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Implementation of Queuing Theory Along with Lean Technique in Manufacturing Industry

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Abstract - **This research provides a context for investigating the integration of queuing theory and scheduling approaches with the goal of more effectively solving scheduling problems arising in dynamic environments. In this thesis main objective of research are applied queuing theories in a production line by using an analytical model, using a queuing model to examine performance of a production line, To give information about the studied production line in this case study and To improve both efficiency and performance of workstations. This research work is carried out in Pressroom Industries limited, Bhopal. This industry produces variety of products such as sprocket, spur gear, helical gear and gear housing etc. In this work spur gear manufacturing is taken for study. At first different manufacturing processes (cutting the bar stock, OD turning, center drilling followed by boring, CNC machining, gear hobbling, debarring, keyway slotting and gear grinding) are identified. It is found the cutting, hobbling, drilling and slotting process are bottle neck processes. From the analysis it is found that the setup time of keyway slotting consumes more time. Using SMED concept single pallet is converted to two pallets.**

Keywords - **Productivity Improvement, Queuing Theory, CNC Machining, Bottleneck Process, Gear Manufacturing.**

I. INTRODUCTION

The history of mankind shows that the way we live our lives has been largely driven by great innovations. Man has always formed novel ways of meeting all upcoming requirements whether it is advent of the wheel or the personal computer or information technology devices. The way these, revolutionizing tools have been used brought a profound impact on the human society. The thirst for knowledge and improving the quality of life has led us to a better understanding of the environment we live in.

Numerous reasons caused man to colonize a venture that would have been unsuccessful if he had not learnt tolerance, especially the patience of waiting for others. One of them stopped somewhere and waited for others to join. It was this tolerance and patience of waiting for others because of which the colonies came into existence. With the growth of the world's population man's colonies grew into urban communities of various sizes. He started leading an ordered life as he had to rely on the services of others to a large extent to satisfy his own demands .If man had followed a philosophy of "immediate service on demand", the result would have been an uneconomical utilization of his total efforts, interpersonal harmony would never have got developed and his problems would have been numerous. Waiting, therefore, became a part of life and waiting line thus is common place usually formed by units, customers, messages that queue up awaiting service while the presence of waiting lines is very obvious and predictable. The prediction about the detailed behavior can be made possible only by a systematic study of waiting lines.The queuing theory in the industry process used simulation models to study behavior of the industry process to improve work station's productivity by reducing waiting time. Engineers have applied results of queuing theory to show how cycle time is related to utilization of machine and statistic of inter-arrival time and service. These analyses provide means and predicting the average cycle time in steady-state condition. Queuing Theory can be applied in the assembly production line by using an analytical model. Validation of the task time value resulted by comparing it with the task time value based on the company database. Queuing model is a guide to improve both efficiency and performance in every workstation at the production line.

II. METHODOLOGY

To accomplish the objectives of this study, the following steps were used

1. Select a production line to be studied.
2. Collect data for each workstation. The data are throughput rate, number of operator, and number of parts that arrived and leave during part processing. Data for the numbers of parts that arrives, and leaves

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are collected at least at the amount of ten samples to make the data is possible to be analyzed by Chi Squared Goodness Test.

3. Analyze the arriving and leaving data by Chi-Squared Goodness Test to determine its variable distribution (Exponential or Poisson distribution).
4. Conduct performance measures of each workstation by using equations based on Queuing theory. The performance measures need to be measured are: utilization factor (ρ), percentage of workstation idle time, number of parts in system (Ls), number of parts in the queue (Lq), waiting time spent in the queue (Wq), waiting time spent in the system (Wa), and task time.
5. Determine the efficiency of each workstation.
6. Make validation of the task time value resulted at step (4) by comparing it with the task time value based on the company database.

The equations based on Queuing theory that is used in this study can be described as follows.

$$\rho = \frac{\lambda}{\mu}$$

where, ρ is utilization factor, λ is average number of parts arriving in one unit of time, and μ is service rate to parts in one unit of time.

Percentage of idle workstation = (1– ρ) 100%

$$L_s = \frac{\lambda}{\mu - \lambda}$$

where, Ls = number of parts in system

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

where, Lq = number of parts in queue

$$W_q = \frac{L_q}{\lambda} = \frac{L_s}{\mu}$$

where, Wq = waiting time spent in

$$W_s = W_q + \frac{1}{\mu}$$

where, Ws = waiting time spent in system

$$\text{Task time} = \frac{1}{\mu}$$

Total task time = setup time + inspection time + task time + waiting time in queue

$$\text{Cycle time} = \frac{\text{production time available per day}}{\text{demand per day or production per day}}$$

$$\text{Efficiency, e} = \frac{\sum \text{task time}}{(\text{number of operator}) \, X \, (\text{assigned cycle time})} \; x \; 100\%$$

$$\text{Maximum number of operator} = \frac{\sum_{i=1}^{m} \text{time for task } i}{\text{cycle time}}$$

III. MANUFACTURING OF SOLID SPUR GEARS

The manufacturing process of solid (conventional) spur gear is shown in figure 1.

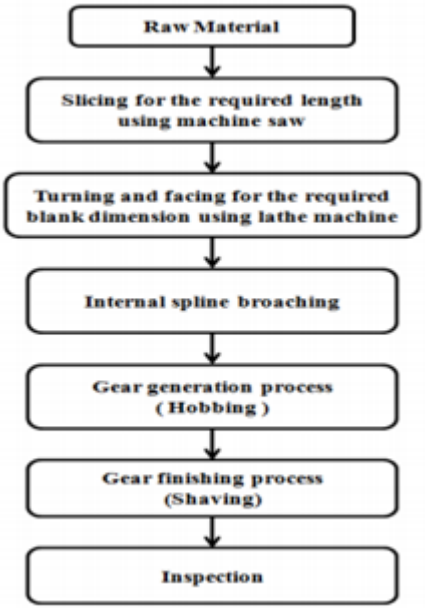

Fig.1. Flowchart of solid gear manufacturing process Satnamia Gear industry, Panipat.

Fig.2. Workstation of gear cutting.

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Fig.3. Workstation (lathe machine).

Fig.4. Spur gear.

IV. RESULTS

Utilization Factor

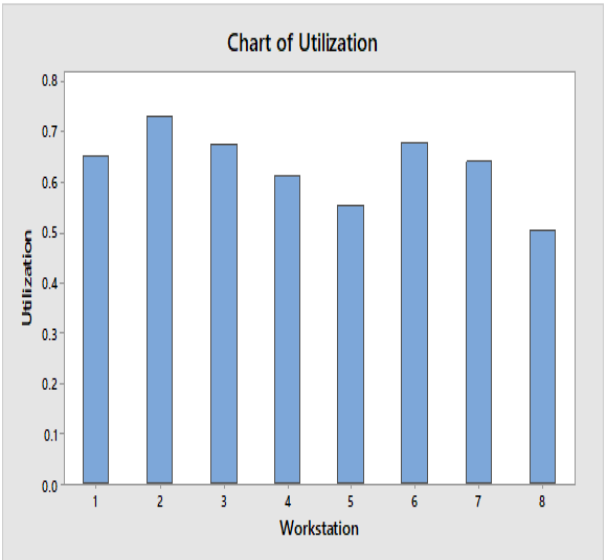

Fig.5: Graph of workstation utilization factor.

Efficiency of Workstation

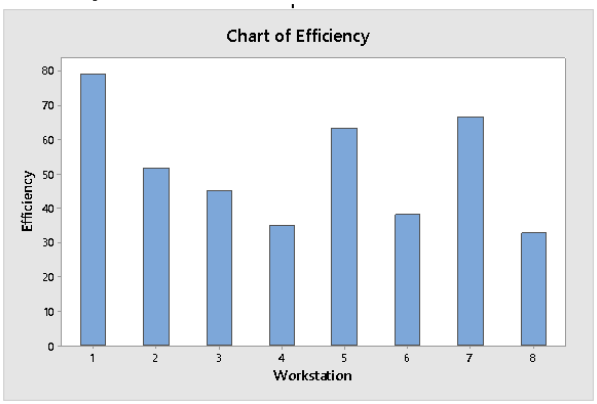

Fig.6. Efficiency of Workstation.

Take Time of The Product

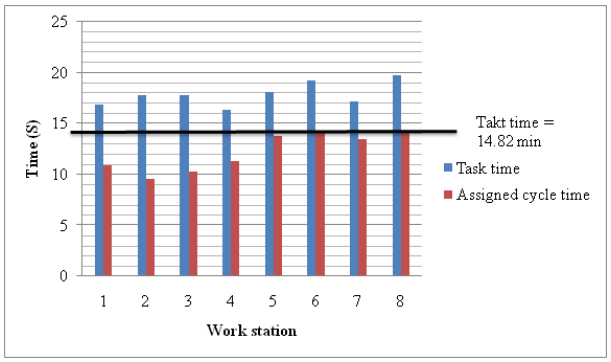

Fig.7. Current take time in cycle time chart..

Current Method To Meet The Demand

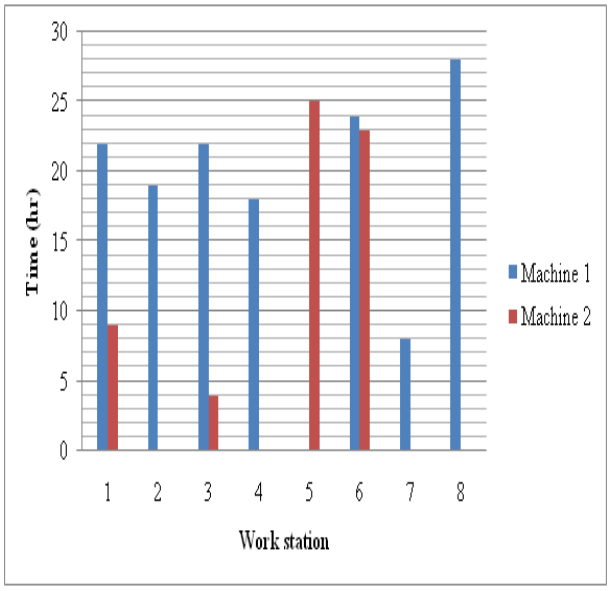

Fig.8. Current working hours per day of each machine to meet demand.

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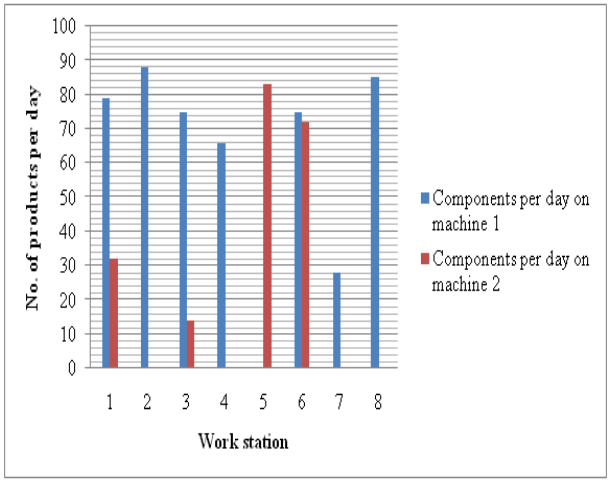

Fig.9. Number of components produced by each machine.

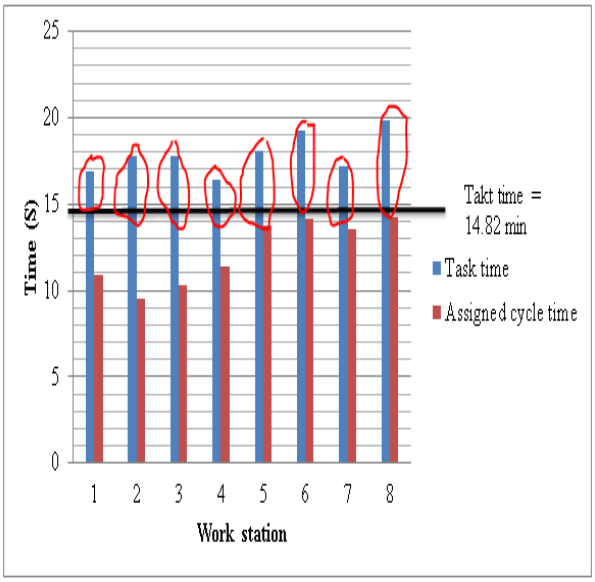

Fig.10. Machining time (value added) and non-machining (non-value added time) in each process.

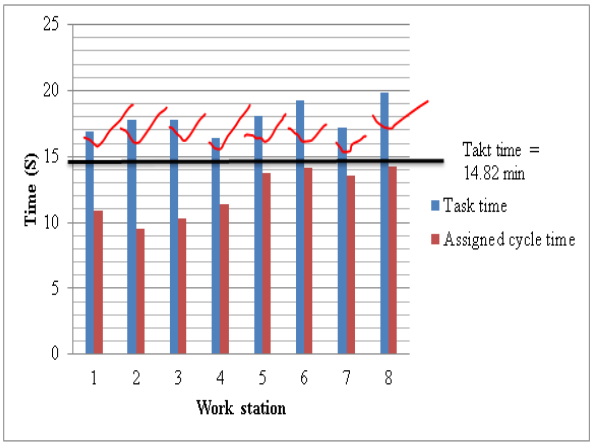

Fig.11. Bottleneck process in gear machining process.

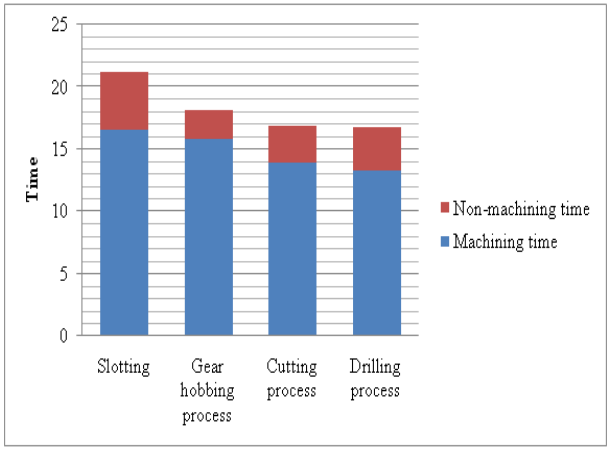

Fig.12. Machining (value added activities) and non-machining (non-value added activities) time for bottleneck process.

V. CONCLUSION

This work is carried out in Satnamia Gear Industries limited, Panipat. This industry produces variety of products such as sprocket, spur gear, helical gear and gear housing etc.

- In this work spur gear manufacturing is taken for study. At first different manufacturing processes (cutting the bar stock, OD turning, centre drilling followed by boring, CNC machining, gear hobbling, debarring, keyway slotting and gear grinding) are identified. Then Cycle time including machining and non-machining time is calculated using simple stop watch method. Then take time and lead time are calculated and value stream mapping has been plotted for the current state. From this bottle neck processes are found based on the cycle time above the take time.
- It is found the cutting, hobbling, drilling and slotting process are bottle neck processes. From the analysis it is found that the setup time of keyway slotting consumes more time. Using SMED concept single pallet is converted to two pallets. In cutting process continuous improvement technique
- One of the major problems more setup time was identified and then study about the current fixture design. Literature survey related to single minute exchange of dies (SMED) was carried out. Current fixture design that about 40% of the total time is non-value added activities so SMED concept was introduced to reduce the setup time.
- Next bottleneck operation is cutting section here continuous improvement is being implemented to utilize the effectiveness of the machine properly. Initially only one work piece is being cut at time but the cutting process has been enhanced that two raw materials can be cut at a time by implementing queuing

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model. The time for cutting process is drastically reduced from 3.8 min to 2.1 min.

- Next bottleneck operation is hobbling process. In this process the problem is more inventories in order to reduce the inventory one more machine is being introduced in the shop floor due to this production also increases simultaneously.
- Finally future state map was drawn after giving the solution to all the bottleneck operations in the lead time is drastically reduced from 26.2 min to 20.9 min therefore the production rate has been increased from 480 products/day to 510 products/day. Thus the production in the company has been enhanced.
- This study is very valuable for the company, because by knowing all information related to the performance of its production line, it is more effective and easier for the management of company to plan their production in the future.

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