Review of optimization of manpower and increasing line productivity

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Abstract

Maximizing the use of recourses is a goal that every company wishes to achieve. This paper seeks to find effective methods and techniques used in optimizing manpower and increasing line productivity. For manpower optimization, lean methods provide multiple solutions to optimize the workers, Standardized Work Combination Table (SWCT) and Eliminate, Combine, Rearrange and Simplify (ECRS) are used to provide continues improvements any different tasks. To insure having an optimized workforce, defining the needed number of workers is one of the important tasks and tools like Man-to-Machine Ratio and Takt time are used to set the required number. For line productivity, Overall Equipment Effectiveness (OEE) is commonly used to measure the productivity of a planned production time.

Index Terms— Productivity, Man-to-Machine Ratio, Work Sequence, Takt Time, Optimization, Manpower

Introduction & Background

Increasing production lines productivity and better utilization of the available resources are necessary to meet the daily targets set by management. With the highly competitive environment that we live in now, companies aim to improve their productivity to fulfill the market's demand. Productivity is one of the most important factors that affect production in any factory and it can be defined many ways one of these definitions is "the amount of work that can be accomplished per unit time using the available resources." There are two main factors affecting productivity and they are utilization and throughput [1]. Also, productivity is defined as the relationship between output and input, the output is goods produced by the company and the input are the resources that go in producing the goods. Productivity could be calculated for labor, materials or machines and can be partial or total. Labor productivity is an example of partial productivity and total productivity is the sum of all factors that produce goods.

Machine productivity= $\frac{\text{Output}}{\text{Total Machine Hours}}$, Labor productivity = $\frac{\text{Total quantity produced}}{\text{Worker-hours used}}$. [2]

Review of Literature

The following are the previous research review based on labor optimization and increasing of a line productivity.

Yerasi [1] conducted a study to improve productivity in an assembly line. In order to reach the desired result, first, a time study was conducted that included the current process study to study the current situation. Then an operation analysis was conducted using process chart to analyze value added and non-value added activates. After that, a simulation system was established to study and optimize the material handling process. By the end of the study, operator productivity was improved by 100%.

A study [3] conducted at a textile company with 4 production lines. The goal of this case study is to increase the productivity for all four lines. Usually, the target for each line is not accomplished. Root causes were identified then a current value stream map was conducted to study the current situation after collecting the cycle time and available time using a video recorder and a stopwatch. After that, the future value stream map was conducted after the process was studied for waste identification and removing major wastes. Finally, the productivity was increased up to 21% [3].

A study [4] investigated the performance of the operators and the efficiency of the machine. In a study aimed to increase the performance of the lines by using the Overall Equipment Effectiveness (OEE) as an indicator of availability, performance, and quality of the machine. They used OEE to identify the loss of performance to reach the root causes of the problem. Also, they calculate the overall labor effectiveness (OLE) which is another measurement tool helps to assess the productivity of the workers. The data of the time loss was collected by the operators and by using Pareto chart the area of improvement was clearly defined.

Hao [5] aimed to increase line efficiency by using line balance technique to minimize imbalance between workers and workloads in order to achieve the target with minimum loss. Line balancing helps to minimize the number of workstations and satisfy the bottlenecks constraint. The line can balance between the workstations by balancing the workload, material, and time.

Mishan & Tap [6] used line balancing and work study to increase the efficiency of a production line from 30% to 76%. Collecting the data is a very critical stage to define the root causes of the problem, observations and time study was used to assign the standard time for each workstation. Distribution of workload between the workstations was measured to identify the bottleneck and analyze the line balance loss. The maximum time in which a final product needs to be completed in order to satisfy customer demand (Takt time) was calculated to help distribute the workload equally. The improvement was achieved by eliminating idle time and non-value-added activities after rearranging the work layout and improving the methods of manual tasks.

Samat et al. [7] aimed to measure the performance of the maintenance comparing to machine efficiency by develop equipment performance and reliability (EPR) model. The models processes are in four steps. First, they used Pareto chart to select the machine with the highest impact on the plant. Second, was to analyze failure impact of the machine by creating failure mode and effect analysis (FMEA). Then, the overall equipment effectiveness (OEE) and reliability principles were used to measure the machine effectiveness. Finally, the maintenance performance level was identified. The model used to improve the maintenance system in the plant.

Pisuchpen & Chansangar [8] conducted a research at company specialized in producing plastic lenses aimed to improve the production line with the highest percentage of sales. The problem was that the average production capacity of fixed working hours does not achieve the target during the one shift. By using waste reduction methods and resources allocation, they identified the bottleneck area and worked to improve it. In the bottleneck area, there were five workstations containing two main processes. This indicates that there is a work in process and time waste. After that, they studied the task time in those two main

processes and calculated the number of workstations needed. They found that they need to reduce the number of workstations and merge them from 5 to 3 according to the concept of line balancing system experts (LBSE). After eliminating the unnecessary tasks and reducing the distance between the stations.

At the end, the result shows that the efficiency was increased by 30.75%, production capacity increased by 1,277 pieces per day and 6 pieces per worker. However, they did not achieve the target, so they decided to apply a computer simulation to verify the validity of the experiment. After the simulation was done, they listed three alternative solutions:

Alternative 1: Apply the work-study and line balancing to increase the productivity by 1,603 pieces per day and increase the average utilization by 6%.

Alternative 2: Adjusting the amount of batch between stations and using input analyzer with Arena to increase the productivity by 494 pieces per day existence utilization.

Alternative 3**:** Allocate resources for each process and get an increase in productivity by 7,738 and increase average use by 17%.

Hemanand et al. [9] conducted a study to improve a manufacturing division's productivity using lean concepts to improve the layout. The study started by creating a flow chart for process sequence to understand the process better. Then, a time study has been carried out for each machine and worker by direct time study method to help to identify problems in the layout. Each worker and machine idle and working time were recorded. Also, cycle time was calculated from the time study table. Operator travel distance and material movements were studied for the current situation then simulation was used to improve layout to reduce travel distance, thus decrease worker idle time. The new layout changes will increase labor utilization by 11.95%.

Mahmood et al. [10] conducted research at a Malaysian automotive technology manufacturer to analysis the power tool production line and to test the effectiveness of simulation in improving productivity. The line chosen by the company for the test had a manual assembly and semi-automatic operations that are controlled by operators. WITNESS simulation program was used after taking the necessary data such as process flow and cycle time for each station. The results were that there are two areas that represent the bottlenecks; balancing and milling area. Although it does not exceed the cycle time of other stations, the milling area needs one operator to set up each cycle and at the same time handle the process at the next station. Therefore, wasting 21.38% of the time because of the operator. It also shows that the utilization for some workstations is less than 50% because it is controlled by only one operator and the tasks are not organized. After simulating the design system, the results were compared before and after the simulation. They developed three solutions that help improve productivity:

Alternative 1: Reduce the number of machines where 64.73% are in idle mode and the machines have been reduced from 8 to 2 machines. But production less than the original rate accelerated 32%.

Alternative 2: Reorganize the tasks for operators and reduce their number from 13 operators to 12 operators, reducing the waiting time, increase production from 2986 to 3272 units and reduced production cost by 9.58%.

Alternative 3: Add a new workstation in the bottleneck area that leads to increase production by 28.06% but this solution requires to study the cost of adding a whole new line. The second

solution was the best and they proved that a simulation is an effective tool for improvement by effectively resource allocating.

A study [11] performed to identify defects at the product by collecting the relevant data and analyses to increase the efficiency. This study divided the production line factors into two types: machine efficiency and manpower utilization. Also, lines are grouped into three types: automated production lines, semi-automated production lines, and manual production lines. To reach their goal they measured machine efficiency, by calculating the Overall Equipment Effectiveness. The overall equipment effectiveness of the machines is at 20.75%, while machines availability is at 83.96%, and the quality was 57.89% and the performance was the lowest at 42.70 %. According to that, the improvements will focus on the performance of the machine. Then the improvement will expend to all factors to improve the efficiency of the machine. The performance of the worker was 22.35%. According to that, a company aimed to optimize its workers. On the other hand, they also measured the performance of supporting department (Total Quality Management (TQM), Planning and Control (PPC) and Maintenance). The performance of the production planning and control departments was at 100%. The performance of the maintenance department was at 98.11% and the maximum performance was for the total quality management department which was at 85.85%. After analyzing each factor. The second key influence is the line's machine. The rejection frequency of units is also high, which shows that the machine is not properly maintained or not operated well by the worker.

Bon et al. [12] conducted a study in a rice processing factory to increase the productivity in processes involving manual tasks and set a standard time for each task. The study was in the packaging phase only because it is affected the speed of operation greatly. Time and motion study were used to measure the standard time during the observation phase by using stopwatch snapback and process flow chart. Statistically Fit and Production Modeler software was used to analyze the data. The results showed that the process was done in 7 stages, the most time-consuming stage was identified. In the analysis of that stage, the result was that the layout of the factory made workers take too much time to transport the materials. Based on that, changes had been made to the layout which decreased the time to perform the work for about ten minutes, thus increased the speed of production.

A study [13] conducted to increase manpower utilization of engine accessories production line, many Lean manufacturing principles were applied. Lean manufacturing concept helps to increase operations speed, quality of a product, and decrease wastes and defects. At the first step of the study, the researcher drew the Flow Process Chart to explain the process flow of the production line. Then, used the stopwatch to study the standard time for each task, and separated the cyclic & non-cyclic activities. Then, Takt time and utilization for each man were calculated. After that, Standardized Work Combination Table (SWCT) was applied to find inactivity of workers and by integrating the concept of (ECRS) it is a Lean tool refer to Eliminate, Combine, Rearrange and Simplify in order to identify wastes and implement immediate improvements. The researcher made the adjustments to increase the utilization rate of the worker which combined some tasks, eliminate some task or simplified some process. At the end the results indicated that the number of workers has been reduced from 10 to 6 and the worker utilization rate was increased, thus reduced the cost of production.

Tonape et al. [14] conducted a study to optimize the manpower in a warehouse, it was noticed that between the time an order is released and the time it takes for it to be put away, there are errors and time losses. The goal for the project was to improve the method for put-away activities in the unloading area. The first problem that the manpower for the warehouse was not fixed. The manpower come in the morning and the supervisor distributes them in loading, unloading and stacking area. The second problem for the supervisor was the cages that were filled were not properly stacked racks. Therefore, workers in the loading area waste take long time searching for products. The improvement was done by placing the materials in more proper and fixed places. Also, the "U" type flow for unloading was applied. On top of that, a time study has been used to calculate the overall time required for unloading trucks coming in. In this technique, loading and unloading time were taken of the truck. As a result, they saved in total 10 workers, and as a cost 2230 Rs. for the worker.

A study [15] conducted to identify the factors that limit the labor productivity of Turkish contractors in Turkmenistan. Therefore, in order to collect the data, questionnaire surveys were distributed to the selected population. This survey ranks the factors limit labor productivity by Likert scale. After that, factors were ordered based on their mean scores. The results show the most 24 factors that limit labor productivity, the top 5 factors were: Lack of local experienced labor, schedule pressure, working overtime, financial weakness of the contractor, rework inadequate financial policies of the Government and working 7 days/week.

A study [16] performed to increase productivity by optimal utilization of machines and manpower of a manufacturing company in Nigeria. By applying an analysis to see the factors that affect productivity and the major areas to increase it. First, labor productivity was calculated for each year from 2007 to 2011. After that, in order to analyses, total productivity has been calculated for each year. As a final step, potential capacity was calculated by taking the average for the five years. As a result, productivity increased for manpower and machines. From the analysis, the percentage of manufacture when the machine is used (calculated machine productivity) exceeds the percentage of labor productivity by a big amount. Also, an increase in the number of labors can also lead to an increase in productivity, even if it has been observed that there are no guarantees that an increase in production affects the increase in productivity ratio.

Halim et al. [17] wanted to minimize costs and utilize manpower at a semiconductor company by determining the right number of workers needed. The study focused on assign the man-to-machine ratio at the critical point of the production.

Man-to-Machine ratio (M2M) technique assigns workers to machines and it uses work study tools like Process Mapping and Multi-Machine Chart. After using M2M, manpower utilization can be improved up to 80%.

Conclusion

Labor and machines have a big impact on any company's performance. Studying ways to improve their utilization and productivity is necessary to reduce operating costs, save time and increase the output of the company. Different industrial engineering techniques have

been proven to be a greatly useful tools in optimizing of manpower and increase line productivity and can be applied to every situation depending on companies need.

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