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Line Balancing and facility optimization of Machine Shop with Work Study and Simulation Tool

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Abstract – *Along with quantity the quality of finished part is examined strictly for the purpose and application of the finished part, the quality of production system is also important. Quality of production system in terms of utilization of machines and humans involved in system is important. Lean manufacturing concept is all about improving the performance continuously by eliminating the waste and to become competitive in production. The study focuses on a machine shop working in industrial sector with its sister companies, fluctuations in demands and also new critical developments for batch production are the main obstacles that shop is facing in their normal routine work. We are studying the newly introduced batch production system to increase the productivity and utilization of facilities involved in the system with work study and simulation tool. The process of machining is studied by method study, The standard times are calculated by time study, the proposed modifications in current working system are examined using simulation tool FlexSim. Simulation assists to study precisely the different manufacturing scenarios and machine arrangements; it gives sophisticated advantages than other methods like mathematical method. FlexSim is best way to compare the results obtained by certain changes in experiments in such cases.*

Key Words: Lean Manufacturing, Method Study, Time Study, Simulation, FlexSim,

1. INTRODUCTION

The Machine shop unit is working almost more than 20 years in automobile parts and ancillary's field. They have achieved great success in developing and supplying of machining critical components to the exact needs. In previous stages industry was not in mass production but working in batch production. In past few years they are facing fluctuations in demands and new critical developments for batch production. These fluctuations lead them into loss of controlled production, production losses due to improper capacity planning. Fluctuations in demands and also new critical developments for batch production are the main obstacles that shop is facing in their normal routine work. Due to such reasons, they are failing to meet monthly targets also the loss of controlled production, idle machines and operators, difficulties in manpower planning. Aim of the study is to observe and analyze the machine shop working having combination of newly introduced batch and old mass production and confirm that the shop is balanced well and put forward the corrective measures.

Machine shop is facing some problems like, No standard time defined for the stages of machining, WIP-Work in process inventory present in inaccurate amount, Idleness of machineries, Failures in meeting the weekly dispatch targets, Idleness of workers, Problems faced in manpower allocation and its planning. With the help of Work study and simulation tool we are going to identify the hidden reasons behind idleness, bottlenecks and provide the suggestions to minimize it.

2. LITERATURE REVIEW

In most of the industries some common types of wastes are present like defects, excess production, excess processing, idleness, unnecessary material movements, etc. These wastes may affect as increase in cost of end products. Basically, lean manufacturing is a bunch of scientific tools which belongs to common departments present in an industry. Lean manufacturing is a way of enhancing productivity by eliminating or reducing these different wastes present in industries as well as eliminating the non-value adding activities.[1.1] Reduction in waste results in reduction of total manufacturing time and improved quality of the product. There are different lean tools for identification of sources of wastes in system and to study its effect on overall system, after the identification some lean tools are helpful for study how the wastes can be eliminated. Though the lean manufacturing is mostly a managerial function its awareness in workshop and lower-level personal is very important to get the benefits of such philosophies.[1.2] The study of designed part or product for the purpose of defining the best suitable method of producing it and also specifying the time to perform it by the chosen method. Therefore, it comprises of two areas of study one is method study or motion study and time study that is work measurement. Method study known as work method design, it is applicable to new parts as well as used for existing parts to find better way of manufacturing the parts that is safe, require less effort, and time.[2.1] Time study provides the standard specified time that is the time needed by a worker to complete a part by the suitable preferred method or the method already defined by method study. Time study is important for proper planning of manpower, machinery, equipment requirement also material requirement planning, per unit cost of production, labor

budget, etc. Hence with the application of method study and time study in industries, we can achieve better output, quality at low cost and hence productivity can be improved.[2.3] In simple words VSM is a tool used for creation of material and information flow map of a product or process. Different departments in any industry use value as a word for different meanings, mostly production department relates it to cost of production. A value adding activity of a process is that activity for which the customer is willing to pay. A value stream consists of non-value adding activities with all the manufacturing processes including supportive activities to convert raw material into finished goods. It is a lean manufacturing tool to develop an efficient production process through systematic data collection and analysis. [3.1] At most of small and medium scale industries parts are produced in batch type production with process type of layout, this results in greater WIP, material handling, difficulties in achieving delivery schedule targets, frequent changes in set ups which leads in improper utilization of machinery. For such situations GT is the technology that adds the advantages of mass production in to the batch production. [4.1] Line Balancing, the word 'line' used in following case is for production or assembly line and its balancing means to make production system smooth and efficient by running all the operations or machines with same pace or dividing the rate of work among the workstations, workers, and machines evenly. Also in another way we can say assignment of proper quantity of machines and workers to each operation to achieve the required rate of production with less idle time. [6.1]

3. METHODOLOGY

The main objective of the current machine shop study must begin by identifying and listing down the problem, then required data should be gathered for the analysis. The area where the improvement is needed to be identified based on the information collected. An analysis should be done to find the exact part that is most likely to be improved. Practical difficulties during actual implementation will be identified through trial execution and the working should be verified by simulation software FlexSim. Discussion must be made on the results of simulation experiments and its results before the conclusions.

4. DATA COLLECTION AND PREPARATION

The machine shop unite works on rough foundry products to make it full finished part involving super finishing processes. By listing the parts that the machine shop having regular demands for the past few years, to understand the working of machine shop we observe each part, how it passes through differ machining process, the sequence and type of material handling systems used, if they move single piece or form an unite load. And developed the process flows of respected part that is machined in machine shop. On collected data and by discussing with shop authorities we selected MK 25 HUB for further studies considering economic contributions, manual efforts involved and the technical considerations.

By collecting all the information and specifications of machine shop facilities we developed the process flow chart and geometric layout for the MK 25 HUB.

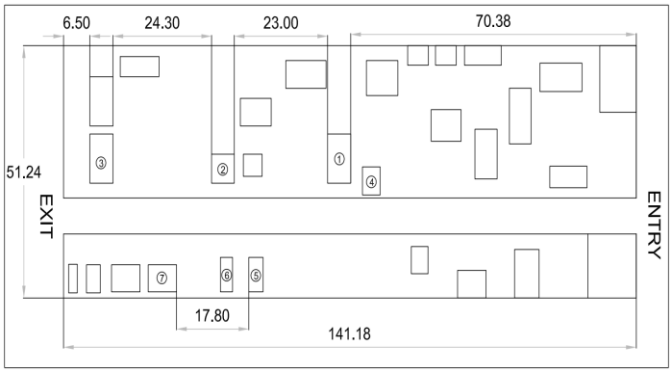

Fig -1: Geometric layout

[1. CNC06, 2. Vertical Broaching Machine, 3. CNC01, 4. Deburring Table, 5. Burnishing Machine, 6. Inspection Table, 7. Grinding Machine]

5. CONCEPTUAL MODEL

As the name itself indicates, model that represents all the important elements and its characteristics as they exist in actual machine shop. Man, Machine, Material, Material handling equipment, inventories, input or incoming material, etc. are the main elements of machine shop as we identified and our machine shop simulation model should have in it.

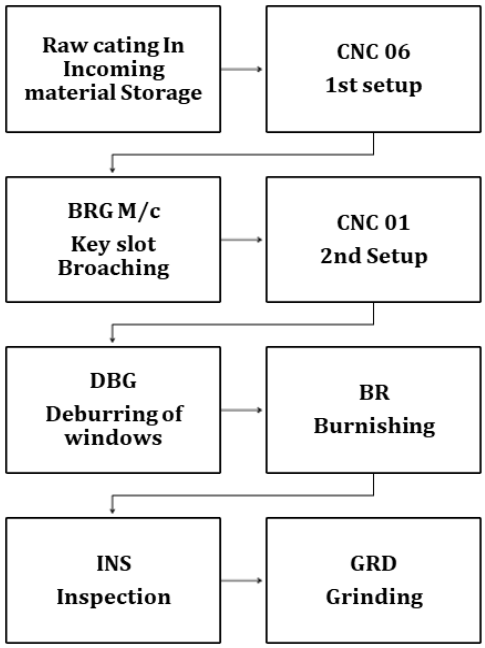

Fig -2: Conceptual Model

5.1 Selection of Process variables

As the objective is to improve productivity the output of system is first performance variable, and second is utilization of machines.

6. WORK MEASUREMENT

Work measurement or simply the time study by video recording of each machining activity then breaking down them into small elements then summarizing and adding allowances to basic time gives the standard cycle times for the processes involved in machining the Hub. Also the summery gives the non value adding activities that should be avoided to reduce cycle time or setup time which will impact positively on total processing time.

Table – 1: Time study summery report for MK25 HUB

Sr no.	Operation	Set up/Loading Unloading Time (sec.)	Process time (sec.)
1	1st Setup	22	240
2	Broaching	46	30
3	Deburring	2	80
4	2nd Setup	24	80
5	Burnishing	10	41
6	Grinding	24	153
Total		128	624
Total (sec.)		752	
Total (min.)		12.53	

7. MODEL TRANSLATION

Using FlexSim Express the actual machine shop unite is imited in flexSim. The dimensional layout in imported and the elements provided by software fixed resources and task executers the machines and operators are placed at the locaton.

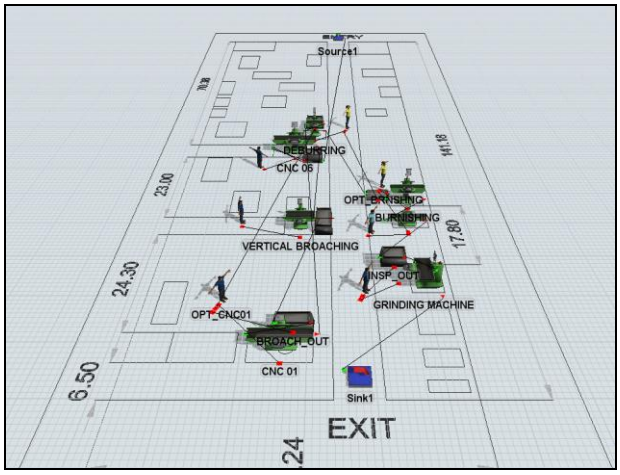

Fig -3: Primary Model

Model verification is done by comparing the developed model with conceptual model and by deterministic approach using average cycle times cross verifying the constant output that system gives on trial runs. Then by using the normal probability distribution for setup and process times of machines validated the model comparing the actual machine shop dispatches and the output of trail runs of system for the same period of time, which will be the stochastic model for the experiments.

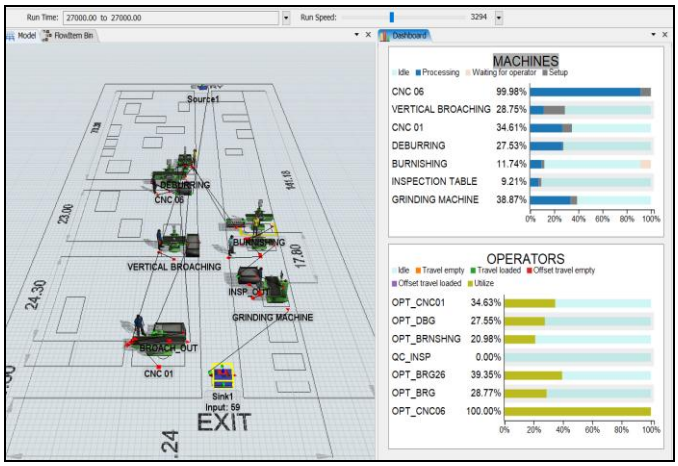

Fig -4: Existing system run for 8Hrs. shift.

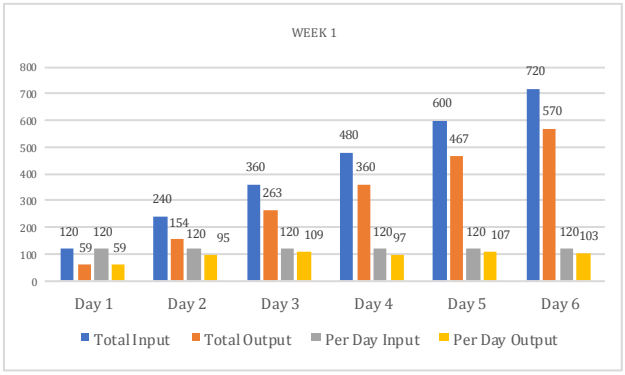

Chart -1: Name System output for a week of 8Hrs. shift.

8. EXPERIMENTATION, RESULTS AND DISCUSSION

Current system shows the output of 59 Hubs. against the input of 120 for 8Hrs. daily shift. And the utilization of all the machines except machine used for 1st setup, also the inventories remain unfinished at the end of shift.

8.1 Experiment No.01:

Focusing on the inventory levels remained unfinished decided to run the shift for 12 Hrs. and it shows that the targets are achieved in fact the system processed the Hubs more than the requirement but the utilization of machines and operators remain belove the 50%.

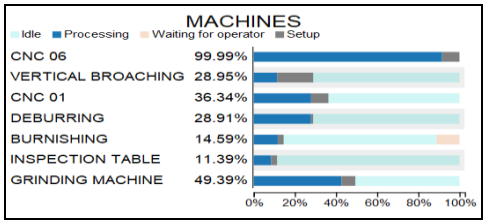

Chart -2: Machine utilization for a week of 12Hrs. shift.

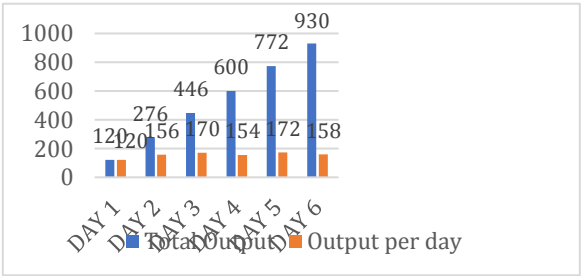

Chart -3: System output for a week of 12Hrs. shift.

8.2 Experiment No.02:

Bottleneck present at the 1st setup of process that idles the other machines in system. The cycle time is almost double the other processes hence introducing additional CNC to the system to match the pace.

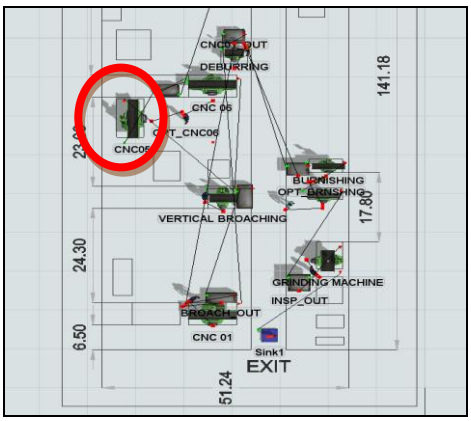

Fig -5: System with additional CNC

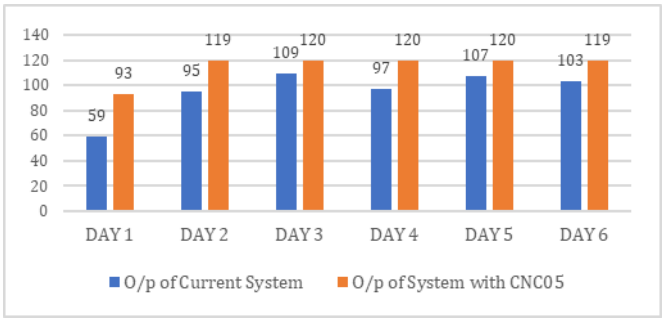

Chart -4: Current system Vs. System with additional CNC

This system produces nearly what actually required by the schedule per day. The output is improved by 21.22%. but looking at utilization rates the all the machines are under utilized also the operators are under utilized hence the system not fulfills our prime objective. Addition of CNC to the 1st setup the bottleneck is shifted from first two machines in the system but observed that the two CNC machines can process basic requirement in half of the shift. And remain idle for the other half. Hence it is better to divide the system in two groups and run them alternately. Also, can request for double the input as the system capacity is increased.

8.3 Experiment No.03:

Dividing our system in two groups,

GROUP A : CNC05 and CNC06

GROUP B : Vertical Broaching, CNC01, Deburring, Burnishing, Grinding Machine.

For the aim of increasing the utilization running the GROUP A in first 8 Hrs. shift and the GROUP B in second 8 Hrs. shift of the day.

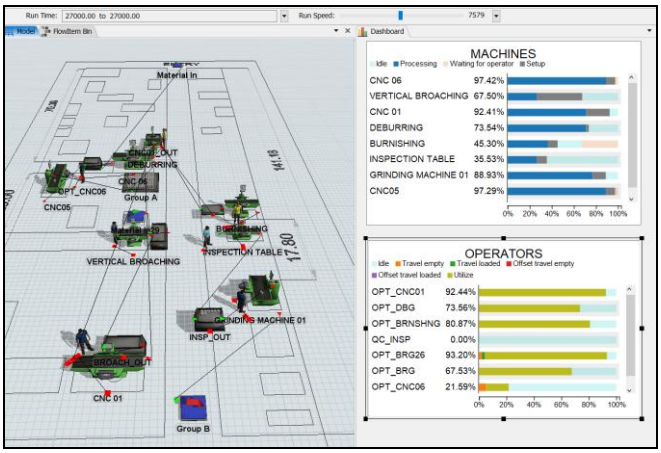

Fig -6: GROUPA and GROUP B run for 8Hrs. shift

GROUP A

The output of the group A (200) is close to the target quantity 240. We are suggesting the cycle time reduction, if possible, for the 1st setup operation with the use of different inserts and tooling which can be used at higher speed feed rates, and the setup time of 22 sec. can also be minimized by operator training. We are asking to CNC setter for reduction of cycle tome by 30 sec. and setup time for 10 sec.

GROUP B

The output of the group is 139 which is not feasible, Reason behind that is the cycle time of grinding machine. Grinding is the bottleneck operation here, as the input to the process is 240 and the output is 139 HUBs.

8.4 Experiment No.04:

Grinding is a finishing process and by studying the process it seems that the operator is fully involved throughout the cycle time and there are small possibilities of reducing the cycle time. Hence, we are looking for the grinding machine which is under maintenance present near the Grinding machine involved in the present system.

In this experiment working for removal of bottleneck present near last process grinding, to tackle the problem assuming the machine under maintenance present near the grinding machine is ready for performing same operation as Grinding Machine 01. Second Modification is the setup and process time of 1st set up is reduced by 10 sec. and 30 sec. respectively.

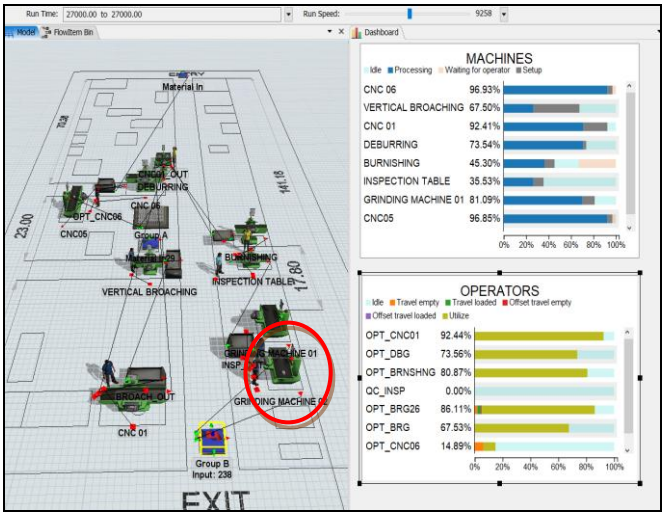

Fig -7: GROUPA and New GROUP B run for 8Hrs. shift

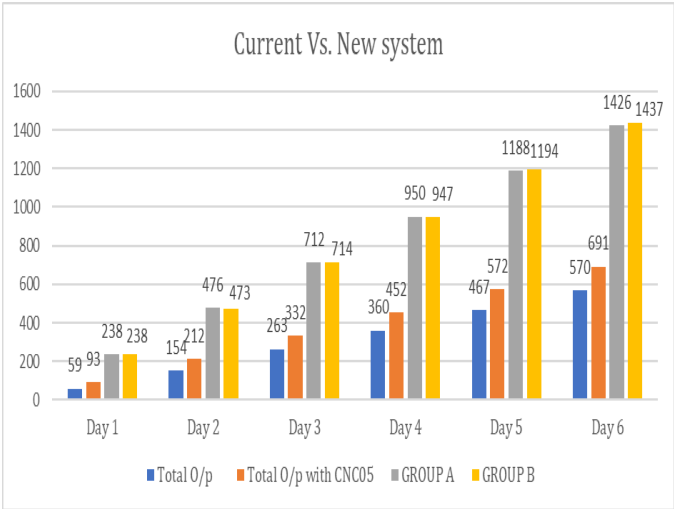

Chart -5: Comparison of all systems experimented

The system run in groups for alternate shift matches the output to the required per day input and the utilization of all the operators and machines involved in processing Hubs are above 70%. It seems that by that modifications all the objectives can be achieved.

9. CONCLUSIONS

In this study, by video recording and time study standard times for the processes involved in the machining of MK 25 HUB is calculated. The cycle times and the time study data can be used as base for the further studies, when ever the supply and demand fluctuate in the future the data can be used to set optimum machining system for the HUB.

Table – 1: Expenditures, Results and Expenses

Experimental Details	Expenses
Experiment No.01 • Current system run for extra 4 Hrs. i.e., Daily shift of 12 working Hrs. • Output – Target achieved • Machines and Operator Utilization – Except CNC06 all are under 40%	Six operator having Avg. daily wadges 390 Rs. Worked for additional 4Hrs. Total30000Rs.Per month
Experiment No.02 • Introduced CNC05 in the system. (bottleneck-CNC06) • Increases in productivity by 21.22% (for same 8Hrs.) • Output of 570 Hubs at the end of week increased to 691 Hubs. • Machines and Operator Utilization - Except CNC06 all are under 40%	Machine Hr. rate(350) of CNC05 added to the expenditure Total 2800 Rs. Per day Total 72800 Rs. Per month
Experiment No.03 • Dividing system in two groups increasing input to 240 unites running them alternately. • Utilization of all the machines above 70%. • Bottleneck present in group B which gives output of 139 finished hubs against 240.	Machine Hr. rate(350) of CNC05 added to the expenditure Total 2800 Rs. Per day Total72800Rs.Per month
Experiment No.04 • Introduction of grinding machine no. 02 in system for bottlenecking near grinding operation. • Daily 240 output after 16 Hrs. • All machines and operator utilization above 70%.	Machine Hr. rate(280) of CNC05 added to the expenditure Total 2240 Rs. Per day Total58240Rs.Per month Operator 10000 Rs. Per month

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