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AGILE MANUFACTURING VS. LEAN MANUFACTURING

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Abstract

The aim of this paper is to describe characteristics of agile manufacturing and analyse the needs and benefits of agile manufacturing under the conditions of uncertainty and market turbulence. It also describes four main changes in the production environment which were implemented thanks to agile methods, and compares the lean and agile manufacturing, while describing their intersections and differences in achieving the set goals. The conclusion summarises the advantages and identified benefits suitable for organizations after implementation of agile manufacturing, as those are the important facts that can play a significant role in the survival and re-establishment of balance in the periods of uncertainty.

Keywords

Agile manufacturing, Lean manufacturing, Market turbulences, Advantages of agile manufacturing

INTRODUCTION

Rapid changes in all areas of life and, last but not least, in production processes form an inevitable part of our lives. Change management thus becomes extremely important. In order to survive, organizations must constantly monitor their surroundings and adapt to emerging situations. Ideally, every organization should be able to use any change to its advantage. If company reacts quickly enough to the change, it has the best prospects to become successful. The starting point is the introduction or at least the adoption of some elements of agile manufacturing. The required changes will bring a positive effect to companies in the form of increased manufacturing and reduced production costs. It will guarantee quick adaptation to market changes. The agile manufacturing is one of the possibilities to face the competition of mass production from low-cost countries and possible technological changes.

The goals of this paper are to describe agile manufacturing under the conditions of uncertainty and market turbulence, then to analyse the needs and benefits of agile manufacturing, and finally to compare the lean and agile manufacturing while presenting their intersections and differences in achieving the set goals.

For companies, changes represent constant product innovation, while focusing on a high number of manufactured variants, fulfilling unpredictable customer requirements, shortening the product life cycle and responding to significant fluctuations in sales. The main principle of the adaptability of production systems is the ability to adopt rapid responses to changes for organizations and technologies at low investment costs. This trend is marked as agile manufacturing and represents the ability to survive and thrive in a competitive environment of continuous and unpredictable changes. Therefore, in periods of uncertainty, it is necessary to react quickly and effectively to the changing markets, while producing the products and services according to customer needs.

THEORETICAL BACKGROUND

In the case of a traditional manufacturing system, we observe a long cycle time with high volumes of warehouse stock, which often causes delays in the delivery of goods. Lack of communication, very weak involvement of employees and high inaccuracy of records are usual shortcomings. However, if talking about agile manufacturing, the advantages are long-term profitability, improved productivity and a shorter time to launch products into the market, when compared to the traditional production system. An agile manufacturing system is focused on integrating design and all aspects of production under one roof. In contrast to the traditional manufacturing strategy, agile manufacturing focuses on enriching customers through cooperation, which can be achieved by integrating people, information and technology in one place. This could also be achieved with a highly educated labour force.

It is important to say, that agile manufacturing is mainly focussed on the production of goods in manufacturing companies in different industrial areas. Customer demands are constantly changing and this is the reason why agile manufacturing deals with preparation, resources and procedures that can help respond to all demands within the industry. Companies have to react to demands when using an agile development plan, using resources and systems with the goal of preventing a drop in productivity, quality of products and cost increases. Responses to consumer requests must be immediate without losing consistency. This is also one of the reasons why consumers and end users will prefer the speed of reactions and of course, the appearance of your organization. It is very important that agile manufacturing strategy leads to preparedness and fast distribution systems without losing the properties of the goods. A smart agile manufacturing strategy should be able to create and implement innovations and, at the same time, decide what is/is not appropriate for the company [1].

Agile manufacturing can be defined as the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services. [2] Agile manufacturing involves putting even more emphasis on providing a rapid response to changing customer demands. In order to maintain a competitive advantage within the market, manufacturing organizations must find a way to satisfy their customer demands within a short time frame. When using an agile framework, local manufacturing becomes advantageous in satisfying customers quickly with personalized products and services [3].

Another definition describes agile manufacturing as a way to create and produce things in a manner that is more flexible and adaptable than traditional methods. This means changing or altering the production process quickly and easily to better meet customer needs and demands. Agile manufacturing systems are designed to be very responsive. They allow manufacturers to rapidly respond to changes, whether those changes are in customer demand, technology or even the marketplace itself [4].

Based on the information above, we can state that agile manufacturing is used by manufacturers with the goal of producing results based on the customer needs, rather than

focussing on results and after that trying to offer them to potential customers. The world of production should be a process that helps with positive and quick support for customer requirements.

Manufacturing keeps changing rapidly while experiencing an era of acceleration. In order to be up-to-date and closer connected with reality, manufacturers must adapt to changes, and thus focus on agile approach. The application of agile methods brings faster access to value and a gradual increase in resilience in the times of production or supply interruptions. It is generally known that agile manufacturing was designed for the purpose of software development, but, on the other hand, agile manufacturing enables manufacturers to gain competitive advantages at a very rapid pace of change.

Based on Figure 1, fundamental values of agile manufacturing emphasize rapid iteration, operational flexibility, operator augmentation and bottom-up innovation. Agile manufacturing enables the innovation based on workers' proposals and also faster responses to customer´s demands.

Fig. 1 *Fundamental values of agile manufacturing [5]*

Four major shifts in the manufacturing landscape have made Agile methods necessary [6]

- Permanent technological development – Manufacturing should be constantly developing, even in times of rapid technological development, new technologies and digitization. Moving forward, manufacturers will be positively affected by the effects of new technologies.
- Rapidly evolving environment - Customers and technologies are evolving rapidly, which means they are driving significant changes in the manufacturing process. Higher standards, cheaper production, faster delivery of goods and customization of products based on customer requirements are expected. If we add to this uncertainty in business stability, complicated supply chains and changes in technical regulations, we find that we are in an environment that requires extremely high flexibility. As an example, let's take the pandemic years, which showed who was and how they were prepared to respond to changing requirements.

- Wider access to information - Factories should be connected with the goal of boundless data production. Sharing data will make it possible to predict maintenance times and optimize inputs at the suppliers' end. Performance will be able to be evaluated in real time and all connected companies will have up-to-date data at every level of management. Problems will be detected long before they occur.
- Workforce transformation - By implementing agile, manufacturers can increase workforce sustainability. Furthermore, it will shorten the reaction time and increase predictability in the case of recruiting qualified workers.

INTERSECTIONS AND DIFFERENCES IN THE LEAN AND AGILE MANUFACTURING

We can say that many lean practices show features of agile manufacturing. The aim of lean manufacturing is to improve productivity and profitability by relentlessly eliminating waste. Many lean practices are also enablers for agile manufacturing. For example, manufacturing in small batches (or even better – manufacturing with one-piece flow), fast changeovers and a culture of continuous improvement are all foundations that pave the road to agile manufacturing [7].

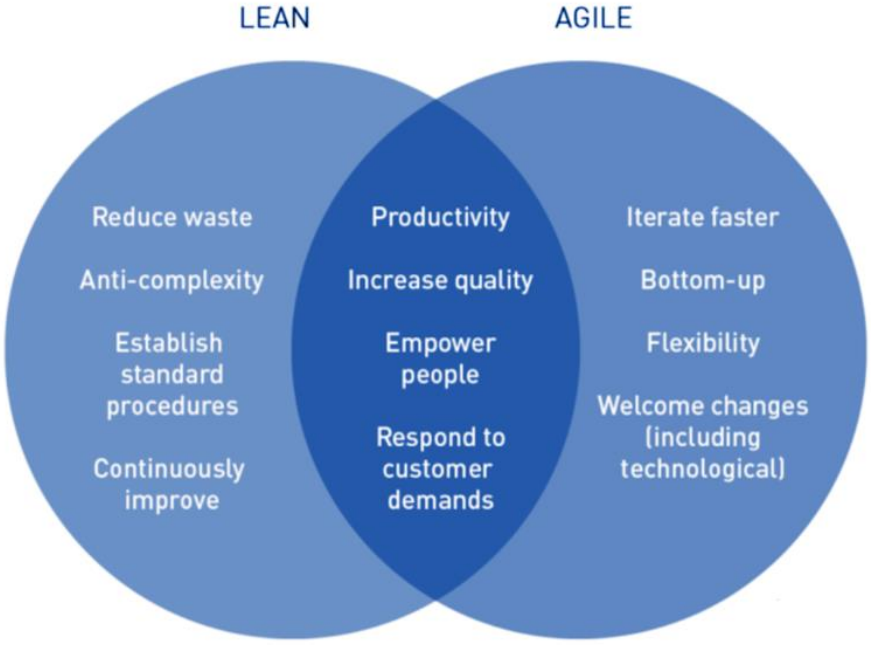

Fig. 2 *Common elements of lean and agile manufacturing [6]*

The agile and lean approaches should not be confused though both of them are very popular. As mentioned above, lean manufacturing is oriented on increasing efficiency by reducing waste. On the other hand, Figure 2 shows quick, parallel and flexible reactions to unexpected situations leading to increased efficiency via agile manufacturing. There are certain intersections of agile and lean manufacturing, but, when it comes to the basic principles, they do not have common features (table 1).

Table 1 Comparison of agile manufacturing and lean manufacturing [8]

Dimension	Lean production	Agile manufacturing
Principles	Eliminate source of waste Perfect first-time quality Flexible production lines Kaizen	Customer enrichment Cooperate to enhance competitiveness Organize to master change Leverage the impact of people and information
Production quantity	Enhancement of mass production	Break with mass production; emphasis on mass customization
Production flexibility	Flexible production for product variety	Greater flexibility for customized products
Emphasis	On technical, operational issues and management of human resources	On organizational and people issues
Application l	To the factory level	To the enterprise level
Area of management	Emphasis on supplier management	Formation of virtual enterprises
Area of change	Relies on smooth production schedule	Attempts to be responsive to change
	Attempts to eliminate source of waste	Embrace unpredictable market change
Market life	Short	Short
Order initiation	Produce to order	Produce to order
Information content	High	High
Customer relationship	Continuing relationship	Continuing relationship
	Pricing by customer value	Pricing by customer value

It is well-known that lean manufacturing requires stronger process foundations, which contributes to a wave of criticism because it can cause a reduction in flexibility for manufacturers. Another well-known fact is that lean manufacturing is best suited to the industries of long product life-cycles, focused on a small variety of products, and predictable demand cycles. On the other hand, agile manufacturing (Table 2) takes uncertainty into account when planning, creating and shipping products to the customer. This means that the main interest of agile manufacturing is connectivity and satisfying customer requirements, whereas lean manufacturing focuses its interest on the elimination of waste. In agile manufacturing, the primary goal is not to bring the product to the market in the shortest possible time, but to work with the customer during the creation process and satisfy their most urgent demands, concerns and needs. It is necessary for companies to prepare for increased satisfaction of customer requirements. An example is the automotive industry, where buyers increasingly demand shorter lead times and customization [9].

Table 2 Structural features of agile manufacturing [10]

Strategies:	**Technologies:**
• Reconfiguration • Virtual business • Strategic alliances • Reengineering • Supply chain integration • Advanced logistics • Heterogeneous computer systems	• Fast hardware • Flexible machines • Devices and preparations • Modular workplaces • Real-time management • Information technologies • CAD/CAE, CAPP, CAM

• Concurrent Engineering	• Multimedia • Graphical simulations
Systems: • MRP II, Internet • E-commerce • ERP • TOC, Kanban, JIT • System integration and database rights	**People:** • Flexible workforce, • Knowledge level of workers • Experience with IT • Knowledge of languages, • Motivation • Top management support • Training and education

A hybrid lean and agile manufacturing system is a very interesting combination for companies. As far as the global economy is concerned, lean strategies can support businesses in building competitiveness and profitability by reducing production costs. Reduced amount of waste, constant increase in productivity, reduction of stock and increase in quality - these are also the key advantages of lean manufacturing. All of this helps companies reduce costs and creates a basis for increasing competition and product availability. Delivering different product variations and taking into account fluctuating customer demand, this is also how we could characterize an agile manufacturing system that helps companies stay efficient in a constantly competitive environment. Agile manufacturing enables companies to respond to changes [11].

Another point of view is illustrated in Figure 3 showing the lean and agile manufacturing principles. The agile and lean approaches use different principles to achieve a set goal.

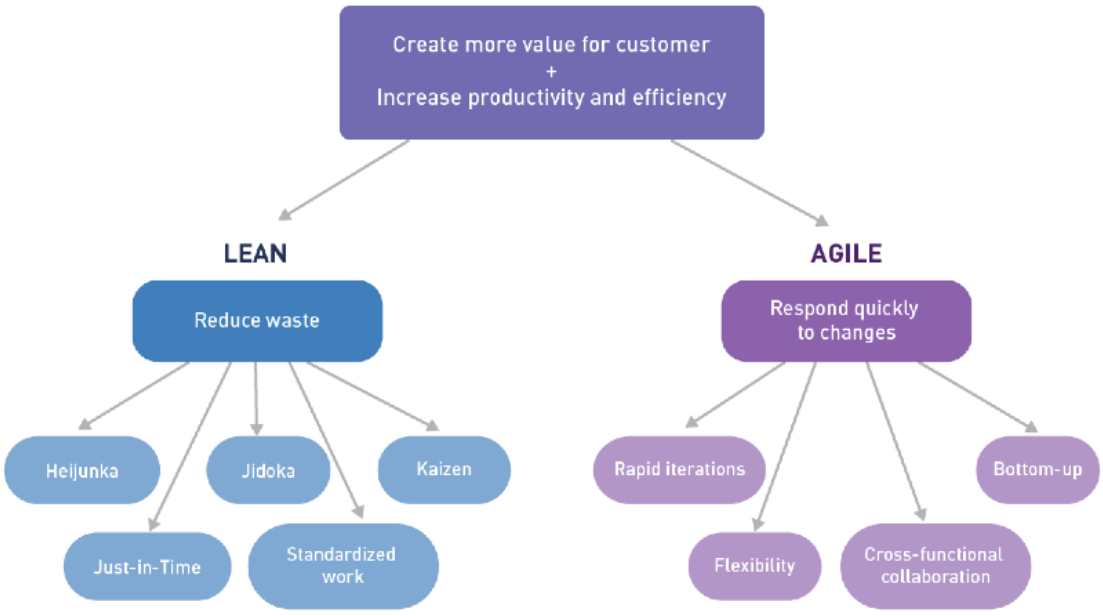

Fig. 3 *Lean and Agile Manufacturing principles [12]*

As Figure 3 shows, agile manufacturing is focused on creating maximum flexibility, supporting bottom-up innovation, cross-functional collaboration and the ability to respond very quickly to changes through timely iterations. Lean manufacturing, on the other hand, is focused on reducing waste through Just-in-time production, Jidoka, Heijunka, Standardized Work and Kaizen.

It is very important that organizations to choose the right approach to manufacturing. They can choose between the lean and agile manufacturing. Both of these approaches are proven, but it is up to organizations to choose the most suitable one.

SURVEY COMPARISONS

Adaptation of agile practices is very important for a wide range of enterprises. The fact that some organizations are more successful and keep improving can be confirmed by the following surveys.

We can see significant progress when using agile manufacturing based on the survey which made a comparative study of the lean and agile manufacturing in the current practice in the United Kingdom. Independent sample tests of significant differences in business performance measures revealed that the agile companies consistently outperformed their lean competitors. The results show the large correlation between agility and business performance [13].

Another survey, that collected and analyzed data from 154 Indian manufacturing industries show the results of positive and significant influence of agile manufacturing attributes in the manufacturing industry's business performance. Base on that survey, agile manufacturing can be considered a suitable approach when seeking improvements in flexibility, competitiveness and overall effectiveness to meet customer demands [14].

A beneficial result of the implementation of agility is represented by an evaluated survey that was carried out in Germany. The main benefit of agility was the improvement in collaboration between teams and multiple departments with a result of 57%. The second place belonged to increased employee satisfaction with a result of 49%. The third place is almost evenly shared by improved customer satisfaction, improved quality and reduced time-to-market [15].

In the 16th annual survey, that is made by State of agile, there were 3,220 respondents from around the world. Over half of the respondents were located in North America and one-quarter in Europe. It can be concluded that Agile represents one of the top visions and priorities for many businesses. High-performing agile teams have a clear culture, empower leadership and create people-centric values, according to 89% of survey respondents. This means that if Agile is successfully executed, the benefits flow not only to the individuals involved but to the entire organization. Based on this result, it is very important that organizations continue to invest resources and time in agile [16].

ADVANTAGES OF AGILE MANUFACTURING

Before you start with the transformation of manufacturing to agile, it is necessary to identify the advantages and disadvantages, and then perform an in-depth analysis in your plant. For now, we can see the benefits below which follow from using agile manufacturing.

Processes can be identified and implemented in a comfortable time space with an agile manufacturing system. By adopting the agile approach, you can [17]:

- Reduce costs before the problem starts.
- Achieve higher performance and productivity
- Be one step ahead of the competition. Monitor changing customer demand and react faster to changes.
- Conduct regular training at appropriate and non-productive times.
- Focus on improving customer satisfaction by delivering quality goods on time.
- Keep a constant overview of the entire supply chain.
- Have a "plan b" in case of changes in the supply chain.

It is always important to be prepared for unexpected events. With the help of the above-mentioned situations, we can be one step ahead of the competition when implementing the required solutions. If you've embraced agile manufacturing, you are well placed to adapt the way you work (rather than having to generate a solution from scratch).

When we increase efficiency in a proper way, agile manufacturing should be very helpful with optimizing efficiency and waste reduction during the whole manufacturing process. This can lead to lower costs and achieve higher profits.

Based on the results of the mentioned surveys and theoretical knowledge, the following useful and beneficial outputs can be stated:

- The goal for entire company is to be able to track and read warning signs, ultimately meaning that they are evident before unsolvable problems arise. With changing production, we can produce flexibly and, at the same time, maintain mass production.
- When talking about a lack of customer patience worldwide, we should state that if they cannot get what they want right away, they are not satisfied. Their expectations are orders on time, no delivery problems and the delivery of goods that have been ordered. They do not care about the problems that may have occurred behind the scenes. Agile manufacturing is about delivering and producing goods based on the customer wishes, when they want it. This is the way to create a loyal customer base and long-term relationships with potential customers.
- If you fail to ensure strong agile manufacturing, you risk losing customers to more agile businesses that have been able to better adapt to conditions of uncertainty. Agile manufacturing helps companies make progress ahead of the competition and helps in the competitive struggle.
- We should not forget to mention another important issue and that is sustainability. Agile manufacturing becomes more efficient and more beneficial, and this is also the reason why it strengthens the position of companies in the market and helps companies operate sustainably.

CONCLUSION

Agile manufacturing is indispensable as a means of enhancing competitive advantage [18]. Agile has become a new vision for manufacturing companies that would like to secure their future in an unpredictable and unstable environment. One of the main benefit is the finding, that agile way of working gives manufacturing companies a new, useful feature for dealing with unexpected technical and organizational traps in projects and also fast-paced product cycles by empowering employees and a feedback-driven approach where the customer always has a voice.

By introducing agile manufacturing, companies should be able react faster to customer demands and wishes without increasing costs and also without additional work or effort from all project team members. It is important to note that agile manufacturing isn't suitable for all companies. At the beginning, a detailed analysis of the entire organization is essential in order to determine whether it is suitable for agile transformation and implementation of agile manufacturing. This is also an important step towards successful application and achieving positive results.

It is a new way of thinking, working and collaborating. This whole transformation requires, in particular, the overall understanding of individuals, the use of their skills, a high level of trust, the bringing and acceptance of new ideas and the self-organization of teams.

Another benefit is that, based on the correct analysis and implementation of agile manufacturing, companies are able to face unpredictable situations and crises caused by war,

lack of semiconductors or Covid-19 pandemic. Agile manufacturing is an effective solution for manufacturing companies in a highly competitive environment. Given the benefits it brings, adopting a flexible manufacturing strategy is a perfectly reasonable idea.

As we have experienced in recent years, the market is sometimes unpredictable. Therefore, it would be very beneficial and interesting to create supplementary analyses of the agile manufacturing implementation after the end of market turbulences i.e. at the times of future security and stability. The result could be an interesting comparison of the behaviour of organizations. Such a comparison could help create a manual of experience for coping with the difficult period ahead.

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