Implementation of tool-technical base of agile manufacturing in Russian industry

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Abstract. The Fourth Industrial Revolution led to a shift in the strategic orientation of industrial enterprises, which explains the generation of new production concepts. In modern realities, the scale of production has lost its relevance. Minimizing costs and the highest quality of products still play an important role, but such a guideline as speed has come to the fore. The main tool-technical base of agile manufacturing approach is considered in terms of changing of enterprises production systems. The aim of this paper is to prove in practice that the agile manufacturing is promising for Russian industry. The approbation of the concept of agile manufacturing in metallurgy was carried out. In 2017, PJSC Severstal launched a major innovation program aimed at ensuring business growth without a significant increase in production, and focusing on three key areas: innovative products, innovative processes, innovative business model. Summarizing, agile manufacturing approach is offered as effective for Russian industry development.

1. Introduction
With the onset of the Fourth Industrial Revolution, the changes that occur with the highest speed and enormous scope, as well as characterized by the systemic nature of the consequences, become a feature of the external environment. It is possible to highlight the following [1]:

- changing consumer expectations;
- product quality is enhanced by data that improves asset performance;
- operational models are transformed into new digital models;
- new partnerships are formed as companies become aware of the importance of new forms of cooperation.

The rapid trend towards a wide variety of finished products with a short development and production time led to the emergence of a number of problems for companies with stocks, overhead costs and operational efficiency. In this case, attempts to use methods of mass production can not be crowned with success. The idea of “producing large quantities of products is more profitable than small ones”, based on achieving the “economies of scale” and low unit cost, has lost its relevance. Mass production paradigm is not applicable when consumers expect to receive high-custom products released by a small batch with customer order decoupling point corresponding to the “engineer to order” position and with the provision of additional services and cost advantages like subsequent updates and reconfiguration of products that are considered so as important as the product itself. In turn, the imperative of lean production introducing also becomes irrelevant due to new environmental challenges and gives way to more competitive paradigms - quick response manufacturing and agile manufacturing. Agile manufacturing is effective and very popular concept in industry of developed countries. The theoretical
and practical aspects of this concept are studied by many scholars. Among them the following scientists are highlighted: P.T. Kidd (1994), S.L. Goldman, R.N. Nagel and K. Preiss (1995), J. Sharp, Z. Irani, and S. Desai (1999), C. Larman (2004), J. Sutherland (2014), A. Gunasekaran (1998, 2014, 2017). In Russian industry, the concept is just beginning to develop.

PJSC Severstal is the flagship of the Russian industry. It includes production, safety, regulations, rules and controls. And at the same time, the company needs new products and ideas. Severstal is actively developing and shows significant success. And therefore, implementation of tool-technical base of one of the modern production concept as agile manufacturing is interesting and indicative for the Russian industry as a whole. Thus, the goal of the study is to prove in practice that the agile manufacturing is promising for Russian industry.

2. Materials and Methods

Agile manufacturing [2-7] acquires particular relevance in the context of the formation of the Fourth Industrial Revolution. It is a strategy whose purpose is to achieve a sustainable company’s development by adapting to all kinds of unpredictable changes. The main tool - technical base for the implementation of the agile manufacturing model includes [8-11]:

- concurrent engineering is a systematic approach to integrated parallel product design and related processes, including manufacturing and assembly. As a rule, parallel development includes the formation of cross-functional teams, which allows engineers and managers of various disciplines to work simultaneously on the design of the product and process. This approach is designed to force from the very beginning to take into account all elements of the product life cycle from concept to disposal. The use of technology in product development indicates that new products are designed to include all interested parties. First of all, we are talking about the consumer, who determines the ultimate success of the product. Only concurrency can allow a company to perform its task - fast delivery of products in small quantities, up to the size of a single order, while creating the minimum number of barriers to sharing knowledge;

- rapid prototyping is a method that allows a multidisciplinary team, within the framework of parallel development, to create a real physical design model for a few days or even hours, not months, as in traditional prototyping methods. Prototyping describes the design and creation of an earlier version of a product. The version does not necessarily have all the functions of the final product, but has enough key functions to test certain aspects (for example, visual, physical, functional) of the product design in accordance with the requirements;

- customer focused product design. Consumers expect more individual attention than ever before. This applies not only to fast service, but also to the products they order. The company should adhere to market demand and also develop the production process so that the desired product changes are taken into account in the production planning process;

- teamwork is carried out by groups of employees who are allowed to function as a unit with very little supervision, and sometimes without it;

- diversified and experienced staff is the result of training programs that are carried out in order to master the knowledge, skills and competencies in order to perform their work in a highly qualified manner and to be able to solve other tasks quickly. The training includes the study of basic information about new manufacturing practices in addition to the new, flexible, customer-oriented format. Waiting for employees to understand the rapid changes and adaptations in which they will participate requires intensive training and the recognition that major changes are occurring;

- full participation of the company. The transition to a new production concept will not work if it is moved back to the team level. The structure of the company should be part of the transformation. Switching usually works better when it comes to entering a new plant or expanding an older one. Thus, the focus can be on bringing the whole new area to new standards;

- electronic commerce means the use of technological advances to promote everything that is commerce. At present, information and communication technologies simplify and improve communication between global trading partners and enable the use of new business methods, such
as global purchasing and supply sources. Since close interaction between customers and suppliers is important, e-commerce inevitably takes into account geographically dispersed customers and their requirements. The main motive of e-commerce is to improve the response time to customer requests as quickly as possible by directly collecting customer requirements through an online communication system, for example, the Internet. It will help reduce time to market and be flexible enough to interact with customers for mutual agreements, as well as add a human factor to the order, working closely with customers;

- the use of information technology (IT) allows you to reduce the time in product development. Projects are developed and managed using information tools. Alternative projects are evaluated, and design issues are solved using simulation analysis. The following requirements are imposed on the IT system: openness, scalability, extensibility and compatibility. Rapid response to market demand is difficult without an integrated technology environment.

3. Results and Discussion

In 2010, a set of principles and tools was formulated under the name of Severstal Business system, aimed at implementing the necessary behavior models among the company's employees and, as a result, the cultural transformation of Severstal and the achievement of the company's strategic goals. Among the main directions of development were identified: safety, customer focus, continuous improvement, people, business standard. The business system has become an expected continuance of earlier projects for the development of the company. Severstal has always given an attention to production efficiency and implemented few projects in this direction: "Total production optimization" (1998), "Production consulting" (2000) and "Continuous improvement" (2009). In 2016 it was marked by the «year of the client» in the company. All departments and teams are involved in the work to improve customer focus. In order to meet each customer's requirement, whether it is product properties or packaging; there is a collection and analysis of customer feedback to understand which processes require improvement. For the convenience of customers in 2016 was launched the first in the Russian mining and metallurgical industry service-online store for the sale of steel products. As a result of the efforts made, the company has achieved the basic goals for all indicators of satisfaction. According to the results of questionnaire survey for the fourth quarter of 2016, the service was satisfied 76% of the respondents, the index of satisfaction with the quality of the product was 66% against 47% for the same period of the previous year. In 2017 at the investor’s day, the Board of Directors of the company approved the strategy for digital innovation in support of the General strategy of "Severstal" to maintain leadership in creating social and economic value for all stakeholders. The culture of innovation accelerates product development and improves internal processes. At the same time, the company remains committed to proven optimization initiatives that help the company remain competitive at cost. Also, the company launched a major innovation program aimed at ensuring business growth without a significant increase in production (the company is working steadily with almost 100% utilization of production capacity). The programme covers three key areas:

- innovation process;
- innovative product;
- innovative business model.

A pilot project in the development of a new type of product was the development of a new, more durable plastic packaging tape for the production of flat products. To release a new product is planned not only for internal customers, but also for external ones. One packing tape is used in almost every redistribution of metallurgical production. According to A. Konakov, the foreman of the site of the cutting units of the metal finishing department No. 2 of the Cherepovets Metallurgical Plant, in his workshop it is used for packing sheets of sheets, as well as for packing rolls. The tape must have high strength, withstand heavy loads, as well as high ductility so that it is not torn during transportation. Thanks to the agile approach, the experts at the beginning selected the optimal chemical composition, which should satisfy the customers' requirements for the packing tape. Next, we tested new product. After the customer and the cross-functional team have reached a final agreement, they will be engaged
in the release of a new cold-rolled tape in flat-rolled products. The team consists of employees of the directorate for sales, marketing, technical quality development, customer support services. Such a team has a single criterion of success - to bring the finished product to the client, satisfy him, and bring the company profit. In their work, the experts used a whole set of tools: scrum-meeting, retrospective, sprint planning. These tools allow you to solve problems independently, promptly and efficiently. According to E.Smirnov, manager of the Severstal business system development center, the speed is achieved through such tools as a retrospective, that is, discussions at the end of two-week sprints, which turned out that further actions did not work. Director of Business System Development "Severgrupp" A.V. Kolobov argues that the use of agile-principles in the work helps in the conditions of "very large uncertainties." He emphasizes constant contact with the client as an integral part of successful activity. Turning to the results of a pilot project for the production of a new type of product - high-strength packaging tape, the efficiency of the achieved indicators is reversed: the product creation period was 9 months, instead of 2-3 years, obtained using traditional methods, that is, acceleration of product launch to than 3 times.

A summary of the project is presented in table 1. This table contains key characteristics of the project described above. The focus is on the goal of the project, the tools used and the results achieved in the context of agile manufacturing. The indicators characterizing the result are compared with similar indicators of the result in the framework of the traditional approach to the organization of production.

### Table 1. Summary of the project «Packaging tape».

| Place of approbation | Cherepovets Metallurgical Plant (PJSC Severstal) |
|----------------------|--------------------------------------------------|
| Goal                | New product development                          |
| Concept             | Development of a new, more durable plastic packaging tape for flat products |
| Tools used          | Task burnout diagram, scrum-meeting, retrospective, task board, value flow map, work in progress diagram, customer involvement |
| Characteristics of short cycles | Only 28 cycles, the duration of each - 2 weeks |
| Success criterion   | The single success criterion is to bring the finished product to the customer, satisfy it, and bring the company's profit |
| Result              | The term of the product creation was 9 months, instead of 2-3 years, obtained using traditional methods, that is, acceleration of the product launch to the market more than 3 times |
| Project period      | 2017                                             |

Schematically, the tool - technical base of the project is reflected in the figure 1. This figure describes the logic of the organization of production in the framework of agile manufacturing with a focus on the tools used. At the beginning, the product that you want to produce is contracted. The following are descriptions of the requirements of the external environment, which are decomposed to the basic
characteristics of this product. The central part of the figure is the implementation of an incremental-iterative orientation of agile manufacturing. And further it is noted that this project is being implemented for the needs of PJSC Severstal.

The tool-technical base, which is used in the Severstal, has an incremental-iterative form [12-17]. This form is a key feature of agile manufacturing. It is clear that in two weeks it will not be possible to bring a partially finished new product to the market and then finish building it. But significantly reduce the path leading to the emergence of a new product, it is absolutely possible. And every two weeks, you can also adjust the direction of its movement.

Principles underlying the project are a single cross-cutting goal, inspiring and unifying; culture of trust - ensures the independence of teams; radical transparency; clear boundaries; constant experiments.

Agile manufacturing has not yet received significant distribution in Russia both at the theoretical and at the practical level. At the moment, any attempts to introduce it are a novation. This project is one of the first attempts to introduce a tool-technical base in Russian industry. And that’s why the scientific contribution of this paper is to consider in practice the implementation of theoretical concepts of agile manufacturing for Russian industry, as well as to conclude about the effectiveness of agile manufacturing for Russian industrial sector of the economy.

Figure 1. The tool-technical base of the project «Packaging tape» (developed by the author on the basis of the approbation of the concept of agile manufacturing in PJSC Severstal)

4. Conclusions
The study has the following conclusions:
1) production has undergone many evolutionary stages and paradigm shifts - from craft industry to mass production; then to lean production and, further, to agile manufacturing. The onset of the Fourth Industrial Revolution provoked another trend change;
2) the change of strategic orientations of industrial enterprises explicates the generation of new production concepts. In modern realities, the scale of production has lost its relevance. Minimize cost and highest quality products continue to play an important role, but this benchmark as the
speed, namely, the shortest time of production release on the market and rapidly responding to changes, has come to the fore;

3) the tool-technical base of agile manufacturing is based on the corresponding base of other production concepts and has its own characteristics. The main tool - technical base for the implementation of the agile manufacturing model is adapted to the actual requirements of the external environment;

4) successful example of PJSC Severstal of the implementation of agile manufacturing tool-technical base, which is distinguished by an incremental-iterative form of introduction, indicate the promising character of this modern production concept for Russian industry. The described example of the agile manufacturing introduction is one of the pioneers in Russian industry.

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