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Execution of Maynard Operation Sequence Technique (MOST) for Bicycle Line Assembly to Enhance Takt Time Efficiency

[1]Yeshwant M. Sonkhaskar, [2]P. B. Shiwalkar, [3]Kshitij S. Thote, [4]Shraddha D. Bhakare
[1]Assistant Professor Department of Mechanical Engineering, [2]Assistant Professor Department of Industrial Engineering,
[3]Student Department of Mechanical Engineering, [4]Student Department of Industrial Engineering

[1,2,3,4]Shri Ramdeobaba College of Engineering and Management, Ramdeo Tekdi, GittiKhadan, Katol Road, Nagpur, 440013, Maharashtra, India

Abstract : This research paper investigates the optimization of takt time efficiency in a bicycle assembly line by employing line balancing techniques, specifically focusing on the Maynard Operation Sequence Technique (MOST). With a backdrop of the crucial need for enhanced productivity and cost-effectiveness in manufacturing, particularly in the bicycle industry, the study underscores the significance of takt time and line balancing in lean manufacturing. Through a case study methodology involving observational data the research identifies bottlenecks and proposes the implementation of the MOST technique to rebalance workloads, minimize idle time, and synchronize operations. The findings demonstrate the effectiveness of the MOST approach in streamlining production flow and reducing cycle times, aligning the assembly line with customer demand. This research contributes to advancing manufacturing principles and provides practical insights into optimizing operational efficiency in bicycle assembly processes, showcasing the applicability of line balancing techniques like MOST across various manufacturing contexts.

IndexTerms **- Line Balancing, MOST, Bicycle assembly line, Takt time.**

I. INTRODUCTION

Introduction: In the realm of manufacturing, the optimization of production processes stands as a fundamental pursuit, especially in industries where efficiency and responsiveness to customer demand are paramount. The bicycle manufacturing sector represents one such industry, characterized by its competitive landscape and the need for streamlined assembly processes to meet market demands effectively. Central to achieving this objective is the concept of takt time, which defines the pace at which products must be produced to match customer demand. In this context, line balancing techniques emerge as indispensable tools for enhancing takt time efficiency by ensuring that workloads across assembly lines are evenly distributed, minimizing idle time and maximizing productivity. Among these techniques, the Maynard Operation Sequence Technique (MOST) stands out for its systematic approach to optimizing work processes. This research paper endeavors to explore the application of line balancing techniques, particularly the MOST technique, in enhancing the takt time efficiency of a bicycle assembly line. By delving into the principles of manufacturing and the significance of takt time optimization, this study seeks to provide insights into how the implementation of line balancing techniques can contribute to the improvement of operational efficiency and competitiveness in the bicycle manufacturing industry. Through empirical investigation and analysis, this research aims to shed light on the effectiveness of the MOST technique in achieving a balanced and efficient assembly process, ultimately offering practical recommendations for enhancing production performance in similar manufacturing contexts.

II. OBJECTIVE

The objectives of this research paper are multifaceted. Firstly, it aims to conduct a comprehensive assessment of the current takt time efficiency within the bicycle assembly line, with a keen focus on identifying existing bottlenecks and areas of inefficiency. Subsequently, the study seeks to delve into the principles and methodologies underpinning line balancing techniques, specifically emphasizing the Maynard Operation Sequence Technique (MOST), as a strategic means to optimize workflows within the assembly line. Following this, the paper endeavors to practically implement the MOST technique within the bicycle assembly line, with the overarching goal of rebalancing workloads, minimizing idle time, and synchronizing operations to enhance overall takt time efficiency. Additionally, it intends to qualitatively evaluate the perceived improvements in workflow efficiency and ergonomic considerations resulting from the application of the MOST technique, gathering feedback from assembly line operators and supervisors. Ultimately, this study aspires to provide valuable insights and recommendations for the practical implementation of line balancing techniques, particularly the MOST technique, in similar manufacturing contexts, thereby facilitating improvements in operational efficiency and competitiveness.

III. METHODOLOGY

To investigate the enhancement of takt time efficiency in a bicycle assembly line through the application of line balancing techniques, specifically focusing on the MOST technique, a structured methodology is proposed. Firstly, a comprehensive understanding of the current assembly process and its performance metrics will be established through direct observation and data collection. This will involve documenting the various tasks involved in the assembly line, their sequence, and the time taken to complete each task. Subsequently, the assembly line will be analyzed to identify bottlenecks and areas of inefficiency that hinder the achievement of optimal takt time. This analysis will be facilitated by the use of process mapping techniques and time-motion studies.

MOST is a work measurement technique used to establish standard work times and enhance resource utilization by refining work methods. Although Maynard introduced the concept of MOST in 1960, its industrial application began in 1967 with Basic MOST. In 1970, Basic MOST was adapted and renamed Clerical MOST to support administrative and clerical tasks in production and service industries. There are three primary versions of MOST in literature: Basic MOST, Mini MOST, and Maxi MOST. For manual work, Basic MOST outlines a sequence of three actions: General Move, Control Move, and Tool Use.

A. General move

The unrestricted movement of an object under study in the air is elucidated and classified within the framework of the General Move Sequence Model.In essence, the General Move model adheres to the Sequence of the actions of GET, PUT, and RETURN, denoted as |A B G|, |A B P|, and |A| respectively, are explained with reference to the parameters A, B, G, and P as outlined in Table 1.

Table 1; Variable used in General move

Illustration	A	B	G	P
Elaboration	Action Distance	Body Motion	Gain Control	Placement

B. Control Move

*T*he Control Move Sequence Model is employed to analyze the motion of an observed element while it interacts with a surface or is affixed to other objects.The control move model follows a sequence of GET, MOVE or ACTUATE, and RETURN phases i.e. |A B G|, |M X I| and |A|. A breakdown of the factors A, B, G, M, X and I are given in Table 2.

Table 2; Variable used in Controlled move

Illustration	A	B	G	M	X	I
Elaboration	Action Distance	Body Motion	Gain Control	Move Controlled	Process Time	Alignment

C. Tool Use

The Tool Use Sequence elucidates the utilization of tools during assembly or production processes.

The Tool Use model comprises a sequence of GET TOOL, PLACE TOOL, TOOL ACTION, PLACE TOOL, and RETURN phases i.e. |A B G|, |A B P|, |U|, |A B P|, and |A|.The Tool phase includes F - Fasten, L- Loosen, C - Cut, S - Surface Treat, M - Measure, R- Record, and T - Think.An elucidation of the variables. A, B, G, P and U are given in Table 3. Followed up by Unit Conversion in table 4.

Table 3; Variable used in Tool Use

Illustration	A	B	G	P	U
Elaboration	Action Distance	Body Motion	Gain Control	Placement	Tool Action

Table 4; Unit Conversation Chart

1 TMU	=	0.00001 HOUR	1 HOUR	=	100,000 TMU
1 TMU	=	0.0006 MINUTE	1 MINUTE	=	1667 TMU
1 TMU	=	0.036 SECOND	1 SECOND	=	27.8 TMU

D. Example of Assembling a pedal through MOST and Calculating Time

Table 5; Activity Chart

. SR NO.	Method Description	Index Value	Frequency	Move
1	Move 1-2 Steps, Stand, pickup scanner scan work order and place with adjustment	A3B3G3 A3B3P3 A0	1	General Move
2	Click on Start button on the screen with help of mouse	A0B3G1 M1X0I1 A0	1	Controlled Move
3	Move 1-2 steps, stand, pick up pedal	A3B3G4 A3B3P3 A0	1	General Move
4	Reach Grasp with adjustment, tighten from wrist with, spanner 13 times	A1B3G1 A0B3P0 T24 A0B0P3 A0	1	Tool Use
5	Move 1-2 steps pick scanner, scan bar code,place with adjustment	A3B3G3 A3B3P3 A0	1	General Move
6	Click on Complete button on the screen with help of mouse	A0B3G1 M1X0I1 A0	1	Controlled Move
7	Move 1-2 steps, stand and press the authorization button to complete	A3B3G0 M1X0I1 A0	1	Controlled Move

Calculation:

Formula: Time= (Sum of index value)X(Assigned Value for Basic Most, i.e 10)X Frequency.

1st Element : (3+3+3+3+3+3+0)x10 x1 = 180 TMU

2nd Element : (3+1+1+1+0)x10x1=60 TMU

3rd Element :(3+3+4+3+3+3+0)x10x1 =190 TMU

4th Element :(1+3+1+0+3+0+24+0+0+3+0)x10x1=350 TMU

5th Element :(3+3+3+3+3+3+0)x10 x1 = 180 TMU

6th Element :(0+3+1+1+0+1+0)x10x1 = 60 TMU

7th Element :(3+3+0+1+0+1+)x10x1 = 80 TMU

TOTAL TTIME: 1,100TMU X0.036= 39.6 Seconds.

IV. DATA PROCESSING

This study encompasses the MOST timing for assembling bicycles across six stations, with detailed variable activities presented in Table 5.Here, the timings are delineated according to each station, and the corresponding calculations are presented in Table 6.

Table 6; Activity Chart

No.of Station	Activity	Time MOST (sec)	Time in TMU
Station 1	Assembling Frame	84 sec	2330 TMU
Station 2	Assembling Front & Back Wheel	104 sec	2888 TMU
Station 3	Assembling Back and Front Mudguard	126 sec	3500 TMU
Station 4	Assembling Front & Back Brake	136 sec	3777 TMU
Station 5	Assembling Crank & Crank Arm	200 sec	5497 TMU
Station 6	Assembling Left,Right Pedal & Stand	120 sec	3333 TMU
TOTAL		770 sec	21325 TMU

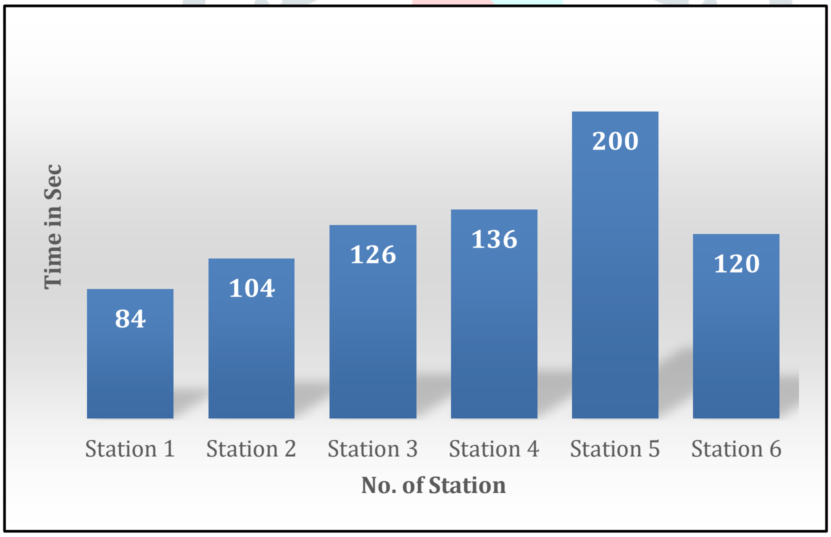

Figure 1 Current time for Station

In the depicted scenario, it's evident that Stations 5, consuming more time, indicating potential bottlenecks due to their extended processing times. By implementing the Maynard Operation Sequence Technique (MOST), these prolonged timings can be addressed to alleviate such bottlenecks. One effective approach is to substitute the current operators with more skilled personnel. This adjustment aims to streamline work flow and ensure smoother operations throughout the process. Table 7 shows the proposed solution .

Table 7; Proposed Solution

Activities	Activity time in seconds (By Existing worker)	Activity time in seconds (By new skilled worker)	Time in TMU (New skilled worker)
Assembling Crank and Crank Arm	200 sec	140 sec	3888 TMU

Table 8; Suggested alteration in the workforce and its impacts.

No.of Station	Activity	Time MOST (sec)	Time in TMU
Station 1	Assembling Frame	84 sec	2330 TMU
Station 2	Assembling Front & Back wheel	104 sec	2888 TMU
Station 3	Assembling Back and Front Mudguard	126 sec	3500 TMU
Station 4	Assembling Front & Back brake	136 sec	3777 TMU
Station 5	Assembling Crank & Crank arm	140 sec	3930 TMU
Station 6	Assembling Left,Right Pedal & Stand	120 sec	3333 TMU
TOTAL		574 sec	19758 TMU

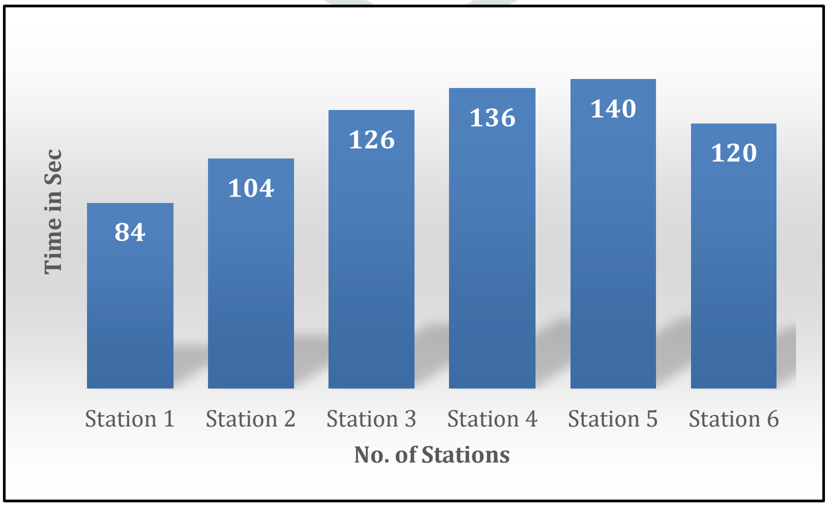

Figure 2 suggested cycle time

As depicted in Figure 2, replacing the operator at workstation 5 minimizes the required bottleneck time. This reduction in bottleneck time signifies that the production line is more balanced following the implementation of the MOST technique.

V. RESULT

This study reveals that prior to implementing the MOST technique in a chosen bicycle manufacturing industry, it took 770 seconds to complete a bicycle. However, after adopting the MOST approach, the bottleneck time decreased, and now only 574 seconds are required to complete the bicycle. Further enhancements in workflow efficiency reduced motion time to 196 seconds after identifying and rectifying bottlenecks.

To assess production efficiency, the assembly line's Takt time, calculated by dividing total available time by customer demand, was determined. The table presents Takt time (cycle time per workstation) and productivity aligned with demand.

Table 9; Execution before MOST

Available working time/day (sec)	Before MOST implementation			
28800	Total Activity Time (sec)	Bottleneck Time (sec)	Takt Time (sec)	Productivity Per Day
	770	200	553.8	36

Table 10; Execution After MOST

Available working time/day (sec)	After MOST implementation				
28800	Total Activity Time (sec)	Bottleneck Time (sec)	Takt Time (sec)	Productivity Per Day	Demand
	574	140	553.8	52	53

Takt time = Available Working Time per shift ÷ Rate of Customer Demand per Shift

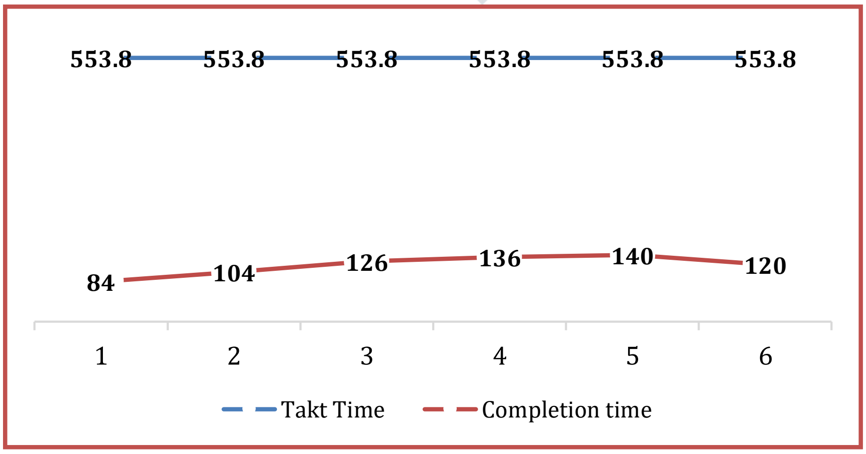

Figure 3 Takt time compared to the time taken for completion.

With an estimated Takt time of 553.8 seconds per bicycle and a daily demand of 53 Bicycles , which must not be compromised by any new practices, the proposed alterations in workstation 5 offer the potential to uphold the daily demand while enhancing productivity.

VI. CONCLUSION

In this study, we endeavored to discover a viable solution for the existing issue within the chosen Bicycle assembly line by employing the MOST technique. It's acknowledged that the Maynard Operation Sequence Technique (MOST) significantly contributes to recognizing and rectifying bottleneck workstations, thereby fostering a competitive industrial atmosphere. MOST also aids in enhancing manufacturing company productivity by diminishing non-value-added tasks. Through the implementation of MOST, there is potential for optimal utilization of total available time and cost savings.

VII. ACKNOWLEDGEMENT

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