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Global Truck Production - The Importance of Having a Robust Manufacturing Preparation Process

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Abstract

Global production networks (GPN) are generally hard to manage due to spread of processes and systems. The amount of product variants adds to the complexity. This study, based on interviews and questionnaires, shows an improvement possibility by standardizing the process for preparing assembly work instructions on a global level. Furthermore, several factors that are negatively affected by not having a standard implemented are identified. The empirical findings suggest that a standardized manufacturing preparation process could improve knowledge and information transfer within a GPN. A standardization of the manufacturing preparation process would also decrease diversification in terms of double work and possibility to simplify infrastructure and to reduce the amount of support systems used.

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1. Introduction

Due to the globalization and access to new markets, larger companies have expanded the customer base by introducing customized products [1,2]. The new way of offering customized and short-lived products for the customers has led to the need for companies to find affordable and efficient processes for designing and producing products [3]. Such methods need to streamline engineering processes and focus on commonality and similarity in products and manufacturing technology [4]. Companies have historically invested in manufacturing capacity abroad due to lower costs in terms of labour, logistics and trade tariffs [5–7].

Acquisitions of other manufacturers has led to that many companies have grown fast. But, with growth comes a price. Doug Tatum [8] gives examples of how rapid growth companies fail substantial business opportunities when they become larger. The main reason is that they are not prepared for what they need in order to be a larger player. To be able to succeed being a global manufacturing company there are several components that needs to be addressed as global quality control, global production planning, global technology innovation, global workforces and total landed cost [7].

Vehicle manufacturing has doubled since 1998 [1] and passenger car manufacturing remains the dominating area. This might be one of the reasons why there are so little research published regarding heavy trucks manufacturing. Heavy vehicles, trucks, are of a complex product type. The product variants are endless and can be customized to suit the needs of the customer. Global multi-brand firms have higher complexity and more constraints to handle in terms of production and performance. The larger production networks, the more important it gets with transparent processes and clear information flow within the network. Manufacturing preparation is a phase/process which is dependent on

[1] In 1998, 37 925 000 cars worldwide were manufactured [24] and 1 893 000 heavy trucks were manufactured [25]. In 2014, 67 525 346 cars worldwide were manufactured [26], while only 3,797,694 heavy trucks (Sweden, Germany and France missing in statistics) were manufactured [27].

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thorough product and process documentation. Offering extensive product variants to the customers put high complexity in the preparation phase.

Acquisitions have a tendency to create diversification of products, processes and systems at global manufacturing firms, which may lead to intensified decentralization in the production network. Therefore, new methods and strategies are needed to improve responsiveness in global production networks. Such manufacturing systems are suggested by researchers to be agile and modular to improve flexibility [9].

This paper investigates how a truck manufacturer handles their manufacturing preparation processes, focusing on the creation of assembly instructions, within their global production network. The industrial study provides examples of consequences related to production performance from a global perspective.

2. Globalization of Production

Global production planning could be improved with a good infrastructure for information and communication [7]. A new global manufacturing revolution is needed where responsive business models and responsive manufacturing systems can cope with the turbulent global economy [10]. The globalization, in modern time speaking, breakthrough was during the 1990's when both India and China opened for foreign products and investments. During the same decade the European Union and North America Free Trade Agreement were established to enable free trading markets [10,11]. Two main reasons for manufacturers to go abroad are the market development and cost reduction potential. However, it is suggested that the potential of cost reduction of the 'entire value chain' is underestimated [5]. The benefits of being a global manufacturer can be summarized by; reduced business risks, reduced manufacturing costs due to lower labour costs and accessibility to new markets [1,10]. The globalization of production is made possible through either outsourcing or offshoring [1]. Firms can encounter disadvantages from globalization due to the fragmentation of their processes and activities [11], due to increased amount of aspects a firm has to take in to account to be successful [12]. Handling a global production network is complex and hard. Hence, global production networks can be a source of competitive advantage if it is being well-managed. Ferdows [13] mentions the amount of variables that lies outside the control of the company as a risk for limiting business success and strategy development.

Training of labour and attraction of skilled labour is two of the major factors when establish new production units abroad. Generally, there are two distinct focuses in the setup of new production units where firms that are relatively new to globalization tends to focus on risks (attract skilled labour) while more experienced firms focus on opportunities (cost savings) [5]. It is also mentioned that language and cultural barriers may block collaboration and knowledge exchange. Moreover, knowledge exchange, expertise and best practices are generally hard to transfer within a production network.

3. Standardization of Product and Processes

The availability of technology has increased and the application areas are larger today compared to just some decades ago. In the automotive industry the amount of optional features is today extremely high in terms of possible product variants. Previous analysis of product variants showed that configuration options differed from below 1000 to over billions of possible configurations (depending on product portfolio strategies and marketing offers) [14]. When it comes to truck division of vehicle manufacturing, the available configurations are even higher to satisfy demanding customer requirements. The amount of customization indicates the need of a solution for handling such product variety. Modularization is such a method or concept for handling product variety. Standardization is only possible if 'a component implements commonly useful functions; and the interface to the component is identical across more than one different product' [15]. Using modular architecture would improve the possibilities that components will be useful for a group of products. The benefit of product standardization is the manufacturability in terms of cost, performance and product development.

If the product is standardized, the manufacturing process can also be standardized and this could be seen as the greatest enabler of 'consistent performance'[16]. The standardization strategy depends on the possibility to modularize its products and processes [17]. This is in line with Nix [18] who lists eight attributes for global integration where two of them are defined as standardization of product and processes and globally integrated information systems. Standardization of the product and the process could also lead to low adjustment costs directed to market fluctuations. With the support from global integration of information systems the decision making process will be more rapid and accurate when the availability of standardized data is high.

An important factor to consider, is to find a good balance between global process standardization and local adaption [19]. Manrodt and Vitasek [19] developed a framework for standardizing global processes where the key steps identified were articulate company strategy, process view of logistics, identify key processes/segments, determine customer impact, select key segments for improvement and identify and train global segment owners. These key steps helped their case company to create global standardized processes which reduced both waste and redundancy in their way of working.

To be able to understand what processes exist and which of them that needs to be standardized, it is also important to understand the background of why the investments of the different factories in the global production network (GPN) were made from the beginning and what roles they serve in the GPN. Six different categories of factories could be included in a production network; offshore factory, source factory, server factory, contributor factory outpost factory and lead factory [6]. Each of these categories serves different purposes in the GPN.

4. Industrial Case Study - Methodologies

Due to acquisitions in the past, Volvo Group has several truck brands and a vast amount of legacy systems and processes to manage. This is particularly noticeable when it comes to creating assembly work instructions for the final assembly process. Therefore, this study has focused to investigate how the firm works with their manufacturing preparation processes.

The data in this study has been collected by two web questionnaires and extensive interviews with key persons within the area of interest. Fig. 1 shows the methodology for this study. In this study a mixed method approach has been used since it was believed that neither quantitative nor qualitative methods alone would provide complete answers to the research question. Creswell and Plano Clark [20] advocate that there are advantages of combining both quantitative elements and qualitative elements in a study as they can provide wider understanding of a phenomenon than a clean methodology can alone.

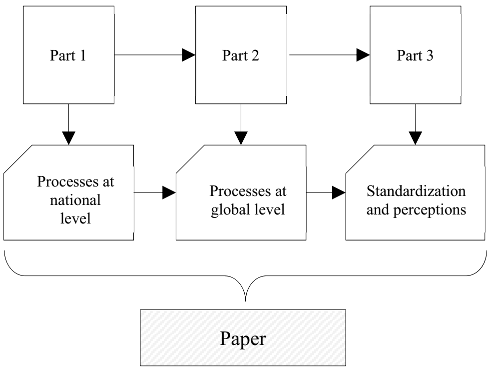

Fig. 1. Mapping of process for preparing assembly work instructions within a Global Production Network.

Part 1 was based on a national web questionnaire containing 17 questions where five questions where of demographic matter. The aim of the questionnaire was to identify which kind of Information Communication Technology (ICT) tools that are used to transfer information from engineering to production and which format and content that they use. It was also investigated in which amount standardization was present in these processes. In total, 35 production engineers within one truck manufacturing company in Sweden participated in this part [21]

Part 2 was based on a global web questionnaire containing 23 questions where seven questions where of demographic matter. This web questionnaire was changed compared to the previous one and was available in seven languages; Dutch, English, French, Japanese Portuguese, Russian and Swedish. The aim was similar as the previous questionnaire, but with more focus on globalization and added questions concerning how well the different tools, information design and contents are functioning. In total, 40 production engineers, 9 team leaders and 9 operators within a global production network (GPN) in the same truck manufacturing company as previously participated in this part [22].

Part 3 was of qualitative nature based on interviews and available process documentation. As part one and part two have functioned as a background to the research, part three has focused on mapping the current state of manufacturing preparation processes, focusing on creating assembly instructions for the operators to be able to better understand the implications from the survey results. The delimitation in this part of the study was truck assembly and engine and transmission assembly within one of the case company's brand [23].

5. Creation of Assembly Work Instructions

The conclusion drawn from the two web questionnaires addressed to production engineers and assembly operators within the GPN indicated that diversity is present in the way information is transferred between engineering departments and assembly operators. It was also shown that the information content as well as information design differed, not only between different brands but also between different production units for the same brand within the GPN. The usage of standards when creating assembly work instructions was also investigated and a majority of the respondents answered that standards were available. In the international web questionnaire, the respondents were also asked to rate to which extent the available standards were followed and the average rating was 3.6 on a scale from 1 (low) to 5 (high). In the national web questionnaire this question was not included.

Since the both web questionnaires suggested that diversity is present in current processes, a deeper analysis of manufacturing preparation processes was suggested which focus should be directed towards the creation of assembly work instructions. The study was addressed to truck assembly for one of the brands and the supplier of engines and transmissions in the GPN. The result from the study is based on 19 interviews of people with both global and local engineering roles. These interviews generated data which describes how the creation of assembly work instructions is carried out and what the process looks like. The results indicated that the manufacturing preparation process is perceived differently at different stages of the process and by different roles. Roles have different responsibilities and therefore, other priorities and different needs for collaboration and holistic view of the process.

In Fig. 2 the key activities in the preparation process are shown. The key activities were identified on basis of the interviews. The design block contains the design for assembly. The review block contains review of the product design to assure manufacturability and minimizing risks/events at the production stage. The time setting activity is where the date is set from when a product/part change is effective in production. The time analysis is carried out to estimate/measure the cycle time of an assembly operation.

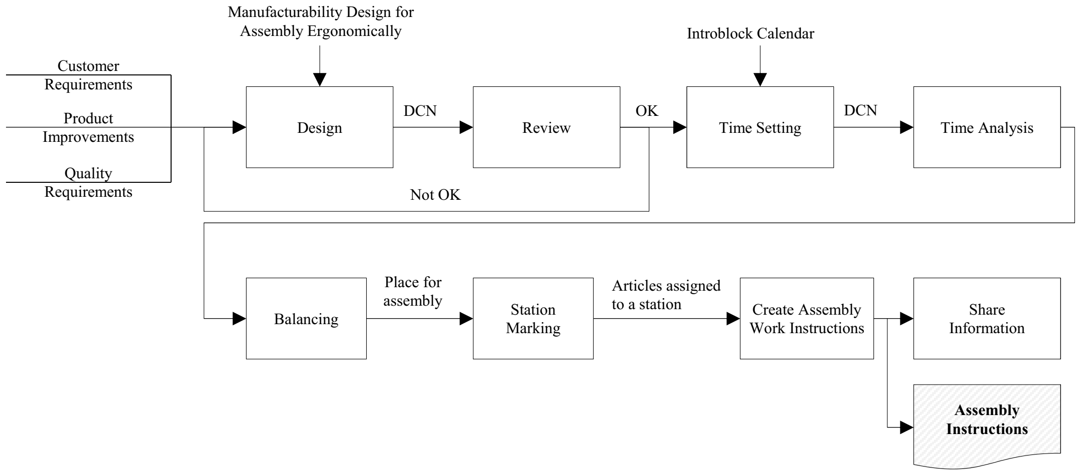

Fig. 2. Key activities in the manufacturing preparation process for preparing assembly work instructions (Delin and Jansson, 2015).

The time analysis is followed by balancing where the assembly operations are distributed in the production flow with respect to chosen takt time. The station marking is where each part (article) is assigned and linked to specific stations. When station marking is completed the assembly work instructions are created containing Bill of Material (BOM), descriptions, illustrations, correct working sequence and equipment. Finally, the changes are communicated and shared to affected parties. Based on collected data, different systems and information structures for the activities in the preparation process are used at *engine & transmission* and *cab & vehicle*.

Based on the interviews a timeline was created as seen in Fig. 3 which indicates where and when the process deviates among the different production units, but also that they share the same starting point. The dashed strokes indicate that the local process itself has not been investigated in detail, only on where and when it deviates from the general preparation principles. It also shows that for *cab & vehicle* assembly in Belgium, Russia and Sweden the process responsibility is centralized and only local adaptation is performed at the production unit. When it comes to *cab & vehicle* assembly in Brazil and Australia, the process is carried out locally from the time that the product design is set. For *engine & transmission* in Sweden the process is similar, but carried out locally. For the other *engine & transmission* production units the interviews indicated that the process is also carried out locally, but the processes themselves were not investigated in detail at those production units.

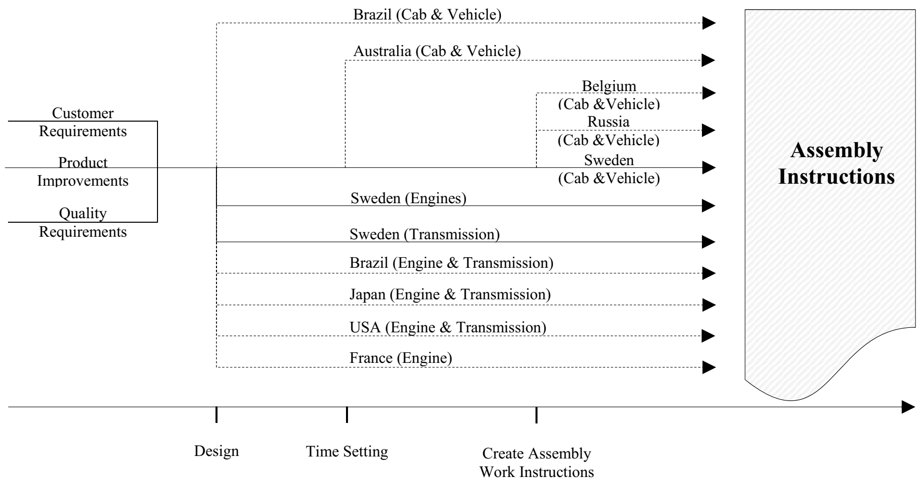

Fig. 3. Overview of the process for preparing assembly work instructions for one of the truck brands (Delin and Jansson, 2015).

Assembly work instructions are structured differently, contain different information and the language is usually regional. Since the assembly instructions are created locally, improvements made on already distributed material are not always shared with other units where the improvements would be effective. It was also indicated that different organizational units work with different process targets; shorter lead times or higher quality which suggested that process targets are not consistent in the GPN

6. Discussion

The empirical findings highlighted the fact that different process targets are used in different organizational units (e.g. shorter lead time or higher quality). These process targets can be contradictory since a decreased lead time might negatively affect quality. These various process targets can be an indicator of that there is no common understanding on what targets that are in focus or lack of communication of these. Common process targets are enablers of improvement as natural collaboration opportunities arises when people work towards the same goals. If this process already was standardized, such effects would be more of natural character.

The production units within the GPN are working with standards differently. Some of them have come much further in the progress of implementing standards, while others have a longer journey reaching the same maturity. A global standard in the preparation process would not only help the different regions to reach maturity, it could also support the work of implementing standardized work as described by Liker and Meier [16].

As seen in Fig. 3 it was found that for *cab & vehicle* in Europe the main part of the process is centralized to Sweden where the main development of the instructions are done. Only the local adaptations as translations etc. are performed on site. As for the other two production units within the brand, they perform major part of the process locally; there are clear indications of redundancy and also risks for limitations in collaboration possibilities. Instead of a decentralized strategy, a centralization of the preparation process would enhance the possibility of collaboration within the brand, but also for cutting lead time and to free up resources as suggested by Manrodt and Vitasek [19]. Such strategy change is in line with streamlining and focusing on similarity and commonality [4]. The drawback of the current decentralization can also be connected to the fact that there are different process targets. When it comes to *engine & transmission*, decentralization was more evident and even though the processes themselves were very similar they were still conducted locally. Even if the products between *cab & vehicle* and *engine & transmission* are different and the manufacturing processes are different, there would still be benefits of having a centralized preparation process to strengthening the collaboration within the GPN. As a clear standardized preparation process, at a global level, is not implemented, language barriers prevent efficient information exchange within the GPN as local processes are structured differently. The absence of a standardized preparation process contributes to that local driven improvements are not sufficiently shared with the rest of the GPN. Another positive gain of standardization from collaboration within the GPN is a simplified interface between product development and production. Improved possibilities for providing good quality requirements in the product development phase would decrease the risks for late changes in the product design. Late changes in product design may have negative effects on the manufacturing preparation process as well as the manufacturing process itself.

As described previously, the preparation process is perceived and described differently depending on where in the process the engineer is working. As there is not an evident common understanding of the process the end result may be affected negatively. A standardization of the preparation process would improve transparency and improve the common understanding of the process as well as enhance collaboration between different roles and departments. This would lead to higher quality of the preparation work and better prerequisites for the assembly operators.

When it comes to infrastructure and systems used it was evident that different systems are used in the preparation process. It was also evident that the same system is structured different at the production units. The lack of common infrastructure and systems limit the possibility to cut redundant work and to share best practices among the production units. Additionally, the end result such as assembly work instructions and the assembly process itself is affected. Instead, a common infrastructure with a standardized system that supports a global preparation process would not only reduce lead time and release resources; it would most definitely improve the possibility of knowledge exchange and communication and to efficiently work with continuous improvements in the GPN as a whole. The manufacturing preparation process would still be needed to be locally anchored to secure that local adaptations are possible to be made. With a global standard in place, such adaptations would not be limited. In fact, if the process and systems are standardized, information and knowledge transfer will be facilitated as well as transparency between factories and central parts of the organization. Additionally, if a common terminology would be used then language barriers would no longer be a limitation in the preparation process.

6.1. Future work

This study has investigated a part of the current practice at one industrial case company and motivated the need for standardizing the manufacturing preparation process. The empirical findings have identified several interesting phenomenon and facts in their current practice which lead to the proposal of investigating which needs exist from engineering department to better perform preparation work. It is also suggested to investigate what information operators need to be able to improve their decision making during assembly. Such study would focus on what type of data is available and what data is needed for both the engineers and operators. By focusing on their needs, new system structure and process with clear interfaces between different responsibility areas could be developed and tested in an industrial environment.

7. Conclusion

This study has identified eight key activities in the manufacturing preparation process in terms of assembly work instruction creation, which are required in a standardized process. The study has also identified both commonality as well as diversification in the process. Depending on brand, product type and localization strategy, the manufacturing preparation process splits up in separate branches at different stages. This indicates that a holistic and global standardized process is not implemented within the GPN. Instead standardization is implemented locally on a much lower level. It was also suggested that the transparency in the process needs improvement to enable common understanding of the process and its components. Furthermore, the result indicated that there are rooms for improvements in terms of communication and knowledge transfer within the GPN. This study, on basis of the empirical findings, suggests implementing a global standard for manufacturing preparation work with a clear description of the process steps as well as pre and post conditions for each step. A global standard would result in performance improvements in terms of efficiency and cost reductions.

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