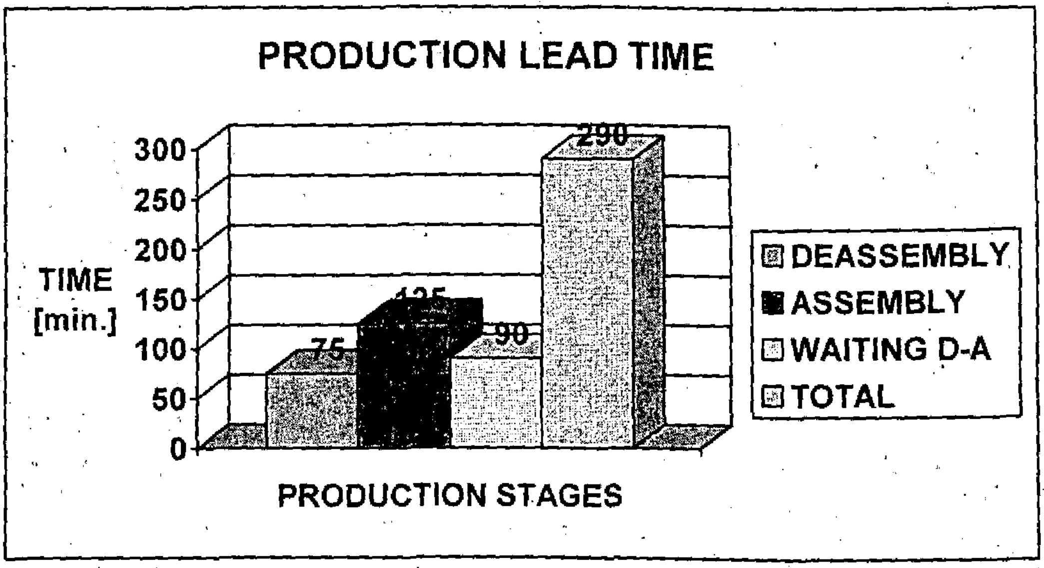

Figure 29. Times of the production stages

During first month after implementation of standardized work the assembly workcell productivity increased from 17 to 20 pieces per hour which is more then 15%. Implementation team expects further increase to 24 pieces per hour in the next months. Also sales pikes were reduced by changing sale target reporting period from one month to two weeks (see fig. 30).

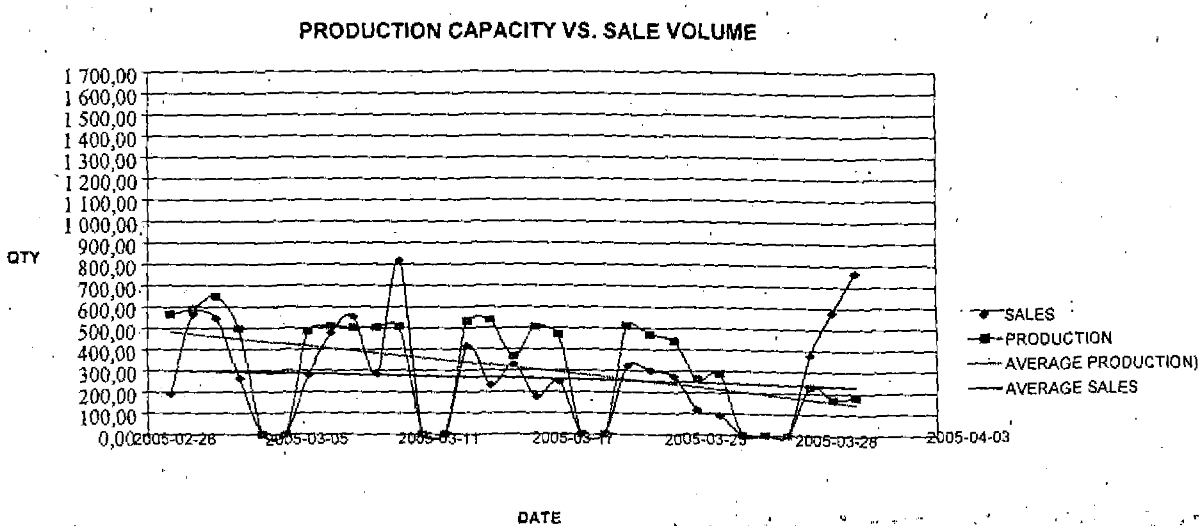

Figure 30. Balanced sales synchronised with production capacity (compare with fig.19).

The results of the changes implemented during realization of e4pq projects were gathered in the table 6.

Table 6. Results of the implementation actions in Inter Mind.

Indicator	Before changes	After changes	Improvement [%]
Planning process L/T	2 days	2 hours – 1 day	50%
Production L/T	690 min.	290 min.	58%
Assembly cell productivity	17 pcs/hr	20 pcs/hr	15%
Sales amplitude/ production volume amplitude (equals to 1 for ideal synchronisation)	2	1,33	33%

The project was realized by the team containing managers and supervisors from Inter Mind and consultants from WCTT. Figure 31 shows part of the implementation team responsible for implementation of continuous flow assembly cells.

Figure 31. Group responsible for implementation of the continuous flow assembly cells. From the left: product engineer, production manager, two production supervisors, and consultant from WCTT.

PART I Dissemination actions

Dissemination of the projects activities and results is important task to broaden the group of enterprises willing to use modern production organization methods to improve the productivity. Another goal of dissemination actions was to involve some foreign partners from central and eastern Europe in the next phases of the project. To disseminate the activities performed by WCTT's team there were web-pages, conferences and networking meetings used.

Dissemination activities through internet web-pages

The information about the project and its results were published on several web-pages:

www.lean.org.pl
This page belongs to Lean Manufacturing Program, which is Polish node of the world-wide lean network coordinated by Lean Enterprise Institute (see www.lean.org). The page was used to announce the events connected to e4pq activities (e.g. the announcing of the Lean Manufacturing Simulation workshop).

www.camt.pl
This page belongs to Centre for Advanced Manufacturing Technologies CAMT, leading research centre for manufacturing technologies, recognized by the European Commission as a Centre of Excellence. The web-page was used to inform about the research activities of the project.

www.e4pq.org
The web-page of e4pq programme was used to inform enterprises about Lean Manufacturing concept, e-technologies connected to Lean Manufacturing and lean tools. Also events organised during project realization were announced using this web-page.

Dissemination during conferences

The first presentation of the project for the industry took place during IV Lean Manufacturing Conference in Wroclaw, 22-24 June 2004. About 300 managers from the industry participated in the conference. Leading world lean experts were special guests e.g. James Womack (co-author of bestsellers "Lean Thinking" and " Machine that changed the world"), Chris Harris (co-author of "Making materials flow" book), John Shook (co-author of "Learning to see" book). Project coordinator Ouseph Padickakudi presented the main goals of e4pq programme to the audience. Also national project coordinator Jaroslaw Papis took part in the event. Also the brochures about e4pq programme were attached to the conference materials. During conference UNIDO representatives met with two management board members of Inter Mind and with scientists from Wroclaw Centre for Technology Transfer WCTT to discuss the possibilities of involving Inter Mind within the project.
Thanks to the meeting the implementation project started in Inter Mind in the end of 2004. In May 2005 the good results of the implementation actions were observed in the company. Company managers decided to publish and present the results during V Lean Manufacturing Conference, which took place in Wroclaw on 15-17 June of 2005. Kamila Wojcik (board member) and Pawel Sawicz (production manager) provided presentation titled "Implementing pull system and continuous flow in Intermind". The paper under the same title, published in conference proceedings was the base for description of the implementation actions in Inter Mind in this report.

Networking Meetings

The first networking meeting took part in WCTT in December 2004. Representatives of WCTT (prof.Tomasz Koch, dr Remigiusz Horbal), Centre for Business Development CSBD from Russia (Svetlana Goodkova, Wolodymir Morskoy) and Slovak Productivity Center SLPC from Slovakia (prof. Milan Gregor). National e4pq programme coordinator Jarosław Papis from UNIDO presented e4pq programme. Prof. Tomasz Koch presented the activities connected to Lean Manufacturing within e4pq programme. Partners from Russia and Slovakia confirmed they interests in participation within the programme in the next phases.
The second meeting took place during V *Lean Manufacturing Conference*. The main goal of the meeting was to built the new nodes of Lean Global Network in central and eastern Europe but also the e4pq programme was discussed. Beside representatives from CSBD and SLPC also guests from Ukraine, prof. Kateryna Maksym, National University "Kyiv-Mohyla Academy", Romania Mariana Prica, Andrei Viorel PRIMA Consulting, and Byelorussia Sergey Parmon, Minsk were present. During the meeting representative from Ukraine confirmed the will of the University to participate in the next phases of e4pq programme.

PART II Conclusions

During the year of activities more then dozen of enterprises took part in trainings about Lean Manufacturing, several dozens of enterprises contacted with WCTT. Two enterprises decided for closer cooperation. ASSO Filter was analysed and potential benefits after implementation of the Lean Manufacturing were estimated. Inter Mind realized dynamic implementation program and gained impressive results. The experiences from Inter Mind are very good case-study, which could be very convincing for the other SMEs in the region. Also the e-learning tools (LeanXeur) have been developed during the project thanks to additional financial resources from European Commission. LeanXeur e-learning tools accelerate the learning of Lean Manufacturing in SMEs and dramatically reduces the need for expensive consulting services during implementation of the lean concepts (see Appendix A).

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Appendix A
Lean Across Europe LeanXeur – Project Description

During preparation phases of e4pq programme it was stated that e-learning tools could significantly speed-up the process of implementation Lean Manufacturing in SMEs and reduce or even eliminate the consulting costs involved in the implementation process. WCTT team begun to contact with its foreign partners to look for a consortium able to develop required e-learning tools. Such consortium were created by University of Limmerick in 2003 and developed the project proposal named LeanXeur (see www.leanxeur.com). The consortium received significant support from European Commission within Leonardo programme.

www.leanxeur.com

LeanXeur encapsulates best practice in LEAN education and training in a user based, on-line format for SMEs. The project builds on the following capability and strengths of the partnership:

1. extensive experience in working with SMEs across European countries
2. subject matter expertise in the application of Lean Thinking,
3. development and delivery of e-learning and training for users in Europe and
4. application of mobile technologies for point of use delivery of learning, when and as needed.

The focus on adapting LEAN training to SMEs, coupled with the use of highly accessible learning methodologies are the key innovative features of LeanXeur.

The project research methodology is as follows:

1. Survey among SMEs in the partner countries and in the selected sectors to discover why LEAN is poorly applied. What is stopping its application among SMEs?
2. Research the most optimum ICT technologies to use in the delivery of training, bearing in mind the technical, financial and cultural restrictions of the general SME environment.
3. The encapsulation of Step 1 into a simplified, adapted core methodology for the introduction of a LEAN programme in SMEs.
4. The encapsulation of Steps 2 and 3 into a training curriculum for Lean in SMEs, including e-learning, exercises, network support services and on-the-job facilitation.
5. Recruitment of a panel of SMEs in the specific sectors to test and validate the methodology.
6. Adaptation of the methodology as appropriate. Analysis of its possible use by individual learners.
7. Translation of the methodology into the languages of the partners– Swedish; Spanish and Polish.

8. Promotion and dissemination of the project and results, including end-of-project event(s).

LeanXeur focuses on 3 specific, representative sectors to ensure wide applicability: small rural industries, food sector and engineering sub-supply companies (including car parts producerts). Validation is carried out through implementation in selected user SMEs from these sectors across the partner countries. Validation encompasses the SME's overall business but with particular emphasis on streamlining the organisation's supply chain. Impact is measured through monitoring key metrics. Issues that are addressed during the validation phase include whether the e-training can exist as stand-alone or whether it is enhanced through other resources, such as remote support, local support, software tools, manuals etc. Case studies will be developed from the end-users and these, as well as the e-learning outputs, will form the basis of the final dissemination materials. Dissemination is undertaken in each country and across Europe. Dissemination begun at project start by generating awareness and identifying interested users (companies, training providers, state agencies and others). On completion of the project, the partnership intends to commercialise LeanXeur and set up an infrastructure throughout Europe to enable it to be available to users across all SME sectors.

The table below (tab. A1) presents the main results expected during realization of the project.

Table A1. The results of LeanXeur project.

No	Description / Type of result	Target group(s)	Languages / Media	When
1	New training method in Policy Deployment, which has been adapted from that used by larger organisations, for specific use in SMEs. This training will enable users to systematically define their key processes, develop and measure metrics of performance and identify priority areas for improvement activity within their business.	The project will initially focus on SMEs from three vulnerable sectors – rural / remote SMEs, sub-supply SMEs and SME in the food sector. Long term, all growth-oriented SMEs of all sectors, including services, will benefit from the results.	Partner languages – English, Swedish, Spanish. Mixed media, primarily web-based with distance learning and face-to-face support. Will also evaluate the use of mobile technologies and t-learning (learning through digital TV)	February 2005
2	New training method in Value Stream Mapping, which has been adapted from that used by larger organisations, for specific use in SMEs. This training will enable users to map their key processes from a value perspective, to understand where waste exists in these key processes, to project the future process map and to identify the actions and activities to close the gap between current and future maps.			May 2005
3	To support the above two outputs, a training delivery and resource centre will be developed to provide the infrastructure under which SMEs can be introduced to the Lean training programmes. This resource website will include the course materials and will provide users with access to tutors, trainers, software tools, background information and any other information that will enhance user learning. This website will be developed early in the project and will be updated to include all outputs as they become available.	As above. Also, it is expected that this will target intermediary organisations who will facilitate their client SMEs to undergo the LeanXeur training.	Single web address with 3 languages – English, Spanish and Swedish.	April 2006

4	Dissemination materials, including Case Studies, promotional literature, press releases, published papers, presentations	General SME body. Intermediary and industry support organisations	Both hard copy and on the web.	Throu gh-out projec t,
5	User Interest Group electronic conference where individuals can address topics related to the implementation of Lean in SMEs.	Individuals from SMEs and from organisations, which support SMEs.	Web media	Septe mber 2004

The first "demo" versions of the developed e-learning tools are available on the web-page www.leanxeur.com.

Appendix B
The leaflet advertising Lean Manufacturing Simulation training

Wrocław, 28 września 2004

SZKOLENIE Z DOFINANSOWANIEM

Szanowni Państwo

Symulacja Lean Manufacturing, to jedno z najchętniej na świecie kupowanych przez przedsiębiorstwa szkoleń. I nie ma w tym nic dziwnego, bowiem już w pierwszych miesiącach po wprowadzeniu do cyklu produkcyjnego zasad „szczupłego" myślenia, widać **mierzalne oszczędności** wykorzystywanego czasu i zasobów.

Dlatego z prawdziwą przyjemnością pragnę zaproponować Państwu uczestnictwo w tym szkoleniu. Jest to edycja o tyle szczególna, że dzięki dofinansowaniu UNIDO - Organizacji Narodów Zjednoczonych ds. Rozwoju Przemysłowego- mogą w nim Państwo uczestniczyć, **pokrywając jedynie 26% jego ceny, czyli 312 zł.** Dofinansowanie to kierowane jest specjalnie do polskich Małych i Średnich Przedsiębiorstw z myślą o podniesieniu ich konkurencyjności i efektywności.

Mam nadzieję, że zarówno atrakcyjność naszego szkolenia jak i fakt jego dofinansowania sprawią, że zechcą Państwo skorzystać z naszej oferty.

Zapraszam serdecznie

Prof. Tomasz Koch
Lider Programu Lean Manufacturing

Politechnika Wrocławska
Wrocławskie Centrum
Transferu Technologii

UNIDO

Formularz Zgłoszeniowy

SYMULACJA LEAN MANUFACTURING

Wrocław, 18 – 19 października 2004

Informacje o firmie		
Pełna nazwa firmy:		
Adres:		
Kod:	Miejscowość:	
Tel:	Fax:	NIP:
Odpowiedzialny za kontakt z WCTT:	e-mail:	

Zgłaszamy udział następujących osób:

L.P.	Imię i nazwisko	Stanowisko	Cena
			312 zł
			312 zł

Upoważniamy Politechnikę Wrocławską do jednorazowego wystawienia faktury VAT bez podpisu odbiorcy

Pieczęć firmy — Podpis osoby upoważnionej

Zgłoszenie prosimy przesłać pocztą lub faksem lub doręczyć osobiście na adres:

Wrocławskie Centrum Transferu Technologii, ul. Smoluchowskiego 48, 50-372 Wrocław

Telefon (071) 320-39-12 fax (071) 320-39-48

Appendix C

The participant list of Lean Manufacturing Simulation training

Lista obecności Symulacja Lean Manufacturing

Numer kurs LMS44 Wrocław ☐ 18th October ☐ 19th October 2004 **WCTT**

Last Name	First Name	Company	Podpis
Barejka	Krzysztof	Fabryka Plastików Pomerania Sp.z o.o.	
Bejm	Michał	P.P.H LINEX	
Biczysko	Paweł	Przedsiębiorstwo Produkcyjno-Handlowe "ASSO"	
Biliński	Karol	Inter mind sp. z o.o.	
Celmer	Tomasz	Przedsiębiorstwo Produkcyjno-Handlowe "ASSO"	
Chodaczyński	Ryszard	Inter mind sp. z o.o.	
Ćwiżewicz	Zbigniew	Fabryka Plastików Gliwica Sp.z o.o.	
Dąbrowska	Ewa	Wibrem Turbomachinery Service Sp.z o.o.	
Dobosz	Łukasz	Inter mind sp. z o.o.	
Góral	Małgorzata	Inter mind sp. z o.o.	
Grabski	Robert	Fabryka Plastików Pomerania Sp.z o.o.	
Grondek	Konrad	Fabryka Plastików Gliwica Sp.z o.o.	
Grucki	Kazimierz	Tyco Electronics Polska Sp. z o.o.	
Janaszak	Jerzy	"ARCHIMEDES" S.A.	
Kaleta	Krzysztof	GT Poland Sp.z o.o.	
Kielich	Tomasz	Inter mind sp. z o.o.	
Kluska	Mariusz	Inter mind sp. z o.o.	

Last Name	First Name	Company	Podpis
Kobucka	Beata	Inter mind sp. z o.o.	
Krajewski	Sławomir	Fabryka Plastików Gliwica Sp.z o.o.	
Liberacki	Grzegorz	Przedsiębiorstwo Produkcyjno-Handlowe "ASSO"	
Lisowski	Jacek	Inter mind sp. z o.o.	
Mackało	Elżbieta	Inter mind sp. z o.o.	
Marek	Waldemar	Inter mind sp. z o.o.	
Matuszczyk	Jerzy	P.P.H LINEX	
Możuch	Maciej	Tyco Electronics Polska Sp. z o.o.	
Ochocki	Marian	Amhil Europa Sp.z o.o.	
Pankała	Stanisław	"ARCHIMEDES" S.A.	
Pietruszka	Czesław	P.P.H LINEX	
Piszczek	Marek	Inter mind sp. z o.o.	
Skorupa	Paweł	Inter mind sp. z o.o.	
Stańczyk	Przemysław	Inter mind sp. z o.o.	
Superson	Robert	P.P.H LINEX	
Wendt	Jarosław	Amhil Europa Sp.z o.o.	
Wielgosz	Krzysztof	Przedsiębiorstwo Produkcyjno-Handlowe "ASSO"	
Wróblewski	Andrzej	Fabryka Plastików Kwidzyn Sp.z o.o. Oddział Mazury w Kętrzyni	
Zbrożek	Izabella	Amhil Europa Sp.z o.o.	

Appendix D
Participant materials for Lean Manufacturing Simulation.

Under the licence of University of Kentucky.

University of Kentucky
Center for Robotics and Manufacturing Systems

Plan symulacji

1 9:00 do 12:50, dzień 1 Wstęp Przebieg 1 Przebieg podstawowy Rozmieszczenie konwencjonalne Przegląd przeb. 1	2 13:20 do 17:00, dzień 1 Przebieg 2 Przepływ części Sterowanie wizualne Kaizen Przegląd przeb. 2
3 9:00 do 12:50, dzień 2 Przebieg 3 Jakość u źródła Standaryzacja Pracy System ssący Przegląd przeb. 3	4 13:20 do 17:00, dzień 2 Przebieg 4 Ciągły przepływ Zrównoważone obciążenie Montaż na zamówienie Ciągły Kaizen Przegląd przeb.4, Podsumowanie

Główne założenia Lean Manufacturing :

Osiągnąć satysfakcję klienta

Maksymalizacja Jakości

- Ciągłe doskonalenie z użyciem całej dostępnej wiedzy i możliwości.

Minimalizacja kosztów

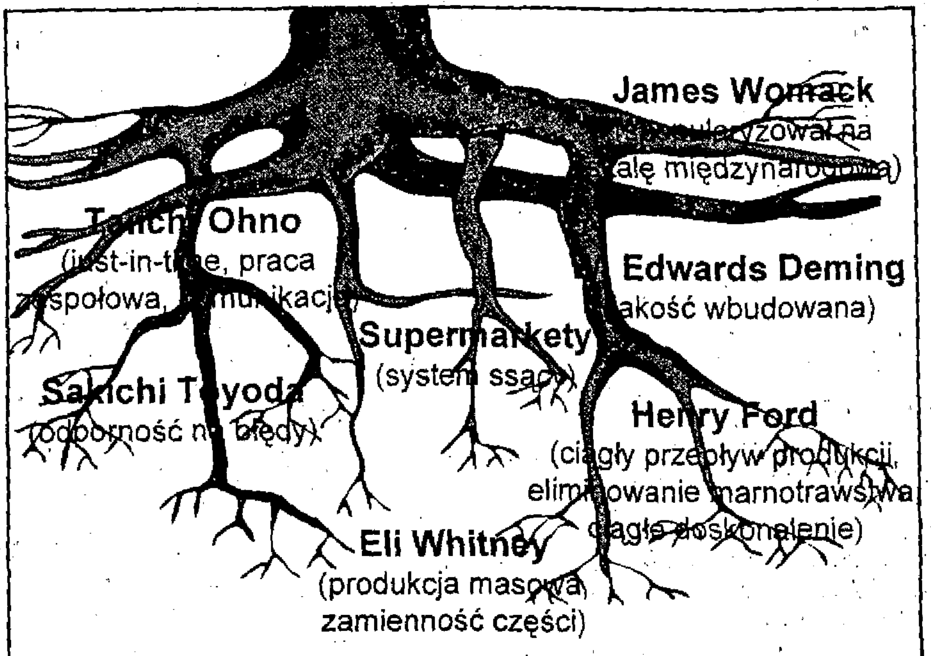
- Dotychczas: *Cena* = *Koszt* + *Zysk*
- Lean Manufacturing: *Zysk* = *Cena* - Koszt

Minimalizacja Czasu

- *Produkcyjny czas realizacji*
  < Oczekiwany przez klienta czas dostawy

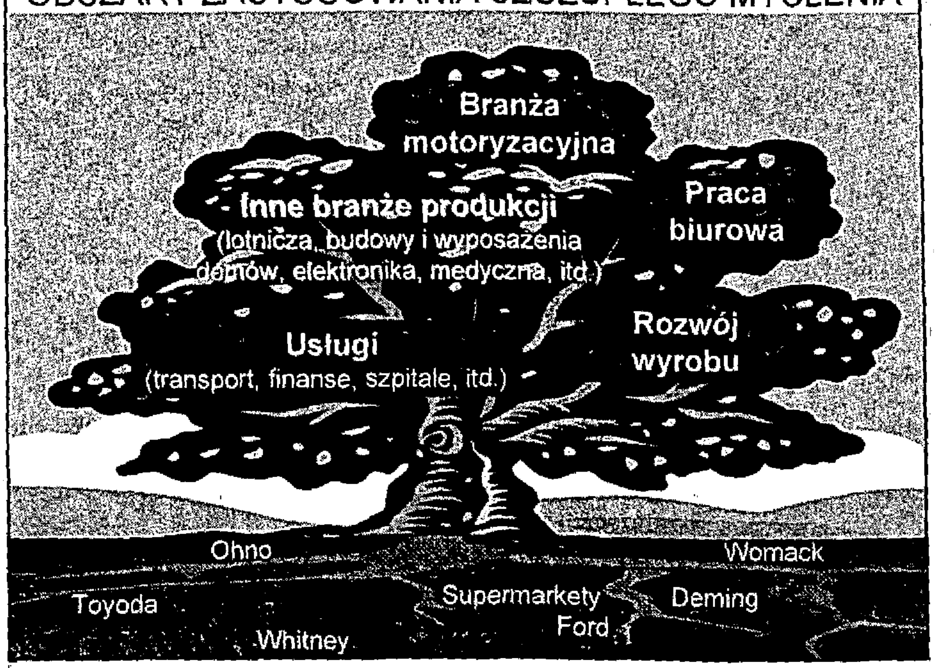
Grupy określają swoje oczekiwania

Wybierz liderów grup



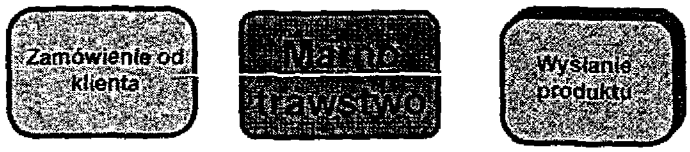
KORZENIE LEAN MANUFACTURING

OBSZARY ZASTOSOWANIA SZCZUPŁEGO MYŚLENIA



Lean Manufacturing jest filozofią wytwarzania, która przez eliminację marnotrawstwa, pozwala na skrócenie czasu pomiędzy złożeniem zamówienia, a wysłaniem produktu.

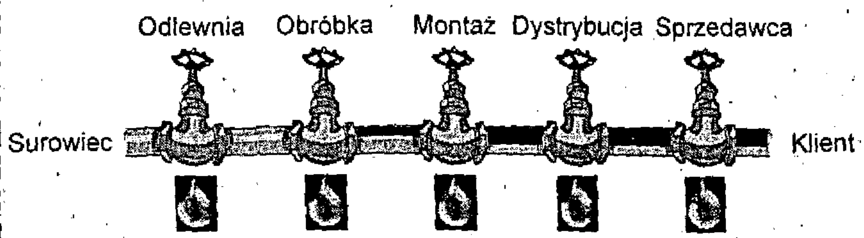
Konwencjonalne wytwarzanie



Lean Manufacturing jest filozofią wytwarzania, która przez eliminację marnotrawstwa, pozwala na skrócenie czasu pomiędzy złożeniem zamówienia, a wysłaniem produktu.

Lean Manufacturing

Strumień wartości to wszystkie działania począwszy od dostawy surowców aż do wysyłki do klienta, które są podejmowane dla wyprodukowania wyrobu lub rodziny wyrobów.



Dodawanie Wartości

Działania za które klient chce zapłacić.

Przykłady z produkcji:

- obróbka
- odlewanie
- formowanie
- malowanie
- montaż
- opracowanie technologii

Przykłady z usług:

- projektowanie produktu
- tworzenie listy płac
- ekspresowa dostawa
- diagnostyka
- patentowanie
- dostęp do internetu

MARNOTRAWSTWO

MARNOTRAWSTWO

- **Nadprodukcja**

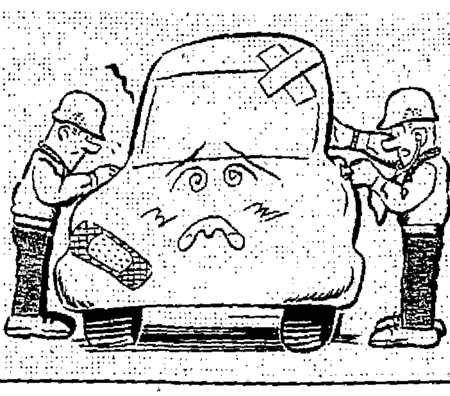
MARNOTRAWSTWO

- Nadprodukcja
- **Zapasy**

ZAPASY UKRYWAJĄ MARNOTRAWSTWO

MARNOTRAWSTWO

- Nadprodukcja
- Zapasy
- **Poprawianie braków oraz błędów**

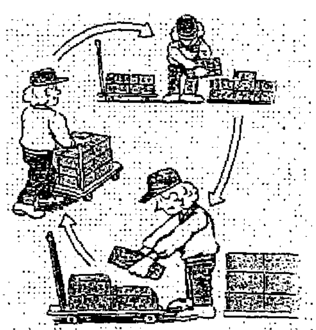


MARNOTRAWSTWO

- Nadprodukcja
- Zapasy
- Poprawianie braków oraz błędów
- **Zbędne przetwarzanie**

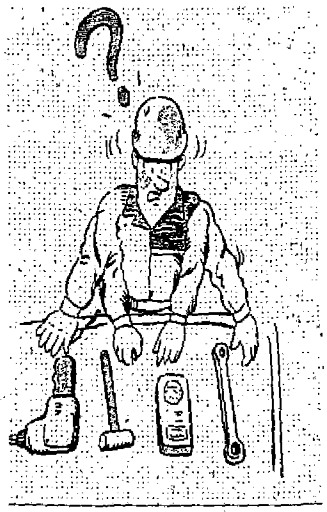
MARNOTRAWSTWO

- Nadprodukcja
- Zapasy
- Poprawianie braków oraz błędów
- Zbędne przetwarzanie
- **Zbędne przemieszczanie materiału**



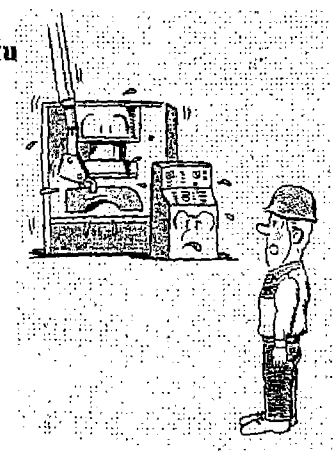
MARNOTRAWSTWO

- Nadprodukcja
- Zapasy
- Poprawianie braków oraz błędów
- Zbędne przetwarzanie
- Zbędne przemieszczanie materiału
- **Nadmierny ruch**



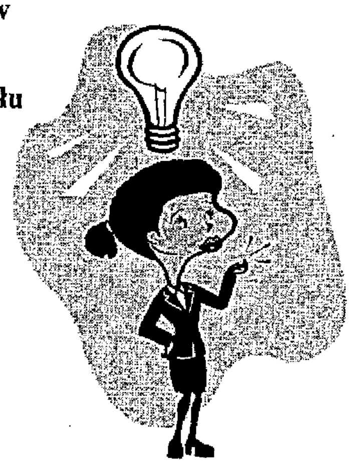
MARNOTRAWSTWO

- Nadprodukcja
- Zapasy
- Poprawianie braków oraz błędów
- Zbędne przetwarzanie
- Zbędne przemieszczanie materiału
- Nadmierny ruch
- **Oczekiwanie**



MARNOTRAWSTWO

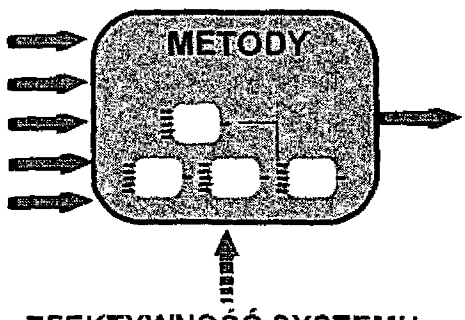
- Nadprodukcja
- Zapasy
- Poprawianie braków oraz błędów
- Zbędne przetwarzanie
- Zbędne przemieszczanie materiału
- Nadmierny ruch
- Oczekiwanie
- **Stracona kreatywność**



Zorientowanie szczupłego podejścia

WEJŚCIA | SYSTEM i PROCESY | WYJŚCIA

Pracownik
Maszyna
Materiał
Informacja
Środowisko



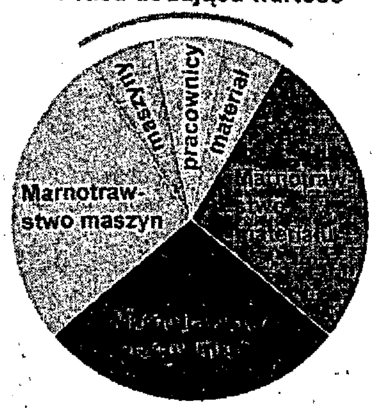
Produkt /Usługa

EFEKTYWNOŚĆ SYSTEMU

Nieefektywność w Strumieniu Wartości = Marnotrawstwo = Koszt

Wartość dodana, a marnotrawstwo w konwencjonalnej fabryce

Praca dodająca wartość



Przezbrojenia

Awarie

Zbędny ruch narzędzia

Produkcja niepotrzebnych produktów

Braki

Wadliwe Produkty

Magazynowanie

Uszkodzenia / Zepsucie

Zbędny ruch

Oczekiwanie

Niepotrzebna praca papierkowa

Zmarnowana kreatywność

Praktyki 5 S

japoński	*angielski*	*polski*
seiri	sort	selekcja
seiton	systemize	systematyka
seiso	sweep	sprzątanie
seiketsu	sanitize	schludność
shitsuke	self-discipline	samodyscyplina

Praktyki 5 S

- **selekcja** - oddzielenie i uprzątnięcie rzeczy niepotrzebnych
- **systematyka** - poukładania i stworzenie uporządkowanego systemu ułożenia pozostałych rzeczy
- **sprzątanie** - wyczyszczenie, wysprzątanie i całkowite uporządkowanie miejsca pracy i jego otoczenia
- **schludność** - utrzymanie czystości, porządku i schludności wokół siebie i wobec siebie
- **samodyscyplina** - stosowanie samodyscypliny (własnego przykładu), szkolenie i rozpowszechnianie 5S, dbanie o środowisko i BHP

Totalne Produktywne Utrzymanie Ruchu
Total Productive Maintenance - TPM

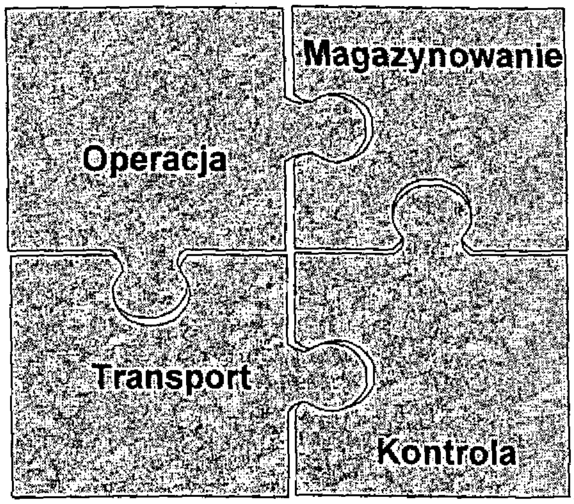
- **zapobieganie awariom urządzeń, przez poszukiwanie i usuwanie przyczyn ich uszkodzeń i potencjalnych zakłóceń**
- **zwiększenie całkowitej efektywności i skuteczności maszyn i urządzeń**
- **obejmuje każdego pracownika, cały zakład, od sprzątaczki po dyrektora naczelnego**

Totalne Produktywne Utrzymanie Ruchu
Total Productive Maintenance - TPM

AUTONOMICZNE UTRZYMANIE - Pierwsza FAZA TPM

- czyszczenie podstawowe
- środki zaradcze przeciwko źródłom zabrudzeń i obszarom występowania problemów
- opracowanie standardów sprzątania, kontroli i smarowania
- rozwój i trening pracowników w przeprowadzaniu samodzielnej konserwacji i przeglądów
- samodzielne konserwowanie i przeglądanie
- organizacja i zarządzanie miejscami pracy
- konsekwentna realizacja samodzielnego utrzymania

Czynności w trakcie pracy



Mercury Marine Video

Pokaz filmu dzięki uprzejmości
firmy Mercury Marine z Brunswick

Studium przypadku:

- Produkcja silnika przyczepnego do łodzi
- Forma mapy strumienia wartości na produkcji
- Udokumentowanie stanu aktualnego przed zmianami

MERCURY MARINE

Produkcja obudowy wału napędu

- 122 kroki,
- 27 kroków produkcji - tylko 20% wszystkich kroków,
- pokonywana odległość 6339m
- 1496 godzin w procesie - około 19 tygodni
- 106 ludzi zaangażowanych w montaż lub pracę "papierkową"

Strategia Lean Manufacturing

Dokładnie tak jak życzy sobie klient.
Produkcja jednej sztuki.
Eliminacja marnotrawstwa.
Ciągłe doskonalenie strumienia wartości.

> To wymaga czasu i zaangażowania począwszy od najwyższego kierownictwa, a skończywszy na każdym pracowniku.

Plan symulacji

1 9:00 do 12:50, dzień 1
Wstep
Przebieg 1
Przebieg podstawowy
Rozmieszczenie konw... alne
Przeglad ...

2 13:20 do 17:00, dzień 1
Przebieg 2
Przepływ części
Sterowanie wizualne
Kaizen
... b. 2

... g... b. 3

... dzień 2
Przebieg 4
Ciągły przepływ
Zrównoważone obciążenie
Montaż na zamówienie
Ciągły Kaizen
Przegląd przeb.4,
Podsumowanie

Przeb. 1

		Licz.	Koszt jedn.	Koszt	Suma
Koszty bezpośrednie	Magazynierzy i spedycja	4	$20,00	$80	
	Produkcja i narzędziownia	11	$20,00	$220	
	Inspekcja	7	$20,00	$140	$440
Koszty ogólne	Menadżer	1	$40,00	$40	
	Liderzy grup	0	$40,00	$0	
	Stoły (powierzchnia fabryki)	10	$40,00	$400	
	Audyt. i koord. Kaizen	1	$20,00	$20	$460
Zapasy i produkcja w toku	Gniazdo 1	7	$2,00	$14	
	Gniazdo 2	10	$4,00	$40	
	Gniazdo 3	10	$6,00	$60	
(Części w gniazdach i magazynie)	Gniazdo 4	5	$8,00	$40	
	Gniazdo 5	10	$10,00	$100	
	Gniazdo 6	5	$12,00	$60	$314
Zap. wyr. gotowych	Niesprzedane	0	$14,00	$0	$0
Braki i insp. końc.	Braki	8	$16,00	$128	$128
Gotowe na starcie	Początkowe	5			
Koszty materiałowe	Licz. poj. dostarcz. na linię	18	$7,50	$135	$135

Koszt całkowity = Koszty bezpoś. + Koszty ogólne + Zapasy prod. w toku +Niesprzedane + Braki + Koszty materiałowe	Koszt całkowity $1 477
9 12 0 5 Liczba wyprodukow. = Zgodne + Opóźn. + Niedostarcz. - Początk.	16
Koszt jedn. = Koszt całkow. / Licz. wyprodukow.	$92,31

Czas realizacji	Czerw.	11	min.	40	sek.	ŚREDNI CZAS REALIZACJI
	Ziel.	11	min.	40	sek.	
	Żółt.	11	min.	40	sek.	> 11 : 40

Dostawy do klienta	Zgodne	9	Satysfakcja klienta=
Zamówione=	Opóźnione	12	Zgodne / Zamówione
Zgodne+Opóźn.+Niedost.	Niedostarcz.	29	18%

Rezultaty przebiegu 1

Kalkulacja kosztu jednostkowego										
Przeb	Praca bezp. #	Praca bezp. $	Koszty ogólne $	Zapasy $	Nie sprzed. $	Złom $	Koszt mater. $	Koszt całkow. $	Licz. wypr. #	Koszt jedn. $
1	22	440	460	314	0	128	135	1477	16	92,31

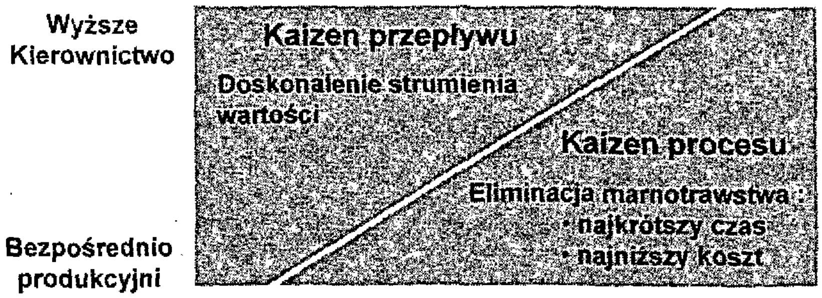
Rezultaty przebiegu 1

Satysfakcja klienta					
Przeb.	Średni czas realizacji min:sek	Zgodne #	Opóźnione #	Niezgodne #	Wskaźn. satysf. klienta %
1	> 11 : 40	9	12	29	18%

Przebieg 2

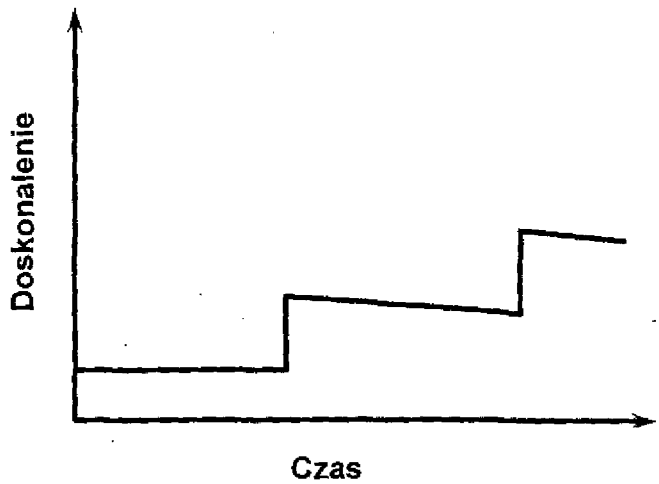
Trening na temat:
Kaizen

Dwa rodzaje Kaizen

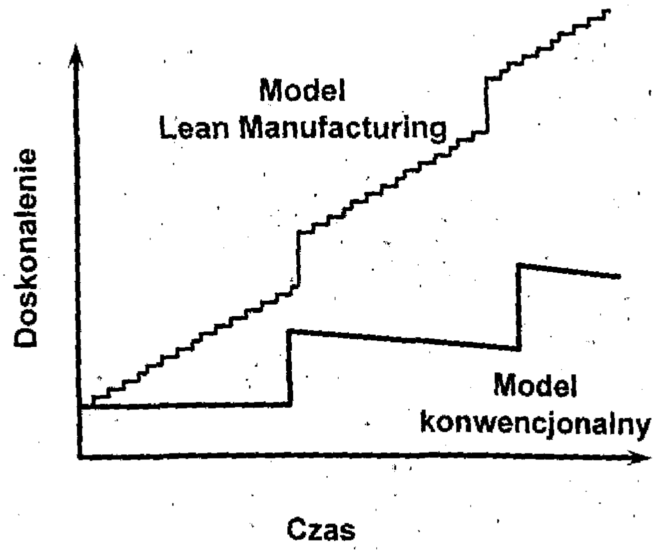


- Kaizen wymaga:
  - ciągłego, stopniowego, bezustannego doskonalenia,
  - przez pracowników na wszystkich poziomach.

Konwencjonalny model doskonalenia



Szczupły model doskonalenia



Idee Kaizen

Porządek
- Eliminacja zagracenia
- Organizacja stanowiska
- Czystość

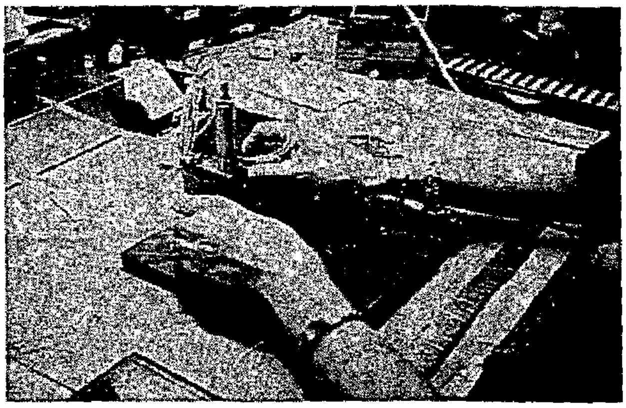
Sterowanie wizualne
- Kodowanie kolorem / etykietowanie
- Szablony / wzorniki
- Sygnalizacja

Narzędzia
- Szybkie przezbrojenia
- Uodparnianie na błędy
- Oprzyrządowanie

Metody pracy
- Uproszczenia
- Techniki
- Równoważenie

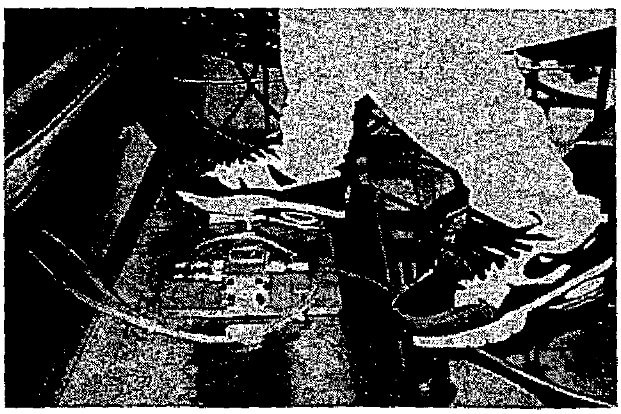
Przeorganizowanie
- Przepływ pracy
- Podawanie / manipulowanie
- Rozmieszczenie materiałów, narzędzi, osób

KAIZEN DLA WYPOSAŻENIA



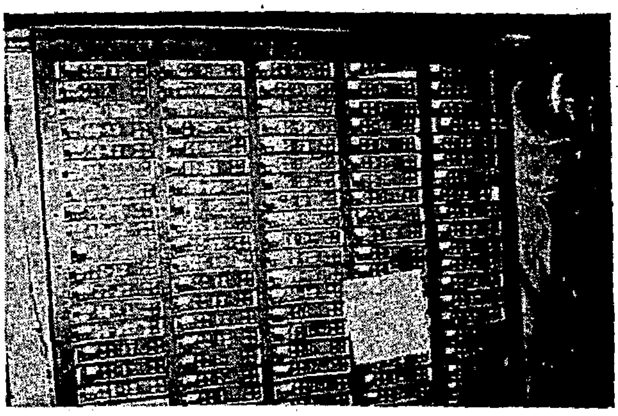
PRZED: Obie ręce użyte do pozycjonowania części. Potrzeba sięgania aby włączyć urządzenie przełącznikiem na skrzynce sterującej.

KAIZEN DLA WYPOSAŻENIA



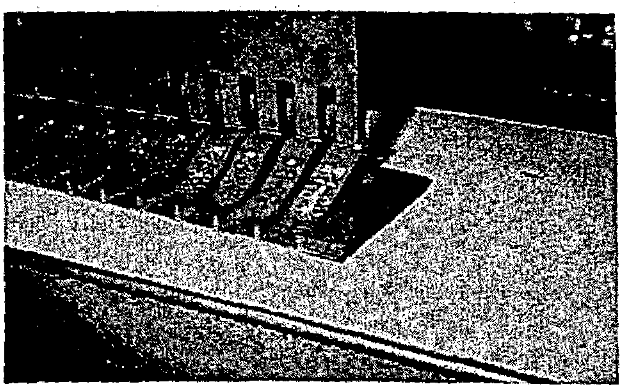
➢POTEM: Włączenie urządzenia stopą.

KAIZEN DLA STANOWISKA



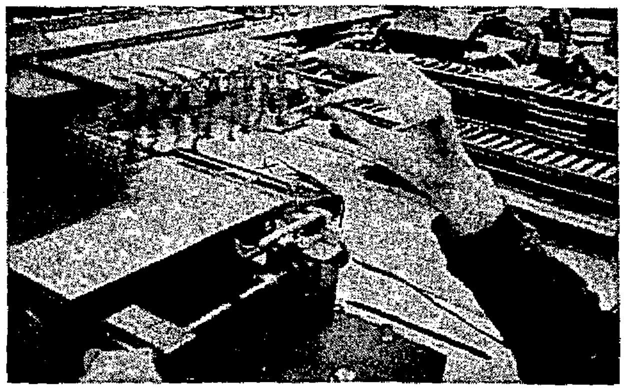
➢PRZED: Elektroniczne obwody elastyczne trudno pobrać z palety.

KAIZEN DLA STANOWISK



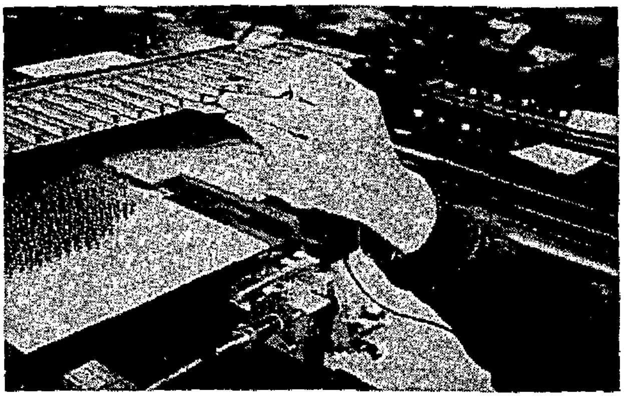
➢PIERWSZY KAIZEN: (1) Grzebień do pobierania obwodów.

KAIZEN DLA STANOWISKA



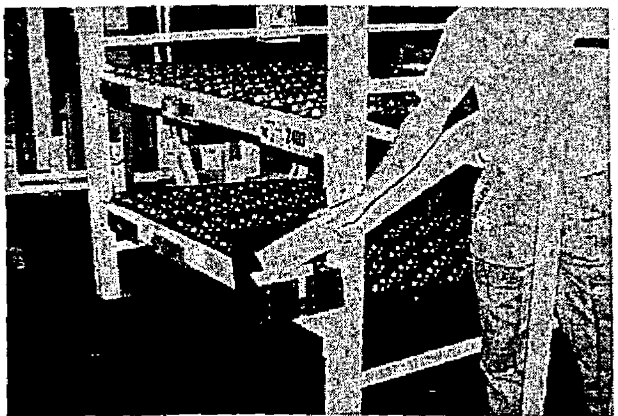
➢PIERWSZY KAIZEN: (2) Grzebień układa obwody elastyczne w uchwycie montażowym.

KAIZEN NA STANOWISKA



➢DRUGI KAIZEN: Mała paleta układana bezpośrednio w uchwycie montażowym.

KAIZEN DLA STANOWISKA

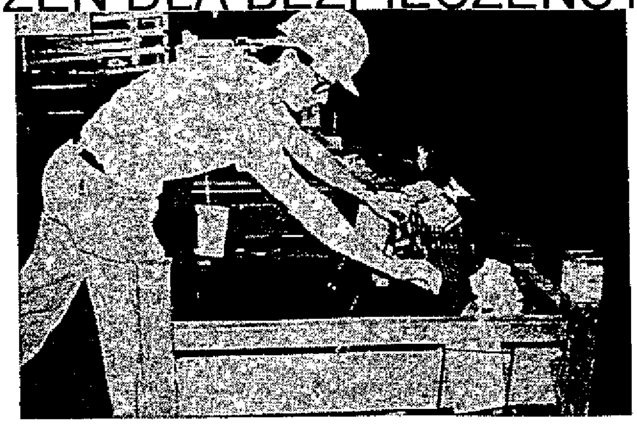


➢PRZED: Pracownik odchodzi ze stanowiska montażu na drugą stronę regału aby umieścić kartę kanban w pudełku.

KAIZEN DLA STANOWISKA

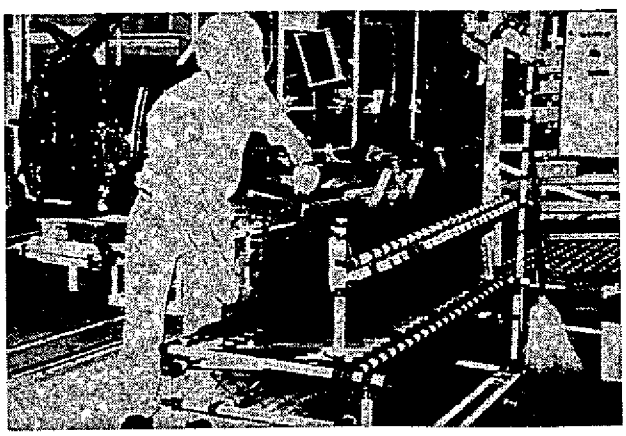
➢POTEM: Pracownik spuszcza karty kanban po pochylni prowadzącej do pudełka.

KAIZEN DLA BEZPIECZEŃSTWA



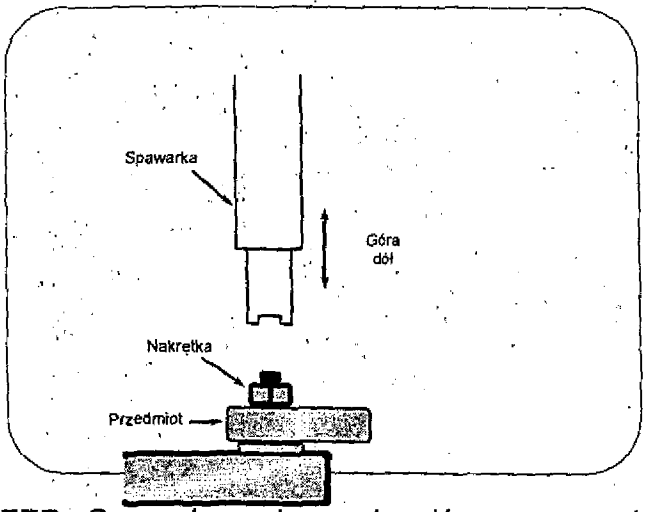
➢PRZED: Wyginanie się i sięganie w celu podniesienia szyby.

KAIZEN DLA BEZPIECZEŃSTWA



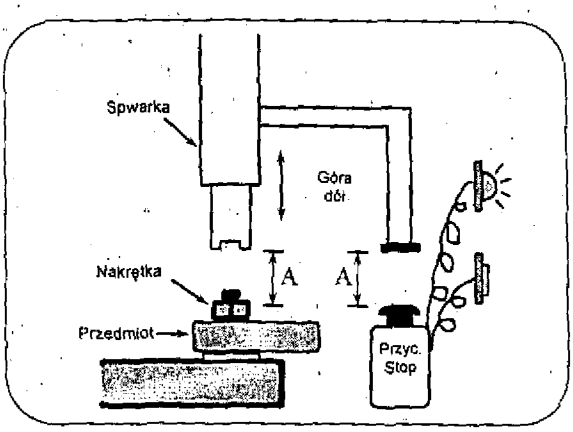
➢POTEM: Regał umożliwia bezpieczne i szybsze podniesienie szyby.

KAIZEN DLA ZPOBIEGANIA BŁĘDOM



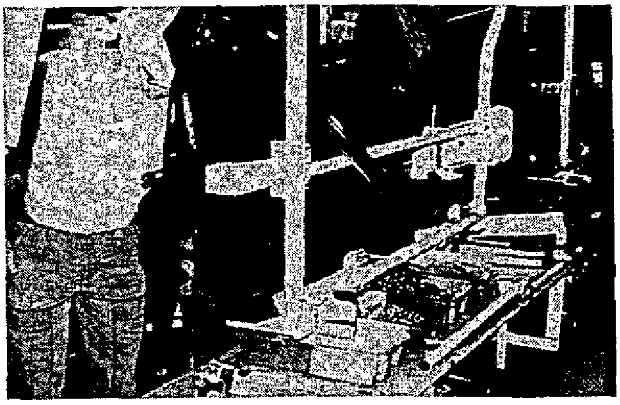
PRZED: Spawarka może uruchomić proces nawet jeśli nakrętka omyłkowo nie została umieszczona na części.

KAIZEN DLA ZPOBIEGANIA BŁĘDOM



POTEM: Przycisk zatrzymujący urządzenie spawające i alarmujący gdy brakuje nakrętki.

KAIZEN DLA STANOWISKA



➢PRZED: Wymagane jest wygięcie się w celu pobierania części.

KAIZEN DLA STANOWISKA

➢POTEM: Palety z częściami są podwyższone i opisane, konieczność wyginania się została wyeliminowana.

Doskonalenie

- Zasadnicze dla przetrwania przedsiębiorstwa
- Będzie powodować zmiany
  - **Zmiana przedmiotu pracy**
  - **Przekwalifikowanie na inny rodzaj pracy**
  - **Zorientowanie pracowników na:**
    - wiele specjalizacji,
    - lepsze wyszkolenie,
    - większą kreatywność i
    - elastyczność.
- Wymaga systematycznego podejścia

CYKL ZWYCIĘŻAJ - ZWYCIĘŻAJ - ZWYCIĘŻAJ

Inwestuj w **Pracowników**
Szkolenia
Poczucie własności
Stabilne zatrudnienie

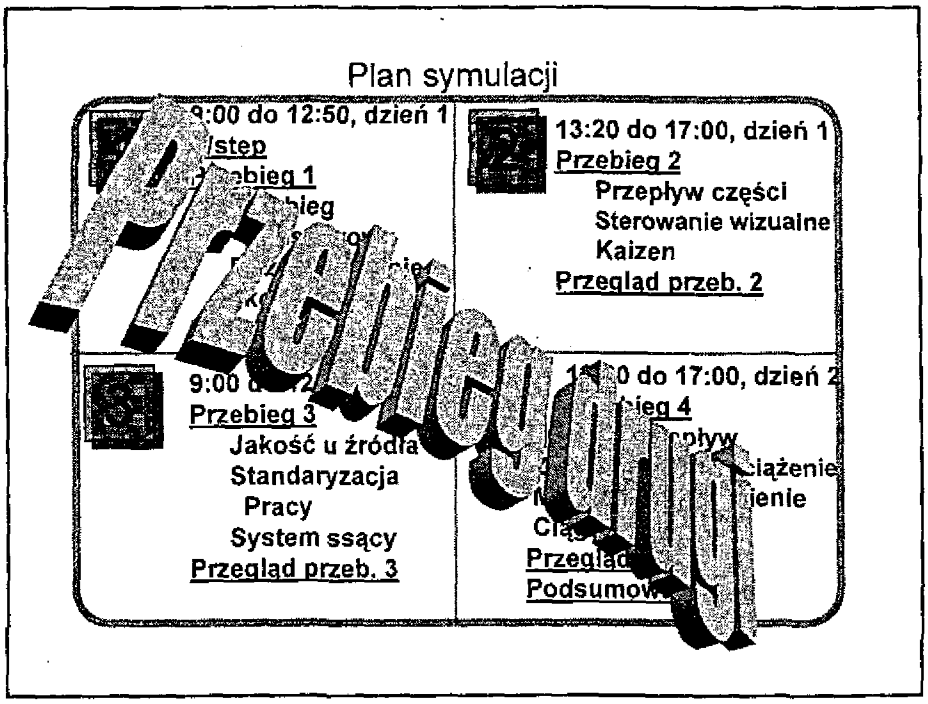
Dochody

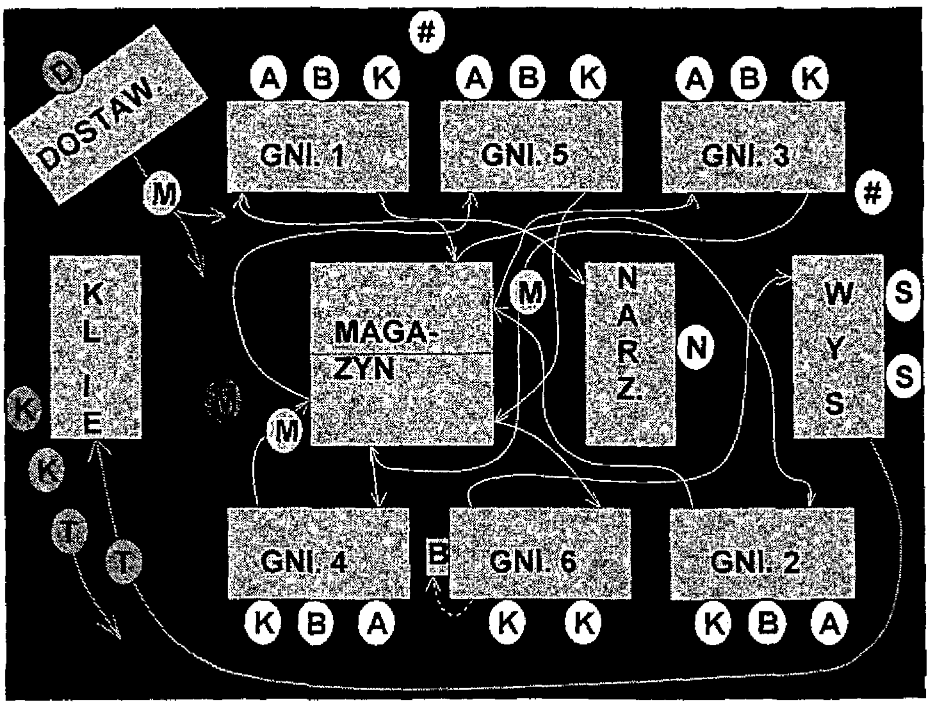
Doskonalenie

Powoduj wzrost **Firmy**
Rozszerz rynek
Zwiększ udział w rynku
Pozyskaj nowe rynki

Zadowalaj **Klienta**
Koszty (Produktywność)
Jakość
Dostawy

Sprzedaż


Plan symulacji
13:20 do 17:00, dzień 1
Przebieg 2
Przepływ części
Sterowanie wizualne
Kaizen
Przegląd przeb. 2
Przebieg 3
Jakość u źródła
Standaryzacja
Pracy
System ssący
Przegląd przeb. 3
Przebieg drugi


DOSTAW.
GNI. 1
GNI. 5
GNI. 3
KLIE
MAGA-
ZYN
NARZ.
WYS
GNI. 4
GNI. 6
GNI. 2

Rezultaty przebiegu 2

Kalkulacja kosztu jednostkowego										
Przeb	Praca bezp. #	Praca bozp. $	Koszty ogólne $	Zapasy $	Nie sprzed. $	Złom $	Koszt mater. $	Koszt całkow. $	Licz. wypr. #	Koszt jedn. $
1	22	440	460	314	0	128	135	1477	16	92,31
2	21	420	360	328	112	0	255	1475	45	32,78

Rezultaty przebiegu 2

Satysfakcja klienta					
Przeb.	Średni czas realizacji min:sek	Zgodne #	Opóźnione #	Niezgodne #	Wskaźn. satysf. klienta %
1	> 11 : 40	9	12	29	18%
2	8 : 41	24	18	8	48%

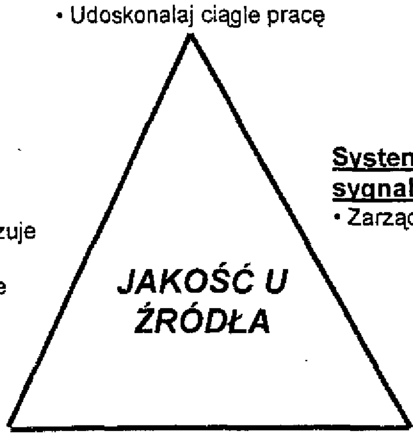
Przebieg 3

Trening na temat:

Jakość u źródła
Standaryzowana praca
System ssący

<u>Odpowiedzialność dodającego wartość</u>
- Osobiści klienci
- Udoskonalaj ciągle pracę

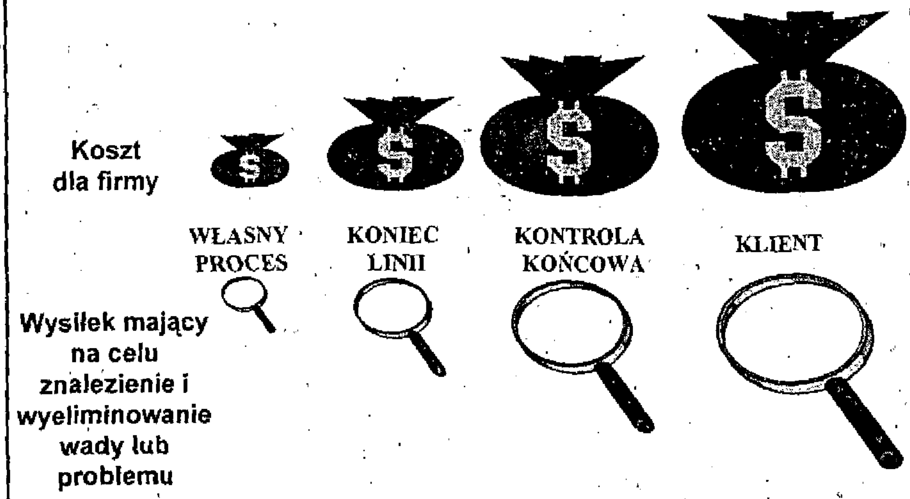
<u>System reagujący</u>
- Wyjaśnia problem
- Zatrzymuje i rozwiązuje problem
- Lokalizuje i eliminuje przyczynę

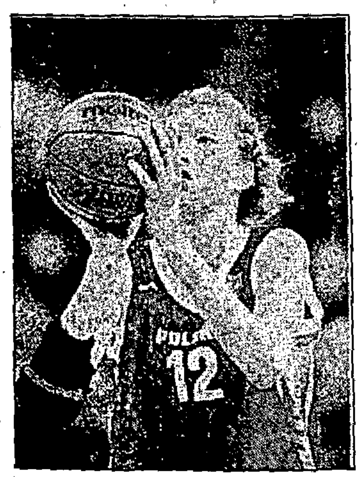


<u>System sygnalizujący</u>
- Zarządzanie wizualne

Jakość u źródła

Zmniejsza koszt oraz wysiłek





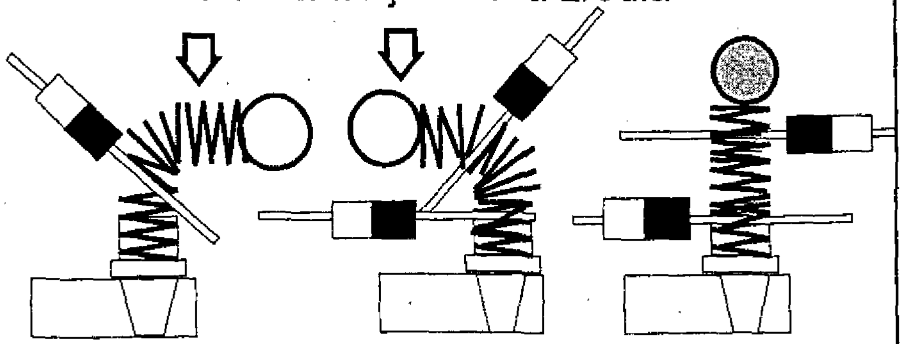
Film przedstawiający standaryzowaną pracę

STANDARYZOWANA PRACA

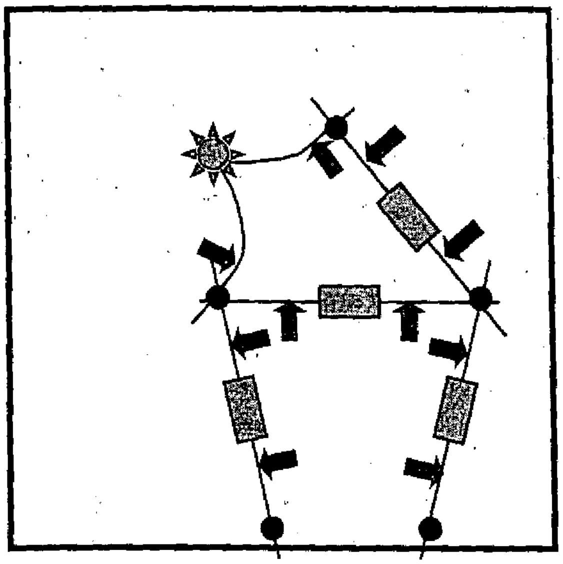
- Podziel pracę na elementy następujące po sobie
- Sprawdź szczegółowo każdy element
- Określ najlepszą metodę dla każdego elementu, korzystając z zasad oraz wskaźników
- Utwórz oraz nauczaj standardu
- Wspieraj standard poprzez zwracanie uwagi i powtarzanie
- Ulepszaj standard, gdy znaleziona zostanie lepsza metoda

STANDARYZOWANA PRACA

Podstawa jakości u źródła

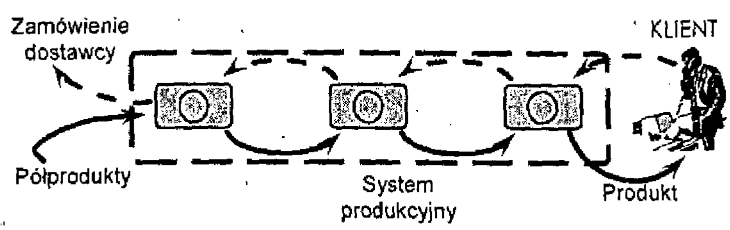


STANDARYZOWANA PRACA

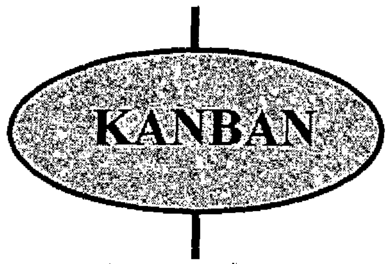


System ssący

System produkcyjny napędzany faktyczną konsumpcją oraz sterowany zsynchronizowanymi sygnałami o uzupełnieniu towaru.



Narzędzie do sterowania systemem ssącym:



- Przenosi informację na temat:
  - Co
  - Kiedy
  - Gdzie
- Może przybierać wiele form

Film prezentujący system ssący

Prelegent: Ken Wantuck
CEO, Ken Wantuck Associates, Inc..

SYSTEM SSĄCY

- System dla wydziału produkcyjnego oraz dostawców

  Wszystkie procesy połączone
  Samoregulujący się, manualny
  Wymaga dyscypliny

Czas Taktu a Czas Cyklu

Czas Taktu
to dopuszczalny jednostkowy czas na wyprodukowanie jednego wyrobu w tempie wynikajacym z zamówień klientów.

$$\text{Czas Taktu} = \frac{\text{Całkowity Czas Operacyjny np. 1 zmiana}}{\text{Całkowita Wymagana Ilość}}$$

Na przykład:
11:40 czas produkcji = 700 sekund
dla zrealizowania 50 zleceń klienta

Czas Taktu = 700 sekund/ 50 zleceń = 14 sekund

Czas Cyklu
to rzeczywisty czas zwykle upływający między chwilami zakończenia procesu nad kolejnymi dwiema częściami

Czas Cyklu musi być mniejszy lub równy od czasu taktu.

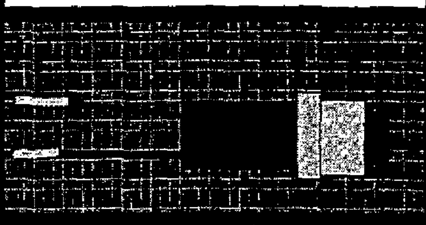
Plan symulacji

Przebieg trzeci

1 ...12:50, dzień 1 Przegląd p...	2 13:20 do 17:00, dzień 1 Przebieg 2 Przepływ części Sterowanie wizualne Kaizen ...d przeb. 2
3 9:00 do 12:50, dzień 2 Przebieg 3 Jakość u źródła Standaryzacja Pracy System ssący Przegląd przeb. 3	4 ...ń 2 Ciągły ... Zrównoważ... ...nie Montaż na zam... Ciągły Kaizen Przegląd przeb.4, Podsumowanie

Kanban dostawcy

Wielkość partii = 15



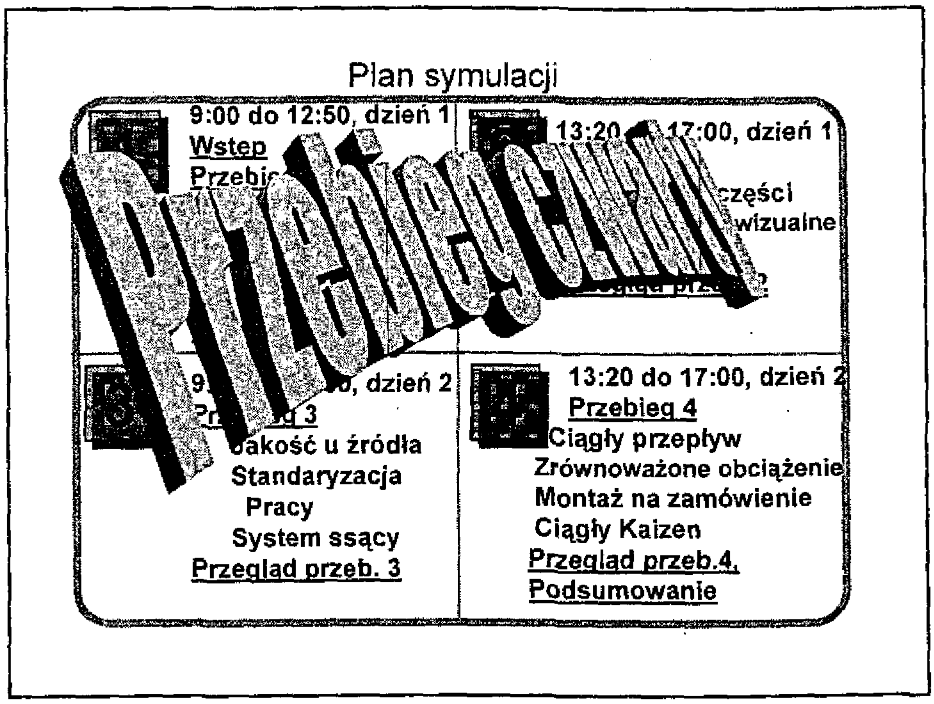
Przełącznik
Używany w gnieździe 4

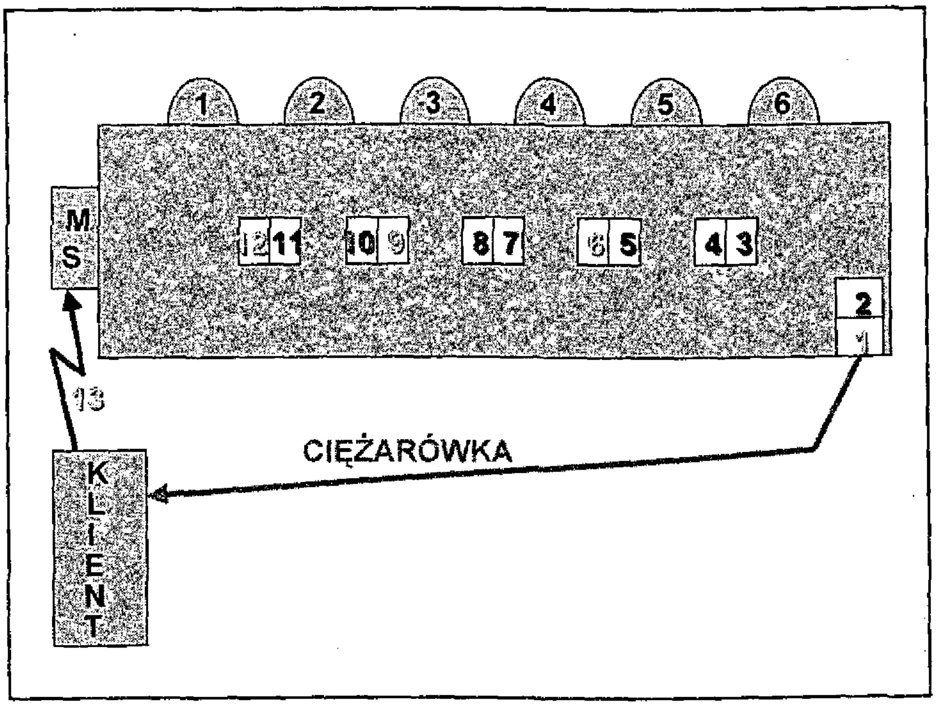
Rezultaty przebiegu 3

Kalkulacja kosztu jednostkowego										
Przeb	Praca bezp. #	Praca bezp. $	Koszty ogólne $	Zapasy $	Nie sprzed. $	Złom $	Koszt mater. $	Koszt całkow. $	Licz. wypr. #	Koszt jedn. $
1	22	440	460	314	0	128	135	1477	16	92,31
2	21	420	360	328	112	0	255	1475	45	32,78
3	14	280	400	174	84	0	294	1231,8	51	24,15

Rezultaty przebiegu 3

Satysfakcja klienta					
Przeb.	Średni czas realizacji min:sek	Zgodne #	Opóźnione #	Niezgodne #	Wskaźn. satysf. klienta %
1	> 11 : 40	9	12	29	18%
2	8 : 41	24	18	8	48%
3	3 : 59	50	0	0	100%


Plan symulacji
Przebieg ćwiczeń
9:00 do 12:50, dzień 1
Wstęp
13:20
17:00, dzień 1
części
wizualne
dzień 2
jakość u źródła
Standaryzacja
Pracy
System ssący
Przegląd przeb. 3
13:20 do 17:00, dzień 2
Przebieg 4
Ciągły przepływ
Zrównoważone obciążenie
Montaż na zamówienie
Ciągły Kaizen
Przegląd przeb.4,
Podsumowanie


1
2
3
4
5
6
M
S
12 11
10 9
8 7
6 5
4 3
2
1
13
CIĘŻARÓWKA
KLIENT

Metoda Kick-Out

- Metoda ta jest potrzebna dla zapewnienia kolejności na linii w przebiegu 4.
- Członkowie grupy powinni wzywać lidera grupy w przypadku pojawienia się problemu na linii.
- Tylko lider grupy może usunąć część z linii jeżeli staje się to konieczne.
- Lider będzie odpowiedzialny za zwrot części, jeżeli jest to możliwe, w odpowiednie miejsce na linii.

Oceny

Rezultaty przebiegu 4

Kalkulacja kosztu jednostkowego										
Przeb	Praca bezp. #	Praca bezp. $	Koszty ogólne $	Zapasy $	Nie sprzed. $	Złom $	Koszt mater. $	Koszt całkow. $	Licz. wypr. #	Koszt jedn. $
1	22	440	460	314	0	128	135	1477	16	92,31
2	21	420	360	328	112	0	255	1475	45	32,78
3	14	280	400	174	84	0	294	1231,8	51	24,15
4-B	7	140	280	20	28	0	269	736,75	50	14,74
4-O	7	140	280	40	0	0	238	697,5	45	15,50
4	14	280	560	60	28	0	506	1434,3	95	15,12

Rezultaty przebiegu 4

Satysfakcja klienta					
Przeb.	Średni czas realizacji min:sek	Zgodne #	Opóźnione #	Niezgodne #	Wskaźn. satysf. klienta %
1	> 11 : 40	9	12	29	18%
2	8 : 41	24	18	8	48%
3	3 : 59	50	0	0	100%
4-B	1 : 54	49	1	0	98%
4-O	3 : 23	38	9	3	76%
4	2 : 38	87	10	3	87%

Strategia Lean Manufacturing

Dokładnie tak jak życzy sobie klient.
Produkcja jednej sztuki.
Eliminacja marnotrawstwa.
Ciągłe doskonalenie strumienia wartości.

To wymaga czasu i zaangażowania począwszy od najwyższego kierownictwa, a skończywszy na każdym pracowniku.

Uwagi końcowe

Appendix E
Participant materials for Value Stream Mapping Workshop.

Based on the book "Learning to see" translated into Polish under the translation agreement with Lean Enterprise Institute.

Program Lean Manufacturing
Wroclaw Centre for Technology Transfer

Mapowanie Strumienia Wartości Warsztaty

Oparte na książce „Naucz się widzieć" M.Rother, J.Shook
Lean Enterprise Institute

Mapowanie Strumienia Wartości

Mapowanie Strumienia Wartości Warsztaty Szkoleniowe

Mapowanie Stanu Aktualnego

- Mapowanie strumienia wartości – wprowadzenie
- Mapa stanu obecnego na przykładzie firmy ACME Stamping
- Ćwiczenie praktyczne – mapowane strumienia wartości w przedsiębiorstwie

Mapowanie Stanu Przyszłego

- Szczupłe techniki wytwarzania – sesja wykładowa
- Mapa stanu przyszłego dla ACME Stamping
- Mapa stanu przyszłego dla przedsiębiorstwa

Mapowanie Strumienia Wartości

Lean Manufacturing - geneza

- Taichi Ohno i sukces Toyoty,
- International Motor Vehicle Study Group w MIT
- Womack,Jones, Shook
  - „Maszyna która zmieniła świat" 1990
  - „Szczupłe myślenie" 1996
- Lean Enterprise Institute LEI
- 60% firm produkcyjnych w USA wdraża Lean
- Lean Manufacturing Program w Polsce od 1999

Mapowanie Strumienia Wartości

Rodzaje marnotrawstw

- ***Nadprodukcja***
- ***Zapasy***
- ***Poprawianie braków oraz błęd***
- ***Zbędne przetwarzanie***
- ***Zbędne przemieszczanie mate***
- ***Nadmierny ruch***
- ***Oczekiwanie***
- ***Stracona kreatywność***

W konwencjonalnej fabryce tylko ok. 15-20% kroków produkcyjnych dodaje wartość.

To stanowi tylko 0,2% czasu jaki materiał spędza w fabryce.

Mapowanie Strumienia Wartości

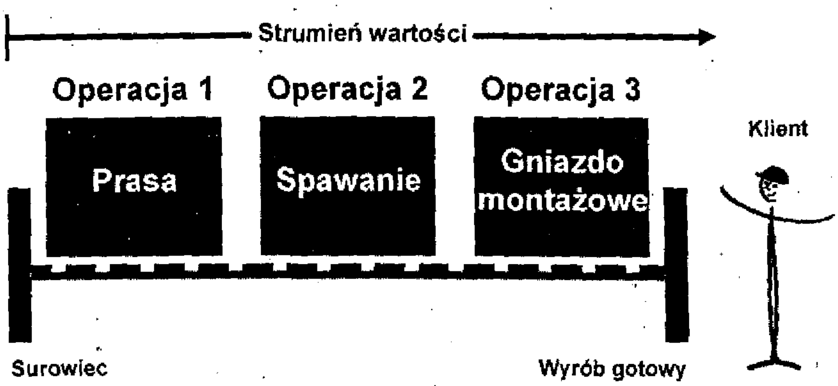
Mapowanie Strumienia Wartości

Cel szkolenia

- Zapoznanie uczestników z techniką mapowania strumienia wartości.
- Rozwinięcie umiejętności widzenia przepływów oraz projektowania kształtu przyszłych (pożądanych) strumieni wartości z wykorzystaniem metod i technik Lean Manufacturing.

Mapowanie Strumienia Wartości

Doskonalenie strumienia wartości a doskonalenie pojedynczych operacji



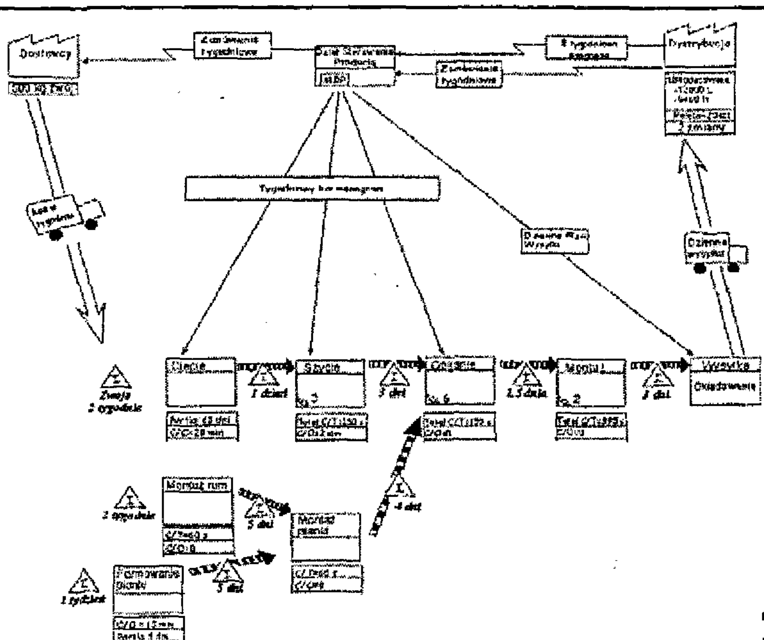
Mapowanie Strumienia Wartości

Mapowanie Strumienia Wartości

- prześledź marszrutę produkcyjną wyrobu od końca do początku, począwszy od klienta a skończywszy na dostawcy (w górę strumienia wartości), szkicując logikę przepływu materiałów i informacji za pomocą ustalonych symboli,

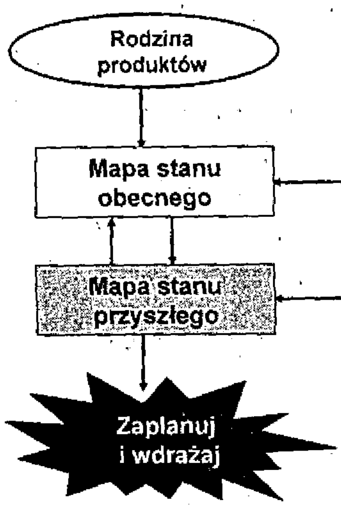
- naszkicuj mapę stanu przyszłego (wskaż pożądany przepływ strumienia wartości).

Mapowanie Strumienia Wartości



Mapowanie Strumienia Wartości

Jak korzystać z mapowania?



Zrozumienie zasad funkcjonowania systemu wytwarzania w obecnej formie. Punkt wyjścia dla stanu pożądanego.

Projekt szczupłego przepływu.

Mapowanie Strumienia Wartości

Skoncentruj się na jednej rodzinie produktów

Określ rodziny produktów poprzez: te same lub podobne procesy (operacje technologiczne) wykonywane na tych samych urządzeniach

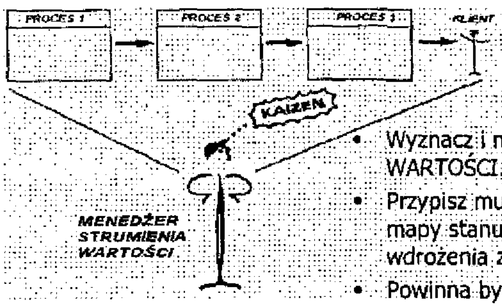
(a nie cechy wyrobu)

		PROCESY						
		Spawanie punktowe	Spawanie ciągłe	Usuwanie zgorzeliny	Malowanie	Montaż ręczny	Montaż oprzyrządowania	Test elektr.
PRODUKTY	Układ kierowniczy lewy	X		X	X	X		
	Układ kierowniczy prawy	X		X	X	X		
	Tablica przyrządów		X				X	X
	Prowadnice siedzeń	X					X	
	Uchwyt zderzaka	X				X	X	

Mapowanie Strumienia Wartości

Menedżer strumienia wartości

Każdy strumień wartości (rodzina produktów) potrzebuje menedżera



- Wyznacz i mianuj MANEDŻERA STRUMIENIA WARTOŚCI.
- Przypisz mu odpowiedzialność za stworzenie mapy stanu przyszłego i przeprowadzenie wdrożenia zawartych w niej pomysłów.
- Powinna być to osoba upoważniona do wprowadzania zmian na poziomie pojedynczych procesów jak i między nimi – na poziomie całego strumienia wartości.
- Osoba ta powinna bezpośrednio raportować osiągane postępy dyrektorowi firmy.

Mapowanie Strumienia Wartości

Poziomy Strumieni Wartości

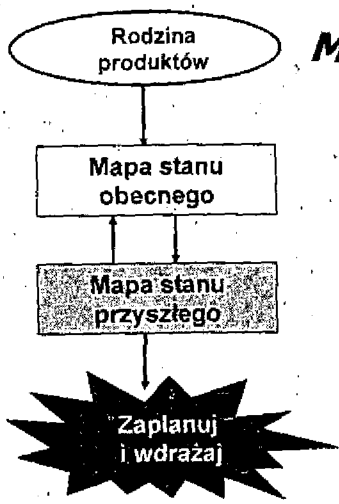
poziom operacji

zakład produkcyjny
„od drzwi do drzwi"

grupa zakładów

łańcuch dostaw

Mapowanie Strumienia Wartości



Mapa stanu obecnego

Zrozumienie zasad funkcjonowania systemu wytwarzania w obecnym kształcie.

- ✓ **Uwzględniamy przepływy materiałowe i informacyjne**
- ✓ **Rysujemy używając ustalonych symboli graficznych na kartce papieru**
- ✓ **Zaczniemy od przepływu w perspektywie „od drzwi do drzwi"**
- ✓ **Przemieszczamy się w górę strumienia i zbieramy faktyczne dane**
  - **Nie korzystamy z czasów założonych z góry!**
  - **Rysujemy ręcznie, przy użyciu ołówka i gumki!**
- ✓ **Mapa stanu obecnego będzie podstawą mapy stanu przyszłego.**

Mapowanie Strumienia Wartości

STUDIUM PRZYPADKU – ACME

ACME jest producentem serii produktów dla przemysłu motoryzacyjnego. Przykład dotyczy jednej rodziny produktów firmy: stalowej konstrukcji nośnej do mocowania konsoli. Produkowana jest ona w dwóch odmianach: prawo i lewostronnej dla tego samego pojazdu. Podzespoły wysyłane są do klienta, którym jest State Street Vehicle Assembly Plant.

- → **WYMAGANIA KLIENTA:**
  - ✓ **18,400 sztuk/miesiąc**
    - → **12,000 szt/msc typu L (lewostronny)**
    - → **6,400 szt/msc typu P (prawostronny)**
  - ✓ **Zakład klienta pracuje w systemie dwuzmianowym**
  - ✓ **Sposób pakowania: pojemniki zwrotne, układane na palecie. Do każdego z pojemników pakowane jest po 20 paneli. Na palecie można ułożyć do 10 pojemników. Klient zamawia wielokrotność palet.**
  - ✓ **Dostawa do klienta: raz dziennie ciężarówką.**
- → **CZAS PRACY:**
  - ✓ **20 dni w miesiącu**
  - ✓ **Praca na dwie zmiany na wszystkich wydziałach produkcyjnych**
  - ✓ **Zmiana trwa 8 godzin. Jeśli zachodzi taka potrzeba, praca wykonywana jest w nadgodzinach.**
  - ✓ **Na każdą zmianę przypada *10* min. przerwy. Operacje wykonywane ręcznie są przerywane podczas przerw.**

Mapowanie Strumienia Wartości

STUDIUM PRZYPADKU – ACME (c.d.)

Dane dotyczące procesów wytwórczych:

Kolejne operacje następują w przedstawionej poniżej kolejności. Każda część przechodzi przez wszystkie wymienione operacje.

1. TŁOCZENIE (prasa tłoczy części dla wielu produktów ACME)
   - ✓ Automatyczna, 200 tonowa prasa z automatycznym podajnikiem surowca
   - ✓ Czas cyklu: 1s (60 części na minutę).
   - ✓ Czas przezbrajania: 1h
   - ✓ Niezawodność maszyny (dostępność): 85%
   - ✓ Proces obsługiwany przez jednego operatora
   - ✓ Zaobserwowane zapasy międzyoperacyjne:
     - ❑ 5 dni w zapasach przed operacją tłoczenia
     - ❑ 4,600 części typu L po zakończonej operacji
     - ❑ 2,400 części typu P po zakończonej operacji
2. SPAWANIE PUNKTOWE STANOWISKO 1 (*stanowisko dedykowane omawianej rodzinie wyrobów*)
   - ✓ Proces wykonywany ręcznie przez jednego operatora
   - ✓ Czas cyklu: 39s
   - ✓ Czas przezbrajania: 10 min. (zmiana zamocowania)
   - ✓ *Niezawodność maszyny (dostępność): 100%*
   - ✓ Zaobserwowane zapasy międzyoperacyjne:
     - ❑ 1,100 części typu L po zakończonej operacji
     - ❑ 600 części typu P po zakończonej

4. GNIAZDO MONTAŻOWE 1(dedykowane omawianej rodzinie wyrobów)
   - ✓ Proces wykonywany ręcznie przez jednego operatora
   - ✓ Czas cyklu: 62s
   - ✓ Czas przezbrajania: 0s
   - ✓ Niezawodność (dostępność): 100%
   - ✓ Zaobserwowane zapasy międzyoperacyjne:
     - ❑ 1,200 części typu L po zakończonej operacji
     - ❑ 640 części typu P po zakończonej operacji
5. GNIAZDO MONTAŻOWE 2 (dedykowane omawianej rodzinie wyrobów)
   - ✓ Proces wykonywany ręcznie przez jednego operatora
   - ✓ Czas cyklu: 40s
   - ✓ Czas przezbrajania: 0s
   - ✓ Niezawodność (dostępność): 100%
   - ✓ Zaobserwowane zapasy w magazynie wyrobów gotowych:
     - ❑ 2,700 części typu L
     - ❑ 1,440 części typu P
6. *DZIAŁ WYSYŁKI*
   - ✓ Przenosi części z Magazynu Wyrobów Gotowych oraz przygotowuje do wysyłki do klienta.

Mapowanie Strumienia Wartości

Wskazówki dla zespołu
Mapa stanu bieżącego

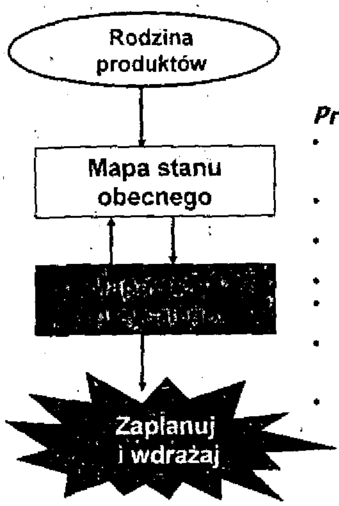
Mapowanie stanu obecnego:

- Przypomnijmy sobie bieżące kroki produkcyjne i obliczmy czas taktu (w pomieszczeniu szkoleniowym).
- Wszyscy rysują mapę podczas pobytu na wydziale produkcyjnym.
- Rysujemy przepływy materiałowe i informacyjne.
- Zawsze przedstawcie się operatorom i powiedzcie, co będziesz robili: rysowanie przepływów w fabryce w ramach odbywającego się szkolenia. Pokażcie im swoje szkice.
- Należy wytypować jedną osobę, która narysuje mapę na tablicy na podstawie rysunków sporządzonych przez grupę na wydziale produkcyjnym.
- Należy obliczyć całkowity produkcyjny czas przejścia oraz sumaryczny czas przetwarzania.

Prezentowanie mapy stanu obecnego:

- Należy wytypować osobę prezentującą.
- Podczas prezentacji należy przedstawić wybraną rodzinę produktów oraz obliczony czas taktu.
- Należy rozpocząć od klienta i przepływu informacji w firmie.
- Następnie należy przedstawić wyniki obliczeń sumarycznego czasu przetworzenia i całkowitego czasu przejścia części.
- Jakie są problemy, które widzimy? Gdzie znaleziono obszary „pchania" produkcji i obszary nadprodukcji?
- Przedyskutujcie pomysły dotyczące stanu przyszłego.

Mapowanie Strumienia Wartości



Mapa stanu przyszłego

Projektowanie szczupłego przepływu

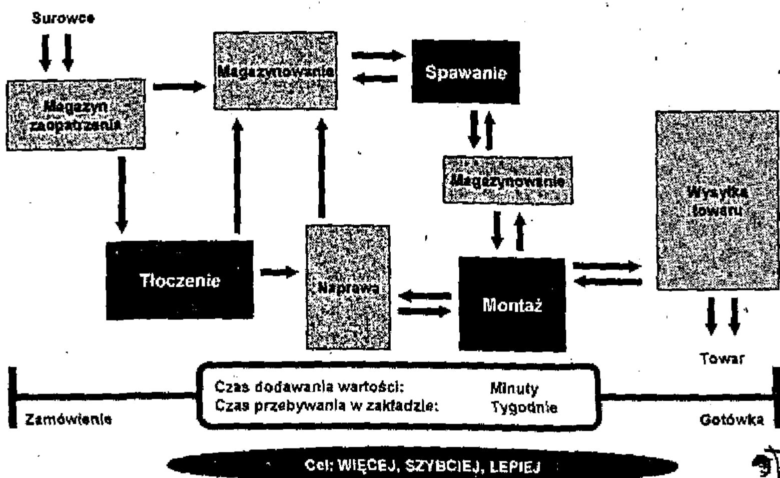
- Ostatecznym celem mapowania jest stworzenie mapy pożądanego stanu jaki chcemy osiągnąć w przyszłości.
- Wystarczy 70% wiedzy o strumieniu w obecnym kształcie – ciągle aktualizuj. Używaj ołówka!
- Wiele szczegółów zostanie dopracowanych podczas wdrożenia.
- Mapuj przepływy materiałowe i informacyjne.
- Mapa będzie stanowić podstawę twojego planu wdrożeń.
- Możesz równolegle rozpocząć mapowanie (kreślenie idei) stanu przyszłego (np. innym kolorem).
- Pierwsze podejście powinno uwzględniać istniejące kroki produkcyjne i wyposażenie (można przemieszczać maszyny, tworzyć kombinacje stanowisk, przewidywać drobne zakupy)

MAMY JEDNAK PROBLEM!

Mapowanie Strumienia Wartości

Produkcja masowa

Duże partie, produkcja pchana, mentalność „odizolowanych wysp"



Mapowanie Strumienia Wartości

Marnotrawstwo

• Te elementy w procesie produkcyjnym, które nie dodają wartości do wyrobu

• Marnotrawstwo dodaje jedynie czas i koszty

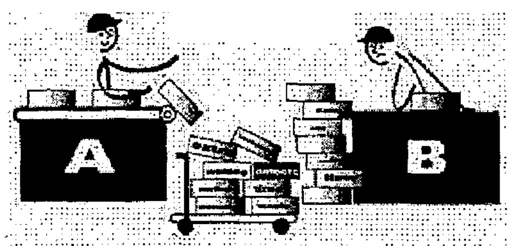
Należy pamiętać, że:

- **Marnotrawstwo jest raczej symptomem problemu niż faktyczną jego przyczyną**
- **Objawy marnotrawstwa wskazują problemy w obrębie systemu (zarówno na poziomie operacji jak i w strumieniu wartości)**
- **Musimy znaleźć i określić przyczyny marnotrawstwa.**

Mapowanie Strumienia Wartości

Nadprodukcja, czyli:

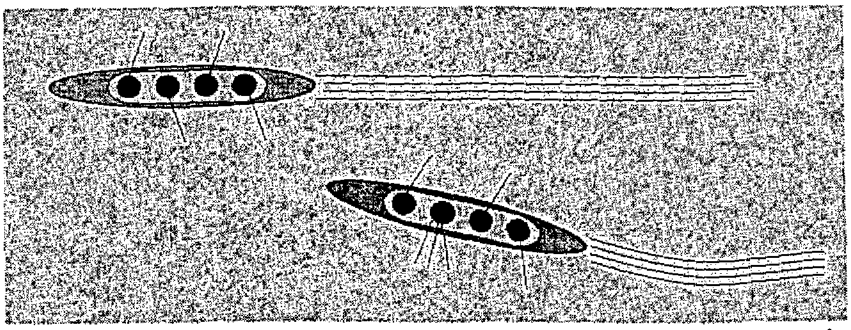
- ❑ Produkowanie większej liczby części, niż jest to wymagane przez następny proces.
- ❑ Produkowanie za wcześnie w stosunku do potrzeb kolejnej operacji.
- ❑ Produkowanie szybciej w stosunku do kolejnej operacji.



Mapowanie Strumienia Wartości

Efektywność pojedynczej operacji
a
efektywność całego systemu

Jak szybko powinniśmy produkować?



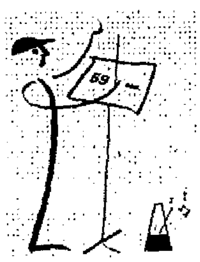
Mapowanie Strumienia Wartości

Czas taktu

Dostosowuje tempo wytwarzania do tempa zamówień składanych przez klienta

Wyznacza tempo montażu na podstawie tempa sprzedaży

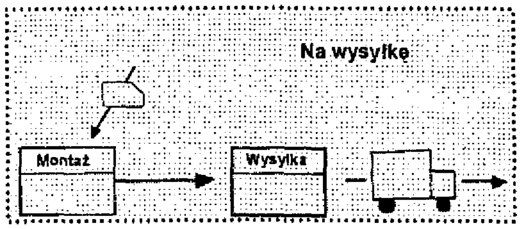
$$\text{Czas taktu} = \frac{\text{Dostępny czas pracy przypadający na jedną zmianę}}{\text{Zapotrzebowanie klienta przypadające na jedną zmianę}}$$

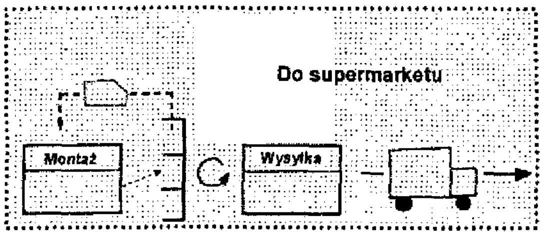


$$\frac{27\,000\text{ s}}{460\text{ sztuk}} = 59\text{ s}$$

Mapowanie Strumienia Wartości

Produkcja do supermarketów czy na wysyłkę?





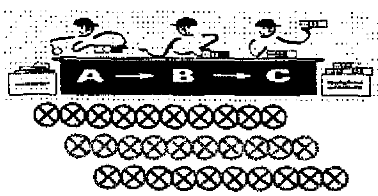
Mapowanie Strumienia Wartości

Przepływ ciągły (przepływ jednej części)

Produkcja w partiach i pchanie

Całkowity produkcyjny czas przejścia: 30++ min. dla całej partii

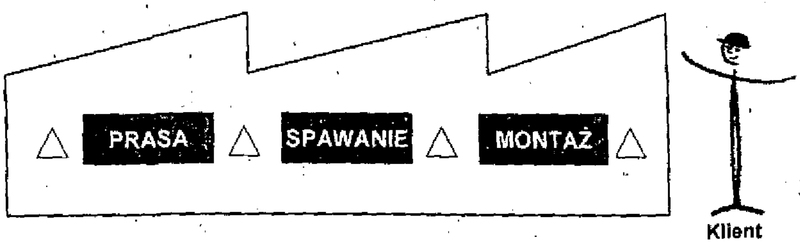
Przepływ ciągły „ produkuj jedną sztukę, przemieszczaj jedną sztukę"



Mapowanie Strumienia Wartości

Krytyczne punkty przepływu

Tam, gdzie kończy się przepływ jednej sztuki



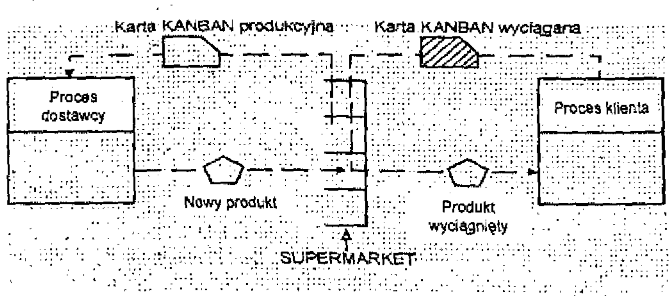
- Jak sterować produkcją pomiędzy etapami o ciągłym przepływie?
- Czy stosować prognozy bazujące na systemach MRP?

Mapowanie Strumienia Wartości

System ssący typu supermarket

1) Proces klienta pobiera z supermarketu to czego potrzebuje i kiedy potrzebuje

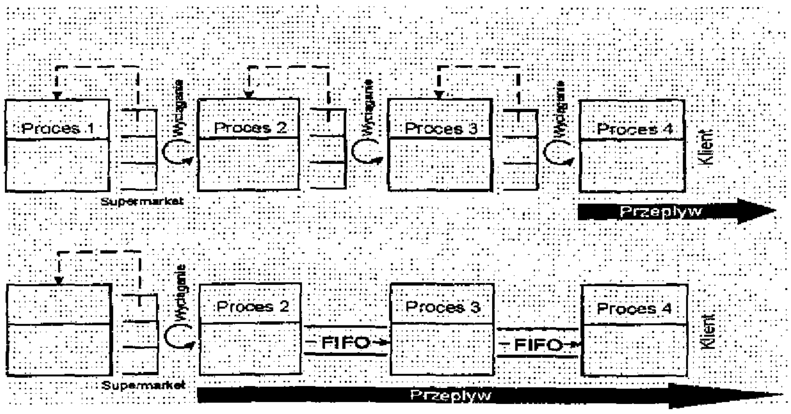
2) Proces dostawcy uzupełnia to co zostało pobrane



**Cel: Sterowanie produkcją między etapami o ciągłym przepływie
Sterowanie produkcją procesu dostawcy bez użycia harmonogramu**

Mapowanie Strumienia Wartości

Spróbuj harmonogramować produkcję tylko w jednym punkcie w przepływie

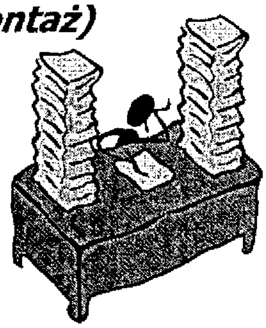


Mapowanie Strumienia Wartości

Mieszanie (poziomowanie) produkcji w stymulatorze (montaż)

Zły sposób mieszania:

Plan montażu
Poniedziałek......400 A
Wtorek...............100 A, 300 B
Środa.................200 B, 200 C
Czwartek...........400 C
Piątek................200 C, 200 A



Ważne:

W stymulatorze procesu powinny być możliwe częste przezbrojenia oraz czas przezbrojenia bliski zeru.

Lepiej: wszystkie typy jednego dnia

Poniedziałek: 140 A, 100 B, 160 C

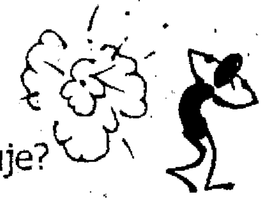
Jeszcze lepiej: wszystkie typy na 1 wysyłkę

Poniedziałek →

60 B, 70 A, 80 C	60 B, 70 A, 80 C

Mapowanie Strumienia Wartości

Co zdarzy się w odchudzonym przepływie ...



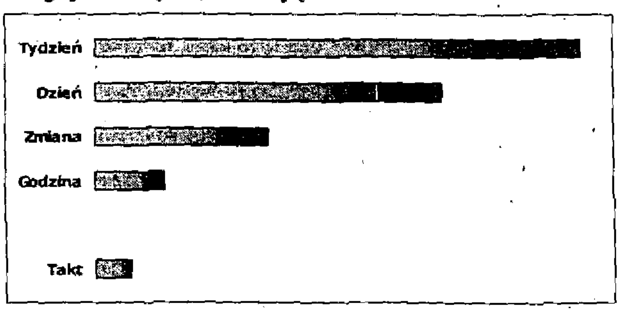
...jeśli maszyna się zepsuje?

...jeśli brak dostanie się do pojemnika z dobrymi częściami?

Mapowanie Strumienia Wartości

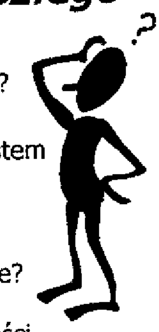
Tempo odbierania produkcji ze stymulatora

- W jakich porcjach wielkość produkcji jest harmonogramowana i odbierana ze stymulatora?
- Porcja ta = ustalona podziałka czasowa sterowania produkcją (jak często możesz porównać wyprodukowaną ilość z zamówieniami klientów?).
- Czy posługujecie się wizualizacją taktu?



Mapowanie Strumienia Wartości

Kluczowe pytania do stanu przyszłego



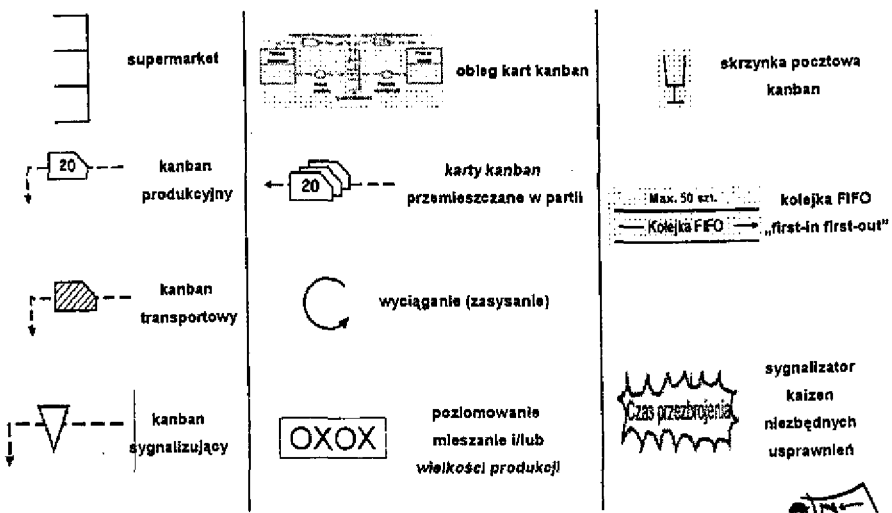
- Jaki jest czas taktu?
- Będziemy produkować na wysyłkę czy do supermarketu?
- Gdzie możemy zastosować przepływ ciągły?
- W których miejscach przepływu musimy zastosować system ssący typu supermarket?
- Który punkt (proces) w przepływie wyznaczymy na stymulator strumienia wartości?
- Jak poziomujemy (mieszamy) produkcję na stymulatorze?
- W jakich porcjach produkcja będzie zlecana procesowi stymulatora i odbierana od niego (poziomowanie wielkości produkcji)?

USPRAWNIENIA WSPOMAGAJĄCE:

Jakiego typu usprawnienia procesów będą niezbędne (np. dotyczące przezbrojeń, dostępności maszyn, szkolenia itp.)

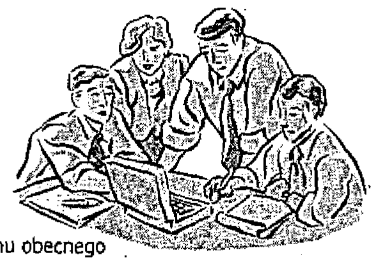
Mapowanie Strumienia Wartości

Ikony stanu przyszłego



Mapowanie Strumienia Wartości

Wskazówki dla zespołu
Mapa stanu przyszłego



Mapowanie stanu przyszłego:
- Użyj listy pytań dla stanu przyszłego
- Zacznij rysować na kopiach mapy stanu obecnego
- Narysuj wizję pożądanego stanu przyszłego

Prezentacja mapy stanu przyszłego:
- Omawiając poniższe punkty wyjaśnij podstawy dokonanego wyboru:
  - ✓ Czas taktu?
  - ✓ Produkować na wysyłkę czy do supermarketu?
  - ✓ Gdzie planujemy przepływ ciągły, gdzie zajdzie potrzeba ssania?
  - ✓ Który z procesów został wybrany na stymulator strumienia wartości?
  - ✓ Gdzie znajduje się punkt harmonogramowania produkcji i ile wynosić będzie podziałka czasowa sterowania produkcją?
  - ✓ Czy zaplanowano poziomowanie mieszania produktów na montażu?
  - ✓ Czy wymagane są dodatkowe usprawnienia procesów?
  - ✓ Jakie są spodziewane wyniki w zakresie całkowitego produkcyjnego czasu przejścia?

Mapowanie Strumienia Wartości

Plan osiągnięcia stanu przyszłego
Plan wdrożeń

- Nie zwlekaj!
- Aby zarządzać zmianami potrzebujesz planu!
  - Powiąż go z celami biznesowymi firmy.
  - Podziel mapę stanu przyszłego na pętle.
  - Stwórz plan Strumienia Wartości: Co ma zostać zrobione i do kiedy.
  - Teraz spróbuj odnieść swoją mapę do faktycznego rozkładu maszyn w firmie (layout'u).
  - Menedżer strumienia wartości powinien dokumentować przegląd strumienia wartości
  - Przeprowadzenie przeglądu strumienia wartości przeprowadza się przemieszczając halę produkcyjną i śledząc przepływ.

Mapowanie Strumienia Wartości