sciendo

Management Systems in Production Engineering

2021, Volume 29, Issue 3, pp. 203-207

Date of submission of the article to the Editor: 03/2021
Date of acceptance of the article by the Editor: 05/2021

DOI 10.2478/mspe-2021-0025

IMPLEMENTATION OF LEAN INSTRUMENTS IN CERAMICS INDUSTRIES

Robert ULEWICZ
Czestochowa University of Technology

Daniel KLESZCZ
Ceramik Sp. z o.o.

Małgorzata ULEWICZ
Czestochowa University of Technology

Abstract:
The article presents the results of the research on the level of implementation of Lean instruments in the ceramics industry. The research was carried out in ceramic factories in Poland and Germany. Based on the results obtained, the most commonly used Lean instruments in the ceramics industry were defined. The dependence of the use of Lean instruments on the size of the enterprise was also determined. It was established that the Lean activities undertaken in the ceramics industry are focused solely on the implementation of individual methods and tools, without a pre-defined goal. This approach in the ceramics industry is ineffective, but unfortunately it is most often used in the implementation of the Lean philosophy, especially in small ceramics enterprises.

Key words: *ceramics industry, SME's, Lean instruments, Lean implementation*

INTRODUCTION

The ceramics industry is exposed to many factors that determine its profitability, in particular in the case of producers of ceramic accessories. Mutual competition of domestic producers on the internal and external market, too high labor costs, as well as the lifting of restrictions on imports to European Union countries of cheap and usually fired once (i.e., characterized by greater absorption and lower mechanical strength) ceramic products from Asia, especially from China led to the liquidation of many small and medium-sized ceramic plants. Therefore, ceramic companies cannot afford non-conformities, defects, alterations, overproduction, processing, unnecessary waiting, wasted traffic, excess inventory, etc. One of the key elements of increasing efficiency in a manufacturing enterprise is continuous improvement and improvement of production processes. Mass production gave way to lean, i.e., lean, agile and sustainable production. Currently, we are dealing with a shift from an economy of scale based on low unit costs of producing identical products to an economy of scope, where the low unit cost is the result of producing a diversified assortment of similar products with modern production organization and advanced manufacturing technologies [1, 2]. As a consequence, knowledge and experience become of key importance in the aspect of changes in the enterprise, which are now a continuous – permanent process. Importantly, the changes made do not take place in a relatively stable and predictable environment, on the contrary, in a turbulent environment rich in unpredictable events (e.g., the Covid-19 pandemic) [3]. Enterprises that have introduced lean cells into their work practice significantly increase their efficiency by changing the rules of organization and management. Literature data [4, 5, 6] for various industries indicate that large savings can be achieved through changes, often low-cost.

LEAN MANUFACTURING

Examples of the application of the Lean concept in many industries show an increase in work efficiency, which proves the legitimacy of using this methodology [7, 8]. However, there is a real risk associated with the selection of the appropriate Lean instruments in the process of improving the enterprise [9, 10, 11, 12].

An improperly selected set of tools may contribute to the emergence of many problems in a given work environment, and thus – to the deterioration of the company's functioning, despite the fact that the assumed, expected result was achieved in another company from a different industry [14, 15, 16]. Therefore, entrepreneurs need appropriate knowledge for the solutions they implement to bring the expected results. Each industry is characterized by individual conditions in terms of production technology, organization and work techniques [17, 18, 19, 20]. It is practically impossible to develop a uniform improvement methodology for all production companies. An improvement in the functioning of a given enterprise may take place when the most important factors influencing the company's management are taken into account. Also, the selection of techniques and tools should be individual, taking into account specific technical and organizational requirements [21, 22]. That is why many organizations strive for Lean Manufacturing (LM), which is a standard in the automotive industry [23, 24, 25] and for other industries in this ceramics industry it is a new production paradigm that focuses on reducing all types of waste and improving efficiency and resource use [26, 27, 28]. The goal of LM is to respond quickly to customer needs in terms of providing high-quality products with minimal - rational effort, minimal inventory, minimal time needed for production, logistics processes, sales and minimal production area of the space [29, 30]. The conducted literature studies have shown that there are many publications on the Lean Manufacturing concept in various industries [28]. The use of the Lean methodology as well as supporting tools has been widely described [4, 31]. However, the problem of using the LM concept in the ceramics industry has not been sufficiently researched. Lean publications in the ceramics industry focus on large ceramic companies with high-volume and mass production [32].

EXPERIMENTAL

The research was carried out in the ceramics industry of the small and medium-sized enterprises sector. 100 questionnaires were sent to selected ceramic companies from Poland and Germany. As part of the survey process, 63 questionnaires were returned. Despite the high rate of return, not all questionnaires were completed correctly or were only partially completed. 43 correctly completed questionnaires were qualified for further research. The aim of the research was to determine the level of knowledge and implementation of Lean instruments in the ceramics industry as well as the selection of a research sample for research on the impact of the level of implementation of Lean instruments on the operational efficiency of plants producing ceramic accessories. The pilot survey consisted of simple 9 questions (Table 1). Additional tenth question concerned the consent to conduct detailed research on the level of implementation of Lean instruments on operational efficiency.

The research group comprised 14.9% micro enterprises, 38.3% small enterprises, 14.9% medium enterprises and 17% large enterprises.

Table 1
Pilot questionnaire questions

No	Question
1	What is the size of your company?
2	Are ceramic accessories one of the manufactured products?
3	Is the concept of waste elimination and continuous improvement known and applied?
4	Is the concept of slimming the flow of material and information known and applied?
5	Are there known and used tools focused on optimization and improvement of work efficiency?
6	Are the effectiveness, efficiency or productivity factors of production known and applied?
7	Are the rules related to the analysis and evaluation of the functioning of organizational units known and applied?
8	Does the company have defined goals to achieve?
9	Are you familiar with Lean Management instruments?

RESULT AND DISCUSION

Among the research group, as many as 46.8% of the surveyed ceramic companies do not know the concept of eliminating waste or the concept of continuous improvement, of the remaining ones, the majority (34.0% of the research sample) know and apply both concepts. The concept of slimming the flow of material and information is known by 66% of the surveyed companies, but only 41.9% of them use it in practice. 21.3% of enterprises do not know the effectiveness, efficiency or productivity coefficients of production, in the remaining group the majority (54.1%) use these coefficients in their activities. As many as 40.4% of the surveyed enterprises do not know and another 38.3% do not apply the rules related to the analysis and assessment of the functioning of organizational units when knowing them. This is definitely to the detriment of the level of organizational culture in the surveyed group of enterprises. The vast majority (over 60%) of the surveyed companies have defined or partially defined (98%) quality and cost targets (Figure 1).

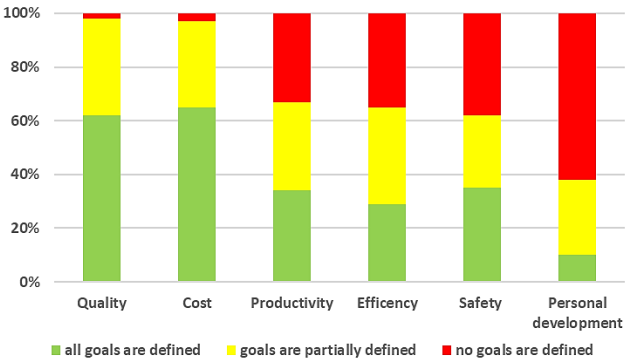

Fig. 1 The level of defined goals to be achieved in the ceramics industry

It can be assumed that these are the best recognized areas in the activities of these enterprises. The situation is worse in the areas of productivity, efficiency and safety. This is due to the greater problem with defining appropriate indicators, as well as the constantly changing Polish guidelines regarding safety standards. When it comes to human resources development, as many as 62% of the surveyed companies do not have defined goals. This is surprising in the conditions of the so-raised "employee market". However, it may be caused by the fact that there are no prospects for dynamic development in a large part of companies – especially smaller ones with a low level of capital and limited perspectives at the same time.

ISO 9001 (Figure 2) is by far the most popular among the indicated instruments. The group of instruments with the highest recognition also includes standardization, Just-in-time and 5S. More than half of the instruments listed in the survey are not known by 50% of the surveyed companies, and instruments such as Andon or Hoshin Kanri are known to less than 20% of the respondents. Obviously, the use of these instruments follows.

The correlation between the knowledge and the use of Lean Management instruments, measured by the Pearson correlation coefficient, is 0.785 and is statistically significant.

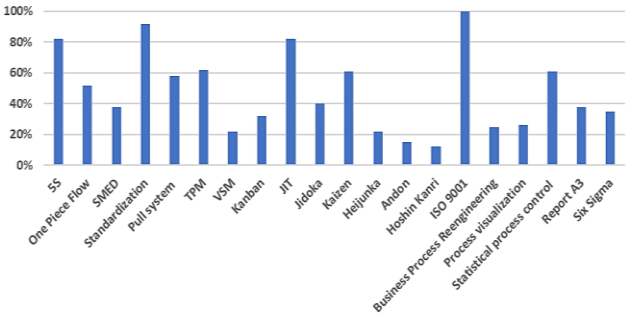

Fig. 2 The level of defined goals to be achieved in the ceramics industry

This proves that the more popular and well-known a given instrument is, the more often it is used. Therefore, we have a kind of indication of the need for continuous training in this area, which allows to get acquainted with other instruments and, consequently, to implement them in order to achieve tangible benefits for enterprises. The obtained data on the use of Lean instruments were analyzed depending on the size of the enterprise (Table 2) and the knowledge of the concept of eliminating waste and continuous improvement (Table 3).

The research confirmed a statistically significant correlation between the knowledge of the concept of waste elimination and continuous improvement with the use of such Lean instruments as: 5S ($\phi = 0.382$; $p = 0.009$), continuous flow ($\phi = 0.432$; $p = 0.003$), standardization ($\phi = 0.534$; $p < 0.001$), TPM ($\phi = 0.305$; $p = 0.037$), ISO 9001 ($\phi = 0.403$; $p = 0.006$) and statistical control of processes ($\phi = 0.403$; $p = 0.009$).

Table 2

Values of correlation coefficients χ^2 and φ – Youla for the use and knowledge of selected instruments depending on the size of enterprises

Instruments	Use			Knowledge		
	χ2	ϕ	p	χ2	ϕ	p
5S	8.001	0.413	0.005	-	-	-
One Piece Flow	9.370	0.447	0.002	8.039	0.414	0.005
SMED	5.860	0.353	0.015	2.910	0.249	0.088
Standardization	10.431	0.471	0.001	-	-	-
Pull system	6.702	0.378	0.010	7.875	0.409	0.005
TPM	11.232	0.489	0.001	4.362	0.305	0.037
VSM	-	-	-	0.535	0.107	0.465
Kanban	-	-	-	6.212	0.364	0.013
JIT	1.238	0.162	0.266	0.002	0.006	0.965
Jidoka	0.063	0.037	0.802	4.801	0.320	0.028
Kaizen	8.240	0.419	0.004	7.466	0.399	0.006
Heijunka	0.482	0.101	0.487	2.162	0.214	0.141
Andon	-	-	-	2.628	0.236	0.105
Hoshin Kanri	0.063	0.037	0.802	3.966	0.291	0.046
ISO 9001	16.558	0.594	0.000	-	-	-
Business Process Reengineering	-	-	-	16.558	0.594	0.000
Process visualization	0.482	0.101	0.487	6.937	0.384	0.008
Statistical process control	22.913	0.698	0.000	7.466	0.399	0.006
Report A3	0.621	0.115	0.431	13.725	0.540	0.000
Six Sigma	-	-	-	4.009	0.292	0.045

Table 3

Values of correlation coefficients χ^2 and φ - Youla for the use and knowledge of selected instruments depending on the knowledge of the concept of eliminating waste and continuous improvement

Instrument	Use			Knowledge		
	χ2	ϕ	p	χ2	ϕ	p
5S	6.850	0.382	0.009	0.915	0.139	0.339
One Piece Flow	8.773	0.432	0.003	9.288	0.445	0.002
SMED	2.878	0.247	0.090	2.751	0.242	0.097
Standardization	13.427	0.534	0.000	-	-	-
Pull system	-	-	-	10.185	0.466	0.001
TPM	4.367	0.305	0.037	9.312	0.445	0.002
VSM	-	-	-	3.345	0.267	0.067
Kanban	-	-	-	8.039	0.414	0.005
JIT	2.128	0.213	0.145	1.864	0.199	0.172
Jidoka	0.152	0.057	0.696	4.086	0.295	0.043
Kaizen	-	-	-	3.418	0.270	0.064
Heijunka	-	-	-	3.345	0.267	0.067
Andon	-	-	-	0.937	0.141	0.333
Hoshin Kanri	-	-	-	-	-	-
ISO 9001	7.618	0.403	0.006	-	-	-
Business Process Reengineering	-	-	-	7.618	0.403	0.006
Process visualization	-	-	-	-	-	-
Statistical process control	7.618	0.403	0.006	6.003	0.357	0.014
Report A3	0.937	0.141	0.333	5.573	0.344	0.018
Six Sigma	-	-	-	0.077	0.041	0.781

Enterprises confirming their knowledge of the concept of waste elimination and continuous improvement used the indicated instruments more often. A similar relationship was noted in the case of the knowledge of the instruments indicated in the survey.

CONCLUSION

The conducted research was aimed at obtaining information on the level of knowledge and the scope of implementation of Lean instruments in the ceramics industry. The obtained results showed large share of enterprises - especially small ones that do not use Lean instruments. In the case of medium and large enterprises, the most frequently used instruments turned out to be: 5S, continuous flow, standardization, pull-system, TPM, ISO 9001 and statistical process control. In this group of ceramic plants, plants using the indicated instruments have an advantage over non-users. In other cases, large enterprises do not use the indicated instruments or there is an advantage of non-applying enterprises over the users. This confirms the assumptions that in ceramics industry does not use systemic Lean solutions, but only individual tools, especially in the group of small enterprises employing up to 50 employees. The studies carried out have limitations. The ceramics industry is characterized by a very wide range of products and technologies. Based on the literature [4, 8, 19] and own research [33, 34], it can be concluded that the implementation of Lean is best in enterprises with a fixed assortment of production and large production series, e.g., the production of ceramic tiles [32], ceramic blocks or electrical insulators [35]. Against this background, manufacturers of ceramic accessories have a significantly difficult process and implementation industry related to a large range of products produced in small production batches that often change in terms of volume, where the critical point determining the effectiveness of the entire process is the forming stage. Further research will focus on analyzing the impact of Lean reference instruments on the operational efficiency of ceramic accessories production in the SME sector.

REFERENCES

[1] R. Ulewicz, D. Jelonek, and M. Mazur, "Implementation of logic flow in planning and production control," *Manag. Prod. Eng. Rev.*, vol. 7, no. 1, pp. 89-94, Mar. 2016.

[2] K. Knop, "Importance of visual management in metal and automotive branch and its influence in building a competitive advantage," *Polish J. Manag. Stud.*, vol. 22, no. 1, pp. 263-278, Dec. 2020.

[3] N. Baryshnikova, O. Kiriliuk, and D. Klimecka-Tatar, "Enterprises' strategies transformation in the real sector of the economy in the context of the COVID-19 pandemic," *Prod. Eng. Arch.*, vol. 27, no. 1, pp. 8-15, Mar. 2021.

[4] I. Belekoukias, J. A. Garza-Reyes, and V. Kumar, "The impact of lean methods and tools on the operational performance of manufacturing organisations," *Int. J. Prod. Res.*, vol. 52, no. 18, pp. 5346-5366, Sep. 2014.

[5] A. Maszke, R. Dwornicka, and R. Ulewicz, "Problems in the implementation of the lean concept at a steel works – Case study," in *MATEC Web of Conferences*, 2018, vol. 183.

[6] M. Nowicka-Skowron and R. Ulewicz, "Problems in the implementation of lean concept in the metal industry companies," in *METAL 2016. 25th Anniversary International Conference on Metallurgy and Materials, Conference Proceedings*, 2016, pp. 1962-1967.

[7] S. Sadiq, M. S. Amjad, M. Z. Rafique, S. Hussain, U. Yasmeen, and M. A. Khan, "An integrated framework for lean manufacturing in relation with blue ocean manufacturing – A case study," *J. Clean. Prod.*, vol. 279, Jan. 2021.

[8] A. Purwanto et al., "Lean six sigma model for pharmacy manufacturing: Yesterday, today and tomorrow," *Syst. Rev. Pharm.*, vol. 11, no. 8, pp. 304-313, Sep. 2020.

[9] R. Ulewicz and R. Kucęba, "Identification of problems of implementation of Lean concept in the SME sector," *Eng. Manag. Prod. Serv.*, vol. 8, no. 1, pp. 19-25, 2016.

[10] S. Singh and K. Kumar, "Review of literature of lean construction and lean tools using systematic literature review technique (2008-2018)," *Ain Shams Engineering Journal*, vol. 11, no. 2. Ain Shams University, pp. 465-471, 01-Jun-2020.

[11] D. Siwiec and A. Pacana, "Method of improve the level of product quality," *Prod. Eng. Arch.*, vol. 27, no. 1, pp. 1-7, Mar. 2021.

[12] A. Pacana, "Comprehensive Improvement Of The Surface Quality Of The Diesel Engine Piston," Hrvatsko Metalursko Društvo (HMD), Jul. 2019.

[13] O. P. Maslova, T. A. Ilyina, V. A. Krichmar, and E. G. Safronov, "Implementing lean manufacturing and solving motivation problems in russian companies," in *Lecture Notes in Networks and Systems*, vol. 139, Springer, 2021, pp. 384-391.

[14] I. Leksic, N. Stefanic, and I. Veza, "The impact of using different lean manufacturing tools on waste reduction," *Adv. Prod. Eng. Manag.*, vol. 15, no. 1, pp. 81-92, Mar. 2020.

[15] T. A. Tran, K. Luu-Nhan, R. Ghabour, and M. Daroczi, "The use of Lean Six-Sigma tools in the improvement of a manufacturing company – Case study," *Prod. Eng. Arch.*, vol. 26, no. 1, pp. 30-35, Mar. 2020.

[16] B. Zhang, Z. Niu, and C. Liu, "Lean tools, knowledge management, and lean sustainability: The moderating effects of study conventions," *Sustain.*, vol. 12, no. 3, p. 956, Feb. 2020.

[17] M. Mazur and H. Momeni, "LEAN Production issues in the organization of the company – results," *Prod. Eng. Arch.*, vol. 22, no. 22, pp. 50-53, Mar. 2019.

[18] M. Mazur and H. Momeni, "LEAN Production issues in the organization of the company – the first stage," *Prod. Eng. Arch.*, vol. 21, no. 21, pp. 36-39, Dec. 2018.

[19] A. C. Gavriluţă, E. L. Niţu, and C. A. Gavriluţă, "Algorithm to Use Some Specific Lean Manufacturing Methods: Application in an Industrial Production Process," *Processes*, vol. 9, no. 4, p. 641, Apr. 2021.

[20] D. Kleszcz, "Assessment of application of 5S practices in ceramic industry," *Prod. Eng. Arch.*, vol. 16, no. 16, pp. 47-51, Sep. 2017.

[21] D. Klimecka-Tatar, "Context of production engineering in management model of Value Stream Flow according to manufacturing industry," *Prod. Eng. Arch.*, vol. 21, no. 21, pp. 32-35, Dec. 2018.

[22] D. Kleszcz, "Barriers and opportunities in implementation of Lean Manufacturing tools in the ceramic industry," *Prod. Eng. Arch.*, vol. 19, no. 19, pp. 48-52, Jun. 2018.

[23] S. Taj, "Lean manufacturing performance in China: Assessment of 65 manufacturing plants," *J. Manuf. Technol. Manag.*, vol. 19, no. 2, pp. 217-234, 2008.
[24] B. Haque and M. James-Moore, "Applying Lean Thinking to new product introduction," *Journal of Engineering Design*, vol. 15, no. 1. pp. 1-31, Feb-2004.
[25] M. Holweg, "The genealogy of lean production," *J. Oper. Manag.*, vol. 25, no. 2, pp. 420-437, Mar. 2007.
[26] J. Bhamu, J. V. S. Kumar, and K. S. Sangwan, "Productivity and quality improvement through value stream mapping: A case study of Indian automotive industry," *Int. J. Product. Qual. Manag.*, vol. 10, no. 3, pp. 288-306, 2012.
[27] E. Järvenpää and M. Lanz, "Lean Manufacturing and Sustainable Development," 2019, pp. 1-10.
[28] R. Shah and P. T. Ward, "Lean manufacturing: Context, practice bundles, and performance," *J. Oper. Manag.*, vol. 21, no. 2, pp. 129-149, Mar. 2003.
[29] T. Melton, "The benefits of lean manufacturing: What lean thinking has to offer the process industries," *Chem. Eng. Res. Des.*, vol. 83, no. 6 A, pp. 662-673, 2005.
[30] M. G. Yang, P. Hong, and S. B. Modi, "Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms," *Int. J. Prod. Econ.*, vol. 129, no. 2, pp. 251-261, Feb. 2011.
[31] S. J. Pavnaskar, J. K. Gershenson, and A. B. Jambekar, "Classification scheme for lean manufacturing tools," *Int. J. Prod. Res.*, vol. 41, no. 13, pp. 3075-3090, Sep. 2003.
[32] T. Bonavia and J. A. Marin, "An empirical study of lean production in the ceramic tile industry in Spain," *Int. J. Oper. Prod. Manag.*, vol. 26, no. 5, pp. 505-531, 2006.
[33] D. Kleszcz, M. Zasadzień, and R. Ulewicz, "Lean Manufacturing in the ceramic industry," *Multidiscip. Asp. Prod. Eng.*, vol. 2, no. 1, pp. 457-466, Sep. 2019.
[34] R. Ulewicz and M. Ulewicz, "Problems in the Implementation of the Lean Concept in the Construction Industries," in *Lecture Notes in Civil Engineering*, vol. 47, Springer, 2020, pp. 495-500.
[35] K. Babu, A. Thirugnanam, and S. P. Sivam, "Lean process management implementation in ceramic industry," *Int. J. Chem. Sci.*, vol. 14, pp. 415-430, 2016.

Robert Ulewicz
ORCID ID: 0000-0002-5694-4284
Czestochowa University of Technology
Department of Production Engineering and Safety
ul. Armii Krajowej 19 B, 42-200 Częstochowa, Poland
e-mail: robert.ulewicz@pcz.pl

Daniel Kleszcz
Ceramik Sp. z o o.
Jana Andrzeja Morsztyna 6, 42-209 Częstochowa, Poland
e-mail: danielkleszcz@go2.pl

Małgorzata Ulewicz
ORCID ID: 0000-0001-8766-8393
Czestochowa University of Technology
Faculty of Civil Engineering
ul. Akademicka 3, 42-201 Częstochowa, Poland
e-mail: malgorzata.ulewicz@pcz.pl