Leaning Lean: A Case of Reengineering in the Automotive Industry

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Abstract
In recent years, more and more companies have begun to adopt the ideas and methodologies of lean six-sigma. However, as lean practitioners we often find that the companies that excessively advertise themselves as lean are often not lean at all. That's because lean six-sigma is a journey. It is a journey in which has no end. It is a journey that, while tough, is extremely rewarding for those daring enough to undertake it. So what happens when a company who has adopted lean six-sigma continues to struggle with high defect rates, high employee turnover and the inability to meet demand? Leaning lean. The scope of this paper focuses on the improvement and reengineering of the die maintenance process for a leading automotive component supplier.

Keywords
Lean; Automotive; Reengineering

1. Introduction
In recent years more and more companies have begun to adopt the ideas and methodologies of lean six-sigma. We now see more job postings than ever before of companies seeking employees with the experience and knowledge of lean six-sigma. The certifications of Lean Six-Sigma Green Belt and Black Belt are highly sought after. Companies boast of their lean transformations and cultures and even add continuous improvement as one of their companies' core values. However, as lean practitioners, we often find that the companies that excessively advertise themselves as lean organizations are often not lean at all. Often times, companies adopt lean six-sigma methodologies and at the beginning of adoption are truly on the path of continuous improvement but as time will tell these companies fall back into their non-continuous improvement ways. That's because lean six-sigma is a journey. It is a journey in which has no end. It is a journey that, while tough, is extremely rewarding for those daring enough to begin. So what happens when a company who has adopted lean six-sigma continues to struggle with high defect rates, high employee turnover and the inability to meet demand? Leaning lean.

The exact scenario aforementioned is what we discovered upon meeting the leaders of a vehicle component manufacturing company with multinational facilities located in Japan, China, Mexico and the United States. Their facility located minutes outside of San Antonio, Texas. The company is a supplier of vehicle components for globally recognized automakers BMW, Toyota and Hyundai to name a few. The leaders explained how they pride themselves on their lean culture, but shortly after our introductory meeting and initial tour, it was clear that the company was far from lean. That became even more evident as they stated the numerous challenges they were currently facing.

2. Literature Review
The scope of this project is focused on the implementation of various tools in lean manufacturing and six-sigma to eliminate waste and improve maintenance processes. Undoubtedly, maintenance processes play a pivotal role in industrial companies and factories. The contemporary business environment has raised the strategic importance of the maintenance function in organizations, which have significant investment in physical assets. [1]. Choosing maintenance strategy were strongly correlated to the size of the manufacturing enterprise; there were large differences in adoption of advanced maintenance practices and diagnostics and prognostics technologies between small and medium-sized enterprises (SMEs) [2]. Many companies investigate the applicability of agile concept for facilities maintenance and to develop an agile integrated facilities maintenance approach to minimize uncertainty in apparel sector[3]. Recent development in the predictive maintenance and reliability market is to leverage the investment already made in process control systems (PLC, DCS, & SCADA). This allows the operations, maintenance, and process control teams to monitor and alarm vibration levels on critical machines [4]. Also developing an on-line testing to detect defects is described [5]. It have been developed a system framework based on Industry 4.0 concepts, which includes the process of fault analysis and treatment for predictive maintenance in machine centers [6]. New technology like 5G technology is expected to play an important role in ensuring connectivity on maintenance performance [7]. Another new technology that has capability is robotic. The proposed model can be used to select, design, test and validate both plants and motion control design to meet desired output performance. [8] The three-link manipulator obtained from the inverse dynamics to calculate the joint states, find and control the location of manipulator's end-effector[9]. In addition, a probable future of maintenance organizations in

digitalized manufacturing in the year 2030, based on an extensive three-round Delphi survey with 25 maintenance experts at strategic level from the largest companies within the Swedish manufacturing industry [10]. Newly developed and tested SACM-algorithms based only on signals, which are available in position controlled, drives such as position, speed and motor current. [11] In maintenance management (MM), as suggested in the paper, should enhance the effectiveness of MM leading to higher machine uptimes with less of maintenance costs. In such steps, the ease of implementation in practical situations has been given due importance [12]. In this paper, using some lean tools is suggested in maintenance process. There are many studies about these tools. Lean thinking is a mindset that focuses on the elimination of waste and encourages learning cycles by focusing on value, value stream, flow, pull and the pursuit of perfection [13] . The term lean was popularized by the success of the 'Toyota Production System' (TPS) developed under the leadership of Taiichi Ohno and Kiichiro Toyoda [13]. Lean is not only a tool in which is used in industries but also it is an appropriate tool in numerous other environments and services. This project has focused on the engineering department and die maintenance of the company. There are studies about eliminating waste in engineering, the use of this systematic method for engineering waste elimination holds significant promise for organizations wanting to outperform their competitors on quality, cost, and delivery [14]. The tools that enable waste elimination in engineering processes are equally important. Value stream mapping for manufacturing is a basic, graphical tool used to describe production processes and highlight sources of waste [15]. In order to achieve high levels of quality, safety and productivity, employees must have a suitable and spacious working environment, this is the main idea behind 5S [16]. 5S is a system of workplace organization and it is a very important tool to structure tidiness on the workplace in a rather simple way[16]. While the most successful lean applications started with the manufacturing process, due to its nature and the ability to identify the process wastes, the full impact of lean thinking can only be achieved when applied at the beginning of t
he product development process starting with early design phases[17]. Another field that can be mentioned is environmental topics. Also in this case, there are many research studies to improve processes that are related to the environment by using lean tools. The lean-green topic is an emerging and a new tool in the present scenario. The main aim of the green practices is to improve operational activities as well as environmental efficiency [18]. In some other study, their new methods in lean manufacturing. The System of system (SOS) approach currently being used in the context of complex military initiatives and on the integration of different tools, each focused on specific aspects of the manufacturing system [19]. Lean has become a "must-use" philosophy for businesses today. Lean manufacturing focuses on the elimination of waste in manufacturing operations [20]. To increase their competitiveness, organizations have started extending TPS principles to other parts of the enterprise. Engineering, especially, is seen as an area with the most potential for waste elimination and dramatic cost and lead-time reductions [20]. Over the past 20 years, there has been an evolution of competing philosophies about how to run manufacturing operations in this case, the importance of linking ERP (Enterprise Resource Planning) and Lean methods is discussed in some papers and they answer to this question "can EPR and lean co-exist?"[21]. The integration of Lean Manufacturing principles and Six Sigma DMAIC methodologies with the help of FRs, DPs and PVs are key elements of Axiomatic Designed [22]. As previously stated, this study has focused on engineering department and die maintenance in the company. There are many studies to use lean and six sigma tools to perform a maintenance system.

3. Body

Faced with a plethora of challenges, we began company's retransformation back to a lean culture within the engineering department, which seemed to be the department facing the most troubles at the time. We began by conducting a time study on the maintenance of a die with an employee of the company. From the time study we were able to develop a value stream map of the die maintenance process. In total the maintaining of the die process took about 3.6 hours. Note, in the essence of time we conducted the time study following the maintenance process of a die on the smaller end of the range of dies the company consistently operates. This overall maintenance process can be seen in **Figure 1** below. In the entirety of the process we determined the uptime to be 216 minutes and down time equated to 1605 minutes.

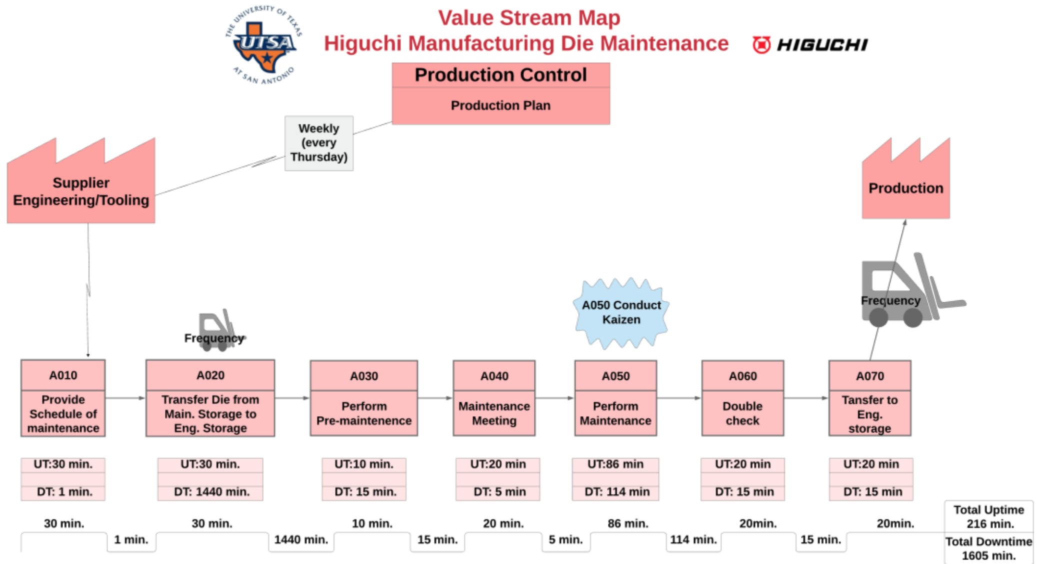


Figure 1: Die maintenance process value stream map.

With our focus lying within the performance maintenance process we developed a process flow map of this process. Shown below in **Figure 2** is this process flow map. Here we can see the total value added time was calculated to be 86 minutes while the total down time equaled 114 minutes. Following standard lean six-sigma tools, identification of areas in which the reduction of downtime could substantially be reduced was noted.

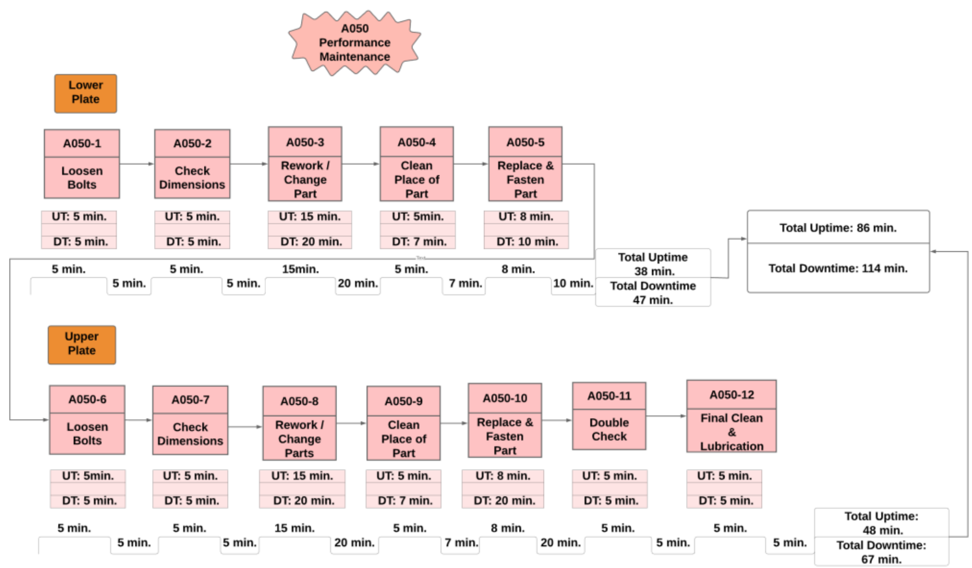
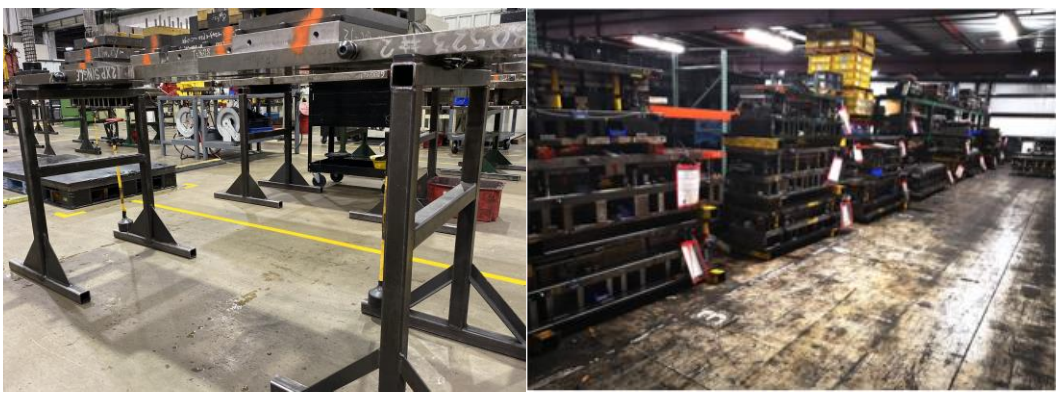


Figure 2: Performance maintenance process flow map.

Below you will find the first of several key areas in which lean six-sigma can be applied to reduce the overall downtime. 5S was badly needed in the implementation of the process; areas found in which would most benefit from this tool included the workbench table shown in **Figure 3**, and the maintenance kit shown in **Figure 4**.

Figures 3 and 4: (3) Workbench table. (4) Maintenance kit.

During our time study when the employee was working on the bottom portion of the die we noticed that he would often drop his wrench or nuts and bolts would fall onto the floor therefore increasing the possibility of damaging these components. An error proofing solution to solve this problem would be the implementation of a net in which can be draped below the die in order to catch these tools to prevent damage. In addition, this tool will prevent the worker from performing the strenuous exercise of having to bend down to the ground to pick these tools up. **Figure 5** shown below illustrates the maintenance platform this innovative solution can be applied to.



Figures 5 and 6: (5) View of die maintenance platform. (6) Storage of dies.

Shown in **Figure 6** above is another area identified needed for improvement. This image shows the storage of the dies. Dies are stored on racks; however in front of the racks are stacked dies, which limit the access to dies on the racks. This fault in the storage of dies can be easily fixed with acquiring more racks to store the dies. With the acquirement of more racks it would be beneficial to arrange the dies in a manner in which the most used are lowest to the ground and closer to the maintenance area for easier access and allows for the reduction of the wastes of motion, over-processing and waiting.

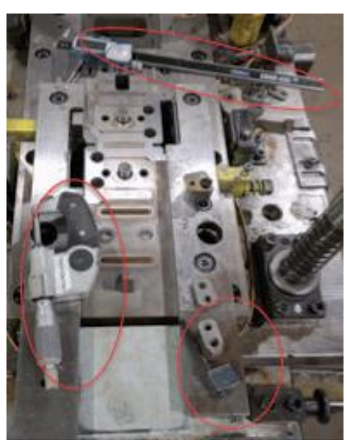


Figure 7: Visual display of tools left on die.

Figure 7 above shows the lack of 5S implemented into the die maintenance process. As you can see during this process the worker has left tools on the die during the maintenance process. This exact reason is the cause for several broken and damaged dies that occurred during the extent of our short 3.5-month long study with the company. With the implementation of 5S, we can expect for the number of broken and damaged dies to decrease.

A few other suggestions for improvement not displayed graphically include the implementation or rather reinforcement of standardized work, implementation of an MRP system and a supervisor alert system. While standardized work instructions are currently in place for die maintenance two issues are occurring. The standardized work instructions are too general and can be interpreted as vague, moreover they're just not being followed. To combat these problems, we have suggested the development of more detailed work instructions and the reinforcement or introduction of standardized work and its usefulness to employees within this area. The employees within this area are relatively new, some new to the department and others new to the company. Hence, this could be a reason as to why standardized work is not followed but with a meeting in which details the importance of standardized work and its usefulness can change this problem. An MRP system was lacking when we first began our project with the company and was ultimately a suggestion we had for the company after hearing of the occasional instances in which shims or punches were out of stock and were only discovered to be out of stock when needed. Since our time in which we first learned of this problem, excitedly the company has since purchased MRP software and it is currently being implemented. Lastly, during our time study conducted with the employee, we noticed often times he had questions or needed advice during the maintenance process from a supervisor. When this occurred, the employee would have to often search throughout the facility in order to get his questions answered. As one can imagine this resulted in a lot of downtime. To eliminate this waste of motion we have come up with a solution by implementing an Andon system, which can alert supervisors when assistance is needed within the department. In addition this system can be used for multiple purposes in that it can serve as an alert system between the production line and maintenance area when a die is ready for production which is yet another problem in which occurs.

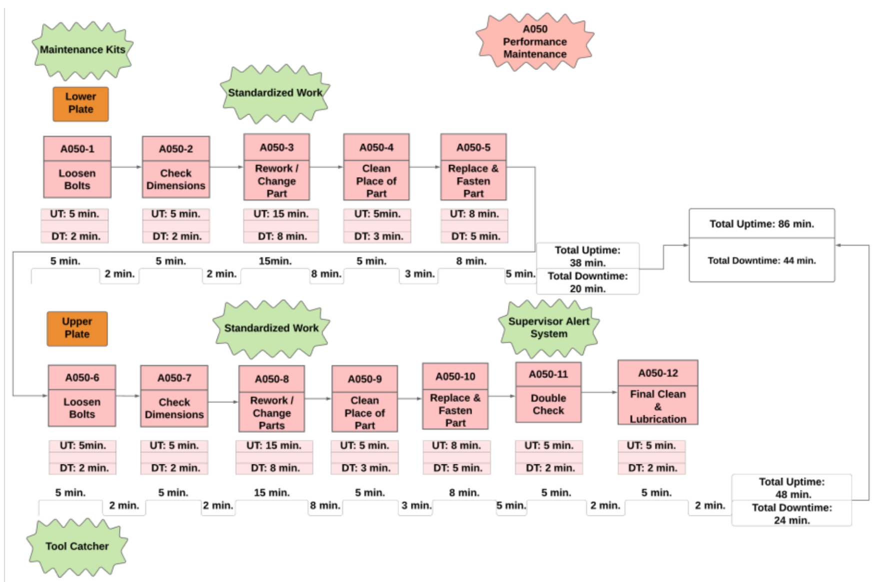


Figure 8: Improved process flow map of performance maintenance.

Figure 8 above shows a future value stream map with the adoption of our suggestions for improvement we've previously mentioned. In this case, we have applied lean six-sigma tools that have been mentioned above. To reiterate this includes maintenance kits, standardized work, a supervisor alert system, 5S and a tool catcher. Some of these very same tools have the ability to solve many of the problems the company is facing not only in this department as shown but throughout the rest of the organization. The adoption of the suggested tools would result in a reduction of downtime to 44 minutes. This equates to a reduction in roughly 60% of down time.

4. Conclusion

Downtime of the die maintenance process has been reduced by approximately 60% through the improvement suggestions of various tools following Lean Six-sigma methodology. This reduction of downtime from 114 minutes to 44 minutes equates to annual savings for the company totaling $60,000.00 USD. While these savings can both be viewed as substantial and minimal, they are a starting point needed to the transformation of this organization back to a lean culture. Following a visit back to the company, a change in the culture is prevalent. The atmosphere amongst the employees of this department, specifically the leadership has been revamped. The leaders of this department are in the process of gradually reengineering this area following our suggestions for improvement and processes with their own ideas of improvement. Following similarly in line with a few of our suggestions for improvement are two improvements the current employees have completed. First to help with the elimination of the wastes of motion and inventory in addition to the decreasing of down time is the organization of the maintenance kits shown previously in **Figure 4.** These kits are gradually becoming organized through 5S with dividers and labels for the extra shims and punches. In addition, the separation of maintenance stations by the placement of ground tape, each station now having its own toolbox and workbench table allowing for employees to further implement 5S are additional improvements.

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