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Dielectric drying effect on properties of fabrics

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The changes in wet fabric properties with applying microwave drying method have been investigated. For this purpose, polyester, polyester-cotton and cotton fabrics have been prepared followed by wet processing and drying. Drying is completed using conventional (convectional) and microwave methods. Fabric properties are determined both before and after drying and then compared. It is observed that the changes in group of properties for microwave drying are not much more than those in conventional drying method. In addition, some product properties get better by using microwave drying method. The results show that the drying method of textile products in electromagnetic field with extremely high changes is much more practicable.

Keywords: Cotton, Dielectric drying, Microwave drying, Polyester, Polyester-cotton fabric

1 Introduction

Both in industry and service sectors, the huge amount of energy consumption is observed in essential drying process of textile product, particularly in wet processing. For better results, different drying methods have been developed[1,2]. One of them is microwave drying method, which is a type of dielectric drying. Microwave drying method is economical and has high efficiency, which has been taken into consideration since last 40-50 years. This method has been used in wood manufacturing and food industry for a long time, however its use in textile sector is being expanded. However, the investigations about textile depend on more technical issues[1,2].

There is no sufficient consideration on practical aspects of drying method, especially how process parameters and drying count affect material properties. There are some investigations about the microwave effect on some textile materials, which are discussed hereunder.

Kotovich *et al.*[3] investigated that how the properties of dried yarn and woven fabric change with different drying methods and observed that the microwave drying is more convenient than conductive and conventional drying methods from some viewpoints. According to Haggag *et al.*[4] use of microwave drying in pre-finishing of silk yarn gives better yarn properties. Kotovic *et al.*[5] investigated that the microwave drying on textile and other cellulose based materials gives better results than conventional drying. Hou *et al.*[6] studied effects of microwave field on cotton fabric structure. The results show that there are increasing breaking strength and breaking elongation while decreasing wrinkle of cotton fabrics. They found that above-mentioned result is obtained due to the change in morphological structure of cotton fibre under microwave field effect.

Bhat *et al.*[7] studied the effects of microwave field on polyester fibres and confirmed that electromagnetic field with high changeable frequency has positive effects on properties of polyester fibre. Although it is observed that textile material properties get better with microwave drying method, there is no investigation reported about drying of wet processing fabrics. Although in some studies changes in fabric properties in microwave drying area have been investigated, the effects of drying parameters on these properties have not been the subject of research.

In this study, changes in properties of wet cotton, polyester and cotton-polyester fabrics after microwave drying, considering the effects of drying counts and drying regimes on these properties have been investigated.

2 Materials and Methods

Wet fabrics have been dried using microwave drying method and changes in properties were studied. For this purpose, cotton, polyester and

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cotton-polyester fabrics were selected. After that wet samples were dried with both conventional (convectional) and microwave methods and then after 24 h their properties were measured. Measurement process were repeated 5 times to know the effect of drying methods on textile properties.

For wet operation, samples were soaked for 5 min in normal water (22° C heat distilled water). After soaking, the fabric was squeezed with hands to get specific weight. Then conventional and microwave drying methods were applied consequently. Fabric properties were determined after 1, 3 and 5 wetting – drying process in order to investigate drying count effects on product properties.

Conventional drying process was carried out in a convectional tumble dryer and microwave drying process was applied in a microwave unit with standard specifications. Drying process in microwave unit was carried out using 3 different power programs, viz Program 1, Program 2 and Program 3. Program 1 has 40% power, Program 2 has 70% power and Program 3 has full power.

Resistance properties, such as tensile strength and elongation, and mechanical properties, such as crease resistance, pilling and resizing were investigated depending on drying method. Evaluation of rub fastness was done for treated and untreated fabrics by crockmeter. Wet and dry rub fastness were also measured for treated and untreated fabrics. To measure surface electrical resistance, which is a static electrification indicator of textile materials, GIGALAB mod. 9265.043 branded ITECO was used.

Property measurements results were subjected to statistical analysis to observe whether they have normal distribution or not. Whether the data, obtained by conventional and microwave drying, belong to the same main population or not has been studied. For that, mean values have been compared[8]. With one-way ANOVA hypotheses following parameters have been tested:

H_0—The differences between means is not important

H_1—At least one mean differs from others considerably.

Statistical analysis was made by MINITAB 16.2.

3 Results and Discussion

Tensile strength tests have been done using TS EN ISO 13934-1 (2002) standards in warp and weft directions of samples. Statistical findings applied to the test results are shown in Fig. 1. In further discussion, T1, T3 and T5 stand for T conventional drying method, and 1, 3, 5 number of drying process and M11…M35 stand for M microwave drying, the first digit shows drying program, and second digit shows a number of drying. As mentioned before tests have been done for 3 fabric types. As a result of one way ANOVA test, the F criteria table value is $F_t\{12; 52\}=1.95$, α=0.05. Because of $F<F_{t,}$. H_0 hypothesis is not rejected. It means that there is no difference between average tensile strength values of samples which are dried by different drying methods or that the applied drying process does not affect tensile strength. In addition, both in conventional and microwave drying methods the number of drying and drying regimes do not affect tensile strength values of textile products.

Elongation has also been measured under the same conditions. The statistical results of measurements are shown in Fig.2. Unfortunately, the same comments as made for tensile strength, cannot be made for elongation. Variation analysis shows that the difference between elongation values is significant. Because for 3 fabric types, $F>F_t$ [$\{12; 52\} = 1.95$, α=0.05]. Figure 2 shows elongation values of dried samples with different drying methods and different variants. The product elongation increases in the direction of warp and weft as a result of drying methods in all circumstances. On the other hand, number of drying increases the deformability of products. These variations depend on the effects of wet and heat treatment on polymer structure of material. Moreover, it is shown that microwave field has more effect on deformability of material.

To test resize rate in samples after drying process TS EN ISO 5077 (2007) standard has been used. Using this standard method, samples were dried by natural, conventional and microwave drying methods. Microwave drying method has been applied in 3 regimes as mentioned before. The graphics according to results are shown in Fig. 3.

It is observed that when polyester fabrics are dried by microwave method it does not affect shrinkage rate in the weft direction. On the other hand, drying by conventional method on polyester fabrics shows some shrinkage on the weft direction. The findings of two methods are found to be different due to the long drying period of conventional method.

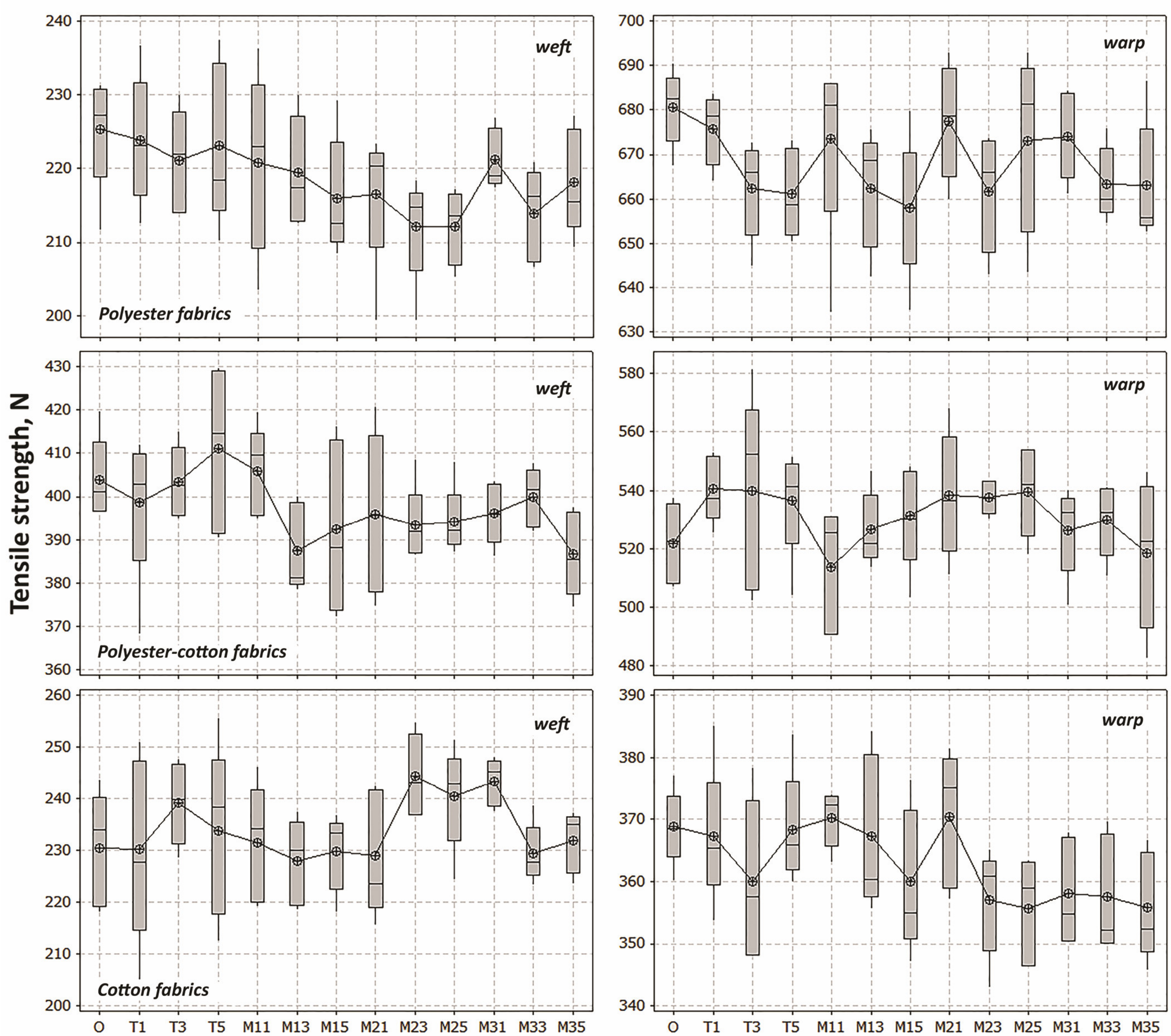

Fig.1—Tensile strength of polyester, polyester-cotton and cotton samples

Shrinkage rate increases with increasing the heat on warp direction.

Drying method does not affect resizing of sample in polyester-cotton fabrics. In cotton fabrics, drying method does not affect resizing of sample in warp direction but it increases shrinkage ratio due to increase in heat and its period. Number of drying does not affect shrinkage ratio in any situation.

After drying process, changes in pilling tendency has been tested with TS EN ISO 12945-2 (2000) standards using Martindale machine. Study shows that drying method and drying count do not affect pilling tendency of textile products.

To observe changes in fabric stiffness after drying process, different drying methods have been tested in different times. The changes in the bending length in both warp and weft direction of samples has been studied using ASTM D1388 - 08 (2012) standard. One-way variance analysis on test results shows the significant difference in two results ($F>F_t[\{12; 192\}=1.62, \alpha=0.05]$). In Fig.4, bending length graphics and ANOVA results are depicted. As seen on graphics, bending length in weft direction does not change much for all 3 fabrics in conventional drying

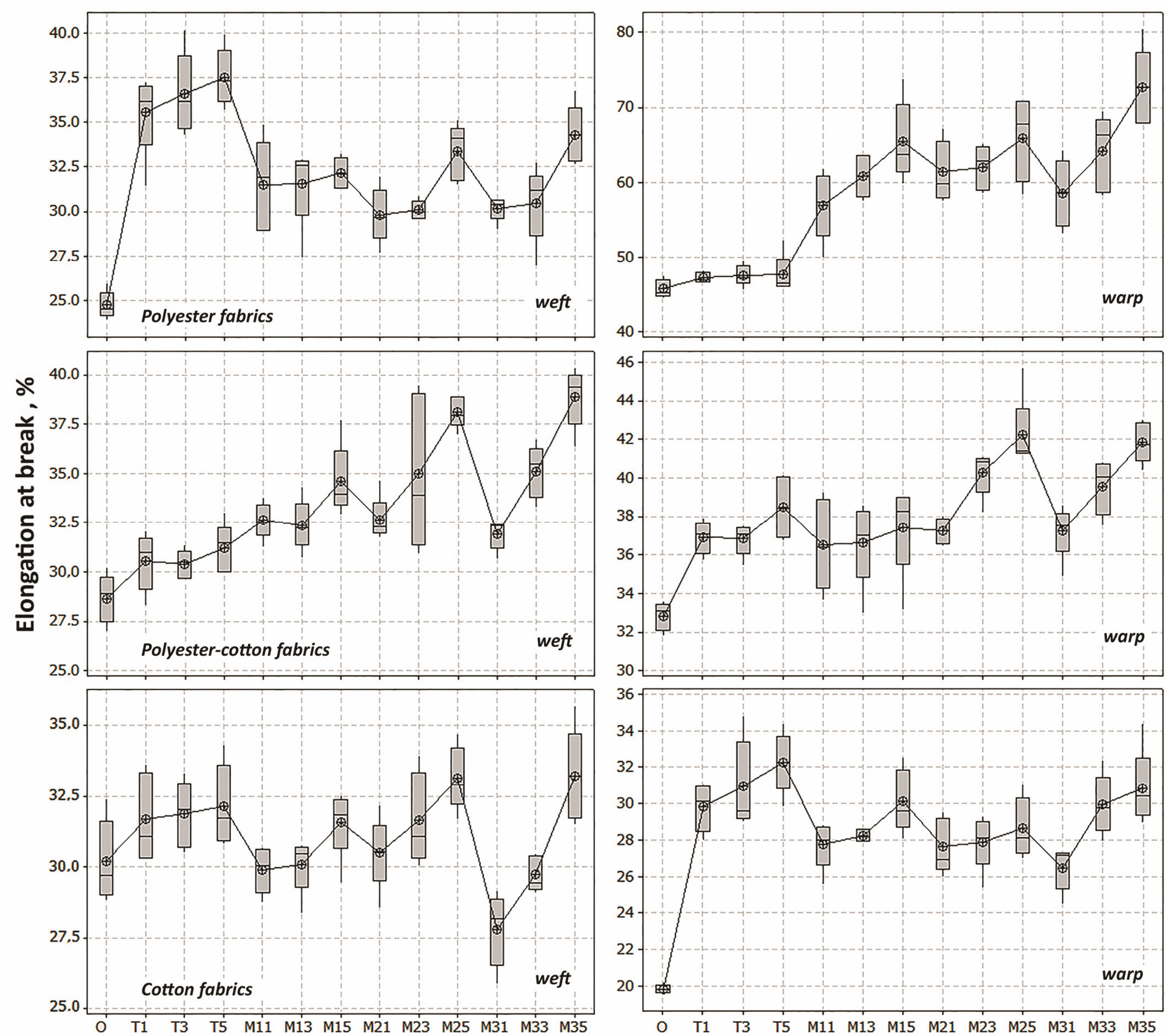

Fig.2— Elongation results of polyester, polyester-cotton and cotton samples

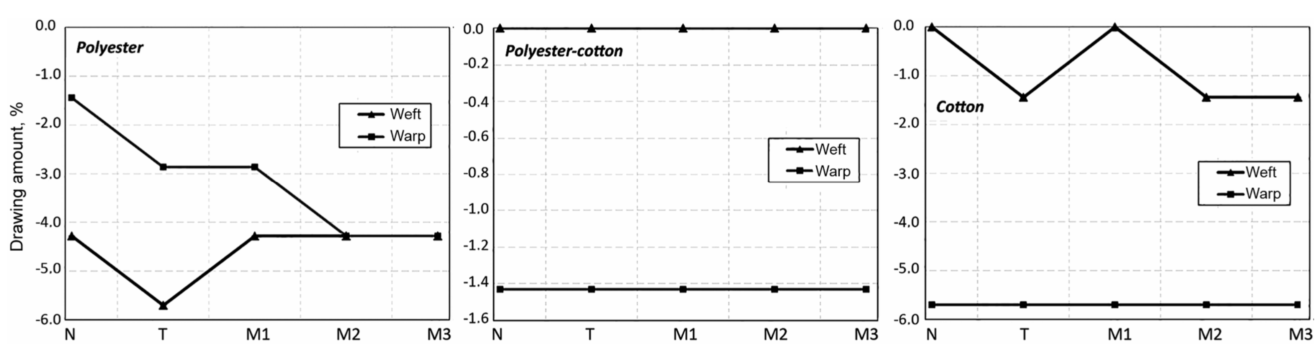

Fig.3 — The results of resize rate of sample after drying

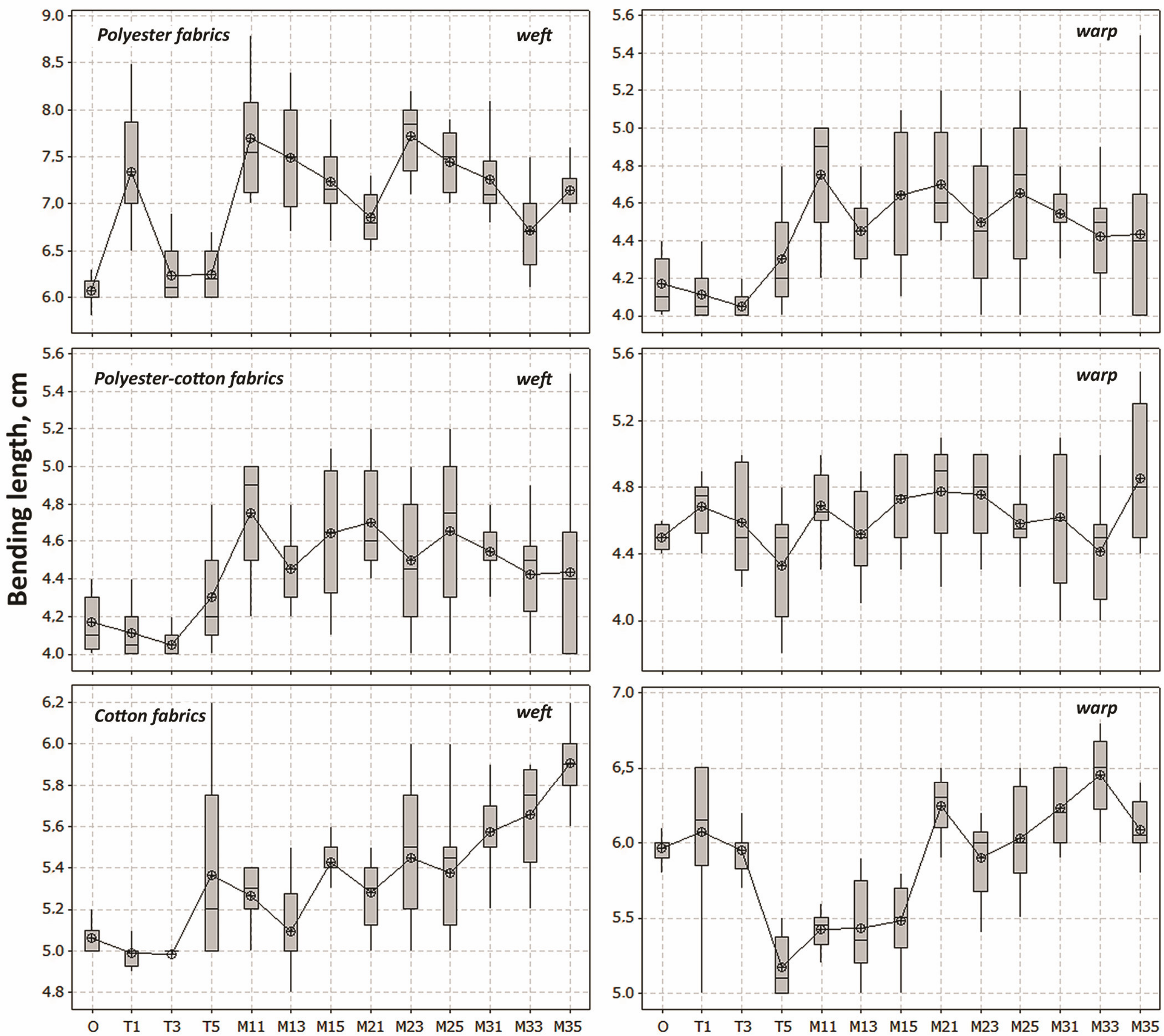

Fig.4—Bending length test results of polyester, polyester-cotton and cotton samples

method. In contrast, the bending length in weft direction is highly increased in microwave drying method. However, bending length in warp direction does not change very much in any situation. Bending length in warp direction is increased a bit in polyester fabrics. For cotton fabrics, bending length decreases as a result of lower power microwave regime. Therefore there is no change in fabric contained both cotton and polyester. In general one can say that microwave drying method reduces fabric stiffness a bit.

To study the effects of microwave drying method on crease resistance of textile products, TS ISO 9867 (2005) standard has been used. Tests have been applied to all 3 samples for both conventional and microwave drying methods. One way variance analysis has been applied to crease resistance test results of samples before and after conventional and microwave drying methods. Under one way ANOVA result, table value of F has been observed as $F_t\{12; 23\}=2.20$, $\alpha=0.05$. Because of $F<F_t$ between average crease resistance values, there is no important difference indicated. Therefore, H_0 is not rejected. As a result, it can be inferred that in both conventional and microwave drying methods, number of drying and drying regimes do not affect crease resistance of textile materials considerably.

Rub fastness tests have been done by crockmeter with standard method (TE SN ISO 105-X12, 2006). Statistical procedures have been applied to the test results. The results are shown in Fig.5. As mentioned before, tests have been done with 3 fabric types. As shown in Fig.5, wet and dry rub fastness values do not change with the change in number of drying and drying method in polyester fabrics.

Dry rub fastness gets smaller values in untreated polyester-cotton fabric as a result of conventional drying method. Microwave drying method does not affect dry rub fastness of material in first and second drying regime. But it is affected in third drying regime. In third drying regime, dry rub fastness of material is increased half point. The same results are also obtained for wet rub fastness. According to one way ANOVA results, specific table value of F is $F_t\{12; 26\}=2,.15$, $\alpha=0.05$. For $F>F_t$, rub fastness values change and hence the difference between rub fastness values of fabrics dried in both conventional and microwave methods is not found important; therefore H_0 is rejected. This means that the method of drying may affect the material rub fastness.

According to figures, drying method and number of drying do not affect rub fastness of cotton and polyester fabrics. But only in third drying regime of microwave drying, wet rub fastness shows half point improvement. It means that, drying process does not affect rub fastness negatively for microwave method. On the contrary, sometimes it gets better.

Figure 6 shows ANOVA results for surface electricity resistance of fabrics and graphics. According to one way ANOVA results, F criteria

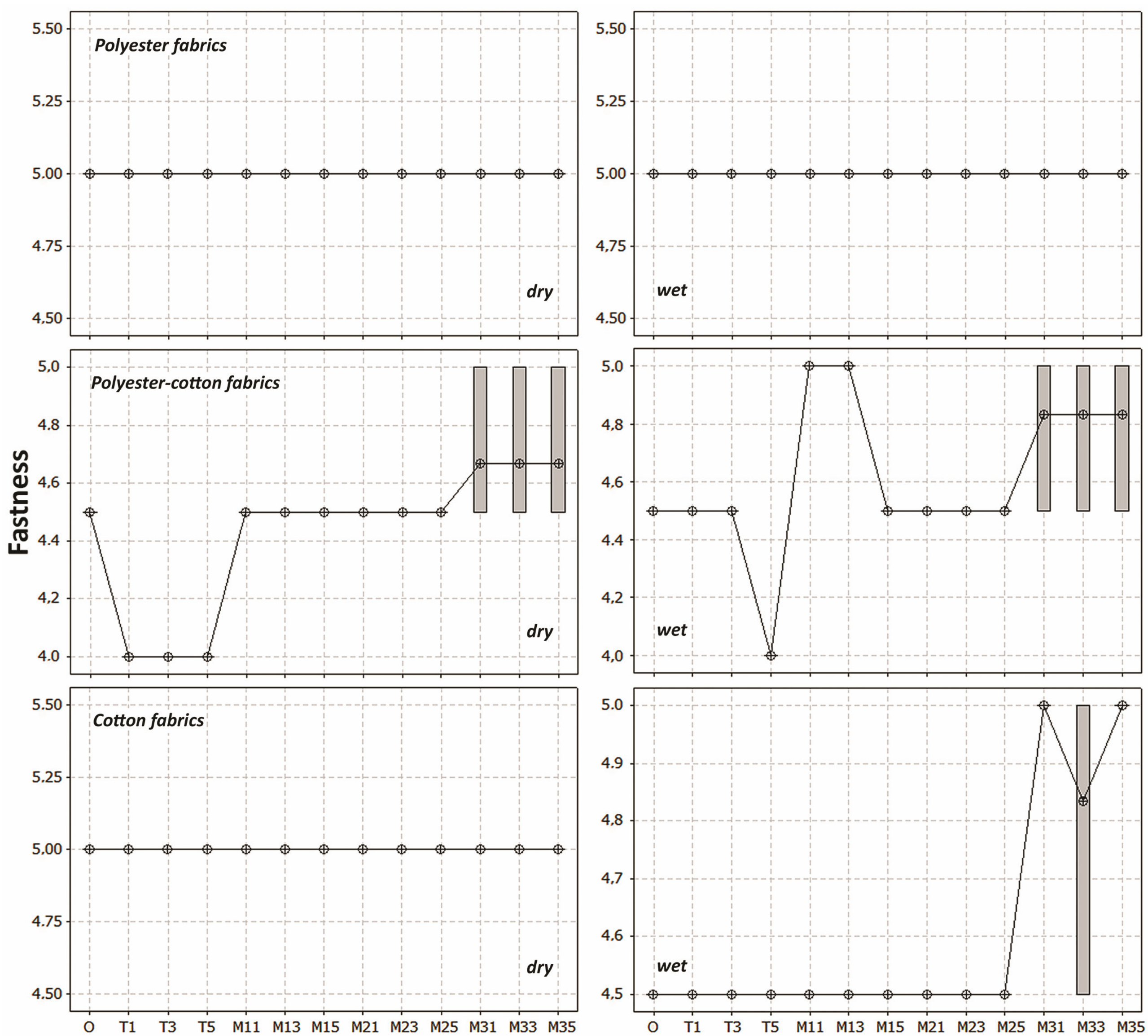

Fig.5—Test results of rub fastness of polyester, polyester-cotton and cotton samples

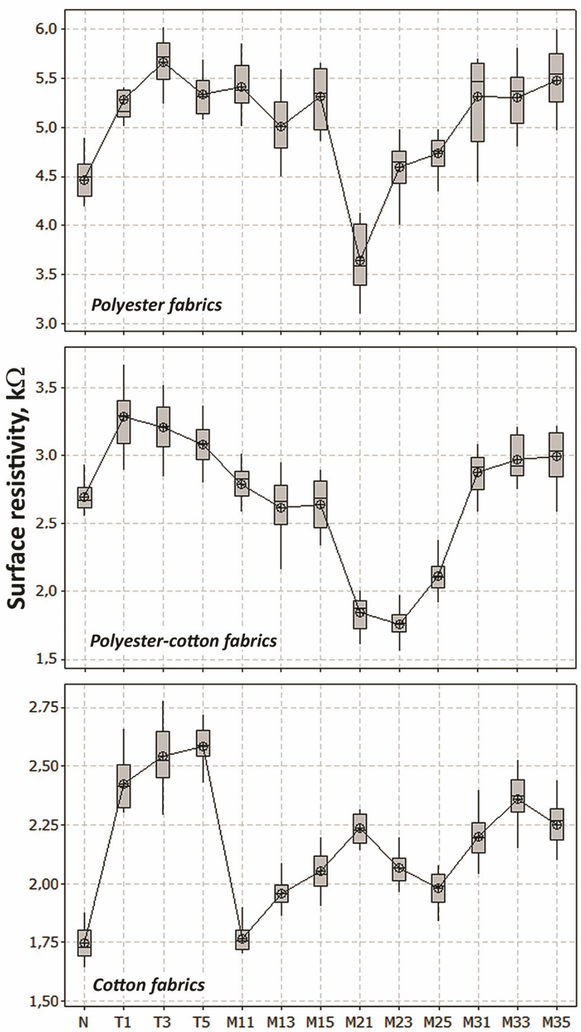

Fig.6—Test results of electricity resistance after drying

table value is $F_t\{12; 240\}=1.60$, $\alpha=0.95$ and $F>F_t$. under specific circumstances. It means that the difference between measurement results is important in terms of drying method and number of drying.

As shown on Fig.6, drying for all fabric types by conventional method increases the electricity resistance. It means that static electrification increases as well. However, number of drying does not show changes in electricity resistance.

Electricity resistance of polyester, cotton and polyester-cotton fabrics related to drying regimes decreases more in microwave drying than in conventional drying method. During drying of polyester and polyester-cotton fabrics with second microwave regime, resistance decreases under normal level. On the other hand, number of drying does not show more changes in electricity resistance.

However, it shows changes in cotton fabrics. Drying cotton fabrics with microwave method increases electricity resistance less than that with conventional method. But after drying process, electricity resistance of cotton fabrics is greater than that in untreated cotton fabrics.

4 Conclusion

It is inferred that microwave drying method does not affect textile product properties negatively in comparison with conventional drying method.

In experimental studies it is observed that after wetting process, change in pilling, non-crease properties and breaking resistance of dried polyester, cotton and blended woven fabrics does not depend on drying method, drying regimes and drying count. In microwave drying method change in material dimensions is found much less than that in conventional drying method. Although material rigidity differs according to material and drying method, this changing amount is low. However, microwave drying method decreases the fabric rigidity a bit more than in conventional method. After drying process material, elongation increases and this increase is more in microwave drying method. But drying count causes increase in elongation under all conditions.

It is observed that in drying using microwave method, rub fastness does not get worse and in some cases it gets better. It is determined that in the drying of polyester, cotton and blended fabrics with microwave method, electrical resistance of samples decreases more in comparison with conventional drying method. After microwave drying process in polyester and polyester mixed fabrics, these indicators can be lower than in untreated fabrics. On the other hand, it is observed that drying count does not affect electrical resistance.

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