International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Improving Productivity by Reducing Cycle Time Through New Fixture Design and Inspection Method

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Abstract: ***In this aggressive global the manufactures need to deliver their product in a shorter term. To fulfill the customers, the manufacture must reduce the unnecessary process time and the errors. In this paper, the clutch operating lever production line in an automobile industry was analysed. The bottleneck operation was found in a fixture design and during the inspection process. A new fixture and an inspection gauge are designed to reduce the setup and inspection time the clutch production. The overall loading and set up change over time is reduced by the newly designed fixture which reduces the end-line defects and saves time and effort. The productivity is highly increased by 55% by the newly designed fixture and the inspection rate is boosted by 80% and the rejection rate is reduced by 83% which is proven by the comparison to older methods.***

Keywords: Clutch operating lever, Fixture design, Inspection time, Cycle time.

I. INTRODUCTION

The clutch of a vehicle plays a major role in its working. This helps us to change gears easily and to move faster with a good amount of torque. These are generally used to control, where the power transmission happens. In simple term, it connects and disconnects two rotating shafts. The clutch has many parts, in that the clutch operating lever is also one important component. A lever assembly performs engaging and disengaging operations of clutch. The manufacturing time taken for the production of the lever is high. This results in increase in cost. The lead time and the cycle time in the operation plays an important in higher production times [1]. The lead time variance can be identified and could also be solved be new optimization methods [2].

Revised Manuscript Received on October 30, 2019.
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The cycle time must be calculated and analyzed for a good improvement of time reduction [3]. The reduction of cycle time of non-value added activities and lean manufacturing will also help in the time reduction. [4]. But in some places the cycle time is important to be maintained, so in those areas the cycle time must be carefully optimized [5]. The planning of the process
flow of a product manufacturing also affects the cycle time. [6]. The usability of a product must be considered and the lack of machines and labor also take account in cycle time problems [7]. The lead time reduction helps in a greater way for many problems arise in the manufacturing [8]. By using new methods in manufacturing, we can reduce many problems involved [9]. In this type of manufacturing, designing a new fixture will greatly decrease the cycle time [10]. The assembly time reduction will also help in cycle time reduction [11]. The inventory of all parts also plays a role in reducing the cycle time of a product during manufacturing [12]. The most import of all is to use lean manufacturing techniques and to give more importance for the quality and timeliness of the product production [13], [14].

II. METHODOLOGY

The clutch operating lever is commonly made of En8 an unalloyed medium carbon steel which has high strength levels due to its thermo mechanical rolling. This lever is assembled with the clutch which helps in engaging and disengaging operations of the clutch. The methods of manufacturing this lever include many different operations like milling, drilling, chamfering and so on.

A. Process flow for clutch operating lever

The process flow diagram shows in figure 1 reveals the various operations and their sequence involved. The process starts with the purchasing of raw material and its inspection. The setup 1 carries the drilling and chamfering operation, followed to setup 2 which carries slot and radius machining and passes to the setup 3 which carries back chamfer. Final inspection follows to dispatching and packing the product.

B. Existing method

The existing method is fully based on vice. Where the component is being held in a vice and drilling and chamfering operations are done and then it is lifted to 12mm to achieve 20 degree another drilling process and radius milling is also done, then finally vice is brought to horizontal position for chamfering. The inspection of the product is done manually with the use of Vernier, height gauge, bevel protractor and a CMM.

The lever placed horizontally for drilling and angularly for slot milling are shown in figure 2 and 3.

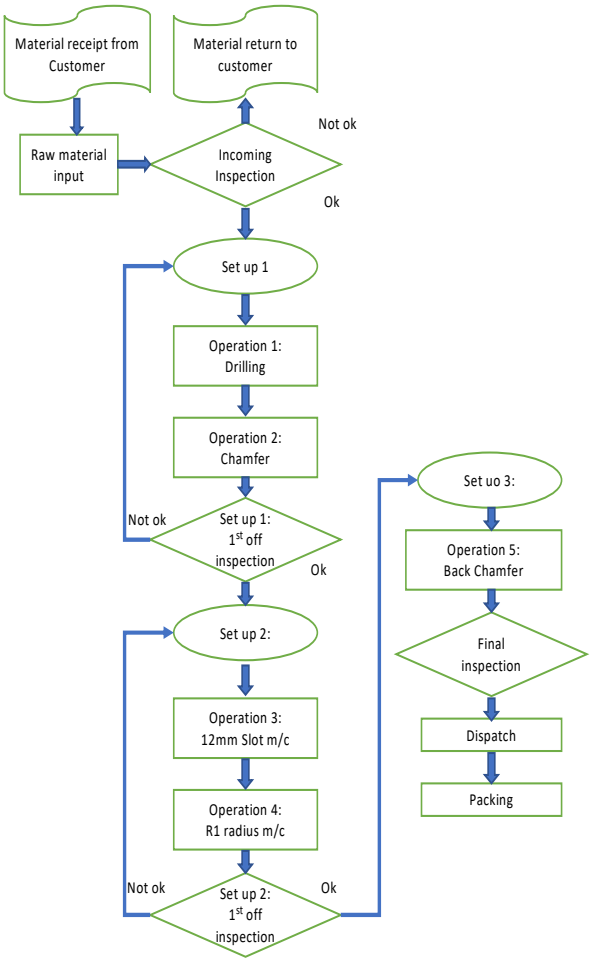

Fig.1. Process flow chart for clutch operating lever

Fig.2. Horizontally placed lever for drilling.

Fig.3. Angularly placed lever for slot milling.

C.Existing process cycle time

The existing process cycle time is shown in figure 4. The setup 1 has two operation drilling and chamfering where the operation time is 2.36 minutes and the setting time is 8 minutes. The setup 2 also has two operations slotting and radius machining where the setting time is 31 minutes and the operation time is 2.02 minutes and finally the setup 3 does back chamfer where the operation time is 0.09 minutes and the setting time is 6 minutes. The total value added time is 4.47 minutes and the non-value added time is 45 minutes.

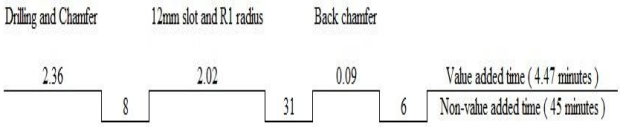

Fig.4. Existing process cycle time chart.

D.Existing inspection method

The existing method for inspecting a single product comes around 30 minutes. This results in lesser production and this causes fatigue in the inspection person which leads to wrong inspection.

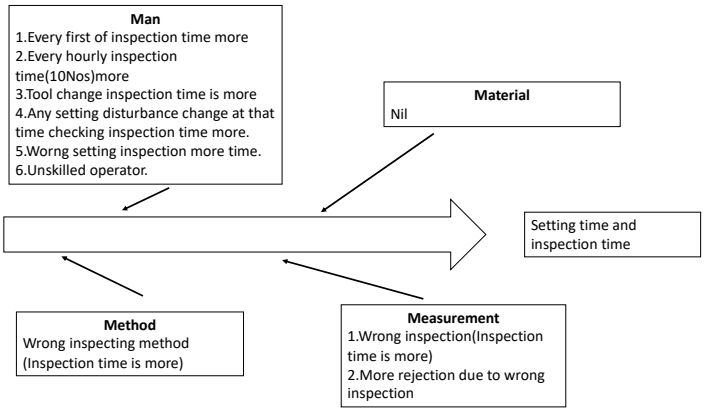

Fig.5. Root cause analysis for inspection method.

The root cause analysis of the setting and inspection time gives out various aspects of errors caused form the individual who does the inspection and the methods used and the measurements taken. The root cause analyse details are shown in figure 5. These errors which are being caused during the setup and inspection time leads to greater errors and waste of time. Then why – why analysis shows the necessity of a new fixture for inspection. The whys are 1) Low production in machining, 2) high setting time, 3) Angle slot milling and its setting difficulty, 4) No proper angle setting method. From all these whys we can conclude that slot off set checking takes more time. This lane a way to use the fixture. The other why – why analysis of inspection is on whys 1) High rejection rate, 2) High setup rejection, 3) No proper method for checking angles, 4) No poka yoka for inspection. This shows the time consumed for certain process is very high which has to be reduced.

III. IMPROVEMENTS

This project is to improve the set up time and to improve the manufacturing time of the clutch operating lever and also to design an inspection gauge which helps in reducing the inspection time and errors happen.

The multi-component fixture helps in improving productivity by reducing the setup time and the idle time of the machine. The inspection gauge improves the efforts of final inspection and prevents from the repetition of common mistakes. On the whole, these factors reduce the cost of production.

A. New production method

A new fixture shown in figure 6 is designed which is shown in figure 6 can accommodate maximum of 24 components considering the length of an axis in the machine. It is loaded for drilling and chamfering operation and the fixture is positioned with the help of dowel pin and clamped downwards with toggle clamp. It is then loaded on 20 degree angle plate. Then turned backwards and loaded for back chamfer operation. The loading and set up time is reduced and minimizes rejections due to improper setting in fixture.

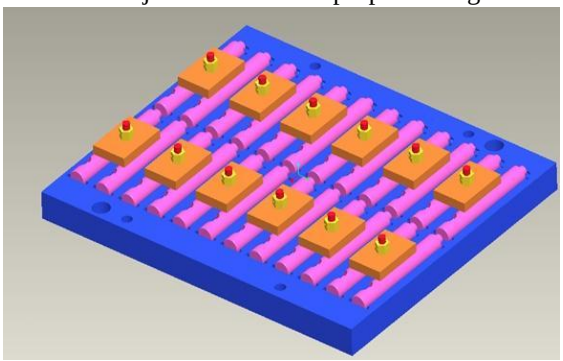

Fig.6.fixture and the clutch operating lever assembly.

A new gauge is designed and the inspection is done using synchronized gauge and shown in figure 7. The overall length, angle of the slot, the true position of drilling hole, diameter of hole, chamfer angle and depth can be checked by using this gauge. It acts as a poka yoke process which helps to eliminate manual errors.

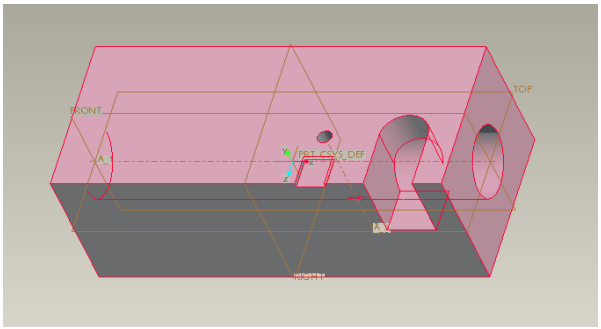

Fig.7. Three dimensional view of the newly designed inspection gauge.

B. Concept of fixtures

The 3-2-1 method is an effective method for locating a rectangular workpiece. In this method 3 datum points support the workpiece, 2 datum points located a flat work piece surface and a 1 datum point locates a second surface perpendicular to the previous surface.

C. Fixture design analysis

The job material is EN8 and the volume of material removed during machining is 2863.76 mm^3. The part load acting on the fixture is 1.30 N/ Part and the total load for 24 parts is 31.25N. The fixture designed and analyzed for EN has maximum load of 125 N considered for 25% of machine load.

D. Fixture production process

The fixture production process follows the Milling, surface grinding, ball nose milling, thread milling, clamping accessories machining, and heat treatment for 55 to 60 hours, surface finishing cleaning, and fixture assembly.

E. New process cycle time

The new process cycle time is shown in figure 8. The operation time taken for the setup 1, setup 2 and setup 3 are 2.36 minutes, 2.02 minutes and 0.09 minutes. The cycle time taken for the setup 1, setup 2 and setup 3 are 6 minutes each. For the new process the total value added time is 4.47 minutes and non-value added time is 18 minutes.

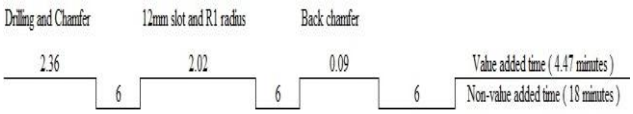

Fig.8. New process cycle time chart.

IV. RESULT AND DISCUSSION

A. Time study

Comparison of existing and new methods for setup 1 is shown in figure 9. The new process method has a lesser setting time compared to a reduction of 2 minutes form 7 minutes to 5 minutes and the total cycle time has a huge reduction from 10.35 minutes to 8.35minutes. The cycle time for 24 pieces is reduced from 248.4 minutes to 200.4 minutes. The percentage of cycle time reduction is 19% and the time saved is 48 minutes.

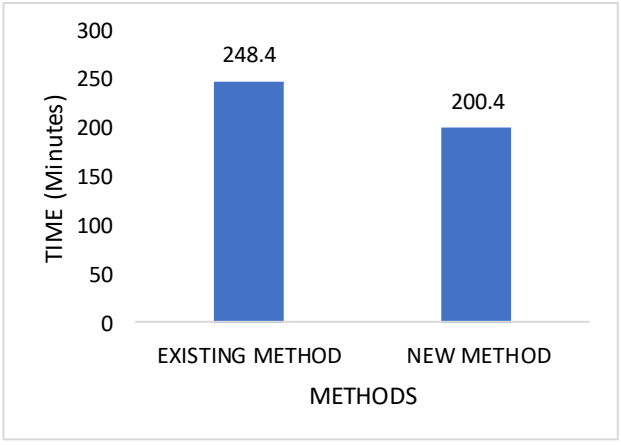

Fig.9. Comparison of existing and new methods for setup 1

Comparison of existing and new methods for setup 2 is shown in figure 10. In setup 2 the setting time is reduced from 30 minutes to 5 minutes and the total cycle time is from 33.02 minutes to 8.02 minutes and the cycle time for 24 pieces has a massive drop from 792.48 minutes to 192.48 minutes. The percentage of cycle time reduction is 76% and the time saved in 3-slot checking is 600 minutes.

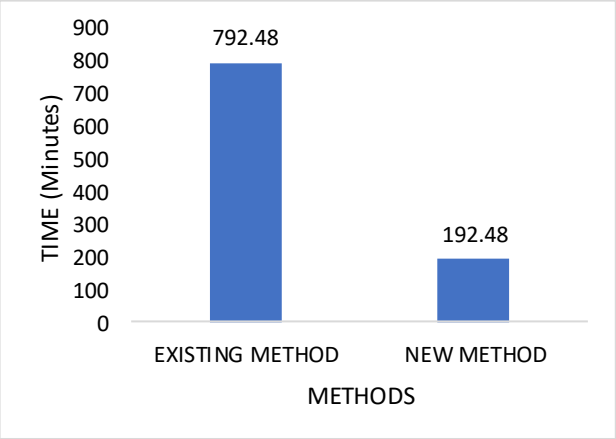

Fig.10. Comparison of existing and new methods for setup 2

Comparison of existing and new methods for setup 3 is shown in figure 11. The cycle time in setup 3 has no big difference and it stays the same and the total cycle time for 24 pieces also stays the same. When compared to the existing method, the production fixture saves a considerable amount of time for. It is seen that on an average of 648 minutes of Productivity time are reduced when using the new fixture.

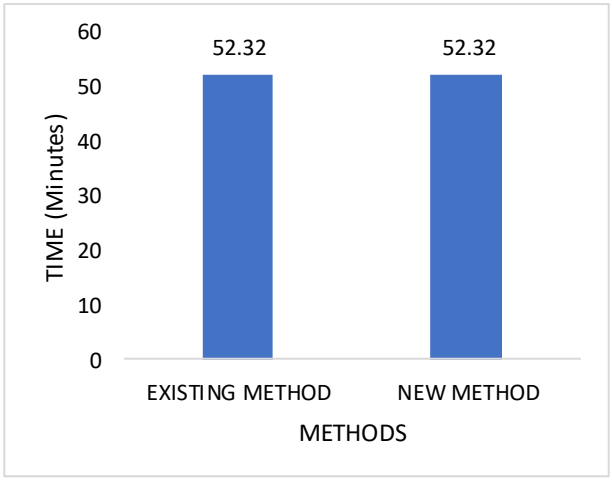

Fig.11. Comparison of existing and new methods for setup 3

B. Total cycle time

Comparison of existing and new methods for Productivity is shown in figure 12. In comparison to the existing method, the use of fixture helps to produce 660 components per day, which enables a faster rate of production 55%. The cycle time of old methods is 49.46 minutes and for the new method is 22.46 minutes.

C. Inspection time

Comparison of existing and new methods for Inspection time is shown in figure 13. In contrast to the existing method, use of newly designed fixture helps us to complete the inspection of 2160 components per day at a rate of 80%. The inspection time for the old method is 10 minutes and the new method is 2 minutes, which is a greater reduction of time and cost.

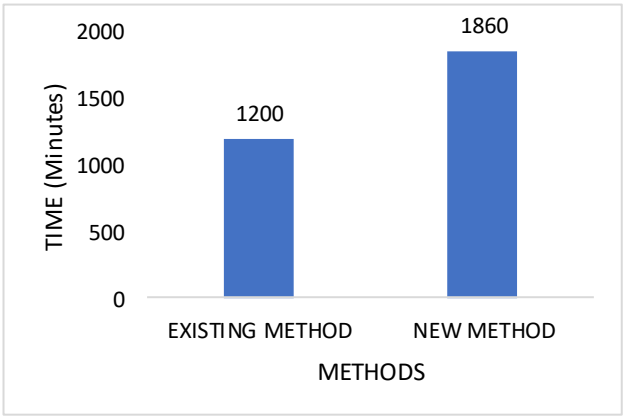

Fig.12. Comparison of existing and new methods for Productivity

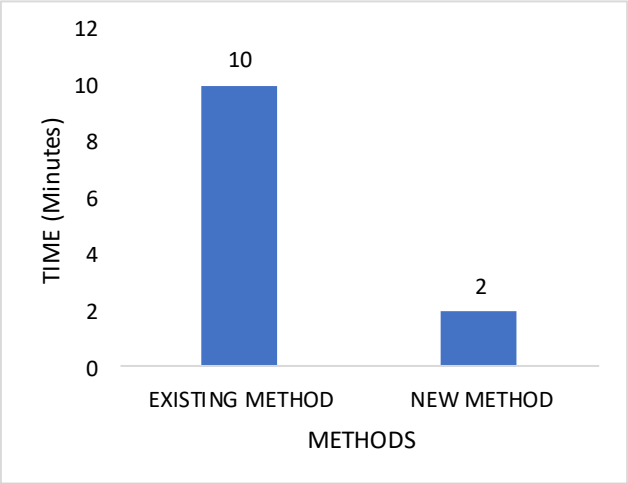

Fig.13. Comparison of existing and new methods for Inspection time

D.Rejection rate

Comparison of existing and new methods for Rejection rate is shown in figure 14. The rate of rejection before and after the usage of the newly designed fixture is from 30 numbers to 5 numbers. The percentage of rejection is aimed to achieve at least 10% to 20%, but the new fixture helped to achieve 1.77% error. The percentage of rejection rate is 83%.

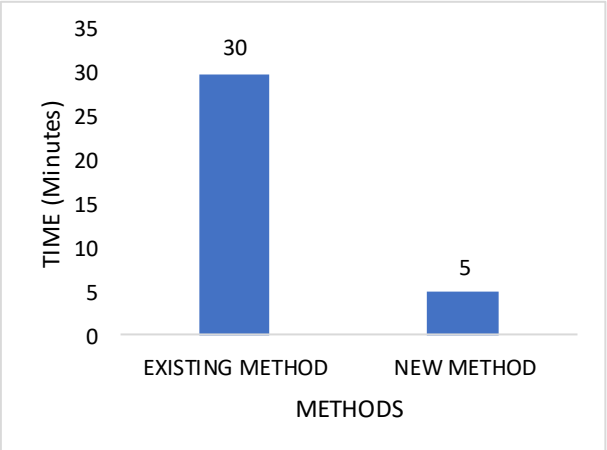

Fig.14. Comparison of existing and new methods for Rejection rate

V. CONCLUSION

A fixture used to hold a workpiece while it is being used for production is termed as Production fixture. In this project fixture was successfully designed and fabricated for improving productivity and & quality. The inspection time for the clutch operating lever is also reduced. The production time reduced drastically by using the newly designed fixture. The productivity time is reduced to 55% of 680 minutes which helps us to achieve a target of 15% to 20%. The use of newly designed inspection gauge reduces the time by 80% and also the rejection of 83% which enables the rate by 1.77%. The considerable saving in production and inspection time is directly proportional to its cost.

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