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Enhancing Operational Efficiency through Stopwatch Time Study: A Systematic Approach for Performance Evaluation

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ABSTRACT

The stopwatch time study methodology is a fundamental approach in industrial engineering, employed to analyze and establish the standard time required for a worker to perform a specific task at a defined level of proficiency. This study aims to provide a systematic framework for implementing stopwatch time study techniques to evaluate work processes, identify inefficiencies, and establish performance benchmarks. The research involved observing and recording the time taken by skilled workers to complete various work elements using a stopwatch. The collected data were analyzed to compute normal time and standard time, accounting for factors such as performance rating and allowances. The findings revealed that the stopwatch time study methodology could effectively quantify the time required for each task, pinpoint bottlenecks, and determine optimal cycle times for workstations. By establishing standardized times, organizations can enhance resource allocation, streamline workflows, and improve overall operational efficiency.

Keywords:
Time study; Stopwatch; Manufacturing; Manual works

1. Introduction

Time study serves as a foundational element in the pursuit of operational excellence, offering invaluable insights into resource utilization, bottleneck identification, and overall workflow enhancement [1] . By deconstructing the production process into its constituent elements, time study enables organizations to quantify the time needed for each task, pinpoint areas for improvement, and implement targeted strategies for operational streamlining. In an era characterized by intense competition and evolving market demands, the ability to produce high-quality goods rapidly and economically emerges as a key determinant of success. Time study equips organizations with the capacity to make well-informed decisions regarding resource allocation,

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manpower utilization, and process optimization, contributing to heightened output and reduced production costs [1].

2. Literature Review

2.1 Time Study

Time study is a methodology employed to ascertain the time necessary for a qualified and well-trained individual, performing at a standard pace, to successfully accomplish a designated task. This technique entails a detailed examination of a particular operation, aiming to delineate the individual elements of work essential for its execution. This process involves identifying the sequence in which these elements transpire and assessing the necessary time for their efficient completion [1,2] . As defined by the International Labour Organization (ILO), time study is characterized as a work measurement technique encompassing [3]:

i. Documenting the durations and rates of work for each element involved in a particular task conducted under predefined conditions.
ii. Scrutinizing the collected data to derive the time required for executing the job at a specified level of performance.

2.2 Uses of Time Study

Time study provides several advantages across diverse industries and applications. It is instrumental in addressing and resolving queries related to [1]:

i. Scheduling and organizing tasks effectively.
ii. Establishing standard costs and integrating them into budget preparation.
iii. Estimating pre-production costs for products, aiding in bid preparation, and determining pricing strategies.
iv. Evaluating machine efficiency, determining the optimal machine-to-operator ratio, and facilitating the balance of assembly lines and conveyor work.
v. Establishing time standards for wage incentive calculations for both direct and indirect labor.
vi. Defining time standards to enable effective control of labor costs.

2.3 Techniques of Time Study

Time study techniques serve as valuable instruments for enhancing productivity, establishing benchmarks, and streamlining operational processes across diverse industries. In the broader context of time study, multiple methods are utilized to scrutinize and enhance work processes. Several noteworthy techniques encompass [1,4]:

i. Predetermined standard systems [5 – 9]
ii. Work sampling [1,3]
iii. Standard data [1,3]
iv. Stopwatch time study [1,10 – 11]

Each of these techniques has its own advantages and disadvantages, and the selection of an approach hinges on factors such as the task's inherent characteristics, the desired level of precision, and the resources at hand.

2.4 Standard Formula Used

Time study entails the observation and documentation of the duration required by a skilled worker to accomplish a task at a normal pace. There are several formulas and terms commonly used in time study [1,12 – 14].

i. Observed time (OT): The actual time taken by a worker to complete a task during the time study. The average observed time can be calculated by using Eq. 1 below.

$$Average\ Observed\ Time = \frac{Sum\ of\ times\ recorded}{Number\ of\ observations} \tag{1}$$

ii. Normal time (NT): The time required for a qualified worker to perform a job or task at a normal working speed and under normal working conditions. Normal time can be computed using Eq. 2 below.

$$Normal\ Time = Average\ Observed\ Time \times Performance\ Rating \tag{2}$$

iii. Standard Time (ST): The predetermined time for completing a specific task under normal working conditions. It includes allowances for rest, delays, and interruptions. Standard time is calculated using Eq. 3 expressed below.

$$Standard\ Time = \frac{Normal\ Time}{(1 - Allowance)} \tag{3}$$

These equations aid in determining practical and attainable standard durations for diverse tasks, taking into account the variability in worker performance and the working environment. Standard times play a pivotal role in production planning, scheduling, cost estimation, and performance evaluation within manufacturing processes.

3. Research Methodology

3.1 Methodology for Stopwatch Time Study

Time Study stands out as one of the prevalent methods employed to address production line issues in the industry. This paper is concentrated on the methodology and procedures employed in stopwatch time study. Fig. 1 below illustrates the flowchart for stopwatch time study.

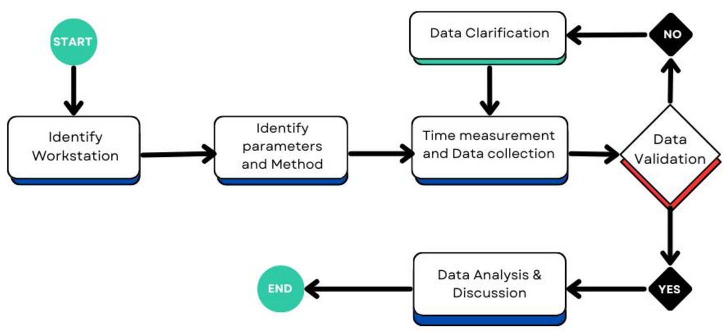

Fig. 1: Flowchart of stopwatch time study

3.2 Identify Workstation

Initiating the stopwatch time study involves the crucial step of identifying workstations within the production line. This initial identification is of paramount importance for several reasons, significantly contributing to the optimization of efficiency and productivity in a production line. Fig. 2 below illustrates an example of the flow process for the production line in the packing department at Company X.

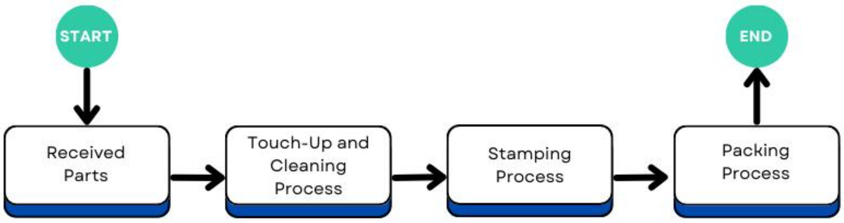

Fig. 2: Flow process of the production line

The process of identifying workstations facilitates the precise allocation of time measurements to specific tasks and locations within the production process. This accuracy ensures a clear comprehension of the time taken for tasks at each workstation, aiding in identifying bottlenecks and areas for improvement. Without identifying workstations, time measurements would be aggregated across diverse locations, leading to inaccurate data and potentially yielding misleading conclusions regarding process efficiency.

3.3 Identify Parameters and Methods

Parameters serve a crucial role as guidelines and references in addressing the stopwatch time study problem, acting as foundational elements before delving deeper into the resolution process. The identification of parameters marks the initial step in this endeavour. Illustratively, parameters pertinent to time study often encompass cycle time, task time, normal time and standard time. These parameters primarily revolve around the dimension of time, with time serving as the fundamental metric for their measurement. Once the parameters are identified and selected, the choice of method is determined. The parameters establish the groundwork for selecting an appropriate method to tackle the case study.

In this paper, the research methodology employed centers on the examination of temporal aspects, with a specific emphasis on time study. Consequently, the selected methodology for this investigation is the utilization of stopwatch time study. This approach involves the systematic measurement and analysis of the duration of various activities, thereby contributing to a comprehensive understanding of the temporal dynamics inherent in the subject under investigation.

3.4 Data Collection

In this stopwatch time study, obtaining the actual operation time is essential. To achieve this, observation methods are employed to systematically record the real operation time of the production line. The recorded operation time is later utilized to compute the cycle time, a pivotal factor in determining the maximum operation time for each workstation in the production line, thereby enhancing overall efficiency.

It is imperative to decompose the workstation into discrete and meaningful work elements, whereby each constituent element signifies a discernible and quantifiable segment of the overarching job. This division facilitates a systematic and organized analysis of the job, allowing for a comprehensive understanding of its constituent parts and enabling precise measurement of individual task performance. Consequently, breaking down the workstations into smaller, manageable components not only enhances clarity and transparency but also establishes a foundation for effective evaluation and optimization of the overall tasks. Fig. 3 below show work elements for workstations.

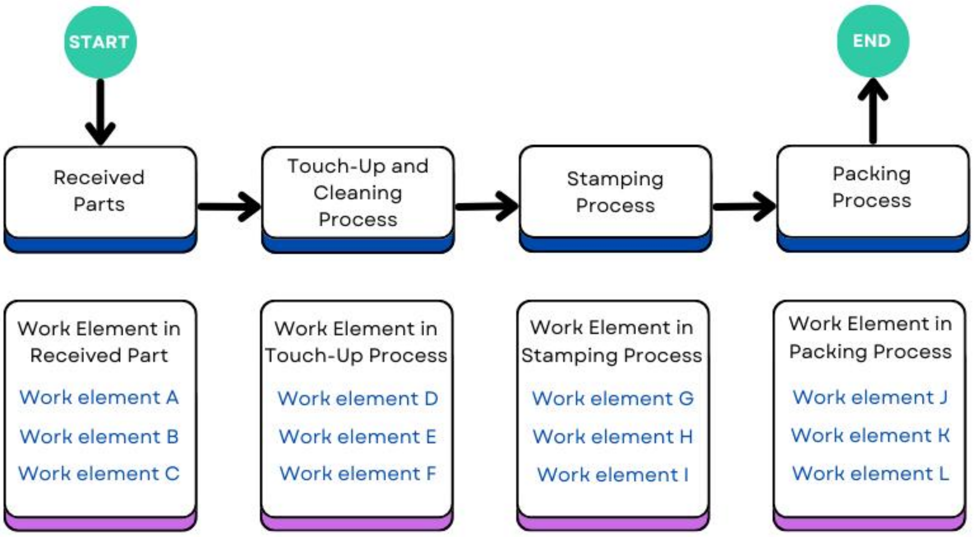

Fig. 3: Work elements for workstations

Table 1 presented below outlines the example of time taken template utilized for recording the time allocated to each work element in the production line. Establishing the appropriate sample size is a crucial step in the case study process. This entails making informed decisions regarding the number of observations or measurements to be undertaken for each work element within the case study. In this context, it is necessary to conduct multiple measurements for each work element, a practice undertaken to enhance the precision, reliability, and overall robustness of the data collected. Thus, the time is recorded 10 times for each work element, and subsequently, the average time is calculated.

Table 1
Example of time taken template

Work Element	Time Recorded (s)										
	1	2	3	4	5	6	7	8	9	10	Avg
A											
B											
C											

Execute the collection of data by employing a stopwatch or a comparable timing device to systematically document the duration of each instance associated with the designated elements. It is imperative to guarantee that these observations are conducted on a representative work element, ensuring a comprehensive and accurate representation of the overall tasks.

3.4.1 Details of Work Elements

Observed and provided a comprehensive detail of each work element, incorporating a specified number of operators assigned to each element, and the established precedence that outlines the sequential order in which tasks must be carried out. Assign a designated number of operators to each work element, coupled with a specified precedence that denotes the sequential order in which tasks must be executed before advancing to the subsequent task. This allocation of operators and establishment of task precedence are essential components in structuring the workflow. The assigned operators represent the workforce allocated to each work element, outlining the human resources devoted to the task, while the precedence designates the specific order or sequence in which tasks within a given work element must be undertaken. Table 2 illustrates example details for work elements.

Table 2
Example details for work elements

Work Element	Work Element Description	Precedence	No. of Operators
A	Move part from waiting bay to touch up and cleaning workstation	-	1
B	Touch up and cleaning process	A	1
C	Checked and move part to waiting bay	B	1

3.4.2 Operation Hour of Production Process

Operation hours constitute the specified time during which the production activities occur, encompassing the commencement and conclusion of the production cycle within a given period. In time studies, the accurate identification and documentation of operation hours provide a foundational framework for the systematic measurement and analysis of various production-related factors. This information ensures that observations and data collection are conducted consistently within the defined operational time, contributing to the reliability and validity of the case study's outcomes. The determination of operation hours should align with the regular working schedule of the production process. It is essential to consider factors such as shift timings, breaks, and any other relevant operational considerations.

3.4.3 Performance Rating of Operators

A performance rating serves as a metric reflecting the efficiency or productivity of an operator in task completion [15,16]. It is instrumental in establishing the normal time, subsequently utilized in computing the standard time required for efficient task completion. Evaluating the performance rating of operators involves observing them in the act of task execution and comparing their performance with the Westinghouse rating system [15,17]. This system assesses operators based on four factors: skill, effort, conditions, and consistency [18,19]. The components of the Westinghouse rating system are delineated in Table 3 below.

Table 3
Components of the Westinghouse rating system [3]

Skills Ratings			Effort Ratings		
+0.15	A1	Superskill	+0.13	A1	Excessive
+0.13	A2	Superskill	+0.12	A2	Excessive
+0.11	B1	Excellent	+0.10	B1	Excellent
+0.08	B2	Excellent	+0.08	B2	Excellent
+0.06	C1	Good	+0.05	C1	Good
+0.03	C2	Good	+0.02	C2	Good
0.00	D	Average	0.00	D	Average
–0.05	E1	Fair	–0.04	E1	Fair
–0.10	E2	Fair	–0.08	E2	Fair
–0.16	F1	Poor	–0.12	F1	Poor
–0.22	F2	Poor	–0.17	F2	Poor
Condition Ratings			Consistency Ratings		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
–0.03	E	Fair	–0.02	E	Fair
–0.07	F	Poor	–0.04	F	Poor

Upon evaluating operators based on the four factors through careful observation and assessment, numerical values corresponding to these factors are calculated. These numerical values are then aggregated to derive the algebraic sum. This sum, in conjunction with the performance factor, is utilized to determine the overall performance rating of the operators [3]. Table 4 below illustrates an example of a breakdown of the performance rating for each operator in their respective processes after assessment [18].

Table 4
Example performance rating of the operators

Factor	Operator 1	Operator 2	Operator 3	Operator 4
Work element	A,B,C	D	E,F,G	H,I,J,K,L
Skill	+0.06	+0.06	0.00	–0.16
Effort	+0.08	+0.05	0.00	–0.04
Conditions	0.00	0.00	0.00	0.00
Consistency	+0.03	+0.01	0.00	–0.02
Algebraic Sum	+0.17	+0.12	0.00	–0.22
Performance Rating	1.17	1.12	1.00	0.78

3.4.4 Allowances

Allowances are essential considerations in recognizing and accounting for periods during which work may be temporarily interrupted or impeded. Rest breaks, unexpected delays, or any other non-productive intervals can impact the overall efficiency of the production process [20,21]. Allowances refer to supplementary time adjustments made to the standard time to accommodate factors not linked to the actual task execution. These adjustments are incorporated into the calculated standard time to establish the total time allotted for operators to complete a task [22]. Additionally, these allowances consider factors that may impede the production process. These measures act as a cushion for operators, enabling them to sustain a regular workflow pace without encountering undue stress or fatigue [23,24].

To address this, predetermined allowances can be introduced to the observed time, acknowledging that not all recorded time is actively contributing to productive work. Adjusting the observed time involves factoring in these allowances to obtain a more accurate representation of the actual productive time spent on the task or process. Table 5 below shows example of allowances for work elements.

Table 5
Example of allowances for work elements

Work Element	Work Element Description	Allowances (%)
A	Move part from waiting bay to touch up and cleaning workstation	12
B	Touch up and cleaning process	15
C	Checked and move part to waiting bay	12

4. Results and Discussion

The results encompass the computation of normal time and standard time through the utilization of time study methods. Normal time represents the anticipated duration required for a qualified worker to accomplish a task under standard or optimal conditions. It serves as a benchmark for assessing task duration expectations, factoring in the inherent nature of the work as well as potential interruptions or delays that may arise. Establishing normal time enables organizations to set realistic performance targets, allocate resources efficiently, and facilitate accurate production planning and scheduling.

Standard time, on the other hand, provides an aggregate measure of the expected time required for a qualified worker to complete an entire job or set of tasks under standard conditions. It accounts for variations across individual work elements, allowing for a holistic assessment of the workflow. Comparing the actual job completion time against the calculated standard time offers insights into the production process's efficiency, highlighting areas necessitating improvement or optimization. The standard time for an entire job serves as a comprehensive metric for evaluating the overall efficiency and performance of the production process.

Table 6 illustrates an example of normal time and standard time calculations for specific work elements. According to the data presented, work elements are subsequently categorized into workstations, defined as designated areas where individuals execute specific tasks as part of a broader process. The configuration and organization of workstations are pivotal in enhancing workflow, productivity, and the overall efficiency of work processes within the production process.

Table 6
Example of normal time and standard time for work elements

Work Element	Work Element Description	Normal Time (s)	Standard Time (s)
A	Move part from waiting bay to touch up and cleaning workstation	10.66	11.98
B	Touch up and cleaning process	107.65	126.47
C	Checked and move part to waiting bay	11.67	13.13

These workstations are determined by the cycle time, as demonstrated in Table 7, which provides an analysis by workstations. The calculated normal times and standard times hold significant implications for various aspects of production management and continuous improvement initiatives. Accurate normal times facilitate the establishment of fair and achievable performance targets, promoting a motivated workforce. Furthermore, they enable efficient resource allocation by providing insights into the expected duration of each task, ensuring optimal utilization of human resources and avoiding bottlenecks or underutilization.

Moreover, normal times contribute to precise production planning and scheduling, enabling organizations to forecast capacity accurately and meet customer demands more effectively. They also aid in identifying training needs by highlighting deviations from established benchmarks, indicating areas where workers may require additional skill development or support. The standard time calculations, which incorporate allowances for factors that may impede the production process, such as fatigue or delays, ensure a sustainable work pace and promote a safe and productive work environment. By comparing actual job completion times against calculated standard times, organizations can evaluate the overall efficiency of their production processes and identify areas for improvement or optimization.

Table 7
Example of analysis by workstations

Workstation	Work Element	Total Normal Time (s)	Total Standard Time (s)
1	A, B, C	136.97	158.57
2	D, E, F	202.15	236.06
3	G, H, I	133.99	152.49
4	J, K, L	315.89	371.91

The analysis presented in Table 7 highlights potential bottlenecks or inefficiencies within the production process, such as Workstation 4, which exhibits the highest total standard time. This information guides organizations in prioritizing their continuous improvement efforts, focusing on areas that offer the greatest potential for cycle time reduction, increased productivity, and cost savings. It is crucial to periodically reassess and update standard times to account for changes in processes, product modifications, or shifts in workforce composition. As processes evolve or new technologies are introduced, the standard times may need to be reevaluated to ensure their accuracy and relevance. In summary, the detailed calculation and analysis of normal time and standard time are critical components of the stopwatch time study methodology, providing organizations with valuable insights into their processes, enabling data-driven decision-making, and facilitating the optimization of operational efficiency across various industries.

5. Conclusion

The stopwatch time study methodology provides a systematic approach for evaluating work processes and establishing performance benchmarks. The study demonstrates the technique's effectiveness in quantifying the time required for work elements and workstations within a production process. The computed standard times serve as valuable references for identifying bottlenecks, balancing workloads, and streamlining workflows. Consideration of performance ratings and allowances ensures that the established standards account for variabilities in worker performance and environmental factors. The methodology contributes to enhancing operational efficiency by providing a structured framework for continuous improvement initiatives. Implementing the recommendations can lead to better cycle time reduction, improved resource utilization, and increased productivity and cost-effectiveness. In conclusion, the stopwatch time study methodology remains a crucial tool for industrial engineers and process improvement professionals, enabling data-driven decision-making and facilitating the optimization of manual operations and human-centered processes across various industries.

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