Review on reducing manufacturing throughput time: Various tools and techniques

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Abstract : **This paper presents a review on manufacturing throughput time reduction. Main purpose of the paper is the development of framework that enables the finding out factors which affect manufacturing throughput time and various tools and techniques to optimize throughput. This paper analyzes applicability of different techniques for manufacturing throughput time reduction. These techniques help to identify and remove non-value added activities. Such techniques include lean manufacturing, kanban system, value stream mapping and method study.**

Key words **– Manufacturing throughput time, Lead time, Lean manufacturing**

I. Introduction

Manufacturing throughput time reduction is a major concern for all manufacturing industries today. It is defined as the amount of time each unit spends in the manufacturing process, this includes time spent actively being worked upon at each step of the process as well as any time spent waiting between steps. The need of throughput time reduction arises because of competition in market and quick availability of products to customers from competitors. It is also necessary to significantly reduce inventories and work in process. Therefore throughput time reduction is a significant in any manufacturing firm. Danny J. Johnson [2] stated that reductions in manufacturing throughput time increase flexibility and reduce the time required to respond to customer orders. Carl R. Schultz [3] explained about Long and unstable cycle times experienced at IBM's San Jose wafer fabrication facility in the early 1990s which had decreased the firm's competitiveness. In section II literature review of various tools and techniques to reduce manufacturing throughput time has been done followed by a Significance of reducing throughput in section III and conclusion and future work in section IV and V respectively.

II. Literature review of various tools and techniques to reduce manufacturing throughput time

There have been extensive studies in throughput time reduction. Those methods and factors are observed during a literature review.

(1) Method study

S. Patel et al. [14] point out that Companies use typical steps to reduce setup times are 1) Selecting the setup which provide greatest return on the investment of the time spent studying them, including those which offer the greatest scope for improvement , or which are causing bottlenecks and delays. 2) Recording all relevant facts of the present setup with respect to the sequence of time, interrelationship of activities and path of movements. 3) Examining those facts critically and in sequence relation to: Purpose; place; sequence; person and means. 4) Developing the most practical, economic and effective method in relation to elimination, combining, changing, and simplification of the setting-up activity. 5) Installing the improved set-up procedure and method. 6) Maintaining the method by periodically checking it in use.

Danny J. Johnson [2] Point out that reductions in processing time per part can be accomplished by reducing the number of operations required, reducing the processing time per operation, and/or reducing scrap and rework. The number of operations per part may be reduced through the adoption of new technology that allows a single operation to do what was previously done by several operations,

Prof. Rahul. R. Joshi et al. [8] applied concept of method study which have been used to reduce lead time. The operations which had higher cycle time, are being focused and method study principles like Combine, eliminate, compression and concurrency are being applied.

(2) Machining parameter and unit load size

Pius J. Egbelu [1] states that many machines are capable of operating at different production rates: In metal processing machines such as milling; different rates are achieved simply by changing the cutting speed, the feed rate, and/or the depth of cut, because the cutting parameter selection affects production rates, it also affects the machine cycle time and total tool change time realized since tool life is sensitive to the parameters used.

Pius J. Egbelu [1] also mentioned that to reduce manufacturing lead time two factors should be considered (I) Machining parameter (Speed, feed and depth of cut) (II) Unit load size in multi stage work station where more than one work stations are there.

(3) Setup time, processing time, move time, waiting time

S. Patel et al. [18] described a SMED technique in which set-up is being done within 10 minutes.

Danny J. Johnson [2] bi-furcated factors, which affect throughput times, are set up time, processing time, move time, and waiting time. He describes that to reduce throughput focus should be on this four factors and more emphasis should be on waiting time as it is major culprit in lead time expansion.

Ali Allahverdi et al. [9] defines set-up time as obtaining tools, positioning, work in process material, returning tools, cleaning up, setting the required jigs and fixtures, adjusting tools and inspecting materials in manufacturing process.

Pearn et al. [10] examine learning and forgetting effects on the problem of scheduling families of jobs on a single machine to minimize the total completion time of all jobs, where a setup time occurs whenever the machine switches the processing of a job from one family to another. Three models are presented and compared to investigate the impact of learning and forgetting. These models include cases with no forgetting, total forgetting, and partial forgetting assuming position dependent job processing times. They provide a branch-and bound algorithm and a heuristic procedure.

Danny J. Johnson [2] , indicates that reductions in waiting time can be accomplished by reducing setup time, processing time per part, move time, production batch sizes, transfer batch sizes, processing time variability, arrival variability, resource utilization, and/or the number of queues. It can also be reduced by increasing access to resources.

Danny J. Johnson [2] also point out that reductions in move time can be accomplished by reducing either the time required per move or the number of moves required. The time required per move can be reduced by increasing the speed of the material handling equipment (which may not be possible due to safety implications), or by reducing the move distance required.

C. Rosera et al. [12] explains about Bottle neck machine in multi-work station and They give the idea of Bottleneck walk to determine Bottleneck machine, During the Bottleneck walk, the observer walks along the line, writing down the inventory levels and process states in one line of the data sheet each round. For practical purposes, the process states are abbreviated with “W” for waiting, “P” for processing, “B” for breakdown, and so on. Subsequently, for every buffer or process where the direction of the bottleneck can be determined, an arrow is drawn on the datasheet in the direction of the bottleneck. The bottleneck then must be between the arrows pointing toward each other. Circling the bottleneck with a red box visualizes the finding.

SUNG-SEOK KO et al. [15] provide a model which decreases a inter arrival time of batch between machine so that constant input of material can be maintained and reduce level of WIP can help reduce throughput.

(4) Lean tools

Ahmed naufal et al. [4] did a case study by implementing *kanban* in Malaysia based firm which helped significantly in reducing lead time of 40% a day. This reduction achieved due to production of product according to kanban card instruction only. Consequently, inventory at both area and space for finished goods also minimized.

Carl R. Schultz [3] explained mechanism of reducing a firm's average cycle time when machine breakdown occurs without increasing in capacity or engineering faster processing times can often be accomplished through an inventory of spare components. He also stated that maintaining an inventory of spare components decreases mean time to repair resulting in increased machine availability and reduced cycle times.

Hari G. et al. [7] decreases the lead time in such a way that they find *takt time* of product then focuses on the operation which is having cycle time higher than takt time and by Cause and effect and why-why analysis, collects a data then design a new fixture to reduce setup time and also make a SOP and implement a 5S.

Renu Yadav et al. [17] used a *VSM* technique by mapping the whole process and proposes layout change to reduce transportation time. Method study concept like Parallel activities and combine concept are being applied to reduce process time.

(5) Production planning and Control

Afzal H. Alad et al. [21] point out that typical functions of a PPC System include planning material requirements, demand management, capacity planning and the scheduling and sequencing of jobs. The key purposes of such functions include reducing Work in Progress (WIP), minimizing flow Times and lead times, lower stockholding costs, improving responsiveness to changes in demand, and improving Delivery Date adherence.

M. Stevenson et al. [22] reviewed classic approaches" to Production Planning and Control (PPC) such as Kanban, Manufacturing Resource Planning (MRP II) and Theory of Constrains (TOC), and elaborated upon the emergence of techniques such as Workload Control (WLC), Constant Work In Process (CONWIP), Paired cell Overlapping Loops of Cards with Authorization (POLCA) and web- or e-based Supply Chain Management (SCM) solutions. This highlights the importance of a PPC implementation strategy.

Premaratne Samaranayake [20] finds out that Production scheduling and manufacturing planning and control (MPC) too can help reduce waiting time.

III. Significance of reducing manufacturing throughput time

Hari G. et al. [7] describes a significance of lead time (throughput) reduction.

1. Investment in finished goods, WIP inventory and financing of receivables decreases.
2. New market opportunities based upon order fulfilment speed and flexibility are enabled, pricing can be strengthened, and customer loyalty enhanced in existing segments through improved service capabilities.
3. Fewer changes to orders and production schedules mean achieving higher manufacturing efficiency levels.
4. Operating costs decrease, and expediting, overtime, and other costs associated with "rush" orders are eliminated
5. Write-offs on raw materials, WIP or finished goods inventories are reduced, as there is less damage during storage, and less risk of obsolescence.
6. Quality problems are detected and resolved earlier, as inventory turns are increased

IV. Conclusion

Factors which affect manufacturing throughput time are (1)Setup time (2) Processing time (3) Move time (4) Waiting time (5) Plant layout (6) Machining parameters (Depth of cut, Speed, Feed) (7) Lot size (Batch production) (8) Machine downtime.
Above are the factors which affect throughput in manufacturing. There are different tools and techniques available to reduce this.

- To reduce set-up time, SMED and method study should be used. Increasing material handling capacity will also reduce it.
- Process time can be reduced by Optimizing machining parameter (Speed, feed, depth of cut) and by increasing machine capability.
- Move time can be reduced by changing layout of the plant and by setting a cellular manufacturing in which group equipment performing sequential operations. Increase in Material handling capacity reduces move time.

- To reduce waiting time, Process time move time and set-up time should be reduced. MPC and PPC is helpful to schedule operations and reduce waiting time of jobs or batches.

V. Future work

Authors are currently working in Elecon engineering Co. Ltd, Vallabh vidyanagar, Gujarat which is Gearbox manufacturing company. The product is Pinion which has a Mfg. throughput time of 12 days, which is used in Gearbox. The Macro-process chart and cycle time study of all Operations in process have been carried out and now with the help of lean tools, throughput reduction has been targeted.

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