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Adoption of lean philosophy in car dismantling companies in Sweden-a case study

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Abstract

At present, Lean manufacturing techniques are widely used in industries to improve the productivity by reducing different types of wastes. A case study has been conducted to investigate how Lean techniques can contribute in car dismantling companies in Sweden. This study gained insight of how car dismantling companies can be benefitted by adopting Lean philosophy. Some eccentric characteristics of this business which act as boundary condition for implementing Lean in Production Planning and control system were also identified.

Keywords: End of life vehicle; car dismantling; car recycling; lean; improve production.

1. Introduction

Managing the End of Life vehicles (ELV) has become a prominent research area in terms of sustainability and life cycle management of automobiles. An ELV contains reusable parts along with different materials, such as iron, aluminum, plastics and rare earth elements which ought to be recovered to enable circularity of materials in the value chain. The legal demands regarding recovery of the ELVs are increasing to ensure sustainability and circularity. There are several recovery options such as: reuse, remanufacturing, recycling and recovery of energy [1]. Reuse refers to use the same part again for its original purpose, and remanufacturing can be defined as processing the main product to return to its original form or a new form [2]. Shredding the raw materials from the product and making new products from those materials can be viewed as recycling [3]. Finally, the usage of wastes for different purpose, such as

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producing energy, can be considered as recovery [1]. Among all of these options, reusing of products corresponds to higher material or energy efficiency [4,5]. In the ELV recycling process, the dismantlers collect ELVs, extract reusable parts and supply those parts to the automotive value chain. Therefore, the dismantlers' role is very crucial in ELV recycling chain.

At present, the number of automobiles is increasing worldwide and so is the number of ELVs. The increased volume of ELV and the increased demand of recovery rate are the main challenges to establish a cost effective and environmentally sustainable car recycling system [6]. Effective car dismantling system can be helpful to overcome these challenges and meet the legislative demands [3,7]. Therefore, the production processes of the dismantling companies need to be improved to attain sustainable ELV recycling systems.

Today, Lean philosophy is widely used to improve the production system in manufacturing and service organizations. Lean has been proved effective to improve efficiency and reduce lead time by eliminating non-value adding times and wastes [8]. In Lean theory- transportation, inventory, motion, waiting, over processing, overproduction, defects, unused employees' creativity- are considered as wastes [9]. Different sectors, such as automobile, FMCG (Fast Moving Consumer Goods), experienced economic benefit because of increased production rates and shorter lead time by adopting lean principles. In car dismantling companies, increasing efficiency might thus result in more throughput and reduced lead time. Increased output which would help them to meet the demand of processing more ELVs, and reduction of lead time would result in faster supply of materials to downstream companies thus shortening the lead time of whole recycling chain. Until so far, no article has been found concerning implementation of Lean techniques to improve a production system of dismantling companies.

Therefore, this paper aims to investigate how Lean manufacturing techniques can contribute to improve the production system of ELV dismantlers. A case study was designed and conducted within a car dismantling company in Sweden to study the result of Lean philosophy in their production system. More specifically the scope of the study was delimited to application of the lean techniques: VSM, task analysis and Kaizen. Also, it was investigated if there are any barriers that affect the implementation of Lean in dismantling business.

1.1. Production Process of ELV dismantlers in Sweden

In Sweden, car dismantlers are numerous and often small since a regulation demands that there should be a car recycling company within 50 kilometers of each house or within each municipality [10]. They follow craft type production system [11] where cars are dismantled by skilled operators in parallel stations. The dismantling tasks are involved with high variety having large cycle time [12] and the operations are mostly manual. The general operational processes of car dismantlers consist of depollution and dismantling. Thereafter the remaining car is shipped to shredding, also see Fig.1 originally presented by Cossu and Lai [13].

Mat Saman & Blount (2006) classified the ELVs which are supplied to the dismantlers into two categories: Natural ELV and Premature ELV [14]. Natural ELV refers to those vehicles which have reached to the end stage of their service period whereas vehicles which are unable to provide service because of being damaged by external factors, such as an accident, can be referred to as premature ELV.

A significant portion of the profit made by the dismantlers comes from selling the spare parts to insurance companies, end consumers, repair shops and automotive companies. Apart from this, a small portion of the revenue is generated from the materials (e.g. bulk car body and extracted metals) which are sold to shredders and recycling companies. The demand of a certain part of a specific model of car is created in the market if the same part of a running vehicle fails or is damaged by an accident which is uncertain. For this reason, push based production planning systems are usually applied. A strategy used by the dismantlers to manage the uncertain demand, is to keep a large inventory of spare parts.

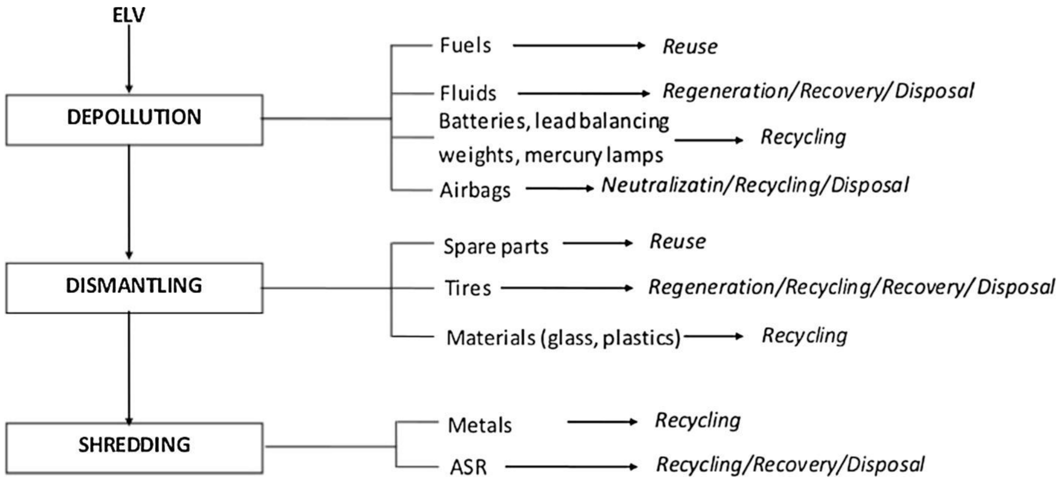

Fig.1. Production processes in dismantling company

1.2. Overview of the case company

The studied company is located Sweden and handles approximately 3000 ELVs each year. The company has implemented 5S, a Lean tool, to some extent, however, has not yet practiced continuous improvement projects, such as Kaizen event, standardization, etc. Neither have they implemented lean in full scale to process improvement, production planning and control system. The production process is similar to that shown in Fig-1. Currently they operate two depolluting stations and four dismantling stations. In a dismantling station, tasks are highly manual as one skilled operator extracts the reusable parts aided by hand tools such as power screw driver, knife and pliers. Each part then goes through a quality control to ensure correct functionality, this control is performed manually and requires a highly skilled worker. In addition to reusable parts materials are extracted both manually and mechanically with an excavator.

A major portion of the profit comes from selling the spare parts of premature ELVs especially which have been launched in the market within last two years. Average holding time of the spare parts of these ELVs' is two to three years. On the other hand, spare parts of premature ELVs which models are running on the street for more than five years, stays in the inventory for three to six months on average. Only few parts are extracted from natural ELVs because of their low demand. The decision on which parts to extract from each ELV and place in storage is made by a production manager after consulting their ERP system holding information on for example the demand, current inventory and estimated selling price of the part.

2. Frame of Reference

The concept of Lean has been interpreted in different ways in the literature [15]. Lean has both philosophical and practical orientation [16] which can be embedded in three levels of Lean thinking- Philosophy, Principles, and tools and techniques [17, 18]. VSM, Task Analysis, Kaizen are considered as part of tools and techniques [18]. Rother and Shook [19] identified VSM as a useful tool to identify value, eliminate waste and create flow more effectively. Its usage has also been suggested by Liker [9] as an initial strategy while implementing Lean at value stream level.

Lean principles and techniques are widely used in car assembling companies and several companies gained remarkable financial success [20], however its adoption is not significant in Swedish car disassembly companies. So far, any research paper has not been found on implementing Lean in ELV dismantling companies. However, much research has been carried out focusing on for example; station layout [21, 22] ergonomics [6, 23] and sustainability of the ELV dismantlers' production system [24], where some authors highlighted the importance of process improvement.

Kazmierczak, Winkel & Westgaard studied the ergonomic issues in dismantling companies in Sweden and found that, despite having a lot of manual tasks with bad posture, musculoskeletal disorder was not significant because the tasks are low repetitive [6]. They highlighted that the variation of cycle time reduces output and cycle time could be reduced by increasing training operators and improving working techniques.

Kosacka & Golińska assessed the sustainability of car dismantling companies in Poland [24]. They found that compared to other operations the dismantling tasks impose greater influence on different perspective of sustainability- social, environmental and economic aspects. They suggested that to achieve economic sustainability main challenge would be- eliminating unnecessary stocks, and reducing dismantling cycle time by eliminating unnecessary transport and waiting times (by implementing Kaizen, 5S).

3. Method

First, the process flow was analyzed through the value streaming mapping (VSM). Different types of wastes were also identified using the VSM, thereafter those wastes were eliminated using kaizen activity.

In order to identify wastes involved with disassembly operation in dismantling stations, task analysis was used. The whole tasks for this process were classified into three different categories: Value adding tasks, required nonvalue adding tasks and pure waste [25]. The value adding tasks can be defined by the activities that creates value to the customers. Tasks that are required to support the value adding tasks, but do not create any value, such as machine setup, material handling, maintenance, can be viewed as required nonvalue adding tasks. Whereas, activities like disturbances, waiting, personal time- in one phrase lean wastes- can be considered as pure waste. For this case study, tasks such as removing the screws to extract a part is considered as value adding task, since it necessarily needs to be carried out. Activities like- picking up tools such as power screw driver, putting down the extracted parts, adjusting the ELV were considered as required nonvalue adding tasks. Unnecessary motions such as walking to take the tools were considered as pure waste.

Further an experiment was conducted where two operators were engaged at a workstation instead of the current single operator. In these experiments dismantling of comparable cars were compared in terms of number of parts produced per man-hour.

While collecting data multiple sources were used to strengthen the validity of the data, i.e. data triangulation [26]. For example, the data of the cycle times of different tasks in dismantling station were collected through observations which were compared with the estimation of production manager of the company. Data relevant to business strategy were collected from the interview of the CEO. The research team was able to make a visit to another dismantling company, and to have an interview session with the CEO and production manager to understand their production system, business model and manufacturing strategy.

4. Result

The value stream mapping (VSM) (see Appendix-A) showed that, there are four major operations for disassembly- Testing & Depolluting of ELV, Dismantling the parts, Cleaning the extracted parts, and finally Quality Inspections. The processing time of each operations shown in Table-1. Every day they receive around 10 ELVs which are depolluted and placed in initial inventory. Operations- Dismantling, Cleaning and Quality Inspection maintain a flow. Number of parts extracted from an ELV ranges from 50 to 100. After quality inspections, extracted parts are stored in a warehouse where they remain from three months to two years. It was found that, initial inventory contained around 200 ELVs and the warehouse contained more than 150,000 finish goods. Buffers between operations- dismantling, cleaning and quality inspections contained 60 parts. Therefore, in term of Lean theory, inventory is one of their wastes.

Each year around 10% of their whole inventory needs to be removed to free up the space for new parts. Usually parts, which have been kept for long time and having small possibility to be sold, are removed from the finished goods inventory. Therefore, these products can be considered as a waste which could be classified as overproduction according to definitions used in manufacturing industries.

Among different operations (shown in Table.1), the processing time of the dismantling operation is very high compared to other operations. And therefore, it was analyzed further to seek reductions. In the dismantling station, the tasks involved with extraction of reusable parts from an ELV were mostly manual. The dismantling operation for a single car was filmed and the corresponding tasks were analyzed. The result showed that (see Table.2) 70% of the whole processing time corresponded to value adding tasks, whereas required nonvalue adding tasks and pure waste were 21% and 9% respectively.

Table 1. Processing time of different operations

Operations	Processing time (min)
Testing & Depolluting	60
Dismantling	570
Cleaning	10
Quality Inspection	2

Table 2. Task analysis of dismantling station

Task type	Amount (%)
Value adding	70
Required nonvalue adding	21
Pure waste	9

After identifying wastes, root causes were analyzed in order to reduce those. It was found that, they have small possibilities to reduce the inventory and overproduction because of the characteristics of the business which will be discussed further in the next chapter. Regarding the unnecessary movement in the dismantling station which occurred mostly because of walking, rearranging the workplace seemed to have a potential to cut down this waste by half. Because of the time constraint, it was not possible to implement the design of a new workplace and find out the actual result. It was hypothesized that through engaging multiple operators to disassemble one car at one workstation, the output could be increased. This was also studied in an experiment where the result showed the same output per man-hour as if they would have worked individually with different cars.

5. Discussion

5.1. Task Analysis

The task analysis showed- 70% of value added tasks, 20% of required nonvalue adding tasks and 10% of pure wastes. The result shows variation from the result of previous research done by Kazmierczak, et al. [6] where they found that value adding tasks- 30%, and 70% of non-value adding tasks. There might be several possible reasons for the variation. First of all, the definition of considered value adding and nonvalue adding tasks might be different as it is based on judgements of the observer. Secondly, the disassembly time and the way to disassemble of a certain part varies a lot based on car model, damage type and operators' skill. Finally, the number of sample might be another crucial factor of this variation. In this study, only one sample was taken. More data could have given different results.

5.2. Process Improvement

Kaizen has been suggested to reduce dismantling cycle time to attain economic sustainability [24]. Kazmierczak et al. suggested that, cycle time can be reduced by operator's training and improving workplace [6]. Based on the result of this case study, it has been found that, applying kaizen like improved workplace design may result in reduction of movement of operators, which could lead to a decrease of cycle time in dismantling stations by 5%. It would help to attain better flow, which is in line with studies identifying optimal facility and workstation layouts [21, 22]. According to rough calculation, this would have a potential to increase the output- processing two more ELVs every month.

The conducted experiment of engaging two operators to disassemble a car jointly in a workstation, produced similar output per man hour as if they would have worked individually in two workstations. This foreshadow the possibility to allow multiple operators working in one workstation which may have certain benefits such as increasing flexibility and capacity without increasing the number of workstations or equipment. Also, this outcome can be utilized to reduce the number of workstations. Moreover, working together helps workers to learn from each other quickly and more effectively, as it allows faster knowledge transfer to novice workers [27]. This knowledge transformation can be related to lean principles on empowering people, and can be utilized to facilitate implementation of the lean tool-standardized work.

5.3. Barriers to apply lean

Based on the observation and interview to the CEOs' of the companies, it was found that there are some barriers to implement lean in production planning and control system which limits the adoption of some of the lean techniques such as Pull based system and Just in Time (JIT)- for dismantling companies. As it was found that, overproduction and excess inventory are part of the wastes and according to Taiichi Ohno, overproduction is the most severe waste [9]. However, due to the nature of the business uncertainty and business strategy, the company had little possibility to reduce the inventory and overproduction. These characteristics of the business will be highlighted as follows.

5.3.1. Uncertainty in both demand and production

Uncertainty in demand and supply act as hinder to implement Lean techniques [28]. Similarly, Katayama & Bennett [29] demonstrated that, during high demand fluctuation lean production system would be incapable to respond. For car dismantlers, there involves high uncertainty in both demand and production. In fact, the characteristic- uncertainty in production, has made its production system special compared to other industries. To articulate this point, let us compare this with other business. When a demand in the market generates, companies which follow make to order based production system, will produce the goods and will deliver that to the customers. For companies which follow make to stock base strategy, they would like to deliver from stock. However, for car dismantlers, if there is a demand of a certain part in market which is not available in stock, it would not be possible for them to fill the demand until a premature ELV becomes available having the specific part undamaged. Because of this uncertainty, it would not be feasible to apply pull based production planning systems in car dismantling companies.

5.3.2. Business strategy

According to Mason-Jones et al. availability is the main order winner for the agile supply chain [30]. Similarly, based on the interview of the CEO, it was found that availability of a part having good condition is the main order winning criteria. Therefore, companies tend to keep the stock filled up with parts of different models of cars. Fortunately, the cost of maintaining inventory is low. For the studied company, it was found that the cost of inventory and unsold items was low compared to their total cost. In addition, there is an external force by the insurance companies, who are the main suppliers of premature ELV. The insurance companies prefer the dismantlers to maintain a high service level. Higher service level requires to have higher safety stock [31] and higher inventory level for slow moving items [32]. This could increase the number of unsold items which can be related to the overproduction of Lean wastes. Therefore, the decision on which parts to pick is important to ensure as little waste as possible.

High service level and high inventory enables their total sale and profit. Because of these reasons, focusing on reducing overproduction and inventory levels might cause detrimental effect on the market share and profitability. The aim of lean tools and principles are centered round creating customer satisfaction [33]. Within the dismantling business this is ensured through having a high service level. Therefore, reducing the inventory and production should not be the focus from a lean perspective without first ensuring another strategy for value creation.

6. Conclusion

The case study showed that, there is a scope to implement lean techniques in dismantling companies to improve their operational process through identifying and eliminate wastes. The VSM highlighted that the cycle time of the disassembly operation was high compared to other operations. Using task analysis, it was found that the disassembly operation involves unnecessary movement. An attempt was made to reduce this waste by applying kaizen on the workplace design which would result better flow and increase output. Therefore, this companies can be benefitted by implementing several lean tools such as Kaizen, 5S, Kaizen Event, standardized work to reduce wastes involved with the operational processes which would contribute to increase the efficiency and output. However, the characteristics of this business such as high uncertainty in both demand and production, and manufacturing strategy with requirement for high service level made it difficult to implement pull based lean production planning and control.

For future research, empirical studies could be conducted for other dismantling companies to further study the feasibility of adoption of Lean. Another interesting area would be creating a mathematical model to predict and forecast the arrival rate and demand of spare parts. Because of lack of information about these two parameters, implementing pull-based system has become difficult. Therefore, finding these parameters would help to overcome the challenge of high stock and overproduction.

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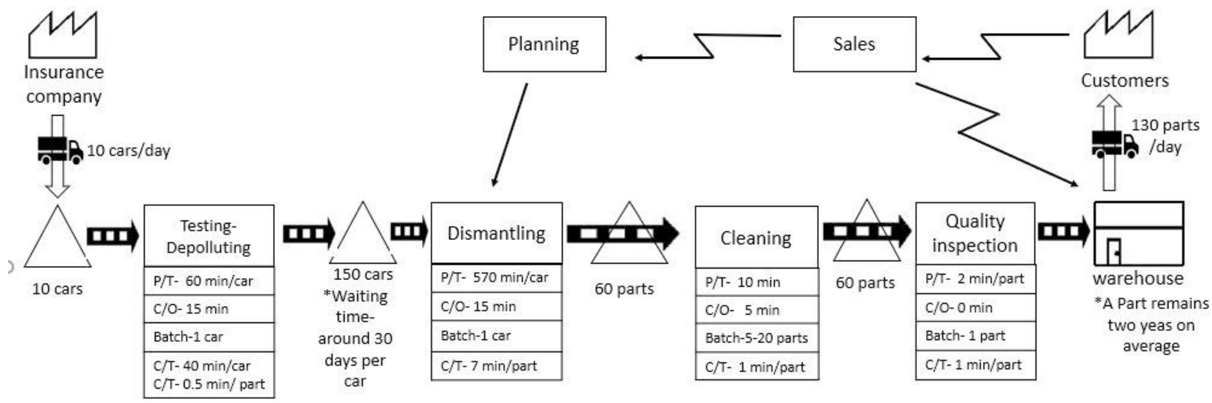
Appendix A. Value Stream Mapping



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