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Improving the Productivity of the Sewing Section through Line Balancing Techniques: A Case Study of Almeda Garment Factory

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Abstract

Nowadays, business manufacturers must have the ability to respond rapidly to customer demands. In order to have this power, the organization generally produces mass volumes of specific products. In mass production systems of specified products, assembly lines are generally used. In assembly production, imbalances are well-known problems. Line balancing (LB) is the leveling of the workload across all processes in a line or value stream to remove bottlenecks and excess capacity. Poor balance causes an increase in the production cycle time as well as idle time. This leads to lower efficiency and subsequently lowers productivity in the organization. Furthermore, this research addresses the implementation of line balancing concepts in Almeda Garment Industry (AGI). The existing operating Garment Industries are facing problems in fulfilling targets demanded by customers, resulting in the use of overtime, to overcome the problem, thus, increasing production cost. At an earlier stage, a review of the literature on productivity and different line balancing models was conducted, from the creation of the concept of productivity to its main tools and techniques. After understanding the concepts of line balancing, a description and critical analysis of the existing system in Almeda Garment Industry was made and the problem diagnosed. Improvement scenarios were suggested relating to resources, method change, and layout arrangement.

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After implementation of some of the solutions, results observed were highly encouraging. Some of the key benefits included, increased balance efficiency (by 25.74%), reduced production cost by (-2.41 birr/pcs), a 35.5% increase in productivity and a production rate increase from 49 to 68 pieces per hour. In the last part of this thesis, results before and after balancing were compared.

Keywords: Productivity; Garment Industries; Sewing Section; Bottleneck Operations; Line Balancing; Balance Efficiency; Line Balance Loss.

1. Introduction

One of the three basic needs for a human is apparel. Hence apparel has retained an important place in human life starting from the pre-historic era to today's modern world. It is a well-documented fact that the textile and apparel industries have been the driving force for all under-developed countries. Productivity therefore, is one of the major issues to be examined in the apparel industry to increase its success in terms of its requirements and income generating capacity. Productivity is the connection between the amount of output and the quantity of input used to generate that output. It is basically a measure of the degree of effectiveness and efficiency of any service and manufacturing organization in generating output, given the resources available.

According to [1], productivity improvements can also be understood at different levels. The productivity of individuals may be reflected in employment rates, wage rates, the stability of employment, job satisfaction or employability across jobs or industries. The productivity of enterprises, in addition to output per worker, may be measured in terms of market share and export performance. The benefits to the community from higher individual and enterprise productivity may be evident in increased competitiveness and employment or in a shift of employment from low to higher productivity sectors [2].

Line Balancing (LB) is the leveling the workload across all processes in a line or value stream process to remove bottlenecks and excess capacity [3]. A line is defined as a group of workers under the control of a production supervisor; therefore line balancing is concerned with the operations and work levels within a line. Balancing an assembly line means, the arrangement of the production line in the form and style which flows easily and creating systematic production sequences from one workstation to the other, so there is no delay in any workstation. In the case of any machine breakdown, awaiting the arrival of the materials or parts to complete the manufacturing operations would cause a stop in the work [4]. According to [5], line balancing is defined as an effective tool to improve the throughput of assembly line while reducing "non-value-added" activities and cycle time. They have also stated that line balancing is the problem of assigning an operation to a workstation along an assembly line, in such a way that the assignment is optimal in some sense. Line balancing is a tool that can be used to optimize the resources in a production line. This tool will assist in the reduction of manufacturing time that maximizes output, while, minimizing cost. An assembly line is a flow oriented production system where the productive units performing the operation, is referred to as the workstation. The workpieces move from one station to another through some kind of transportation system [6].

Line balancing is important in an assembly line as it can affect the performance and efficiency of the system. It is observed that a balanced assembly line enhances efficiency and productivity. Very often, assembly line balancing has been defined as the problem of allocating tasks among workstation in an assembly line so that the given objective functions are optimized [7]. Line balancing loss percentage (%LBL) is presented to identify the seriousness of the problem [8] and is calculated as follows:

$$\%LBL = \frac{nT_{max} - \Sigma t_i}{nT_{max}} \text{ x } 100\% \quad (1)$$

Where; n = number of workstations
T_{Max} = value of the highest cycle time
$\sum t_i$ = Total cycle time

Another measurement point of line balancing is smoothness index (SI) which describes relative smoothness for a given assembly line. Perfect balance is indicated by smoothness index of 0 [9]. This index is calculated in the following manner:

$$SI = \sqrt{\sum_{i=1}^{n} (Tmax - Ti)2} \quad (2)$$

Where: T_{max} = maximum operation time (in most cases cycle time),

T_i = Operation time of operation *i*.

Cycle Time can be defined as the maximum amount of time allowed at each station. This can be found by dividing required units to production time available per day.

$$\text{Cycle Time (CT)}_{\text{required}} = \frac{Process\ Time}{Demand} \quad (3)$$

Another important factor of the production line is the value of the task times. The task times are classified as deterministic and stochastic. The automated manufacturing systems or assembly lines which are equipped with flexible machines or robots are assumed to work at a constant speed hence the deterministic task times are well-fit. Sometimes the variations of the task times may be significant in affecting the performance of the system, hence the task times are stochastic [10]. When the lines are operated manually, the variations of the task times are expected due to the skills and motivations of the employees. Moreover, due to the learning effects or successive improvements of the production process variations between the task times may occur. This is supported by [11] that assembly line balancing problems can be classified into two groups: stochastic and deterministic assembly lines. When the assembly line fully automated, all the tasks will have fixed operation times. Variability (or stochasticity) comes into the picture when tasks are performed manually at the workstations [10]. For productivity improvement [12], published a paper on balancing of parallel assembly lines. Productivity improvement in assembly lines is very important because it increases capacity and reduces cost. If the capacity of the line is insufficient, one possible way to increase the capacity is to construct parallel lines. In this study, new procedures and a mathematical model of the single model assembly line balancing problem with parallel lines were proposed. Reference [13], works on assembly line balancing with station paralleling. In their study, they assume that an arbitrary number of parallel workstations can be assigned to each stage. Every task requires a specified tooling/equipment, and this tooling/equipment should be available in all parallel workstations of the stage to which the task was assigned. Their objective was to find an assignment of tasks to stages so as to minimize the sum of station opening and tooling/equipment costs. They propose two branch and bound algorithms: one for optimal solutions and one for near optimal solutions.

2. Methodology

The methodology of this research work was a case study, conducted in Almeda Garments Industry (AGI). The study gave an idea of the existing scenario of the sewing assembly line. It also dealt with line balancing, productivity and various factors that lead to making the line imbalanced. So, the research method was a strategy of analysis, which moved from the underlying to research design, and data collection [14]. Although there are other distinctions in the research methods, the most common classification of research methods is into qualitative and quantitative. At one level, qualitative and quantitative refer to distinctions about the nature of knowledge: how one understands the world and the ultimate purpose of the research. On another level of discourse, the terms refer to research methods, that is, the way in which data are collected and analyzed, and the type of generalizations and representations derived from the data. So, in this work, mixed research methods have been used. The overall work process for this research work was divided into different phases, which can be seen in Figure 2.1. Further, Figure 2.1, itself is a result of the pre-study process and was utilized as a guideline for the subsequent work process. Due to the purpose of the research work, a mix of different study methods was utilized, and it was therefore decided to use a case study approach with its practical application.

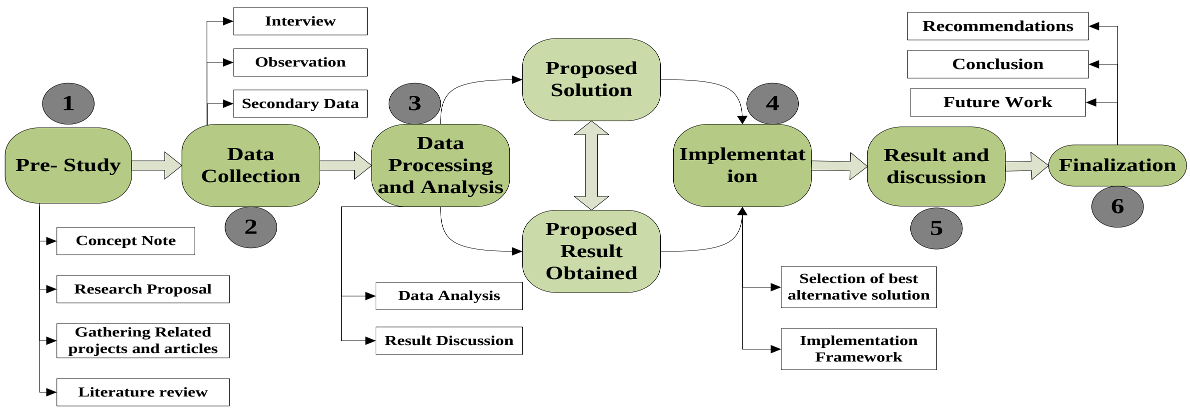

Figure 2.1: Research Work process

2.1. Data Collection Phase

The next phase is data collection phase, which aimed at collecting relevant data from the case company. The authors traveled to Almeda, to conduct observations and collect data from the case study firm (Almeda Garment

Industry). The gathering of empirical data was divided into qualitative and quantitative parts. The qualitative data was collected mainly through interviewing staff from different management levels of the organization, production employees, and examining some past record of the industrial engineering department and planning department of the industry. Major quantitative data were collected through direct involvement in the line by observation of the production floor. The data was focused on a production line specifically on the sewing section. The main goal was to collect data that support the process of identifying production bottlenecks. Generally, data was collected through primary and secondary systems.

2.2. Data Analysis and Calculations of the Existing Line

The first process of line balancing is to break down the garment into sequential operations. The existing operation breakdown was revised to better understand and implement the sequential order of the product processing steps. During analysis of the selected product, joint precedence graph consisting of all tasks, machine, manpower and actual processing time was created to see the relationship of each operation. Before line balancing, the existing production scenario is measured considering different key performance indicators (KPIs) as illustrated in Table 2.1.

Table 2.1: Performance measure by running the existing production line

S/N	Key Performance Indicators	Results	Remarks
1	Working Time (WT)	450Minute (8 Hour/Shift)	2 Shifts in a day
2	Number of Workforces	51 (37 Machinist, 2 QC,12 Helpers)	
3	Number of Workstation	34	
4	Output Quantity/Shift	368 theoretically,	
5	Processing Time (SAM)	2112 Seconds (35.19 min)	
6	Cycle Time (C_t)	89.7 Seconds (1.495min)	C_t = Working Time/Demand (output)
7	Production Cost (WIP)	6.93 birr/pcs	Sewing room only
8	Production Rate (R_p)	0.011 Pcs/Sec (0.67 Pcs/min)	R_p = Output/Working Time
9	Line Balance Efficiency (E_b)	56.36%	
10	Percentage of Line Balancing Loss (%LBL)	43.64%	2
11	Workers Productivity (P)	7.22 Pcs/Operators	P = Daily Output/No. of Workforce
12	Input Factor (%IF)	11.50%	

Process wise capacity utilization of each operation has been shown in figure 3.2 to see the variations of workload assigned to each workstation. As different researchers studied the benchmark balance efficiency of a line ranges from 80-85%. Observation before balancing the line has been reflected as labor productivity is 7.22, with line balance efficiency of 56.36%. Besides, the input factor (IF) percentage of the line is calculated as there is a shortage of input.

$$Input\ Factor(\%) = Existing\ line\ balance - \left(\frac{Actual\ monthly\ average\ input}{Minimum\ monthly\ required\ input} * 100\%\right) \quad (4)$$

2.3. Drawbacks of the Existing Scenario

In the existing line, the following drawbacks have been observed

- Missing tasks from the total process time
- Inefficient use of manpower amounting to an unequal workload distribution
- Wrong use of working methods which leading to addition unnecessary manpower
- Non-value added activities and unnecessary workers
- Disorganized layout resulting in long distances covered during operations
- Low productivity levels

2.4. Development of Solutions

In developing alternative solutions, the researchers have proposed and experimented with different scenarios and come up with the following optimal solutions.

I. Increasing level of resources at the bottleneck operations

The levels of output of each operation in the existing scenario are investigated and the bottleneck operation with low daily output are listed in Table 2.2.

Table 2.2: Highly Bottleneck Operation in the Existing Scenarios

Op No.	Bottleneck Operations	Machine Type	Existing Resources	Process Time (Min)	Hourly Output	Existing Line Output	Existing Balance Efficiency	Proposed Resources	Proposed Line Output	Existing Balance Efficiency
5	Placket Attach	SNLS	2	1.88	64	49 Pcs/Hour 368 Pcs/Day	56.36%	3	68 Pcs/Hour 509 Pcs/Day	75.17%
22	Sleeve Tuck	SNLS	1	1.22	49			2		

*Where, “Op No.” stands for Operation Number and “Pcs” stands for pieces

Therefore, the addition of resources to those operations decreases the level of WIP at each station and increase the amount of output as well as the line balancing efficiency.

II. Avoiding Non-Value Added Activities by changing Work-Methods and Layout Arrangement

The second alternative solution is generated by modifying the alternative I. The modification is made based on the concept of eliminating, combining and simplifying the assembly line process without any additional resources of machine and manpower. Some stations have multiple duplications of resource but their capacity utilization is below 50% with the reference of daily customer demand. In these stations duplications, unnecessary resources found. Therefore, these unnecessary resources should be reduced from the system by building new work method and re-arranging flow processes.

III. Combining Operations having Similar Machines and assigning to one Worker

The third alternative solution is generated by modifying the previous alternatives. The modification is made based on the concept of merging operations with similar machines to simplify the assembly process without any additional machine and manpower.

IV. Combination of Scenario II and III with Adjustments

To achieve better efficiency and productivity, combining scenario II and III and running together can increase the balancing efficiency up to 82.1% making it the highest of the overall scenarios. The capacity utilization of operation number 4 is 27.22%, because of the uniqueness of the machine it cannot be combined with other operations but assigned to work for two lines and its capacity utilization is then increased to 75.5%.

3. Results and Discussion

The comparison of the production line of the polo shirt before and after the balancing process is summarized and shown in figure 3.1 - 3.7 below.

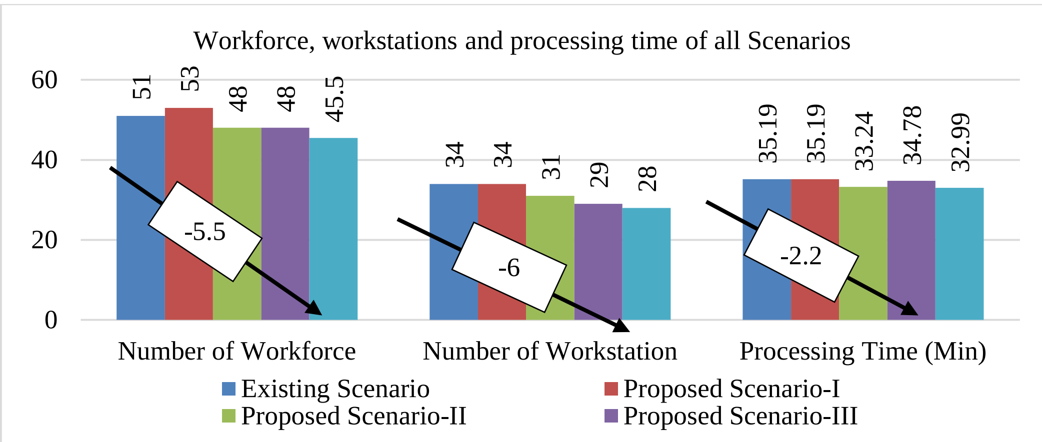

Figure 3.1: Comparison of workers, workstations and processing time of the existing and proposed scenarios

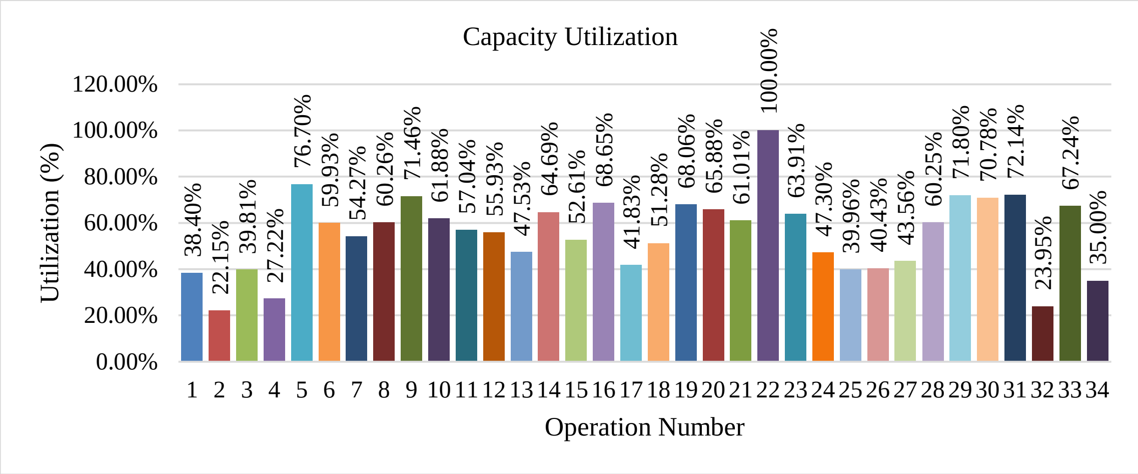

Figure 3.2: Existing Capacity Utilization of each resource assigned

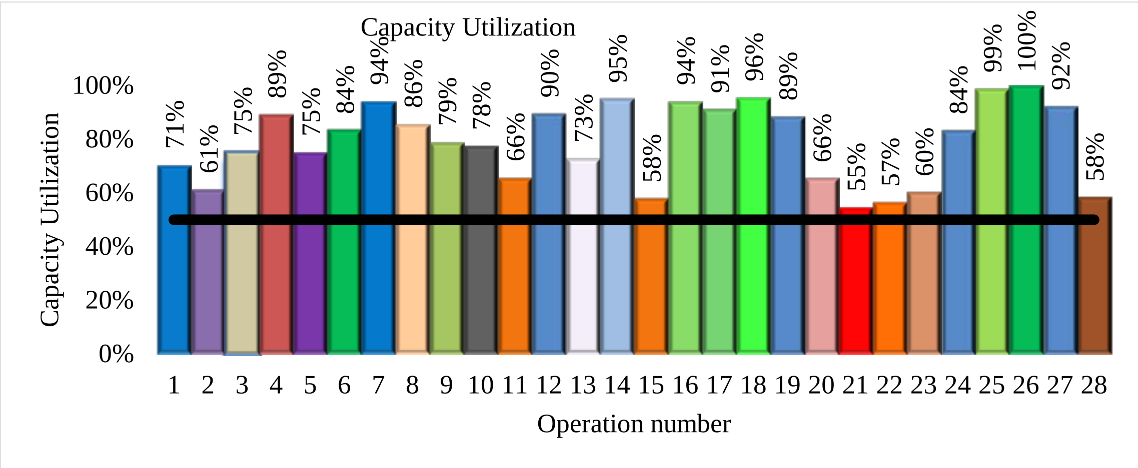

Figure 3.3: Improved capacity utilization of scenario – IV

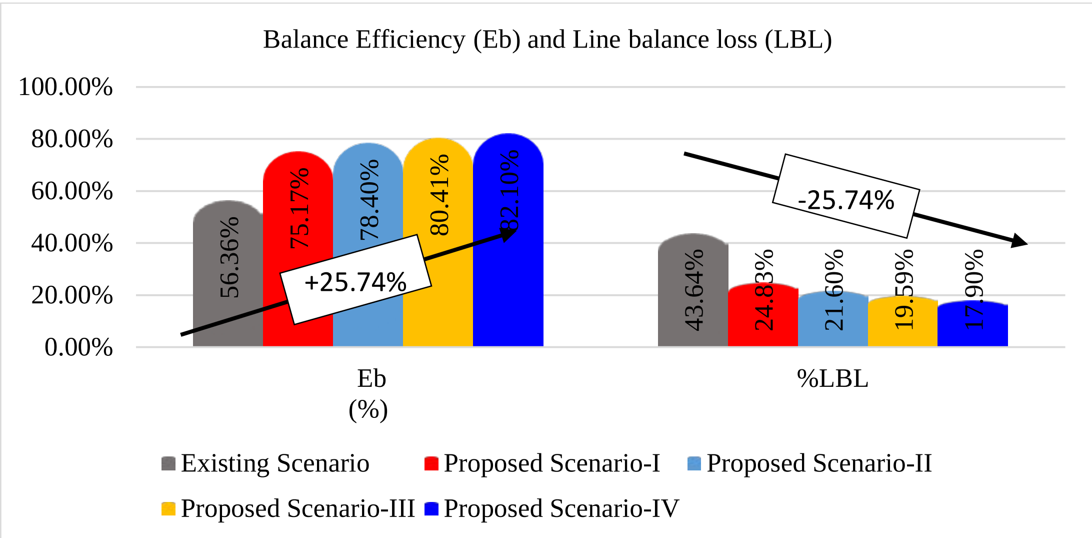

Figure 3.4: Comparison of balance efficiency and balance loss of the existing and proposed scenarios

In shift working time of the company the existing line producing 368pcs with a balance efficiency 56.36% but with the improved scenarios I, II, III, and IV the balance efficiency has been increased to 75.17%, 78.40%, 80.41% and 82.10% respectively.

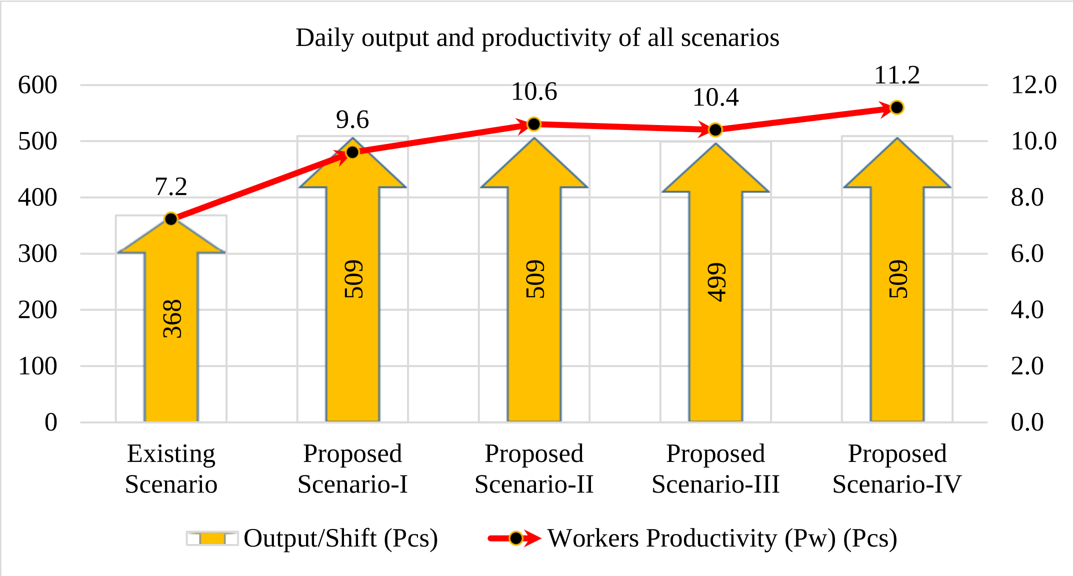

Figure 3.5: Comparison of daily output and productivity of the existing and all the proposed scenarios

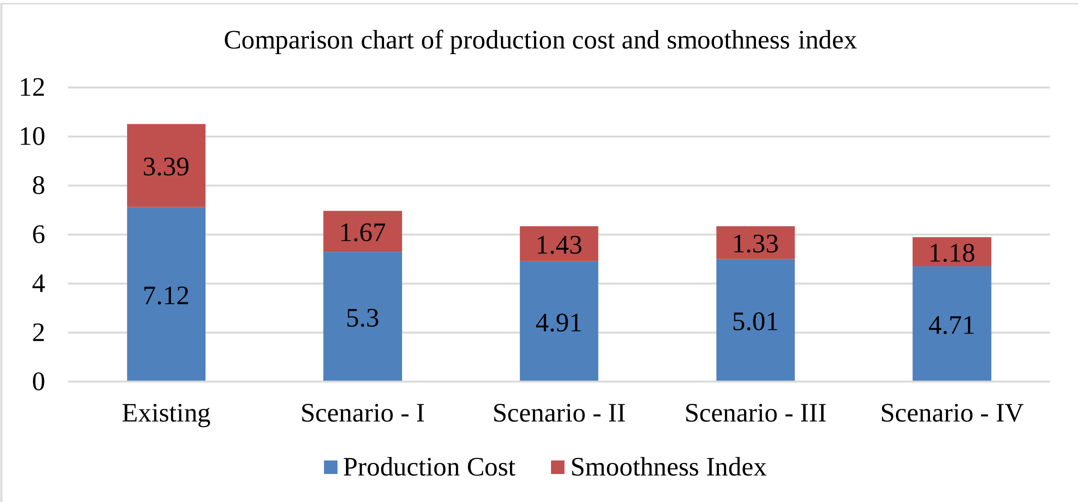

Figure 3.6: Comparison chart of production cost and smoothness index for existing and all proposed scenarios

This is the summarized improvement rate of each key performance indicator (KPIs) as it is shown in figure 3.7. For example the number of workers was reduced from the existing of 51 operators to 45.5 operators at a reduction rate of 14.71%. Other KPIs were daily output and productivity which has been increased from 368 pieces per day per shift and 7.22 pieces per operator to 509 pieces per day per shift and 11.2 pieces per operator with incremental rate 38.32% and 55.12% respectively.

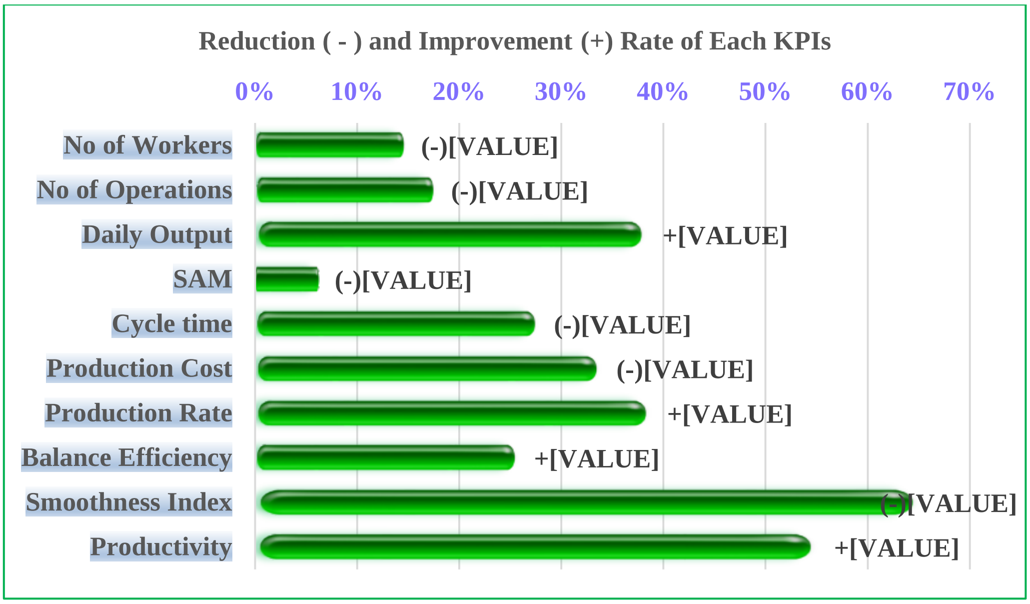

Figure 3.7: Improvement rate of each key performance indicators

4. Conclusions

The objective of this thesis was to improve the productivity of the manual single model assembly line. Line balancing concept was applied to a case study problem and four different assembly solutions were developed and compared, namely (I) Increasing level of resources at bottleneck process, (II) avoiding non-value added activities by changing work method and layout, (III) merging operations having similar machines and (IV) combination of scenario II and III. Based on the analysis of each key performance indicator (KPIs), after measuring results, the fourth scenario was suggested for implementation. As Figure 3.5 and 3.6 shows that the proposed system results in increased productivity and reduced production cost with respect to the resources used. The original assembly line had a production rate of 49 pieces per hour and productivity of 7.22 polo shirt/operator/shift, whereas, the improved fourth scenario resulted in 68 pieces per hour and 11.2 polo shirt/operator/shift respectively. When fully implemented the company can save Birr 1,226 per day per shift (Birr 31,894 monthly) from one line in terms of only production cost.

5. Recommendations

Based on the discoveries of the study, the researcher would like to suggest some specific issues that are considered vital for the proposed line balancing. According to the findings, it is the belief of the researcher that the factory can produce at a higher rate than the existing when the input rate against the customer demand is equal or more. In addition to that, during implementing the modified assembly line, the researcher strongly recommend that the company should maintain the input factor investigated which is 11.54% in order to produce the expected results. Not only the amount of input required but also the quality of those inputs should be assured as per the customer requirements; besides, tight follow up is required in the capacity utilization of each resource assigned in the line.

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