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Seru production as an alternative to a traditional assembly line

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ABSTRACT
The article presents the concept of seru production and a simple simulation experiment to check the application effectiveness of the seru production concept in the assembly line of finished products. The article presents the concept of seru production created by Japanese electronics manufacturing companies in the 90s. The simulation experiment showed, better results using the seru production concept compared to a traditional assembly line. Three types of production cells were used and each option turned out to be better than a traditional assembly line.

KEY WORDS
seru production, production management, simulation

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Introduction

The currently prevailing market conditions can be described as unstable. The reason behind the restless market is mainly factors, such as short product life cycle, a variety of existing products and those required by consumers, and the need to adapt to these requirements. Meeting customer requirements require a high degree of production flexibility, reducing production costs and production batch size and shortening delivery times (Gálová et al., 2018). The concentration of future operations and the development strategy (businesses, regions) containing key factors for technological development can contribute to the ultimate success. In the context of prospective management of the technological development, a selection of key factors can form the basis for the construction of the desired development scenarios for an object or system (Nazarko et al., 2017). An important element of a company's operation is to anticipate the future and opportunities that may arise. Knowledge concerning the current trends in technological development is also necessary. The concepts allowing to predict the future state of technology include technology assessment, technological forecasting, and technological foresight (Halicka, 2018).

Many approaches have been developed to improve the competitive ability in an unstable market. They help companies to manage decisions and organise production processes. Lean management and agile management are among the most commonly used concepts. These concepts are very well known and widespread among enterprises

Seru production is one of the newer Japanese concepts of production management. The main premise of the Japanese method used to organise cheese production was the transformation of traditional assembly lines into production cells. The cellular arrangement of production is considered an ideal combination of lean and agile models (Yin et al., 2012).

The transformation of traditional production lines into cell production is mainly caused by changes in the market, which force the producers to change the management approach to the production process, enabling a quick response to market opportunities, as well as customer requirements. Seru production seems to be a response to such changes taking place in the environment surrounding a company (Zwierzyński, 2018, p. 530).

The article is divided into three parts. The first part presents the concept of seru production as an alternative to traditional production lines. The second part presents a simple simulation experiment and the achieved results. In the last part, a short summary of the article is given.

1. Seru production

Wemmerlöv and Hyer described seru production as a production type that belongs to the cell production group, whose main assumption is the creation of production sites for a family of parts or products with similar process requirements, clustering of various processes in close proximity, and designing supporting social engineering systems (Zwierzyński, 2018).

Transformation of an assembly line into seru cells, which was initiated in Sony factories, was considered by Kaku an innovation of assembly systems and has been widely applied in the Japanese electronical industry (Kaku, 2017).

Villa and Taurino indicated the following reasons for the emergence of seru production in Japan (Villa & Taurino, 2013):

- customer requirements,
- low flexibility of an assembly line,
- a long period of stagnation in Japan after 1991,
- low morale of employees working on traditional production lines,
- Toyota Production System (TPS) restrictions,
- globalisation and increased competition.

Despite using Toyota's concept in the production of goods, the changing environment and customer requirements forced Sony to reorganise its production line, which lacked the flexibility to take advantage of the emerging market opportunities. At that time, Yamada Hitoshi divided a production line of one of the offered products into many smaller lines creating production cells (Zwierzyński, 2018). A detailed description of the introduction of the seru production concept and its management mechanisms has been offered by Yin, Stecke and Kaku (Yin et al., 2008), and Stecke, Yin, Kaku and Swink (Yin et al., 2012).

The concept of seru production is similar to assembly cells — a widely used assembly system in Western industries. The type and method of using equipment, machines and tools are less important in the concept of seru production compared to cell production. As an assembly system focused on a human being, a seru cell is an old-fashioned factory where a craftsman independently assembles an entire product from the beginning to the end. The arrangement of production according to the seru concept is considered an ideal combination of lean and agile models.

One of the main assumptions of the seru production concept is to transform a traditional production line into many short lines eventually leading to the creation of cells with one employee. The Japanese form of cell production has been clearly developed as an alternative to the Toyota Production System. An example of the transformation of a cheese production line is given in Fig. 1.

By removing a traditional assembly line and creating seru cells, it is possible to reduce the number of employees while maintaining or increasing efficiency. The Japanese concept of seru production assumes that seru cells should be cheap, repeatable, and suita-

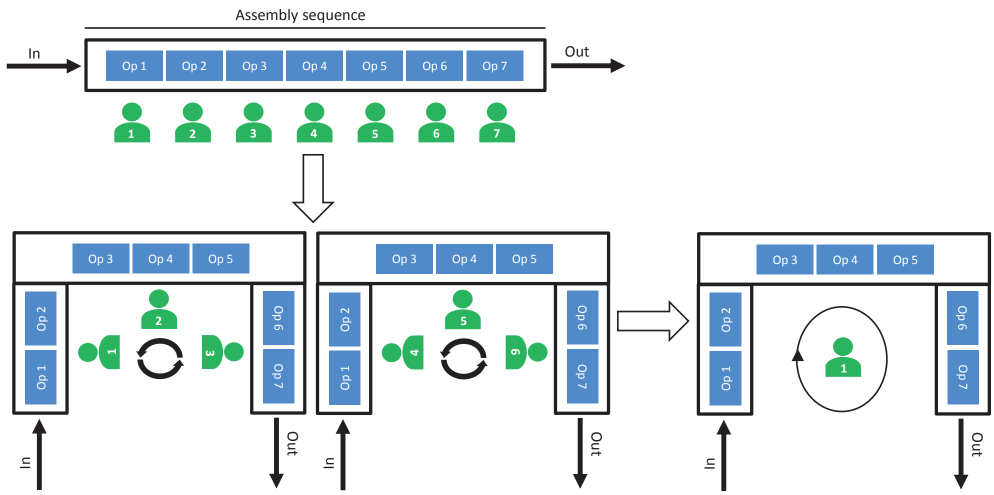

Fig. 1. Conversion of the assembly line to seru cells

Tab. 1. Results achieved by Sony and Canon after the implementation of seru production

SONY	CANON
Increased productivity Employment reduced by 25% The length of assembly lines reduced by 35000 m Improved product quality Required space decreased by 710 000 sq. m	Increased productivity The length of the assembly lines reduced by 20000 m Required space decreased by 720 000 sq. m Employment reduced by 25% Costs decreased by 230 billion yen Order fulfilment time reduced by 30%

ble for many tasks. Seru cells are easily adapted to different production depending on the product range.

Many scientists argue whether seru production is a new concept or something that belongs to the cellular production arrangement. Indeed, there are very many features common to both forms of production management. Nevertheless, seru production differs from cell production by one essential feature, namely, employee competencies. The concept of employee competencies is the subject of interest for many scientific publications. The colloquial, everyday approach uses the notions of competencies, skills, qualifications, authorisations and duties interchangeably (Gudanowska et al., 2018). In seru production, a significant role is attached to employee skills with the aim of having staff able to perform many activities in different production cells. Fig. 1 shows the limitation of the number of workers in converting an assembly line into seru cells. In the last case, one employee performs the activities previously performed by many employees. An example of using such an approach is presented later in the publication.

The seru production concept has been widely used in the Japanese electronics industry. The best described and documented cases involve Sony and Canon. The results achieved by these enterprises are presented in Tab. 1.

Seru application history is still not long enough to solve many of the production problems. Many factories could not improve their performance by implementing seru production methods, mainly because most manufacturing managers are unfamiliar with the basic knowledge of seru production, and because the implementation of seru production differs from factory to factory with different conditions and market environments (Liu et al., 2014). Other research has argued that the implementation of seru production systems might be associated with additional cost for training and assigning multi-skilled workers, which need special care to be minimized (Ying & Tsai, 2017).

Hence, this article aims at enhancing the understanding and implementation of seru production in both academia and industry.

2. Computer simulations

Due to their potential to efficiently solve complex problems, computer simulations have gained and continue gaining importance and popularity. The growing popularity of this research method has contributed to the development of newer programming languages and tools that enable the performance of increasingly complex and demanding simulation experiments.

Simulations of production processes are a form of experiments on a computer model. The goal of the experiment is to answer the question of how a change in the production process will affect results. Implementation of computer solutions in production engineering allows reducing costs incurred by enterprises due to wrong decisions when planning and modernising production. Simulation experiments are also helpful in shortening production time, planning new products and selecting production strategies by enterprises (Kikolski, 2016).

Simulation programs offer great opportunities to analyse even the smallest changes in production processes. When creating a model, it is important to decide whether the primary phenomena are events or whether the continuity of change is important (Badura, 2017). Adding a warehouse between operations, changing the order of production processes, or even changing the amount of one-time goods to individual positions can give positive results. A change in the arrangement of production is also a change that can produce positive results. However, this is a big upgrade, and the use of simulations seems to be the best solution.

The author of the publication used the Simul8 simulation program to carry out a simple simulation experiment. The program has a simple assembly process of the finished product using a traditional assembly line.

SIMUL8 simulation software is a product of the SIMUL8 Corporation used for simulating systems that involve processing of discrete entities at discrete times. This program is a tool for planning, design, optimisation and re-engineering of real production, manufacturing, logistics or service provision systems. SIMUL8 allows its user to create a computer model, which takes into account real life constraints, capacities, failure rates, shift patterns, and other factors affecting the total performance and efficiency of production.

This model makes it possible to test real scenarios in a virtual environment, for example, simulate planned function and load of the system, change parameters affecting system performance, carry out extreme-load tests, verify by experiments the proposed solutions and select the optimal solution. A common feature of problems solved in SIMUL8 is that they are concerned with cost, time and inventory.

3. Simulation experiment

Simul8 simulation software has been mapped to a simple assembly line of the finished product. The assembly process of product A is implemented in six consecutive assembly operations. Each assembly operation on the assembly line takes an average of one minute. The components are delivered to the plant once a day in an amount of 200 pieces. The plant works five days a week, eight hours a day. Each operation is performed by one employee. Employees work for eight hours, and their availability is 100%. The experiment assumes that the conversion of the assembly line into cells does not generate higher costs, the time of performing the activities is unchanged, and the work efficiency does not change. Fig. 2 shows the mapping of the production process in the Simul8 software.

In the traditional assembly line, 753 pieces of the finished product were made. In the next steps of the simulation experiment, the assembly line was converted into seru cells. First, two shorter assembly lines were created (Fig. 3), where each of the employees performed two assembly operations.

The next step was to convert the assembly process into three seru cells, with two employees performing three assembly operations. The mapping of this process in the Simul8 software is shown in Fig. 4.

The last step was to convert the assembly process into six seru cells, serviced by one employee performing six assembly operations. The mapping of this process in the Simul8 software is shown in Fig. 5.

4. Discussion of the results

The results obtained from each option are shown in Fig. 6. Six indicators were compared, namely, produced, stocks, the average time in the process, the average waiting time in the process, cost and the use of employees. One can notice a high improvement in the results achieved in the cellular organisation compared to the results of the traditional assembly line.

In a traditional assembly line, the manufactured products do not exceed 800 pieces, amounting to only 753 pieces per week. Such an arrangement of the production causes the accumulation of stock, increases the average production time, and limits the use of employees.

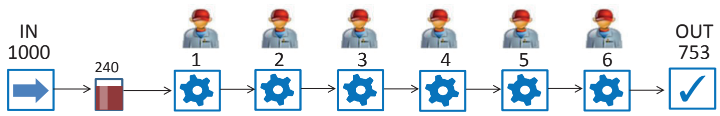

Fig. 2. Product A assembly line

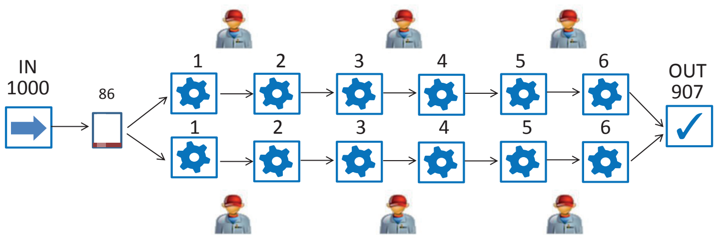

Fig. 3. Seru production 1

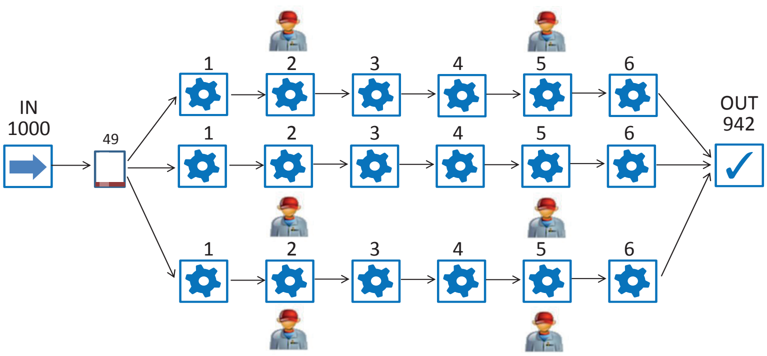

Fig. 4. Seru production 2

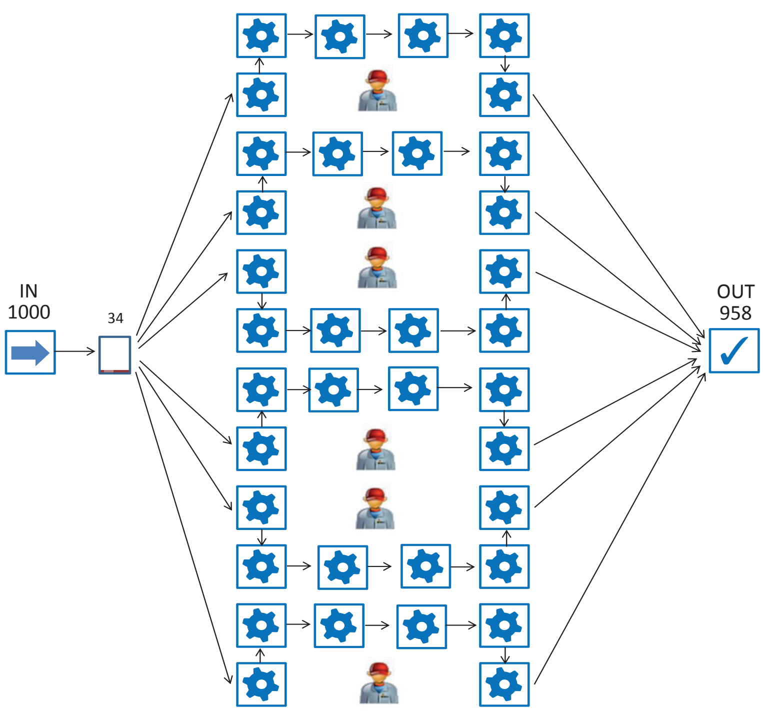

Fig. 5. Seru production 3

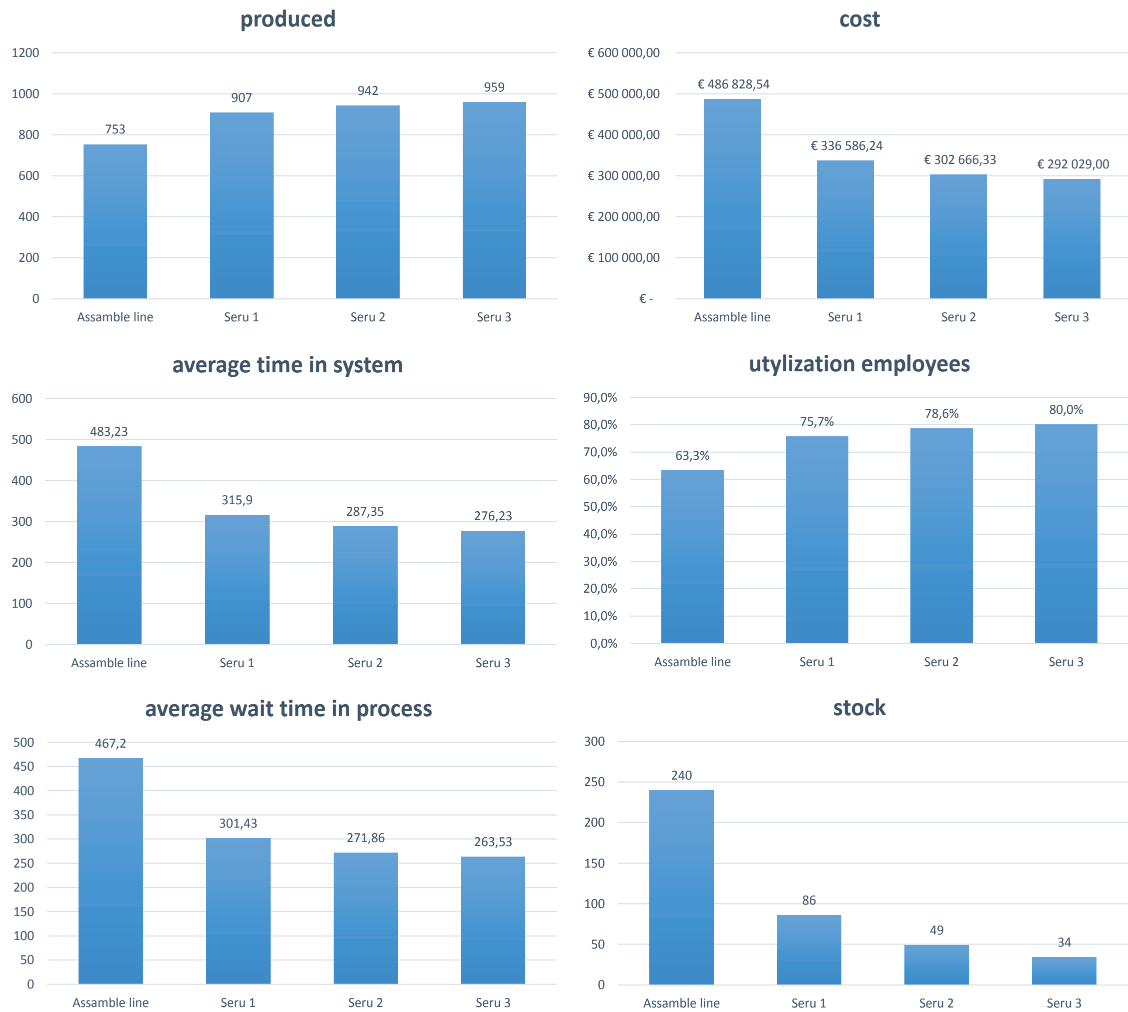

Fig. 6. Results

When seru cells are used, improvements are clearly visible. The number of finished products in each of the options exceed 900, and the remaining indicators demonstrate improvement. Increased production when using the seru production concept is visible already at the state of the division of the line into two cells operated by three employees in each. Conversion of the line into cells resulted in an increase in finished products by 154 items. The division into smaller cells operated by a smaller number of employees resulted in an increase in production by 189 items and 206 items, respectively.

After the assembly line was converted into seru cells, the cost of production decreased as well. Costs of the production line amounted to EUR 486 828.54, and in the case of two production cells, it was reduced to EUR 336 586.24, which amounted to a cost reduction of approximately 31%. The division of lines into smaller production cells also reduced the production costs by 38% and 40%, respectively, compared to the assembly line.

In each case, the use of seru production reduced the average time of product manufacture from the moment a component is delivered to the enterprise. In a traditional assembly line, the average product assembly time was 483.23 minutes. After converting the assembly line into production cells, the average time was 315.9, 287.35, and 276.23 minutes. Accordingly, the average time in the system can be reduced by 2077 minutes or by about 43%.

The use of employees increased together with the division of the assembly line into production cells. Initially, the average use of employees on the assembly line was 63.3%. The seru production concept allowed to increase the use of employees 80% for the case of six cells.

The average waiting time was reduced in every case of seru production. In a traditional assembly line, the average waiting time was 467.2 minutes. After converting the assembly line into production cells, the average time was 301.43, 271.86, 263.53 minutes. As can be seen, the average waiting time can be reduced by 203.67 minutes or by about 43%.

The components required for a finished product were delivered each day in quantities of 200 items and stored at the warehouse. The use of a traditional assembly line resulted in their accumulation and related costs. At the end of the simulation period, there were 240 items at the warehouse. The conversion of the assembly line into production cells has allowed reducing the component storage by 154 items for the case of two cells, 191 items for the case of three cells, and 206 items for the case of six cells.

Comparing individual forms of mobile organisations, the differences between the results achieved are not as large. Therefore, a more profound analysis of the profitability of transforming larger production cells into smaller ones should be carried out. When conducting a more accurate simulation experiment, one should consider the efficiency of more activities performed by one employee.

Conclusions

The article aimed to review the literature in the field of seru production and make this topic more relevant to readers. The literature review confirmed the author's belief regarding the need to change the way production in enterprises is organised. The changing market conditions force companies to think about how to achieve a competitive advantage in the market. One of the ways may be to transform a traditional assembly line into seru cells.

The results achieved by Japanese electronics companies are convincing. This form of production arrangement can be an alternative to traditional production lines. The author of the article, however, did not find successful examples of seru production implementation in other types of industry. Therefore, it should also be considered whether this method could be used in other types of industry.

The article also presented a simple simulation experiment. This experiment only concerned the assembly process of one product and did not consider many complex factors. The assembly process consisted of six activities performed by six employees. The purpose of this simulation experiment was to check the efficiency of transforming traditional production lines into seru cells.

The results obtained using Simul8 software allowed stating that this form of production arrangement can be more effective than traditional production lines. The comparison of the results received using a traditional assembly line production cells showed improvement possibilities. The results of the six analysed indicators in each case were definitely better when using the cellular method of production. The experiment resulted in reduced stocks, average time in the process, average waiting time in the process, and cost. The use of employees, as well as the number of finished products, was improved.

The decision regarding the number of cells as well as people working in these cells is, however, more difficult. The results achieved in three different seru production options are very similar to each other.

However, determining the cost-effectiveness of converting a traditional production line into seru cells is a complex problem. The author is aware that such a simple experiment can only serve as means for future research and the reflection on the subject of cheese production.

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