

The Using of Elements of Lean Production to Increase Efficiency and Competitiveness of Organizations in the Engineering Industry

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Abstract

The contribution deals with the application of elements of lean production, especially 5S method. 5S method is used as a label for the 5 basic rules that should guide organizations seeking to implement lean, uncluttered and clean production. It is also an important part of efforts to increase the efficiency and competitiveness of the organization, investigating and improving the organization of work and consumption surveys of production time. For this specific area of the body work has been developed and are still developing the tools to the methods of analysis of the effectiveness of the organization and process workflows, the entire production process. They were practically used in the assembly of semi-automatic lifting platform for the disabled. 5S method was applied in this operation in order to increase efficiency, standardization and systematization of process. 5S method meets another requirement for successful development of the company, and thus a change in mindset and attitude of employees to work. The basis of productive manufacturing is to create a clear, organized, clean, disciplined work.

Keywords

Production, 5S method, productive manufacturing, lean production, organization

Introduction

A significant part of the effort to increase productivity and competitiveness of organizations is investigation and improvement of work organization and determining of time consumption. Tools have been and still are being developed for these specific activities, i.e. methods of analyzing of organizational affectivity and work process procedures within the whole production process. Work organization and standardization share in analysis and determination of optimum work conditions to a large extent. Data that determine what should be the optimum work conditions are a necessary part of documentation, together with details that set technical and organizational conditions, work procedures and times of individual activities. Setting of optimum work conditions is not an exclusive matter of organization and standardization of work. Also participation of experts that specialize on the safety and health protection at work is necessary for analysis of work conditions and setting of requirements that are implemented to create these optimum conditions, as well as for creation of the appropriate documentation.

1. Workplace space arrangement

Work conditions are also affected by spatial and dimensional arrangements of workplace, extent and technical level of manipulation and regulation equipment, work tools and aids. These are influences, whose respecting manifests itself in a selection of suitable work positions, respecting of dimensions and shapes of human body, moving and sensual capabilities, and meeting of safety and health requirements to create comfortable work conditions. The arrangement and equipment of workplace that meets natural characteristics, and capabilities of a human body should secure suitable:

- Visual conditions.
- Work position.
- Conditions for economic performance of work movements.
- Biomechanical conditions, especially allowable values of loads and expenditure of appropriate regulation forces.
- Work tools, aids and means (work tables, seats, foot rests, etc.).
- Controllers, keyboards and communicators.
- Resolving of these questions again requires cooperation of experts.

2. 5S Method

The 5S method and other elements of lean production were implemented for the first time in the Toyota Company in the fifties and sixties of the last century. The company management tried to solve the question of production methodology, since this type of demand did not exist in the Japan market as opposed to the USA. Productivity of one worker in Japan was one third of the German one and one ninth of the American one. Japanese assumed that against the American competition they were performing some extra unnecessary activities. Thus originated the idea to get rid of these redundant activities and at the same time to keep the production with a high level of flexibility by increasing the work productivity. The 5S method approach represents implementation of high efficiency, order and cleanliness in the workplace. Probably that is why many companies claim that they implemented 5S as the first step in implementation of lean production. 5S meets the requirements for successful development of a company, meaning the change in thinking and attitude of people towards work. The absence of 5S can mean inefficiency in a company, the existence of fruitless waste and employees without stronger relationship to their workplace. The result of implementation and maintenance of individual phases of this method is obtaining of well-arranged, orderly, clean and disciplined workplace. Some sources also mention one more step of this method and that is safety of the workplace. Other sources consider this step unnecessary and argue that proper performance of all five S leads in its effect to a safe work environment. Removal of unused things and tools influence elimination of movements and activities that do not add to a product value and thus leads to time saving.

Advantages of the 5S method:

- Decrease of work area
- Decrease of stock in the workplace
- Improvement of quality
- Shortening of search time
- Shortening of assembly operations

Table 1: 5S method

	JAPAN	ENGLISH
1 st S	SEIRI	SORT
2 nd S	SEITON	SET IN ORDER
3 rd S	SEISO	SHINE
4 th S	SEIKETSU	STANDARDIZE
5 th S	SHITSUKE	SUSTAIN

5S demonstrably leads to efficiency and a new stronger relationship of people to their work. Work character becomes more exact, and the following is analyzed: WHAT I do and WHY I do it this way. A strong motive is the fact that if a person creates a positive relationship to something, he will hardly cause intentional or even unintentional damage to the thing.

1st S: Sense of order

The idea of effort in this approach is to achieve more orderly workplace due to clear differentiation of needed and unnecessary things. Unnecessary and sometimes completely useless things (tools, equipment, stores of work in progress, etc.) occupy space and complicate speedy search for subjects necessary for performance of specific tasks. The first S was implemented in the Pars Komponenty s. r. o. company after the people were familiarized what the purpose and goal of the above mentioned changes. What should the changes bring to the people personally and to the company as a whole.

The first was the classification of subjects in the workplace to three groups:

OFTEN – LESS OFTEN – RARELY

The subjects that were placed in the first group should be placed onto a work area or its nearest vicinity. Subjects in the second group will be placed in reach, however not in the nearest vicinity. The subjects that fall into the third group will be placed to a set and labeled location.

2nd S: Systemization

After the order is achieved it is necessary to determine, where things belong, and where they should be stored. Systemization thus implemented eliminates searching, saves time and thus adds to higher work productivity. It is important to propose such system that can be understood by each employee from technicians and foremen to an ordinary laborer. Typical problems connected to the search of things can be:

- Unmarked things
- Not knowing their exact name
- Not knowing the label of their exact location
- Complexity of identification

Tools are placed in reach, and it should be easy to take a hold of them by hand and again to place them back. Their silhouettes can be drawn on a table, wall, on a shelf, and if this silhouette is empty, then the tool is in use or is missing for some other reason. You can encounter such detail arrangement of a workplace more in a large scale production. At an assembly workplace all components that enter platforms are stored in shelves and on pallets. Thus stored parts were often stored in disorder and could be mixed together. This led to time consuming search of components.



Figure 1: Before introducing 5S method

After the discussion with employees all components were divided to specific types of platforms and the shelves were marked by informative signs with names, drawing numbers and pictures. Thus the place gained a clearly marked area and orientation was made simpler for assembly workers and also for handlers, who take the unfinished products and transport them to the hall.



Figure 2: After introducing 5S method

Another step in the arrangement of assembly workplace was necessary marking of individual boxes with connection material on a movable stand. Unmarked boxes uselessly held back selection of bolts, nuts and other connection material. The picture shows the marked stand.



Figure 3: Marking rack fasteners

The last step in workplace arrangement was the effort to make the tool storage area simpler. After consultation with a production manager and assembly workers I was not able to push through description of individual tools, so I selected a simpler method, namely description of individual work table drawers. This marking is not much of a benefit for the existing platform assembly workers, however, new employees will benefit from better orientation, while looking for their tools.



Figure 4: After marking

Application of the second S is narrowly connected with ergonomics of the workplace. The English term ergonomics originated from joining of two Greek words *ergon* - work, work force and *nomos* - order, rule. A subject of ergonomics is the study of relationships between a man, work means and work environment, and application of knowledge from this study by implementation of limits of human efficiency (mental, sensory, anthropometric and biomechanical) during machine and technical equipment design, innovations and rationalizations, during planning of technical development, etc.

A goal of ergonomically designed work location is to create such working conditions that eliminate unreasonable work load, for example, of muscle-skeletal apparatus. All distances, heights and angles must be set so they correspond to anthropometric and biochemical requirements and physiognomy of the appropriate user. The work location must be adapted to a human, not the other way around. The most used work positions are the seating and standing ones, but other positions like kneeling, forward bend, squat and lying position cannot be eliminated. Also walking is considered a basic human position. From the physiological standpoint a seating position is less energetically demanding and lower extremities are not constantly loaded during this position. However, constant seating work position is not acceptable.

Generally unsuitable or improper work positions that should be eliminated or limited as much as possible are:

- Constant standing position without moving
- Constant or frequent forward bend, i.e. more than 15 back bends

- Trunk bend, deep bends or unnatural body positions during squat
- Frequent standing on one leg (control of a machine by one-sided foot lever)
- Long-time work with extended arms or arms forward

Assuming of improper work positions and making of unnatural movements, in dependence on the time of performed work and many other factors, sooner or later cause painful injuries. They result in consequent sick time of affected workers, which, in turn, can cause large financial losses to the employer. Providing of suitable ergonomical conditions requires and will require certain financial costs. However, compared with expenditures related to resolution of work injuries or sicknesses these costs are many times smaller in the end. Ergonomics at workplaces and during assembly work require attention, since taking care in this area brings long-term advantages both for employers and primarily for workers in the long run. These activities can significantly improve physical and mental comfort of workers during performance of their work.

3rd S: Cleanliness

Regular cleaning of a workplace adds to improvement of work environment (elimination of dust, dirt, shavings, construction material remnants, humidity, mildew, oil residue, etc.). Certain other shortcomings can be identified during cleaning, especially coming up defects of machines and equipment. Systematic maintenance of company environment can often identify various problems in advance. These are regular routines that should be natural to everybody and each employee should keep his or her place clean similarly like in his or her house, especially at the following instances.

- (They should not) work with dirty objects
- (They should not) spill
- (They should not) throw thing about themselves
- Work tools should be cleaned immediately after finish of work
- Object with tendency to fall should be attached

After implementation of the first three S significant changes in the workplace can be observed. More space for work is obtained. Work is made easier by better arrangement and order and simpler and faster access to necessary objects is also gained, especially when needed. The risk of work injuries and spoilage goes down significantly.

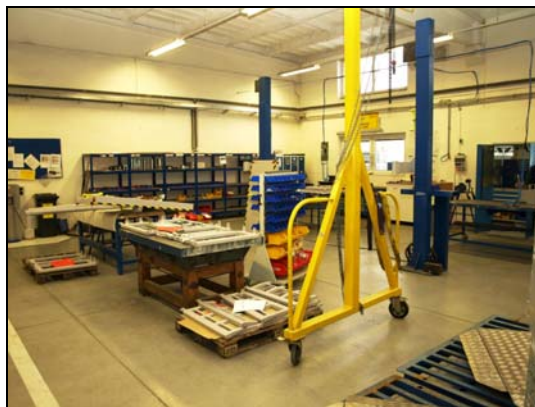


Figure 5: Department of assembly

4th S: Standardization

A subject of standardization is implementation and maintenance of a series of principles that can permanently improve work conditions. This can be, for instance, maintaining of proper intensity of workplace lighting, temperature conditions, air exchange, implementation and timely exchange of appropriate cloth for individual professions, implementation, if necessary, prescribed head covering. Simply speaking this is constant and repeated maintenance of a company in order and cleanliness with focus on so called visual management. This is understandable and detailed information on what should be where, when and in what quantity. Characteristic elements of visual management are:

- Simplicity

- Understandability
- Attractiveness
- Specificity
- Timeliness

The fourth S is often unjustly simplified as constant repeatability of the first to third S. The content of the 4th S is no less demanding as the previous elements of the 5S approach and simply speaking includes the following:

- Increased pressure on maintenance of personal safety at work
- Visualization of principles and especially results
- Stressing of best practices and procedures, which is often marked as standardization

Motivation and integrating people into the process of changes is important. People themselves will start showing what is wrong, inexact and insufficiently implemented, what is not identified at all and vice versa.

5th S: Maintaining

Performing work goals and instructions, keeping of all set instructions for work performance (qualitative, safety, environmental, economical, etc.), maintenance of appropriate lists, adherence to work breaks, etc. These are typical features focused on discipline during work. It is in the interest of Pars Komponenty s.r.o. to control and evaluate maintenance of agreed standards that should become habit and matter of fact during everyday work. All employees should cultivate their sense for order, exactness, perfection, and also their relationship to their workplaces and the company. They should:

- Regularly perform checks of performance of set goals
- Improve themselves in performing their duties
- Master the best forms of communication
- Maintain cleanliness and order at workplace
- Learn proper reactions during crisis situations

To be satisfied with the status quo means preserving the existing situation and declare after some time that we do not have much of the original status. Setting of new goals, visions and targets is natural continuation of work in the company. It is hard to get people interested in things, it is harder to keep them interested, and it is hardest to continue and develop them more. If we set a target or if we say what keeping to 5S rules will bring new and better to people in the future, then we will not be able to follow up on it. Looking for losses and eliminating them, struggling for better quality and economy must always be a new and further challenge, rather than a scarecrow of potential lay-offs.

3. Evaluation for practice – standard time consumption

An important criterion for the introduction and use of assessment methods 5S in the production environment of the company is to calculate the time consumption during production and assembly of new products. The direct measurement of time is very laborious and time-consuming for staff performing measurement and uncomfortable for the observed workers. Given the current high intensity of production processes, the urgent need time information for an offer for the timely preparation of production and management of the implementation phase is the use of direct measuring methods are less frequent. They are mainly temporal database computers, based on the preserved data quality professional and national norms and normative system of movements. But it is still necessary to know the method to determine the initial time data, especially when they are in the production of new products. In such cases no choice but to establish new procedures and methods of measurement to determine the direct consumption of time. This is particularly true in the case of new products, yet not carried operations and tasks. Similar situations occur in small batch and unit production, which is of course a small repeatability and so is the use of direct measuring methods problematic.

Methods of measurement of consumption of time

- Frame working day
- Frame work operations
- Torque observations

When designing the new standard time consumption for semi-automatic lifting platform method was used to image the working operation, which is a direct method of measuring the real time consumption for repetitive operations

and their parts. The measured values are evaluated at the various component parts and the whole operation attributable to the processing unit. Through the frame work operations are derived substrates to improve work organization, work processes, reduce time consumption and control of the operation. The data obtained are the basis for the direct determination of standards and operation time for the creation of standards. In setting the new standard time consumption used one of two types of image operations, and continuous chronometry.

Assembly supporting pole is divided into three parts, details A, B and C (figure 6). In detail A comprises the upper bracket, which then connects to the column. In detail, the B pillar mounted detent column and detail C consists of the mast foot and the bottom of the column lock.

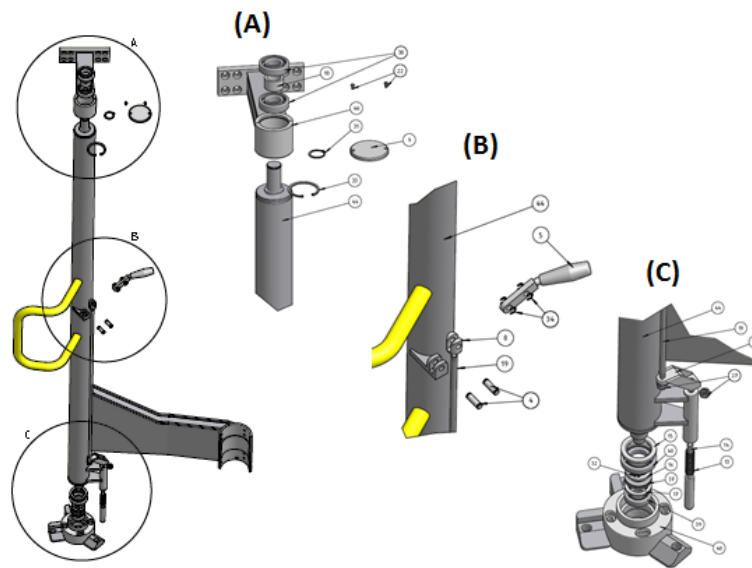


Figure 6: Assembly parts of loaded column

Detail A:

$$t_{AA} = 30 \text{ min}$$

$$t_{BA} = 15 \text{ min}$$

Index surcharge on irregular activities used in Pars Komponenty s.r.o. is 1,05

$$t_{AA} = 30 \cdot 1,05 = 31,5 \text{ min}$$

Index surcharges normative shift in company time used Pars Komponenty s.r.o. is 1,06

$$t_{AA} = 31,5 \cdot 1,06 = 33,4 \text{ min}$$

Norma time started surcharge on irregular and shift the charge:

$$t_{AA} = 33,4 \text{ min}$$

$$t_{BA} = 15 \text{ min}$$

Detail B:

$$t_{AB} = 15 \text{ min}$$

$$t_{BB} = 10 \text{ min}$$

Index surcharge on irregular activities is 1,05

$$t_{AB} = 15 \cdot 1,05 = 15,75 \text{ min}$$

Index surcharges normative shift time is 1,06

$$t_{AB} = 15,75 \cdot 1,06 = 16,69 \text{ min}$$

Standard time started surcharge on irregular and shift the charge:

$$t_{AB} = 16,69 \text{ min}$$

$$t_{BB} = 10 \text{ min}$$

Detail C:

$$t_{AC} = 30 \text{ min}$$

$$t_{BC} = 10 \text{ min}$$

Index surcharge on irregular activities is 1,05

$$t_{AC} = 30 \cdot 1,05 = 31,5 \text{ min}$$

Index surcharges normative shift time is 1,06

$$t_{AC} = 31,5 \cdot 1,06 = 33,4 \text{ min}$$

Standard time started surcharge on irregular and shift the charge:

$$t_{AC} = 33,4 \text{ min}$$

$$t_{BC} = 10 \text{ min}$$

Total time standard for the installation of the pylon is:

$$t_{ANM} = t_{AA} + t_{AB} + t_{AC} \quad (1)$$

$$t_{ANM} = 33,4 + 16,69 + 33,4$$

$$t_{ANM} = 83,49 \text{ min}$$

$$t_{BNM} = t_{BA} + t_{BB} + t_{BC} \quad (2)$$

$$t_{BNM} = 15 + 10 + 10$$

$$t_{BNM} = 35 \text{ min}$$

t_{ANM} unit time a new method of assembly [min]

t_{BNM} batch time a new method of assembly [min]

Comparison with existing time standards supporting column:

$$t_{ASM} = 315 \text{ min}$$

$$t_{BSM} = 0 \text{ min}$$

t_{ASM} unit time of existing assembly [min]

t_{BSM} batch time of existing assembly [min]

$$U = t_{ASM} - t_{ANM} \quad (3)$$

$$U = 315 - 83,49$$

$$U = 231,51 \text{ min}$$

U saving of unite time [min]

$$PT = \frac{t_{ANM}}{t_{ASM}} \cdot 100 \quad (4)$$

$$PT = \frac{83,49}{315} \cdot 100$$

$$PT = 26,5 \%$$

PT.....compared time standards existing and new installation [%]

Save standards unit at the time of the pylon assembly is reduced to 26.5% of 100% of the current assembly.

Table 2: Compare time standard

	Unit time [min]	Batch time [min]
The existing assembly	315	0
New method of assembly	83,49	35

4. Conclusion

Today we can encounter even 6S. This is described, for instance, by EPA – American Environmental Protection Agency. Strong five are augmented by a new element that relates to safety and protection of health during work and creation of environment for safer work. Also in this case 6S is understood as an excellent preparation for application of lean production elements. The Pars Komponenty s.r.o. company made first steps in implementation of the 5S method, and can already observe its advantages that will lead to more effective production process

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Biography

Jana Petru is a Head of Department of Machining and Assembly and expert in the field of conventional and unconventional machining and assembly. She is a tutor of the course Assembly works and automatization of assembly works and Technology. She is a coordinator of several education and research projects for evaluation of the quality of the surface after machining, selection of the appropriate cutting conditions for machining of special materials, assembly working. The author or co-author of more than 40 verified technologies, 5 functional samples, 2 prototypes according to the present methodology of the government council for the R&D, which have been successfully introduced in practice and confirmed by a company. Principal investigator or co-investigator of more than 5 commercial agreements within cooperation with a number of companies from the Czech Republic that solve reducing cost of technologies.

Current list of R&D results at: <http://innet.vsb.cz/profil/cs/nov92/vedeckovyzkumnevystupy>.

Tomas Zlamal is a full time doctoral student at Department of Machining and Assembly at the VSB – Technical University of Ostrava. He is an author of many papers in international journal and co-authored one article in a journal with an impact factor. He also has one article with an impact factor in the review proceedings in journals with IF. In addition to regularly publish the results of his research at national and international conferences. He actively participates in projects of the student grant competitions, educational and industrial projects, where he has a large project and economic activity. He actively cooperates with foreign universities with industry and multinational companies such as Honeywell Aerospace Ltd., John Crane to which he has very good relations. This action also

confirms the formation of several proven technologies and functional samples. He regularly participates in training to support his further education.

Robert Cep is Associate Professor at Department of Machining and Assembly. He is dealing by theory and technology of Machining, Engineering Metrology and Accuracy Measuring of Machine Tools. He is author or co-author of 8 papers in journals with Impact Factor and has 15 records in Web of Science and 24 in SCOPUS databases. Also he is author or co-author of more than 12 verified technologies, 3 prototypes, 2 pieces of software and 1 utility design according to the present methodology of the government council for the R&D, which have been successfully introduced in practice and confirmed by a company. Principal investigator or co-investigator of more than 10 commercial agreements within cooperation with a number of companies from the Czech Republic that solve reducing cost of technologies. Cooperation with leading Czech machine tools producers in the development of the methodology of testing cutting tools during interrupted cutting.

Marek Pavlica is full time Ph.D. student at Department of Machining and Assembly and his tutor is Assoc. Prof. Robert Cep. HE is dealing by technology of machining, surface integrity and quality before bonding. He is author or co-author of many papers in international journal and conferences and he has great cooperation with PARS Komponenty, a.s. company. He is also actively at solving of research projects at department and technical problems of regional companies, especially with cost reduction. Theoretical and practical skill from problem solving he applies at teaching process with students. He was participant of many trainings for support his further education.