

# A RESEARCH ON THE EFFECT OF METHOD STUDY ON PRODUCTION VOLUME AND ASSEMBLY LINE EFFECIENCY

## METOT ANALİZİNİN ÜRETİM HACMİ VE MONTAJ HATTI VERİMLİLİĞİNE ETKİSİNİN ARAŞTIRILMASI

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### ABSTRACT

Method study which is one of the two basic elements of work study is the most effective methods that are used to produce more effectively with current machines and labor without any need for investment. In this research, the operations in blouse sewing line are analyzed critically and the results of method study which is applied on four operations are investigated. Following that, assembly line balancing is conducted by using Ranked Positional Weight Method considering operation durations which are obtained from method study and current operation times. The aim of this research is to analyze the effects of method study on production volume and assembly line efficiency and to indicate the importance of method studies.

**Key Words:** Method study, Work measurement, Productivity, Production volume, Sewing, Assembly line balancing, Ranked Positional Weight.

### ÖZET

İş etüdünün iki temel bileşeninden biri olan metot analizi, özellikle mevcut işgücü ve makinelerle, herhangi bir yatırıma ihtiyaç duyulmaksızın daha verimli üretimin gerçekleştirilebilmesi için uygulanan en etkili yöntemlerden birisidir. Bu çalışmada bluz dikim bandında gerçekleştirilen operasyonlar eleştirel bir gözle incelenmiş ve 4 operasyon üzerinde yapılan metot analizi çalışmalarının sonuçları verilmiştir. Daha sonra mevcut durumdaki operasyon süreleri ile metot analizi çalışmaları sonucunda elde edilen operasyon süreleri dikkate alınarak Konum Ağırlık Yöntemi ile montaj hattı dengelemesi yapılmıştır. Bu çalışmanın amacı, metot analizinin üretim hacmi ve montaj hattı verimliliği üzerine etkisini incelemek ve metot analizi çalışmalarının önemine vurgu yapmaktır.

**Anahtar Kelimeler:** Metot analizi, İş ölçümü, Verimlilik, Üretim hacmi, Dikim, Montaj hattı dengeleme, Konum Ağırlık Yöntemi.

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### INTRODUCTION

Productivity, with its widely used definition, is a relation between output which is produced by a production process or service system and input which is used to produce output. (1). Productivity is one of the major determinants that enable manufacturing organizations to compete in the global market (2). One of the most important factors which increase competitive capacity of companies is to use their production bases in the most effective way. Therefore, to minimize loss of the factors related to labor, machine and material provides opportunity to increase productivity. (3).

In apparel companies, the sewing room is a production department where the most of the labors operate and the size of apparel companies are considered with their sewing

capacity. Besides quickness and productivity of apparel production is also determined by considering sewing room (4). Consequently, the studies which are applied to increase productivity in sewing department substantially affect productivity of companies (5).

The factors affecting the productivity of a production unit are many and vary. Productivity can be increased by several methods such as modernization, automation and technological improvements but this involves substantial capital investment. The productivity is the better utilization of existing resources. The work study aims at improving the productivity through the systematic analysis of existing operations, processes, work methods and resources with a view to increasing their efficiency (6).

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Work studies provide to increase companies productivity by means of designating production efficiency, job engineering and standardization of job in a correct way and for this reason companies have to use work study techniques (3). The British standards institution defines work study as "A management service based on those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts, and which lead to the systematic investigation of all the resources and factors which affect the efficiency and economy of the situations being reviewed in order to effect improvement" (7).

Work study is one of the common techniques that can be used to evaluate and improve productivity in operations (8). Work study is combination of method study and work measurement. Method study deals with method of doing work and work measurement deals with the time required to do work (9).

Most of the managers pay attention to number of products rather than paying attention how these products are produced. It causes not to have enough information about whether productions are performed ideally or not. By means of method study, the detail of the activities which are performed by operators can be viewed and unnecessary activities can be removed or eliminated. Finally it enables to work more ideally rather than to work harder (10). The objective of method study is to find better ways of doing things and to contribute to the improved efficiency by eliminating unnecessary work, avoidable delays and other forms of waste (7). Production wastes make the manufacturing processes inefficient that directly hampered the productivity. So it is high time to make the manufacturing processes waste free and dynamic. It may be possible to reduce any kind of non-value added activities from the manufacturing processes (11).

Method study is one of the most effective ways to eliminate unnecessary and non-value adding activities as a result of analyzing these activities. When the activities which are performed during the operation are examined, 3 types of activity can be described. These activities are; main activities, incidental activities and additional activities. Main activity is type of operations which are performed for main production. Incidental activity is type of operations which are performed after and before the main activity and add more value to production within main activity. Additional activity is a type of operations which don't add value to production. On the contrary additional activities are type of operations which are not wanted to be performed. It especially results in waste of labor cost, time, and energy and machine usage (8).

When sewing process is analyzed, it can be understood that it consists of main and incidental activities. Therefore it can be indicated that sewing operation results in more than one sub operations. Sub of these sub operations can generate loss of time and labor job because of applied method. It causes operation durations to last longer and to decrease production volume. It also causes to have longer cycle time and to have difficulty to balance assembly line (5).

Method Study can be defined as the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods, and reducing costs (12).

Method Study concerned with the way in which work is done. Method study is essentially used for finding better ways of doing work. It is a technique for cost reduction. The philosophy of method study is that "there is always a better way of doing a job" and the tools of method study are designed to systematically arrive at this better way of doing a job (13). It mainly focuses most effective use of plant, equipment, human effort & human work evaluation. Under method study every activity critically observed and their corresponding working time is taken then examines the activities whether it is necessary or not. It may be possible to reduce any kind of non-value added activities from the manufacturing processes (14).

Method study may be applied to the process either to eliminate, combine or simplify certain operations. Reduction of process or operational time, cutting down of delays, increased output, improved quality and similar factors may prompt method study investigation (6). Method study can be applied to any type of work. But to get the best advantages, it is better to apply method study to repetitive type of work (9).

The objectives for method study including increasing operator performance, to improve safety as well as decreasing fatigue and hazard (3).

At every stage of the production, hand and body movements, machines and instruments which are used to produce, place, setup, and product design which are needed to produce are examined. As a result of these analyses, the cost is brought down by providing economy, simplicity for human endeavor and saving for time and material (15).

Steps in method study can be sorted as seven steps as selecting the work to be studied, recording the existing work method and all other relevant facts, examining the method, developing the most efficient method of doing the work, defining the method, installing this method as standard practice and maintaining this practice (12).

In method study it will be really effective to give priority to the activities which can result in bottleneck (15).

Assembly lines are the places where parts and components of the products are pieced together and treated in different ways. The basic specialty of an assembly line is to transfer work pieces from one station to another. (3). Assembly line balancing or line balancing is to attain needed operations during the product formation to assembly stations in a way that duration of lost times can be reduced. In other words it is described as allocating work pieces to operation systems (8). Assembly line balancing methods based solution approaches are threefold: Heuristic methods, analytical methods and simulation techniques. (12).

### Literature review

Although many researches applied on work study and efficiency there is no sufficient research on method study. These studies put emphasize on work measurement.

When the researches on method study are investigated it can be seen that most of researches are about increasing the productivity (2, 10). In a research conducted by Kayar, product standard time is considerably shortened and it is indicated that this shortening increases production volume (5). In a research conducted by Islama and his colleagues, a

contrastive method study is conducted to shorten print time. On the other hand in this research it is claimed that cycle time of each operation is shortened and labor productivity increases along with general productivity by means of method study (14). In a research conducted by Mayank and his colleagues, ineffectual processes are eliminated, and number of process is increased, productivity of land usage increases, production and operation durations are shortened (16). In a research conducted by Bon and Ariffin, some work processes are eliminated or reunited by a study aiming to improve processes (17).

When the history of researches applied on assembly line balancing is investigated, it appeared that the idea of assembly line balancing was originally suggested by Bryton, in his article called "Balancing of Continuous Production Line" in 1954 (18). The first published research is called "The assembly Line Balancing Problem" and it was conducted by Salveson in 1995 (19). After this study a great variety of researches are conducted by academics who gave its name as assembly line balancing method. The names of the researchers that can be given as example are; Bowman in 1960, Kilbridge and Wester, Helgeson and Birnie, Tonge in 1961, Hoffman in 1963, Moodie and Young in 1965, Arcus in 1966, Talbotin 1975 and following years, F.B. and Patterson, J.H., Gehrlein, W. V in 1984 and 1986, Agrawal ve El-Sayed ile Boucher in 1985, Baybars in 1986 and Hoffman in 1990. (20-33).

When the studies on assembly line balancing in apparel industry are reviewed, the first comes to mind is the study conducted by Basmak, in which a new method was developed for assembly line balancing problem (34). The studies on apparel assembly line balancing were conducted by Eryuruk and his colleagues (35, 36). Different studies were also conducted by Guner and his colleagues on apparel assembly line (37, 38).

## 2. EXPERIMENTAL

In this research knitted blouse is analyzed. The model of the analyzed blouse is shown in figure 1.

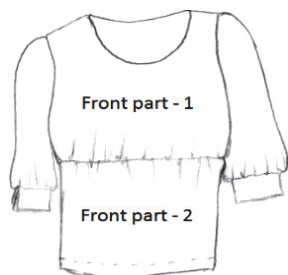


Figure 1. Model of knitted blouse

The blouse which is shown above consists of 8 parts including front 1 and 2, back, sleeve (2), cuff (2) and collar (1). The blouse produced when parts are treated in appropriate machines according to operation order.

### 2.1. Work measurement

Time study provides needed information to design, to plan, to organize and to control the production process (1, 39).

The most widely technique among work measurement techniques used in the companies is the time study, in other

words it is called the stopwatch technique (5). All operation times are measured by using stopwatch to determine the standard time of production of blouse sewing.

The measurements are also made for operations which improved by method study. The measurements are done as PM (percentage- minute) and they are turned into minute (percentage-minute/ 60) by calculating their arithmetic means. As these measurements are being done, the data on how many measurements are necessary for each operation are provided by means of the formula given below. These measurements are repeated by considering the data which are obtained. In this statistical method, several pre-observations ( $n^1$ ) are conducted. Afterwards the formula given below is solved for 95,45 security level and  $\pm$  % 5 error margin (8).

$$n = \left( \frac{40 \sqrt{n^1 \sum x^2 - (\sum x)^2}}{\sum x} \right)^2$$

Where:

$n$  is Actual Sample Size,  $n^1$  is number of pre-observations,  $x$  is measured time.

Pre-observations are done for each operation (the number of pre-observations is 5). In parallel with these pre-observations, the formula is used to determine how many times operations are needed to be measured. The maximum rate regarding to measurement numbers for all operations is found as 10. In parallel with this result taken from pre-observations 10 measurements are done for every operation.

Time studies also necessitate hecatically use of the techniques such as performance assessment to attain operation speed and to link operation speed with standard operation pace (1). While operation durations are being measured, performance assessment is done for each operation.

Normal time is calculated by multiplying measured time by performance. Some additions should be added to normal time. Some operations that cannot be repeated in every loop, unpredictable loss of time, some reasons as fatigue require increasing normal duration with deliberately appointed additions. These additions that are attained to increase the normal duration are called tolerance (highly forgiving) (39). During the interview that is conducted with executives of the company in which blouse are produces, it is stated that tolerance share was calculated as %15 as a result of previous measurements and this rate is used to estimate the standard time.

Afterwards the standard time is calculated for each operation by using formula shown below.

$$ST = MT \times R + MT \times R \times t$$

Where:

$ST$  is standard time,  $MT$  is measured time,  $R$  is performance,  $t$  is tolerance (40).

As a result of the calculations, the durations of the operations in terms of minute which are performed before and after method study are obtained.

## 2.2. Method study

During the time measurement, the operations which can be improved are detected in consequence of analyze of labor movement and their working techniques along with time measurements. By means of performed improvements, it enables to operate more easily and in shorter time. The operations are addressed within the scope of method study are put in order below.

“Front part puckering”, “Sewing shoulder”, “Assembling cuff to sleeve”, “Collar overlock”.

Activities are shown as block or bar on a time scale in an activity chart. Times of the activities are determined according to length of the bars (15). However in the activity charts that belong to operations below, instead of activity time, the sub operations which results in activities are shown. The meaning of the symbols in given in activity charts can be described as below.

- Machine or operator works independently
- Machine or operator works at the same time
- ▨ Machine or operator waits without operating

### 1. Front part puckering

When operation performing process is analyzed, sub operations which are performed by operators are put in order as below (Figure 2);

1. Getting front part-1 with two hands and place under the pressure foot.
2. Place the transparent elastic band under the pressure foot.
3. Sewing transparent elastic band to bottom of front part-1 for 1 cm.
4. Getting ruler.
5. To measure 10 cm distance with the ruler on transparent elastic band.
6. Marking.
7. Leaving ruler.
8. Getting scissors.
9. Cutting transparent elastic band from marked point with the scissors.
10. Leaving scissors.
11. Sewing transparent elastic band to bottom of front part-1 completely.
12. Getting the piece with one hand and leaving aside.

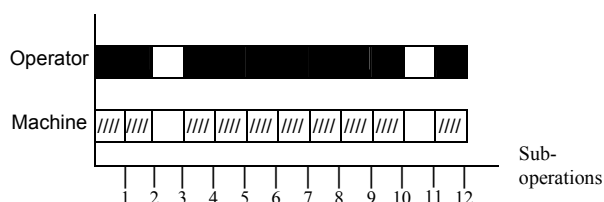


Figure 2. Sub operations performed before method study front part puckering operation

When the process of the operation is analyzed after method study; the sub operations performed by the operator are put in order as below (Figure 3);

1. Getting front part-1 with two hands and place under the pressure foot.
2. Place the transparent elastic band under the pressure foot.
3. Sewing transparent elastic band to bottom of front part-1 for 1 cm.
4. Marking according to ten centimeters distance which is pointed on the machine table before.
5. Getting scissors.
6. Cutting transparent elastic band from marked point with the scissors.
7. Leaving scissors.
8. Sewing transparent elastic band to bottom of front part-1 completely.
9. Getting the piece with one hand and leaving aside.

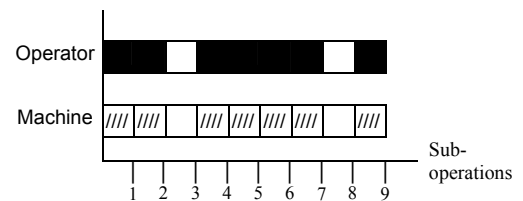


Figure 3. Sub operations performed after method study front part puckering operation

As it can be seen from the activity charts which are given above, the new method is performed in shorter time than the previous method is performed. By changing the operation of transparent elastic band measurement, the sub operations numbered 4, 5, and 7 are removed. As a result of this, operation duration decreases from 0.571 minute to 0.462 minute.

### 2. Sewing shoulder

When operation performing process is analyzed, sub operations which are performed by operators are put in order as below (Figure 4);

1. Getting front part with two hands and place under the pressure foot.
2. Getting back part with two hands and place under the pressure foot.
3. Sewing the front and back parts from shoulder.
4. Getting the sewn parts with one hand.
5. Getting scissors with one hand,
6. Making regulate (cut off the excess fabric)
7. Leaving scissors,
8. Getting the piece with two hand and leaving aside.

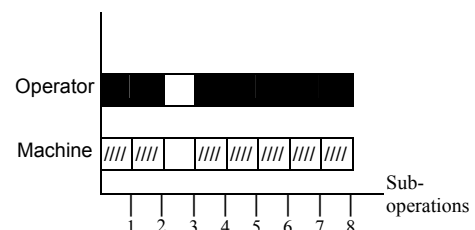
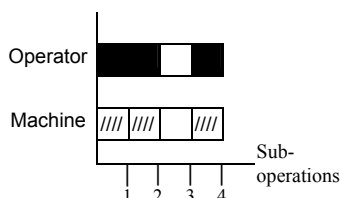


Figure 4. Sub operations performed before method study shoulder sewing operation

When the process of the operation is analyzed after method study; the sub operations performed by the operator are put in order as below (Figure 5);

1. Getting front part with two hands and place under the pressure foot.
2. Getting back part with two hands and place under the pressure foot.
3. Sewing the front and back parts from shoulder.
4. Getting the piece with two hand and leaving aside.



**Figure 5.** Sub operations performed after method study shoulder sewing operation

As it can be interpreted from the activity charts above, the recommended method is applied in shorter time than the method applied before.

The sub operations numbered 4, 5, 6 and 7 are removed and machine usage rate is increased by means of making another operator perform for regulate operation which is an operation performed after shoulder sewing.

The operation time is decreased from 0.590 minutes to 0.383 minute by means of eliminating the sub operations that are mentioned above.

The operation time of being performed regulate process by another operator is calculated as 0.193 minutes.

In the frame of the recommended method, the total duration decreased  $0.383+0.193=0.576$  minutes. While the machine is kept occupied for 0.590 minute by using the previous method, it is kept occupied for 0.383 minute by using the recommended method.

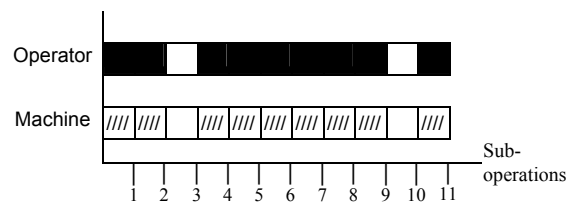
### 3. Assembling cuff to sleeve

When operation performing process is analyzed, sub operations which are performed by operators are put in order as below (Figure 6);

1. Getting cuff with one hand and place under the pressure foot.
2. Regulating selvages of cuff by superimposing them
3. Sewing selvages of cuff parts by folding them in the middle
4. Getting scissors,
5. Cutting the excess of thread
6. Leaving scissors,
7. Leaving aside the cuff with one hand
8. Getting sleeve with two hands and place under the pressure foot.
9. Getting cuff with two hands and place under the pressure foot.

10. Sewing cuff to sleeve

11. Leaving aside the sewn pieces with one hand.

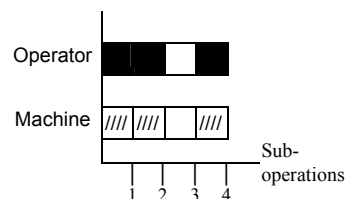


**Figure 6.** Sub operations performed before method study sewing cuff to sleeve operation

When the duration of operation which is performed in the recommended way is analyzed; as a result of being performed cuff preparing operation and assembling cuff to sleeve operation by another operator, sub operations of each operation are put in order as below.

*Cuff preparing:*

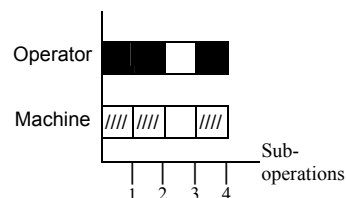
1. Getting cuff with one hand and place under the pressure foot.
2. Regulating selvages of cuff by superimposing them.
3. Sewing selvages of cuff parts by binding them in the middle.
4. Surplus tread trimming after every ten cuff preparing operations.



**Figure 7.** Sub operations performed after method study cuff preparing operation

*Assembling cuff to sleeve:*

1. Getting sleeve with two hands and place under the pressure foot.
2. Getting cuff with two hands and place under the pressure foot.
3. Sewing cuff to sleeve
4. Leaving aside the sewn pieces with one hand.



**Figure 8.** Sub operations performed after method study assembling cuff to sleeve operation

As it can be understood from the activity charts which are given above, the recommended method is applied in shorter time than the performed method. In case cuff preparing operation and attaching cuff to sleeve operation are performed separately, the cuff preparing operation lasts

0.151 minute and the attaching cuff to sleeve operation lasts 0.205 minute. A single operation which can be performed in 0.423 minute by previous method, it can be totally performed in 0.356 minute (0.151+0.205) by using this method. Hereby it can be possible to eliminate bottleneck which can be encountered in assembly line which is set in the company.

#### 4. Collar overlock

While the collar overlock operation is performed after a collar part is sewed on a body part by using the previous method, it is performed before a collar part is sewed on a body part. Therefore regulations which are made during sewing and moving collar part and body part simultaneously on the machine are substantially eliminated since it enables to move collar part alone on the machine. Accordingly, the new method not only provides advantages in terms of time but also enables to perform the operation by worrying the operator less.

The sub operations which are performed by using the previous method and the recommended method and the activity charts of these operations are shown below.

1. Getting collar with two hands and place under the pressure foot.
2. Making overlock stitch
3. Correction
4. Making overlock stitch
5. Correction
6. Making overlock stitch
7. Cutting the excess of thread
8. Leaving aside the piece with two hand.

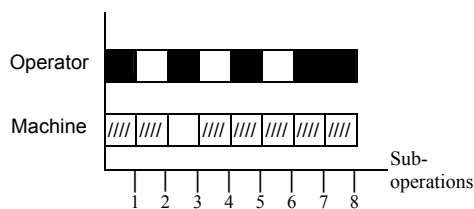


Figure 9. Sub operations performed before method study collar overlock operation

When the duration of performing the operation in the recommended way is analyzed, the number of the regulation process which the operator has to make by using the previous method becomes 1 since the collar overlock process is performed before collar part is sewed on the body part.

1. Getting collar with one hand and place under the pressure foot.
2. Making overlock stitch
3. Surplus tread trimming after every ten collar overlock operations.

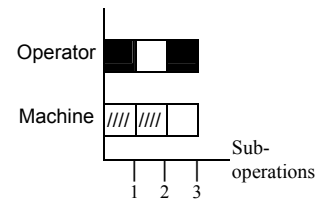


Figure 10. Sub operations performed after method study collar overlock operation

As it can be seen from the activity charts which are given above, the operation lasts in 0.394 minute by using the previous method. It lasts 0.292 minute by using recommended method. Current and developed durations of four operations above which are considered in the frame of method study (MS) activities and list of ordered operations which belongs to blouse sewing and machines that are used during the operations are shown in the table below.

As it can be seen in the table which is given above, after the method study, performing duration of machine and operator during the four operations decreases from 1.978 minute to 1.493 minute. In terms of machine usage efficiency it provides 0.485 minute saving of time. "Shoulder regulate" operation is distinguished from "Shoulder Sewing" operation and it enables the machine not to wait without performing for any operation.

Table 1 also shows that before the method study is applied, the duration of blouse sewing process is 8.957 minutes within the scope of the method study. As a result of developed works of the four operations, the duration of blouse sewing process becomes 8.665 minutes. It provides 0.292 minute time saving.

#### 2.3. Assembly line balancing

Ranked Positional Weight Method which is one of the Heuristic Methods used for assembly line balancing was applied.

The duration of a workstation cannot be shorter than the longest duration of a work unit and it cannot be longer than cycle time (41). Because of this principle, the cycle time in assembly line balancing studies is accepted as 0.887 minute. Loss of balance of assembly lines, their efficiency and their daily total production amount is estimated by using formulas which are given below.

$$*LB = ((nC - \sum C_o) / nC) 100$$

$$*LE = (1 - LB) 100$$

$$*PA = T / C$$

Where:

LB is Loss of Balance, LE is Line Efficiency, C is Cycle Time, n is Total Number of Work Stations,  $C_o$  is Average of Work Station Time, PA is Daily Total Production Amount and T is Daily Total Production Time (5).

In all assembly line balancing studies which are carried out within the scope of this study, it is supposed that *hand-made operations are done by all operators* on condition that operations are done by same type of machines.

**Table 1.** The list of ordered knitted blouse operations which are performed before and after the method study, durations of operations, machines that are used and the previous operations

Op. No.	Operations before Method Study (MS)	Op. No.	Operations after Method Study (MS)	Machine type	Operation times before MS (min.)	Operation times after MS (min.)	Previous operations after MS
1	Front part (1) puckering	1	Front part (1) puckering	Lock-stitch sewing machine	0.571	0.462	-
2	Assembling the upper (1) and lower (2) piece of the front	2	Assembling the upper (1) and lower (2) piece of the front	3 thread overlock	0.408	0.408	1
3	Sewing shoulder	3	Sewing shoulder	3 thread overlock	0.590	0.383	2
4	Sewing shoulder	4	Shoulder Regulate	Hand-made		0.193	3
4	Sleeve hem puckering	5	Sleeve hem puckering	Lock-stitch sewing machine	0.341	0.341	-
5	Assembling cuff to sleeve	6	Cuff preparing	3 thread overlock	0.423	0.151	-
		7	Assembling cuff to sleeve	3 thread overlock		0.205	5 – 6
6	Sleeve sewing	8	Sleeve sewing	3 thread overlock	0.541	0.541	4 – 7
7	Side seam	9	Side seam	3 thread overlock	0.837	0.837	8
8	Hem cover seam	10	Hem cover seam	Cover stitch machine	0.588	0.588	9
9	Collar sign	11	Collar sign	Hand-made	0.229	0.229	-
10	Collar preparing	12	Collar preparing	Lock-stitch sewing machine	0.450	0.450	11
11	Sewing collar	13	Collar overlock	3 thread overlock	0.517	0.292	12
12	Collar overlock	14	Sewing collar	3 thread overlock	0.394	0.517	10 – 13
13	Collar edge stich	15	Collar edge stich	Lock-stitch sewing machine	0.481	0.481	14
14	Collar topstitch	16	Collar topstitch	Lock-stitch sewing machine	0.887	0.887	15
15	Sleeve hem topstitch	17	Sleeve hem topstitch	Lock-stitch sewing machine	0.373	0.373	16
16	Label attaching	18	Label attaching	Lock-stitch sewing machine	0.536	0.536	17
17	Yarn severing	19	Yarn severing	Hand-made	0.791	0.791	18
<b>Total Time</b>					<b>8.957</b>	<b>8.665</b>	

#### 2.4. Assembly line balancing study before method study

Assembly line balancing study is carried out according to blouse production which consists of 17 (before method study) operations which are shown in Figure 11 with its diagram. The operation time which belongs to blouse sewing, machines which are used during this operation and previous operations are shown in Table 1 above.

To be able to apply this method on assembly line balancing the table which is shown below must be created (Table 2).

In table 2, operation numbers are shown in the first column and operation times are shown in the second column. In the mid-section of the table factor priorities are given.

For instance; 1<sup>st</sup> operation is followed by 2<sup>nd</sup> operation and 3<sup>rd</sup> operation and 5<sup>th</sup> operation is followed by 6<sup>th</sup> operation. "1" which is written in the midsection indicates the operation which comes just after an operation, "+" represents the operations which comes after an operation and have relation with others. In the last column positional weights for each factor are given. Positional weights are estimated by adding operation time of each factor to standard time of all operations that follow this operation (41).

While making valuation, primarily, the operation numbered 1 which has the highest positional weight is assigned to 1<sup>st</sup> work station. The residual time of 1<sup>st</sup> work station is  $C-t_1 = 0.887 - 0.571 = 0.316$  minute. After the assignment of operation numbered 1, operation numbered 2 which has higher position weight cannot be assigned because operation duration of 2 is higher than remaining time of the 1<sup>st</sup> work station and also due to using different type of machine. Among the rest of the operations, when priority and type of the machines are considered only the operation

numbered 9 is assigned to 1<sup>st</sup> work station and remaining time of 1<sup>st</sup> work station is calculated as  $C-t_9 = 0.316 - 0.229 = 0.087$  minute.

The operation numbered 2 is assigned to 2<sup>nd</sup> work station. The residual time of 2<sup>nd</sup> work station is  $C-t_2 = 0.887 - 0.408 = 0.479$  minute. After the assignment of operation numbered 2, operation numbered 4 (0.341 min.) which has higher position weight is shorter than remaining time of the 2<sup>nd</sup> work station, but it cannot be assigned because of a different type of machine is used. Among the rest of the operations when priority and type of the machine are considered, another operation cannot be assigned to this station.

The operation numbered 4 is assigned to 3<sup>rd</sup> work station. The residual time of the 3<sup>rd</sup> work station is  $C-t_4 = 0.887 - 0.341 = 0.546$  minute.

After the assignment of operation numbered 4, operation numbered 3 which has higher position weight cannot be assigned because operation duration of 3 is higher than remaining time of the 3<sup>rd</sup> work station and also due to using different type of machine. Among the rest of the operations, when priority and type of the machines are considered only the operation numbered 10 is assigned to the 3<sup>rd</sup> work station and remaining time of the 3<sup>rd</sup> work station is calculated as  $C-t_{10} = 0.546 - 0.450 = 0.096$  minute.

As it can be seen in the assignment example which is done for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> work station, one can achieve a solution. The solution results according to designing assembly line by using Ranked Positional Weight Method are shown Table 3.

As it can be seen from table above, the assembly line is designed according to have 0.887 minute cycle time with 15

work stations. Loss of balance and assembly line efficiency of designed assembly line are shown below.

$$LB = \frac{((15 \times 0.887) - (8.957))}{(15 \times 0.887)} \times 100 = 32.679\%$$

$$LE = (1 - 0.32679) \times 100 = 67.32\%$$

### 2.5. Assembly line balancing study after method study

Assembly line balancing study is carried out according to blouse production which consists of 19 (after method study) operations which are shown in figure 12 with its diagram. The operation time which belongs to blouse sewing, machines which are used during this operation and previous operations are shown in Table 1 above.

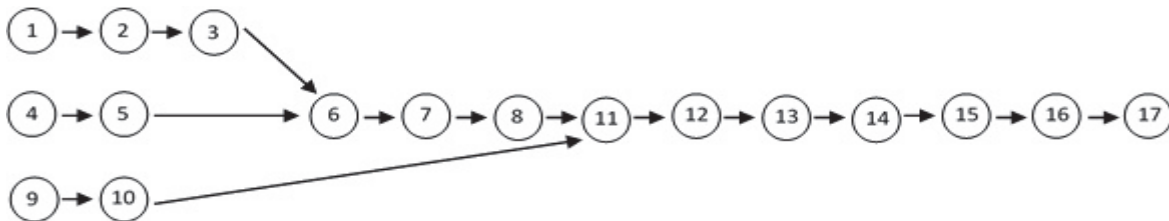


Figure 11. Priority diagram for blouse sewing before method study

Table 2. Solution of problem using of Ranked Positional Weight Method

Operation No	Time (min.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Ranked Positional Weight Value
1	0.571		1	+			+	+	+			+	+	+	+	+	+	+	7.514
2	0.408			1			+	+	+			+	+	+	+	+	+	+	6.943
3	0.590						1	+	+			+	+	+	+	+	+	+	6.535
4	0.341					1	+	+	+			+	+	+	+	+	+	+	6.709
5	0.423						1	+	+			+	+	+	+	+	+	+	6.368
6	0.541							1	+			+	+	+	+	+	+	+	5.945
7	0.837								1			+	+	+	+	+	+	+	5.404
8	0.588											1	+	+	+	+	+	+	4.567
9	0.229										1	+	+	+	+	+	+	+	4.658
10	0.450											1	+	+	+	+	+	+	4.429
11	0.517												1	+	+	+	+	+	3.979
12	0.394													1	+	+	+	+	3.462
13	0.481														1	+	+	+	3.068
14	0.887															1	+	+	2.587
15	0.373																1	+	1.700
16	0.536																	1	1.327
17	0.791																		0.791

Table 3. Line balancing results

Workstation Number	Operation No	Machine Type	Time (min.)	Total Time for Work Station (x)	Remaining Time (C-x)
1	1	Lock-stitch sewing machine	0.571	0.800	0.087
	9	Hand-made	0.229		
2	2	3 thread overlock	0.408	0.408	0.479
3	4	Lock-stitch sewing machine	0.341	0.791	0.096
	10		0.450		
4	3	3 thread overlock	0.590	0.590	0.279
5	5	3 thread overlock	0.423	0.423	0.464
6	6	3 thread overlock	0.541	0.541	0.346
7	7	3 thread overlock	0.837	0.837	0.050
8	8	Cover stitch machine	0.588	0.588	0.299
9	11	3 thread overlock	0.517	0.517	0.370
10	12	3 thread overlock	0.394	0.394	0.493
11	13	Lock-stitch sewing machine	0.481	0.481	0.406
12	14	Lock-stitch sewing machine	0.887	0.887	0.000
13	15	Lock-stitch sewing machine	0.373	0.373	0.514
14	16	Lock-stitch sewing machine	0.536	0.536	0.351
15	17	Hand-made	0.791	0.791	0.096

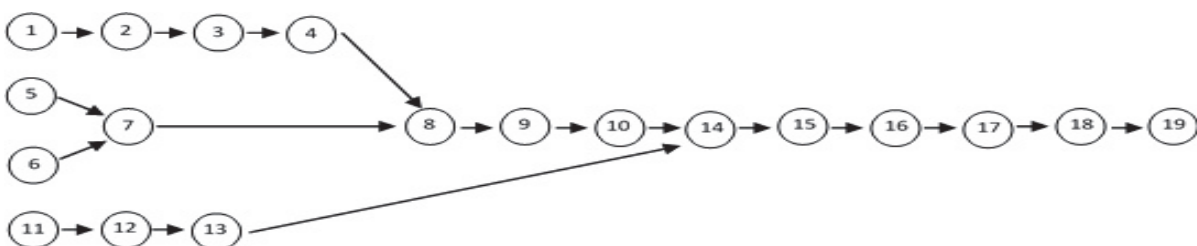


Figure 12. Priority diagram for blouse sewing after method study



To be able to apply this method on assembly line balancing the table which is shown below must be created (Table 4).

**Table 4.** Solution of problem using of Ranked Positional Weight method

Operation No	Time (min.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Ranked Positional Weight Value
1	0.462		1	+	+				+	+	+				+	+	+	+	+	+	6.997
2	0.408			1	+				+	+	+				+	+	+	+	+	+	6.535
3	0.383				1				+	+	+				+	+	+	+	+	+	6.127
4	0.193								1	+	+				+	+	+	+	+	+	5.744
5	0.341							1	+	+	+				+	+	+	+	+	+	6.097
6	0.151							1	+	+	+				+	+	+	+	+	+	5.907
7	0.205								1	+	+				+	+	+	+	+	+	5.756
8	0.541									1	+				+	+	+	+	+	+	5.551
9	0.837										1				+	+	+	+	+	+	5.010
10	0.588														1	+	+	+	+	+	4.173
11	0.229												1	+	+	+	+	+	+	+	4.556
12	0.450													1	+	+	+	+	+	+	4.327
13	0.292														1	+	+	+	+	+	3.877
14	0.517															1	+	+	+	+	3.585
15	0.481																1	+	+	+	3.068
16	0.887																	1	+	+	2.587
17	0.373																		1	+	1.700
18	0.536																			1	1.327
19	0.791																				0.791

While making valuation, primarily, the operation numbered 1 which has the highest positional weight is assigned to the 1<sup>st</sup> work station. The residual time of 1<sup>st</sup> work station is  $C-t_1 = 0.887 - 0.462 = 0.425$  minute.

After the operation numbered 1 is assigned, although the time of the operation numbered 2 is shorter than the remaining time of the 1<sup>st</sup> station, it cannot be assigned as a different type of machine is used. Among the rest of the operations, when priority and type of the machines are considered only the operation numbered 5 is assigned to the 1<sup>st</sup> work station and remaining time of the 1<sup>st</sup> work station is calculated as  $C-t_5 = 0.425 - 0.341 = 0.084$  minute.

The operation numbered 2 is assigned to 2<sup>nd</sup> work station. The residual time of 2<sup>nd</sup> work station is  $C-t_2 = 0.887 - 0.408 = 0.479$  minute.

After the assignment of operation numbered 2, operation numbered 3 (0.383 min.) which has higher position weight can be assigned because operation duration of 2 is shorter than remaining time of the 2<sup>nd</sup> work station and a same type of machine is used. Remaining time of the 2<sup>nd</sup> work station is calculated as  $C-t_3 = 0.479 - 0.383 = 0.096$  minute.

The operation numbered 6 is assigned to 3<sup>rd</sup> work station. The remaining time of 3<sup>rd</sup> work station is  $C-t_6 = 0.887 - 0.151 = 0.736$  minute.

After the assignment of operation numbered 6, operation numbered 7 which has higher position weight can be assigned because operation duration of 7 is shorter than remaining time of the 3<sup>rd</sup> work station and a same type of machines is used. The residual time of 3<sup>rd</sup> work station is  $C-t_7 = 0.736 - 0.205 = 0.531$  minute. After the assignment of operation numbered 7, operation numbered 4 which has higher position weight can be assigned because operation duration of 4 is shorter than remaining time of the 3<sup>rd</sup> work station and a same type of machines is used. The residual time of 3<sup>rd</sup> work station is  $C-t_4 = 0.531 - 0.193 = 0.338$  minute. After the assignment of operation numbered 4, operation numbered 8 which has higher position weight cannot be assigned because operation duration of 8 is higher than remaining time of 3<sup>rd</sup> work station. Among the rest of the operations, when priority and type of the machines are considered only the operation numbered 11 can be assigned to 3<sup>rd</sup> work station and remaining time of 3<sup>rd</sup> work station is calculated as  $C-t_{11} = 0.338 - 0.229 = 0.109$  minute.

As it can be seen in the assignment example which is done for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> work station, one can achieve a solution. The solution results according to designing assembly line by using Ranked Positional Weight Method are shown Table 5.

**Table 5.** Line balancing results

Workstation Number	Operation No	Machine Type	Time (min.)	Total Time for Work Station (x)	Remaining Time (C-x)
1	1	Lock-stitch sewing machine	0.462	0.803	0.084
	5		0.341		
2	2	3 thread overlock	0.408	0.791	0.096
	3		0.383		
3	4	Hand-made	0.193	0.778	0.109
	6	3 thread overlock	0.151		
	7	3 thread overlock	0.205		
	11	Hand-made	0.229		
4	8	3 thread overlock	0.541	0.541	0.346
5	9	3 thread overlock	0.837	0.837	0.050
6	12	Lock-stitch sewing machine	0.450	0.450	0.437
7	10	Cover stitch machine	0.588	0.588	0.299
8	13	3 thread overlock	0.292	0.809	0.078
	14		0.517		
9	15	Lock-stitch sewing machine	0.481	0.481	0.406
10	16	Lock-stitch sewing machine	0.887	0.887	0.000
11	17	Lock-stitch sewing machine	0.373	0.373	0.514
12	18	Lock-stitch sewing machine	0.536	0.536	0.351
13	19	Hand-made	0.791	0.791	0.096

As it can be seen from Table above, the assembly line is designed according to having 0.887 minute cycle time with 13 work stations. Loss of balance and assembly line efficiency of designed assembly line are shown below.

$$LB = (((13 \times 0.887) - (8.665)) / (13 \times 0.887)) \times 100 = 24.85\%$$

$$LE = (1 - 0.2485) \times 100 = 75.15\%$$

### 3. RESULTS

In this work, operations which is carried out in blouse sewing were examined with a critical eye. Method study is applied on operations which are suitable for to be improved. After the method study on current output and assembly line efficiencies are examined.

Before the method study, duration of blouse production process which consists of 17 operations is 8.957 minute, after the method study is applied, although the number of the operations become 19, duration of these operations is 8.665 minute. By means of method study, total 0.292 minute saving is gained.

The main reason of increase in number of operations is that the two operations which are currently performed as a single operation are performed separately. Herewith machine usage rate increases and duration of operations decreases.

As it can be seen in the table which is given below, 0.485 minute (1.978 - 1.493) is in question from the point of the duration in which operator and machine performs together.

To demonstrate the effect of the method study on production volume, the formulas which are given below are used.

$$PA = T / C$$

$$PA = (NOM \times T) / TOT$$

Where:

PA is Daily Total Production Amount, T is Daily Total Production Time, C is Cycle Time, NOM is Number of Operator - Machine and TOT is Total Operation Time (5).

Daily total production time is 540 minutes and cycle time is 0.887. Daily total production amount (volume) is calculated by using the formula which is given above.

$$PA = 540 / 0.887 \Rightarrow PA = 608 \text{ pieces / day}$$

When the production volume is 608, 15 operators - machines performed. After the method study is applied, 13 operators- machines are needed to perform the operation.

If 15 operators and machines perform in assembly line by grounding duration of blouse production in both situations, daily current output is expected to be as it is given below.

$$PA = (NOM \times T) / TOT$$

$$PA = (15 \times 540) / 8.957 \Rightarrow PA = 904 \text{ pieces / day (before method study)}$$

$$PA = (15 \times 540) / 8.665 \Rightarrow PA = 934 \text{ pieces / day (after method study)}$$

As it can be understood from the calculation which is given above, as a result of method study, daily current output increases in 30. Based on total duration of production which is attained after method study, if the efficiency is assumed as %100, the efficiency increased in 3.12%  $(100 - (904/934) \times 100)$  according to the condition exists before the method study.

When the effect of the method study on assembly line efficiency is analyzed, it can be seen that improvements of operations and increase in duration have positive impact on assembly line efficiency. It can be concluded that 15 workstations are necessary for assembly line balancing which is designed by considering present condition and assembly line efficiency is calculated as 67.32%. It can be seen from the study of assembly line balancing which is conducted after method study that 13 workstations are necessary and assembly line efficiency is 75.15 %. This rate shows that assembly line efficiency increases in 7.83%.

However it is appeared that performing the operations "sewing shoulder" and "assembling cuff to sleeve" separately which are normally performed as a single operation enables to decrease the number of work stations in assembly line balancing.

### 4. CONCLUSION

The aim of this study was to analyze the effect of method study on production volume and assembly line efficiency and indicate the importance of method studies.

The results above shows that method study provides productivity growth with regards to almost all factors that affect the production. From the point of the results that are obtained within this study, the advantages of the method study can be specified as below.

**Table 6.** Comparison of durations of operations performed before and after method study application

Operations Before Method Study	Operation Times (min.)	Operations After Method Study	Operation Times (min.)
Front part puckering	0.571	Front part puckering	0.462
Sewing shoulder	0.590	Sewing shoulder	0.383
		Shoulder regulate	0.193
Assembling cuff to sleeve	0.423	Cuff preparing	0.151
		Assembling cuff to sleeve	0.205
Collar overlock	0.394	Collar overlock	0.292
Total	1.978		1.686
<b>Total sewing duration</b>	<b>1.978</b>		<b>1.493</b>

1. Achieving same production volume by using less machines and operators
2. Operators' performing the same operation in shorter time and with less effort.
3. Reduction of labor and energy costs by means of less usage of operators and machines.
4. Reduction of product cost as a result of reduction of all costs.
5. Saving on production area as a result of being need fewer machine and operators
6. Productivity growth
7. Producing more intelligently
8. Having more assembly line efficiency

9. Results of method studies' being propulsive force for continuous development

It is possible to add more about the advantages that method study has but results of this research is single-handedly enough to indicate the importance of the method study.

One more point that is necessary to mention is that there isn't another method that are used within gaining higher productivity, reduction of costs by using present resources without incremental costs.

Consequently, method study is an important weapon that needs to be used by all companies to prevent wastage and to use the sources in more effective way and these results in increasing companies' competitive capacity.

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