# Microwave Treatment of Open-end and Ring yarn Woven fabrics

Ghada Ali Abou-Nassif

Fashion Design Department, Design and Art Faculty, King Abdul Aziz University, Jeddah, Saudi Arabia.
E-mail: drghada2017@gmail.com

**Abstract:** Microwave irradiation is considered one of the newest and powerful techniques of non-contacting heating and has been used for reacting, heating and drying the textile materials. This study aimed to compare between microwave treated fabrics in terms of tensile properties, tearing strength, air permeability, roughness and color properties. Two types of woven fabrics, namely open-end and ring yarn fabrics were used in this study. One –way AANOVA was utilized to disclose the significance of microwave power influence on fabric properties. The findings of this study revealed that microwave irradiation deteriorated the tensile and tearing strength of the treated fabrics. While the rest of fabric's properties have been enhanced by the treatment with microwave irradiation.
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**Keywords**: Microwave; Treatment; Open-end; Ring yarn Woven fabrics

## 1. Introduction

As reported in a physical definition, the oscillating magnetic and electric fields traveling together in the space are termed as electromagnetic waves. In this radiation spectrum, these microwaves has weave length ranges between 1mm and 1 m, this means that it lies between radio and infrared wave frequencies [1].

During the World War II and specifically in 1939, the term "microwaves" was coined and utilized in the radar and communication technologies. In general, because of the non-dependence of volumetric heating on convection or conduction heat transfer, microwave heating can be widely used in applications that don't use traditional heating. The consumption of low energy and low requirements of equipments for textile finishing have been achieved largely via the modification of microwave technology [2, 3].

By 1970, when the cellulosic fabrics have been handled with finishing of Durable press and then curing in microwave oven, the first idea of textile finishing using microwave technology has been originated [4]. Textile finishing is still used by microwave irradiation technology so far [5]. Specifically, this new technology has been used for wet processing such as, desizing, scouring, bleaching, dyeing and printing processes [6-7] It can also be used for drying process as well as for insect removal from wool textiles [8]. Drying method of warp sizing using microwave technology exhibited better results compared to conduction or convection drying ones [9]

Esterquat softener as textile softening agent was synthesized using microwave irradiation and conventional heating methods. The results revealed that softeners which has been synthesized by microwave technology exhibited better wettability, softening, anti crease properties with short time, lower cost, higher yield and purity compared to traditional thermal methods [10]. Properties of dyed wool fabrics using microwave technology was extensively researched. It was found that microwave irradiation has a damaging effect on wool fiber structure which reduces the S-S bonds concentration in keratin, which increases the ability of wool fiber to absorb the dye molecules [11].

Cotton and polyester fabrics were dried and sterilized using 2450-MHZ microwave radiation. These fabrics were assessed in relation to Staphylococcus aureus, Escherichia coli and Bacillus cereus. The findings of this study revealed that E. coli was the most sensitive microorganism to microwave irradiation, whereas B. cereus was the most tolerant. Within seven minutes exposure to microwave irradiation, it was noticed that all S. aureus and E. coli were killed. It was also found that microwave treatment has no effect on fabric elongation, while fabric tensile strength was decreased by about 10% after five minutes of exposure to microwave [12].

Nowadays, Open-end (OE) and Ring spinning are considered the most popular and efficient spinning systems. The yarns emerged from both systems are different with respect to their structural, mechanical and physical properties. Hence, fabrics woven from both yarns are probably to be different also. Many research works [13-16] have been conducted to compare both types of yarns and the fabrics woven from the both. These researches concluded that yarns spun from open end spinning technique are weaker, more extensible, more even and less hairy than ring spun yarns [12-14]. Ring yarn fabrics were found to have better tensile and bursting strength compared to open-end yarn fabrics. By contrast, Open-end yarn fabrics exhibited more resistance to abrasion compared to ring yarn fabrics [15]. Open-end yarns and fabrics woven from them take up dye rapidly and the shed looks deeper compared to ring yarns and fabrics [16].

The present study proposes a comparison between open-end and ring yarn woven fabrics in relation to tensile, whiteness index, color strength, tear strength, and roughness properties after treatment with microwave radiation.

## 2. Materials

In this study, two types of woven cotton fabrics, i.e. open-end and ring yarn fabrics were produced. These types of fabrics have the same constructional parameters except for the type of weft yarns which made up both yarn types. All woven fabric samples were made from Egyptian cotton and with weave structure plain 1/1. Warp yarn and weft yarn counts were 30/1 Ne. Weft and warp yarn densities were 68 ppi and 72 ends/inch respectively. Using a Picanol Air-jet weaving machine of speed 880 rpm, all fabric samples under study were woven on.

### Wet processing

To be desized, cotton woven fabrics were dipped in a hot water at 90 $^{O}$C. After that fabrics were scoured via sodium hydroxide (NaOH) according to figure 1. After scouring, the woven fabrics were bleached by conventional hydrogen peroxide method using the bleaching agents given in table 1.

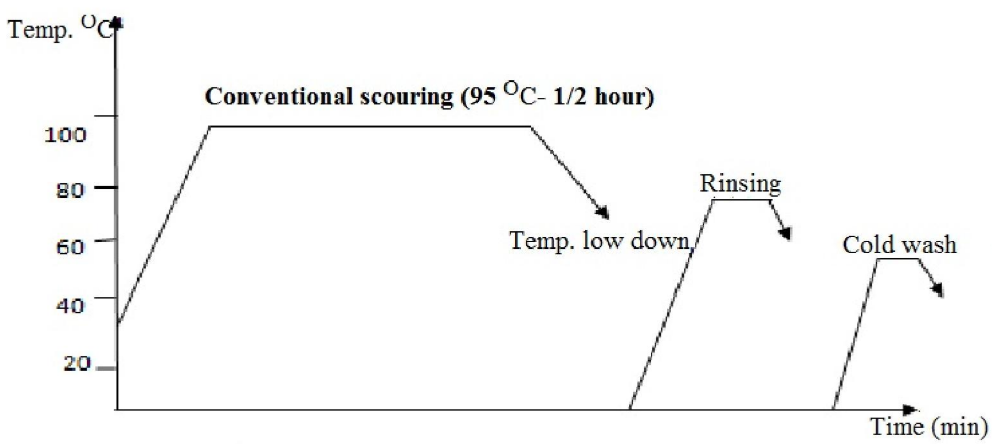


**Figure 1: Scouring curve for cotton fabrics**

After bleaching, the woven fabrics were dyed by using reactive dye. The dye bath contains 0.5% of Ramazol Blue R special dye, 13 g/l liquid soda ash (Sodium carbonate Na2CO3) and 50 g/l NaCl. The dyeing procedure was executed at a temperature of 60 $^{O}$C and time of 60 min. The salt is added to obtain evenness of color throughout the fabric and soda ash is added to fix the color in the fabric.

Table 1: Parameters of the conventional bleaching method using hydrogen peroxide

| Parameter | Value |
|---|---|
| H2O2 (grams per liter) | 20 |
| NaOH (grams per liter) | 2 |
| stabilizer (grams per liter) | 3 |
| Wetting (grams per liter) | 1 |
| Liquor ratio | 50:1 |
| pH | 10 |
| Temperature | 90 |
| Time | 60 min |

### Microwave treatment

The bleached and dyed woven fabrics were laid in the microwave oven and then treated using its radiation. The microwave oven power in watt was adjusted to different levels, namely 350, 480, 620 and 710 watt respectively for duration of 30 minutes. After treatment with microwave irradiation, the treated fabrics were removed from the microwave oven and left to cool slowly in the room temperature.

### Laboratory testing

Before testing, all fabric samples were put in a standard atmospheric condition for twenty four hours. As the main difference between fabric samples lies in the type of the weft yarn, all tests were performed in the weft direction of the fabrics. Each fabric sample was tested 10 times and the average of all individual readings was calculated. Breaking load and elongation of fabric samples handled with irradiation microwave were measured in accordance with the standard test method ASTM D5035-90 with an Instron tensile tester 4111 instrument. Tearing strength of woven fabrics treated with microwave was executed with Intensity tearing tester in accordance with standard test method ASTM D1424. The air permeability of treated samples was devalued using air permeability tester according to ASTM D737-96. Also, surface roughness measuring apparatus of model SE 1700 α (Japan) was used to evaluate roughness index of treated samples. Whiteness index and color strength measurement were measured according to AATCC test method 153 – 1985.

**Statistical analysis**

To detect the effects of fabric type and microwave power on fabric properties, a 4 × 2 full factorial design was carried out using SPP software package version 13. The significant effects of independent variables were quantified at levels 0.05≤ α≤0.01. To derive the regression relationship between microwave power in watt and each of fabric properties, a linear regression analysis was performed. The linear regression model which correlates microwave power with fabric properties is as follows:

Y= a + b × X

Where,

Y= dependent variable, i.e. woven fabric property

X= microwave power, watt

a= constant, and

b= regression coefficient.

The power and linearity of the relationship between dependent and independent variables was quantified using the correlation coefficient which ranges between +1 and -1.

## 3. Results and Discussion

**Fabric breaking load**

Breaking load is one of the important properties required in the woven fabric. This property distinguishes the woven fabrics from knitted or non-woven fabrics. The fabric breaking load relies mainly on the breaking load of its constituent yarns, fabric structure and many different parameters [17- 19].

Breaking load of fabric samples under study treated with microwave radiation is illustrated in figure 2. It was observed that the power of microwave radiation and the type of woven fabrics make a great difference to the fabric breaking load. A decreasing trend that was disclosed has proved that as the microwave power increases the fabric breaking load decreases. Also it was evident that open-end yarn woven fabrics is more weaker than those woven from ring spun yarns and the difference between breaking load of both fabrics is significant.

It was determined that increasing power of the microwave radiation from 350 to 710 watt leads to reduce the ring yarn fabric breaking load and open-end yarn fabric breaking load by approximately 17% and 10% respectively. It was also shown and as expected that the ring yarn fabrics is outperformed open-end yarn fabric in relation to breaking load. The lower breaking load of fabrics woven from open-end yarns may be due to the hooked and wrapped fibers around the open-end yarn surface which decreases the yarn tensile strength and hence reducing fabric tensile strength.

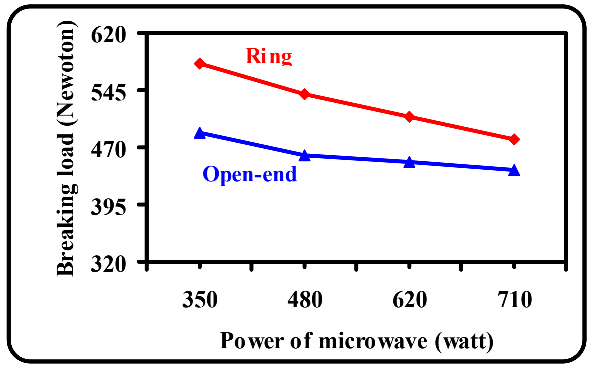


**Figure 2: Breaking load of open-end and ring yarn fabrics treated with microwave radiation**

The regression models which correlate microwave radiation power with breaking loads of both fabrics are as follows:

Breaking load (Newton) (ring fabric) = -33 × power of microwave (watt) + 610

Breaking load (Newton) (open-end fabric) = -16 × power of microwave (watt) + 500

The negative sign in these modes denotes that microwave power negatively affect the fabric breaking load. The linear correlation coefficients were - 0.99 and -0.95 for ring and open-end yarn fabric respectively. This signifies that the negative and strong relation between the two variables.

**Fabric breaking elongation**

Variations of open-end and ring yarn woven fabrics breaking elongations according to microwave power are plotted in figure 3. It was proved that breaking elongation is significantly and negatively affected with power of microwave radiation. A decreasing trend was disclosed confirming that breaking elongation of both types of fabrics decreases as the power of microwave increases the. Increasing microwave radiation from 350 Watt to 710 Watt leads to reduce the breaking load by 18% open end yarn fabrics and by 20% for ring yarn fabrics. It was also shown that breaking elongation of open-end yarn fabric is higher than breaking elongation ring yarn fabrics. The higher breaking elongation associated with fabrics woven from open end yarns because of the wrapped and hooked fibers in the structure of this type of yarns.

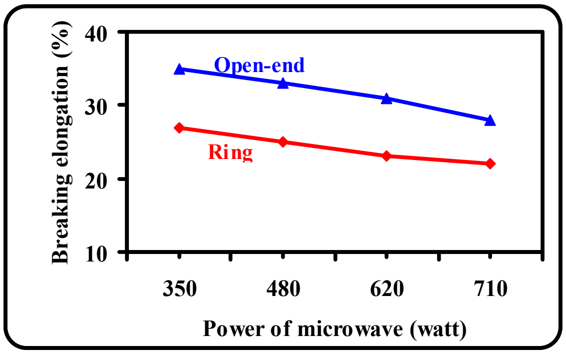


**Figure 3: Breaking elongation of open-end and ring yarn fabrics treated with microwave radiation**

Regression models which correlate power of microwave radiation with breaking elongation of woven fabrics have the following forms:

Breaking elongation (%) (ring fabric) = -1.7 × power of microwave (watt) + 28.5

Breaking elongation (%) (open-end fabric) = -2.3 × power of microwave (watt) + 37.5

The correlation coefficients between both variables were found to equal -0.98 and -0.97 for open-end and ring yarn fabrics. The values of the correlation coefficients refer to the strong and negative relationship between microwave power and breaking elongation of the woven fabrics.

**Fabric tearing strength**

Woven fabrics' tearing strength is related to large extent with fabric serviceability. Tearing strength of open-end and ring yarn woven fabrics at different levels of microwave radiation power is plotted in figure 4. Form this figure it can be seen the significant influence of power of microwave radiation on fabric tearing strength. A as the microwave power increases the tearing strength decreases. Increasing microwave power causes a decrease of fabric tearing strength by about 17.3% and 17.9% for ring and open-end yarn fabrics.

It was also disclosed that there is no a significant difference between open-end and ring yarn fabrics in terms of their tearing strengths. In general, and as expected, tearing strength of ring yarn fabrics is more than open end yarn fabrics. This result is natural due to the higher tenacity of ring spun yarns compared to the other spun yarns.

Regression models which correlate microwave power with fabric tear strength are as follows:

Tearing strength (Newton) (ring fabric) = -28 × power of microwave (watt) + 490

Tearing strength (Newton) (open-end fabric) = -27.5 × power of microwave (watt) + 475

The correlation coefficients between microwave power and fabric tearing strength are -0.98 and -0.99 for open-end and ring yarn fabrics. The values of the correlation coefficients refer to the strong and negative relationship between both variables.

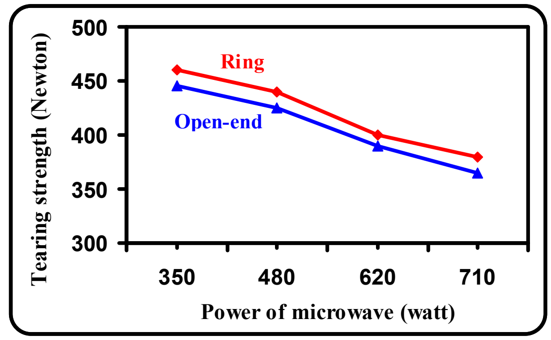


**Figure 4: Tearing strength of open-end and ring yarn fabrics treated with microwave radiation**

**Fabric roughness**

Roughness is considered one of the most effective and fundamental factors that describe the tactile comfort and handling of the woven fabrics. Roughness can be defined as the high frequency range variation of the surface of the woven fabrics. Roughness is measured by the surface vertical deviation from the ideal form. Large deviations denote the surface is rough. In general, the higher the roughness value of the fabric surface, the lower is the surface smoothness.

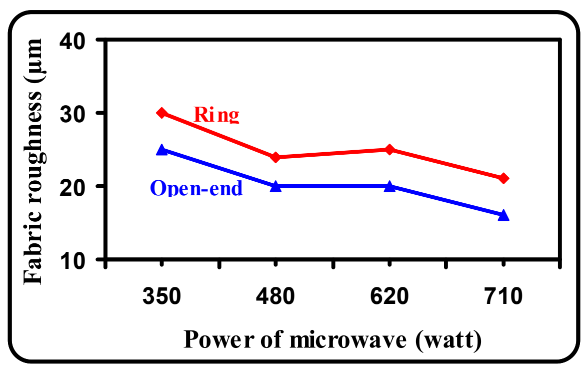


**Figure 5: Roughness of open-end and ring yarn fabrics treated with microwave radiation.**

Values of surface roughness of open-end and ring yarn fabrics versus the power of microwave radiation is presented in figure 5. It was noticed that as A microwave power increases, the roughness of woven fabrics decreases. This means that treatment of woven fabric surface using microwave radiation has enhanced the texture of fabric surface, namely increased the smoothness of woven fabric surface. It was determined that increasing microwave power leads to decrease woven fabric roughness. In other words, increasing microwave power enhanced the smoothness of the fabric surface. Generally, treatment of woven fabrics using microwave radiation increased surface smoothness by approximately 30% and 36% for ring spun and open-end yarn fabrics.

It was also noticed that roughness of open-end yarn fabrics is lower than those woven from ring spun yarns. That is surface of open-end yarn fabrics is smoother than ring spun yarn fabrics. The smoother surface of ring yarn fabrics may be due to the wrapped and hooked fibers that the structure of this type of yarns contains.

The relationship between fabric roughness and the microwave radiation power is as the following linear forms:

Roughness (μm) (ring fabric) = -2.6 × power of microwave (watt) + 31.5

Tearing strength (μm) (open-end fabric) = -2.7 × power of microwave (watt) + 27

The correlation coefficient between microwave power and surface roughness of open-end and ring yarn fabrics is -0.89 and -0.94 respectively.

**Fabric air permeability**

Air permeability refers to the resistance of fabric to the passage of air under constant and preset pressure. Permeability of woven fabrics to the air is considered one of the most important attributes that controls textile materials performance. This attribute is taken into consideration for many and different textile products, for instance clothing, vacuum cleaners, air bag fabrics, parachute fabrics and filter fabrics. It also affects greatly fabric comfort [17-19].

The values of air permeability of open-end and ring yarn woven fabrics versus microwave radiation power are shown if figure 6. It was estimated that air permeability of woven fabrics is significantly affected by microwave power. The higher the microwave radiation power is, the higher is the air permeability of both fabrics. Increasing the power of microwave resulted in increasing the open-end yarn fabrics permeability of by approximately 14% and by 15% for ring spun yarn fabrics.

The lower open end yarn fabrics permeability may be due to the higher bulkiness of these yarns, which lower the air permeability through fabric and yarn structure.

The relationship between fabric air permeability and the microwave radiation power is as the following linear forms:

Air permeability ($cm^3/cm^2.sec$) (ring fabric) = 3.2 × power of microwave (watt) + 62.5

Tearing strength ($cm^3/cm^2.sec$) (open-end fabric) = 2.6 × power of microwave (watt) + 54.5

The correlation coefficient between microwave power and surface roughness of open-end and ring yarn fabrics is 0.97 and 0.99 respectively. The positive signs of correlation coefficients signify that the relation between independent and dependent variables is positive.

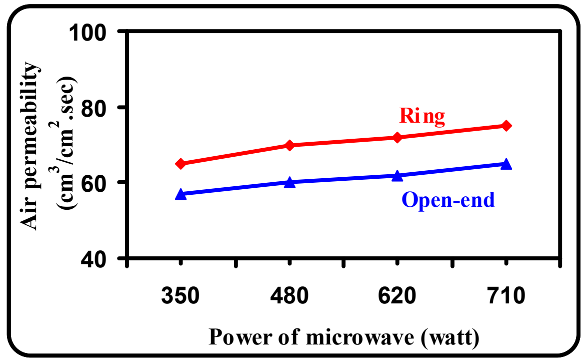


**Figure 6: Air permeability of open-end and ring yarn fabrics treated with microwave radiation.**

**Whiteness index**

The values of whiteness index of both fabrics treated with microwave radiation at different powers were depicted in figure 7. It was proved that microwave radiation power has an eminent effect on whiteness index of the woven fabrics. In general, treatment of woven fabrics with microwave radiation has enhanced their whiteness index. This means that increasing the power of microwave treatment leads to increase the values of whiteness index of the woven fabrics by about 14% for open-end and ring yarn fabrics.

It can also be noticed that ring yarn fabrics have whiteness index values than open-end yarn fabrics. This is because the bulkiness of the open-end fabrics which makes it needs more quantity of hydrogen peroxide to get the same degree of whiteness as ring yarn fabrics.

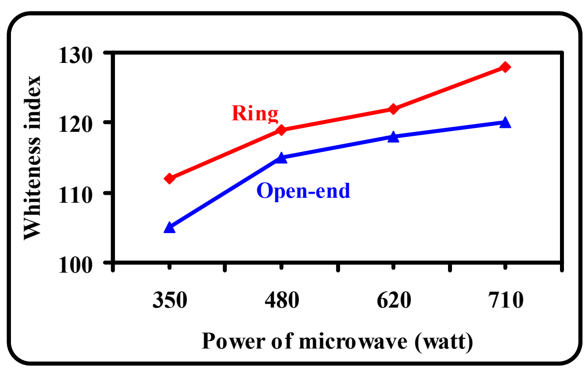


**Figure 7: Whiteness index of open-end and ring yarn fabrics treated with microwave radiation**

The regression models which correlate whiteness index of woven fabrics with the power of microwave radiation have the following forms:

Whiteness index (ring fabric) = 5.1 × power of microwave (watt) + 107.5

Whiteness index (open-end fabric) = 4.8 × power of microwave (watt) + 102.5

The correlation coefficient between microwave power and surface roughness of open-end and ring yarn fabrics is 0.98 and 0.93 respectively. The positive signs of correlation coefficients signify that the relation between independent and dependent variables is positive

**Color strength**

In this study, the color strength of woven fabrics was characterized using k/s values. The values of K/S against the power of microwave radiation for both types of woven fabrics were illustrated in figure 8. It was confirmed that color strength of both fabrics were greatly affected by the power of microwave radiation. It was noticed that as the power of microwave increases the woven fabrics' color strength has the same trend. It was determined that increasing the power of microwave from 350 Watt to 710 Watt leads to an increase of K/S values by 21% and 33% for ring and open-end yarn fabrics respectively. That is the influence of microwave power on color strength is pronounced greatly in open-en yarn fabrics than in ring yarn fabrics.

It was also shown that K/S values associated with ring yarn fabrics are more than those associated with open-end yarn fabrics. The lower color strength fabrics woven from open ed yarns may be due to the bulkiness these yarns which make it needs to absorb more dye to get the same color strength as ring yarn fabrics.

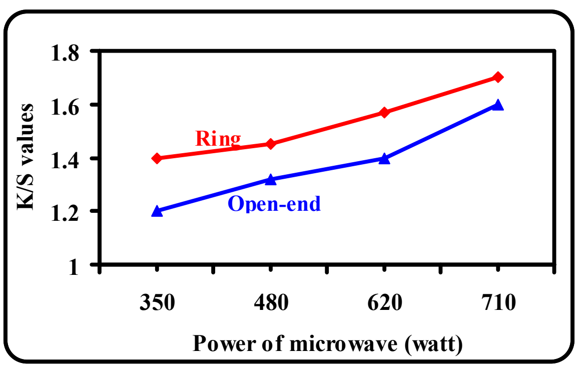


**Figure 8: Color strength of open-end and ring yarn fabrics treated with microwave radiation**

The power of microwave radiation correlated with color strength of the woven fabrics have the following linear forms:

K/S value (ring fabric) = 0.1 × power of microwave (watt) + 1.3

K/S value (open-end fabric) = 0.13 × power of microwave (watt) + 1.1

The correlation coefficient between microwave power and surface roughness for both types of woven fabrics is 0.97.

**Conclusions**

Microwave irradiation is one of the newest and powerful techniques of non-contacting heating and has been used for reacting, heating and drying the textile materials. This paper focuses on treatment of different types of woven fabrics using microwave irradiation. Open-end and ring yarn woven fabrics were used throughout this study. The effects of microwave power on some physical and color properties of both types of fabrics were investigated. The findings of this study can be summed up as follows:

- Microwave irradiation has impaired the tensile properties and tearing strength of the woven fabrics. As the power of microwave increases, the breaking load, elongation and tearing strength of the woven fabrics also decreases.

- Tensile and tearing strengths of ring yarn fabrics were more than those woven from ring spun yarn. By contrast, the open-end yarn fabrics elongation was higher than ring yarn fabrics because of the wrapped and hooked fibers in the structure of this type of yarns.

- It was also found that microwave irradiation enhanced significantly the roughness, ir permeability and color properties of the woven fabrics. As the power of microwave increases, the smoothness, whiteness index and color strength of woven fabrics also increases.

- Ring yarn fabrics exhibited more air permeability, roughness, whiteness, and color strength compared to open-end yarn fabrics.

**References**

1. Metaxas, A.C., Meredith, R.J. (1983). Industrial Microwave Heating, Peter Peregrinus, pp. 111-150, ISBN 0-90604-889-3, London.
2. Kale, M. J., & Bhat, N. V. (2011). Effect of microwave pretreatment on the dyeing behaviour of polyester fabric. Coloration Technology, 127, 365–371.
3. Kalia, S., & Sheoran, R. (2011). Modification of ramie fibers using microwave assisted grafting and cellulase enzymeassisted biopolishing: A comparative study of morphology, thermal stability, and crystallinity. International Journal of Polymer Analysis and Characterization, 16, 307–318.
4. Englert, R.D., Berriman, L.P. (1974), Curing chemically treated cellulosic fabrics, US Patent 3846845, 1974. 1112.

5. Anonymus (1996). Microwave Processes for the Combined Desizing, Scouring and Bleaching of Grey Cotton Fabrics, J. Text. Institute, 3, pp. 602-607, ISSN 0400-5000.
6. Nanda, R., Patel, G. (2002). Microwave Oven: A tool for guide response in shade translation in reactive dyeing, Colourage 49,12, pp.83-88,, ISSN 0010-1826.
7. Neral, B., Sostar Turk, S., Schneider, R (2007). Efficiency of Microwave Fixation of Digital Prints of the Reactive Dyestuff, Tekstil 56, 6, pp.358-367, ISSN 0492-5882.
8. Reagan, B.M. (1982), Eradication of insects from wool textiles, Journal of the American Institute for Conservation 21, 2, pp. 1-34, ISSN 0197-1360.
9. Katović, D. Kovacevic, Bischof Vukusic, S., Schwarz I., Flincec Grgac, S. (2008). The Effect of Microwave on Warp Sizing, Textile Research Journal 74, pp. 353-360, ISSN 0040-5175.
10. N. Esmaeilian, M. Arami, F.M. Mazaheri and S.M. Bidoki. A comparison between microwave-assisted and thermally synthesized esterquat softeners used as textile softening agents. The Journal of The Textile Institute, 2014 Vol. 105, No. 6, 569–574.
11. Zhao Xue. Study of dyeing properties of wool fabrics treated with microwave. The Journal of The Textile Institute, 2015.
12. Barbara M., Ann M. and James E. Microwave Sanitization of Polyester and Cotton. Textile Research Journal, 52(3), 1982, 186-192.
13. S A Mansour, A E Morsy and S. Almetwally. Twist loss on Air – Jets: Effects on Various Fabric Properties. The Indian Textile Journal, September 1998, PP.12-17.
14. Alsaid Ahmed Almetwally, M. M. Mourad and Abeer Ebraheem Eldsoky Mohammed. A Study of Yarn Breaks on Warping Machine, Life Science Journal, 10(1), 2013.
15. Rameshkumar C., Anandkumar P., Senthilnathan P., Jeevitha R. and Anbumani N. Comparative studies on ring, rotor and vortex yarn knitted fabrics. AUTEX Research Journal, Vol. 8, No4, December 2008.
16. V. Lyre. Dyeing behavior of open-end and ring-spun cotton yarns. Indian Journal of Fiber and textile Research, 16(9), 1991, 236-238.
17. Alsaid Ahmed Almetwally and M.M. Mourad. Effects of spandex drawing ratio and weave structure on the physical properties of cotton/spandex woven fabrics. The Journal of the Textile Institute, 2014, Vol. 105, No. 3, 235-245.
18. Alsaid Ahmed Almetwally, H. F. Idrees and Ali Ali Hebeish. Predecting the Tensile Properties of cotton/ spandex core-spun yarns using Artificial Neural networks and regression models. The Journal of the Textile Institute, 2014, Vol. 105, No. 11, 1221-1229.
19. Yasser. M. Eid, Ahmed Alsalmawy, and Alsaid. A. Almetwally. Performance of Woven Fabrics Containing Spandex. Textile Asia, volume XL1 No. 5, PP 39-42, May 2010.


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