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Implementation of Lean Principle to Reduce Cycle Time and Optimization of Tool Travel Path in an Indian SME

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***Abstract:* - Implementation of lean principles in manufacturing organization is rapidly increasing because of ability of lean tools to identify the wastages to remove the wastages from various stages of manufacturing. Lean mainly focuses systematic elimination of non-value added activity and wastes from a manufacturing process. This paper presents use of lean principles in a small and medium scale organization (SME) involved in manufacturing of Cam Follower Levers from an Indian Manufacturing Sector. Tool travel is identified as a waste in the current system which directly affects the cycle time and indirectly to the overall productivity. Total waste of tool travel was 1702.48 mm in previous system which after implementation of lean principle was reduced to 1629.67 mm. The reduction in cycle time found to be 1 min 35 sec.**

Keywords: Lean, Cycle Time, Productivity,

I. INTRODUCTION

Lean manufacturing is a systematic approach to identify and eliminate wastages for a manufacturing system to improve the overall productivity of the organization. Lean was developed by Taiichi Ohno, a production executive with Toyota, in response to a number of problems that plagued Japanese industry. The main problem at that time was high-variety production required to serve the domestic Japanese market. Mass production techniques, which were developed by Henry Ford to economically produce long runs of identical product, were ill-suited to the situation faced by Toyota. Today the conditions faced by Toyota in the late 1940s are common throughout industry and Lean is being adopted by businesses all over the world as a way to improve efficiency and to serve customers better [1].

Lean creates a manufacturing operation which is more focused on continuous improvement through a self-directed work force and driven by output-based measures aligned with customer performance criteria. Lean basically develops workforce which is capable of making use of the lean tools and techniques necessary to satisfy world-class expectations now and into the future [2].Lean Manufacturing and Lean Production are interchangeable terms. It is called Lean because at the end of implementation of lean principles the process can run:

- Using less material
- Requiring less investment
- Using less inventory
- Consuming less space and
- Using less people

A lean process is characterized by a flow and predictability that severely reduces the uncertainties and chaos of typical manufacturing plants [3].The concept of lean manufacturing represents a significant departure from the automated factory so popular in recent years. The "less is better" approach to manufacturing leads to a vastly simplified, remarkably uncluttered environment that is carefully tuned to the manufacturer's demands. Products are manufactured one at a time in response to the customer's requirements rather than batch manufactured for stock. The goal is to produce only the quantity required and no more. And since limited numbers of parts are produced, it may be necessary to change processes during the day--to accommodate different parts and to make maximum use of personnel, equipment and floor space. The flexibility inherent in manual assembly cells is therefore preferable to automated assembly. This requirement for maximum flexibility creates unique demands on the lean workcell and the components that make up the lean workcell[4].

Lean principles and methods focus on creating a continual improvement culture that engages employees in reducing the intensity of time, materials, and capital necessary for meeting customer's needs. While lean production's fundamental focus is on the systematic elimination of non-value added activity and waste from the production process, the implementation of lean principles and methods also results in improved environmental performance[5]

II. IDENTIFICATION OF PROBLEM

This works describes implementation of lean concept in a small medium scale industry. General Machine Tools is involved in supplying finished Cam Follower Levers(Fig.1). The main goal of implementation of lean framework in any organization starts with identification of wastages and after that strategies are finalized to eliminate or minimize the wastages from the organization. The wastages may come in form of over-production, time, inventory, unnecessary movement of material, transportation etc. The wastage which has been identified in this investigation is tool travel. During the implementation of lean principles in the organization we started finding out types of wastages. Since the organization is involved in manufacturing of automotive components the main was given to identify wastages during

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the production. During study of process of lever we found that tool is over travelling during the operation which directly increase the cycle time of the process. So efforts were taken to minimize the tool travel by changing the pattern.

Table 1 Shaft hole and Pin Hole Operations

Sr. No.	Drilling Diameter (D)	Pre-Drilled Hole Diameter (d)	
			SHAFT HOLE
1	Drill 18.80	-	
2	Reamer 19.025	18.8	
3	Chamfer 19.025	19.025	
4	Drill 18.80	15	PIN HOLE
5	Core Drill 21.80	18.8	
6	Reamer 22.207	21.8	
7	Chamfer 22.207	22.207	

Fig.1 LEVER before and after Machining

III. OPTIMIZATION OF TOOL TRAVEL:INITIATION OF LEAN

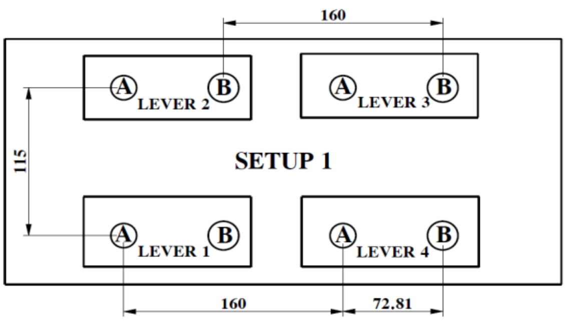

Fig.2 Arrangement of levers during machining

The Fig.2 shown above shows four levers mounted on fixture at setup 1, for carrying out operation No. 20 i.e. drilling & finishing of pin bore and shaft bore. In fig. Above A represent the shaft hole and B represent pin hole. Four levers can be machined in single setup.

The operations details of setup 1 are as follows.

As shown in the table 1above, the cycle consists of drilling, reaming and chamfering of pin hole and shaft hole. For the first drilling cycle of shaft hole i.e. for drilling holes marked as A for all four levers, the operation is started by first drilling the shaft hole of lever 1, then drilling shaft hole of lever 2, then drilling the shaft hole of lever 3 and the cycle ends with drilling the last shaft hole of lever 4. Thus, the pattern of tool travel is from Lever 1 – Lever 2 – Lever 3-Lever 4. When drilling of all holes in a cycle is completed, the tool again returns to its original position. i.e. at the hole A of lever 1. For the next operation, i.e. reaming of shaft hole, the drilling tool is changed at this original position and the process proceeds with the same pattern. The total distance travelled by the tool is-

From Shaft hole (A) of Lever 1 to Shaft hole (A) of Lever 2 = 115 mm

From Shaft hole (A) of Lever 2 to Shaft hole (A) of Lever 3 = 160 mm

From Shaft hole (A) of Lever 3 to Shaft hole (A) of Lever 4 = 115 mm

Return Travel to original position (i.e. return travel to shaft hole A) = 160 mm

Total tool travel = 115 +160 + 115 + 160 = 550 mm

When we analysed the above tool travel pattern, we found that the return travel of tool to its original position is the unnecessary tool travel which is consumes more time. If we consider all the above cycles of drilling, reaming and chamfering of shaft bore, a return travel of 550 mm will be included in each cycle.

Thus, the total return travel of tool that will increase the cycle

time = 160 $\times$ 3 = 480 mm.

Similarly, when the operations of drilling, reaming and chamfering of pin bore are started the initial position of tool will be at shaft hole of A where the previous tool will be changed. The tool will then travel for respective operation from shaft hole A of lever 1 to pin hole B of lever 1. This distance will be 72.81 mm. This distance will be for all operations of pin bore. Also after the last operation on lever 4 is completed, the tool will return again to shaft hole A of lever 1 to change the tool for next operation. This return travel will be 160 + 72.81 = 232.81 mm.

The total distance travelled by the tool is-

From Shaft hole (A) of Lever 1 to Pin Hole (B) of Lever 1= 72.81 mm

From Pin Hole (B) of Lever 1 to Pin Hole of (B) of Lever 2 = 115 mm

From Pin Hole (B) of Lever 2 to Pin Hole of (B) of Lever 3 = 160 mm

From Pin Hole (B) of Lever 3 to Pin Hole of (B) of Lever 4 = 115 mm

Return Travel to original position (i.e. return travel to shaft hole A) = 160 + 72.81 = 232.81 mm

This tool travel from Shaft hole (A) of Lever 1 to Pin Hole (B) of Lever 1 after changing the tool for next operation and return tool travel to its original position will be added in every operation cycles of pin bore.

Thus, the total return travel of tool that will increase the cycle

time = (232.81 + 72.81) $\times$ 4 = 1222.48 mm.

Thus the total waste of tool travel on for setup 1 = Tool travel waste in machining of (A)

+

Tool travel waste in machining of (B)

Total waste of tool travel on for setup 1 = 480 + 1222.48= 1702.48 mm

This distance is the unnecessary tool travel during the drilling, reaming and chamfering operations of pin bore and shaft bore. Thus, this is a machining pattern waste that is eliminated by changing the tool travel pattern.

In the new tool travel pattern, machining of shaft bore is carried out as follows-

From Shaft hole (A) of Lever 1 to Shaft hole (A) of Lever 2 = 115 mm

From Shaft hole (A) of Lever 2 to Shaft hole (A) of Lever 3 = 160 mm

From Shaft hole (A) of Lever 3 to Shaft hole (A) of Lever 4 = 115 mm

Change of tool at shaft hole (A) of lever 4 & machining commences from lever 4 itself in reverse path i.e. Lever 4 – Lever 3 – Lever 2 – Lever 1. Thus, the unnecessary tool travel of 160 mm during the return travel to initial position i.e. to shaft hole (A) of Lever 1 is eliminated.

Similarly, in new tool travel pattern, machining of pin bore is carried out as follows-

From Shaft hole (A) of Lever 1 to Pin Hole (B) of Lever 1= 72.81 mm

From Pin Hole (B) of Lever 1 to Pin Hole of (B) of Lever 2 = 115 mm

From Pin Hole (B) of Lever 2 to Pin Hole of (B) of Lever 3 = 160 mm

From Pin Hole (B) of Lever 3 to Pin Hole of (B) of Lever 4 = 115 mm

Change of tool at pin hole (B) of lever 4 & machining commences from lever 4 itself in reverse path i.e. Lever 4 – Lever 3 – Lever 2 –Lever 1. Thus, the unnecessary tool travel of 232.81 mm during the return travel to initial position i.e. to shaft hole (A) of Lever 1 is eliminated. Also, the tool travel from shaft hole (A) to pin hole (B) lever 1 which is 72.81 mm in each cycle will be eliminated.

Hence, the total tool travel waste reduced = 480 + 1149.67 = 1629.67 mm

This elimination of this tool travel results in reduction of cycle time by 3 sec in machining operations of setup 1. Hence the total cycle time is reduced by 1 min 35 sec. The final cycle time is 3 min 55 sec.

The reduction in cycle time increases productivity.

The working hours / shift = 6.5 hours = 390 min.

Initially, for four components, time required is 5 min 30 sec. i.e. 5.5 min.

Setups completed with initial cycle time = $\frac{390}{5.5}$ = 70 setups.

Total cycle time reduced = 1 min 35 sec = 1.58 min.

New cycle time = 3.91 min.

Setups completed with initial cycle time = $\frac{390}{3.91}$ = 100 setups.

Hence, 30 setups can be increased in each shift due to the reduced cycle time.

IV. CONCLUSION

Implementation of lean principles in a small and medium scale organization (SME) involved in manufacturing of Cam Follower Levers from an Indian Manufacturing Sector. In a manufacturing organization variety of wastages can be identified during different processes. In this study it has been indicated that how a small change in set up can minimize wastage of time in the production to improve the cycle time. Tool travel is identified as a waste in the current system which directly affects the cycle time and indirectly to the overall productivity. Total waste of tool travel was 1702.48 mm in previous system which after implementation of lean principle was reduced to 1629.67 mm. Due to this small change the reduction in cycle time found to be 1 min 35 sec.ie previously the cycle time was 5 min 30 and due to reduction of unnecessary travel of tool the new cycle time is sec 3 min 55.So this increases the number of set ups completed in one shift from 70 to 100.Hence overall productivity of organization also improves.

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