# The Use of Lean Methods in SMEs

Hakan Turan[1*], Hasan Çiçek[2], Emre Kaplan[2], Gökmen Turan[2] and Kemal Güzel[3]

[1]*Bilig Opex Consultant, Istanbul, Turkey*
[2]*Department of Industrial Engineering, Uskudar University, Turkey*
[3]*Aktaş Holding, Bursa, Turkey*

[*]*(hakan.turan@biligopex.com) Email of the corresponding author*

***Abstract*** **–** The way to gain a competitive advantage in today's companies is to use modern common techniques. In this study, the improvements achieved by the use of lean manufacturing techniques for a profile manufacturing SME are discussed. First of all, in order to speed up the flow and prevent wastage (Muda), a settlement suitable for cellular manufacturing has been adopted. For this, a layout suitable for a one-piece flow is provided. The Spaghetti Diagram was used to determine the distances and directions of travel and to eliminate waste based on them. After that, the process was improved step with Kaizen. The staff pertaining to lean manufacturing can easily use it for production. In order to avoid inter-operational stocks in the process, the pull system philosophy has been determined. Kanban cards were used for this purpose. This study, it is aimed to show the small improvements to be used easily for SMEs with different techniques. The outcomes represent that lean manufacturing is capable of effectively implementing small and medium enterprises.

*Keywords – Cell Manufacturing, Spaghetti Diagram, One Piece Flow, Kaizen, Kanban*

## I. INTRODUCTION

In today's conditions, the way to compete with competitors is to increase profits. Increasing prices for this is a difficult step. Increasing prices means leaving the market to competitors. The most basic way to make a profit is to reduce costs. To implement this, it is necessary to use lean production tools. Lean manufacturing not only reduces costs but also increases speed. At the same time, it offers a great advantage to companies by eliminating quality problems. The approach, which was developed by the Japanese in the 1950s and known as the Toyota production system, was known all over the world as lean manufacturing after the book "The Machine That Changes the World" written by James Womack. This approach, which reduces waste and takes the employees in touch, is generally seen as a speed and cost-oriented approach. It has become widespread all over the world, especially after the 90s. A lot of work has been done on this.

In this study, a study based on the combined use of more than one lean manufacturing technique was carried out in SMEs. The study, it was aimed to reduce the 7 basic waste-based errors with the cellular manufacturing approach, the single-piece flow of the cell, and thus faster production. Similarly, the spaghetti diagram, it is aimed to reduce errors based on movement. The process flow has been improved by using the Kaizen technique. Kanban numbers are determined and it is aimed to prevent intermediate stocks.

In the first part of the study, a literature review was made. In the second part, the production is explained. In the third part, the methodology is discussed. The application is explained in Chapter 4. In Chapter 5, the results are discussed. In the last part, the results are discussed.

## II. MATERIALS AND METHOD

Businesses use different processes and almost every business process differs. There are many process improvement methods when the process improvement methodology is desired to be applied. Among these improvement methods, companies should analyze and choose the one that is suitable for them. If the chosen improvement method does not appeal to the company and if the method is applied incorrectly, the desired result may not be achieved, but it may affect the process even more negatively. The biggest factor in using these methods is to develop a technique to predetermine and solve the errors that occur. Some of the methods used in process improvement methods are as follows:

Cellular manufacturing, as an application of group technology philosophy, was introduced by Mitrafanov in the former Soviet Union in the 1950s and later developed by Burbidge in England. II. It is seen that it has spread to Western and Eastern Europe, India, Hong Kong, Japan, and the United States since the years following World War II. The cellular manufacturing system, which has been widely used since the 1970s, has attracted great interest in both practical and academic fields. Today, this production system has found widespread application, especially in developed countries (1). Production systems that aim to reduce delivery processes, increase production efficiency and reduce in-process intermediate stocks by bringing together parts with similar production processes are defined as cellular production systems (2). Firms engaged in batch-type production can further optimize their efficiency-efficiency management with cellular production systems. With these production systems, a small number of lot quantities can be produced more economically by clustering the parts according to their properties (3). Production cells are created using group technology and a connection is established between cells and product families. In this way, while processing similar parts, production cells are created with a small number of machines. While creating production cells, the current production flow should be examined first. One of the most used methods in examining the production flow is process flow mapping. The formation of production cells is facilitated by addressing and prioritizing the processes of the products in the facility. As process flow mapping will provide the opportunity to examine the production process as a whole, it can see the bottlenecks in the process and the processes that do not add value to the product and can provide solutions to these problems during the design phase of the new layout plan. After process mapping, products with common features are grouped in the same production cells (4). The purpose and application reasons of the cellular production system are as follows;

- Reducing in-production stocks
- Minimizing preparation and processing times
- Saving time in carrying out work and operations
- Reducing material handling times
- Ability to set production times
- Developing and increasing the quality of the products produced
- Fulfilling orders on time
- Saving production time
- Controlling the material flow
- Optimizing profits by minimizing costs (5).

The Kanban method is the warehouse-production control system of lean production. Kanbans, like lean production logic, are visualization-based. They enable keeping the stock under control by visualizing the in-process stock levels and also coordinating the communication between the relevant units. The word literally means "card". In the system, kanban cards are used to direct the materials determined for production to production (6). Kanban is the tool to ensure just-in-time production; becomes the neural network of the production line. It gives the responsibility of decision-making to the employee and clearly shows the managers and supervisors where and what needs to be done. It encourages improvement in processes and machinery. It indicates the work to be done to eliminate the waste points. In a manufacturing environment, Kanban is a powerful tool for reducing labor and inventory, eliminating faulty manufacturing, and preventing recurring breakdowns (7). In the mass production system, where production is perceived as a flow from the first station to the final assembly, the previous station pushes the goods to

be processed. In the lean production system, on the other hand, the production process is considered as a flow from the last station to the first station, with the application of the opposite situation. For this reason, the production flow is defined as the pull system. Starting from the fina assembly line, the shooting event is pulled from the workshop to the workshop or from the sub-industry to the main industrial factory (8). When we look at the kanban production system, there are three different types of kanban. These are: Pull kanban, production kanban and supplier kanban and they are as follows;

- The previous process produces according to the order of the incoming kanbans and the number of kanbans.
- The next process takes as many products as specified in the kanban from the previous process.
- None are transported or produced without a material kanban.
- Kanban always moves with the products.
- Defective products are never sent to the next process. Thus, 100% defect-free products are created.
- Reducing the number of kanbans increases the sensitivity (9).

A spaghetti diagram is a method of displaying the movement of a product or object in the system with
the help of a line. The moving object under consideration; a worker, material, edit to be. A system in which such objects move can be a production area, part of a building, or a workshop. It gives the result, which resembles spaghetti, its name (10). Using the spaghetti diagram, it is possible to analyze the products, workers, intermediates, etc. We can follow the path of movement. It is also possible to use differecolorsurs for various products, worke, rs or technical tools and to monitor movement at different times. After analysis, we can determine motion lengths, number of motions, overlapping and intersecting moti,ons, and their characteristics according to the chosen classification. By applying the result of the spaghetti diagram, one can identify inefficient movements and ineffective areas, eliminate headcont and make changes in work organization or workstation layout (11). A spaghetti diagram is used to visualize transport waste and improve e layout. The reason why this diagram is called a spaghetti diagram is that the lines are dratowardrds the points where the product or object should go. Therefore, the less efficient the layout, the more the diagram looks like a plate of spaghetti. Finally, the total lengtraveledled by the product needs to be calculated. This tool is used to measure transportation waste (12).

The Kaizen method aims to improve the process. Improvement in results in short periods and improvement in long periods. The importance and place of the human factor in Kaizhavehas a special place. Due to the importance of the human factor, the functioning of teamwork is also important. In the Kaizen steps, both production and management are expected to contribute and support the process. Opinions of the people working at each stage are taken and ideas and thoughts are used as data in the processes. It is aimed to find permanent rather than temporary solutions to the problems by providing different tasks by forming a team in the solution phase after the problems are revealed (13). Kaizen is aimed at eliminating waste in business processes. For this reason, it aims to move towards the maturation stage of the trade/investment system in businesses by constantly researching, using risk management methods, applying new methods and s, and taking into account technology. In this direction, it also includes performance and risk measurements and analysis of nonconformities, and finding their root causes (14). Kaizen is an approach that emphasizes the whole process, not results-oriented. What every individual in the organization needs to do for the successful implementation of kaizen is to create projects for improvement by targeting the better in their own duties. Therefore, Kaizen enables multidisciplinary teamwork and is used as a model that is also a part of the quality control process (15).

## METHODOLOGY

In the methodology, firstly, the steps of the profile production process are extracted. AAfterward time study of this process was studied. The size of the problem was revealed by calculating the durations. Then the spaghetti diagram was made. Unnecessary movements have been identified. The process steps are presented. The ideal action plan has been revealed according to the spaghetti diagram. Accordingly, a cellular manufacturing plan was made. The layout plan was rearranged. The mold was improved by using the

Kaizen technique. Thus, the number of operations decreased.

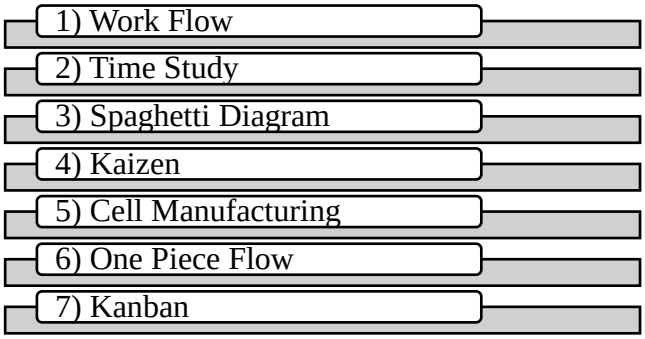


Figure 1. Methodology

## CASE STUDY

The Steel Profile production facility located in Istanbul, shapes and manufactures molds according to customer requests and demands. Special Profile production facility with a wide product range, mainly shelf profiles, Steel Construction Profiles, Shelf Profiles, Cable Ladder Profiles, Automotive Profiles, and Construction. It produces Profiles, Rail and Cable Carrier Profiles. Production time, production capacity, and production flow may vary depending on product demand. The profile, whose project and dimensions are prepared in line with the customer's request, is processed in 2 or 3 different ways according to the production plan. The most important characteristic of these processes is whether they are perforated or not. Profiles without holes are processed in 2 processes, and profiles with holes in 3 processes. The production story of the rolls in profile production is as follows; In the first stage, the Steel Coil is sliced. Steel coils come to the Steel Coil Slitting Line; It is cut according to the determined dimensions. The cutting process is carried out according to the width of the product. If the slicing steel rolls are to be pressed, they will go directly to the profile line if they are pressed in the press line and the groove is not pressed to the profile line. There are 3 stages 2 stages of product type and 2 types of production according to the structure of the desired product. In the study, the profile production process was first created in an SME that produces profiles. Profile production process steps are as follows.

-3 Stage Production;

The rolls arrive at the Slicing Line. The parts coming out of the Steel Coil Slitting Line to go to the Press Line according to the project plan. Parts going to Press Line are usually Rack etc. are perforated profile parts. Steel coils coming from the Press Line to the Steel Coil Slicing Line are pressed and punched. Rolls that have been pressed enter the Profile Line. Here, pressed rolls are shaped by crushing and abrading with 18 different rotating heads.

-2 Stage Production;

The rolls arrive at the Slicing Line. Steel Coils, which come out of the Steel Coil Slitting Line and do not need to go to the Press Line, enter the Profile Line to take shape. Here, pressed rolls are shaped by crushing and abrading with 18 different rotating heads. There are 1 Steel Coil Slitting Machine, 1 Steel Coil Press Machine, and 2 Steel Coil Profile Machines in the Production Facility. One of the Steel Coil Profile machines has a 500-coiled Steel Coils capacity, while the other has a 350-coiled Steel Coil capacity. The machine to be used is determined by the size of the roll. There are 2 cranes in the Production Facility as the steel coils have a high weight. One of them has the capacity to carry 15 tons and the other 30 tons.

In our project, a layout planning study was carried out and suggestions were made. The area covered by the Production Facility and the distances between all the lines and the machines on the lines in the production facility were measured. As a result of the measurements we took, the drawings of the lines and machines were made in AutoCAD to see the current order. After completing the drawings of the lines and machines, they were placed in the facility according to the distance measurements between each other, and the efficiency of the line layout was reviewed and analyzed. The results of our observations and analyzes are as follows; The line layout is not planned according to the order of operations. The fact that the line layout is not planned according to the order of operations negatively affects the production workflow. Negatively affecting the workflow increases unnecessary work and unnecessary machine use. This affects the cycle time. The process flow of the part to be produced in the Production Facility is as follows: Slitting Line - Press Line – Profile Line. According to the Logistics door in the layout, there is the Press Line at the front, the Slitting Line behind the Press Line, the Profile line 2 behind the Slitting Line, and Profile line 1 next to the Profile line 2. The current layout and workflow are as follows;

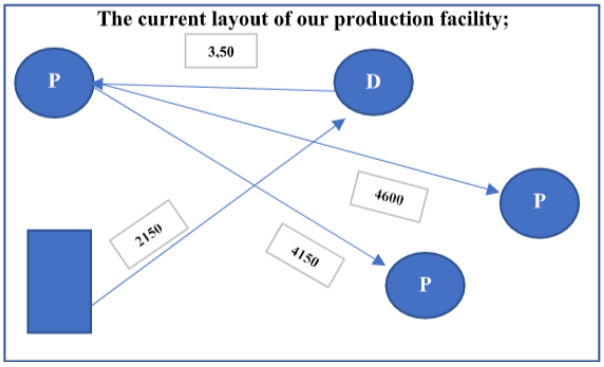


Figure 2 Current Flow

The line layout shown in the figure is the current line layout business diagram of our production facility. As can be seen in the figure, the line layout. With the wrong planning, the roll goes an unnecessary way. Starting from logistics and ending at the profile line, the production journey has been measured as 6650 cm (66.50 m). The stowage area from the Profile 1 line is 10m and the total travel time is 7650 cm (77m). The fact that the distance covered in the journey is so long affects the production time as well as the crane life and increases the maintenance and electricity costs. At the same time, long journeys create difficulties for the operators in terms of occupational health and safety, as the transition between the lines is provided with a crane. The working diagram we have done in order to reduce the transportation time between the lines is shown next.

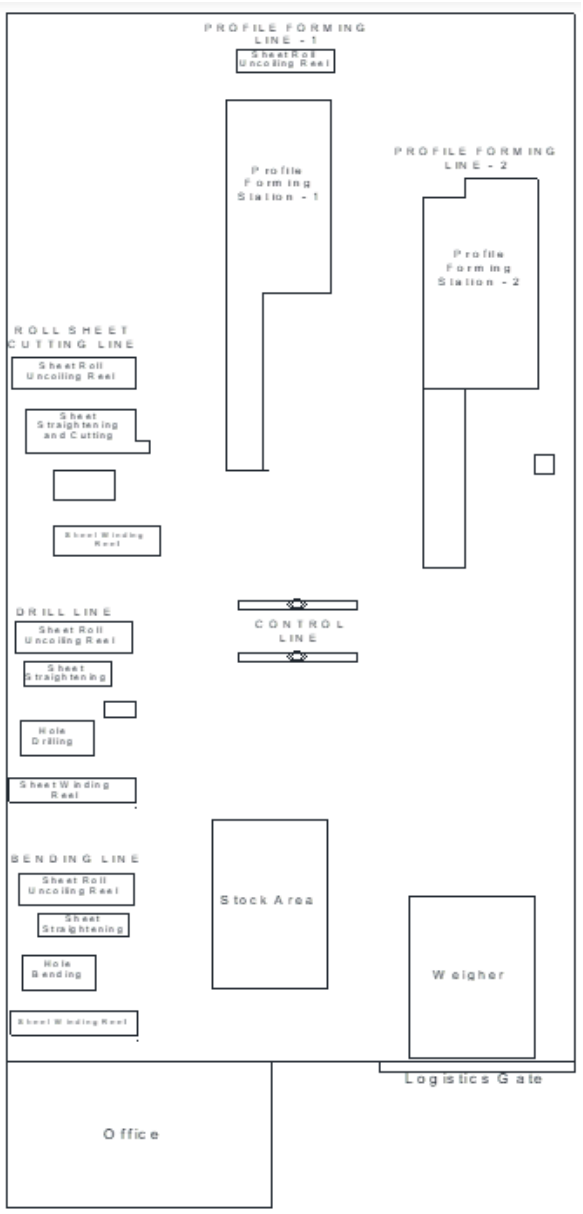


Figure 3 Current Production Area

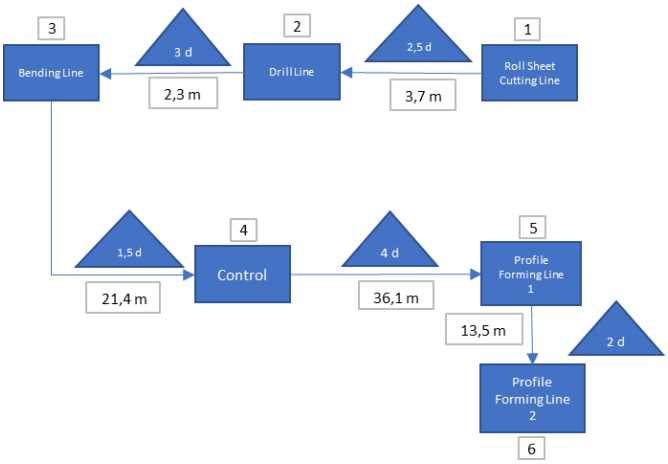


Figure 4 Current Production Flow

Current Line:

Machine Time Of Standard Roll

Roll Sheet Cutting Line – 33 min. 28 sec.

Drill Line – 38 min. 41 sec.

Bending Line – 24 min. 32 sec.

Control – 18 min. 37 sec.

Profile Forming Line 1 – 52 min. 43 sec.

Profile Forming Line 2 – 43 min. 11 sec.

Table 1. Current Line Time and Total Distance

| Process | Distance (Meter) | Transport Time (Second) |
|---|---|---|
| Roll Sheet Cutting Line - Drill Line | 3,7 | 77,4 |
| Drill Line - Bending Line | 2,3 | 48,1 |
| Bending Line - Control | 21,4 | 447,9 |
| Control - Profile Forming Line 1 | 36,1 | 755,6 |
| Profile Forming Line 1 - Profile Forming Line 2 | 13,5 | 282,56 |

| Total Time (Second) | Total Distance (Meter) |
|---|---|
| 1611,56 | 77 |

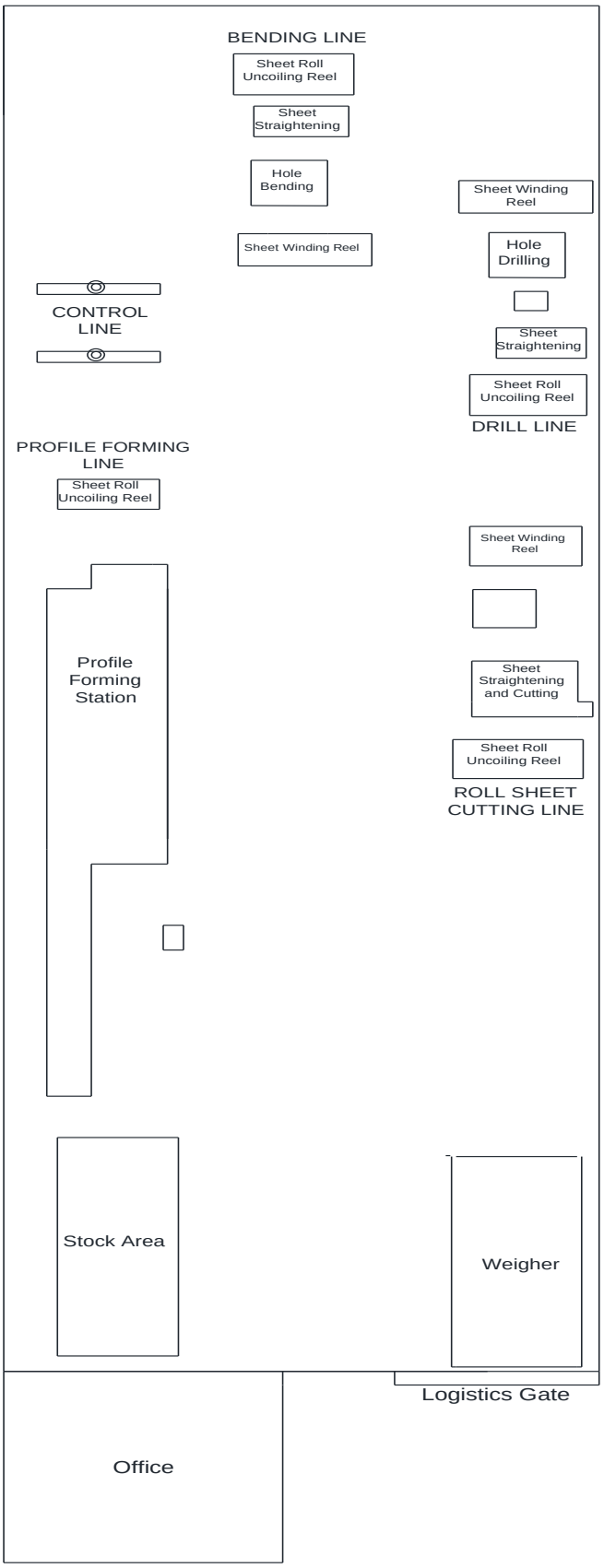


Figure 5 Improved Production Area

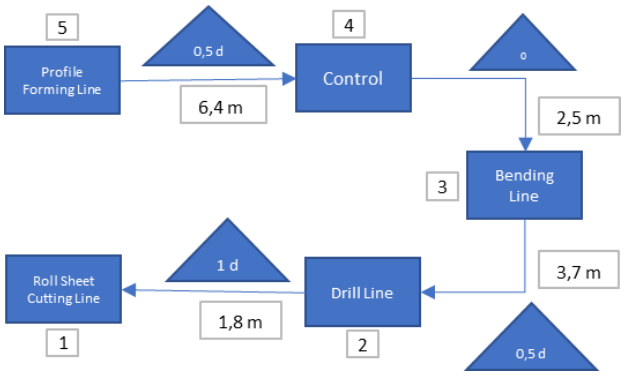


Figure 6 Improved Production Flow

The profile forming process has been reduced from two operations to one operation. There were two different profile-forming stations in the current layout, one of the stations was reduced to a single operation by making mold improvements.

Improved Line

Machine Time for A Standard Roll

Roll Sheet Cutting Line – 33 min 28 sec

Drill Line – 38 min 41 sec

Bending Line – 24 min 32 sec

Control – 18 min 37 sec

*Profile Forming Line – 49 min 37 sec

Table 2. Improved Line Time and Total Distance

| Process | Distance (Meter) | Transport Time (Second) |
|---|---|---|
| Roll Sheet Cutting Line - Drill Line | 1,8 | 37,7 |
| Drill Line - Bending Line | 3,7 | 77,4 |
| Bending Line - Control | 2,5 | 52,3 |
| Control - Profile Forming Line 1 | 6,4 | 133,9 |

| Total Time (Second) | Total Distance (Meter) |
|---|---|
| 301,3 | 14,4 |

Since the Kanban calculation is made according to the formulas below, the results are found as follows.

Minimum Lot Size = ((Average Demand)*(1+ α))/Average Number of Preparations (1) Number of Kanbans = ((Average Demand)*(1+ α)*Kanban Cycle Time)/Container Size (2)

As a result, operation times, distances between them, and waiting times were determined by time study and spaghetti diagram. In light of this information and based on operation times, the cellular structure was prepared. At the same time, the preliminary preparation for the one-piece flow in the future has been completed. At the same time, the unnecessary operation is prevented thanks to the improvement of the mold. Accordingly, the settlement has been made more effective. The average demand is 800, the number of mold changes is 6 pieces (2 shifts), the type of part to be produced is 4, minimum lot size is 586.7 (rounded to 600). The container size is 150 pcs. Kanban cycle time is 148 minutes, Kanban Number is 0.9 (1 if rounded) (Safety Factor is taken as 10%). Thus, in order to reduce stocks in production, the infrastructure was prepared by determining values such as the number of Kanbans and the minimum lot size.

## III. CONCLUSION

The application of lean manufacturing techniques in SMEs is extremely important. The study achieved improvements in terms of time and cost by using multiple lean production tools. While unnecessary movements are reduced with cellular manufacturing and spaghetti diagram, intermediate stocks are prevented with Kanban. As a result of the improvement made in the mold with Kaizen, the flow has accelerated and thus a more efficient use of the area for cellular manufacturing has been achieved. Although the one-piece flow is partially applied for the continuous production of the materials, it is not applied at the continuous point due to the discontinuous production and the dimensions of the parts. However, in order to accelerate the flow, it stands out as a step that should be considered for future studies. At the same time, in order to see the big picture, it can be decided which methods to use and where with the value stream mapping study. Standard work can be studied so that employees do things the same way. Ergonomics can be considered for the employees to work effectively and to protect them from occupational diseases. Also, the CONWIP structure can be used in addition to Kanban. The milk run method can also be used. It can benefit from the SMED technique to reduce the change time of molds. POKA YOKE is among the tools that can be used to prevent human errors and to

facilitate the work. At the same time, 5S can be used to effectively use the area and to prevent calls. Thus, the flow of material and information can be faster and more accurate.

## REFERENCES


[1] S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.

[2] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.

[3] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IEEE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.

[4] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High-resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, paper 11.3.4, p. 109.

[5] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.

[6] (2002) The IEEE website. [Online]. Available: http://www.ieee.org/

[7] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/

[8] *FLEXChip Signal Processor (MC68175/D)*, Motorola, 1996.

[9] "PDCA12-70 datasheet," Opto Speed SA, Mezzovico, Switzerland.

[10] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.

[11] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.

[12] *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification*, IEEE Std. 802.11, 1997.

[13] Karakaya, Ş. (2019), Performance Enhancement with Kaizen System and Packaging Industry Applications, Trakya University, Institute of Science and Technology, Master Thesis, Edirne.

[14] Erdeniz, M. (2018), Effects of 5S and Kaizen Applications on Business Performance, An Application in the Furniture Sector, Nuh Naci Yazgan University, Department of Business Administration, Master Thesis, Kayseri.

[15] Uyurdağ, N., Yıldırım, A., Köse, U.T. (2022), Continuous Improvement Models in Health Care, Hacettepe Journal of Health Administration.