Measurement and Description of Flammable Behavior in Surface Pile of Carpet When Exposed to Combustion

Hend Ahmed Amen Abdallah

Spinning, weaving and knitting Dept, -Faculty of Applied Arts, - Helwan University
hend_a.a2007@yahoo.com

Abstract: In the current era the protection of our environment has become very necessary and vital, particularly with modern technological development that led to modern and easy convenient life require the use of modern equipment which has become inseparability human everywhere. Statistics have proven that the risks that can be exposed to human has increased and that the risk of fire is the most harshness and severity. Therefore industries, especially the textile industry, including carpet is no longer interested only in the shape of the product, but extended it to include a focus on the design and development of specifications check element of safety when using these products, as currently anywhere is not free from the presence of carpet products. This research focuses on the study of the impact of the difference structural installation on the behaviour of carpet surface pile when exposed to combustion, by measuring Burned length, Time of flaming and Flame spread. Three kinds of pile yarns were used polypropylene 100%, polypropylene /Acrylic 60/40% and Nylon 100% to produce 27 samples of carpet are different in number of pile rows, pile height, surface pile thickness, and surface pile weight. More results were reached, for examples, samples produced with pile yarn Nylon 100% had recorded the highest rates of resistance to flame spread, whereas samples produced with pile yarn polypropylene /Acrylic 60/40% have recorded the lowest rates. It was also found that there are direct relationship between number of pile rows per cm and resistance to flame spread. All samples have achieved the expected results and all samples produced with high thickness and weight have achieved the best results.

[Hend Ahmed Amen Abdallah. **Measurement and Description of Flammable Behavior in Surface Pile of Carpet When Exposed to Combustion.** *Life Sci J* 2014;11(9s):636-647]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 121

Key words: face to face woven carpet, carpet construction, pile height, carpet pile thickness, carpet flammability, combustion process, thermoplastic property.

1-Introduction:-

Carpet and floor coverings are the most common type of textile produced in the field of textile industries, it is also known that any house or building is not free from the presence of these products, while using these products may be subject to many risks, which include fire risks and this may result in the loss of human and material[1]. Hence the importance of studying the effect of different structural composition for carpet on flammability behavior, and this to determine the design requirements for security against fire for these products that commensurate with the job performance safely and reliably, and where the security design is the most important characteristics of the design process, and safety requirements for industrial products in general and carpets in particular considered as serves as the foundation for the basic functional requirements of the modern era. Among these previous studies, which focused in the field of susceptibility of carpet for flammable, this study for the development of a carpet flammability test procedure[2], and the following study to it, which focused on comparison between the US and Proposed BS tests[3], the another study which centered on realization the international code for combustion of woven floor coverings that woven from pile yarns made of wool blended with polyester by using different mixing ratios[4]. At the local level of cases of fires that occurred and the existence of carpet and floor coverings easily helped on outbreak the fire and caused a higher loss in human lives and high financial losses. For example and not limitation, the two successive huge fires have occurred in a major company a leader in the carpet industry, which caused the fall of many of the engineers and workers, and witnesses have told that the fire broke out in the stores too quickly and the flame height reached to about 40 meters in the air, and 53 ambulance failed to extinguish the fire, which pay to use two planes belonging to the Egyptian armed forces to participate in extinguishing the fire. Also it was the massive fire that broke out in the building of Shura Council in Egypt, Where the existence of the carpet helped to sustain this fire for a long time until it was extinguished. That generally preventing the outbreak of fires is one of the safety practices that are of great importance due to what caused this fire of material losses exceed to include the loss of life. For all that this research was to study the effect of different structural installation of carpet produced on the face to

face machines on the flammable behavior of these products, where 27 of carpet samples have produced differ in the structural installation of the pile on the surface of the carpet, and these differences include some important construction parameters (such as pile density, pile height, and yarn type material).

2-Theoretical studies:-

2-1- The Combustion Process:

Combustion means to burn. For the combustion process to take place, fuel, oxygen, and an ignition heat source are required to start a chemical chain reaction; in a campfire [5].

Fuel: Fuel is the substance that burns during the combustion process. All fuels contain chemical potential energy; this is the amount of energy that will be released during a chemical reaction[5].

Oxygen: For fuel to burn in the combustion process, it must also have oxygen. The most common source is the air, which contains about 21% oxygen. Other sources, often known as oxidizers or oxidizing agents, include hydrogen peroxide, potassium nitrate, and many more. When an oxidizing agent is introduced to a fuel, it releases oxygen and can increase the speed at which the fire burns[5].

Heat: Heat or ignition is what starts the combustion process. Since heat is also produced when something burns, once the process starts, additional heat is not always necessary to keep the chemical chain reaction going. The initial spark that triggers the chemical process can be provided by a flame, friction, or even the heat of the sun[5].

Controlling the Combustion Process: As all three parts are required for combustion, increasing or decreasing any of them will affect the process. Increasing the amount of oxygen added to a fire by using an oxidizing agent, for example, will make the fire burn faster. Removing or reducing the fuel source will make it burn smaller or die out.

There are three basic ways to stop the combustion process[5]:

1- take away the fuel,
2- remove the oxygen,
3- and/or take away the heat.

2-2- Risks that may result from fire:

Risk profile (risk to individuals): Are risks that endanger the lives of individuals for injuries that require the provision of measures to escape from dangers in the event of a fire[6].

Destructive danger: Is the destruction that occurs in buildings and facilities as a result of fire, and intensity of destruction vary depending on the type of flammable materials that in the building[6].

The endanger (danger to the neighborhood): Are the risks that threaten the sites near the scene of the fire, so-called external danger, does not require that there be a direct connection between the fire and the building at risk[6].

2-3- Human dangers caused by fires:

Thermal radiation: One of the main dangers of fire is its thermal radiation and the effect of that radiation on people and property. Thermal radiation diminishes with the inverse square of distance[7].

Smoke: Fires generate smoke, which is a mixture of soot particles, toxic gases, and water vapor. Factors such as smoke yield, fire size, particle size, and ambient conditions dictate smoke's transport into the environment. Studies show that soot particles can be generated in a range of 0 to 20 percent of fuel by weight during a pool fire. However, the air-to-fuel ratio and the amount of carbon in the molecular structure of chemicals play a major role in soot yield[7].

2-4-The division of textiles according to their resistance to ignition:

2-4-1- Fire-Proof Textile: Are textiles which are never affected by the flame, its do not ignite or melt, but it happens a slight change in its physical and chemical properties when exposed to direct flame, such as Asbestos and fiberglass.

2-4-2- Glow- resistant Textile: Textiles that are resistant to combustion by turning off the ignition mechanical, where producing carbon crust or fused Once the demise of direct flame source.

2-4-3- Flame- Resistance Textile: Are textiles that do not support the continuation of the ignition process after the removal of its source, although it will continue to burn for a period due to mechanical of glow in spite of the lack of direct flame, and also have the ability to configure the carbon crust and fusion.

2-4-4- Fire- Resistance Textile: Are textiles that combine resistance to ignition and glow, which means the stopping of glow process once the removal direct flame source, which also have the capability of fusion and configure the carbon crust[8].

3-Experimental work:-

3-1- Fabric samples produced under research:-

In this study, a number of 27 face-to-face woven carpets have produced, in order to study the effect of their different factors of textile structural on their Flammable behavior, Table (1) shows the specification of the machine used for producing samples under study.

Table (1): The specification of the machine used for producing samples under study:-

No.	Property	Specification
1	Machine	Face-to-face. Single rapier.
2	Machine type	Michel Van de Wiele
3	Weaving technique	ASR 91-410
4	Reed used(dents / cm)	3 dents /cm
5	Warp yarn count and type material	Ne 20/5, 35% PET:65% cotton
6	Weft yarn count and type material	Ne 8/2, 100% jute
7	Pile yarn count	Ne 4/1
8	Ground weave	2/2

The carpet samples specification produced in this research are given in Table (2).

Table (2): Carpet specification in this research

Sample no.	Pile material	Number of pile rows / cm	Pile height mm
1	polypropylene 00%	5	5
2	polypropylene 00%	5	8
3	polypropylene 00%	5	11
4	polypropylene 00%	7	5
5	polypropylene 00%	7	8
6	polypropylene 00%	7	11
7	polypropylene 00%	9	5
8	polypropylene 00%	9	8
9	polypropylene 00%	9	11
10	polypropylene /Acrylic 60/40%	5	5
11	polypropylene /Acrylic 60/40%	5	8
12	polypropylene /Acrylic 60/40%	5	11
13	polypropylene /Acrylic 60/40%	7	5
14	polypropylene /Acrylic 60/40%	7	8
15	polypropylene /Acrylic 60/40%	7	11
16	polypropylene /Acrylic 60/40%	9	5
17	polypropylene /Acrylic 60/40%	9	8
18	polypropylene /Acrylic 60/40%	9	11
19	Nylon 100%	5	5
20	Nylon 100%	5	8
21	Nylon 100%	5	11
22	Nylon 100%	7	5
23	Nylon 100%	7	8
24	Nylon 100%	7	11
25	Nylon 100%	9	5
26	Nylon 100%	9	8
27	Nylon 100%	9	11

3-2- Laboratory Testing:-

In this paper we used the existing methods to measure the change in the behavior of carpets when exposed to fire by changing their textile structural factors.

3-2-1- Determination of surface pile weight for carpet:

This test was carried out by using Metter PI 200 according to the American Standard specifications of (ASTM-D3776-85) [(9)].

3-2-2- Determination of surface pile thickness for carpet:

This test was carried out by using Helios Tester according to the American Standard specifications of (ASTM-D1777-64) [(10)].

3-2-3- The flame spread test:

This test was carried out by using FTT- Single Flame Source Test- UK according to International standard specification (EN ISO 11925-2). Where were measured Burned length (cm), Time of flaming (sec) and Flame spread (cm/sec) [(11)].

4-Results and discussion-:

Results of experimental tests carried out on the produced samples were statistically analyzed and presented in the following tables and graphs.

Table (3) Results of all tests applied to samples under study:-

Sample No.	Surface pile weight (g/m^2)	Surface pile thickness (mm)	Burned length (cm)	Time of flaming (sec)	Flame spread (cm/sec)
1	703.2	3.94	12.2	4	0.813
2	830.4	4.58	9.5	2	0.633
3	937.8	5.25	8.7	0	0.580
4	860.95	4.26	8.1	3	0.540
5	992.94	5.46	7.6	2	0.507
6	1121.58	6.55	7.2	0	0.480
7	1020.25	5.66	7.5	3	0.500
8	1179.64	6.96	6.9	0	0.460
9	1360.59	8.12	6.3	0	0.420
10	904.2	5.03	13.2	5	0.880
11	1062.6	5.39	10.3	4	0.687
12	1096.8	5.68	10.0	3	0.667
13	1089.42	6.17	8.5	4	0.567
14	1232.13	7.97	8	3	0.533
15	1361.27	8.46	7.8	1	0.520
16	1340.57	7.06	8.1	3	0.540
17	1536.15	9.17	7.5	1	0.500
18	1697.85	10.06	7.3	0	0.487
19	799	4.33	10.1	2	0.673
20	950	5.05	8.8	0	0.587
21	1035.6	5.82	7.7	0	0.513
22	1086.47	5.14	7.2	0	0.480
23	1118.23	6.17	6.5	0	0.433
24	1227.44	7.34	6.1	0	0.407
25	1166.55	6.54	6.2	0	0.413
26	1359.82	8.05	5.9	0	0.393
27	1531.53	9.75	5.4	0	0.360

4-1- Effect of research variables on surface pile weight:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, number of pile rows/cm, and pile height on surface pile weight of carpet are set out in table (4).

Table (4): Regression equation and correlation coefficient for surface pile weight by the effect of pile yarn material, number of pile rows/cm, and pile height:-

Pile yarn material	Number of pile rows / cm	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 511 + 391 X	0.998815
polypropylene 100%	7	Y = 644.3167 + 43.43833 X	0.999972
polypropylene 100%	9	Y = 733.04 + 56.723333 X	0.99932
polypropylene /Acrylic 60/40%	5	Y = 764.4 + 32.1 X	0.937155
polypropylene /Acrylic 60/40%	7	Y = 856.14 + 45.30833 X	0.999585
polypropylene /Acrylic 60/40%	9	Y = 1048.483 + 59.54667 X	0.998505
Nylon 100%	5	Y = 612.7333 + 39.43333 X	0.987504
Nylon 100%	7	Y = 956.086 + 23.495 X	0.953196
Nylon 100%	9	Y = 865.9933 + 60.83 X	0.999419

Y = surface pile weight (g/m2), **X** = Pile height (mm)

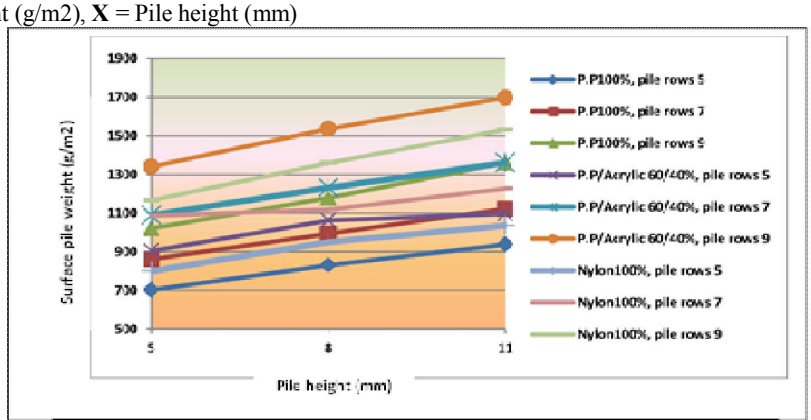

Figure (1): Effect of pile yarn material, number of pile rows, and pile height on surface pile weight of carpet.

4-1-1- Effect of pile yarn material on surface pile weight:-

It is obvious from table (4) and figure (1) that there is a highly significant effect of pile material type on surface pile weight of carpet. It is clear that all samples made of pile yarn material polypropylene /Acrylic 60/40% had recorded the highest rates of surface pile weight compared to the samples made of Nylon 100% and other samples made of polypropylene 100% which have recorded the lowest rates. This due to the Specific density of these materials, as Acrylic has the highest value of specific density1.17 g/cm^3 compared to Nylon 1.14 g/cm^3 and polypropylene which has the lowest value 0.91 g/cm^3.

4-1-2- Effect of number of pile rows on surface pile weight:-

Table (4) and figure (1) signify that there is a highly significant effect of number of pile rows on surface pile weight of carpet. We can state that there is a direct relationship between number of pile rows of carpet / cm and its surface pile weight. I can report that, this is because of the fact that the increase in pile rows of carpet / cm means an increase of pile density per unit, and thereby increase the surface pile weight of carpet.

4-1-3- Effect of pile height on surface pile weight:-

From table (4) and figure (1), it can be seen that there is a highly significant effect of pile height on surface pile weight of carpet. It can be seen that there is a direct relationship between pile height and its surface pile weight. This is most probably due to the increase in pile height would allow to the surface of carpet to contain more length of yarns and, in turn, increases its pile density, and thereby increases the surface pile weight of carpet.

4-2- Effect of research variables on Surface pile thickness:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, number of pile rows, and pile height on surface pile thickness of carpet are set out in table (5).

Table (5): Regression equation and correlation coefficient for surface pile thickness by the effect of pile yarn material, number of pile rows, and pile height:-

Pile yarn material	Number of pile rows / cm	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 2.843333 + 0.218333 X	0.99913
polypropylene 100%	7	Y = 2.37 + 0.381667 X	0.999616
polypropylene 100%	9	Y = 3.633333 + 0.41 X	0.999461
polypropylene /Acrylic 60/40%	5	Y = 4.5 + 0.108333 X	0.998073
polypropylene /Acrylic 60/40%	7	Y = 4.48 + 0.381667 X	0.949551
polypropylene /Acrylic 60/40%	9	Y = 4.763333 + 0.5 X	0.973527
Nylon 100%	5	Y = 3.08 + 0.248333 X	0.999812
Nylon 100%	7	Y = 3.283333 + 0.366667 X	0.999326
Nylon 100%	9	Y = 3.833333 + 0.999417 X	0.999417

Y = Surface pile thickness (mm), **X** = Pile height (mm)

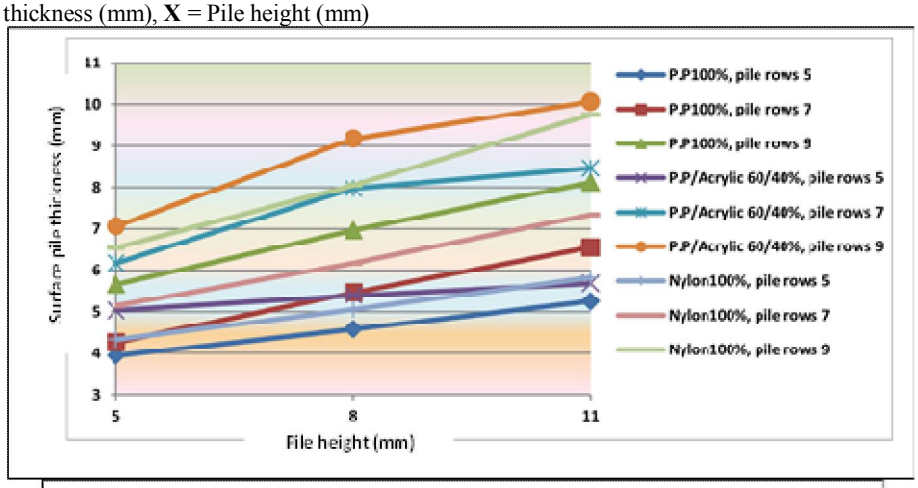

Figure (2): Effect of pile yarn material, number of pile rows, and pile height on surface pile thickness of carpet.

4-2-1- Effect of pile yarn material on surface pile thickness:-

Table (5) and figure (2) signify that there is a highly significant effect of pile material type on surface pile thickness of carpet. It can be seen that all samples made of pile yarn material polypropylene /Acrylic 60/40% had recorded the highest rates of surface pile thickness compared to the samples made of Nylon 100% and other

samples made of polypropylene 100% which have recorded the lowest rates. This is most probably due to the Specific density of these materials, as Acrylic has the highest value of specific density1.17 g/cm^3 compared to Nylon 1.14 g/cm^3 and polypropylene which has the lowest value 0.91 g/cm^3. Besides this probably due to the Acrylic structure of the yarns, such structure which makes it bulked yarns and have a large porous.

4-2-2- Effect of number of pile rows on surface pile thickness:-

From table (5) and figure (2), it can be seen that there is a highly significant effect of number of pile rows/cm on surface pile thickness of carpet. It is clear that there is a direct relationship between number of pile rows of carpet / cm and its surface pile thickness. I can report that, this is because of the fact that the increase in pile rows of carpet / cm means a decrease in number of free spaces between piles and each other per unit area, causing that the direction of the pile yarns tend to the vertical position much larger than the horizontal position which leads to the increase in fabric thickness..

4-2-3- Effect of pile height on surface pile thickness:-

It is obvious from table (5) and figure (2) that there is a highly significant effect of pile height on surface pile thickness of carpet. We can state that there is a direct relationship between pile height of carpet and its surface pile thickness. This due to the increase in pile height would allow to the surface of carpet to contain more length of yarns and, in turn, increases its pile density, and thereby increases the surface pile thickness of carpet.

4-3- The effect of research variables on the behavior of carpet surface pile when exposed to combustion:-

To study the behavior of carpet surface pile when exposed to combustion it was necessary to determine the following: Burned length (cm), Time of flaming (sec) and Flame spread (cm/sec) [11].

4-3-1- The effect of research variables on burned length and flame spread of carpet surface pile when exposed to combustion:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, number of pile rows, pile height, surface pile weight and, surface pile thickness on burned length and flame spread of carpet surface pile when exposed to combustion are set out in tables (6) to (9).

Table (6): Regression equation and correlation coefficient for the burned length of carpet surface pile when exposed to combustion by the effect of pile yarn material, number of pile rows, and Surface pile weight:-

Pile yarn material	Number of pile rows / cm	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 22.58176 – 0.01511 X	-0.96766
polypropylene 100%	7	Y = 11.05971 – 0.00345 X	-0.9984
polypropylene 100%	9	Y = 11.07903 – 0.00352 X	-0.99933
polypropylene /Acrylic 60/40%	5	Y = 28.67061 – 0.01714 X	-0.99662
polypropylene /Acrylic 60/40%	7	Y = 11.28092 – 0.00259 X	-0.97724
polypropylene /Acrylic 60/40%	9	Y = 11.0913 – 0.00227 X	-0.97449
Nylon 100%	5	Y = 18.11871 – 0.00997 X	-0.999394
Nylon 100%	7	Y = 14.30588 – 0.00674 X	-0.89457
Nylon 100%	9	Y = 8.780149 – 0.00218 X	-0.9843

Y = Burned length of carpet surface pile (cm), **X** = Surface pile weight (g/m^2)

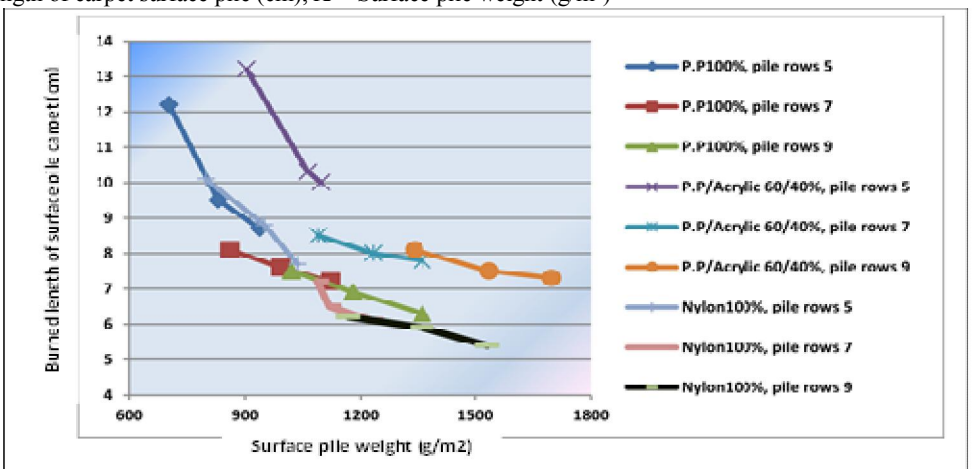

Figure (3): Effect of pile yarn material, number of pile rows, and surface pile weight on burned length of carpet surface pile (cm).

Table (7): Regression equation and correlation coefficient for the burned length of carpet surface pile when exposed to combustion by the effect of pile yarn material, pile height, and Surface pile thickness:-

Pile yarn material	pile height	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 18.8555 – 2.03872 X	-0.92907
polypropylene 100%	8	Y = 13.81093 – 1.02546 X	-0.93724
polypropylene 100%	11	Y = 12.89288 – 0.82724 X	-0.98054
polypropylene /Acrylic 60/40%	5	Y = 25.67465 – 2.5862 X	-0.92791
polypropylene /Acrylic 60/40%	8	Y = 14.34301 – 0.76472 X	-0.98912
polypropylene /Acrylic 60/40%	11	Y = 13.49633 – 0.63591 X	-0.98117
Nylon 100%	5	Y = 16.63362 – 1.64902 X	-0.91016
Nylon 100%	8	Y = 12.84491 – 0.89957 X	-0.91085
Nylon 100%	11	Y = 10.66436 – 0.55841 X	-0.93862

Y = Burned length of carpet surface pile (cm), **X** = Surface pile thickness (mm)

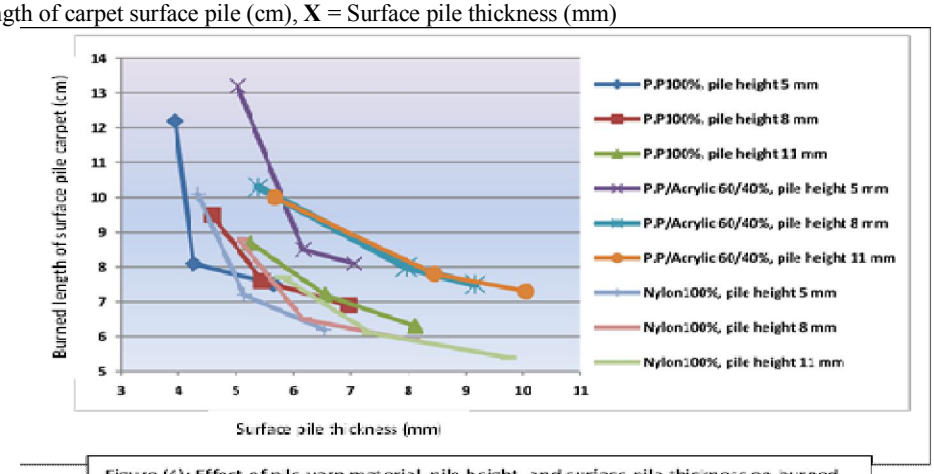

Figure (4): Effect of pile yarn material, pile height, and surface pile thickness on burned length of carpet surface pile (cm).

Table (8): Regression equation and correlation coefficient for flame spread of carpet surface pile when exposed to combustion by the effect of pile yarn material, number of pile rows, and surface pile weight:-

Pile yarn material	Number of pile rows / cm	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 1.504093 – 0.00101 X	-0.96737
polypropylene 100%	7	Y = 0.737414 – 0.00023 X	-0.99874
polypropylene 100%	9	Y = 0.738602 – 0.00023 X	-0.99933
polypropylene /Acrylic 60/40%	5	Y = 1.909711 – 0.00114 X	-0.99663
polypropylene /Acrylic 60/40%	7	Y = 0.753641 – 0.00017 X	-0.97509
polypropylene /Acrylic 60/40%	9	Y = 0.738157 – 0.00015 X	-0.97336
Nylon 100%	5	Y = 1.207333 – 0.00066 X	-0.99934
Nylon 100%	7	Y = 0.949917 – 0.00045 X	-0.89078
Nylon 100%	9	Y = 0.583911 – 0.00014 X	-0.98477

Y = Flame spread (cm/sec), **X** = Surface pile weight (g/m^2)

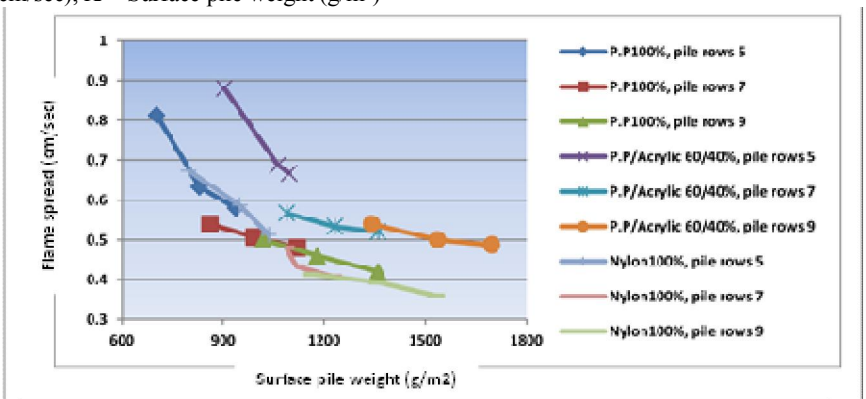

Figure (5): Effect of pile yarn material, number of pile rows, and surface pile weight on flame spread of carpet surface pile (cm/sec).

Table (9): Regression equation and correlation coefficient for flame spread of carpet surface pile when exposed to combustion by the effect of pile yarn material, pile height, and surface pile thickness:-

Pile yarn material	pile height	Regression equation	Correlation coefficient
polypropylene 100%	5	Y = 1.244966 – 0.13578 X	-0.92916
polypropylene 100%	8	Y = 0.920155 – 0.06856 X	-0.93829
polypropylene 100%	11	Y = 0.859525 – 0.05515 X	-0.98054
polypropylene /Acrylic 60/40%	5	Y = 1.711672 – 0.1724 X	-0.92852
polypropylene /Acrylic 60/40%	8	Y = 0.957066 – 0.0511 X	-0.9888
polypropylene /Acrylic 60/40%	11	Y = 0.900085 – 0.04241 X	-0.98081
Nylon 100%	5	Y = 1.108826 – 0.10996 X	-0.91073
Nylon 100%	8	Y = 0.857495 – 0.06017 X	-0.91053
Nylon 100%	11	Y = 0.710466 – 0.03716 X	-0.93969

Y = Flame spread (cm/sec), **X** = Surface pile thickness (mm)

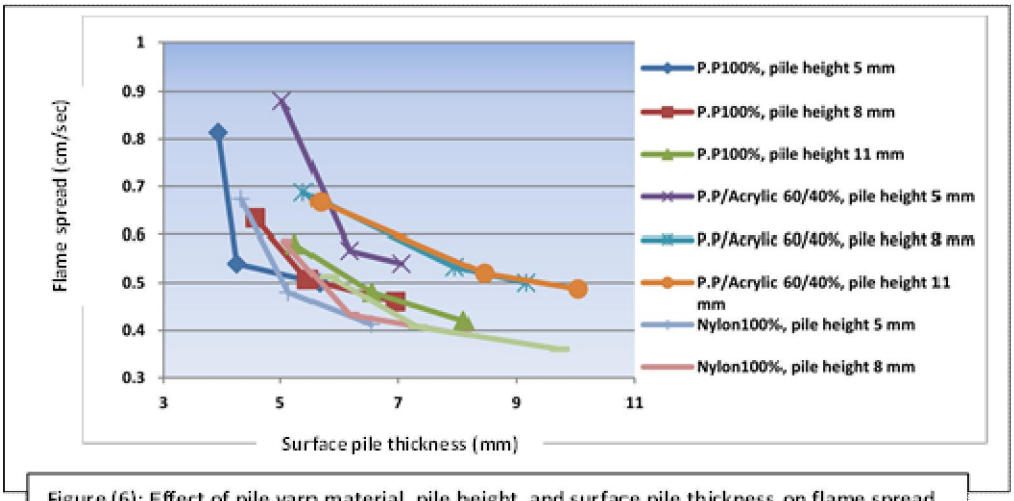

Figure (6): Effect of pile yarn material, pile height, and surface pile thickness on flame spread of carpet surface pile (cm/sec).

4-3-1-1- The effect of pile yarn material on burned length and flame spread of carpet surface pile when exposed to combustion:-

Tables from (6) to (9) and figures from (3) to (6) disclose that, there is a highly significant effect of pile material type on burned length and flame spread of carpet surface pile when exposed to combustion. It can be seen that all samples made of pile yarn material polypropylene /Acrylic 60/40% had recorded the highest rates of burned length and flame spread of surface pile compared to the samples made of polypropylene 100% and other samples made of Nylon 100% which have recorded the lowest rates. This is most probably due to the structure of these materials. This structure, which makes acrylic bulked yarns and have a large porous, that would have air inside its lumen which increases the air volume in the surface pile and, in turn, the amount of oxygen trapped between these fibers increases, which helps to increase the rate of combustion by achieving the highest rates of burned length and flame spread of surface pile**.** Besides this the thermal properties of polypropylene fibers, where it's were considered flammable, but slowly. Accordingly all samples made of pile yarn material polypropylene 100% had recorded better rates for burned length and flame spread of surface pile compared to the samples made of pile yarn material polypropylene /Acrylic 60/40%. Whereas the samples made of pile yarn material Nylon 100% has achieved the best results because nylon is non-flammable fiber. Figure (7) illustrates the effect of pile yarn material on burned length and flame spread of carpet surface pile when exposed to combustion, where the samples were arranged according to the results from the lowest to the best.

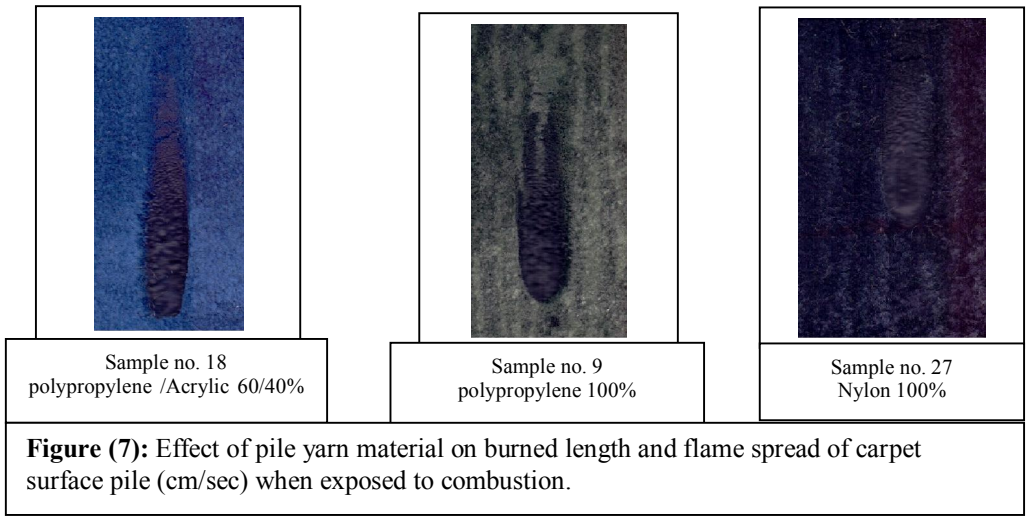

Figure (7): Effect of pile yarn material on burned length and flame spread of carpet surface pile (cm/sec) when exposed to combustion.

4-3-1-2- The effect of number of pile rows on burned length and flame spread of carpet surface pile when exposed to combustion:-

It is clear from and tables (6),(8) and figures (3),(5) that there is a highly significant effect of number of pile rows on burned length and flame spread of carpet surface pile when exposed to combustion. It can be seen that there is an inverse relationship between number of pile rows and both of burned length and flame spread of carpet surface pile. I can state that the increase in number of pile rows per unit area decreases the free spaces in surface pile of carpet and so air volume in the surface pile will be decreased which reduces the amount of oxygen. And thus the rates of burned length and flame spread of surface pile will be decreased which helps to decrease the rate of combustion. Besides this the ability of all raw materials used in this research to melting under the influence of flame and immediately the molten fibers harden on cooling (thermoplastic property)[12], Accordingly the increase in number of rows on the surface means an increasing in the amount of molten fibers per unit area when exposed to ignition, which harden immediately and prevents the spread of flame on the carpet surface pil**e.**

Also it can be noticed from figure (8) that the sample number (11) which had the lowest value in number of pile rows per unit, and so the amount of molten pile had decreased so that the ignition arrived to the ground of carpet easily, causing an increasing the burned length and flame spread, and thus the susceptibility of sample to ignition increased. In the case of sample number (14), the increase in number of pile rows per unit helped to increase the number of molten pile under the influence of fire, and therefore the access of fire to ground of carpet will be decreased. Accordingly the burned length of surface pile will be also decreased causing a decreasing in flame spread. But in the case of the sample number (17), which has the highest value in the number of pile rows/ cm, the best result had been achieved where that the amount of molten pile by the impact of fire increased, which preventing the flame spread, and thus did not reach the ground of carpet as shown in figure (8).

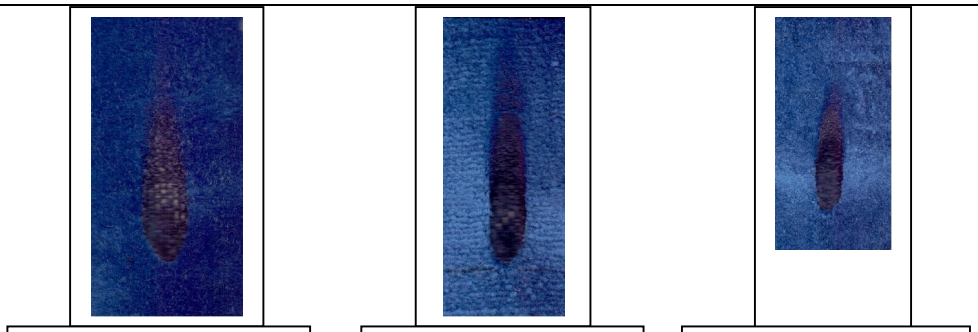

Figure (8): Effect of number of pile rows on burned length and flame spread of carpet surface pile when exposed to ignition.

4-3-1-3- The effect of pile height on burned length and flame spread of carpet surface pile when exposed to combustion:-

It is obvious from tables (7),(9) and figures (4),(6) that there is an inverse relationship between pile height and both of burned length and flame spread of carpet surface pile. I can report that, this is because of the fact that the ability of materials used in this search to melting under the influence of flame and immediately the molten fibers harden on cooling (thermoplastic property)[12]. Accordingly the increase in height of pile on the surface means an increasing in the amount of molten fibers per unit area when exposed to ignition, which harden immediately and prevents the spread of flame on the carpet surface pile. Also it is clear from figure (9) that the sample No. (6) which has the highest value of pile height has been achieved the best result of combustion as it has recorded the lowest rates of burned length and flame spread. This due to the increase in the amount of molten pile by the impact of fire, which preventing the flame spread, and thus did not reach the ground of carpet. This compared to the sample No.(5) and the other sample No.(4) which has recorded the height rates of burned length and flame spread, this is because it has the lowest value of pile height.

4-3-1-4- The effect of surface pile weight on burned length and flame spread of carpet surface pile when exposed to combustion:-

Tables (6),(8) and figures (3),(5), signify that there is a highly significant effect of surface pile weight in the carpet on both of burned length and flame spread of carpet surface pile when exposed to combustion. It is clear that there is an inverse relationship between surface pile weight and both of burned length and flame spread of carpet surface pile. I can state that this is mainly, because the increase in surface pile weight means an increasing in the number of piles per unit area and also a decrease in air volume in the surface pile, and so the amount of oxygen in the surface pile will be decreased which helps to ignition, leading to the decrease in the ability of carpet surface pile to combustion because of the decrease in the amount of oxygen and the increase in the amount of molten fibers which harden immediately and prevents the spread of flame on the carpet surface pile**.**

4-3-1-5- The effect of surface pile thickness on burned length and flame spread of carpet surface pile when exposed to combustion:-

From tables (7),(9) and figures (4),(6), it can be seen that there is an inverse relationship between surface pile thickness and both of burned length and flame spread of carpet surface pile when exposed to combustion. This is because of the fact that the increase in surface pile thickness increases the number of piles per unit area. Accordingly the ability of carpet surface pile to combustion will be decreased because of the increase in the amount of molten fibers which harden immediately and prevents the spread of flame, leading to the decrease in burned length on the carpet surface pile.

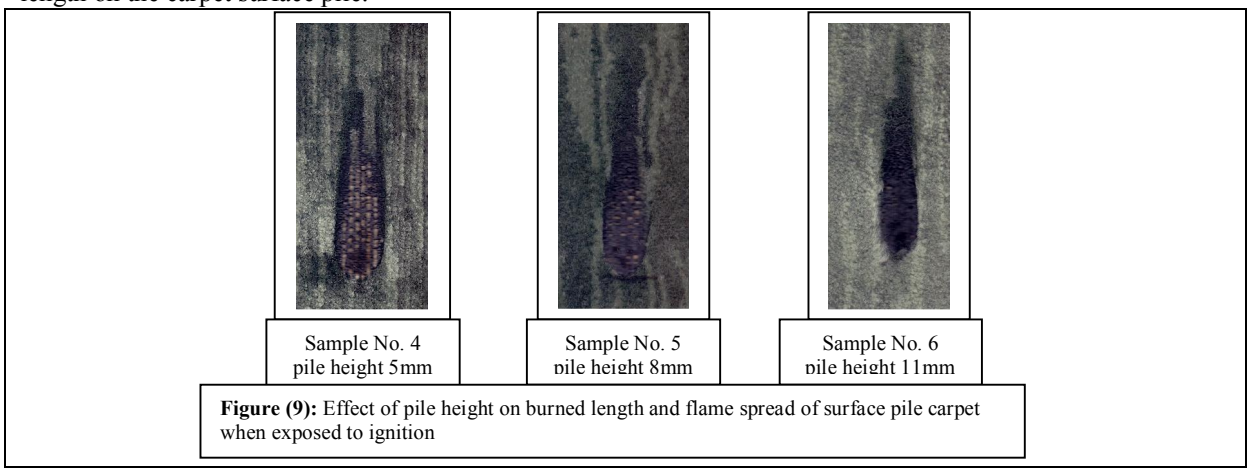

Figure (9): Effect of pile height on burned length and flame spread of surface pile carpet when exposed to ignition

4-3-2- The effect of research variables on time of flaming in carpet surface pile when exposed to combustion:-

Table (3) discloses the effect of research variables on time of flaming in carpet surface pile when exposed to combustion. It can be noticed from this table the following report:

- Time of flame for all samples made of pile yarn material Nylon 100% is almost non-existent except for sample No. 19. I can state that this is mainly, because the nylon is from non-flammable materials and, in turn, all samples did not ignite despite the differences in other factors (number of pile rows - pile height- surface pile thickness - surface pile weight), either the sample No. 19 Because it has the less valuable in terms of the structural factors previously mentioned and so the oxygen which has been abundantly in the air around the sample and in free spaces in carpet surface pile due to the weakness structural installation helped on ignition for only two seconds.

- On the other hand, time of flaming for samples made of pile yarn material polypropylene continued for a few seconds, this due to the ability of polypropylene for ignition, but as can be seen from Figure (10), the increase in pile height and the number of pile rows means the decrease in time ignition even be non-existent, this because of the increasing in density of carpet surface pile and the decrease in air volume in the surface pile which impedes the spread of flame as already mentioned.

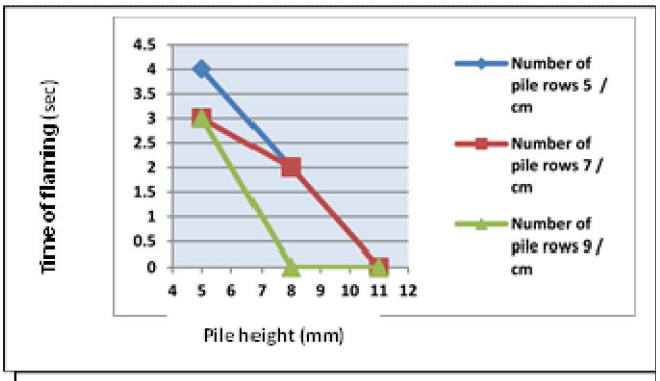

Figure (10): Effect of pile height and number of pile rows / cm for samples made of pile yarn material polypropylene 100% on time of flaming

- all samples made of pile yarn material polypropylene /Acrylic 60/40% had recorded the highest rates of time of flaming compared to the samples made of polypropylene 100% and other samples made of Nylon 100%. This is most probably due to the ability of polypropylene for ignition. Besides this the structure of acrylic which makes its yarns bulked and have a large porous, that would have air inside it, in turn, the amount of oxygen trapped between these fibers would increase. It is obvious from figure (11) that the time of flaming decreases even be non-existent with the increase in both of pile height and the number of pile rows/cm, this due to the increasing in thickness and weight of carpet surface pile which impedes the spread of flame.

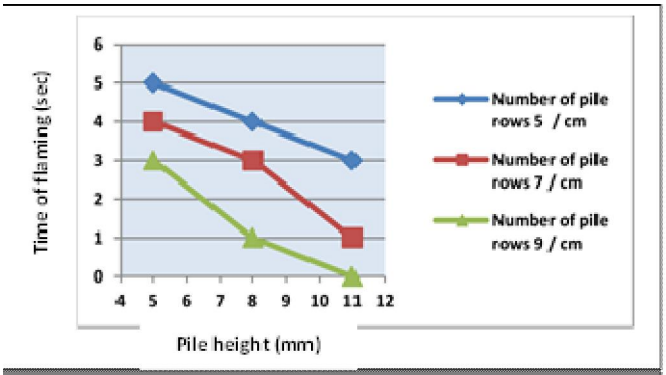

Figure (11): Effect of pile height and number of pile rows / cm for samples made of pile yarn material polypropylene /Acrylic 60/40% on time of flaming

5-Conclusions:-

Modern technology which currently applied in the textile industry in general, and in the carpet industry in particular, has diversified and has added a lot of the requirements of this industry resulting in diversity of specifications and carpet products to meet all the requirements and desires of consumers. And with modern technological development that has swept the whole world and has resulted in easy modern life and what it requires from using many technological devices have increased and multiplied the risks to human life, where the risk of fire is considered the most dangerous and the most influential of these risks. Currently any public place or private is not without from carpet products, which is longer the most dangerous element on human life surrounding him. Therefore, was this study to determine the impact of some factors of structural

composition of carpets on its behavior when exposed to combustion for assign the extent to which its dangerous. Three kinds of pile yarns were used polypropylene 100%, polypropylene /Acrylic 60/40% and Nylon 100% to produce 27 samples of carpet are different in number of pile rows, pile height, surface pile thickness, and surface pile weight, where were carried out tests of Burned length, Time of flaming and Flame spread.

The following conclusions were illustrated from this present study:

- All samples made of pile yarn material polypropylene /Acrylic 60/40% had recorded the highest rates of burned length and flame spread of surface pile compared to the samples made of polypropylene 100% and other samples made of Nylon 100% which have recorded the lowest rates.
- There is an inverse relationship between number of pile rows per unit and both of burned length and flame spread of carpet surface pile.
- There is an inverse relationship between pile height and both of burned length and flame spread of carpet surface pile.
- There is an inverse relationship between the increase in surface pile weight and both of burned length and flame spread of carpet surface pile.
- There is an inverse relationship between surface pile thickness and both burned length and flame spread of carpet surface pile when exposed to combustion.
-All samples made of pile yarn material Nylon 100% had recorded the lowest rates of flaming time for surface pile compared to the samples made of polypropylene 100% and other samples made of polypropylene /Acrylic 60/40% which have recorded the highest rates.

8/26/2014

6-References:

1-NEPA 101life safety code, Quincy, Mass: National fire protection Association, Inc., 1981.
2-Barnes, J., W., The Development of A Carpet Flammability Test Procedure, Textile Institute and Industry, April, 1971.
3- Barnes, J., W., Flammability of Textile Floorcoverings Comparison between the US and Proposed BS Tests, Textile Institute and Industry, July, 1972.
4-Anany, S., M., Realization the International Code for Combustion of Woven Floor Covering by Using Different Construction, Ph.D., Faculty of Applied Arts, Helwan University, Cairo, Egypt, 2010.
5-.http://www.wisegeek.com/what-is-the-combustion-process.htm, July, 2014.
6- Irving Sax, N., Dangerous Properties of Industrial Materials, Van Nostrand Co., Sixth Edition, 1984.
7-. http://ohsonline.com/Articles/The-Many-Faces-of-Fire-Hazards-in-Industrial-Settings.aspx, December, 2010.
8-Bajaj, P., Protective clothing, PW Harrison BSC, Textile Institute, 1992.
9- ASTM-D3776-85, American Standard specifications for determining fabric weight.
10- ASTM-D1777-64, American Standard specifications for determining fabric thickness.
11- EN ISO 11925-2, International standard specification for the flame spread test.
12-Soltan, M., Textile materials, Mnchaat Almaaref Publisher, Alexandria, No. Depository 8429, 1989.