Practice of production system improvement in energy complex

O Yu Myasnikova¹, L F Popova² and M N Yashina²

¹ Saratov branch PJSC “T Plus”, 124 Chernyshevsky str., Saratov, 410028, Russian Federation
² Saratov Socio-Economic Institute (branch) Plekhanov Russian University of Economics, 89 Radishchev str., Saratov, 410003, Russian Federation

E-mail: lolafaritpopova@gmail.com

Abstract. The energy complex makes a significant contribution to the socio-economic development of the country. Russian energy industry at present faces a number of problems including high depreciation of infrastructure and production assets, as well as the gap in the technological backwardness of the industry with developed countries. Private energy enterprises also face such problems as energy surplus of regions, high competition from large companies, high prices for fuel, huge losses of heat energy during transportation, and non-payment of consumers. As a result all these factors reduce the level of the competitiveness of modern energy enterprises. The study aims to share the experience of lean manufacturing implementation with those who plan to do the same. The authors explain the difficulties and effects it is possible to expect from the implementation of tools of the lean production approach. In this paper we will deal with the experience of implementation of tools of lean production approach and its results in the case of Russia’s largest private power company PJSC “T Plus”, Saratov branch. It should be noted that the paper contains a number of implemented measures and tools for the development of the production system of PJSC “T Plus”, Saratov branch.

1. Introduction
Enhancing the competitiveness of Russian energy complex is possible on the basis of increasing the efficiency of enterprises functioning through the introduction of lean production approach. This approach helps to increase the operational efficiency of the business without significant investments. Today the leaders of Russian enterprises are beginning to realize that an established production system is a real tool for creating a long-term competitive advantage [1]. This is evidenced by best practices of big Russian enterprises in lean production implementation. But unfortunately the very large number of domestic enterprises have not taken any steps to improve the efficiency of their operation. Many companies implement superficial implementation of lean production approach, focusing only on 5S tools and the “just in time” system not perceiving lean production as a single system, without providing properly support from the top management of the company [2].

A few years ago the executives of the company PJSC ”T Plus”, Saratov branch have interested in a lean production approach initiated in Japan at Toyota enterprises which was spread significantly abroad and found successful implementation at domestic enterprises.

The one of key objectives of building an effective production system is minimization of losses. It is necessary to interpret the losses correctly (“muda” – in Japanese) and apply the tools for their elimination and minimization. It is important to be able to identify all types of losses, not only those that occur in production [3]. Accordingly, managers and employees of all ranks should be involved in the search for
losses and determining the direction of their reduction. Under the research according to Tayichi Ono classification the major losses within the work of PJSC "T Plus" Saratov Branch were identified [4]:

1. Overproduction. There is an excess condensation capacity, which is poorly sold in the market and leads to the reduction in the thermal efficiency of stations and the branch as a whole. Excessive generation of heat energy, caused by huge (up to 40-50%) losses in heating networks (due to their sharpening life) during transmission and distribution to the customer results in unnecessary costs for fuel.

2. Waiting. The operations managers and team members are simply have to sit without work while the authorized order is being issued for carrying out work.

3. Transportation. There are lacks of standards and regulations for the implementation of one or another operation, which leads to additional staff walking and reduces productivity.

4. Over-processing. There are non-essential operations for treating parts. There is ineffective processing of parts due to poor quality of the instrument or unreasoned constructive solutions, which results in unnecessary movements and defects. There are losses caused by overstated quality requirements. There is lack of quality standards and completeness of the reports made available, lack of clear guidance for creating reports and performing operation, lack of standards.

5. Unnecessary Inventory. There are unbalanced warehouse logistics of the stations; lack in rapid adjustments to supply overalls and inventory items when there is a need. It leads to additional transport and storage costs.

6. Unnecessary / Excess Motion. All unnecessary movements that employees have to do in the process of work: searching for what is needed, the need to reach for tools, details, etc. or to lay them down. There are unsuitable equipped workplaces.

7. Defects. Production of defective parts and correction of defects. Repair, alteration, wastes, replacement of products and its verification leads to the losses of time and efforts.

8. Lean Thinking, Underutilization of Employees There is the lack of a standard for the submission and implementation of rationalization proposals. There is the lack of standards and regulations for the working day schedule for top management of the branch and Thermal Power Plants (TPPs).

2. The experience studing of production system implementation
In 2015 with the direct participation of one of the largest consulting firms PJSC "T Plus" started the project of production systems building. Saratov branch was chosen to be as a pilot project for the implementation of such a project because of the worst operating profit. Under the guidance of consultants company began the diagnostics and work on the implementation of lean production tools. The project was launched at two Thermal Power Plants (Engels TPP-3 and Saratov HPP-5) and in Territorial heat supply authority of Saratov city. The analysis of the existing state was carried out, the potential was identified and actions were planned to achieve the identified effects.

Within the framework of the project under the guidance of consultants, the following activities were implemented:

- the list of standards was developed, some of which were implemented at pilot stations;
- the repair and investment measures were proposed
- the options for non-core activities were proposed
- the need to include additional functionality for TPP employees through the adjustment of job descriptions was identified
- proposals to improve the effectiveness of meetings were made
- the system of behavioral audits was proposed
- A number of systemic problems in the performing of repairs were identifies and proposals for improving the situation were made
- Were made proposals to replace the isolation of priority areas, to automate boiler houses and to reduce commercial losses
The service for the dispatching of repair works has been introduced, the principles for the distribution of repair work and the leave schedule for the central repair service department have been changed, the elements for optimizing capital expenditures were also introduced.

The motivation system of operational personnel was proposed and implemented at pilot stations with key technical and economic indicators and key performance indicators (KPIs).

The implementation of 5S system at the workplaces had began.

Regular trainings for personnel in the field of lean production approach were organized.

The total effect during the first year of implementation only a few tools of lean production approach amounted to 33, 56 million rubbles for two TPPs and 25 million rubbles for Territorial heat supply authority of Saratov.

Having ascertained that the project implementation brings a significant effect, the company's management decided to further develop the production system of PJSC "T Plus" Saratov branch and translate this experience to other facilities of the branch.

However the implementation of lean production approach was met with resistance from the staff, who were to become executors of the proposals developed by the consultants. As a result of the situation analysis, we identified the following reasons for the strong resistance of the personnel:

- the period of “lean production” tools implementation coincide with the period of staff optimization at Stations and at branch as a whole;
- the proposed tools were poorly described, required significant modifications from the representatives of stations, operating and maintenance personnel; required certain time, effort and desire;
- the effects calculated by the consultants were based on incorrect benchmarking (without regard to comparability in terms of work conditions and equipment, including the types of equipment and their operating time, which contradicts the condition of ensuring comparability of options);
- the effects from the proposals were exaggerated, there was no transparent methodology for calculating the effects, the calculations were not consistent with the specialists of enterprises;
- there was a complete lack of motivation system for personnel, which was involved in the development of proposals and implementation of actions. The work was carried out forcibly without tangible or intangible benefits to the staff;
- the implementation of innovations was carried out without participation and involvement of employees at the highest levels of management that subsequently affected on the lack of management support for the proposals being implemented and the termination of projects.

As a result, by the end of 2015 the managing organization refused to cooperate with a consulting firm. The cost of external consultants exceeded the economic effect of the implemented project by 2.4 times. At the same time the set of fully or partially unimplemented "lean production" tools was formed.

Many of developed initiatives were not brought to the state of readiness for implementation, and a number of used tools were not formalized. All this has led to some chaos at the development of the production system of PJSC "T Plus" Saratov branch. However the efficiency of many “lean production” tools was demonstrated, and the branch management was interested in implementing the project to develop the production system. In January 2016, one of the authors of this paper, Myasnikova Olga was appointed to undertake the project by the branch itself in the direction of “Maintenance”. The task was to unify and finalize instruments that are suitable to use at pilot Stations and transpose them to the remaining TPPs of Saratov Branch.

The new round of production system development was highly supported by the direction of the Saratov branch. It should be noted how important role of the leader in the implementation of new projects, it is "the trigger mechanism of the system, so that all technical elements, concepts, principles begin to live" [5].

3. The results of product system implementation
Table 1 presents the results of the project implementation by the branch in comparison with the work of the consultants.
Table 1. Comparison of the results for Project on development of production system carried out by external consultants and by the forces of the branch itself.

| Status at 01.04.16 (after the work of external consultants) | Status at 01.04.2017 (after the work of the branch) |
|-------------------------------------------------------------|-----------------------------------------------------|
| TPPs production system is disaggregated                      | The tools "Daily Management" (DM) and "Problem Solving" (PS) were created and assigned to the stations and the branch office. |
| There are no common approaches to the production system understanding | General approaches to understanding the production system are the same and understandable at all TPPs; top management is involved in the process |
| The tools of the production system are not unified           | All the tools of the production system are unified for all TPPs |
| The methods to calculate the effects have not been worked out | The methods of calculating the effects have been developed and approved |
| There are no unified forms of standards and regulations      | Forms of standards and regulations are unified for all TPPs of the branch |
| There are no orders to put standards into operation, coverage of equipment is minimal and random | All standards were put into effect by the orders, the single database was created on a separate network system of the branch with a description of all implemented production system tools, coverage of equipment of stations – maximum |
| None are responsible for compliance with standard operating procedures (SOPs), regulations | There are responsible actors for compliance with SOP, regulations are appointed by orders, SOPs and regulations are implemented |
| No developers of standards and regulations                   | A working group has been set up to develop the production system |
| There are no common approaches to analysis of technical-and-economic performance indicators | Approaches to the analysis of technical-and-economic performance indicators are unified for all TPPs, a mock-up of the calculation with output for weekly EBITDA was created. |
| The key performance indicators (KPIs) of operational personnel were not correctly specified (some indicators were overestimated) | The KPIs of operational personnel were corrected and established by order (application of the multiplier is appropriate and transparent) |
| Experts in the field of production systems are only at three sites. They do not have enough knowledge about enterprise activity | There are motivated employees who are ready to work on the development of the production system |
| There are no ideas and plans for the development of the branch | Development plan for each TPP has been established for years ahead |

**Economic effect: 57 million rubles**

**Economic effect: 101 million rubles**

The majority of effects are derived from the introduction of such a lean tool as standardization. Standard is an accurate description of each action, including the cycle time, the takt time, the sequence of certain tasks and minimum number of stocks to perform the work [6]. As such we should recall the attitude to the standards of the Aleksei Gastev, Soviet scientist, who recognized the standard as a "temporary form of adapting the given production to a certain product or to certain equipment [7]" and paid considerable attention to developing the organization's ability to constantly improve of "installations" (word, which Gastev preferred to use instead of "standarts"). The standard is understood as the best current state of the operating system. Standards should always be improved.

4. Discussion
The process of standardization covered the work of the main equipment and mechanisms of own needs at the pilot stations of TPP under this project. The standard of work for core equipment (boilers, turbines) defines the set of actions: "what and in which case is required to do". The operational standards are designed to help the operator of the boiler (turbine) or the power unit to rapidly respond to the situation that has arisen, to deal with these emerging challenge quickly, with the smallest deviations in the
operating mode of the equipment; to identify and record defects in time, and to be more efficiently prepared for certification when appointing for a new position.

### Selection of Steam Jet Pumps

- Determine the flow rate of feed water necessary to ensure a given load and select the appropriate optimum operating mode of SJP.
- If the optimal mode is not possible (for example, SJP in repair), select the next highest priority mode.
- When the pressure of the supply water before the FCV drops to 178.5 kg/cm², it is necessary to go to the next level of pattern despite the consumption of feed water.

| Feed water consumption (tons per hour) | Optimal | Top priority |
|----------------------------------------|---------|--------------|
| 0 – 250                                | 6       | 8            |
| 251 – 330                              | 6       | 9            |
| 331 – 380                              | 8       | 7            |
| 381 – 570                              | 10      | 8            |
| 571 – 680                              | 8       | 7            |
| 681 – 910                              | 10      | 8            |

This algorithm should be considered in accordance with the current instructions, STDs and management orders.

**Figure 1.** Standard for selection of Steam jet pumps for the staff at Engels CHPP-3.

The standardization of the auxiliary equipment operation work is aimed at reducing the cost of electricity for own needs of the stations, which are now purchased by TPPs on the wholesale electricity power market. Within the framework of this direction were studied the mechanisms of own needs which are working in a group at the pilot stations: at Engels TPP-3 there are pumps of onshore water pump station, which are pumping Volga water; circulating pumps operating at the turbine of Power plant №3 and Power plant №5; line pumps and steam jet pumps, which can work with any composition of the main equipment. At Saratov CHPP №5 were studied pumps from the onshore pumping station and
circulating pumps, which can work with any composition of the main equipment. To develop the standards the personnel of the Boiler-turbine Department and Operation and Service Department of turbine and boiler equipment have provided tests in order to identify the least energy-intensive and sufficient mechanisms and to integrate them into work on a priority basis. According to the circulation pumps of CHPP-3, the standard defines the number of working pumps depending on the load of the turbine (one or two). Priorities are set for the inclusion of feed water pumps, depending on the environmental costs. The test results are presented as a standards. The example of such a standard is shown in Figure 1.

When building a standard we should take into consideration that lean production is a process of continuous improvement, therefore the standards are subject to constant analysis by personnel using them and to periodic revision after changing the conditions of the equipment (for example, after repair).

Visualization of processes is equally important to identify the savings potential. The mechanism of "Daily management" which are based on vision boards of monitored parameters is continuously improving. The following categories of information for each shift are subject to fixation on boards: the state of the equipment (in operation, in repair), electricity generation, heat supply, electricity consumption for own needs, steam and condensate losses, cost items of the annual operating program, deviations in the equipment operation parameters on key technical and economic indicators (initial parameters of steam, temperature of outgoing gases and oxygen content in the regime section of boilers, vacuum in the condenser of turbines, temperature of nutrient water), comments on labor protection and production control, cleaning equipment. Constant monitoring of key technical and economic indicators allows to react quickly to deviations with their subsequent elimination, which increases the thermal efficiency of the plants.

5. Conclusion
The project of the production system development has shown a high saving of fixed and variable costs in the Saratov branch in the results of 2015 and 2016 years. Saratov branch reached top positions in the rating of regional branches of PJSC "T Plus". And it should be noted that not all planned activities have been implemented. Work continues: a long-term plan of production system development for all TPPs has been approved. The enterprise still has a lot of work to develop the production system. The production system improvement must become the ongoing process and the integral part of the organizational culture of the enterprise.

Our practice has shown that tools of lean production work in various fields of activity. Each enterprise can successfully work under its efficiency improvement. In the process of reducing losses and increasing the value of the product / service, staff also begins to receive job satisfaction [8]. The success of the production system development project largely depends on its support by the management of the enterprise and the creation of conditions for the high involvement of personnel in the process of continuous improvement. All this allows to increase the productivity, reduce the prime cost and improve the quality of products and services of enterprises.

Acknowledgements
The research has been supported by Plekhanov Russian University of Economics. The theme of project “The mechanism of the Russian industrial enterprises’ quality management system’s adaption to the international standards’ requirements of for getting to the sixth technological paradigm”

References
[1] Popova L, Bocharova S, Cherkashnev R, Yashina M 2018 Development of methodology of indentification of the quality management system processes Quality-Access to Success 19(164) 43–7
[2] Liker J K 2004 The Toyota way: 14 management principles from the world’s greatest manufacturer (Moscow: Alpina Bussness Books) p 473
[3] Glazunov A V, Serov M E 2013 Wastes’ management Methods of quality management 6 4–9
[4] Taiichi Ohno 2008 *The Toyota production system. Departing from mass production* (Moscow: Institute for Complex Strategic Studies) p 194
[5] Adler Yu P, Lipkina V V 2000 The leadership as mechanism constant maintenance of competitiveness *Standards and quality* **10** 14–22
[6] Rother M, Shook J 2008 *Learning to See: Value-Stream Mapping to Create Value* (Moscow: Alpina Bussness Books) p 144
[7] Gastev A K 1972 *How to Work: Practical Introduction into the Science of Labour Organization* 2nd ed (Moscow: Economy) p 478
[8] Womack JP, Jones DT 2006 *Lean thinking* (Moscow: Alpina Bussness Books) p 473