Evaluation of Abrasion Behaviour of Knitted Fabrics under Different Paths of Martindale Tester

N. A. Kotb[1], Z. M. Abdel Megeid[2]

1. Faculty of Education, Department of Technical education, Helwan, University, Egypt
2 .National Research Center, Textile Research Division, Dokki, Cairo, Egypt
nabihakotb@yahoo.com

Abstract: The Martindale tester is used for both the abrasion, pilling resistance of fabrics, and straight line test by adjusting three moving parts, each one has three setting levels; making twenty seven paths possibilities. According to the standards there are only three types of motion to perform different tests. Therefore the aim of this study is to evaluate the effect of other setting possibilities on abrasion behaviour. The Lissajous patterns which consist of the Path traced by the fabric over the abradent in Martindale tester have been drawn in continuously changing directions at different setting. The total numbers of working conditions are sixteen patterns, since some adjustments did not work or gave the same path or lines. Then the areas of all patterns have been calculated and analyzed. Three samples of knitted fabrics produced from three counts have been tested at the combinations of different path of the Martindale tester. Therefore forty eight results of abrasion resistance for all fabrics at different settings have been measured and analyzed. Using Martindale standard testing setting is not enough to determine the actual abrasion behaviour of knitted fabrics. Other probabilities of setting, producing other different patterns in area and shape, could be simulated to the actual abrasion behaviour of fabrics during the end use. It could help the textile designer and producer to understand and improve their products according to the actual performance requirements.

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1. Introduction

However abrasion is generally only one of several factors contributing to wear performance or durability as experienced in the actual use of the material [3], but abrasion behavior is an important property of textile materials that governs the quality and efficiency of processing and the performance of products [6].

Abrasion is the mechanical deterioration of fabric components by rubbing them against another surface [8]. Therefore it is affected by many factors in a very complex, and as yet little understood manner [5]. Many researchers have investigated the influence of raw material, yarn production technology, yarn twist and chemical treatment on the abrasion resistance property of woven, knitted and nonwoven fabric [2, 5, 6, 7, 8 12, 14, 15, 16, and 17].

The measurement of resistance to abrasion is also greatly affected by the nature of the abradant, variable action of the abradant over the area of specimen abraded, the tension of the specimen, and the dimensional changes in the specimen [9].

It is quite clear that no test can be made to forecast the service life of a fabric in so many hours, but the test conditions should imitate the required service conditions as far as possible [10].

Various types of devices have been created for testing abrasion resistance which is often defined in terms of the number of cycles of abrasion applied by a specified machine, using a specified technique to produce a specified degree or amount of abrasion. In general, abrasion resistance test findings are unreliable for prediction of actual wear life in specific end uses unless data exists showing the specific relationship between the abrasion resistance test results and actual wear in the intended end use [1].

Martindale Abrasion Tester can be used for a variety of purposes. The way in which it is used depends on the operator who must decide which method appears most applicable and suitable for the problem in hand [10]. The Path traced by the test specimens over the Abradant is known as Lissajous figure [11, 13]. This family of figures was investigated by Nathaniel Bowditch in 1815, and later in more detail by J., A., Lissajous in 1857 [4]. It changes from nearly a circle shape to gradually narrowing ellipses, until it becomes a straight line, from which progressively widening ellipses develop, in a diagonally opposite direction, before the pattern is repeated [13].

The resistance to abrasion in Martindale test method is affected greatly by the conditions of the tests, such as the nature of abradant; variable action of the abradant over the area of specimen abraded, the tension on the specimen, the pressure between the specimen and abradant, and the dimensional changes in the specimen. The Martindale tester contains three moving parts. Consideration should be given to the nature of these moving parts. However, only three types of motion to perform different tests by Martindale Tester are used for abrasion Test, Pilling Test, and Straight Line Test. The set up for each of the three tests is described in figure 1 [11].

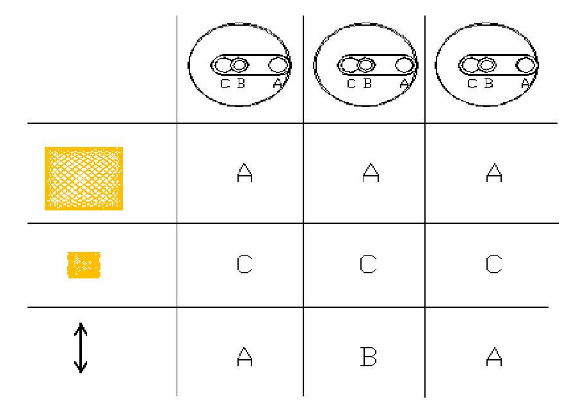

Figure 1: The standard setting for Martindale tester

For an abrasion test: All 3-bearing support blocks must be in position A, and for a pilling test: All 3-bearing support blocks must be in position C, however for a straight line test: The two outer bearing support blocks must be in position A and the inner bearing support block in position B [11].

Therefore this study was undertaken to evaluate the effect of the other setting possibilities on abrasion resistance of knitted fabrics.

2. Experimental work:

As mentioned above The Martindale instrument contains three moving parts to perform different tests by Lifting out the bearing support block and move it into the correct position on the drive crank. Adjusting each one of these three bearing support blocks (P1, P2, and P3) could be at three levels (A, B, and C); making twenty seven possibilities. According to the standards only two are applied, for testing abrasion and pilling.

The complete Lissajous Motion Diagrams for all setting possibilities were drawn by inserting the instrument pen into a specimen holder spindle bearing, so as the ball tip of the pen resting on the surface of the paper was used firstly to draw the twenty seven possibilities of paths.

The total numbers of working paths for testing fabric abrasion have been only sixteen, since some adjustments don't work or give the same path or line. The abrasion areas of the sixteen figures have been calculated using MATLAB program.

For evaluating the effect of different figures on abrasion of the fabrics, three samples of single knitted fabrics produced from three counts(Ne) 24/1, 30/1, 40/1Ne have been tested at the abrasion sixteen figures which results from the combinations of different path of the Martindale tester. The characteristics of the three knitted fabrics were determined as shown in table (1).

Table (1) the characteristics of the produced knitted fabric

Sample No.	Ne*	Weight/ m2 (gm)	Thickness (mm)	course/ cm	Wales /cm
1	24/1	187	0.61	20	15
2	30/1	153	0.55	20	15.5
3	40/1	121	0.50	20.5	15.5

*Ne is cotton yarn count

The M235 Martindale Tester- SDL Atlas was used to determine the abrasion resistance of fabrics according to ASTM D 4966 standard. The sand paper for abradant used in testing was P1000, and the specimens were abraded under low pressure (250gm) at the standard speed (47.5r.p.m.). The abrading was continued until a hole was occurred on the fabric when one thread is broken.

Therefore the different areas of abrasion geometric pattern and abrasion resistance of the knitted fabrics were measured and analyzed.

3. Results and discussion:

The experiment has been consisted of sixteen patterns on three different fabrics depending on the yarn count. Hence the results of abrasion test for all fabrics are 48 results, rubbed in a figure eight-like motion(the Lissajous pattern) to evaluate the effect of setting possibilities of Martindale tester on abrasion resistance of weft knitted fabrics.

After drawing the abrasion paths pattern on paper using the Martindale pen as shown in figure (2), the MATLAB program was used for measuring the area of each pattern. The results are different of each pattern shape and area. It is also clear that the patterns no. 1,13 in figure(2) which are the standard for ASTM test method for testing abrasion and pilling resistance have only the square Lissajous shape, their path shapes are big and small basic Lissajous square pattern (16 Revolutions) in order. The pattern no.1 (AAA) in figure (2) has the greatest area compared with other patterns.

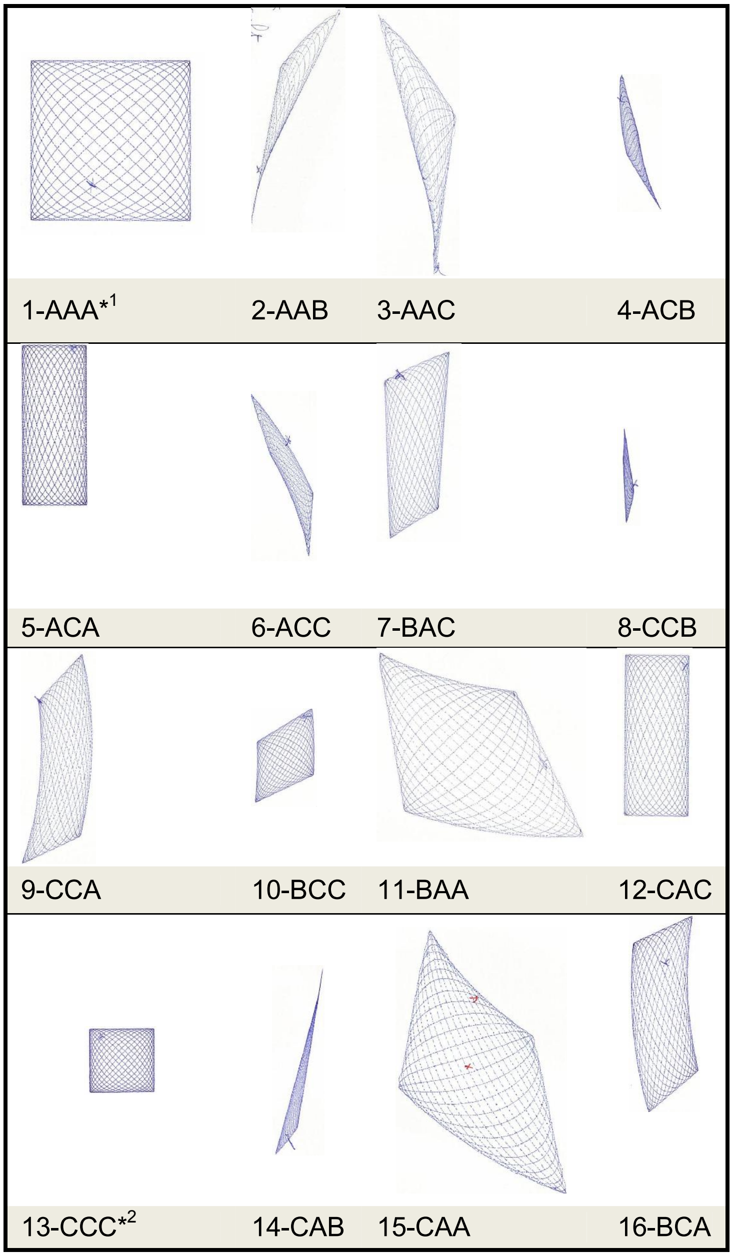

Figure 2: The patterns of the drawn paths by pen using different setting of Martindale tester P1,P2,and P3 the moving parts 1,2, and 3 in order

A,B, and C the setting levels of the moving parts where A is level 1, B is level 2, and C is level 3

*1 the ASTM standard motion setting for testing abrasion

*2 the ASTM standard motion setting for testing pilling

Once the areas of abrasion pattern were recorded for each path pattern, the relation between the area of abrasion patterns and the setting of Martindale tester using the regression analysis has been performed. The result is shown in equation (1).

Path Area= $0.43- 0.07P_1 -0.19P_2- 0.29P_3+ 0.17 P_1*P_3+0.88P_3*P_2- 0.06 P_1* P_2* P_3 -0.03P_2*P_3$ Multiple R =0.99 (1)

From the above equation it could concluded that the pattern area is increased by using the setting position (A) for the three moving parts in the tester. Therefore the largest area is occurred in setting the moving parts at (AAA) position which is the standard path in testing the abrasion resistance (path pattern no.1) in figure (2). The third moving part (P3) has also the greatest effect in the equation that has also interacted and quadratic effect. When the data of paths area is arranged and drawn in figure (3), it has been confirmed that the standard path in testing the abrasion resistance (path pattern no.1) in figure (2) has the largest area of all patterns.

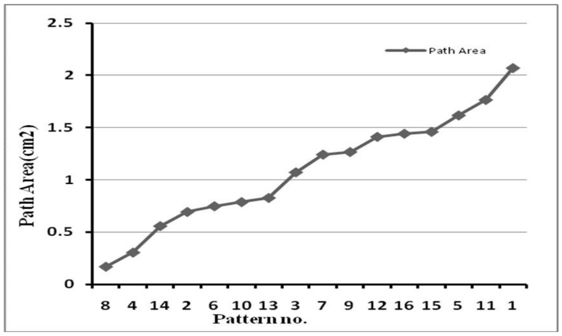

Figure 3: Arranged areas of different abrasion paths

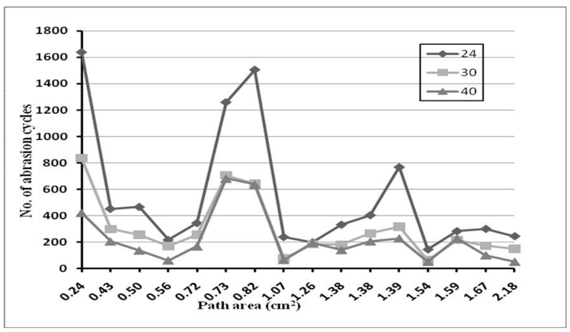

Figure 4: The relation between paths area and fabric abrasion

The results of abrasion test reveals the differences in abrasion between fabrics of the different yarn count in the experiment for each path pattern of the Martindale tester. The relation between the abrasion resistance of fabrics produced from different yarn counts and abrasion pattern areas is shown in figure (4). It could be observed that the abrasion properties of the weft knitted fabrics are varied depending on yarn count of the fabric and abrasion path area. There is no doubt that increasing the path area and yarn fineness tend to decrease the abrasion resistance of fabrics but this relation is not linear. As it was expected the abrasion resistance of weft knitted fabrics is increased by increasing yarn thickness since the weight and thickness of fabric increased as yarn thickness increased as shown in table (1).

The regression analysis has been performed for investigating fabric abrasion resistance using variables include: the setting level of the three moving parts, path area and yarn count of fabric for all samples, and is indicated in equation (2).

$$\mathbf{Abrasion = 431-120Area+118P_1+147P_2+81.7P_3+139P_1*P_3+85.3P_1*P_2+77.9P_2*P_3-163Ne+86.9Ne^2}$$

Multiple R =0.87 (2)

Trying to reveal the effect of Martindale moving setting on the abrasion resistance separately, the results of regression analyzing to abrasion resistance of fabrics of each count are summarized in equations (3), (4), and(5).

$$\mathbf{Abrasion=550.4+214.3P_1+255.7P_2+178.2P_3+188.4P_1*P_3+161.9P_1*P_2+130.9P_2*P_3 \quad MultipleR=0.89 \quad (3)}$$

$$\mathbf{Abrasion=300.5+90.4P_1+132.3P_2+85.5P_3+86.6P_1*P_3+58.4P_1*P_2+62.3P_2*P_3 \quad MultipleR=0.89 \quad (4)}$$

$$\mathbf{Abrasion=224.4+72.3P_1+122.1P_2+87.1P_3+80.2P_1*P_3+36.7P_1*P_2+52.4P_2*P_3 \quad MultipleR=0.93 \quad (5)}$$

The following results have been obtained from the initial regression analysis;

Using the setting position (A) of Martindale moving parts decreases the fabric abrasion resistance. Weft knitted fabrics have more resistance to rubbing in setting the moving parts at (C) position than (A) position. These results are in agreement with the paths pattern areas.

However the path pattern no. 1 in figure (2) (the standard setting for Martindale tester) does not have the lowest number of abrasion cycles for all fabrics although it has the largest area. That means this setting is much related to abrasion resistance but not enough to determine the actual abrasion behavior for all fabrics during the end use, where the shape of the path and the yarn count of the fabric beside to the path area have also played an important role in determining the abrasion behavior.

The surface rubbing properties of weft knitted fabrics do not show similar tendencies with the Martindale setting. These effects may be correlated with the path shape during the abrasion test.

Using Martindale standard testing settings which draw the square patterns are not enough to determine the actual abrasion behavior of knitted fabrics. Because the lissajous patterns produced of different settings could be simulated to the actual abrasion behavior of fabrics during the end use, it could help in studying the fabric abrasion behavior in the laboratory and helping the textile designers and producers to improve their products according to the actual performance. The changes in the surface of a fabric during processing, use, and care could be realized also.

Many researches should be conducted to predict the actual abrasion behavior of fabrics of the combination parameters of Martindale abrasion tester and fabric, and examine this phenomenon since evaluating surface wear has been a challenging and contentious issue.

4. Conclusion:

Martindale abrasion tester is most widely accepted tester although it may be the most complex. The Path traced by the test specimens over the abradant is known as Lissajous pattern. The instrument contains three moving parts each one has three setting levels. The test method standard is using only three settings for abrasion, pilling and straight line test in order. However, according to the setting of the three moving parts in the Martindale tester, other probabilities of setting could be used producing other different patterns in area and shape. This study has been undertaken to determine the area and shape of the produced patterns and evaluate the abrasion behavior of fabrics at different abrasion setting motions.

Only sixteen patterns have been produced, drawn and illustrated. The areas of all patterns have been measured and analyzed using regression analysis. The effects of Martindale abrasion motion settings on three weft knitted fabrics produced of yarn count (24/1, 30/1, 40/1) have been investigated and characterized. Therefore the experiment consisted of 48 abrasion results.

The abrasion properties have been showed remarkable differences with the patterns of abrasion paths and their areas. The increase in abrasion is occurred at the setting of Martindale moving parts at (A) position since the area of the abrasion decreases. Finer yarns have been expected to wear more quickly than larger yarns.

Using Martindale standard testing settings which draw the square patterns are not enough to determine the actual abrasion behavior of knitted fabrics. Other probabilities of setting, producing other different patterns in area and shape, could be simulated to the actual abrasion behavior of fabrics during the end use. It could help the textile designer and producer to understand and improve their products according to the actual performance requirements.

Many researches should be conducted to predict the actual abrasion behavior of fabrics of the combination parameters of Martindale abrasion tester and fabric, and examine this phenomenon since evaluating surface wear has been a challenging and contentious issue.

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