

Effect of some construction elements on the flammability of upholstery fabrics

Dr. Hafez S. Hawas

Lecturer at Spinning, weaving and knitting dept. Faculty of Applied Arts, Helwan University

Abstract:

This research is concerned with studying the effect of some construction factors, including weave structure, pile length and pile materials on the flame retardant property of chenille fabrics which used in upholstered furniture application, to improve its properties to meet the functional purpose it is produced for. Flammability property can be improved by preventing or delaying the ignition process using a technology that prevents thermal penetration or more thermally stable cushioning materials. Eight chenille fabrics were produced using three parameters mentioned before and treated with the same fire-retardant substance, (Flacavon H12/10). Our findings show that there is a direct relationship between fabric weight, thickness, char length and flame resistance of produced fabrics.

Keywords:

*Upholstery Fabrics
Fire-Retardant
Chenille Fabrics*

Paper received 25th July 2017, Accepted 13th August 2017, Published 1st of October 2017

I. Introduction:

Chenille yarns have recently attracted more and more application areas in textile industry such as furnishing fabrics, car interiors, and floor coverings. ⁽¹⁾ Textiles play an essential role in forming the aesthetic concept of interior design and furnishing. They also have a great effect on the origins and spread of fire. ⁽²⁾ During the last decade, there is a high concern about the fire safety of textile materials, where a number of fires

all-over the world appears to be increasing. ⁽³⁾

Upholstered furniture was identified as a source of dangerous fire potential forty years ago. During a home fire, upholstered furniture can become a significant fuel source. ⁽⁴⁾ And that a cigarette was the most common ignition source. ⁽⁵⁾ Statistical studies show clearly that there is a relationship between the flammability of soft furnishings as first ignited items in residential fires and fire fatalities as witnessed from Figure (1). ⁽⁶⁾

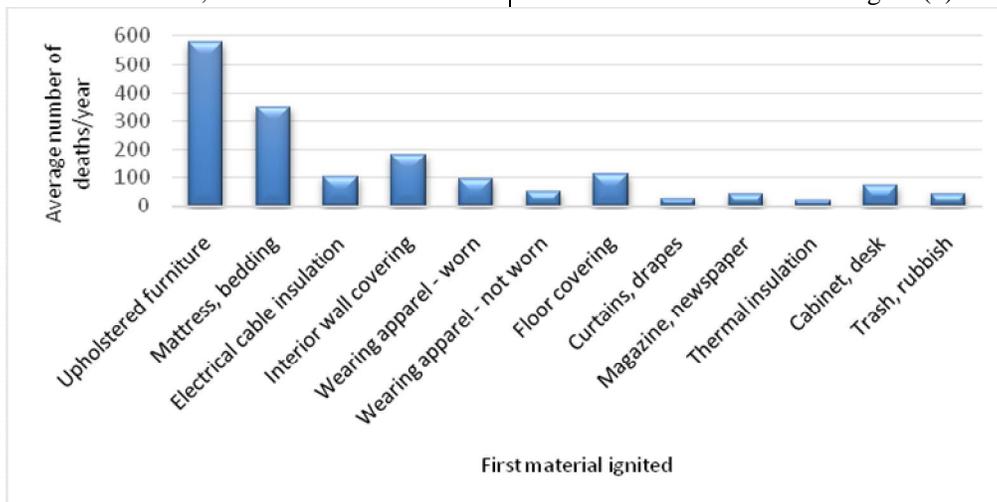


Fig. (1) Average number of fatalities in residential fires (2003–2005) broken down by the first item ignited. ⁽⁷⁾

According to National Fire Protection Association's (NFPA's) reports during 2010-2014, there is an average of 5,630 reported home structure fires per year were ignited by upholstered furniture as the first item catching fire. These fires caused an annual average of 440 civilian deaths, 700 civilian injuries, and \$269 million in direct property damage. Overall, fires beginning with upholstered furniture accounted for 2% of reported home fires, but 18% of home fire deaths. ⁽⁸⁾

The flammability characteristics of produced fabrics were affected by Three principal groups of fabric properties as:

- Physical properties (fabric mass, construction, and configuration)
- Chemical properties (fibers used in the fabrication, determine chemical properties of the fabric)
- Thermal properties (defined as the ability of textiles to absorb heat, which can ordain its

ignition temperature and burning rate)⁽⁹⁾
 Flammability property can be improved by preventing or delaying the ignition process using a technology that prevents thermal penetration (e.g., fire barrier materials)⁽¹⁰⁾ or more thermally stable cushioning materials.⁽¹¹⁾

Increasing government regulations and safety concerns necessitate that certain classes of garments and home textiles such as children's sleepwear, carpets, upholstery fabrics and bedding be made flame-retardant or resistant. Using inherently flame-retardant materials such as Kevlar and Nomex, applying a flame-retardant finish or a combination of these methods are commonly used to make clothing and textiles flame retardant.⁽¹¹⁾

II. Materials and Methods.

2-1: Specification of produced fabrics.

In this research eight chenille fabrics were produced by using three parameters and treated with the same fire-retardant substance, (Flacavon H12/10; Schill & Seilacher, with concentration 400g/L) then these fabrics were tested for flame

resistance to determine the effect of Physical properties of produced fabric on the ignition properties.

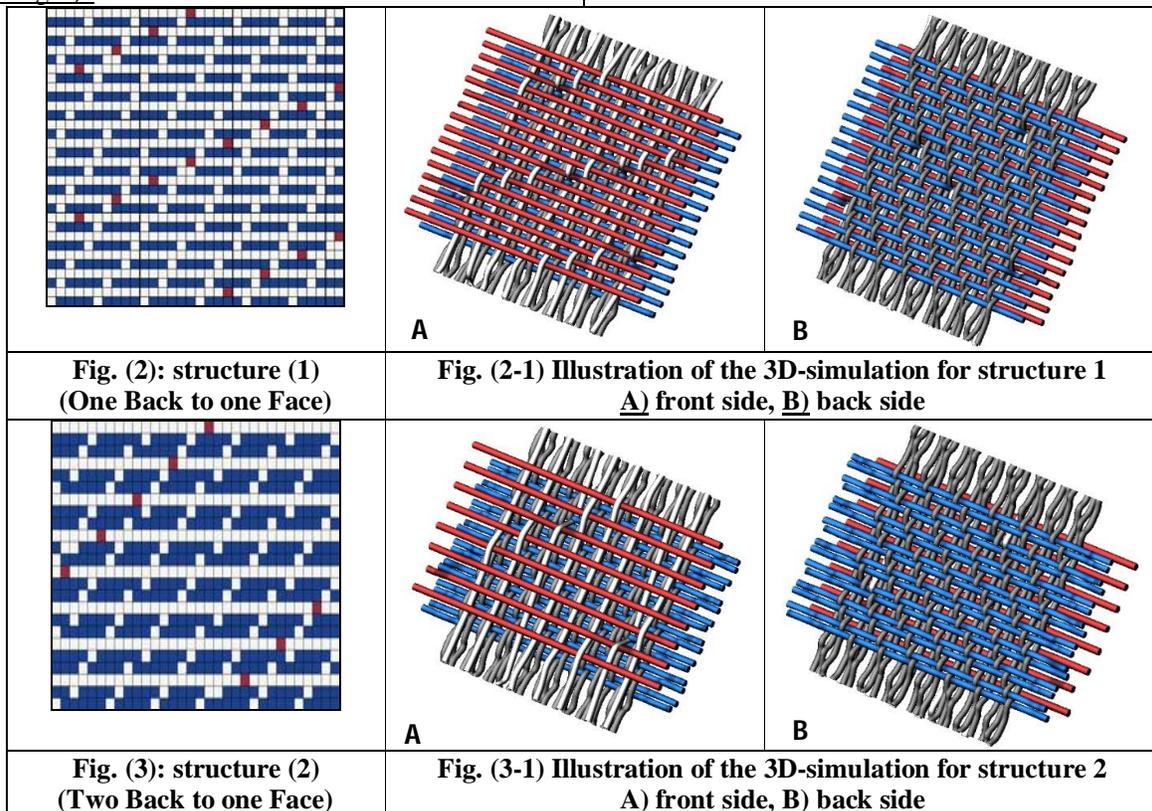
2-1-1: The pile length and materials of the produced fabrics.

- **Face weft (Chenille)**
 - A. **Pile materials:** Polyester, 80 denier & viscose, 36/1 Ne.
 - B. **Pile length:** Two chenille yarns with different pile lengths (1mm & 3 mm) were used in this research, as shown in below table (1).

- **Back weft materials:**
 The same weft material was used in producing the research samples (viscose, 36/1 Ne)

2-1-2: The weave structure of the produced fabrics.

Two weave structures were used in this research both of them follow the double - cloth construction, with the difference in the ratio of face weft to back weft.



*Note: ■ Back weft (viscose), ■ Face weft (chenille)

The methodology of using a different number of picks for producing the research samples was based on the following facts:

- In this research, our objective is to use the maximum number of picks per centimeter for producing tightly configure fabrics.

- The ratio of face weft (chenille / bulkier yarn) to back weft (viscose / thinner yarn) is different in the two weave structures used in this research, upon this we needed to increase the number of picks in (structure 2) more than (structure 1) to achieve our objective.

Table (1) Parameters of the produced fabrics

samples	Parameters					Maximum No. of Picks / cm
	Variable parameters			Constant parameters		
	Weave Structure	Pile length (mm)	Face weft Material & Count (Chenille)	Warp Material	Back Weft Material	
1	1	1	Polyester, 5 Ne.	PET, 150 denier	viscose	45
2	1	3	Polyester, 3.3Ne.	PET, 150 denier	viscose	42
3	1	1	viscose, 2.2 Ne.	PET, 150 denier	viscose	42
4	1	3	viscose, 1.9 Ne.	PET, 150 denier	viscose	40
5	2	1	Polyester, 5 Ne.	PET, 150 denier	viscose	55
6	2	3	Polyester, 3.3Ne.	PET, 150 denier	viscose	48
7	2	1	viscose, 2.2 Ne	PET, 150 denier	viscose	48
8	2	3	viscose, 1.9 Ne.	PET, 150 denier	viscose	42

* PET: abbreviations of polyester fiber

Table (2) Specifications of the loom used in producing research fabrics.

No.	Property	Specification
1	Weft insertion device	Rapier
2	Manufacturing company	SMIT
3	Shedding device	Jacquard
4	Manufacturing company	Stäubli
5	Design hooks	2560 hooks
6	Speed of the machine	300 picks/min.
7	Width of warp without selvage	140 cm
8	Reed used (dents per cm)	9 dents / cm
9	Denting	8 ends / dent

2-2 Laboratory test:

2-2-1: Fabric weight test:

This test was carried out on produced samples before and after treated with fire - retardant material according to the American Standard Specification of (ASTM D3776:09).⁽¹²⁾

2-2-2: Flame resistance of textile (Vertical method):

The test was carried out according to the American standard specification of (ASTM -D6413-99).⁽¹³⁾

III. Result and Discussion:

Table (3) Producing fabrics testing results

Samples NO.	Treated Fabric Weight g/m ²	Weight gain %	Treated Fabric Thickness mm	Char area Cm ²	Char length cm
1	750	10.5	2	4.4	3.3
2	1022	9.1	2.5	1.8	1.7
3	1269	15.9	2.7	0.46	0.4
4	1479	11.2	3.4	0.23	0.23
5	730	17.2	1.8	5.9	3.9
6	1005	13.7	2.3	3.64	3.2
7	1190	26.6	2.6	0.55	0.4
8	1250	22.4	3.2	0.31	0.33

3-1: Fabric weight:

All samples were weighed before and after the treatment and the values were fitted to the below

Equation to obtain add-on percents (or weight gain %):⁽¹⁴⁾

$$\text{Weight gain \%} = \left[\frac{\text{weight}_{\text{after treatment}} - \text{weight}_{\text{before treatment}}}{\text{weight}_{\text{before treatment}}} \right] \times 100$$

3-1-1: Effect of fabric structure on the weight gain percentage.

From figure (4) it can be seen that Structure 2 has recorded the highest rates of weight gain followed by Structure 1. This is mainly because of the increase in chenille yarns percentage in the weave

structure 1 which lead to a decrease in the porosity of the fabric and increases the covering of the fabric surface, so as a result, the fabric absorption of the fire retardant substance during the treatment process decreases.

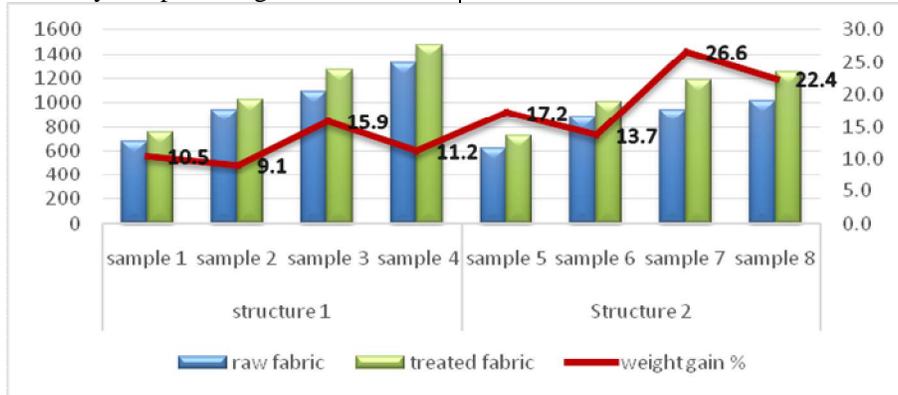


Fig. (4) Relationship between weave structure and the weight gain percentage

3-1-2: Effect of pile length on the weight gain percentage.

From figure (5) it can be observed that there is an inverse relationship between the weight gain of produced fabrics and the pile length. This is due to

the fact that, an increase in pile length increases the covering of the fabric surface so the fabric becomes less porous and hence its absorption of the fire retardant substance during the treatment process decreases.

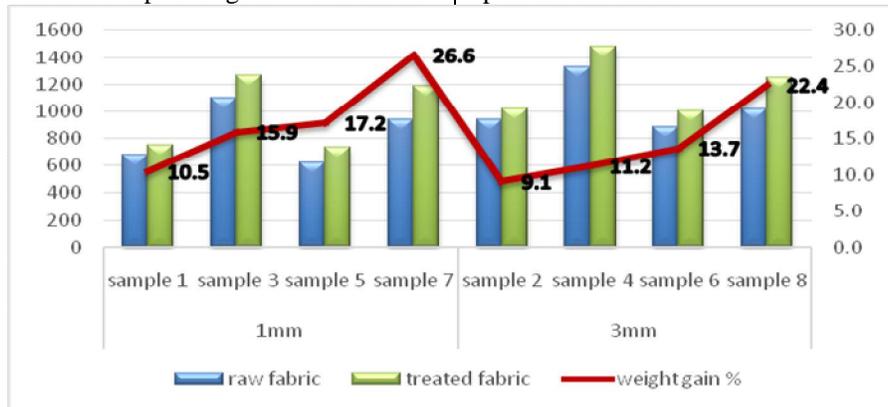


Fig. (5) Relationship between pile length and the weight gain percentage

3-1-3: Effect of weft materials on the weight gain percentage.

It is clear from the figure (6) that fabrics produced from viscose have recorded the highest rates of the weight gain followed by polyester. This is owing

to the physical properties of viscose which has a high amorphous region than polyester, that leads to an increase in the absorption of the fire retardant material for viscose more than polyester.

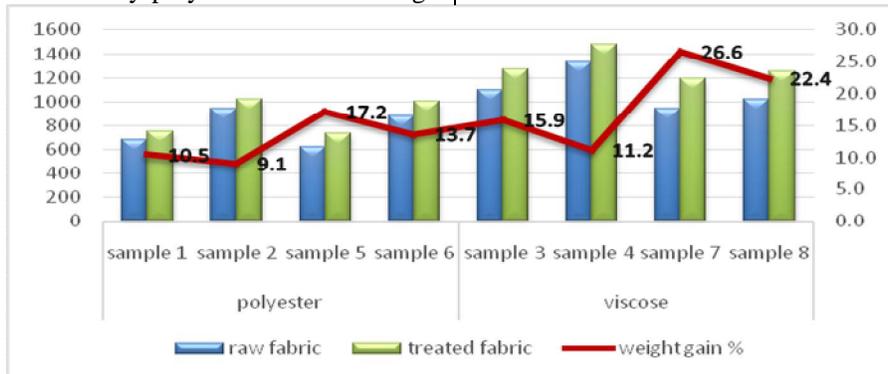


Fig. (6) Relationship between pile materials and the weight gain percentage

3-2: Flame resistance:

Table (3) shows the results of flame resistance test carried out on the produced samples using the following parameters: weave structure, pile length, and pile materials.

3-2-1: Effect of fabric structure on flame resistance.

From figure (7) it can be seen that Structure 1 has scored high rates of flame resistance followed by

Structure 2, This is due to structure 1 gave heavy fabric compared to the other structure. So that the heavy fabrics withstand the fire more than the light fabrics because during ignition the fire-retardant material reacts with the gases and tars generated by the burned fabric, converting the gases and tars to carbon char, which is non-flammable thus drastically slowing the fabric's burning rate.⁽¹⁵⁾

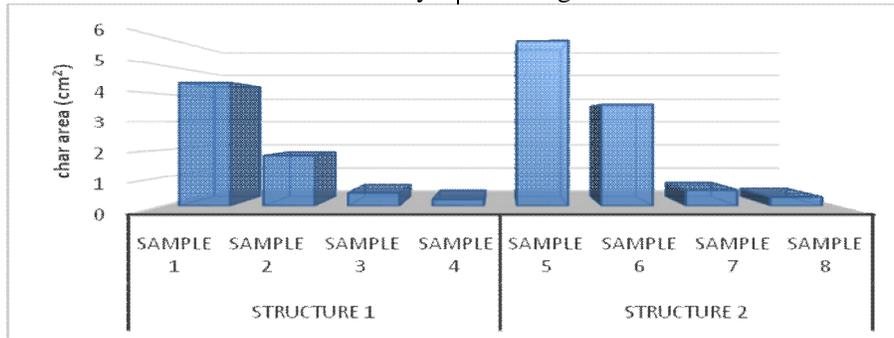


Fig. (7) Relationship between weave structure and flame resistance

3-2-2: Effect of pile length on flame resistance.

It can be noticed from the figure (8) that, there is an inverse relationship between the fabric flammability and the pile length. This is due to,

short pile length offer, a great Pore size in produced fabrics which tie up the fiber to resist the flame. So as the result fabric with a short pile length ignites and burn quickly.

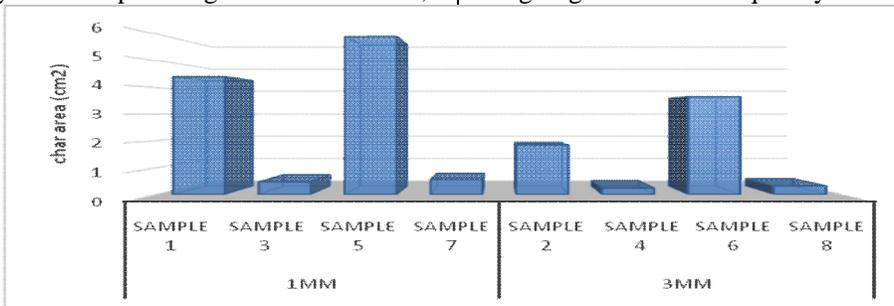


Fig. (8) Relationship between pile length and flame resistance

3-2-3: Effect of weft materials on flame resistance.

It is clear from the figure (6) & (9) the fabrics produced from viscose have recorded the highest rates of flame resistance followed by polyester. This is owing to the physical properties of viscose which has a high amorphous region than polyester, that leads to an increase in the absorption of the fire retardant substance for viscose more than polyester. So that the fabrics which hold a higher

amount of fire retardant material resist the ignition more than other fabrics. Where Flame retardant act on gas-phase combustion region, catch free radical of the combustion reaction, thereby constrain propagation of flame from, enkindle regional flame density fell, ultimately enkindle reaction rate fell till terminate⁽¹⁶⁾. Addition to viscose gives heavier fabrics than polyester which leads to an increase in fire resistance.

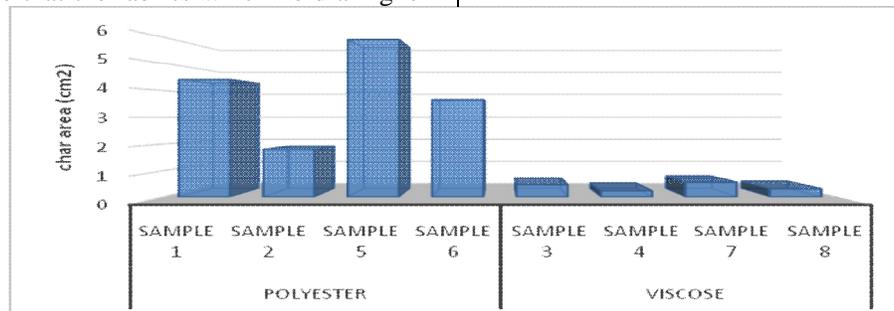


Fig. (9) Relationship between weft materials and flame resistance

3-2-4: Effect of fabric’s weight on flame resistance.

From figure (10) there is a direct relationship between the fabric weight and flame resistance. As they increase in fabric weight reveals to tight

fabric construction, that leads to the decrease of oxygen level available to support combustion ⁽⁹⁾ and vice versa.

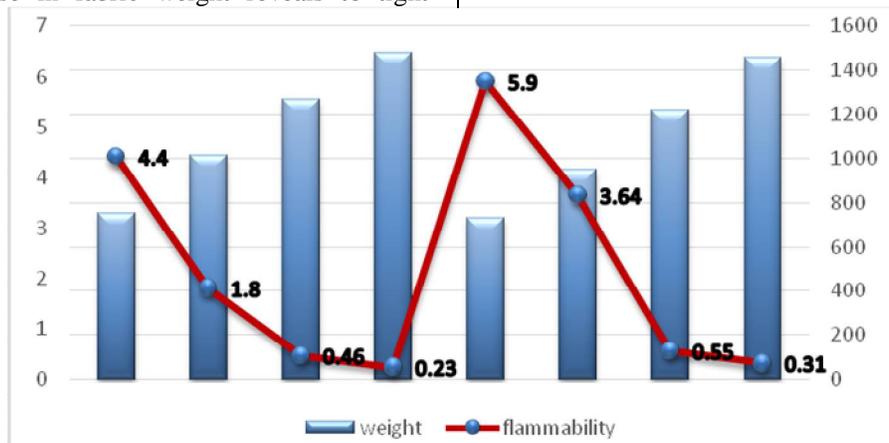


Fig. (10) Relationship between fabric’s weight and flame resistance

3-2-5: Effect of fabric’s thickness on flame resistance.

From figure (11) it is obvious that there is a direct relationship between the fabric thickness and flame resistance, this is due to thickness has an important effect on ignition time ⁽¹⁷⁾. So that, thicker fabric gives a low rate of char area (fire

area) more than thinner fabrics, and this causes an increase in the flame resistance of produced fabrics after a constant time. Addition to the Thick specimens are generally more difficult to ignite as there is more bulk material acting as a heat sink. Once ignited, thick specimens have the potential to burn for a longer time ⁽⁶⁾

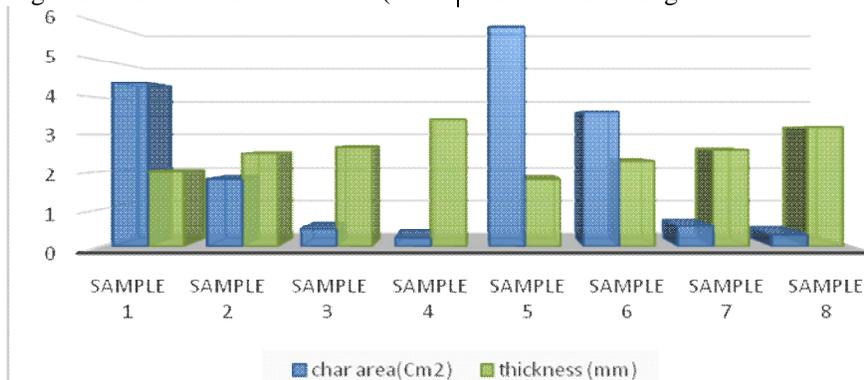


Fig. (11) Relationship between fabric’s thickness and flame resistance

3-2-5: Effect of char length on char area.

It is clear from the figure (12) that there is a direct relation between char length and the charred area

(fire area). This is owing to the increase in the burned area of tested fabrics associated with increasing the char length.

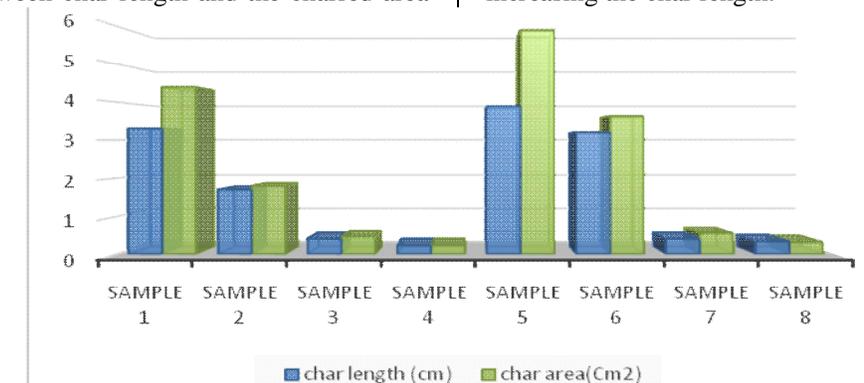


Fig. (12) Relationship between char length and char area (fire area)

Conclusions:

1. Structure 1 has scored the high rates of flame resistance followed by Structure 2.
2. It is concluded that; pile length has an inverse relationship with fabric flammability
3. Based on the results, we also conclude that the fabrics which produced from viscose have recorded the highest rates of flame resistance followed by polyester
4. As far as the effect of fabric's weight on flame resistance is concerned, it has been found that the flammability of fabrics is affected by the change in fabric weight where the heavier fabrics resist the ignition more than lightweight fabrics.
5. There is a direct relationship between the fabric thickness and flame resistance, where the denser fabrics resist the ignition more than the thinner fabrics.
6. Our findings show that there is a direct relation between char length and the charred area (fire area).

References:

1. S. Ulku, H.G. Ortlek, S. Omeroğlu, "The Effect of Chenille Yarn Properties on the Abrasion Resistance of Upholstery Fabrics", *FIBRES & TEXTILES in Eastern Europe*, Vol. 11, No. 3, 2003, pp. 38: 41
2. fabric for ideas - Trevira products catalogs, available online at www.trevira.com, July 2017
3. K.P.S. Cheng, W.K. Chow, S.S. Han, "On Assessing Flammability of Textiles", *Research Journal of Textile and Apparel*, Vol. 10 Issue: 1, 2006, pp.65-72
4. Thomas Fabian, "Upholstered Furniture Flammability", Underwriters Laboratories Inc, 2013
5. Walter Fung, "Coated and laminated textiles", Woodhead Publishing Limited and CRC Press LLC, 2002, pp. 71
6. A. R. Horrocks, D. Price "Advances in fire retardant materials", Woodhead Publishing Limited and CRC Press LLC, 2008, pp. 9&239
7. T. Rowe, "Interior textiles Design and developments", Woodhead Publishing Limited and CRC Press LLC, 2009, pp. 230
8. Marty Ahrens, "Home Fires That Began with Upholstered Furniture", The National Fire Protection Association (NFPA), 2017, pp.1
9. Avinash W. Kolhatkar, "Investigation of Factors Influencing Flammability and Prediction of Hazard Potential of Saree" PH. D, The Maharaja Sayajirao University, Textile Engineering Dept., Faculty of Technology & Engineering, 2006, pp. 8&9
- 10.F. Selcen Kilinc, "Handbook of fire resistant textiles", Woodhead Publishing Limited and CRC Press LLC, 2013, pp. 457
- 11.Richard A. Scott, "Textiles for protection", Wood head Publishing Ltd and CRC Press LLC, 2005, pp. 6
- 12.ASTM D3776 -09 "Standard Test Methods for Mass Per Unit Area (Weight) of Fabric"
- 13.(ASTM -D6413-99) "Standard Test Methods for Flame resistance of textile (Vertical method) "
- 14.Nguyen, T.-M., Chang, S., Condon, B. and Smith, J.," Fire Self-Extinguishing Cotton Fabric: Development of Piperazine Derivatives Containing Phosphorous-Sulfur-Nitrogen and Their Flame Retardant and Thermal Behaviors. *Materials Sciences and Applications*, 5, 2014, pp.789-802, available online at <http://dx.doi.org/10.4236/msa.2014.511079>
- 15.Mohamed Dorgham, Mohamed Abd El-Gawad, "The effect of certain geometrical construction elements on flame resistance property of velvet fabrics", *International Design Journal*, Volume 5, Issue 2,2015, pp 361-365
- 16.Hongkun Zhang, "Textile Flame Retardant Review", *Modern Applied Science*, Vol. 3 Issue: 2, 2009, pp.129:133
- 17.Gulay Ozcan, Habip Dayioglu, Cevza Candan, "Effect of Gray Fabric Properties on Flame Resistance of Knitted Fabric", *Textile Research Journal*, Vol 73, Issue 10, pp. 883 – 891