WORLD CLASS MANUFACTURING AS A PRODUCTION MANAGEMENT SYSTEM IN THE CERAMIC INDUSTRY

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ABSTRACT

World Class Manufacturing (WCM) is the generalization of the managing system commonly known as the "Toyota Production System". WCM is the kind of philosophy which organizes manufacturing and logistics, including the interaction with suppliers and customers. This system is known under different names: as Lean Manufacturing, as well as Kaizen. It was largely created by the founder of Toyota, Sakichi Toyoda, Kiichiro Toyoda and Taiichi Ohno. The System also takes advantage of some elements from the work of Edwards Deming and Henry Ford. The main goals of WCM are to design out overburden, smooth production and eliminate 7 basic wastes (overproduction, transportation, inventory processing, waiting, defects, motion). The main benefits to be obtained are: strong reduction of lead time, increased productivity (decreased production cost), reduction of work-in-progress inventory, improvement of quality, reduction of use of space, and the commitment of all employees. In this paper the author wants to transfer his own experience and knowledge resulting form 3 years managing the implementation of this system in a ceramic factory.

1. INTRODUCTION

WCM program (*World Class Manufacturing*) is well-known the in engineering industry, especially in the motor industry, aerospace and machinery industry. In view of the author's own experience, the program can be successfully implemented in many different branches (examples are metallurgy: Aichi Steel, ARCELOR, toys: LEGO, electrotools: Bosch, Vulcano Housekeeping: Electrolux, tires: Pirelli, MATADOR) as well as in the ceramic industry (TOTO Company, Glassworks Gostynin, SANITEC, EPCOS Piezo Technology, BPB Gipsum).

Let us look at the essence of this program. Its basics is a mix of American and European managing rules with Japanese ones, in addition to some Japanese national features, such as national pride, patience, devotion, diligence, care of details, obedience.

In Japan already before the 2nd World War, Sakishi Toyoda (future founder of the Toyota Company), a small-scale industrialist and inventor, possessed small weave workshop. By observing the looms' work he formulated the first rules of what was to become the basis of the Toyota Production System (WCM, also KAIZEN), namely MUDA and Jidoka and JiT.

In Japanese MUDA means, **waste** but S. Toyoda defined seven types of WASTES (overproduction, inventories, defects, waiting, transportation, motion, over-processing). The first rule of this new production management system was the elimination of all possible wastes.

Jidoka has the same meaning as "autonomation" and is the term used in WCM to mean "automation with a human touch" or "intelligent automation". In this sense, "autonomation" implements some supervisory functions rather than production functions. In the case any abnormal situation arises, the device stops and the operators can stop the production line. This system prevents the production of defective products, eliminates overproduction and focuses attention on understanding the problem and ensuring that it never recurs.

The first example of the application of the idea of "autonomation" and eliminating defects was invented and patented as a "semi-activist" system of the loom by S. Toyoda (Fig. 1. – from Toyota Museum), which was stopped immediately and automatically after detecting any irregularity in the device.

Figure 1. S. Toyoda's loom first device that owned the element of WCM (Toyota's museum).

The third idea, JiT, has been taken from the Ford Factory and developed firstly by S. Toyoda and later by Koichiro Toyoda (*son of S. Toyoda*) and Taichi Ohno. JiT (just in time) means "right material in the right place, in the right time and right quantity". The extension of the JiT system is the Supermarket and Kanban systems, which are common in the car or machinery industry.

After the 2nd World War modern economy did not exist in Japan, it was a strong imperial system with feudalistic trends and the country was occupied by American forces. When the "Cold War" developed, the USA needed a strong ally rather than a devastated and hostile country. It was a beginning of a big reconstruction schedule of a Japan. The industry was rebuilt and new technologies were transferred. Many managing specialists were sent there (such as, E. Deming or W. Shewhard), who visited Japan many times in order to teach local industrialists quality management through the standardization and statistical control of a production process. Representatives of the Japan industry studied in the USA, where they served a factory apprenticeship. They were acquainted with the rules of mass-production using the assembly line and standardization of the production process.

This process lasted a dozen or so years. The first symptoms (Table 1) of a quick implementation of foreign inventions and their far going improvements in USA and Europe were ignored, but they still showed quick changes in Japan industry. We have to remember that an invention is an idea, sometimes with an operative prototype or a single batch of products and an innovation is an invention implemented into normal production and had a market (outlet).

Invention	Creator	Innovator
Transistor radio	Regency (USA)	Sony
Video	Amper (USA)	Sony, Matsushita
Rotary engine	Felix Wankel	Mazda
CD player	Philips (Holland)	Sony

Table 1. Inventions vs. innovations.

The world was shocked by the first energy crisis in 1970s. It was exactly then that Japan showed small, economical and especially fail-proof cars to the world. It was the real beginning of the expansion of the Japanese goods to the whole world. How was it possible that an ineffective economy could produce such good products? What was their way to achieve such a high efficiency and low production costs?

During the same time two of various managing elements dominated in Europe (and they are still dominating in many places) such as keeping "status quo" and "innovations". They have particular importance in production companies. First element is linked to all the activities directed at keeping the standards (managing system, technological and production parameters and procedures). It is linked with our mentality and activities which results from overriding managing systems, like ISO. In many companies, there are Standard Operations Procedures, the board makes the company policy, mission, and vision; purchase, production,

sale and complaint procedures are made. Later all take care, in order to obey these procedures. There is a lot of training, and managing is based on an oriented system: "top to bottom" and worker discipline. The cases of a change in procedures occur seldom and accidentally. Most of the time and energy is devoted for maintenance of the "status quo".

The second element, innovation is a method of implementing changes, but in principle just the big ones. In this way, we are implementing new trends in managing or we make some breakthrough or major change in production. We include, change of the technology (new technology or some new aspects of technology), implementation of new, modern devices in the production lines, implementation of new products. In other departments, it would be implementations of new computer system, new methods of cost accounting, financial control, etc. Changes like those are usually big events, which the whole team is focused on, and on which they spend a lot of time. This event is accompanied by making new standards, associated trainings and finally we come back to keeping a "status quo". The truth is that Japanese have taken all the advantages from our system and adding, besides some certain national features, and one "small" element: "continuous improvement".

The transfer of WCM know-how from Japan to some European and North American countries started in the 1980s, as a result of Japanese investment in new factories. In Japan, mother-companies already used this modern production managing system and corporations implemented it in their new plants. Additionally they required similar actions from their co-operators and suppliers. The WCM program, known under many different names, was becoming more popular. In 1982 in Japan a KAIZEN Institute was established, and in 1996 the WSA Lean Enterprise Institute, the goal of both these organizations was to popularise and spread the WCM philosophy.

In Poland, the WCM history began in particular in the middle of the 1990s, and it was linked, as in other countries, with the entry of Japanese and Western companies and the construction of new ones. Polish branches of KAIZEN Institute and the Lean Enterprise Institute were established. Many consulting and training companies arose, focused on the introduction of the WCM rules, and the technical universities conducted courses and programs for this purpose. The WCM Program is becoming more popular, not only in the auto and machine companies but also in the food industry, chemical, pharmaceutical and ceramic industry.

2. THE TALE OF WCM IN POLISH CERAMICS INDUSTRY

Let us start with a single, but very important statement. WCM Program is not a kind of panacea against problems in companies; it is not a system ready for immediate implementation. WCM is a kind of philosophy, a long-lasting process, a basic knowledge about what to do in order to achieve changes and success. The major advantage is that it is all-purpose, the system can be introduced in every industry, in little and big factories, it can be implemented for logistic systems, for offices - practically everywhere. After a period of time, a program spontaneously fits to requirements and needs of the branch, a specification of the company and people competences. The second advantage is that it is an easy way to achieve an effect of self-speeding up of the program; the first visible changes activate a

growth of involvement and an avalanche of initiatives from shop-floor employees. Certainly, everything under certain conditions.

The biggest weakness and danger of the WCM program is the necessity to engage the whole organization (from top management to operators) in its implementation and it is hard work to change the mentality of the workers, and especially to change their attitude towards their work. Until now, workers did what they were told to do, according to the procedures. In the new system they are required to take all the responsibility for their job, according to the rule: "Do the same thing, but start thinking, what can be done in order to make your job easier, lighter, more effective and better quality. In other words try to show people possible effects, give them tools, teach them how to use them and encourage them to use them. In the author's opinion it is the most important and also the most difficult element of the implementation of WCM Program. The whole idea of this program is based on people, their cooperation, passing all the responsibility and decision-making to the line workers. We know that only 5 to 10% of the people accept changes in their environment quickly; about 15 to 20% sympathise with the changes, but they wait for the visible results; the rest of the team are sceptical or hostile (this last group is also about 5 to 10%). Additionally if we think about the vertical managing structures that are used now in factories, the most difficult thing is to convince middle level managers.

The second weakness of the initial implementation period is the long wait for the first effects, and it is also very important for there to be visible and active involvement of the top management and careful choice of the initiatives and implementation area.

In a company, where I worked from 2003 to the end of the year 2006 as Production Director, an action using the WCM program began in year 2004 as a result of a meeting with people in charge of the realization of such a program in other companies. This led to a visit to a glassworks company (also ceramics), in which the program was strongly involved (implementation of SixSigma metrology), although the success was achieved after a second introduction. It was a very interesting experience, initial defeat and later success. The next step was a tentative presentation for the Board Management about the possibilities of the WCM program, and a proposal of a preparation of the implementation of the WCM program, which was approved. The second stage was getting a wider knowledge about WCM, taking part in an International Congresses dedicated to these issues. These meetings, especially getting to know and discussing the subject with many people from many branches of the industry brought some changes in our attitude towards the WCM implementation program. New contacts allowed us to visit some factories that were implementing the WCM program such as Toyota in Wałbrzych, Pratt&Whitney in Kalisz, plasterboards producer RIGIPS, CanPack cans producer.

The next stage was meetings with four chosen WCM consulting companies. Those companies made inside WCM audits and Value Stream Mapping in our company. The results of the audits, meetings and visits, which lasted two weeks allowed us to prepare a schedule and cost estimate of our plans, and we also chose a company that could support the implementation of the program. Additionally we built a small two-person WCM Team - inside Changes Agents and Trainings Coaches. Certainly, Steering Committee was formed with members from the Board representatives (CEO and CFO), Production and Logistic Manager, Chief of the

WCM Team and Factory Manager. During every two week meeting the committee discussed the progress in the implementation schedule and made key decisions about the whole program. Indeed, one of steering committee representative always took part in meetings of the production lines team, group leaders, team trainings and they encouraged the rest of the workers to get to know the WCM program. The full responsibility for implementation was taken by the author. The whole schedule of the WCM program implementation is shown in Fig. 2.

The main objectives of the program were:

- elimination of wastes
- production only in accordance with orders
- no device breakdowns
- no production stops
- 100% quality

Some of the goals mentioned above may seem abstract, but cannot "zero" or 100% be goals? In Japan during a visit of continuity steel cast lines in Aichi Steel Company, they told us that 15 years ago line stops were recorded of more than 2 hours, 5 years ago more than 5 minutes, and nowadays stops are rated stops when the assembly line stops more than 15 seconds !!!! The opinion of whether this is zero of close to zero is left up to the readers.

3. WCM PROGRAM - KPI'S (KEY PERFORMANCE INDICATORS)

The company I wish to talk about in the lecture is made up of three independent industrial plants built at different times. The first one is more than 50 years old, the second one is almost 30 years old, and the most modern one is 8 years old. The older plants were modernized of course, the technology, devices and equipment were changed there, but if we look to the production forces, buildings constructions and internal transport systems they are not comparable. As a pilot area the intermediate aged one was chosen. It is a plant, which is so technically exploited that it needs care by Professional Maintenance, and it is so technologically advanced that would be easy to pass any result and experience gained during the implementation of the program to both other plants. The pilot area was assigned, where elements of the WCM program had to be gradually implemented. On this area, there were 10 production lines and about 100 workers worked there, who have created separate teams on each line. It was decided to start from following elements: 5S, SMED and TPM. For each element, the convenient KPI were determined for each element and one overriding one - OEE. This stage was preceded by a series of trainings on the rules of WCM, 5S, SMED and TPM for all the workers of this department, and later for the spontaneously emerging team leaders, ("Soft Skill's" training as a team build, teamwork, a role of the leader in changes, etc.). After the achievement of successes, we wanted to start the implementation gradually: workers ideas, system with elements of the continuous improvement rules, and finally autonomous maintenance system and TQM.

Figure 2. Schedule of the implementation of the WCM program.

3.1. 5S

The idea of 5S comes from five Japanese words (five tasks), describing the essence of the program:

- SERI – Sort
- SEITON – Set in order
- SEISO – Shine
- SEIKETSU – Standardize
- SHITSUKE – Sustain

In practice it is a separation of the useful from the useless things (the useless are marked with the red cards and accumulated in the red cards centre for 30 days till the moment of their identification and potential application - otherwise they are eliminated). Next, the introduction of frequent self-controls in the work-place, systematic cleaning up, standardization of the all actions, visualization of all the elements and periodic auditing of the 5S area. In the last stage, which is monthly for every defined category, there is a check of the number of criteria, giving from zero to three points for each. The average number of points in each 5S category shows the improvement or lack of work in the program. Presentation of the audits results are shown on Fig. 3 (showing a mark of the results on two chosen production lines in the 1st department in July 2005) and Fig. 4 (showing changes of the average mark for all the pilot area in July 2005 vs. July 2006).

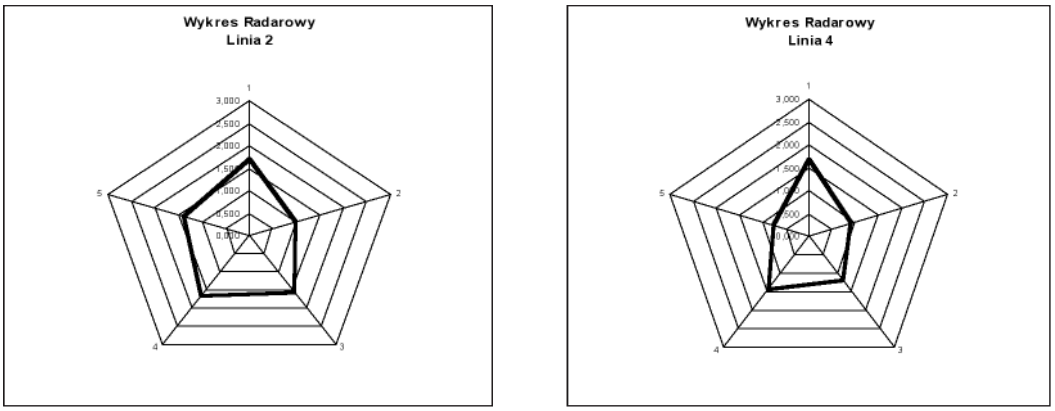

Figure 3. Results of the 5S audits for both production lines in July 2005, after 5 months of program implementation.

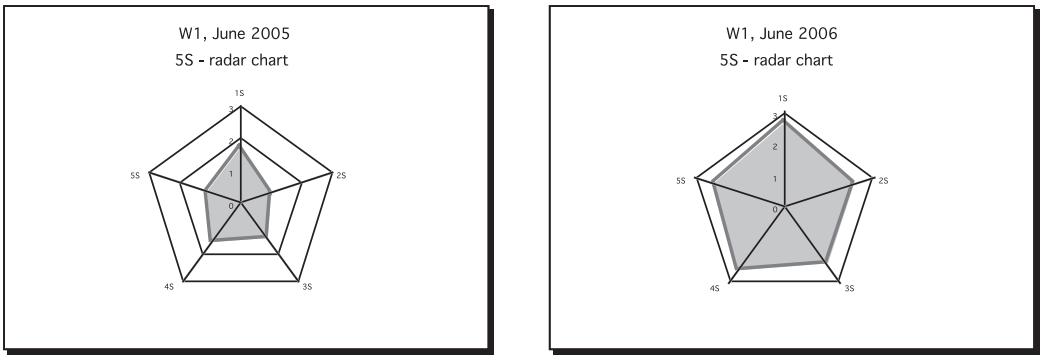

Figure 4. Results of the 5S audits for the entire 1st department, in an interval of 12 months of program implementation.

Every axis of the graph shows a mark in several categories of the 5S program. To put it briefly, the valuation is a measure of the competences and involvement of the departments' workers, who see a chance of their own development as well as plant and business' development. Every month, the best team is awarded the title of best in 5S and they are allowed to display a 5S flag over their area with the inscription: "WE ARE THE BEST IN 5S".

A very important element in the WCM program and for every element is a visualization of the work of each team (progress or reverse), achieved improvement of planned tasks, relations from the meetings, trainings, schedule of meetings. Fig. 5 shows samples of the visualization - tables of two teams in pilot area.

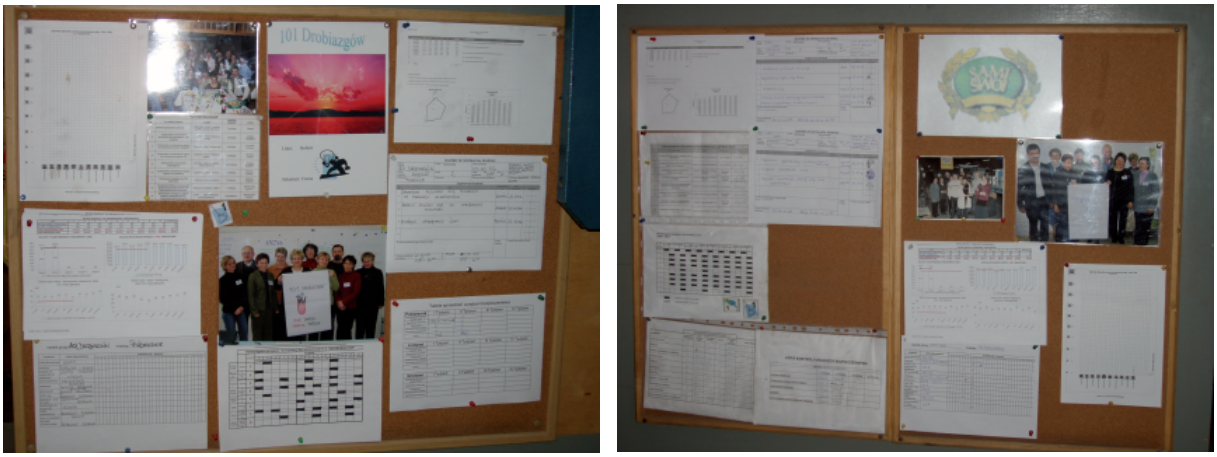

Figure 5. Information tables of two teams in the pilot area during the WCM program.

It is necessary to state, in comparison with a quantity of the visualization tables which author saw during training for a European top management group in Japanese plants of sanitary ware, this was just a beginning.

Figure 6. Examples of the WCM information tables in Japanese sanitary ware plants.

Is necessary to note that the 5S program was initially not accepted by the operators or accepted with strong mistrust; however, after some period of time, there was a big change in their approach to the work and to the WCM Program.

When it is fully implemented, the 5S Program creates a positive impression on customers, increases efficiency and improves internal organization. Not only will employees feel better about where they work, the effect on continuous improvement can lead to less waste, better quality and faster lead times. Any of which will make your organization more profitable and competitive in the market place.

3.2. SMED. SINGLE MINUTE EXCHANGE OF DIES

A SMED description is defined in the title of the subsection. Exchanges of Dies can mean a change layout of all the production line or its elements, an adjustment of the line's devices to produce another assortment or just a change of line parameters. Every kind of exchange needs a partly or even complete stop of the production line for some time. Returning to the MUDA idea (waste) it is clear that every stop is a waste, which according to the WCM program principles should be eliminated. The SMED program goal is such reorganization of the exchange process to lead to simple one minute adaptation of the line to a different production. Many tools were used to help us to analyze the exchange process, to draw conclusions from and implement the new exchange process in the normal practice in plant. Basic and the most frequent approach is mapping of the process. Filming is commonly done of all the change using one to three cameras and than analyzing all the process with its performers. Using a results analysis, a new scheme is then created for next process. After a new exchange; again: mapping, analysis, action plan, activity, mapping …... For every exchange process a KPI is recorded, defined in advance, in this case a time of the exchange. After 3 to 5 months the teams were taking the initiative and full responsibility individually organizing meetings before and after the exchanges, planning actions and discussing the improvements. Every action, conclusion, and their results were shown on the tables of several teams and in this stage they were created by the workers.

The results of SMED project in the pilot area are shown in Fig. 7 (black column means a reference with an average time of the exchanges from the year 2004, the following columns show the changes in average exchange times in the following months).

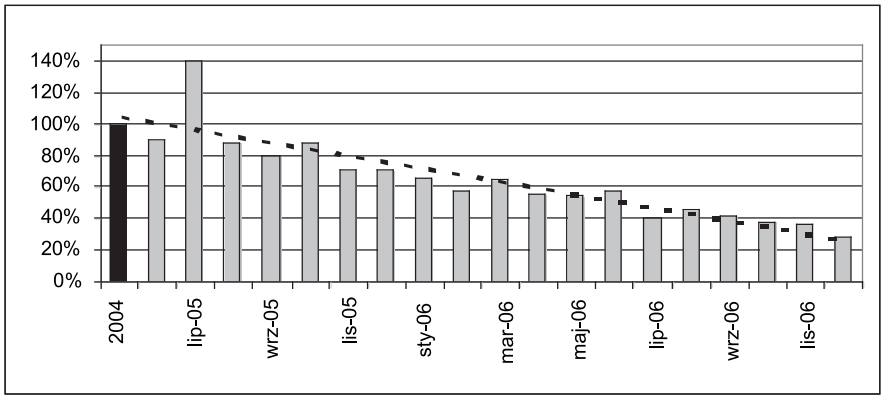

Figure 7. Changes in average exchange times in the pilot area where the WCM program was implemented.

3.3. TPM (TOTAL PRODUCTIVE MAINTENANCE)

Total Productive Maintenance means management over all the devices in the company, involving all workers (not only Professional Maintenance) to keep production continuity through team wastes elimination connected with the stops, machines and devices breakdowns. The main goals of the TPM are: no machine faults, no production defects and no accidents during the work. TPM is an inseparable part of the WCM program, and I know few plants, which base their production managing system on TPM. Simplifying, we can say that TPM is:

- absolute priority under the maintenance and service of all the machines under a production plan
- teamwork to eliminate stops and faults and finding methods of preventive prevention

This is quite different, in comparison to the traditional understanding of Maintenance in factories. Let us remember that in the traditional approach, Maintenance Service in a plant serves to "put out or extinguish a fire", if there were a fault, in this it was attempted to keep the machine part in good enough condition in order to keep the production going, and production plans have a priority under a schedule of planned services and maintenance.

The transfer to the new role of Maintenance Service is a give the machines operators more responsibility for the machine park and increase the knowledge and competences in the cleaning, service and removal of the faults and breakdowns. The last stage of the TPM implementation should be an Autonomous Maintenance when it comes to very big limitation of the people or to elimination of the Professional Maintenance Service, and the entire responsibility for the devices being taken by their operators. Even highly worn equipment, after such a change of attitude shows much better results and production effectiveness, mainly through the decrease in the quantity of faults and breakdowns, as shown in Fig. 8.

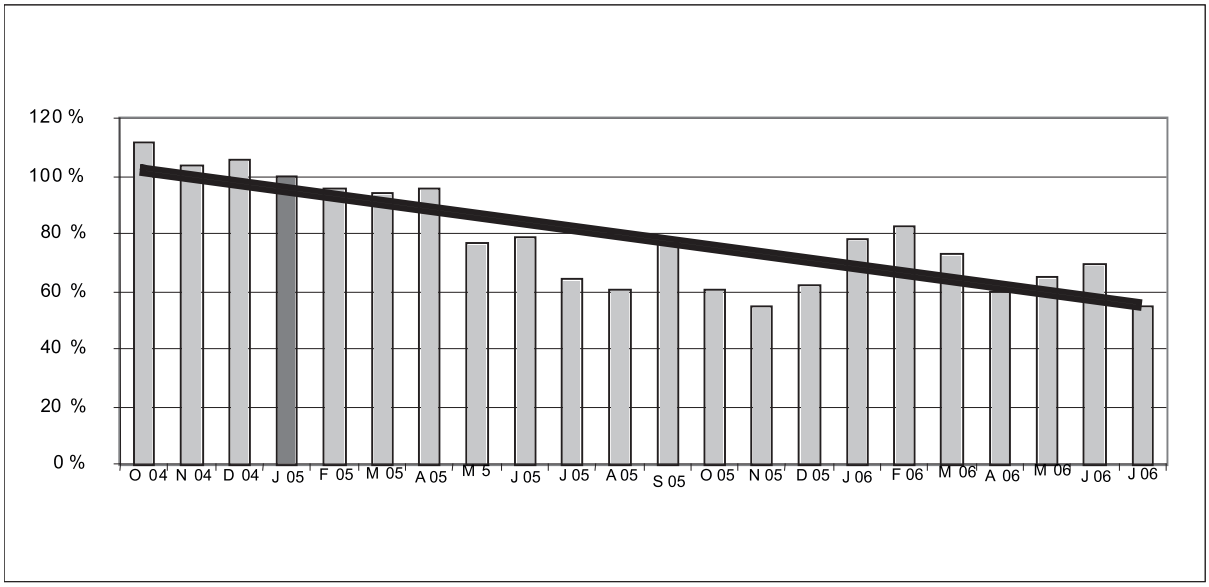

Figure 8. Changes in the devices faults in the pilot area during the implementation of the WCM program.

3.4. OEE (OVERALL EQUIPMENT EFFICIENCY)

In every company, many devices could work more efficiently. According to the literature, the majority of the devices produce only half of what could they produce and the entire use of their productiveness is between 30 and 60% of their capacity.

There are many ways to measure how good or how bad devices work. We often use indicators such as MTBF, MTTR or value of the production in the unit of time. They are good and proven methods but one of their weaknesses is the impossibility of benchmarking with other companies from the same branch and from every other branch. The universal method that allows us to compare the devices, lines, production processes, plants and companies is making an OEE (Overall Equipment Efficiency) coefficient.

OEE is a method that shows quantitatively the wastes results related with the different kinds of stoppages, micro stops, and decreases in the device work speed, which affect effectiveness and thereby the efficiency of the line, department or plant.

If we talk about the effectiveness of the device we think about equipment that is:

- available for production most of the time, and does not have different stops and faults
- effective – works all the time with nominal speed
- able to make products with acceptable quality

To avoid optimization of the single indicators we measure "General Efficiency of the Equipment" which is a multiple of three factors:

- availability (S)
- utilization (O)
- quality (J)

$$\mathbf{OEE = D \times O \times J}$$

The changes in the key OEE indicator for the piloting area from January 2005 to November 2006 are shown in Fig. 9.

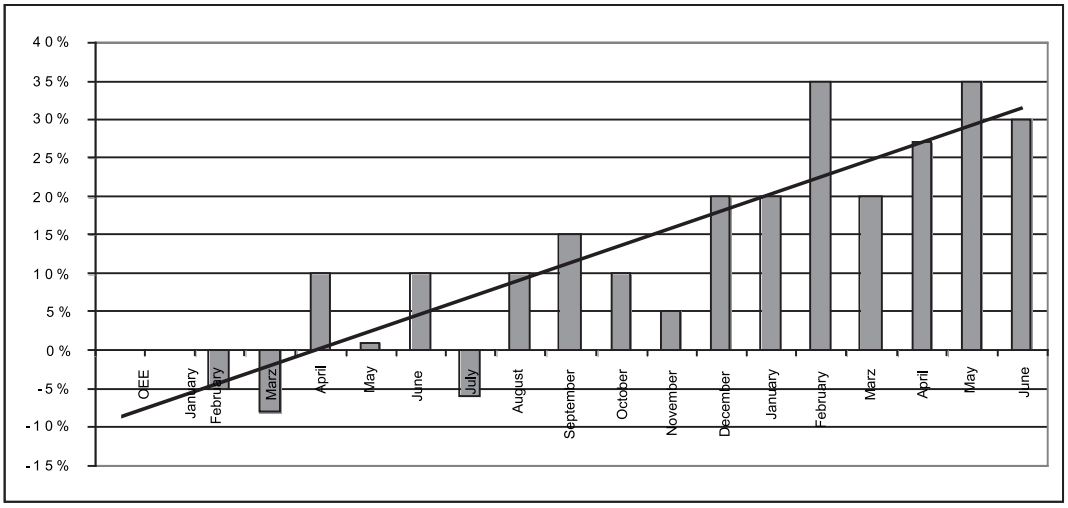

Figure 9. Changes in the OEE indicator for the 1st department coming from WCM program

3.5. WORKERS IDEAS PROGRAM

The program for the realization of workers' ideas was initiated in April 2006, also in the pilot area. The ideas submitted by the workers were related to improvements of the devices, greater efficiency, easy access to all the device elements, doing work more safely, improvements with the exchanges, etc. All the ideas brought many measurable effects: it may be noted that every invested 1€ (if the money were necessary) paid back at least 2€ and maximum 10€ during the next 1 to 4 months.

4. CONCLUSIONS

The following conclusions may be drawn:

- The World Class Manufacturing Program shown in this lecture is a perfect tool to improve efficiency in industry production plants
- Indicators that were presented in this lecture showing the progresses during the implementation of the WCM program in elements such as: 5S, SMED, TPM, show the profitable changes that occurred in functions of the chosen production department

- World Class Manufacturing Program is one of the most modern and the most efficient systems in support of production management
- Finally, yet importantly, I want to emphasize that WCM program is still changing with our knowledge about this subject, widening our knowledge and the competences of the line operators. Changes consist of constantly adapting the program to needs, modifying the schedule, but not to delaying the realization of the tasks, rather adding some new elements or their modifications. Though the start may be difficult, the paper shows that the program is alive and spontaneously starts to provide continuous improvement of the implementation process. We have to remember to control the program, and not to go beyond our abilities.

5. MY ADVICE FOR A ROAD MAP OF WCM

If you are thinking about starting a WCM program and you are a beginner in this method, please read the remarks below:

- Get the sufficient knowledge about the WCM program by yourself
- If you know a company where the WCM program is on a high level, try to see it, talk with the people who were in charge of implementation (*change agent*), talk with people from the board and with line operators
- Find in your company (or hire) "Change Agent" – with adequately knowledge and experience (*or maybe you are the right person*)
- Give that person the opportunity to explore more about WCM
- Start the implementation from defining the added value in your company and Value Stream Mapping
- Share your own experiences with other people and use their advice – you can only find new helpful solutions
- In a big company, choose an important but not too big pilot area; using it you should be able to show the rest of the team the basics and the rules of the program and you will achieve visible results faster
- Visualize every progress, every success, every problem, and show them to all employees
- As fast as you are able, try to extend the program to the next departments in your company
- Implement the WCM program the fastest you can to all the offices, unless it will split up workers in your company
- Do not pay extras for progress in implementation of the program
- REMEMBER THAT IT IS NOT A TYPICAL PROJECT WITH AN END DATE AND SUMMARY OF THE RESULTS: IT IS A CONSTANT WORK – CONTINUOUS IMPROVEMENT BECOMES A BIG ELEMENT OF THE LONG RUN EFFECT

- ONLY AUTHENTIC INVOLVEMENT OF THE TEAM (FROM CEO TO CLEANERS) WOULD BRING VISIBLE EFFECTS

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