IMPROVEMENT OF IMPLEMENTATION OF THE 5S METHOD USING THE SIMPLIFIED FMEA METHOD

Małgorzata KAWALEC[1*], Andrzej PACANA[2], Jan REWILAK[3]

[1*] Rzeszów; mkawalec@onet.eu
[2] Katedra Technologii Maszyn i Inżynierii Produkcji, Wydział Budowy Maszyn i Lotnictwa, Politechnika Rzeszowska; app@prz.edu.pl
[3] Instytut Technologii Maszyn i Automatyzacji Produkcji, Katedra Inżynierii Procesów Produkcyjnych, Politechnika Krakowska; jrewilak@pk.edu.pl

Abstract: Paper presents a proposal for improvement of implementation concerning one of Lean Manufacturing (LM) tools, in particular 5S method. For that purpose there was applied Failure Mode and Effects Analysis (FMEA) in simplified form. A test analysis concerning implementation of the 5S method in one of Subcarpathian companies was performed by a team consisting of workers involved in that implementation of and external experts. Results of that analysis showed that the biggest difficulties playing role in implementation of the FMEA are the ones associated with laziness of workers and shortage of understanding advisability of 5S implementation. Obtained results are aimed at improving implementation of the 5S method in the company. They might be, however, also helpful in implementation of that method in other enterprises.

Keywords: Lean Manufacturing, Failure Mode and Effects Analysis, implementation of 5S.

1. Introduction

Dynamic social and economic changes which take place last years and growing competition forces companies to implement adjustments in management and their functioning. Those changes influence all areas and processes in companies (Bednárová, 2008; Hamrol, Mantura, 2011).

Pursuing to more effective managing of available sources, struggle with wastage, minimization of loss during manufacturing and improving quality are for no doubt very important challenges which must be addressed by organizers and leaders. The ability to properly use company's sources and capability to effectively reaching targets with smaller funds is currently considered a key element of a company's asset, especially under conditions of competition. Lean Manufacturing (LM) is an idea which suitably falls into real life. Generally, LM is one of management techniques which applies – as priority tasks – creating

simple structures in a company and increasing labor resources in a way making possible their optimal use. That idea is defined, assuming big simplification, as limitation of waste. In the process of Lean manufacturing implementation there should be used suitable tools available within LM. One of those tools is the 5S method which consists of the following elements: selection, systematics, cleaning, cleanliness and self-discipline (in Japanese: Serii, Seiton, Seiso, Seiketsu, Shitsuke*)*. The 5S practice leads to creation of harmonious work environment which in turn influences company's effectiveness. In order to properly implement 5S it becomes purposeful to use, yet before beginning realization of 5S implementation, application of the Failure Mode and Effects Analysis (FMEA) (Antypin, 2008; Bielecki, 2008).

2. FMEA Method

FMEA is a proactive method used for consistent eliminating of potential failures and mistakes by identification of their causes and application of suitable counter-measures. The main target of that method is recognition of potential failures, their causes and effects in new products or in products generating many problems by utilization of experience, knowledge and forecasts of design team. The results of FMEA are used for planning of proactive actions (new products/processes) or correcting actions (products/processes already causing difficulties) aiming at the reduction of risk associated with occurring of fault/discrepancy of a product or a process. Consistent application of that method secures and organizes realization of requirement concerning constant development of products and processes (ISO 9001). It also facilitates implementation of new products and processes in a company thanks to standardization of proactive actions (Pacana, 2012; Rewilak, 2005; Sęp, Pacana, 2001).

FMEA is applied for (Huber, 2006; Stamatis, 2003):

- identification of different types of errors, faulty things/products and showing consequences caused by those errors and faults,
- designation of areas which require more intensive control,
- planning of control and early warnings concerning of weak points as well as eliminating them; thanks to those actions it becomes possible to reduce costs associated with e.g., adjustments and reworkings,
- searching of solutions concerning potential or emerging and growing up difficulties,
- elimination of repeatable errors, thanks to keeping suitable records.

The main idea of application of the FMEA in manufacturing process consists in the following steps:

1. Identification of all process elements.
2. Creation of a list of possible faults.
3. Creation of a list probable effects of those faults.

4. Creation of a list containing possible causes of those faults.
5. Estimation of risk including association of priority numbers (rates) to potential faults:
   - OPN (Occurrence Priority Number) – informs about the probability of emerging a fault or some cause of a fault,
   - SPN (Severity Priority Number) – informs about some estimate of how severe could the effect of a failure be for the internal or external customer,
   - DPN (Detection Priority Number) – informs about the probability of detecting a process failure or its cause yet during the process durance.

Those numbers are determined from tables available in various publications in the area of FMEA e.g. Antypin, 2008; Bednárová, 2008 and publications created for the use in particular organization. Computing the Risk Priority Number (RPN) takes place according to the following formula:

$$RPN=OPN*SPN*DPN \quad (1)$$

1. Sorting of potential faults and their causes according to their weights.
2. Indicating of remedial actions (proactive or correcting) (Wolniak, 2011; Wolniak, Skotnicka, 2007).

The Risk Priority Number can vary in range <1, 1000>. The limiting value of the RPN, i.e. RPN_{max} is widely assumed as acceptable level of risk in a process. Overstepping the maximum acceptable value RPN_{max} causes the necessity of planning and implementation of actions aiming at diminishing risk by elimination of the most serious faults (rarely possible), decreasing probability of fault and cause occurrences (often than not advised) or improving their delectability. Frequently occurring values of the RPN_{max} in industry are, in general, 125, 100, 80 or 60 (depending on the branch, customer requirements and function of a product). It should be noticed that it is more often advised taking decisions concerning the need and the sequence of implementing improving actions on the grounds of other prerogatives than the RPN_{max} values e.g., on the basis of matrix of risk or sorting faults according to rates (http://webshop.vda.de/…; Potential Failure Mode…; Quality management…; Surface Vehicle Standard…).

3. FMEA of 5S implementation

In order to rationalize the process of 5S implementation, the FMEA was made after a pilot 5S implementation in one of Subcarpathian companies manufacturing steel structures. During that implementation there were applied methods based on team work and the Ishikawa diagram. Experiences gained during that implementation allowed to estimate the priority numbers according to the accepted guidelines (Tab. 1-3) and perform FMEA clearly. The aim

of those actions was preventing potential troubles in the process of implementing 5S on particular workplaces in considered company as well as in other enterprises.

Table 1.
*Guidelines for determining the **Occurrence** Priority Number (OPN) – meaning*

OPN	DESCRIPTIONS	EXPECTED FREQUENCY
1	**Incredible** Occurrence of the problem is almost not possible.	Averagely below one of ten implementations per year.
2-3	**Rarely** Problem can occur occasionally.	Averagely below one of seven to nine implementations per year.
4-6	**Averagely** Problems do not occur more often than in the case of other processes.	Averagely below one of five to six implementations per year.
7-8	**Large** Problem is serious and occurs more often than in the case of other processes concerning implementation of a method.	Averagely below one of three to four implementations per year.
9-10	**Very large** Problem is very serious and is becomes definite that it will occur for sure in implementation process. That problem can not be, probably, omitted.	Averagely every second or each similar implementation per year.

The first step consisted in preparing tables for the selection of priority numbers and creating suitable form used for the analysis of FMEA. Tables 1-3 contain the guidelines for determining of particular priority numbers allowing to assess their values on the basis of gained knowledge and experience as well as collected results of the preceding actions. Those actions were mainly focused on valuating, in as reliable way as possible, the priority numbers – representing in certain sense the main considered features, i.e.: occurrence, severity and detectability: OPN, SPN and DPN. The determined priority numbers were used for the FMEA concerning the implementation of 5S process. The following step in analysis was filling in prepared form associated with the FMEA. The effects of that step are shown in Tab. 4.

In order to better understand and, in consequence, better implement 5S method there was developed a modified FMEA analysis. That modification consisted in ascribing a cause not only to its faults but both to its faults and effects. Such simplification of the FMEA method was done because of the character of analyzed process and due to the need to analyze the main dangers to succeeding stages of 5S implementation quickly as well as comprehensively.

Table 2.
*Guidelines for determining the **Severity** Priority Number (SPN) – meaning*

SPN	DESCRIPTION
1	**Absence** It should not be expected that implementation problem will have any influence on the 5S system, process or product. Problem will not influence 5S system functioning. Probably nobody will notice a problem.
2-3	**Small** Implementation problem will cause small perturbations in the 5S system (e.g., incidental and short searching of a thing or problem with cleanliness of little account) and it may cause workers' dissatisfaction as well as discouragement.

cont. table 2

4-6	**Averagely** Implementation problem causes noticeable limitation of 5S system functionality (e.g., relatively frequent but short searching of a thing or problem with cleanliness of medium importance) and can cause workers' dissatisfaction as well as discouragement.
7-8	**Significant** Implementation problem causes significant limitation of 5S system functionality (e.g., frequent and medium time-consuming searching of a things or significant problem with cleanliness) and can cause workers' outrage as well as significant discouragement.
9	**Large** Implementation problem causes significant limitation of 5S system functionality (e.g., very frequent and very time-consuming searching of a things or very significant problem with cleanliness) and can lead to serious (expensive) failure. There is no danger for workers' safety.
10	**Very large** Implementation problem causes significant limitation of 5S system functionality and a failure will occur or 5S system will not be implemented. Workers' safety may be violated.

Table 3.
*Guidelines for determining the **Detection** Priority Number (DPN) – meaning*

DPN	DESCRIPTION
1-2	**Very large** Applied measures will definitely detect potential implementation problem or its cause.
3-4	**Large** Applied measures may detect with big probability potential implementation problem or its cause.
5-6	**Medium** Applied measures may detect with medium probability potential implementation problem or its cause.
7-8	**Small** It is of small probability that applied measures can detect potential implementation problem or its cause.
9	**Very small** **Applied measures will probably not detect** potential implementation problem or its cause.
10	**Absence** **Applied measures will not detect** potential implementation problem or its cause, or **no measures are applied.**

Table 4.
The FMEA form filled for the case of the 5S method implementation

FMEA		**Concerns:** ***5S implementation process***						**No:** **----**
No	**Fault (in succeeding stages of the 5S implementation)**	**Effects of the fault**	**Causes of fault**	**OPN**	**SPN**	**DPN**	**RPN**	**Correcting / preventive actions**
1.	Lack of **selection** on a workplace	Troubles with quick finding of necessary things (e.g. tools), troubles with cleaning and order each succeeding 5S stage time-intensive.	Too many things (necessary) on a workplace (after completion of the selection stage).	7	8	3	168	Reduce the number of tools on a workplace.

cont. table 4

2.		Lack of place for convenient storage of necessary things, troubles with finding / taking them, difficulties with cleaning and establishing and maintaining order, each succeeding 5S stage time-intensive.	Unnecessary and rarely used things taking place on workplace (after completion of selection stage).	5	7	3	105	absence
3.		Difficulties in moving and transport, risk of accident, mess, troubles with finding necessary things, each succeeding 5S stage time-intensive.	Waste stored on a workplace or very close outside destination (after completion of selection stage).	4	6	2	48	absence
4.		Request for leaving big number of tools and spare parts for quick removing accidents at a workplace – troubles with place, systematics and maintaining order. Lack of time for doing reliable selection due perturbations caused by accidents and need to making up the manufacturing plan.	Big frequency of a machine failures.	4	3	3	36	absence
5.		Risk of accident, risk of failure of other things, inaccuracy of manufacturing or measuring, risk of risk of making a product incompatible with requirements.	Inefficient tools, tooling and machine parts on a workplace (after completion of selection stage).	6	5	3	90	absence
6.	Lack of **syste-matic** actions on a workplace	Long time for searching necessary things, troubles with constant maintaining of order.	Unmarked or undurably/ unreadably marked places for storage of things necessary for work.	3	3	2	18	absence
7.		Trouble with quick finding of necessary tool, bigger worker's fatigue.	Lack of systematics (ergonomics / logic) in arrangement of tools.	8	4	4	128	Implement ordering rules.
8.		Trouble with finding suitable documentation, risk of using unsuitable/ out of date documentation or working by hart, risk of risk of making a product incompatible with requirements.	Lack of designated place for documentation.	7	6	2	84	absence

cont. table 4

9.		Lack of required tool on a workplace, long time of searching, risk of temporary use of other tool (type and rate of wear), too big inaccuracy of manufacturing, risk of risk of making a product incompatible with requirements.	The same tools used by many workers.	4	6	3	72	absence
10.		Risk of accident, risk of damage of other things.	Unmarked or undurably/ unreadably marked places for storage of waste.	7	8	2	112	absence
11.	Workplace is wrongly **cleaned**	Complicated/ prolonged cleaning or lack of possibility of cleaning up, using interim measures and tools, risk of violating of occupational safety and health, possibility of damaging machine, tool, tooling, lack of willingness for the following stages.	Lack of measures and tools for establishing cleanliness on a workplace (at the stage of implementation – the first cleaning).	4	6	3	72	absence
12.		Difficult/extended cleaning or lack of cleaning, using interim measures and tools, risk of violating of occupational safety and health, possibility of damaging machine, tool, tooling, workers' demotivation and resistance, negative effects of the last 5S stage.	Periodic or permanent lack of measures and tools for maintaining cleanliness on a workplace.	8	4	2	64	absence
13.	Lack of worker's **cleanliness** on a workplace	Lack of cleaning or rough cleaning, simulation of clearing, loss of work time, demotivation of other workers (also on other workplaces), lack of willingness for the following 5S stage.	Lack of worker's competence/ awareness/ motivation/time for cleaning/ cleaning (for 5S).	6	7	4	168	Organize meetings, trainings. Develop rules for establi-shing order on a workplace.
14.		Lack of systematic cleaning of a workplace, loss of worker's motivation, demotivating example for other workplaces (being before implementation/during implementation/after implementation of the 5S) negative results of the last 5S stage.	Lack of standard/ instruction/ schedule of cleaning/doing cleaning-up or schedules/ standards/ instructions out of date/unreadable/ unclear/ inaccessible for a worker schedules/ standards/ instructions.	7	3	2	42	absence

cont. table 4

15.		Lack of systematic cleaning of a workplace, rough cleaning, putting forward a motion concerning overtime, delays in starting the following shift, arrearage in manufacturing plans.	Standards/ instructions/ schedules of cleaning/doing clearing-up by worker imposing new duties requiring additional time not falling in working shift.					absence
16.		Lack of cleaning up of a workplace or only rough cleaning up a workplace due to unavailability of a workplace/machine or succeeding re-soiling caused by machine failure. Lack of time for realization of cleaning schedule, necessity of additional out of schedule cleaning of a machine after its failure extending planned standard methods, risk of violation of occupational safety and health.	Failure frequency of machines.					absence
17.		Lack of cleaning of a workplace, lack of willingness for the following 5S stages.	Lack of specific responsibility or inconsistently defined responsibility for executing cleaning of workplace maintained by several operators.	2	4	2	16	absence
18.		Lack of cleaning, unsystematic or occasional cleaning in the cases of dramatic difficulties with keeping cleanliness/ disorder, resistance of workers, simulation of cleaning, simulation of cleaning, waste of working time, demotivation example for other workplaces (being before/ during implementation/ after implementation of the 5S).	Lack of worker's competence/ awareness/ motivation/for handling tasks associated with maintaining cleanliness at a workplace. Potential source reasons: lack of training/ in-effective trainings of workers at the stage of imple-mentation of the 5S, poor communication of an implement-tation team with workers.	6	5	6	180	Implement successive work on creating workers' awareness

cont. table 4

19.	Lack of **self-discipline**	Lack of feedback information concerning 5S functioning/ideas for its development, lack of encouragement of workers to improve methods/ standards, discouragement and resistance of workers, demotivation, lack of continuity in maintaining cleanliness of a workplace, negative effects of the last 5S stage.	Poor communication worker – middle level of supervision (leader, master, foreman).	9	2	2	36	absence
20.		Demotivation of workers, unsystematic and rough cleaning, creating by workers their own unapproved methods – danger of violation of occupational safety and health, simulation of cleaning, simulation of cleaning, waste of working time, demotivation example for other workplaces (being before implementation/during implementation/after implementation of the 5S) negative results of the last 5S stage.	Methods and/or periods of cleaning/ tidying up a very burdensome/ labor-intensive position for an employee.	6	5	3	90	absence
21.		Diminishing of motivation and understanding by workers of the 5S targets, perception of 5S only as formal requirement taking time necessary for entire realization of manufacturing plan, difficulties in current implementation of the 5S and its future implementation on succeeding workplaces.	Lack of presentation/ visualization/ communication concerning the process of implementation and obtained results of 5S in a company.	6	2	5	60	absence
22.		Return to former practices, loss of long-term benefits, need for rebuilding trust and motivation, more difficult implementation of the 5S on succeeding workplaces.	Lack of system actions in order to supervise and develop of 5S (reviews/grading/ audits/ competition/ awards).	4	2	2	16	absence
Developed by team composed of:			Signature:	Date:		Comments:		

Performed analysis showed that the biggest problem in the 5S implementation can be: lack of worker's competence/awareness/motivation/for handling tasks associated with maintaining cleanliness at a workplace, including, among other things, cleaning, too many things on a workplace and lack of systematics in location of tools. Those causes reached the RPN bigger than 125. Even in the introductory assessment obtained results seem to be realistic. In order to prevent such difficulties in implementing the 5S method it is proposed to deploy gradual work focused on creating workers' awareness concerning the necessity of application of the developed 5S methodology. That is a very hard and long-lasting work of company's administration, mainly the first line, oriented towards improving workers' awareness. It would be good to make it not in form of trainings with big number of workers but in form of smaller trainings (small number of workers and short time) which not necessarily should have strictly formalized character. They can be e.g., short meetings realized at workplaces and focused on practical aspects. Before implementing 5S those meetings should concern that method and in particular practical examples, benefits as well as potential difficulties. Activation of workers by application of team work methods seems well grounded and purposeful.

The FMEA presented in Tab. 4 has a test character. It was done on one workplace in one selected company. However, even rough analysis of FMEA results shows its universal character. There exists big probability, that in significant part presented study will look almost the same in the case of other 5S implementations. Therefore, conclusions may have instructional character for people implementing the 5S method.

4. Conclusions

Lean Management is a philosophy for improving managing a company towards making organization more lean and enabling creation of simple and as clear as possible structures in considered company. That idea allows to eliminate actions which do not bring additional value to product or service while they are applied in the process of creating considered product or service. Making company more lean is performed using certain instruments (tools, methods, rules). One of them is the 5S method. The 5S method focuses on organizing workplace in a way to obtain well ordered, clean workplace without unnecessary things. The aim of that method is beginning of improvement program and reinforcing processes which undergo on a workplace. Thanks to that it supports increasing company's effectiveness. Results of the method are:

- better organization of a workplace,
- elimination of wastages which follow the loss and failures,
- improving occupational safety and health,
- making the working environment more simple.

The 5S method is a foundation for improving manufacturing processes. Therefore, it should be implemented and that implementation must be done properly. To obtain such effect it becomes reasonable to make analysis of causes and effects concerning potential implementation difficulties. The results of performed test analysis showed that the biggest difficulty with implementing 5S can be the lack of worker's competence/awareness/ motivation/for handling tasks associated with maintaining cleanliness at a workplace, including, among other things, cleaning, too many things on a workplace and lack of systematics in location of tools.

It is to be hoped that presented analysis and conclusions drawn from the analysis can allow properly implement of the 5S method.

Bibliography

1. Antypin, P. (2008). *Opracowanie oraz wdrożenie systemu 5S w firmie motoryzacyjnej. Problemy Jakości, 40, 2*, 41-47.
2. Bednárová, L. (2008). *Ekonomická efektívnosť environmentálneho manažérstva: environmentálne účtovníctvo.* Prešov: Prešovská Univerzita, Fakulta Manažmentu.
3. Bielecki, M. (2008). Wykorzystanie wybranych technik i narzędzi TQM do wdrożenia praktyk 5S. *Logistyka, 2.*
4. Hamrol, A., Mantura, W. (2011). *Zarządzanie jakością. Teoria i praktyka.* Warszawa: PWN.
5. http://webshop.vda.de/QMC/product_info.php?cPath=23_24&products_id=190&language=en.
6. Huber, Z. (2006). *Analiza FMEA procesu.* Gliwice: Wydawnictwo Złote Myśli.
7. Pacana, A. (2012). Причины и следствия недостатков (FMEA) в процессах внутреннего аудита. *Zeszyty Naukowe Politechniki Rzeszowskiej, s. Zarządzanie; Kwartalnik Folia Scientiarum Universitatis Technice Resoviensis, 260.* Rzeszów, 79-86.
8. Potential Failure Mode and Effects Analysis. FMEA, 2008, Chrysler LLC, Ford Motor Company, General Motors Corporation. AIAG (Automotive Industry Action Group).
9. Quality management in the Automotive Industry. Quality Assurance in the Processs Landscape. Volume 4, Product and Process FMEA. VDA (Verband der Automobilindustrie), December 2006, updated June 2012.
10. Rewilak, J. (2005). FMEA – jak dobrze, czyli „po imieniu" nazywać wady? *Zarządzanie Jakością, 2*, 67-70.
11. Sęp, J., Pacana, A. (2001). *Metody i narzędzia zarządzania jakością*. Rzeszów: Oficyna Wydawnicza Politechniki Rzeszowskiej.

12. Stamatis, D.H. (2003). *Failure mode and effect analysis: FMEA from theory to execution.* Milwaukee: Quality Press.
13. *Surface Vehicle Standard – SAE J1739:2009 Potential Failure Mode and Effects Analysis in Design (Design FMEA)*. Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA). SAE International, 2009.
14. Wolniak, R. (2011). *Wspomaganie metody FMEA w przedsiębiorstwie produkcyjnym*. Warszawa: Problemy Jakości.
15. Wolniak, R., Skotnicka B. (2007). *Metody i narzędzia zarządzania jakością. Teoria i praktyka.* Gliwice: Wydawnictwo Politechniki Śląskiej.