MANTECH Publications
Journal of Product Design, Quality Engineering & Technology
Volume 7, Issue 3, September-December 2022

Product Development Design Process for Decreasing Production Cycle Duration

Abhishek Sanjay Shinde [1], Harish Bhist[2]
Assistant Professor[1], Student[2]
Department of Mechanical Engineering
Shivalik College of Engineering Dehradun
Email id: *bhistharish_07@gmail.com[2]*

Abstract

The ancient saying "time is money" has been broadened to mean "time is a competitive weapon" in today's economic climate. Customers today expect speedy delivery and high quality at a fair price. Companies face various challenges when entering the global market, the most significant of which is the lengthy period required for new product development. Thus, in order to ensure client satisfaction in a worldwide market, short lead times are required. From the manufacturer's perspective, lead time is the period that elapses between placing an order and receiving the items ordered. Setup time, process time, move time, and waiting time are all components of lead time. This article examines numerous tools and approaches for reducing lead time. This difficulty can be overcome by switching from sequential to concurrent engineering. According to a review of published works on the subject of creating teams in large corporations, a three-level team structure is recommended, as well as a workgroup consisting of four fundamental teams. Method research approaches are used to assess present work practises and build successful methods based on activity reduction, merging, modifying, and simplicity. Lean technologies such as Single Minute Exchange of Dies (SMED), 5S, Poka-yoke, Kanban, Just-in-time (JIT), Value Stream Mapping (VSM), Jidoka, and Cellular Manufacturing, among others, aid in reducing lead time. Manufacturing Resource Planning (MRPII), Theory of Constraints (TOC), and conventional Production Planning and Control (PPC) methodologies are also used to decrease work in process (WIP) and flow time.

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

***Keywords**: - Global market, Manufacturing Resource Planning, Value Stream Mapping, Single Minute Exchange of Dies, Product Development*

INTRODUCTION

After analyzing the three-level team structure, we concluded that in SMEs, a two-level team structure and a workgroup comprised of two basic teams should be favoured. The outcomes of establishing a two-level team structure are discussed, as well as the project of transitioning to concurrent development of a mini-loader. The article explains the concurrent product development method. Small and medium-sized businesses (SMEs) are being forced by the market to switch from sequential engineering to concurrent engineering. Since teamwork is the foundation of concurrent engineering, special attention is being paid to the formation of teams and workgroups in the loops of an SME's concurrent product development process.

Problem Description

According to little's law, for a given production rate, lead time is directly related to inventory.

Equation 1 depicts Little's law, which is applicable to practically every waiting condition. It demonstrates that by maintaining the same production rate, a reduction in lead time will reduce WIP,or that the best way to discover the greatest component of lead time is to identify the largest inventories and strive to reduce them [3].

Inventory = production rate * Lead time(1)

Section 2 delves into lead time metrics and the many components of lead time. Section 3 examines several tools and strategies for reducing lead time that have been offered in the literature. Section 4 demonstrates the advantages of reducing lead time. Part 5 of the study examines and categorizes the applicability of the tools and techniques discussed in the preceding section to aid practitioners in selecting relevant tools and strategies. Section 6 identifies topics that require more investigation.

Concurrent Engineering

Concurrent engineering refers to multidisciplinary collaboration and parallel effort toward a single set of consistent goals in product development, manufacture, and sales. Product responsibility is shifted to teams created for the duration of the development of novel goods.

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

Goals of Concurrent Engineering

The following objectives should be met via concurrent engineering: Significantly quicker new product development time, lower new product development expenses, and higher quality of new goods in terms of client demands. Because of the following factors, concurrent product development time is decreased by 50% or more: Activities occur concurrently, team members meet on a regular basis to share information in a timely and efficient manner, and responsibility for all product features is given to teams (no time is wasted looking for the person "who is to blame for errors"). The stages and actions involved in the creation of a new product the product development process is often divided into seven stages: goal definition, feasibility research, development, design, process planning, manufacturing and assembly, and delivery.

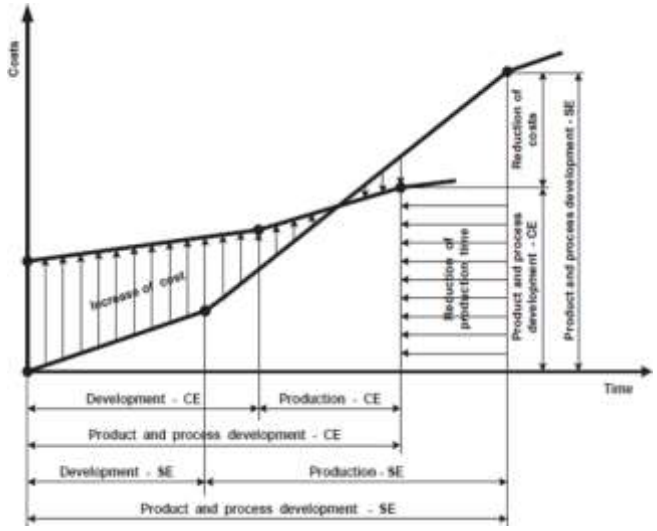

Figure 1: Costs of Sequential and Concurrent Product and Process Development

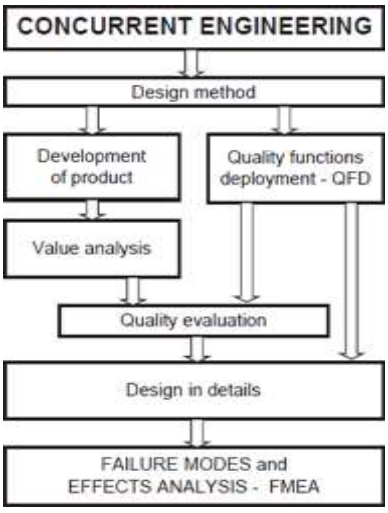

Figure 2: Concurrent Engineering Tools

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

PROBLEM DESCRIPTION

Lead Time Measures

An old saying says, "The path one takes matters only if one understands where they are and where they are attempting to go." Firms must have a cycle time performance baseline against which to assess the outcomes of new processes. Abbie Griffin (1993) proposed one set of product development measuring tools that organizations may use to determine baseline product development cycle time performance. She has discovered correlations between development time and percent change throughout product generations, as well as complexity and whether or not a formal approach was employed. She also shows how to utilise them to either anticipate projected project length if your development process has not changed, or to assess whether a process change has really reduced development cycle time [5].

The lead time is the total of the processing time, setup time, move time, queue time, wait-in-batch, wait-to-batch, and wait-to-match durations. Because queue, wait-in-batch, wait-to-batch, and wait-to-match timings all include waiting, they are all referred to as "waiting time. Equation 2 is a lead time calculation formula. Waiting time is often the longest of the four components, accounting for up to 90% of production lag time in some systems.

Danny J. Johnson (2003) investigated the fundamental elements that influence manufacturing throughput time and explained why each component arises. Manufacturing throughput time is the time it takes between the release of an order to the manufacturing floor and its reception into finished goods inventory. These parameters are processing time, manufacturing and transfer batch size, setup and move time, variability, and workstation usage. The author also offered a conceptual framework that depicts the actions that may be performed to reduce each element, as well as the links between them. The Production Throughput Framework is an easy-to-use tool that managers may use to choose a course of action to reduce production throughput in their own plants [6].

Lead time = Setup time + Processing time + Move time + Waiting time (2)

Tools and Techniques for Lead Time Reduction

As described earlier lead time is compose of setup time, processing time, move time and waiting time. There are different tools for different component. This section first shows tools for setup time reduction, and

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

then discussed tools to reduce other component.

a. Setup Time Reduction
b. Processing, Move and Waiting time reduction
c. Production Planning and Control
d. Design for Production (DFP)

Setup Time Reduction

A. Allahverdi and H. M. Soroush (2008) revealed that the setup time and costs have a significant impact on activity scheduling. Separating preparation and processing times and costs allow processes to be conducted concurrently, improving resource usage [7].

M.Diaby et al. (2013) created a nonlinear optimization model to calculate the best degree of setup reduction, defect rate reduction, and production cycle time for each product while keeping demand, process improvement budget, and manufacturing and warehousing capacity restrictions in mind. A convex geometric programming approximation has been devised to solve these problems [8].

Single Minute Exchange of Die (SMED)

S.Patel et al. (2001) illustrate that reducing set-up time mainly by teamwork; standardization methods S.Patel et al. (2001) demonstrate how cooperation, standardization approaches, work study, new machinery/technology, empowerment, fixtures/fittings, pre-set tooling, and automatic tool changers may help reduce set-up time. If firms want to cut setup times to single digits, they must use the SMED technique [9]. S.Patel et al. (2001) investigated ways of reducing set-up time and error proofing in a small firm involved in the machining of precision components in small batches with considerable variation for the aerospace sector. The authors examined the setup to see what kinds of changes may be made by utilizing Shingo's SMED technique [10]. By adopting the SMED technique on a CNC machine that manufactured plates, down time was reduced from 113.75 minutes to 59.75 minutes per month. Platen output is also increasing [11].

Method Study

According to S. Patel et al. (2001), corporations are lowering setup time by adopting method research methodologies rather than Shingo's SMED methodology. Companies often employ the following steps to decrease setup times: 1) selecting the setup that provides the best return on investment for the time spent studying it, including those with the most room for improvement or that are generating bottlenecks and delays. 2) Documenting all important details about the current

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

configuration in terms of time sequence, activity interdependence, and movement path. 3) Critically examining those facts in respect to: purpose; place; sequence; person; and methods. 4) Developing the most practical, cost-effective, and efficient approach for eliminating, merging, altering, and simplifying the setting-up process.5) Implementing the enhanced setup procedure and approach. 6) Maintaining the approach by checking it in use on a regular basis [9].

Design for Production (DFP)

DFP examines how many pieces the manufacturing system can produce and how long each order will take. That is, it assesses production capacity and calculates manufacturing time. Product development teams want methodologies that can predict the production cycle time of a particular product design early in the product development process. If the estimated manufacturing cycle time is too long, the team can shorten it by redesigning the product or changing the manufacturing method. DFP techniques assess a product design by comparing its production needs to available capacity and calculating manufacturing cycle time.

Jeffrey W. Herrmann and Mandar M. Chincholkar (2000) created the DFP decision support tool, which assesses capacity needs, calculates the new product's production cycle time, and offers input to the product development team. This feedback is used by the product development team to shorten the production cycle time. The decision-making tool is divided into five modules: Design structure matrix 5 (DSM) Steward invented the Design Structure Matrix (DSM) in 1989. It is also known as the dependence structure matrix. DSM is a technique for identifying activity dependencies and sequencing the development process. The DSM is a square matrix that has one row (I) and one column (j) for each activity. The actions are organized roughly chronologically. Figure 3 depicts the DSM matrix. In a basic DSM, diagonal components serve as placeholders, whereas off-diagonal elements represent activity interfaces. Sub diagonal matrix components represent feed-forward information, whereas super diagonal matrix elements represent feedback. As a result, if no activities in the DSM's rows and columns have direct interfaces, the matrix entries ij and ji will be empty. However, both entries ij and ji are filled, indicating a two-way interdependence. Gantt charts and the traditional CPM/PERT approach do not appropriately portray this sort of connection.

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

	A	B	C	D	E	F	G	H	I
A									
B	x								
C	x	x							
D			x						
E	x	x	x						
F		x	x	x	x				
G	x	x	x			x		x	x
H	x	x				x	x		x
I							x	x	

Figure 3: Design Structure Matrix

Benefits of Lead Time Reduction

There are several advantages to reducing lead time. The following are the primary advantages: WIP should be reduced. Reduce your safety stock. Reduce your expenses with product quality improvements. Responding to consumer needs more quickly, increasing adaptability, shorten the time to market. Boost Profitability:

SUMMARY

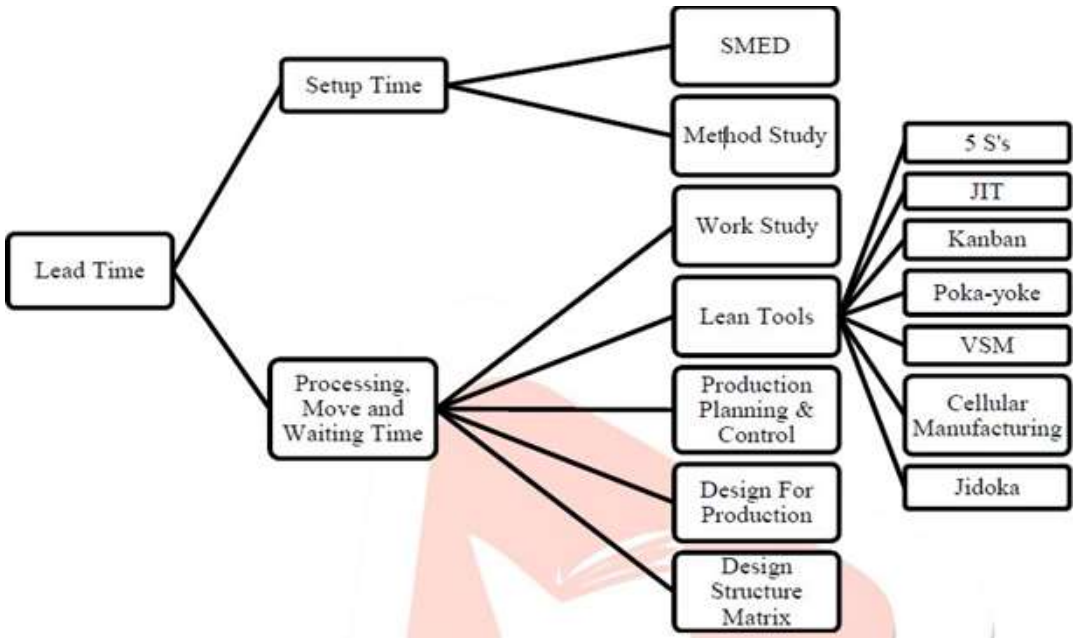

Figure 4: Summary of Tools and Techniques for Lead Time Reduction

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

Figure 4 illustrates several tools and techniques that may be used to reduce lead time. SMED is a series of tools that may minimize setup time from hours to minutes. Work study approaches are used to simplify jobs, minimize work content, and eliminate ineffective time. Lean manufacturing focuses on reducing all types of waste in order to provide a continuous flow of work, minimize lead time, reduce worker movement, remove non-value-added activities, and reduce inventory in the production area. Improved production planning and control also reduces lead time. DFP techniques assess a product design by comparing its production needs to existing capacity and estimating manufacturing lead time. If the anticipated lead time is excessively long, the time can be reduced by redesigning the product. By properly sequencing development processes, DSM helps to decrease lead time.

REFERENCES

1. Marc H. Meyer, James M. Utterback, "Product Development Cycle Time and Commercial Success" IEEE Transactions on Engineering Management, Vol. 42, No. 4, pp. 297-304, November 1995.
2. A.J Senapati, P.C.Mishra, B.C.Routra, A. Biswas, "An Extensive Literature Review on Lead Time Reduction in Inventory Control" International Journal of Engineering and Advanced Technology, Volume-1, Issue-6, pp. 104- 111, August 2012.
3. Wallace J. Hopp, Mark L. Spearman, David L. Woodruff, "Practical Strategies for Lead time Reduction" American Society of Mechanical Engineer, Manufacturing review vol.3, no.2, June-1990 pp. 78-84.
4. R. Mason-Jones, D.R. Towill, "Total cycle time compression and the agile supply chain" Int. J. Production Economics 62 (1999) pp. 61-73.
5. Abbie Griffin, "Metrics for Measuring Product Development Cycle Time" J PROD INNOV MANAG, 1993; 10:112-125.
6. Danny J. Johnson, "A Framework for Reducing Manufacturing Throughput Time" Journal of Manufacturing Systems, Vol. 22/No. 41, pp. 283-298, 2003.

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved

7. A. Allahverdi, H.M. Soroush, "The significance of reducing setup times/setup costs" European Journal of Operational Research 187 (2008) pp.978-984.

8. MoustaphaDiaby, Jose M. Cruz, Aaron L. Nsakanda, "Shortening cycle times in multi-product, capacitated production environments through quality level improvements and setup reduction" European Journal of Operational Research 228 (2013) 526-535.

9. S. Patel, B.G. Dale, P. Shaw, "Set-up time reduction and mistake proofing methods: an examination in precision component manufacturing" The TQM Magazine Volume 13. Number 3, 2001. pp. 175-179.

10. S. Patel, P. Shaw, B.G. Dale, "Set-up time reduction and mistake proofing methods: A study of application in a small company" Business Process Management Journal, Vol. 7 No. 1, 2001, pp. 65-75.

11. P.C Kumar, "Set up Reduction-A perfect way for productivity improvement of computer numerical control (CNC) set up in manufacturing company" Journal of Mechanical Engineering Research, Vol. 5(8), pp. 166-170, November 2013.

12. International Labour Office, "Introduction to Work Study", 3rd edition, Geneva, Universal Book Corporation, pp 29.

13. Khalid S. Al-Saleh, "Productivity improvement of a motor vehicle inspection station using motion and time study techniques" Journal of King Saud University-Engineering Sciences (2011) 23, pp. 33-41.

14. Joel S. Jensen, Mark N. Frolick, "Cycle Time Reduction in the General Motors Service Parts Operation" 2000.

Page 46-56 © MANTECH PUBLICATIONS 2022. All Rights Reserved