American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-12, pp-01-08
www.ajer.org

Research Paper Open Access

Implementation of Gas Plasma Treatment on Cotton Fabric Tailor ability

Dr. Elsisy, W.S
Assistant Professor of Apparel Design Dept., Faculty of Family Science Taibah University , Kingdom of Saudi Arabia

Abstract: - The primary objective of current research was to examine the effects of fabric finishes on fabric tailor ability in relation to low stress measurements (Fabric Assurance by Simple Testing, "FAST). Plasma-finishing in textile technology is very promising due to various end uses like protective textiles for soldiers, medical textiles and smart textiles. Gas plasma finishing was applied to cotton fabric with the use of a no polymerizing gas, namely air, argon , helium, and nitrogen. Properties of the gas plasma treated samples including low stress mechanical behavior, fabric tailor ability index (performance - % improvement – efficiency), and total fabric-skin comfort value, were evaluated in this study, Fabric Assurance by Simple Testing, "FAST", was employed to evaluate the influence of dray treatment on tested fabrics. The change in the fabric tailor ability parameters of the gas plasma and / or mercerized, or mercerized- plasma treatments were in good agreement with the earlier findings and can be attributed to the amount of air trapped between the yarns and fibers. This study suggested that the gas plasma finishing and/or mercerized- gas plasma processes can influence the final fabric tailor ability properties of cotton queen fabrics, and also provide information for developing mercerized – gas plasma processes treated cotton fabric for very high quality queen fabrics .

Keywords: - *Fabric wet processing (fabric mercerization), Fabric dry process (non-polymerized gas treatment),Fabric assurance by simple testing (FAST), The Balanced Scorecard Concepts – Demand Triangle.*

I. INTRODUCTION

Future automation and robotisation of apparel manufacturing processes will undoubtedly require that the machines and systems are selected based on the specific properties of the fabric being processed. Thus it is essential to develop and use objective evaluation methods for producing fabric compatibility data which are necessary for control of material handling, sewing and other processes involved in the conversion of fabrics into garments. The qualitative and quantitative analyses of relationships between properties of apparel fabrics and garment making-up processes are focused on. Studies of mechanical properties of fabrics such as extension, shear and bending and their relationship to objective tailor ability determinations constitute the main part of this research work

1.1-Adding Value with Dry Treatment:

Cotton fiber is the purest form of natural cellulose and has very little lignin or pectin compounds in the cellulose, such as flax, jute , hemp or wood. However, it still contains several unwanted impurities .The need for removal of impurities is obvious to make grey fabrics white and absorbent and to prepare them for dying, printing or chemical finishing. The effect of their various treatments is to bring about deterioration, degradation of cotton fabrics, plus its impact on environmental. In essence, the method described here is based on the concept of fabric dray treatment using non-polymerized gas.

The information's given in this section are mainly abstracted from Refs.[1- 14] .The textile and clothing industries in some developed countries are facing some big challenges today, largely because of the globalization process. Therefore, the shift to high- functional, added value and technical textiles is deemed to be essential for their sustainable growth. The growing environmental and energy-saving concerns will also lead to the gradual replacement of many traditional wet chemistry-based textile processing, using large amounts of water , energy and effluents, by various forms of low-liquor and dry-finishing processes.

1.2. Advantages of Plasma Treatments for Textiles [5 & 7]:

As it has been demonstrated, plasma treatments of textiles look very promising. They **can be** used both in substitution of conventional processes and for the production of innovative textile materials with properties that cannot be achieved via wet processing. [7]

a) They are applicable, in principle, to all substrates, even to those that cannot be modified by conventional method.
b) The modification is fairly uniform over the whole substrate.
c) In general, no significant alteration of bulk properties is produced.
d) A broad range of functional groups can be introduced at the surface, by varying the monomer gas used.
e) They are fast and extremely gentle, as well as environmentally friendly.
f) Being dry processes plasma treatment is characterized by low consumption of chemicals and energy. When they cannot replace an existing wet process (dyeing and some finishing), if used as pre-treatments, they can reduce markedly the amount of chemicals required by the process and the concentration of pollutants in the effluents. [5]

Low-temperature, low-pressure plasma (LTLPP) is already used industrially for the treatment of certain metals, semiconductors and polymer materials. For example, in chemical, pharmaceutical, biological and medical equipment low-pressure plasma is used to treat plastic surfaces, such as moldings from polyethylene for bottles, pipes and containers. LTLPP is also used for the treatment of polymer surfaces in the packing industry. There have not, however, been many applications for the treatment of fiber and textile materials, mainly for the reason that LTLPP systems have to be vacuum based which is expensive and such systems are only suitable for batch processing, although some attempts have been made at developing continuous low pressure plasma machines.

For plasma processing methods to be used in the textile industry, they need to based on atmospheric pressure, low temperature plasma (APLTP) and a number of such systems are now being developed commercially. Nevertheless, most of the research studies that have identified the potential plasma surface treatment offers, have been undertaken with LTLPP; the technology transfer to APLTP is seen as mainly a matter of modification to process conditions. The following is, therefore, a summary of the findings from LTLPP treatments of various textile structures and fiber types.

LTLPP technology has been widely investigated for the surface modification of textiles and an overview of such plasma treatments has been published by Mordent et al. Many of the improvements to fabrics of various fiber types largely depended on the gas employed

1.3. Objective:

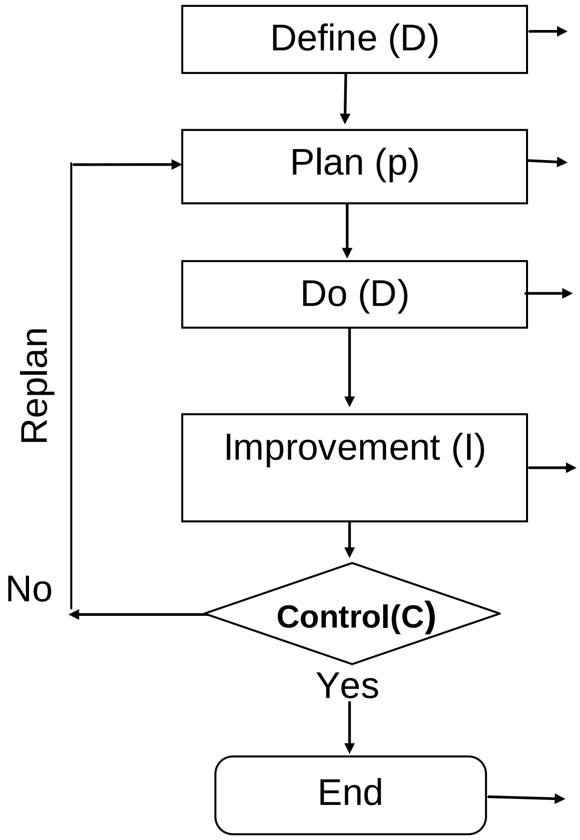
Disadvantages of fabric wet processing are: i) they are tedious and lengthy, ii) they are costly (water, energy, chemicals, and others), and iii) they can not be used without environmental impacts.. In the same time, evaluation properties of plasma treated fabrics, required, a costly equipments such as, SEM, atomic force microscope, contact angle and capillary rise measurements. Also, deals with the qualitative and quantitative analysis of the tailor ability of lightweight fabrics, as well as studies related to the interaction between the ease of tailor ability and performance characteristics of garment fabrics. The role of mechanical/physical properties of fabric in the making-up process as regards lightweight apparel fabrics must be fully understood in order to achieve trouble-free tailoring of garments made from such fabrics. Thus, it is obvious that a rapid and simple method for fabric finishing and its evaluation is badly needed .The present work was undertaken to fill this gap.

II. MATERIALS AND TESTING.

Common finishes include: mercerization (this process makes the material more comfortable, gives it a luster and added strength); plasma treatment; and conjunction of mercerization and plasma treatment-this new process makes the fabric equal to queen textiles in all required properties, such as comfortable, warm in winter, cooling summer, resists wrinkling, absorbs moisture, dries quickly, does not soil easily.

2.1. Plan (Experimental Road-map):

Influence of dry processing on fabric, tailor ability & hand [15]
Dry processing improved fabric quality by 20% 100%Cotton fabric subjected to dry processing and measured its properties before and after treatment Hypothesis testing



Y1: Y2

Fig.1 shows the experimental plan.

Trials have been made to find out the influence of dray processing on fabric performance (overall fabric tailor ability index) . For this purpose different fabric finishing processes are used ,i.e., wet and dray fabric treatment .In order to study the effect of plasma treatment on mercerized cotton fabrics, the general plan of this research will be as follows (See Fig. 1 and Table 2):

Step (A) Step (B) Step(C)

1-Grey Cotton Fabrics

2-Mercerized Cotton Fabrics

In order to study the effect of plasma treatment on mercerized cotton fabrics, the general plan of this research will be as follows (See Fig. 2 and Table 1):

Step (A) Step (B) Step(C)

1-Grey Cotton Fabrics

2-Mercerized Cotton Fabrics "FAST" Fabric Selection

3- Plasma Treated Cotton Fabrics

Fig.2 shows the experimental roadmap.

Table1. Properties of Mercerized Fabric [16].

structure	Fabric width(cm)	Yarn density per inch	Mass per unit area (g/m^2)
Plain 1/1	130	83x66	118

2.2. Gas Plasma Finishing:

The plasma process cylinder is 15 Cm diameter, and 35 Cm length. The radio frequency is 20 MH$_{z..}$ The system possesses two gas channels with a mass flow controller and magnetic valves for programmed, automatic precise gas flow in the process cylinder. The cotton fabric samples were placed in the plasma cylinder as shown in Figs.2. The plasma cylinder was first pumped down to 0.187 tore (25 pas) then the gas was injected automatically by opening the gas valves. The gas flow rate was kept constant at, 60mL/min. [16].

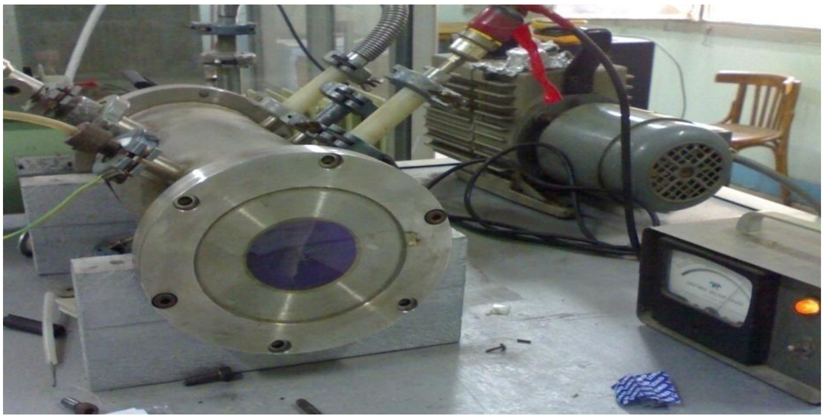


Fig. 3. Plasma apparatus.

2.3. - Fabric assurance by simple testing “FAST”.

It measures properties which are closely related to the ease of garment making – up and the durability of fabric finishing. FAST-1 gives a direct reading of fabric thickness over a range of loads with micrometer resolution. FAST-2, measures the fabric bending length and it's bending rigidity. FAST- 3, measures fabric extensibility at low loads as well as its shear rigidity. FAST- 4 is a quick test for measuring fabric dimensional stability, including both the relaxation shrinkage and the Hygral expansion, i.e. FAST, is a system of objective measurements for assessing the appearance, handle, and performance properties of fabrics, using an integrated set of instruments and test methods [17]. Therefore fabric tailor ability refers to the ease with which a fabric can be fashioned to create a garment, and includes factors such as sew ability, drape, setting, shape-retention, and wrinkle-resistance.

2.4. Data Presentation.

There are actually two different ways to scale each parameter on a radius: (a) parameters without data normalization process: The raw data of each parameter will be adjusted and the scale on each radius determined so that the maximum and the minimum values of the parameters can all be accommodated on the whole range of its radius, (b) parameters after normalization: Another way either more generality is to normalize all the raw data as shown in equation (1), [18]:

$$Xj' = \frac{Xj_{\max} - Xj}{Xj_{\max} - Xj_{\min}} \text{ ----------------- } \rightarrow (1)$$

Where Xj, Xj' the values of jth parameters before and after normalization, Xj_{max} and Xj_{min} are the maximum and minimum values of this parameter. By normalizing the data, all parameters will range from 1 to 0, so the circle becomes a unit radius.
In this article, only the second method is illustrated.

III. RESULTS AND DISCUSSION

3.1. Objective evaluation of feel and handle, appearance and tailor ability of fabrics

Fabric hand, one of the most significant properties of a fabric, is tested not only by manufacturers, but also by consumers prior to purchase. Over the years textile manufacturers have used several different methods to measure fabric hand. Prior to the development of the Kawabata Evaluation System of Fabric (KES-F) and the Fabric Assurance by Simple Testing Method (FAST), fabric hand was evaluated subjectively by touch and feel. Both the KES-F and FAST systems use precise instruments that help manufacturers evaluate a product and maintain a desired hand. While these instruments provide valuable information, both are time consuming and costly to run. Furthermore, data produced by the two methods are sometimes difficult to interpret. There have been several studies conducted focusing on ways of determining fabric hand using methods that are relatively simple, fast, and less costly than current methods. El-Hadidy., Mosbah ,M. and Abd-Allh,H. [16], published a study that evaluated fabric hand using fabric draw force through a metal cone. On the other hand the relationship between fabric handle and different types of fabric finishing (Wet processing and dry processing parameters) is still needs to study. The effectiveness of a gas plasma treatment is governed by a variety of factors such as: x_1=the composition of the gas; x_2= the type of fabric; x_3= the pressure within the plasma camper; x_4= the frequency and power of the electrical supply; and; x5 = the temperature and duration of the treatment. In our study variables, x_1, x2, x4and temperature are constant.
It was found that:

1- Fabrics tested the stability of gas plasma finishing (as a function of fabric handle) affected by each of the treatment time (ranged from 2 min . to 6 min.) and the type of gas used (air, Ar, He, and N2):-
a-improves stability (form 0.234 to 0.228) , an increase of time with, "N2", gas
a- improving stability and then getting worse with time, an increase of , "Ar, gas, from 0.225 to 0.231, and
b- worse stability increase of time with, "He", gas, from 0.235 to, 0.237,
2- Fabric tailor ability is affected by all of the processing time and type of gas as follows:
i- worsen an increase of time from 2 min. to 6 min with, "He", gas, from 0.618 to 0.538
ii- getting better and then worse than 2 min to 6 min with, "Ar", gas, from 0.713 to 0.681, and
iii- worse then better than, 2 min. to 6 min with, "N2", gas.
3- Plasma treatment with, 'Ar", gave better results(0.677) than treatment with air (0.599),
4- Best results (0.677) were registered after both mercerization plus gas plasma treatment, followed by the results fabric mercerization (0.610) and finally the results of grey fabric (0.384).
5- Figs.4 – 8, show the effect of both fabric wet processing, i.e., fabric mercerization , and fabric dry processing ,i.e., non-polymerizes gas plasma treatment on fabric tailor ability ,measured by ,fabric assurance by simple testing ,FAST.

Fig.4 SHows Fabric Tailorability Parameters(Sample 1).

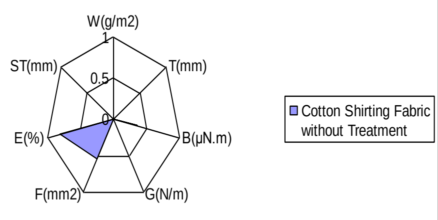


Fig.5 Fabric Tailorability Parameters after Mercerization.

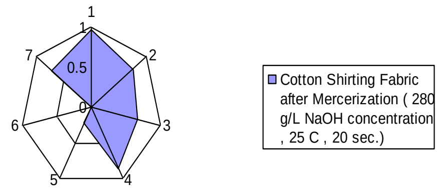


Fig.6, Fabric Tailorability Parameters after Plasma Treatment (Sample No.8 , Ranking 18)

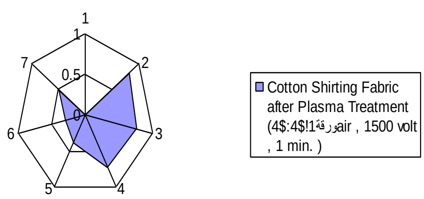
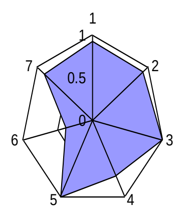


Fig. 7 ,Cotton Shirting Fabric after Plasma Treatment(Ar , 2000 volt , 40 min. -Sample No. 18 , Ranking 1).



The changes in these properties are believed to be related closely to the inter-fiber and inter-yarn frictional force induced by the low temperature plasma (LTP). The increase in overall fabric tailor ability index of the "LTP" – treated cotton fabric was found to be probably due to the plasma action effect on change in fabric surface morphology. The change in the tailor ability properties of the "LTP" treated finished cotton fabric was in good agreement with the above finding and can be attributed to the amount of air trapped between the yams and fibers.

In the evolution of the low-stress mechanical properties of the plasma – treated fabric, the plasma treatment showed different effects on the extensibility, bending rigidity, shear rigidity, surface thickness, and formability. However, the overall fabric tailor ability index (equation No.1) confirmed that the plasma treatment could alter the low- stress mechanical properties related to fabric tailor ability of tested cotton fabrics. Out of the varieties examined samples, No., "1, show the lowest value (total comfort value reaches zero), whereas, samples No. 4(0.899), shows the highest total fabric- skin comfort value. On the other hand fabric relative value reaches, "0.169" with sample, "4", and,"0.038", with grey fabric.

3. 2. Results of fabric performance improve

The effectiveness of gas plasma treatment is governed by a variety of factors, x_1=the composition of the gas(Argon); x_2= the type of textile (100% cotton fabric, plain weave 1/1) 123 g/m^2); x_3= the pressure within the plasma champers(2000 volt); x_4= the frequency and power of the electrical supply; (1500 volt); and x_5= the temperature(25C^o), and duration of the treatment(40 min) .

The following data (Table 2), are the results of fabric performance, before and after; mercerization, gas plasma, and mercerized-gas plasma treatment.

Table 2. Tested fabric performance Results [17 & 18].

Fabric sample	Fabric performance				% Imp.
	Grey	Mercerized	Gas plasma	Mercerized +Gas Plasma	
1- Grey Fabric	0.384	--	--	--	0
2- Mercerized	0.384	0.601	--	--	56.5
3- Gas plasma	0.384	--	0.677	--	76.3
4- Mercerized + Gas plasma	0.384	--	--	0.833	116.9

Table 2 shows that the percentage improves in fabric performance of tested fabric mercerized plus gas plasma, tailor ability index reaches 116.9 %, while fabric tailor ability index reached 20% as predicted value.

3.2. The Balanced Scorecard Concepts and / or Demand Triangle:

The Balanced Scorecard concept involves creating a set of measurements for four strategic perspectives. These perspectives include: 1) financial, 2) customer, 3) internal business process and 4) learning and growth. The idea is to develop between four and seven measurements for each perspective

Nevertheless, the application of plasma treatments to textiles is still limited to technical products. Several explanations can be given. Correct application of plasma processes requires a good knowledge of the physical and chemical nature of plasmas, especially if the treatments have to be applied to different materials, as is the normal case for most textile small and medium enterprises, (internal business process -Innovation).

Therefore, skilled labors is required, which is, however, not generally available either in textile or in textile machinery companies. Without the capacity to understand the nature of the problems that can occur and to adopt the relevant correct actions, plasma treatments may lack reproducibility and give rise to disappointment and delusion. Moreover, the very wide variety of plasma technologies makes it difficult to decide which the best solution to be adopted (learning and growth -Innovation).

These perspectives include: 1) financial, 2) customer, 3) internal business process and 4) learning and growth. The idea is to develop between four and seven measurements for each perspective. Two graphic illustrations appear below to help convey the idea [19]. In this study a similar benchmarked is used, i.e., Demand Triangle. The results of Demand Triangle of all tested fabrics are given in Figs.10 – 13, respectively.

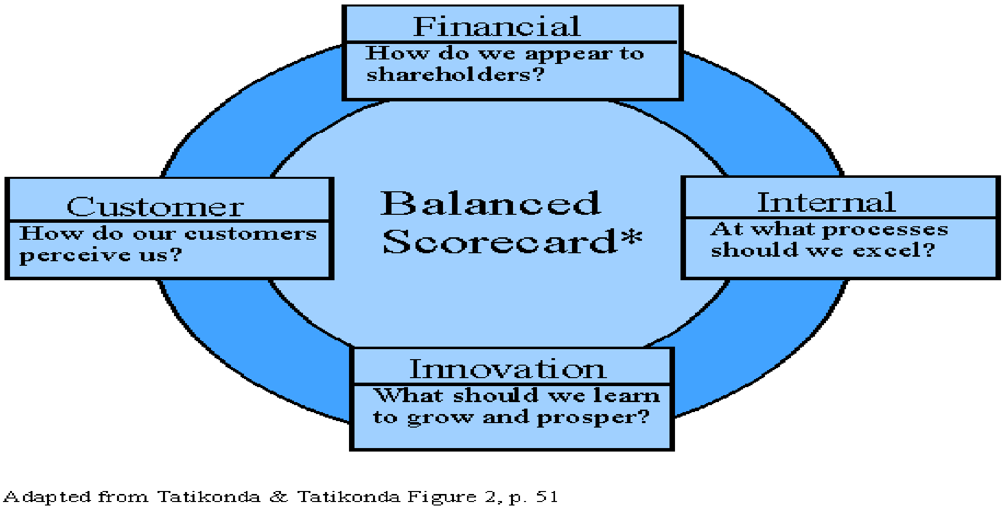


Fig.9. shows the concept of balanced scored concept [19].

The concept of balanced scored, has been discussed in details in Ref.19.But in this work, Demand Triangle, was used instead of it, the results were shown in Figs. 10 -13, respectively.

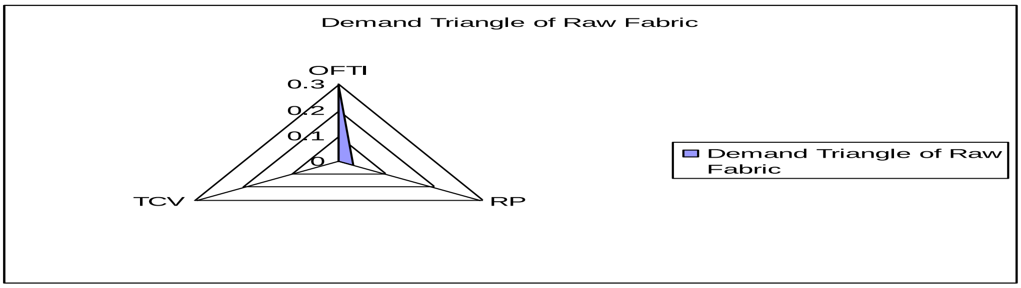


Fig.10 Balanced scored results of raw fabric.

Fig. 10 shows balanced scores results as a function od demonad triangle of fabric without treatment ,where ,OFTI = overall fabric tailorability index ,RP = relative price (cost) , and TCV = total comfort value .It is evedent that the area of result demond triangle is so small (percentage improve reaches zero).

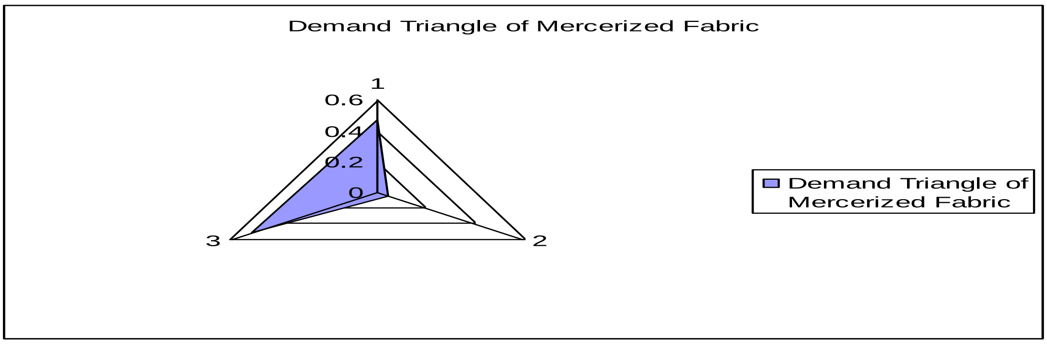


Fig.11 Balanced scored results of mercerized fabric.

As can be see from Fig.11 , the area of demoand triangle is increased ,due to wet processng ,anf percentage improved reaches ,56.5%.

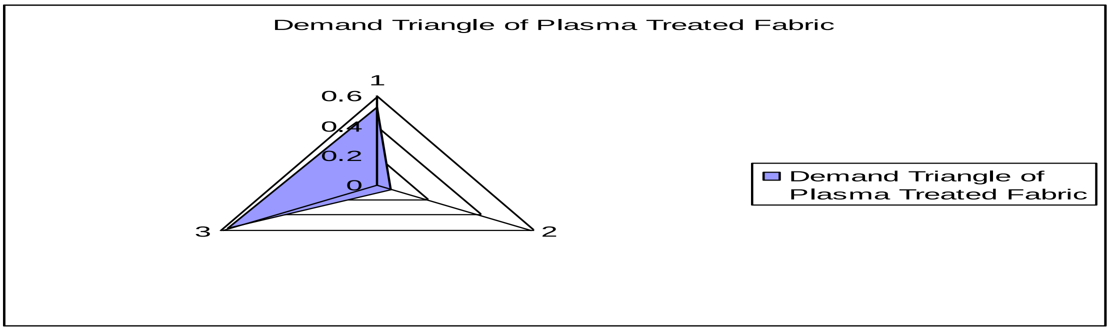


Fig.12 Demand triangle, results of gas plasma treated fabric.

On the otherhand ,Fig.12 ,indicate that ,the area of demond triangle ,is reaching the maxiumum value ,where ,the the percentage of improvement reaches ,116.9%.

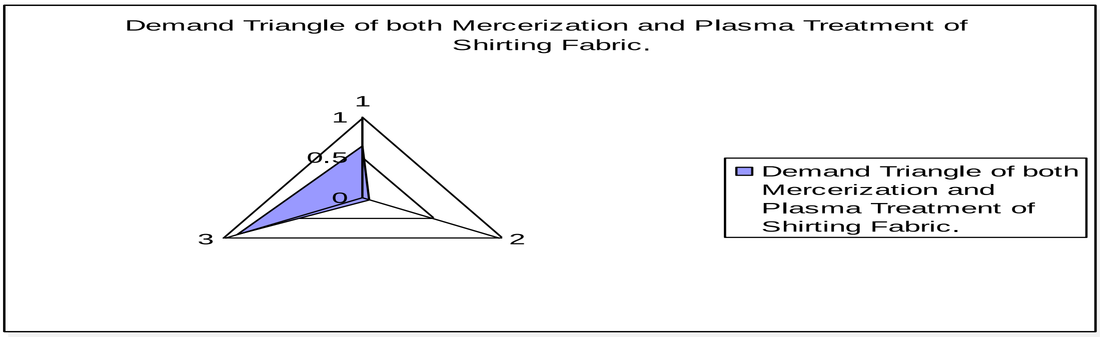


Fig.13 Demand triangle, results of wet processing plus ,gas plasma treated fabric.

It is clear from Fig. 13 , that the non-polymerized gas plasma (Ar, 2000 v , and 2 second),plus fabric mercerization ,gives the best ranking (as a function of the area of demand triangle).As can be seen , the figures reveal one common feature, i.e. dray processing improves fabric tailor ability properties [16].

IV. CONCLUSION

There are a number of different treatment methods which suit different products, but one of the most interesting aspects of plasma coating is its flexibility - it can be used to treat for yarn, fabrics and even whole garments. The application of fabric finishing with both mercerization plus gas plasma was investigated It was found that the fabric tailor ability parameters of light weight cotton fabrics finished with both mercerization plus gas plasma together, were superior to those mercerized only. Substitution of conventional finishing treatments with plasma treatments has much longer pay-off times, especially if water, energy and waste treatment costs are not exactly taken into account. FAST, system may be used instead of, SAM, AFM, capillary rise, and /or contact angle, method, to evaluate the influence of plasma treatment on tested fabrics. The same is for Demand triangle and Balanced score system.

REFERENCE

[1] Shishoo R., Plasma technologies for textiles, Woodhead Publishing L td., the Textile Institute, Cambridge, England (2007).

[2] Federal Ministry of Education and Research , "Plasma Technology --Process Diversity & Sustainability" Germany (2001)

[3] Ricardo d'Agostino, Pietro Favia, Christian Oehr, Michael R,Wertheimer Low-Temperature Plasma Processing of Materials: Past, Present, and Future",. Plasma Process. Polymer. (2005),

[4] Shyam Sundar P, Prabhu K H, and K arthikeyan N, Fourth state treat men for textiles",www.fibre2fashion.com

[5] M Radetic, P Jovancic, N Puac and Z L, Petrovic, "Environmental impact of plasma application to textiles" , Journal of Physics: Conference Series 71 (2007)

[6] Richard Moore, "Plasma surface functional inaction of textiles", Nanotechnology technology and Smart Textiles (March 2008), www.acteco.org

[7] B.Mar Candall And C.Riccard "Plasma treatments of fibers and textiles", 2006

[8] Suzanne Rodden Matthews , Plasma Aided Finishing of Textile materials" , A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy ,Fiber And Polymer Science (2005)

[9] Amelia Sparavigna, "Plasma treatment advantages for textile" Physics (Popular Physics) (2008) http://arxiv.org/abs/0801.3727v1

[10] Aasim Ahmed, "Atmospheric plasma treatment for surface modification of fibre assemblies", Textile Research & Innovation Centre, Textile Institute of Pakistan (2008)

[11] 'TNO Defence, Security and Safety' "E examples of plasma enhanced textile modification" Dutch Ministry of Defense, Netherlands www.tno.nl

[12] Qufu Wei, Hinging Wang, Qin Yang and Liang an Y u, "Fictionalization of Textile Materials by Plasma Enhanced Modification, Journal of Industrial Textiles, Vol. 36, No. 4 -301 April 2007

[13] http://www.sciencedaily.com/releases/.htm

[14] D. Hegemann And D.J .Balazs "Niño-scale treatment of textiles using plasma technology" (2006)

[15] El-Hadidy, Mesbas, M. and Abdelah, H. The relationship between fabrics sew ability and fabric handle .MEJ, 2010.

[16] El-Hadidy, A. and El-Sisy, W.S (2012) Influence of Plasma treatment on fabric tailors ability. International Conference , Faculty of Applied Arts , Cairo , 8 – 10 ,Oct.2012.

[17] El-Hadidy, a .M. "Tailor ability Analyses of Value- added Fabric of Plasma Treatment of Apparel Fabrics, International Conference Turkey, (2013)

[18] El-Hadidy, A., Eid, R., and Abd-Elaziz, L.:(2013) Effects of plasma treatment in enhancing fabric tailorability of protective fabrics, journal of faculty oh home economics, Shibean EL- Kum , Oct.2013.

[19] http://www.sciencedaily.com/releases/.htm, Balanced **scored.**