Lead time reduction and increasing productivity by implementing lean manufacturing methods in cnc processing center

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Abstract. Growing competitiveness of manufacturing companies has led companies board to look for new innovative solutions to increase the productive efficiency. More and more companies are looking to maximize profit through different ways, some of them use classical methods that are focused on increasing production capacity, expanding the product portfolio, manufacturing and marketing campaigns, other operational activities, are implementing modern techniques to reduce losses. This paper propose to present the way that productivity is increased by reducing lead time through Lean Manufacturing method implementation. For this purpose a piece will be manufactured using a CNC processing center, which will contribute significantly to processing the part at a higher precision, and at the same time eliminating the down times. To highlight the contribution and the efficiency of the CNC processing center, will be present the classic production method using a classical milling machine, respectively FUS 22, the method that was also implemented, according to this case study. To analyze and graphically illustrate these two production methods, respectively classic and modern methods, VSM will be built, then the 2 methods will be compared.

1. Introduction

With increasing the competitiveness of manufacturing companies, more and more companies are investing massively in developing flexible production systems, acquiring latest technologies. Along with the new technologies and flexible manufacturing systems, it is also necessary to implement innovative techniques and methods to increase production efficiency. To this end, manufacturing companies and not only, build their strategy by using different methods and techniques for streamlining processes, and Lean manufacturing is one of the most known methods for continuous improvement that these companies have implemented [1].

Lean Manufacturing is a concept developed by the Japanese from the Toyota Production System (TPS) after the second World War (1950), when the car industry and not only were looking for new solutions to reduces production costs, and also increases production capacity [2].

Thereby, this concept of Lean Manufacturing has been developed which is a long - term strategy, having as objective identifying, respectively reducing / eliminating waste, with a focus on continuous improvement of all operational processes by implementing Lean Manufacturing specific techniques such as: Kaizen, Value Stream Mapping, just in time, Poka Yoke, 5S, Kanban, Single minute exchange of die (SMED), Pull System, Gemba, etc. [3, 4].

According to some analyzed case studies, Lean manufacturing has proven to be one of the most effective methodologies applied in the manufacturing industry, contributing significantly to the elimination of waste due to techniques and tools for continuous improvement [5, 6, 7, 8].

One of the most popular methods for identifying waste in Lean manufacturing is Value Stream Mapping (VSM), which aims to graphically visualize the entire operational flow (material flow and informational flow) [9, 10].

Once the waste from the operational process are identified, different innovative solutions are proposed through which these waste are eliminated.

In Lean manufacturing, the are called muda (in Japanese), and these waste can identified in different forms, and the waste that most affect production are transportation, waiting time and unnecessary motion [11].

Eliminating these waste (those activities that do not create value) lead to a reduction in lead time, respectively productivity growth, which is the main objective of manufacturing companies [12].

The implementation of various Lean tools within the CNC processing centers leads to optimization the production process and the elimination of dead times [13].

2. Methodology

The research methodology is based on the use of a Lean manufacturing technique, respectively VSM, with the help of which it is exemplified graphical the operational process for manufacturing a mobile plate. Data analyzed in this case study, were obtained from a production company, a company that executed this part using both production methods, respectively modern methods, using a CNC processing center and classical method using a classic machine tool. With the help of this method will be presented in parallel the benefits of production of mobile plate on a CNC processing center, respectively the classic production on a conventional machine tool. The results of the research highlight the identification and elimination of some waste in the production on CNC processing center, compared to the classic production. It reduces and eliminates certain down times, which leads to reducing lead time and increasing productivity.

3. Application of VSM and lead time reduction – a case study

In the below figures are presented the execution drawing of a mobile plate, which was executed on a CNC processing center (HAAS VF-2) and also on a conventional machine tool (FUS 22).

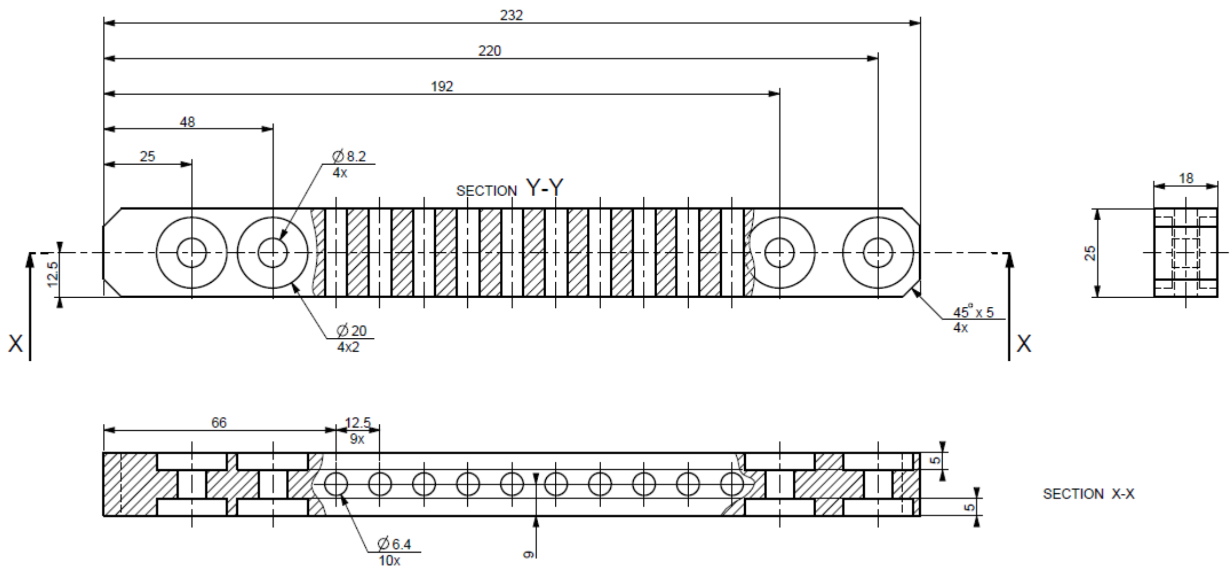

Figure 1. Mobile plate - 2D view (own source).

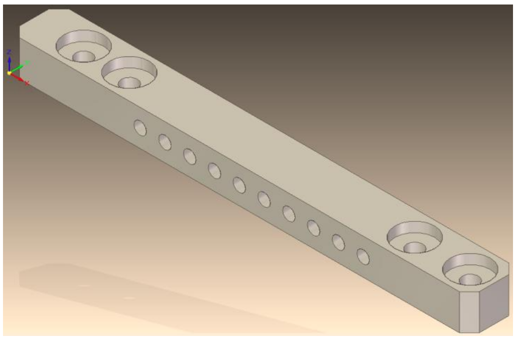

Figure 2. Mobile plate - 3D view (own source).

Part name: mobile plate
Material OLC 45 (C45)
Processing of this piece requires 3 fasteners:
1. Front Centering Φ 2, Drilling Φ 8,2, . Lamar Φ 20 plus chamfering holes outline;
2. Lamar Φ 20 (the other side) plus chamfering holes outline;
3. Front Centering Φ 2, Drilling Φ 6,4 on the front area, chamfering holes.

For processing the workpiece, the mobile plate requires the following cutting tools:
1. Drilling center Φ 2;
2. Drill Φ 8,2;
3. Milling Φ 20 with 2 teeth;
4. Hole chamfer Φ 20 at 90^0;
5. Drill Φ 6,4.

In order to execute this piece, the necessary times for the three clamps were summed up, respectively: time for setting coordinates according to the 2D execution drawing, tool changing time, tool setting time, cycle time and interphase measurement time.

After identifying the operations and the time required for the execution of the workpiece, the VSM was built, exemplifying both operational flow, respectively classic production and CNC production (according to the two figures below).

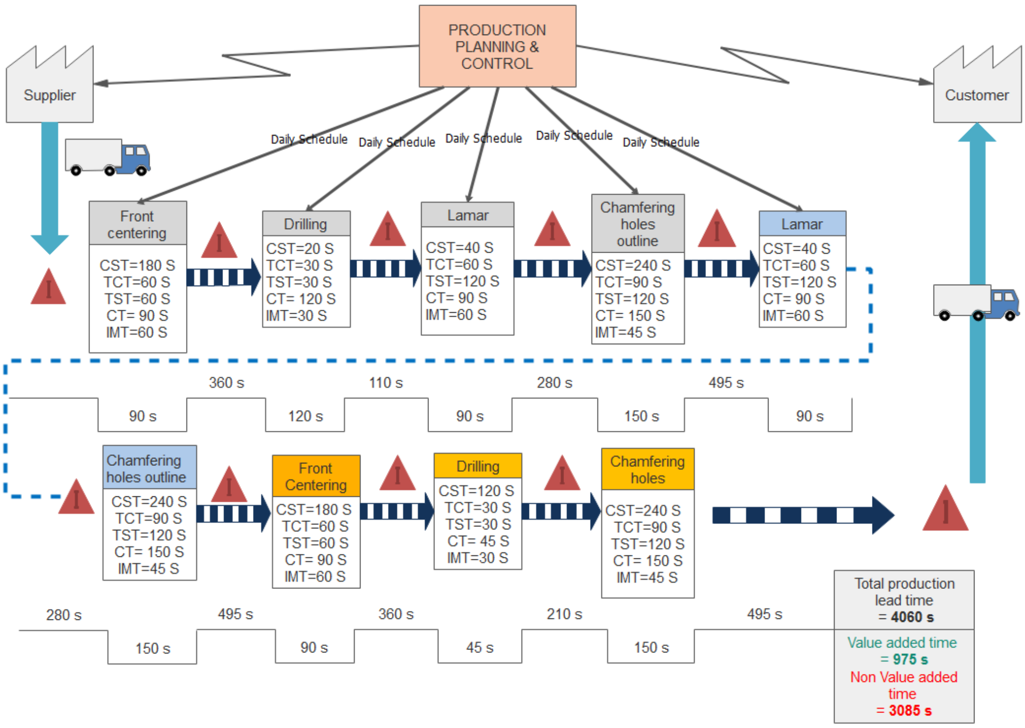

Figure 3. VSM - classical production on FUS 22 (own source).

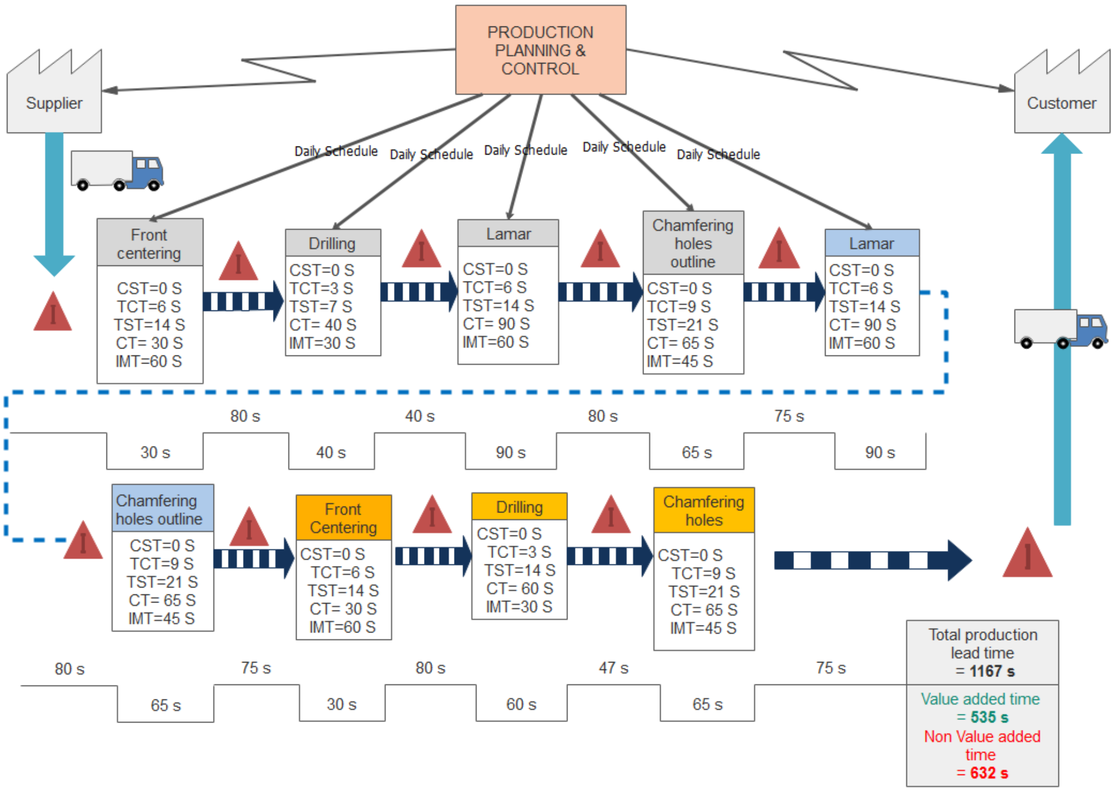

Figure 4. VSM - CNC production on HAAS VF-2 (own source).

4. Results and conclusion

The fundamental purpose of this research is to identify and eliminate the waste, respectively those activities that do not create value in the manufacturing process and also to increase productivity by reducing the lead time. Following the completion of this research, through the implementation of VSM, the percentage of down time in the classic production process was identified, as compared to the percentage of down time in the manufacturing process at the CNC processing center.

In the case of classical production, the total production lead time is 4060 seconds for a single piece, of which the value-added time (VAT) is 975 seconds and the non-value added time (NVAT) is 3085 seconds, which in the Lean production are identified as waste.

In the case of production on CNC processing center, the total production lead time is 1167 seconds for a single piece, of which the VAT is 535 seconds and the NVAT is 632 seconds (figure 5).

Applying VSM and production on CNC processing center the lead time were reduced by 2893 seconds, respectively by 71.25%.

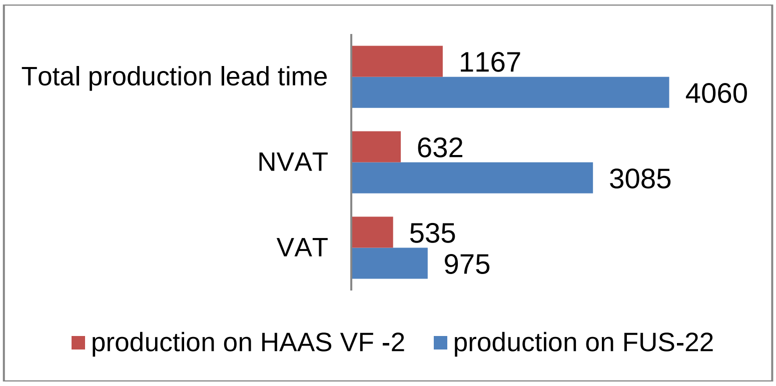

Figure 5. CNC production vs classic production (own source).

Here are some of the conclusions that was reached after comparing the two methods of production:

- processing on FUS 22 involves many down times (working with individual tools, no tool magazine, operator must move the machine table by following the coordinates)
- CNC processing reduces a lot of down times (because it has a tool magazine, displacement at the coordinates of the holes is done automatically, calculating the distances from 0 "zero" is done automatically)
- Checking the depths of the lamar (5 mm) at the processing on FUS 22, while at CNC processing center this value is respected at a precision of 0.01 mm
- the most of down time is at the change sharpening tools by hand and adjust them to the benchmark part, while at the CNC it is insert all the necessary tools, adjusts the offset of the part with the Renishaw system and then it starts without any need to stop the machine until the part is finished. The only down time being is picking up the tool from the CNC magazine.

The final results of this study confirm again the benefits of implementing Lean manufacturing methods in manufacturing companies, as well as the benefit of production on CNC machining centers compared to classical production methods.

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