Developing a System to Calculate Cutting Process Time of Garments

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Abstract

The paper includes a methodology to calculate the fabric laying and cutting times for a cutting department of an apparel manufacturing company. The methodology was developed based on the data collected for woven trouser patterns. A data base of basic times was developed for fabric laying and cutting operations. By analyzing the variations in time values in relation to the parameters that effect the process relationships were developed which were used to calculate the standard minute values for the process. The methodology can be used to calculate the SMV for a lay and it can be further used to develop incentive schemes for the cutting department.

1. Introduction

Apparel industry plays an important role in Sri Lanka's economy. Being the second largest contributor to the national economy, the industry managed to surpass $ 4 billion of export value mark during the last year, despite the loss of European GSP+ concessions [5]. Product quality and on time delivery are two main strengths that the Sri Lankan apparel industry has and helped it to gain business from many world recognized brands and to survive in spite of the strong competitive countries[5].

The cutting department of a garment manufacturing factory supplies the cut panels required for the production modules. Therefore, the cutting process is one of the main value adding processes in a factory [6]. There are several functions in a cutting department such as fabric laying, cutting and bundling of cut panels. Time taken for laying, cutting and bundling can be considered as cutting process time. Cutting and laying methods are similar in most of the garment manufacturing factories but different cut panel bundling methods are used.

Time taken for manual fabric laying and manual fabric cutting are considered as cutting process time in the research. Bundling time is not taken into account because of the large number of methods available and the time limitations do not permit studying all the available methods. Among the manual fabric cutting methods available in the industry cutting stationary lays using the straight knife and manual one way fabric laying is only considered as cutting process time when developing the methodology.

Proper calculation of cutting process time is important for accurate lay planning and thereby to reduce lead time and cost involved in the cutting process. The main objective of the research is to develop a methodology to calculate cutting process time of garments.

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1.1 Background

At present in the garment industry cutting process time is calculated using analytical estimating and mainly based on management decisions. Based on this calculated cutting times of garments lay planning and costing for the cutting process is done. This value has to be accurate because otherwise lay plan will not tally with the plan of the production department. Then the cutting department will be unable to provide the required cut panels to the production modules in time. It is important to have an accurate system to calculate cutting process time in order to have a smooth flow of the work in the cutting department and also in the production department.

It is difficult to calculate the efficiency level of operators in the cutting department due to non-availability of accurate values for cutting times for garments. Currently in the industry, incentives are not given to cutting operators based on their actual efficiency levels due to lack of a proper system to calculate cutting times. Therefore when it comes to developing incentive schemes for cutting operators knowing accurate values for cutting time is important. Further the through- put time of the cutting department is calculated using analytical estimating. Having an accurate system to calculate the cutting process will be useful for costing as well.

Most of the garment factories implement lean manufacturing to develop their processes. Reducing work in progress by on time delivery is one area that they focus on under the lean concepts [4, 9]. In the future most cutting departments are trying to achieve online cutting processes. For that purpose, knowing accurate values for cutting time of garments is important.

There are many cutting machineries available in the industry. Cutting equipment can be broadly categorized as automatic cutting equipment and manual cutting equipment. Band knife, straight knife falls under manual cutting equipment and automatic cutting blades, laser cutters fall under automatic cutting equipment [10]. Similarly fabric laying can be divided into two sub categories as semi automatic laying machines and manual laying [10].

1.2 Importance of Developing a System to Calculate Cutting Process Time

Several factories were visited and discussions were carried out with cutting managers and work study managers to study the cutting process time calculation methods at those factories and to identify the problems and drawbacks of current cutting process time calculation methods.

Most of the factories visited were using past data and analytical estimation to calculate the time taken for cutting and laying operations. In some factories a total time taken to cut the marker was ascertained and that value was divided by total perimeter length of the marker. From that value the time per unit perimeter is decided and the cutting process was planned based on that value. The difficulties involved in cutting various shapes in the markers were not captured in this method. When doing this a rating factor was allocated considering the entire cutting process of the marker. As the rating of cutting operators varies throughout the process using an average value will affect the final results.

Incentives are given to operators based on their efficiency levels [1]. In the case of sewing operators the output from each operator can be measured by the number of pieces that they produce. The efficiency levels of individuals can be easily calculated when data for the standard minute values for the sewing operations [3] is available. In most of the cutting departments visited the laying and cutting operations were carried out as a team and incentives were given on a team basis. Due to lack of data for cutting times it was difficult to measure the individual performance level of the operators. When team wise incentives are given to laying and cutting operators their individual performance levels are not taken into account. This is unfair for the operators with higher performance levels and can lead to demotivation of employees and can have an impact on the performance of the cutting department.

The current cutting process time calculation methods have proven to be unsuccessful due to their inaccuracy and inconsistency. The need therefore arises for a time determination technique in this area, that would be consistent and accurate, and which would provide a database of information that is dynamic to accommodate the variations that occur in the cutting environment. A reliable, predictive and ethical means of establishing standard time for cutting and laying processes is therefore an essential element for today's apparel manufacturing factories.

1.3. Goals and Objectives

- Study the available laying and cutting methods
- Explore the parameters which affect the cutting time of garments
- Develop a methodology to calculate cutting process time

2. Methodology

Before starting the data collection a literature review was done to study the background of the research. Several factories were visited before starting the data collection. During those visits the process of the cutting sections, equipment used, parameters that affect the cutting process time currently used cutting process time calculation methods and the method of giving incentive schemas to cutting and laying operators were studied. A centralized cutting section of a factory was selected for data collection and the main product of this factory was woven trousers. Data collection for fabric cutting times and laying times were done only for woven trouser patterns. The methodology to calculate cutting process time is developed based on the data collected for woven trousers. This methodology is applicable to other garments and fabric types to calculate the cutting process time, by developing a data base of fabric cutting and laying times of the particular garment type.

For the fabric laying semi automatic spreading machines and manual laying were used. For fabric cutting automatic laser cutting machines and manual cutting methods were used. Band knife and straight knife were the manual cutting equipment used in the centralized cutting section. For bundling and numbering several methods were used because this centralized cutting section was catering to several factories and the method used for bundling and numbering were different depending on the systems used at those factories. As defined earlier the research was carried out only based on manual fabric laying and cutting stationery lays using the straight knife; the bundling and numbering processes were not timed during the data collection. But these processes were studied because bundling and numbering were two main functions of a cutting department. Discussions were carried out with different personnel at the cutting department such as cutting manager, operators etc. to get a better understanding of the process.

2.1 Data Collection for Fabric Cutting

The CAD section was visited and the process of the marker making was studied. Factories use different software for marker making and TUKA system was used by the factory which was selected for data collection [13]. Gerber and Lectra are two other marker making systems used in the apparel industry [11, 12]. During the time spent at the CAD section a study about the patterns and markers was done because having a better understanding about the marker types and pattern shape, prior to data collection, was very important.

Data collection for cutting different lengths was carried out based on the parameters that affect the cutting time. Fabric types, ply height, pattern shapes in the marker were the parameters considered in data collection for cutting times [8]. Before starting data collection for cutting times a mini marker was plotted in the style that is to be cut and the pattern shapes were studied. Data collection for a particular day was planned in the previous day by referring the cut plan of the next day. By referring to the cut plan the styles for timing were selected and the mini markers were plotted. That mini marker was used to study the available pattern lengths and to plan the data collection for that particular marker.

Data collections for woven fabrics cutting were done for fabrics of different GSM (Grams per square meter) values. Time values were mainly taken for straight lengths and curvature lengths. For example in a belt loop there were straight lengths in the pattern. In a front panel of a trouser there were straight lengths as well as curvature lengths. Lengths such as pocket mouth, rise, out leg, in leg were curvature lengths. Timing was done for each straight length and curvature length separately. Collection of cutting times for straight and curvature lengths were done for different ply heights used in the factory.

Earlier, data collection markers were analyzed and a data recording sheet was prepared according to the available shape lengths. This was done mainly to reduce the time taken for data collection. During the data recording the chart prepared was filled according to the cutting times of pattern lengths cut by the cutting machine operator.

Fabric cutting was the only value adding operation involved in the cutting process. Other than that there were several non- value adding activities involved in the cutting process such as placing the marker on the lay, moving and adjusting the marker, clipping, sharpening the blade, walking, talking, relaxing etc. An activity sampling was done to identify the other activities involved in the fabric cutting process. After timing a marker the data collected were cross checked with the marker.

Performance levels of operators were decided by their individual skill levels and the level of training that they have in the relevant field [2]. During the data collection operators were rated based on their performance levels during the cutting of a marker. When considering the cutting process performance level of an operator, it is not the same throughout the process. The efficiency level of an operator will change from time to time during the cutting process. When collecting data an individual operator was rated throughout the cutting process of the lay based on the changes in their performance level. Cutting time and the rating factors were recorded in the data recording sheet.

Measuring the pattern lengths that were timed was done after collection of data for cutting straight and curvature lengths and rating of operators. The observed cutting times were multiplied by the rating factors in order to calculate the basic times according to the British Rating Standards [1].

To study the variation of fabric cutting times in relation to parameters such as fabric types, ply height, pattern shapes, graphs were plotted for the basic times obtained in the data collection. Graphs were plotted to study the behavior of fabric cutting times of straight and curvature pattern lengths with the variation of ply height and the GSM value of the fabrics.

By analyzing the variations in the plotted graphs mathematical equations were developed to calculate the basic times for cutting straight and curvature lengths for different ply heights and fabric types. Finally a chart was developed to calculate basic times for cutting different straight lengths based on the parameters fabric type and ply height.

The curvatures were divided into categories based on the time taken to cut them. This was done mainly considering the difficulty involved in handling the straight knife when cutting a curvature length. A difficulty factor was calculated for every curve category considering the straight line cutting time of the same length as the curve length. By using the calculated difficulty factors a chart was developed to calculate the basic times for cutting curvature lengths based on parameters fabric GSM value and ply height.

2.2 Data Collection for Fabric Laying

Data collection for laying different lengths was carried out based on the parameters that affect the laying time such as lay length and fabric type. As previously mentioned manual one way fabric laying was only taken into account for data collection among the available various laying methods.

When manual one way fabric laying is considered there are two operators on either side of the laying table. Initially lay length is marked on a paper laid on the table. According to the lay length number of fabric rolls is brought to the laying table and one roller was loaded for laying. After loading the fabric roll the end is cut off and removed. For the convenience of data collection the one way laying process is broken down in- to the following four elements.

- Two operators on either sides of the laying table grab the fabric by two selvedges and lay the required length, which was previously marked.
- Keeping a weight on the fabric at the end position.
- Moving towards the starting position adjusting and removing creased and folded places in the lay.
- Cutting the end of the laid ply.

Sometimes the numbers of lays required were taken from one fabric roll. If the requirement is for more than one fabric roll, removing the empty roller and loading a new one has to be done during the laying process.

The time duration for all the above steps were gathered during the data collection and the operators were rated throughout the laying process. The observed element times were multiplied by the rating factors in order to calculate the basic times according to the British Rating Standards.

To study the variation of laying times with the lay length, graphs were plotted against the lay length and the laying times. To analyze the variation of laying time in relation to the change of the GSM value of the fabrics the plotted graphs against the lay length and the laying times for various GSM values were compared. Relationships were built between the laying times and the lay lengths and those developed equations were used to calculate basic times for the laying process.

3. Results and Discussion

3.1 Parameters Affecting the Fabric Cutting Time

When the pattern shapes available in a marker are considered, they can be defined as combinations of straight lengths and curvature lengths. The time taken to cut a panel will depend on the type of straight lengths and curvature lengths in it as the cutting operator has to move the cutting knife along these different pattern lengths. In the case of a straight length the operator has to guide the knife in a straight line but when cutting a curved length the knife has to be moved in that curved path which is not comparable to cutting a straight length.

Analysis on the effect on pattern shape on fabric cutting time was done for straight lengths and curvatures. For an example consider the Figure 1 for the variation of cutting times with the straight lengths for ply height 36 of a twill fabric (GSM 336). There are gaps in the graphs because those lengths are not available in the timed markers.

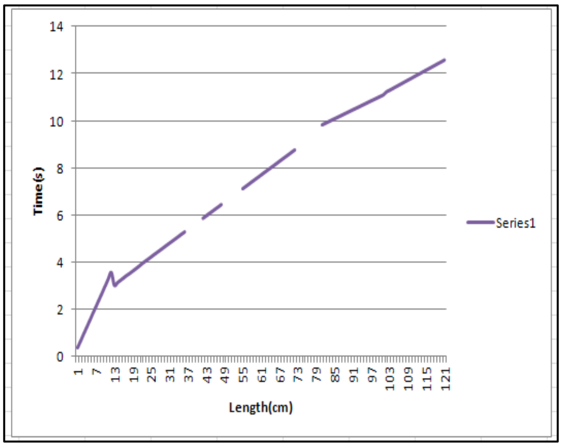

Figure 1: Variation of cutting times for straight lengths (Ply Height 36)

When analyzing the data collected for other fabric types and ply heights same sort of a discrete variation was observed. The variation can be analyzed by dividing into small intervals of linear relationships. From the observations it can be concluded that as the straight length increases the time taken to cut that will increase. From the observations it was evident that when the curve type is changing the cutting time will change accordingly. There were different methods available for curve categorization but those methods were difficult and complicated to use for analyzing pattern shapes [7].Curves were categorized in the research based on the difficulty level of cutting curved lengths considering the time values taken to cut them. That categorization was used for the analysis of curved length cutting times. The categorization of curves and the analysis was later described in the discussion. The number of plies in a lay is a key parameter that decides the fabric cutting time. The Figure 2 shows the straight length cutting times for different ply heights of a twill fabric (GSM 336).

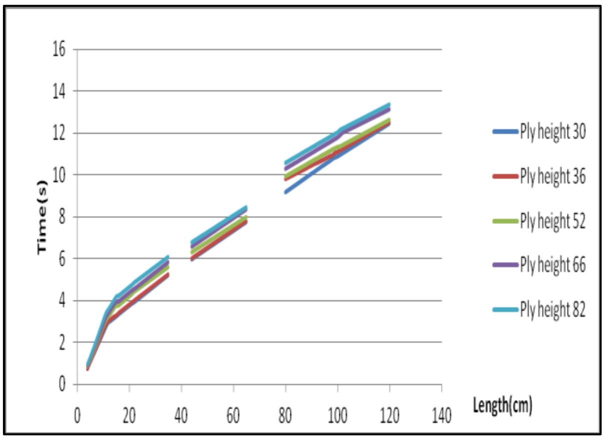

Figure 2: Straight length cutting times for different ply heights of a twill fabric (GSM 336)

According to the graph there is an increase in the cutting times as the number of plies in the lay increases. This variation was observed for other fabric types as well. As the number of plies in the lay increases the height of the lay will increase. This factor can affect the cutting time because the increase in the number of plies in a lay can generate more resistance to the operator who guides the knife through the fabric. There are different types of fabrics available in the industry such as woven fabrics, knitted fabrics, non woven fabrics etc. The fabric properties can be altered by the type of yarn used for the construction and finishing applied to the fabric. GSM value of a fabric gives the weight of one square meter area of the fabric in grams As the GSM of the fabrics become higher they will become heavier. The fabric properties have an impact on the fabric cutting time. During the cutting process the lay has to be moved in various directions. So the weight of the material will determine the ease of moving the lay.

The construction of the fabric will mainly have a significant impact on the ability of penetrating the knife through the fabric structure. If the fabric is too compact it will be more difficult to cut than a loose fabric structure. In the research, data collection was carried out only for fabric types that were used to manufacture woven trousers. The main fabric type used was twill fabrics. So the analysis on the effect of fabric type on cutting time was done based on the GSM values of the fabrics. The variation of fabric cutting times for three twill fabrics (GSM values of A, B, C fabrics are 336, 276 and 289) is shown in Figure 3.

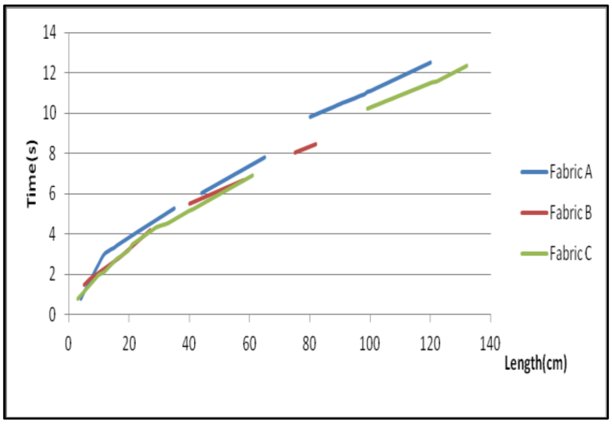

Figure 3: Variation of fabric cutting times for three twill fabrics (GSM values of A, B, C fabrics are 336, 276 and 289)

From the results it was proven that once the GSM value of the fabrics are increasing there is a slight increase in the cutting times.

3.2 Data Analysis for Fabric Cutting Times

An increase in the time was evident with the increase of the length. This variation was not a linear relationship. The discrete variation graph can be divided into small intervals of straight lengths where the relationship between the lengths and cutting times were linear. The corresponding linear relationships for ply height 36 of fabric type "A" are shown in the Table 1.

Table 1: Relationships between the straight length cutting times and the length ranges for ply height 36 of fabric type "A"

Straight length(cm)	Linear relationship
0-11	Y=0.2897*x+0.3831
11-16	Y=0.1017*x+1.8081
16-21	Y=0.0990*x+1.8425
21-35	Y=0.0965*x+1.9087
80-100	Y=0.0633*x+4.7646
100-120	Y=0.0713*x+4.017

Basic time for cutting a straight length can be calculated by using these linear relationships. A difficulty in this analysis was the unavailability of cutting times for certain lengths. Some lengths were not available in the timed markers. After analyzing the collected data tables for the available ply heights, were developed for fabric types to calculate basic times.

Equations were developed for the variation of all available curvature types according to the same method followed for analyzing straight lengths.

When analyzing curvature cutting times, first the equivalent straight length cutting time for the particular curvature length was calculated from the developed equations. After that a difficulty factor was calculated between the ratio of curvature length cutting time and the equivalent straight length cutting time for that particular curvature in order to categorize the curvatures.

Difficulty factor (DF) = Curvature length cutting time / Equivalent straight length cutting time

The basic time to cut a curvature length can be calculated using the difficulty factor values. The curve types can be divided into categories based on the difficulty factors. Since the data collection was done only on woven trousers, only a limited number of curve types were available for the analysis. A broad categorization can be done by collecting data for curvatures of other garment types.

3.3 Parameters Affecting the Fabric Laying Time

The time taken to lay a ply will depend on the lay length as the operators have to move from the starting point of the lay to its ending point. Analysis on the effect on lay length on laying time was done by drawing a graph for the variation between lay lengths and laying time. The variation can be analyzed by developing equations according to the same methodology followed for analyzing cutting times. From the observations it can be concluded that as the lay length increases the time taken to lay the fabric increases. The variation of laying time with the lay length for a twill fabric (GSM 336) is shown in Figure 4.

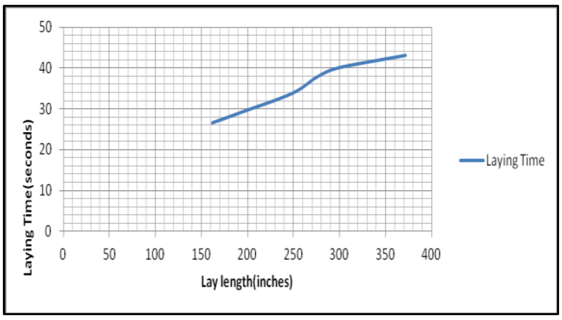

Figure 4: Variation of laying time with the lay length for a twill fabric (GSM 336)

As the lay length increases the distance that the laying operators have to walk in order to lay the fabric will increase. This will ultimately result in accumulating a longer time to lay the fabric. As the ply height increases the number of cycles the operators have to lay the fabric will increase. Once the number of working cycles to complete the job increases the total time taken for the process will increase.

The fabric type can have an impact on the time taken to manually lay it. During the laying process the ply end has to be carried manually along the lay length.

Therefore the weight of the material will determine the ease of carrying the lay. The construction of the fabric will also have a significant impact on the slippage of the fabric ply. It will decide the handling of the fabric and the ease of removing wrinkles that occur during the laying process. Before starting the laying of fabrics the fabric rolls have to be loaded first. Once a fabric roll is empty, depending on the requirement reloading has to be done manually by the laying operator. Thus the weight of the fabric has a significant effect on the loading process since the operators have to put in a greater effort when lifting a heavy weight than a light weight.

3.4 Data Analysis for Fabric Laying Times

An increase in the time was evident with the increase of the lay length. This variation is closely equivalent to a linear relationship. Basic time for a given lay length can be calculated by using these relationships. Equations developed for the fabric laying process is shown in Table 2. In the equations "x" denotes the lay length.

Table 2: Equations of laying time for Twill fabrics (GSM values of A, B, C fabrics are 336, 276 and 289)

Fabric type	Linear relationship
A	0.174x + 0.4107
B	0.084x + 13.359
C	0.1218x + 13.464

A difficulty in this analysis was the unavailability of laying times for certain lengths. Some lengths were not available in the timed markers. With the time availability, the data collection was carried out only for woven trousers fabrics. According to the Figure 4 lay lengths of 162, 195,249,276, 299 and 372 were available in the timed markers. By collecting data for a wide range of lay lengths a larger data base can be developed.

4. Conclusions and Recommendations

The methodology to calculate cutting process time was developed for manual one way fabric laying and cutting of stationery lays using the straight knife. From the system developed cutting time of fabrics can be calculated in relation to parameters such as fabric type, ply height and the shape of the pattern. Also fabric laying time can be calculated in relation to parameters such as fabric type and lay length.

The research was carried out based on trouser patterns and woven fabrics. The methodology developed for woven trousers in the research is applicable to calculate cutting process times of other garment types as well.

When using this methodology for another garment and fabric type, the first step is to create a data base of fabric cutting and laying times in relation to the parameters that affect the process such as fabric type, ply height, pattern shape, lay length etc. After analyzing the variations in the cutting process time in relation to these parameters, relationships should be built to calculate cutting process time. Finally the equations developed will be used to determine the basic time taken for the process.

The methodology to calculate cutting process time was developed based on data collected for woven trousers. The lack of time availability was a constraint when collecting data for other garment types and fabric types.

The unavailability of pattern lengths, ply heights and fabrics of different GSM values was a limitation. By expanding the ranges of pattern lengths, ply heights and GSM values a larger data base can be developed to improve the system further to calculate cutting process time of garments.

The total time taken to cut a marker can be calculated using the basic times calculated from the developed system. Allowances should be added to the calculated value to get the final SMV for the cutting time of a lay. Allowances for personal needs of the operators, machine handling and manual movements of the lay by the operators should be added to the calculated cutting time. The amount of allowances added will depend mainly on the policies of the factory.

As an additional improvement with the calculated cutting time for a marker, the work study department can specify a methodology to follow when cutting a lay. It can be designed to minimize the manual handling and movements involved in the fabric cutting process.

Basic times for the cutting process can be calculated using the developed system and those values can be used to develop incentive schemas for cutting operators. It will help the factory management to introduce an incentive scheme based on the individual performance level of the operators in the cutting department.

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