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Development of a KPI Subsystem for a Russian Confectionery Company: A Case Study

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Abstract

The article presents a case study of KPI subsystem development based on the application of methods and tools of lean production in a Russian confectionery factory. We report on an analysis of production problems at the enterprise, as well as proposed solutions and results of their implementation. The lean KPI subsystem resulted in significant improvements in the company. The results of this case study are relevant for business practices in general, as the proposed measures can be used to improve a company's investment attractiveness. Additionally, the findings are useful for lean managers working in the confectionery industry, as our study illustrates key success factors, as well as the impact and role of lean manufacturing in this industry.

Key words: *lean production, subsystem, key performance indicators, confectionery.*

1. INTRODUCTION

Enterprises in Europe and the USA have proved they can successfully use lean production in practice. In Russia today the principles of lean production are mainly implemented in such industries as metalworking, mechanical engineering, metallurgy, automobile, and aerospace industry. There are isolated examples of successful implementation of lean manufacturing in consumer goods production and banking.

The food industry is one of the leaders of the Russian economy in terms of industrial development. Modern development of the food industry in the Russian economy is provided for by strategic solutions. In particular, the development strategy of the food and processing industry of the Russian Federation for the period up to 2020 is to fully ensure the independence of the country in all major types of foods and become the world's largest supplier of food.

High budget allocations for 2012-2020 are stipulated in the "Development of Industry and Increasing Its Competitiveness" state program, including investment in mechanical engineering for the food industry. In this program, it is noted that the food industry is attractive for Russian and foreign business investors. This is demonstrated by the dynamics of the investment in its modernization, which totals 203.1 billion rubles in 2014 (10.3% more than in 2013).

The confectionery industry is a well-functioning link in the Russian agro-industrial complex. In 2014, the volume of confectionery production in Russia amounted to 3,450.4 thousand tons, or 23.6 kg per capita. Confectionery consumption in Russia has almost reached the European level, with flour and sugar confectionery consumption being balanced.

In recent years, many Russian confectionery organizations have modernized their production equipment, using a high proportion of imported machinery and highly skilled personnel. However, the wear of production equipment across the industry is 40%. In addition, the confectionery industry depends on the import of certain raw materials, which are impossible to produce in Russia.

In the upcoming period until 2020, certain industries and technology streams are to be re-equipped with high-performance machinery that would allow consistently high quality and low cost of production. The total investment in the production of bread and long-life flour confectionery, as well as cocoa, chocolate and sugar confectionery is expected to total 158,377.5 million rubles. The volume of confectionery production in Russia should amount to 3,580 thousand tons by 2020.

The main system problems and limitations for Russian enterprises in the food industry are:

- Lack of agricultural raw material of appropriate quality;
- Moral and physical wear of processing equipment and shortage of production capacities for certain types of processing of agricultural raw materials;
- Low level of competitiveness of Russian food producers on the domestic and foreign food markets;
- Poor infrastructure for storage, transportation and distribution of food products, including infrastructure catering for social institutions;
- Insufficient compliance with environmental requirements for industrial zones of food industry organizations;
- High volatility of raw material prices.

The development strategy for domestic food supply both at the all-country level and for individual businesses stipulates:

- Prioritizing the modernization of industry;
- Adopting modern management methods;
- Introducing technologies that reduce losses of raw materials;
- Training high-skilled industrial personnel.

The present challenge in the Russian food industry is that, although the government has developed general strategies, there is still a lack of practical solutions and projects implementing lean production. This negatively affects the investment attractiveness of companies.

At present, foreign investment and capital are concentrated in the confectionery, fat-and-oil and dairy sectors of the food industry, as well as in the production of canned fruits and vegetables, juices and beverages. Thus, it is obvious that the confectionery industry is of direct relevance for investors.

The goals of this study are:

1. To systematize the theory of lean production in the confectionery sector of the food industry.
2. To identify ways of using European companies' experience of implementing lean manufacturing in the Russian confectionery industry.
3. To develop and propose lean measures for production improvement at one of the leading Russian companies in the food industry – the macaroni and confectionery factory Babylon llc.
4. To evaluate the effectiveness of the proposed measures based on Babylon's KPI subsystem.

This paper aims to share practical experience gained in implementing lean methods at a Russian confectionery factory in the presence of investment attractiveness for Russian and foreign business.

2. THEORETICAL BACKGROUND

Identification and elimination of losses is an important area of continuous improvement for any company, because losses directly affect the company's performance. The classic types of losses have been systematized by T. Ohno, creator of the Toyota Production System [6]. The engineering side of implementing the Toyota Production System has been described by Japanese engineer S. Shingo [5]. T. Fujimoto illustrated the evolution of the Toyota Production System, underlining the connection between three subsystems: supplier, development and production [7]. Y. Monden discussed ways to integrate the subsystems to improve efficiency while focusing on the entire system [21].

An assessment of the impact of the lean methods and tools on the development of company culture has been conducted by D. Mann at the system level [15]. J. Womack and D. Jones pay special attention to the solution of consumer problems based on the system approach in lean thinking [17]. J. Liker studied the culture and transformations of the Toyota Production System [13, 14, 19, 20]. A systematization of optimum metrics has been carried out in a study by S. Bhasin, who conducted a lean audit and made recommendations for using these metrics [4].

Based on best practices of well-known companies, J. Black has suggested ten 'lessons' coordinating the evaluation and implementation of world-class lean manufacturing [8]. R. Charron, J. Harrington, F. Voehl, and H. Wiggin have outlined the transformations and transition from the house of lean production to the house of lean management at the system level [3]. A systematization of the theoretical foundations and seminal research papers on lean production makes it easier to understand the practical feasibility of developing KPI systems or subsystems.

Each KPI should serve a specific purpose. The system-level management of the company is concerned with achieving optimal results, which can be expressed as 'five Ps' [3]:

1. Pride;
2. Performance;
3. Profit;
4. Prestige;
5. Pleasure.

Reviewing KPIs annually is essential for any company implementing lean production because this provides opportunities for enhancing business activity. However, core KPIs are not subject to changes [2].

Core KPIs are focused on the key elements of the process and may reflect [2]:

1. Production efficiency;
2. Labor productivity;
3. Material yield;
4. Product quality;
5. Availability.

Thus, it is obvious that the development of a KPI subsystem has to be in alignment with the core KPIs. Additionally, the task implies identifying causes of problems, concentrating ideas and finding ways of applying lean production, using lean techniques and tools in the subsystems and the system of the company as a whole. A KPI subsystem serves as the basis for optimal decision-making and the formation of new measures to improve the competitiveness of enterprises.

2.1 **Solutions for a successful introduction of a lean KPI subsystem**

Solutions for successfully introducing KPIs mainly involve the system management level and are designed to accommodate a lean system as a whole. It is really effective for situations when the enterprise is already running on lean principles. M. Tanco, J. Santos, J. L. Rodriguez and J. Reich outlined systemic solutions for the use of lean techniques in a Latin American chocolate factory, covering the entire activity of the enterprise [23]. These authors conclude that it is necessary to use a special version of lean manufacturing tools and introducing lean across the whole enterprise. L. Stevenson and R. Jain studied lean manufacturing in the food industry [24]. A number of scholars have linked the development of production and quality improvement solutions with methods and tools of lean manufacturing, based on best practices in the food industry [26, 28, 29, 36]. S. Bhasin has given the most complete account of performance measurement in large lean companies [38, 39]. Recent literature reviews demonstrate the relationship of the evolution of lean and sustainable development [31, 32, 37, 40]. A successful implementation of KPIs should be coordinated with the influence of cultural environment on decision-making [44], the need for integrating modern technology [45], as well as introducing an ERP-class information system [42].

Our work differs in that it describes the development of a KPI subsystem for a confectionery company transitioning from a push production system to a pull system of lean production, and focuses on the problematic shops of the enterprise. In the following sections of this paper, we describe the theoretical background in lean production and the development of KPIs, European confectionery companies' experience, application of lean manufacturing methods adapted for a Russian confectionery factory, results obtained when testing a KPI subsystem, and, finally, the findings and discussion.

2.2 **Ways of implementing lean manufacturing at European confectionery companies Cloetta and Leaf**

Lean production in the food industry in Europe is still at an early stage of its development, although the industry is the largest manufacturing sector with a turnover of 965 billion euros, employing 4.4 million people. As an example, we briefly discuss the ways of implementing lean production at two confectionery factories, Cloetta and Leaf.

Cloetta is a leading confectionery company in Scandinavia, the Netherlands and Italy, founded in 1862 by the Cloetta brothers. It produces sugar confectionery, chocolate products, as well as marshmallow and chewing gum. The company's products are sold in over 50 countries around the world.

In order to improve manufacturing, the company launched a lean manufacturing project in late 2010 - early 2011, aimed at simplifying the production process and reducing order execution time.

The company's management system at the time covered the areas of health and safety of employees, quality and safety of products, as well as the environment. The management was based on periodic risk assessment and continuous improvement. One of the important management practices was to have regular meetings to monitor interim results, so as to understand whether the objectives were being met and to invite suggestions on how to eliminate negative deviations. The employees were always aware of the current state of affairs in the company, since all objectives and results were presented on displays and notice boards. The visualization of these indicators contributed to raising awareness and increasing employee involvement in production planning.

The company is constantly working on improving production and maximizing capacity utilization. Key success factors include long-term and daily efforts to achieve continuous improvement and establish a culture of continuous learning. This is achieved through a systematic use of lean methods, such as improving equipment effectiveness by reducing readjustment times and number of stops caused by failures and malfunctions of equipment, as well as optimizing operations and amount of unfinished production, etc. Improvement at Cloetta usually results from employee suggestions. This boosts employee motivation and commitment to development and continuous improvement, which also leads to cost savings.

All of the company's factories are certified for compliance with the BRC Global standard for food safety and/or ISO 9001. The company has a well-developed planning system, integrated with the entire supply chain from suppliers to end consumers, which also covers financial and pricing planning. Efficient production planning results helps the company avoid storing excess raw materials and finished products. Cloetta uses the following methods: 5S, standardization and visualization, TPM, SMED, Kaizen, and JIT.

The Belgian confectionery factory Leaf was founded in 1940; it became part of Cloetta in 2012. In 2009, Leaf often failed to supply its products to customers on time due to weak production control. Production-related decision-making and employee empowerment were limited, there were problems with quality, and the company suffered heavy losses. The managers blamed rank-and-file employees, considering them incompetent. However, October 2010 saw a new management team appointed, and after some rational transformations, the company was again profitable.

According to the staff, the main problem was that the company did not apply the ideas of lean manufacturing. The main objective was to enhance the reliability of production equipment; however, the company staff had to first change their way of thinking to start improving production processes together, becoming more open to each other.

The team that implemented lean production used the following techniques and ideas:

- Changing the associative perception in the employees by making them aware of their roles in the future changes in the company.

- Streamlining the process of problem detection and information exchange between all employees.
- Coordinating the departments towards a common goal.
- Organizing staff training in lean manufacturing.
- Creating a comfortable atmosphere by staff involvement, eliminating fears that limited employee creativity, and focusing on positive outcomes, allowing employees to be proud of themselves and making them happier.

The company developed a new culture of relationships. Fifteen lean leaders were trained in October 2010 through February 2011. The main objective of training was to master team-building and conflict management techniques rather than the methods and tools of lean production. Roleplays and various other exercises allowed lean leaders to progress fast.

The first lean projects were focused on improving the quality of equipment maintenance and implementing TPM. The managers applied the principles of 5S to create a clean and comfortable working environment and designed 5S schedules for autonomous equipment maintenance.

Every Friday one of the two production lines stopped, and 4-5 teams developed improvement projects. The management detected a problem area, and Kaizen teams fully developed and implemented the solution. This motivated the employees, generating enthusiasm for their work. The employees celebrated the company's successes together, for instance, by going to the restaurant.

One of the completed projects was called "Clean Floor". It was aimed at reducing the amount of products falling onto the floor. Such losses amounted to 50% of all manufactured products. To improve the situation, the production area was divided into 8 zones, according to the number of "bottlenecks". The solution to this problem was placing trays under each "bottleneck". This solution was temporary, as the company was planning to create a continuous production flow, but it still allowed the company to save 25,000 euros per year.

The introduction of lean manufacturing resulted in:

- Smooth and stable functioning of equipment;
- Stable increase in the company's profits;
- Better staff relationships.

With the new management team who did not view the employees as the source of all the problems, but saw an inexhaustible potential for development, employee behavior changed dramatically. The staff became a cohesive group, more energetic and motivated. They developed a desire to improve and to solve any problems that arise.

3. METHODS

Before describing the methods used, it is necessary to give some background information on the enterprise that we worked with. The Cheboksary macaroni and confectionery factory Babylon llc. was founded in 1999. Today, Babylon is one of the largest food producers in the Volga region. The factory produces confectionery, pastas and extrusion products, as well as soft drinks; the products are sold in 21 regions of Russia. Due to the increasing competition in the market, changes in production and reduction of losses are required, which also influences the product range. The latter currently includes about 200 items.

Initially, the enterprise specialized in the production of pastas, manufactured on Russian-made automatic lines with a capacity of 15 tons per day. Later, the factory purchased three automatic lines by the Swiss company Bühler, which allowed the production of elbow macaroni, vermicelli and noodles at the rate of up to 45 tons per day.

Since 2004, Babylon has been producing puff cookies on Italian-made equipment by Canol, Mixer and Polin at the rate of up to 60 tons per day. The company also produces corn sticks and bread crisps. In 2007, Babylon began to use two automatic production lines of sugar cookies and wafer sticks.

The company was one of the first in the Volga Federal District to receive certificates of the international quality standards ISO 9001 and ISO 22000. Babylon gives priority to the customer's values and interests, focusing on continuous improvement and consistent quality.

We investigated Babylon's production workshops of puff cookies and sugar cookies. Loss analysis in the puff cookie shop revealed four types of causes of losses:

1. Manual labor errors made by the shop employees (such as inaccurately following the recipe, incorrectly folding the dough, and violations of the production order), negligence, and limitations in employees' physical capabilities for manual work.
2. Equipment-related causes, such as poor use of equipment (resulting in the highest percentage of waste), equipment breakdowns and malfunctions, time-consuming readjustment.
3. Poor decisions causing such losses as additional financial costs and transaction losses.
4. Planning and organization problems: inadequate materials and supplies causing additional material and time costs, inefficient layout of machinery and equipment, and underqualified personnel.

In the company, the decision which product to manufacture next was usually made using the software 1C: AccountingSuite, based on the recommended amount in stock for each type of product. The production plan was set daily for each shift. However, despite focusing on the recommended stock, the supervisor still had to consult the sales department several times a day to finally make a production decision.

This was due to the following:

1. 1C: AccountingSuite did not show high-priority products when the current stock of multiple items was below the recommended level, so the supervisor had to find out about them from the chief sales officer.

2. 1C: AccountingSuite showed only the warehouse stock, i.e. there was no information on large orders placed, so the supervisor also had to get this information from the chief sales officer.
3. It was preferable for the company to have in stock all of the products specified in the order. However, if there was not enough of some product to complete the order, it was desirable to start producing that particular item. Again, the supervisor had to contact the chief sales officer for the necessary information.

Clearly, the factory's production decision-making system had to be reconsidered. Firstly, the company had a push system of production maintaining a certain required number of finished products in the warehouse. Secondly, the production of puff cookies was not conducted daily, but only when the stock was below the recommended level. The shops, having three shifts of workers, were capable of just-in-time production, yet they stockpiled products in the warehouse.

From the chief sales officer's perspective, it was more convenient for the sales department to leave production planning to shop supervisors. Additionally, according to the chief sales officer, the existing production system based on the 1C software was suboptimal, since products piles up in the warehouse and sometimes spoiled.

From the work organization viewpoint, it was observed that each employee had a workspace to perform his or her primary and secondary duties. All the necessary packaging materials, labels, repair and cleaning tools were placed in specially designated storage areas in accordance with sanitary requirements. In addition, almost all employees had the skills to work on various operations, making the production process more flexible.

However, according to the map of the value stream, only certain workers received information about the production plan, in the form of assignments, hand-written by the supervisor. Other employees learned about the production plan from either their colleagues, or having asked the supervisor. Furthermore, all additional information that was required had to be obtained from the supervisor.

Table 1. Losses and problems in the puff cookie shop

Stage	Problems and losses	Type of losses
The drawing of the production plan by the shop supervisor	There is no clearly established system of production planning: the decisions are based on the 1C software and consultations with the chief sales officer.	(3)
Kneading the dough and preparing the fillings	Kneader is idle during flour mixing. The flour falls sideways onto the floor during the mixing.	(4) (4)
Rolling	The flour falls onto the floor. There is no information about the production queue for the current shift.	(4) (4)
Forming	Frequent shortages of filling due to delays by the operator of the line, which results in four employees being idle for up to 55 minutes.	(4)
Baking	The baker is idle while the product is being cooked. The stove works more slowly than the line, so carts fill the space around the stove forming a queue. Products are unevenly baked.	(4) (4) (2)
Packaging	Time is spent on requesting gloves and Scotch tape. At the packaging stage, up to 50% of products are found to be defective because of uneven baking.	(4) (2)
Storage	The factory's operation is demand-oriented, which results in product storage for 10 days and more. Some products spoil in the warehouse due to: 1) low sales; 2) violation of the FIFO principle; 3) inadequate setting of the recommended stock level in the 1C software; 4) shop's overproduction	(3) (3)

In the sugar cookie production workshop, there were similar problems with the decision-making process and lack of methods of visual control like in the puff cookie shop. The sugar cookie production consists of two lines. The first line is for making sugar cookies of the "Favor of Taste" brand, the second for "Intuitio" and other brands. The production process includes the following steps:

1. Acceptance and storage of raw materials. Before each first shift, the necessary amount of raw materials (flour, oil, fillings, etc.) is ordered from the warehouse. The materials, which are accompanied by proper paperwork, are checked for quality and quantity.
2. Preparation of raw materials and semi-finished products for production. Raw materials are released from packaging, mixed, filtered, crushed, sieved, grated, etc.
3. Dough making. The dough is made according to the prescribed formulas in a periodic-action kneading machine by mixing fat mass with flour. 50-60 batches of dough are kneaded per shift.

4. Forming. This is done on a rotary machine by extrusion, when the dough is forced up to 3.5–4 mm deep into the recesses of the molding shaft. Before this procedure, the rotary machine is greased with vegetable oil to prevent the dough from sticking to the rotor shaft.
5. Baking. A gas furnace is used, with the temperature and duration depending on the type of the product, as prescribed by product engineers. The duration and baking modes may vary depending on the type of furnace, its load, and the baking temperature.
6. Cooling. The cookies are cooled on a conveyor in the shop, where the products are passed from the furnace. After this, the cookies are either packaged as a finished product or passed on to the next stage for filling (sandwich cookies). The filling is made in a periodic-action mixer. The raw materials are put in the container and mixed until smooth.
7. The filling of sandwich cookies is done on a machine consisting of a reservoir for the cream, two heads and the output conveyor. The filling is put on one of the cookies and covered with the other.
8. Packaging and storage. Cooled sugar cookies are transported into the packaging area. They are manually stacked in the corrugated packaging, then weighed, marked with labels and are wrapped in the packing machine. Cookie boxes are stacked on pallets to a height of up to 2 meters. The number of packed boxes is recorded in the logbook.

A significant problem area that was noticed in the shop was that due to large stock and high performance the company's effectiveness was decreased under low order intensity. According to warehouse records, overproduction of sugar cookies amounted to 33%-67% per week. On average, one line produced 3815 kg per 8-hour shift (with a 30-minute lunch break). Takt time showed that one kilogram of the product had to move to the next stage of production every 7 seconds.

Thus, the workshop produced one or two types of cookies daily, creating a large stock in the warehouse. Equalization would enable small batch production, so that the factory would be able to respond flexibly to changes in demand.

Figure 1. Babylon's sugar cookie production workshop

Table 2. Production line problems in the sugar cookie shop

Operation	Problem
Forming	Small amounts of dough fall onto the floor
Cooling	Some finished cookies fall off the conveyor belt onto the floor
Kneading	Materials like flour and powdered sugar fly about, staining the floor and the walls

Figure 2. Forming problem area

Figure 3. Conveyor belt problem area at the cooling stage

Figure 4. Kneading problem area

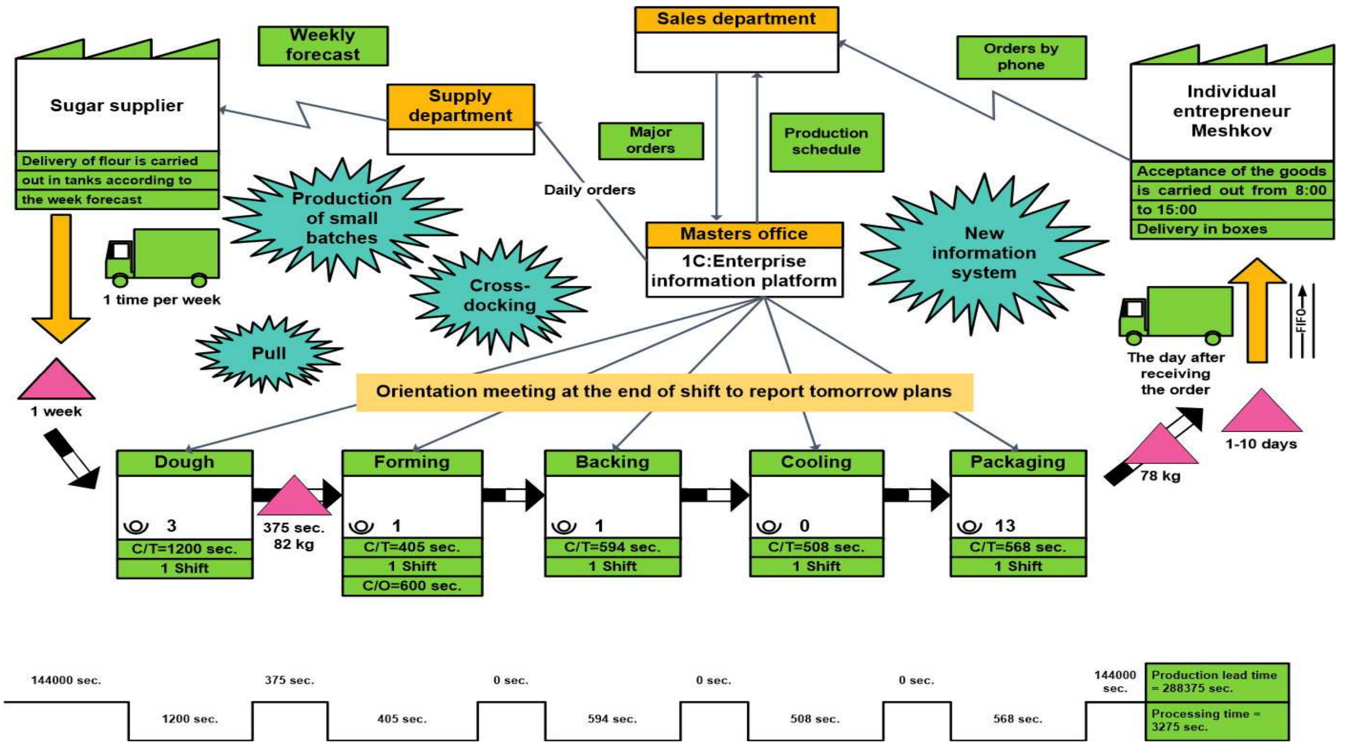

Figure 5. Value stream map of Babylon's sugar cookie workshop

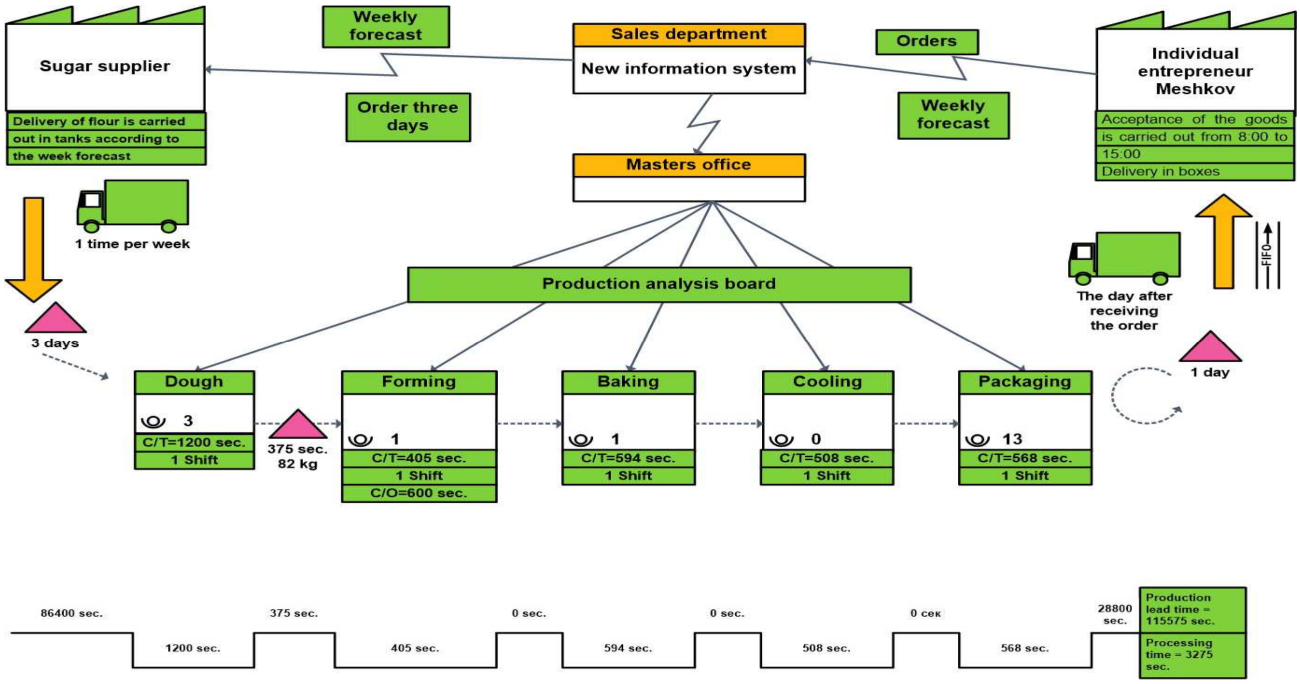

Figure 6. Proposed value stream map of Babylon's sugar cookie workshop

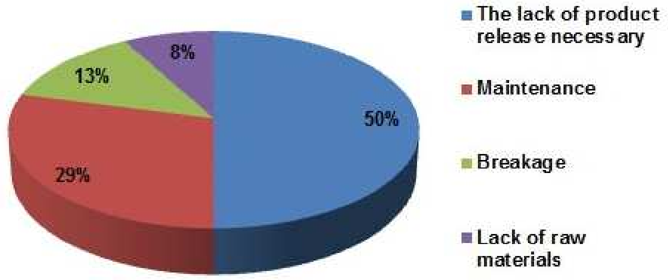

Figure 7. Downtime causes of rotary forming equipment

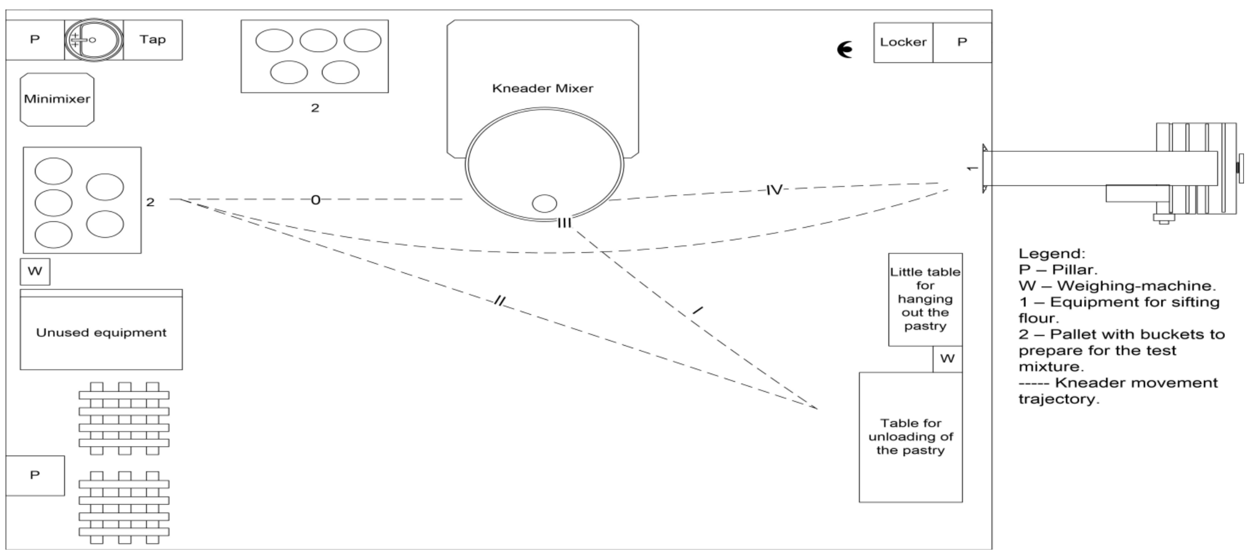

Figure 8. Map of equipment, materials and supplies in the kneading area before the changes

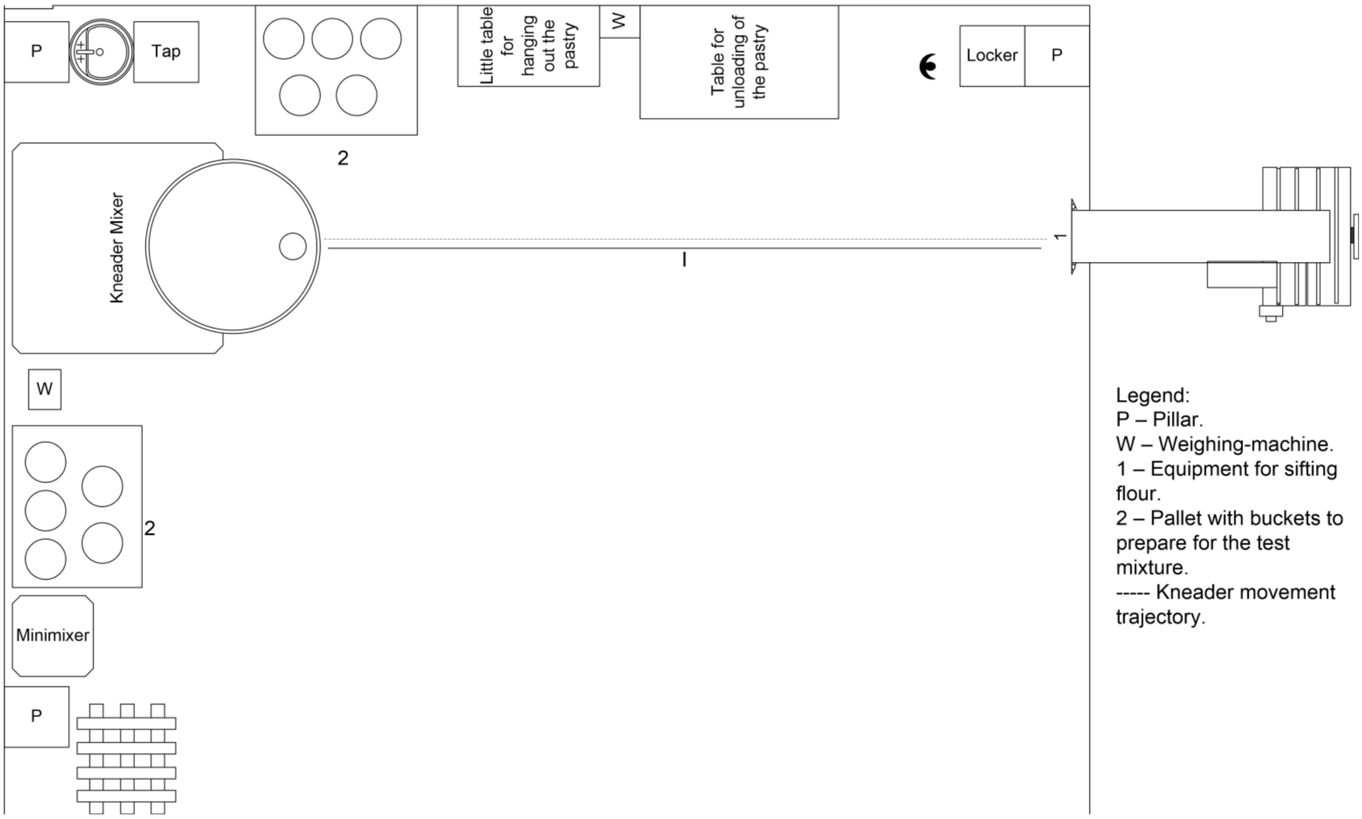

Figure 9. Map of equipment, materials and supplies in the kneading area after the changes

Table 3. Subsystem of core KPIs for the food industry

Operator-related KPIs	% of equipment repair by the operator	(ratio of the number of equipment repairs done by employees to the total number of repairs of this equipment for a period of time)*100%
Equipment-related KPIs	% of downtime caused by breakdowns	(ratio of equipment downtime caused by breakdowns to total downtime)*100%
	equipment performance	(total amount produced over some time, such as per minute, hour, or shift)*100%
	equipment readjustment time	time between the production of the last item of one type and the first non-defective product of another type
	% of downtime caused to lack of raw materials	(ratio of equipment downtime caused by lack of raw materials to total downtime)*100%
Product quality-related KPIs	% of non-defective products	(ratio of the number of non-defective products to the total output)*100%
	% of products with defects of a certain type	(ratio of the number of products with a certain type of defect to the total number of defective products)*100%

4. RESULTS

During the evaluation of the KPI subsystem the following results were obtained for the enterprise:

1. Problem areas in the puff and sugar workshops were identified.
2. Measures to address the identified problems were proposed.
3. Losses in the workshops were reduced.
4. A subsystem of KPIs for a confectionery manufacturing enterprise was developed.

Results obtained for the sugar cookie shop:

1. Overproduction was decreased by 67%.
2. Excess reserves were decreased by 99%.
3. The efficiency coefficient of the production cycle is 2.5 times higher than prior to the changes.

Results for the puff cookie shop:

1. Idle time was decreased by more than 30 minutes.
2. Unnecessary transportation was decreased by 6 minutes, from 31 minutes to 25 minutes.
3. Redundant processing steps were eliminated.
4. Productivity was increased by 29%, from 14 to 18 batches.
5. Unnecessary movement was reduced by 9 minutes.

The KPI subsystem for puff and sugar cookie production shops has been developed with due regard to the core KPIs recommended for the food industry [2], as illustrated by Table 3. Strategic indicators were not calculated for confidentiality reasons. Below are the main values of the KPI subsystem for Babylon's puff and sugar cookie production shops.

Daily cell efficiency:

$$E_C = \left[\frac{Q_t - Q_c}{Qt}\right] \cdot 100\%, \quad (1)$$

where:

Q_t is the total number of items produced in the cell;

Q_d is the total number of defective items produced in the cell.

Calculation of daily cell efficiency:

$$E_C = \left[\frac{3900-195}{3900}\right] \cdot 100\% = 95\%, \quad (2)$$

Overall equipment effectiveness:

$$OEE = [A \cdot P \cdot Q] \cdot 100\%, \quad (3)$$

where:

A is availability;

P is performance;

Q is quality.

Calculation of overall equipment effectiveness:

$$OEE = \left[\frac{450}{480} \cdot \frac{3900}{3900} \cdot \frac{3705}{3900}\right] \cdot 100\% = 89\%, \quad (4)$$

Production line performance:

$$P_L = \frac{Q_p \cdot T}{P \cdot X \cdot O} = \frac{3900 \cdot 7}{8 \cdot 3600 \cdot 18} = 0.0527, \quad (5)$$

where:

Q_p is the quantity of the product;

T is the standard production time for the product (minutes);

P is the duration of the work shift (8 hours);

X is the number for converting work shift hours into minutes (60);

O is the number of operators.

The planned ratio of work in progress to the amount of work standardized is equal to 1, which implies the absence of WIP by the end of the shift.

Below are downtime causes for the rotary forming machine:

1. Breakdown (3 times);
2. Maintenance (7);
3. Lack of raw materials (2);
4. No need for production (12).

Thus, there were 24 times that the machine was idle during the year.

Key indicators for the rotary forming machine:

1) Repairs performed by the operator:

$$d_r = \frac{0}{24} \cdot 100\% = 0, \quad (6)$$

2) Downtime caused by equipment failure:

$$d_b = \frac{3}{24} \cdot 100\% = 12.5\%, \quad (7)$$

3) Performance of the rotary forming machine:

$$P_r = \frac{3900kg}{8h} \cdot 100\% = 487.5\left(\frac{kg}{h}\right), \quad (8)$$

4) Readjustment time: 9 minutes, is due to forming shaft replacement.

5) Downtime caused by lack of raw materials:

$$d_r = \frac{2}{24} \cdot 100\% = 8.3\%, \quad (9)$$

Based on the values calculated, it can be concluded that, in general, the equipment functions well, with 29.2% of downtime due to maintenance, 12.5% due to breakage, and only 8.3% caused by lack of raw materials. Half of the downtime of the first line was connected with the functioning of the second line, where the output is carried out only once a month because there is no need to produce cookies of a certain type more frequently. There were no cases of equipment repairs performed by the operators, as the factory employs mechanics, whose duties include repairing and adjusting the equipment.

In general, the equipment runs smoothly and efficiently. However, its operation is push-based, which sometimes results in overstocking.

Almost all problems in the puff cookie shop could be solved by implementing the 5S system. These problems are:

- There are too many buckets, as well as too much raw material on the pallets.
- Time is wasted on searching for the cleaning tools because there is no permanent place for storing these.
- There are no ways of visual management.

- The operations are not standardized.

The shops need information boards for the supervisor to write tasks on and for the workers to inform the supervisor about plan fulfilment for each operation. This would allow the employees to be always fully informed and to see the results of their work.

5. FINDINGS AND DISCUSSION

Analysis of Babylon's production process enabled the development of new measures aimed at improving the competitiveness of the enterprise. We proposed using the 4R methodology and a set of tools that are the most suitable for Babylon:

1. 5S reduces time waste, helps to identify problems that can lead to downtime and problems with quality.
2. Autonomation, jidoka and poka-yoke prevent internal failures and product returns, which are due to losses of personnel's time, materials and energy.
3. Production design for the manufacturing of confectionery has a number of advantages:
   - Reduction of material and energy requirements, through the implementation of process change projects.
   - Simplifying processes, which leads to less time waste.
   - Improvement in the manufacture and processing that increases value for the consumer.
4. Production leveling and implementing a pull system lead to reducing stock and decreasing time waste.
5. Preventive maintenance of equipment results in fewer breakdowns and, consequently, reduced losses of materials and personnel's time.
6. SMED reduces cycle time and thus product-related time loss, as well as staff's time loss related to labor-intensive types of work.

The 4R methodology is based on the use of lean tools and includes the following types of rational activity:

1. Refuse to waste resources;
2. Reduce waste;
3. Reuse resources;
4. Recycle.

We proposed the following recommendations for the factory: to introduce a just-in-time production system based on the pull principle. Another recommendation was to develop a new information system or upgrade the old one to ensure that all incoming orders from customers are gathered in a single database, which orients the production towards existing orders rather than recommended remains in the warehouse. Following this recommendation, such a system was introduced.

Specifically, the existing 1C system was modernized to accommodate just-in-time production rather than trying to predict average sales. This system provides information on production priority for each workshop. Thus, when there are large orders, the shop is able to choose the optimum and most convenient production queue. The new information system performs the following tasks:

1. Provide full and clear information about orders, assisting workshop supervisors in decision-making.
2. Show if there is a surplus of finished products in stock.
3. Notify of expired products in the warehouse.
4. Reduce the workload of the chief sales officer who no longer need to address production-related issues, providing him with more time to perform his duties.

The novelty of this study is in the further development of the lean methodology and the solution of key problems in puff and sugar cookie workshops of a confectionary company. The practical significance of this work lies in the adaptation of the research results to the company's operations. That is, the proposed measures were used to increase efficiency in manufacturing workshops, and the developed subsystem of KPIs was applied for measuring the results of implementing lean.

6. CONCLUSION

The present study significantly contributes to the application of lean in confectionery industry companies. We have demonstrated the application of lean tools in a Russian company, using the experience of foreign confectionery enterprises.

Workplace enhancement activities developed have increased employee motivation, improved working atmosphere, contributed to transforming the culture of the enterprise. We also identified a number of problems in the puff and sugar cookie shops, which were taken into account by the management.

The developed subsystem of KPIs is suitable for lean companies in the confectionery industry. The proposed KPIs will be useful for lean managers, coordinating production activities in confectionery factories.

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Razvoj KPI podsistema za ruske konditorske kompanije: Studija slučaja

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Apstrakt

Ovaj članak predstavlja studiju slučaja razvoja KPI podsistema na osnovu primene metoda i alata za lean proizvodnju u ruskoj konditorskoj fabrici. U radu je sadržan izveštaj o analizi proizvodnih problema u preduzeću, kao i predložena rešenja i rezultati njihove primene. The Lean KPI podsistem doveo je do značajnog poboljšanja u kompaniji. Rezultati ove studije slučaja su relevantni za poslovne prakse generalno, jer se predložene mere za poboljšanje investicione atraktivnosti kompanije mogu naširoko primenjivati. Osim toga, nalazi su korisni za Lean menadžere u konditorskoj industriji, iz razloga što studija pokazuje ključne faktore uspeha, kao i uticaj i ulogu Lean proizvodnje u ovoj industriji.

Ključne reči: *Lean proizvodnja, podsistem, ključni pokazatelji uspešnosti, konditorska industrija.*