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Agility Challenges in Finnish Manufacturing Companies – Manufacturing Operations Management Viewpoint

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Abstract. This paper presents an analysis of the manufacturing operations management related challenges which hinder agility in Finnish manufacturing companies. Critical challenges were identified by performing cause-effect analysis between different challenges identified from the interview material collected from 25 manufacturing companies. The main output is a relationships graph which visualizes interconnections between 49 agility related challenges. The graph supports the identification and prioritization of the actions to be taken while seeking for better agility.

Keywords: Agile manufacturing, manufacturing operations management, agility challenges, manufacturing IT systems

1 Introduction

Today's production environment is characterised by frequent changes in terms of high product variation, small batch sizes, high demand fluctuation as well as random unexpected disturbances on the factory floor. In order to prosper, the manufacturing companies and their production systems and networks need to rapidly adapt to these changing requirements. Thus, rapid responsiveness and agility has become a new strategic goal for manufacturing enterprises alongside with quality and costs [1]. Literature offers numerous definitions for agility. For instance Stamatis [2] defines agility as the *ability to thrive in a competitive environment of continuous and unanticipated change and to respond quickly to rapidly changing market driven by customer-specified products and services*. Christopher [3], on the other hand defines agility as the *ability of an organization to rapidly respond to changes in demand, both in terms of volume and variety*.

The objective of this paper is to analyse the manufacturing operations management (MOM) related challenges which affect negatively to agility in Finnish manufacturing companies. Second goal is to identify actions that could improve the situation. According to the ISA-95 standard [4], *the activities of manufacturing operations management are those activities of a manufacturing facility that coordinate the personnel, equipment, material and energy in the conversion of raw materials and/or parts into*

products. The analysis is based on interview study conducted during LeanMES-project among 25 Finnish manufacturing companies [5].

2 Research method

The research was divided into three sub-objectives and associated methods:

- 1) To investigate the enablers of agility by reviewing the existing literature in the field of agile manufacturing.
- 2) To identify challenges that hinder agility in Finnish manufacturing companies. This objective was approached by comparing the existing interview material from 25 Finnish manufacturing companies against the identified agility enablers. The interviews were conducted during the fall 2013 and spring 2014 with the original goal to study the current challenges and practices regarding the manufacturing operations management [5].
- 3) To find out the most critical challenges hindering agility, based on the interview material, and to propose actions for solving those challenges. This objective was approached by defining interconnections between the challenges with cause-effect analysis and drawing a relationship map. These interconnections were defined in several workshops with the research group.

3 Background – Enablers of Agility

Yusuf et al. [6] identified the core concepts of agile manufacturing as: Core competence management; Virtual enterprise; Capability for re-configuration; and Knowledge-driven enterprise. Gunasekaran [7] presented a framework, which divides different enablers of agile manufacturing under four major categories, namely Strategies, Technologies, Systems and People. Under the strategy he mentioned concurrent engineering, virtual enterprise and rapid partnership formation. As stated by Sanchez and Nagi [8] agile manufacturing requires resources that are beyond the reach of a single company, which means that sharing resources and technologies among companies is necessary. In virtual enterprise the core competencies of carefully chosen real organizations are integrated as temporary alliances are formed.

Under systems category Gunasekaran [7] included design systems and production planning and control systems, while under technologies he listed hardware, i.e. equipment and tools, as well as information technologies (IT). Reconfigurable and modular manufacturing resources enabling rapid changeover are examples of agile-enabled hardware technologies [9]. Fast and easy interchange of information in dynamic manufacturing environment requires IT systems that support and enable quick responds to changes. Gunasekaran [7] stated that IT has a fundamental role in integrating physically distributed manufacturing firms in today's global manufacturing environment. Avoiding human related errors in information exchange is one key issue which can be addressed by increasing the use of IT. Mondragon et al. [10] emphasized the importance of IT systems in supporting manufacturing, and stated that for instance real-time monitoring of manufacturing operations enhances manufacturing

agility. According to Kletti [11], faster flow of information between every level in a manufacturing company enable problems and unplanned events to be detected faster, and thus allows rapid reaction. Wiendahl et al. [9] mentioned the adaptive production planning and control as a one important enabler of changeability.

Under the people category Gunasekaran [7] included flexible and motivated workforce, top management support and employee empowerment. An agile workforce should be multi-skilled and flexible, thus having a capability of shifting job functions and carry out other tasks rapidly, when a need occurs. Therefore, agile companies must be committed to continuous workforce training and education. Continuous learning, self-organising and reconfigurable teams are attributes of an agile workforce. [12]

Yusuf et al. [6] listed 32 attributes of an agile organization. Those relating tightly to MOM-domain are summarised here: Concurrent execution of activities; Enterprise integration; Information accessible to employees; Empowered individuals working in cross-functional teams; Teams across company borders; Decentralized decision making; Skill and knowledge enhancing technologies; Flexible production technology; Continuous improvement; Rapid partnership formation; Close relationship with suppliers; Multi-skilled and flexible people; Continuous training and development.

4 Analysis of the agility challenges

4.1 Identified challenges and their interconnections

The challenges Finnish manufacturing companies face with their current manufacturing operations management practices have been discussed in [5]. For this research, the challenges relating especially to the agility enablers were collected. Altogether 49 challenges affecting agility were identified from the interview material for further analysis. These are shown in the relationship map in **Fig. 1**.

In summary, it can be said that in large OEM companies one of the biggest challenges was lack of information transparency between different departments and actors in the network. In supplier side the difficult forecasting and unexpected disturbances, e.g. rush orders or machine breakdowns, were causing the main uncertainties for the manufacturing operations management and thus set requirements for agile reaction. In general the identified challenges hindering agility were very similar in different company types. One of the most visible issue was that most of the companies didn't have proper IT systems for production planning and control, such as MES (Manufacturing Execution System) and APS (Advanced Planning and Scheduling), to support rapid reactions to changes. This issue is strongly reflected in the analysis.

Fig. 1 presents the relationships map drawn to illustrate the cause-effect relations between the different agility challenges identified from the interviews. The relationships map is intended to serve two purposes: 1) To identify the most critical challenges, which are causing multiple other challenges; 2) To increase understanding on how different kind of challenges relate to each other in order to be able to identify what may be the reasons behind some challenges.

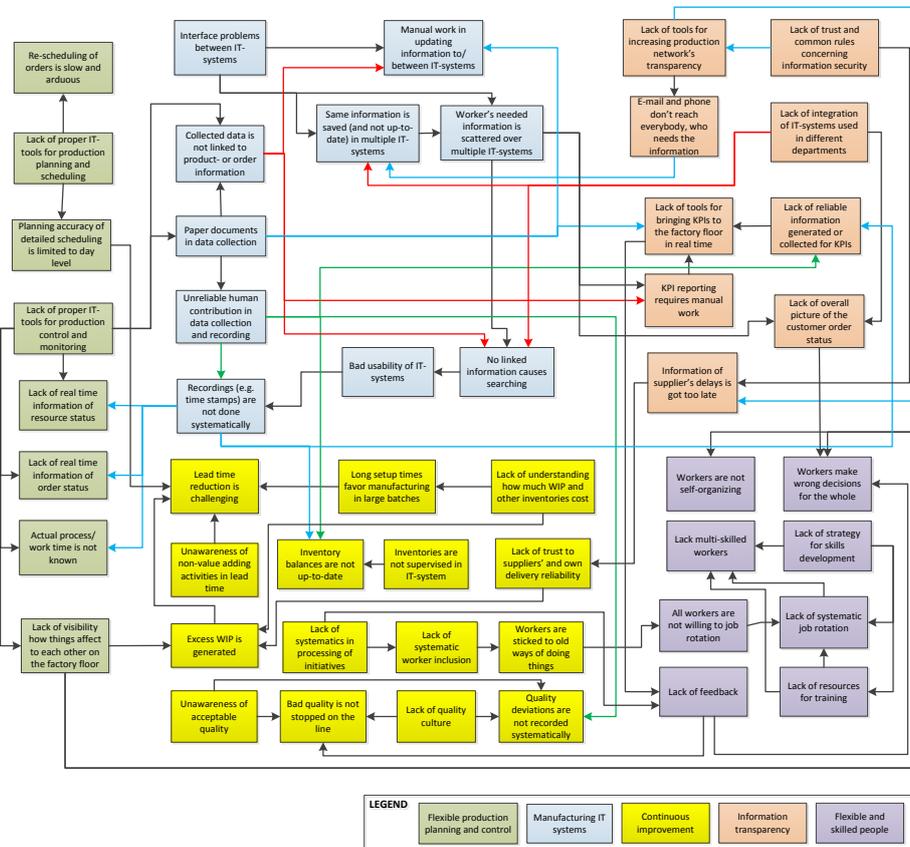


Fig. 1. Relationships map showing the identified interconnections between agility challenges (please see the digital version for colours).

4.2 Analysis of critical challenges

As the relationships map indicates, the amount of direct effects originating from an individual challenge is varying from zero to six. The higher the number, the more critical the challenge is assumed to be. However, it has to be mentioned that in some cases it was difficult to identify which is the cause and which is the effect (i.e. chicken-egg problem).

Few challenges having direct effect on six to four other challenges can be identified from the map. Based on this analysis those challenges are considered to be critical challenges hindering agility in Finnish manufacturing companies. In the following figures, these challenges and their effect chains are shown. Two “levels” of effects are included in these graphs. **Fig. 2** shows the effect chains for two connected challenges, namely “Lack of proper IT tools for production control and monitoring”, and “Paper documents in data collection”. It has to be noted that this analysis includes only those challenges and causes that came up during the interviews. Thus, there may be several

reasons still behind the identified “root causes”. E.g. the lack of proper IT tools may be caused by lack of resources – human, money or time – to implement such tools, lack of knowledge or interest, or reluctance to change the old ways of working. Each company may have their own reasons and therefore they are not analysed any further.

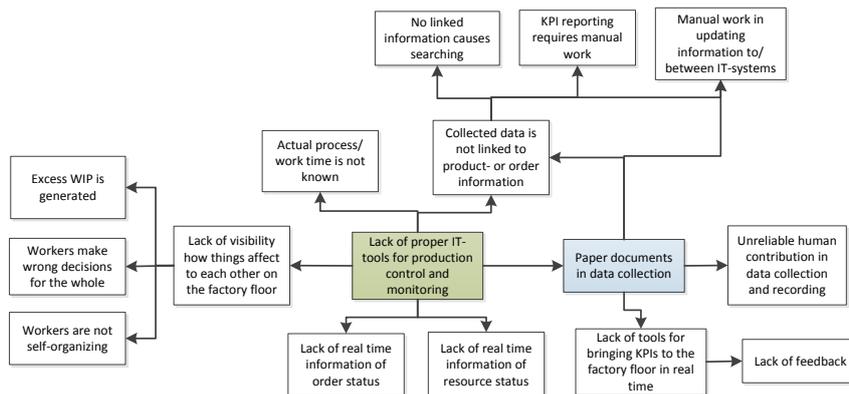


Fig. 2. Effect chains for challenges “Lack of proper IT-tools for production control and monitoring” and “Paper documents in data collection”.

The first critical challenge refers to the lack of IT-support for production control and monitoring, i.e. lack of MES-functionality, which was a major challenge in most of the interviewed companies. As **Fig. 2** indicates, it causes lack of visibility to the real time situation on the factory floor, e.g. the resource or order status. This hinders the worker’s ability to self-organize and make good decisions for the whole. Lack of MES also makes the collection of history data cumbersome, requiring a lot of manual information inputting and updating, e.g. when the information is collected to various spreadsheets or paper documents. This also leads to the fact that the information is not linked to the product and order information in upper level management systems, which again means that information needs to be searched from, maintained and updated in multiple places.

Second critical challenge is the usage of paper documents in data collection. It slows down information flows, causes human errors and affect negatively to information management and transparency. They cause unnecessary manual typing of data to the IT systems. Furthermore, it hinders the real time calculation of Key Performance Indicators (KPIs), not to mention bringing feedback to the production workers through KPIs in real time.

Third critical challenge is “Unreliable human contribution in data collection and recording” (**Fig. 3**). Although the usage of paper documents has a direct effect to human contribution, this challenge may also exist without the previous. Elimination of paper documents from data collection does not remove the risk that human for instance forgets to make recordings to the IT system. In the same figure, another critical challenge “Recordings (e.g. time stamps) are not done systematically”, is also analysed as it is direct effect of unreliable human contribution, and also direct cause

for five other challenges. If the workers don't make the recordings systematically, no reliable history information e.g. relating to work phase duration is generated. Same applies to the generation of reliable KPI information. Also, it makes it difficult to keep on track of the resource and order statuses. Faulty inventory balances can also be caused by human, if recordings are not done immediately when material is picked from the storage.

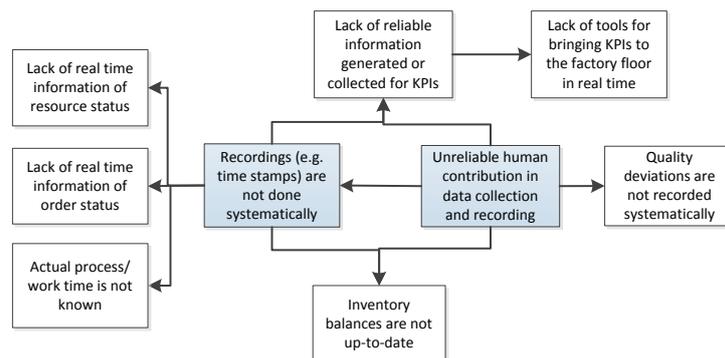


Fig. 3. Effect chains for challenges “Recordings (e.g. time stamps) are not done systematically” and “Unreliable human contribution in data collection and recording”.

Other important critical challenge recognized from the relationship map was the “interface problems between IT systems”. Since the IT systems used for different purposes lack capabilities to communicate with each other, information flow is non-existent. Information is often scattered over multiple IT systems and due to the interoperability issues, updating information in these multiple systems typically requires manual error prone typing. Scattered information causes a problem that the overall “big picture”, e.g. of customer order status, is difficult to get. From the worker skills perspective an important challenge “Lack of strategy for skills development” was identified. It causes insufficient allocation of resources for training, lack of systematic job rotation and therefore the companies lack multi-skilled workers. From the continuous improvement perspective, the “Lack of quality culture” was regarded as an issue, since it caused lack of systematic quality reporting and the habit to let the low quality product travel through the whole production line.

4.3 Actions for improving agility

The presented relationship map helps to prioritize the actions that need to be taken while seeking for better agility. However, it has to be noted that the presented analysis didn't take into consideration the severity of each challenge, i.e. some of the challenges may be more severe than others, even they would be directly causing fewer other challenges. For example, the challenge “*lack of proper IT tools for production planning and scheduling*”, which refers to lack of APS systems, affects only two other challenges included in the map. However, implementing an APS system would enable faster and easier re-scheduling of orders, and allow increasing the planning

accuracy of detailed scheduling, both of which are important factors for agility. This example indicates that the number of interconnections must be considered at some level, but the type of the challenge counts as well.

Based on the collected interview material and the conducted cause-effect analysis, implementation of MES and APS systems could significantly reduce the number of challenges by ensuring that real-time information flows between different actors within a manufacturing company. As human contribution should be minimized in data collection, a relevant action is to increase automatic data collection. Minimizing human contribution is made easier with correct manufacturing IT systems in place. The usage of paper documents on the factory floor should be decreased, especially the recordings should be made digitally and also the information needed by the worker should be presented in a digital form. For increasing information transparency in production network, better integration between the OEM and subcontractor IT system, or common portals would be needed. This would support digital information flow and reduce the need for manual inputting of information to order management systems based on the email and telephone communications.

For solving challenges related to quality issues, three actions are proposed. Firstly, a quality culture should be built throughout the company. It is of high importance that workers are engaged to report about quality problems immediately when they are noticed. Secondly, clear visualized instructions of acceptable quality should be provided to the workers. Thirdly, clear procedures for more systematic quality monitoring procedures should be created. Regarding multi-skilled workers, companies should first make sure that they have a clear strategy for skills development. It would make sure that enough resources are allocated for training and that job rotation is practiced systematically. Multi-skilled workers would contribute towards agility by allowing workers to rapidly change between workstations and tasks when need occurs.

For systematic lead time reduction, value stream analysis is suggested. It helps to identify the non-value adding activities and make them visible to everybody in the organization. Regarding the large inventories, due to the delivery reliability issues, companies may find it difficult to minimise the inventories. Implementing first the actions for solving quality related issues and improving production network's transparency will create certain readiness for companies to operate with smaller inventories. Through faster information flow in production network, delivery reliability can be improved, and less need for excess inventories exists. Furthermore, when quality issues are minimized, not so much buffer is needed to compensate them.

5 Conclusions

This paper focused on analysing the most critical challenges hindering agility in Finnish manufacturing companies from manufacturing operations management perspective, and proposing actions for solving these challenges. Interconnections between the identified challenges were defined with cause-effect analysis and the results were visualized in the relationships map. Cause-effect analysis helped to identify few critical challenges, which were considered as causes for several other challenges.

These were: lack of proper manufacturing IT tools; usage of paper documents in data collection; recordings are not done systematically; unreliable human contribution in data collection; interface problems between IT systems; lack of strategy for skills development.

As a main result, this paper presented a visual map, which can be utilized in identifying and prioritizing development activities while thriving towards higher agility. The relationships map increases the understanding on how problems may be generated and how they are connected to each other. An individual manufacturing company may use the map to find out what could be possible causes for certain challenges they encounter in their operations. However, the relationships map only presents the challenges that emerged during the interviews. Therefore, the map is unable to provide information of all possible challenges or reasons hindering agility among manufacturing companies. Instead, it presents challenges that are mostly related to manufacturing operations management, and highly concentrated to IT aspects.

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