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Analysis And Implementation Of Productivity Improvement In Cylinder Head Rough Machining

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Abstract— The cylinder head rough machining unit at Chennai plant continues to face the challenges of improving productivity. It is important to provide the desired quantity to the end consumer by improving the efficiency of the plant. The company has a production capacity of almost 142 components per day. This capacity cannot be produced due to various losses. The study aimed at identifying the root cause of these losses and to propose methods to increase the productivity. Pareto chart and bar graph are used to plot various factors that affect productivity. This project mainly focuses on reasons for breakdown, part rejection and high cycle time, which is a threat to the organization. In order to improve the productivity of the organization, the most severe cause is identified which is the high cycle time of the process. Then it is studied in detail and found that among 15 operations, the operation 85 (Bolt hole drilling) exceeds the target time. On observing the split-up time of operation 85, it is found that the time taken by the drilling cycle is high. Hence it was suggested to increase the feed (m/min) of the tool in order to increase the productivity. Thus, a better system was proposed and implemented in the organization under study.

Keywords— Bar graph, breakdown, cycle time, cylinder head, drilling cycle, pareto chart, productivity, target time

I. INTRODUCTION

The global market for motorcycles continues to grow, with an estimated 100 million units currently in use. In this expanding market, it is imperative that manufacturers of high-volume motorcycle components reduce scrap and maximize machine productivity to meet the growing demand, as well as increase profits[1]. Manufacturers of motorcycle cylinder heads use CNC machining centres for high-volume, small-tool drilling and tapping operations. Such light machining operations are at risk of high tool breakage rates, resulting in potentially significant scrap volumes and related costs[2] [3]. High scrap also results in significant non-productive time in terms of rework and machine down-time.

The problem was that the cylinder head rough machiningunit of the industry was not able to fulfil the customer requirements. The company's actual production was very less as compared to customer requirement. The company wasproducing 132 numbers per day while the requirement was of 142 numbers per day. So, there was the gap of 10 numbersper day. Hence in order to meet the customer's requirements,certain major factors are studied and recorded.

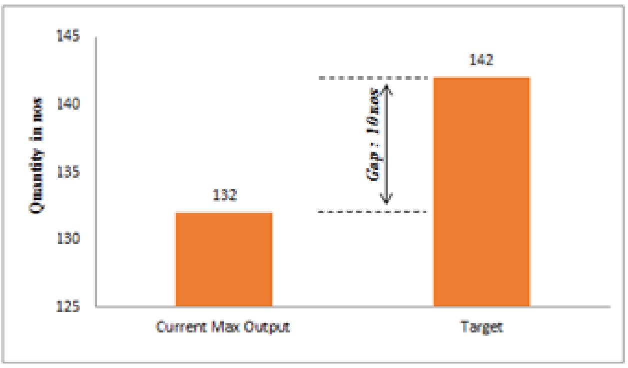

Fig. 1. Problem description chart

In an internal combustion engine, the cylinder head sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. Thehead can also be a place to mount the valves, spark plugs, and fuel injectors.

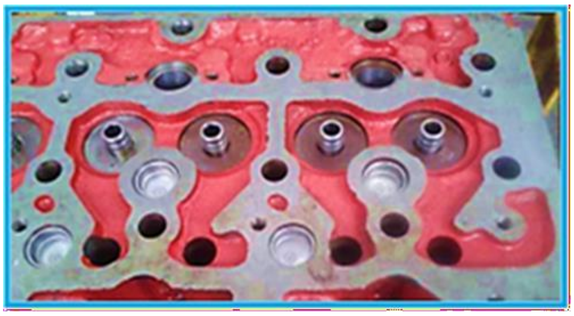

Fig. 2. Cylinder head

Operations in Cylinder Head Rough Machining Unit; The following operations take place in the Cylinder Head Rough Machining unit in Shop VII:

TABLE I. OPERATIONS LIST OF MACHINING PROCESS

Operation	Machine	Operation Description

Num ber	No.	
10	114 94	Rough Mill Rocker Face
20	114 95	Rough Mill Combustion Face
30	114 96	Semi-Finish Mill Rocker Face
40	114 97	Semi-Finish Mill Combustion Face
50	115 31	Generate Process Dowel and Mill front face
60	114 98	Rough and Semi finish mill EMF and IMF
80	115 00	Push Rod Holes
85	114 04	Bolt hole drilling
90	115 01	General Washing
100	115 35	VG. Spring seat, Rocker shaft fixing holes, WP operations, Bolt hole Spot face, Chamfer
110	115 32	IMF, Front and Rear End Operation
120	115 33	EMF Operation.
130	115 34	Injector bore & Injector Fixing holes
140	115 36	Cuttering on IN &Ex, Valve Seat -In &Ex, VG -Counter bore, Oil Hole, Water Holes
150	115 02	Sp. Holes Wash

Total number of machines = 15

II. ANALYSIS ON FACTORS AFFECTINGPRODUCTIVITY

The various factors affecting the production rate areanalysed. These factors are listed below:

A. Analysis on Breakdown

B. Analysis on part rejection
C. Analysis on cycle time of the machining process..

A. Analysis on Breakdown

Identification of causes for breakdown

The breakdown occurred during the year 2017 has been analyzed and sorted based on their frequency of occurrence. The breakdown is caused due to many parameters such as breakdown due to machines, absenteeism, material, power, plnd cut and tools. These causes are compiled by using Microsoft Excel 2016.

The following are the details of the performance of the unit during the period April 2017-January 2018:

Fig. 3. Performance graph

By analyzing the graph drawn above, it is clear that the breakdown due to machine contributes 10.08% than the other parameters causing the breakdown. Hence it is further analyzed so that it gives the number of breakdowns caused by each operation of the rough machining process. Also, the breakdown that are caused due to tools are studied in order to achieve the target.

B. Analysis on Part Rejection

Identification of causes for part rejection

In order to identify the various reasons for the rejection of the component, observation for the rejection of component has been studied and the major contributing reasons has been correlated and put down in figures. It is given as follows.

Fig. 4. Parts rejection details

In the above figure the analysis of the part rejection hasbeen putdown in diagrams denoting the various causes for the part rejection. Thus, by observing the figure it is found that the major contributing factor is the material scrap, front end unwashed and missing of operations. Hence to reduce the component being rejected, it is necessary to find out the root causes for these issues and the appropriate actions must be suggested.

Root cause analysis for part rejection

In order to identify the origin of the problem (i.e.) the primary cause of the problem, certain specific steps where followed. The root causes for the factors are given below:

Material Scrap

Material scrap is due to blow holes, inclusion and cracks in the casting material, where gas bubbles are called blowholesor blisters. Such defects can be caused by air entrained in the melt, steam or smoke from the casting sand. Scrap consists of recyclable materials left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. Unlike waste, scrap has monetary value, especially recovered metals, and non- metallic materials are also recovered for recycling.

Inclusions are caused due to break-up of mould sections during stripping of patterns, core setting or assembling of moulding flasks and uneven compaction of moulds.

Front end unwashed

- When the front face of the cylinder head is not completely machined at the end of the process, then it is known as front end unwashed. This is due to the misalignment of the male and female part of the core. This is one of the most common reason for the part rejection and thus this holds the majority of the percentage of the reason for part rejection.

Missing of operations

- This due to the operators' mistake during machining process. Around shop seven if anyone of the operation is missed that will lead to part rejection because it makes the component unfit for further uses.
- If a component is missed out in any one of the operations then it will either rejected and it will be sentto rework.

Suggestions to solve the root causes

Improve core venting, provide venting channels, ensure coreprints are free of dressing.

- Reduce amounts of gas. Use slow-reacting binder.Reduce quantity of
- Apply dressing to cores, thus slowing down the rate ofheating and reducing gas pressure.
- Operators must inspect properly at the end of eachoperation of the machining process.
- Front end unwash can be reduced, if there is a proper foundry practices which includes melt preparation and mould design.

C. Analysis on Cycle Time of Machining Process

Cycle time is the total time from the beginning to the end of the process, as defined by the industry. Cycle time includes process time, during which a unit is acted upon to bring it closer to an output. This is one of the causes which decreases the production rate of the unit. Therefore, to increase the productivity, the cycle time must be reduced so that the machining line can produce the desired number of components that are required by the customer.

The following equipment is needed for time study work.Timing device

Time study observation sheetTime study observation boardOther equipment

Methodology Assessment

The first step in any cycle-time reduction program is to understand the current state (i.e.) measuring the time taken by each component at each operation of the cylinder head. After obtaining the data, it will be understood that which operation has the highest effect on cycle time. The information is given in the form of a Pareto chart which will be used later as a guideline for cycle-time improvement.

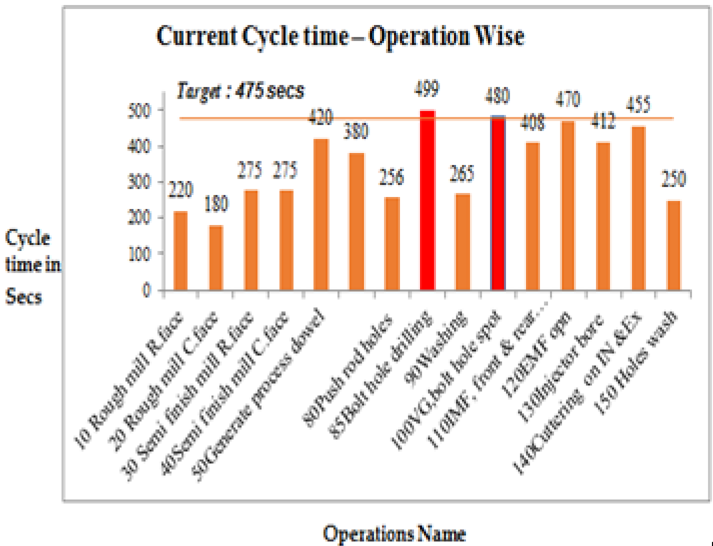

Fig. 6. Cycle time for various operations

Therefore, the operations 85 (Bolt hole drilling) and 100 (Valve guide spring seat, fixing holes, WP operations, Bolt hole spot) are exceeding the takt time. Takt time is theavailable production time divided by the units of customer demands. It is the rate at which a finished product needs to be completed in order to meet customer demand. Hence it is clear that the cycle time for the above operations had to be reduced in order to meet the requirement.

From the observed unit, it has been inferred that if the effects due to factors such as breakdown and part rejection are rectified, the required target cannot be achieved. The reason behind this being the fact that there is a high probability of the reason for the breakdown recurring in the future. The reason for breakdown includes ATC oil leak, seat check issue, end effectors issue and etc. Another major reason for the loss in the production rate is the rejection of the manufactured product and this is due to defects thatoccur during casting i.e., casting defects such as blow holes, inclusions, cracks, reduced thickness of wall and etc. Thus, by analyzing the unit, a conclusion has been arrived to that by reducing the cycle time of the process, the entire productivity of the unit can be increased to a satisfactory level. Thus, the operation 85 (Bolt hole drilling) which has the highest cycle time, is studied in detail so that certain action can be taken in order to reduce the cycle time whichin turn will increase the productivity.

Fig. 7. Bolt hole on cylinder head

Analysis of split up time

Once the bottleneck operations had been identified, the next step is to determine the split-up time for the operation. Each operation is associated with loading, clamping, machining, unclamping and unloading. Hence the time taken for the process has been recorded and it is put down in the form of Pareto chart. The Pareto chart is one of the seven basic tools of quality control. The Pareto principle also known as the 80/20 rule, the law of the vital few, states that, for many events, roughly 80% of the effects come from 20% of the causes.

Fig. 8. Pareto chart for operation 85

On observing the above Pareto chart, it is clear that the time taken for machining is contributing 75.4% of the process. Therefore, the machining time is further measured and it is also given in the form of Pareto chart.

Fig. 9. Pareto chart for machining time

By Pareto chart analysis, it is observed that the machining time is contributed by the time taken by drilling cycle, Feed approach, next drilling cycle position, rapid return, rapid approach of Z axis, rapid movement to spindle unit. Fromthe graph, it is found that more than 90% of total cycle time is due to the time taken by drilling cycle and also the operation is done by a single tool.

Process optimization is the discipline of adjusting a process so as to optimize some specified set of parameters without violating some constraint. The most common goals are minimizing cost and maximizing throughput and/or efficiency. This is one of the major quantitative tools in industrial decision making. When optimizing a process, the goal is to maximize one or more of the process specifications, while keeping all others within their constraints. This can be done by using a process mining tool, discovering the critical activities and bottlenecks, and acting only on them.

In order to reduce the cycle time and to optimize the process, it was suggested to increase the speed of the tool. Feed is the distance through which the tool advances into the workpiece during one revolution of the workpiece or the cutter. The machining parameters of the existing tool and new tool are given as below:

TABLE II. COMPARISON OF CUTTING CONDITIONS

Content	Operation	Speed Rev/min	Feed mm/min	Cutting speed m/min
Before	Drilling Cycle	1400	434	57
After	Drilling Cycle	1850	500	76

Thus, by analyzing the above parameters, the suggestion given to reduce the cycle time is to increase the feed of the tool. In order to increase the feed certain range has to be fixed, so that the required specification can be obtained.This range is fixed by increasing the feed in discrete steps to a fresh tool with old specification. This process is stopped when the targeted time is reached. The new specification and application of the tool is given as:

Old Tool specification

Diameter: 13mm solid carbide drill Specification: KC7935 grade comparison Make: Kennametal

2 New Tool specification:

Solid Carbide Drill Diameter: 13mmMake: Kennametal

Specifications: KC7215, Grade CRM:0065036 – SteppedSolid Carbide drill

III. IMPLEMENTATION OF NEW TOOL TO IMPROVEPRODUCTIVITY

Drilling tool is modified to remove more amount of metal from the material in order to reduce the cycle time by increasing the feed. It is also modified to eliminate the coolant blockage by providing provision for coolant on the periphery of the drill. It ensures proper coolant flow to the bolt hole to avoid burr accumulation.

After implementing the modified tool, the test trial report provided by the supplier is analyzed and compared with the old specification and put down in figures. Therefore, the targeted cycle time is achieved and with this cycle time the productivity can be increased to fill the gap and it will be sufficient to satisfy customer’s requirement.

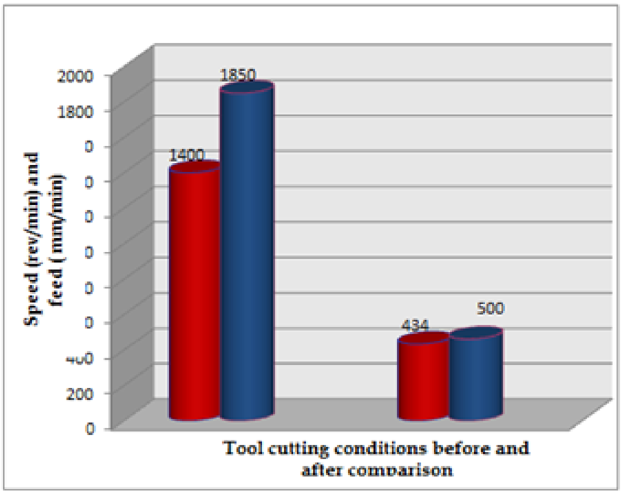

Fig. 10. Cutting conditions

Fig. 11. Cycle time comparison chart

IV. CONCLUSION

The cylinder head rough machining unit, under the study faces many issues related to productivity loss. By analysis, the root causes were identified. The study identifiesbreakdown, part rejection and high cycle time as the major cause for loss of productivity. It was found that among the three major causes, if the effects caused by the high cycle time is rectified then the unit can increase the production rate.

Therefore, a proposal was given to reduce the cycle time. The proposal was that to increase the feed (mm/min) of the tool. Thus, the proposal was implemented by the unit and it has reached the rate per day from 132 no. of components to 142 no. of components, which is the quantity required by the customer.

[2] Hong Liu, Fan Peng, and Yi Liu, "Final Machining of Large-Scale Engine Block with Modularized Fixture and Virtual Manufacturing Technologies" Hindawi Journal of Engineering Volume 2017,
Article ID 3648954, 6 pages; https://doi.org/10.1155/2017/3648954

[3] Taro Nakamura, "The Development of High Efficient Machining and Transfer Process for Cylinder Head/Block Machining Line'', SAE International 2015-01-0507 Published 04/14/2015.

[4] Tejaskumar S. Parsana, “A case study: to reduce process variability of valve seat depth in cylinder head using Six Sigma methodology,”
Int. J. Productivity and Quality Management, Vol. 17, No. 4, 2016
[5] Yongguo Wang, a, Xiaoguang Chen and Gang Liu, PCD Reamer for Machining Cylinder Head,” Solid State Phenomena Vol. 175 (2011) pp 321-325.
[6] Jeffrey Q. Xie, John S. Agapiou, David A. Stephenson and Patrick Hilber "Machining Quality Analysis of an Engine Cylinder Head Using Finite Element Methods," Journal of Manufacturing ProcessesVol. 5/No. 2, 2003
[7] Juvinall RC, Marshek KM. Fundamentals of machine component design. 5th ed. New York: John Wiley and Sons; 2011.
[8] Stephens RI, Fatemi A, Stephens RR, Fuchs HO. Metal fatigue in engineering. 2nd ed. New York: John Wiley and Sons, Inc; 2000.
[9] Barky ME, Zhang S. Fatigue spot welds. In: Lee YL, Pan J, Hathaway RB, Barkey ME, editors. Fatigue testing and analysis: Theory and practice, New York: Butterworth Heinrahmanemann, 2005, p 285-311.
[10] Evaluation of machining strategies in cylinder-block manufacturing Dynamic modeling, Maria Floriana Bianchi Master’s Thesis, Maria Floriana Bianchi.
[11] European Aluminium Association (auto@eaa.be) The Aluminium Automotive Manual, 2011.
[12] OHC JOURNAL REPAIRS by Larry Carley Technical Editor lcarley@engine-builder.com ENGINE BUILDER, 6 2002.
[13] Motorcycle cylinder head machining: reduce scrap and increase machine productivity, Case Brief, RENISHAW, Issued: 09, 2015
[14] Tungaloy - Industry Solutions -providing solutions for each industry.

REFERENCES

[1] Vikas Gulati and Harwinder Singh, "Improving Machining Productivity of Single Cylinder Engine Block – A Case Study of Manufacturing Organization," International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 5 (2018) pp. 2147-2157.