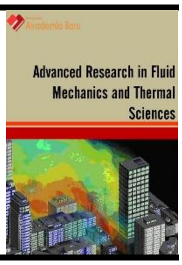
Journal of Advanced Research in Fluid Mechanics and Thermal Sciences 62, Issue 2 (2019) 250-255

Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences

Journal homepage: www.akademiabaru.com/arfmts.html
ISSN: 2289-7879



Preliminary Study of Effect of Natural Thread Distance on Angle Dependency of Flame Spread Behaviour over Kenaf/Polyester Fabric

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ARTICLE INFO

Article history:
Received 3 May 2019
Received in revised form 12 July 2019
Accepted 30 September 2019
Available online 27 October 2019

ABSTRACT

Research in fabric flammability is essential in order to improve fire safety engineering. In order to improve the technical capability for fire preventions, the fundamental approach is essential which can be applied at the design stage. Such approach requires detailed understanding of the combustion process from an engineering viewpoint. From previous studies, natural thread has different flame spread characteristic than synthetic thread. This different characteristic may influence on flame behavior of combined fabric. In this research, the combined fabric was made by using 50% kenaf as the natural thread and 50% polyester as the synthetic thread. Samples are fabricated based on two conditions; one is distance between kenaf thread and another is the weft thread angle. For the first condition, two types of samples are chosen for different threads distance of kenaf; such as 0 mm and 20 mm. For both samples, distance between polyester threads is fixed for 20 mm. For the second condition, experiments for each sample are conducted for different weft thread angle; which is measured between polyester thread and horizontal line. In this research weft thread angle of 0°, 45°, and 90° are chosen. Sample is ignited from top of the edge and the flame propagated in the downward direction. The flame spread behavior is recorded by camera to analyze the data. For results, it is seen that both thread distances exhibit similar shape of flame front. However, the significant difference of the flame front is seen in different weft thread angles. As additional, both types of fabrics have a similar angle dependency of flame spread rate. The spread rate decreases as weft thread angle increases. However, based on result of V_ϑ/V_0, the fabric with 20 mm of kenaf thread have small angle dependency from the one of the fabrics with 0 mm of kenaf thread.

Keywords:
Flame spread; Fabric; Kenaf; Polyester

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1. Introduction

Fire safety engineering is an application of science to improve the safety from the destructive effects of the fire. There are many researches on the fire safety engineering have been done in the previous and it is beginning to focus the research on the technical capability for fire preventions in complex issues. In order to improve the technical capability for fire preventions, the fundamental approach is essential which can be applied at the design stage. Such approach requires detailed understanding of the combustion process from an engineering viewpoint.

The fabric is commonly used in many forms such as in a design of sofa, bed covers, curtains and etc. There are two types of materials usually used in fabric, known as natural thread, such as kenaf and cotton, and synthetic thread, such as polyester and nylon. Both types of materials have different behavior of flame spread. This different behavior may influence on the flame spread behavior of combined fabric.

There are several researches have been done related to the flame spread rate. Bhattacharjee *et al.*, [1] have made an apparatus for flame spread study. The spread rate can be measured by tracking the position of visible edge of the flame through video recording. There are several factors influencing on flame spread rate. Fernandez-Pello *et al.,* [2] found that the flame spread rate can be affected by ambient and fuel conditions. Ding *et al.*, [3] simulated the fire spread. Results show that spread characteristics have major relation with material of solid, width, thickness, placed angle and atmospheric pressure. It is also discovered that the increment in oxygen concentration will cause the external radiant flux required for flame spread to decrease. Flame spread characteristics of many thin materials will be varied with effect from material thickness, external heat flux, oxygen concentration, pressure and forced flow velocity [4]. Higher heat flux results in a higher heat release rate and peak mass loss rate and the fabrics will burn more violently. The density of the structure and moisture content also has effects on burning behavior of fabrics. The arrangement order of types of fabrics in increasing fire risk: wollen fabrics > sponge fabrics > cotton fabrics > linen fabrics [5]. It is stated that cellulosic fabrics burn with a yellow flame, light smoke, and have glowing embers. Synthetic fabrics catch fire quickly or shrink from the flame initially. Nylon, lastol, olefin, polyester, and spandex burn slowly and melting. It also can melt and pull away from small flames without igniting. The residue is hot molten and difficult to get rid. The burning of these fabrics can self-extinguish [6].

Nowadays, the fabric is always fabricated by using two different types of thread; natural/natural threads, natural/synthetic threads or synthetic/synthetic threads. There are several researches have been done to examine the flame spread rate over combined fabric. Mohd Azahari *et al.,* [7] have conducted experiments to study the flame spread behavior over the combined fabric of cotton/polyester. The experiment is conducted for several weft trade angles from 0° to 90°. Results show a significant difference in the shape of burning front between θ = 0° and 90°. It is also found that the flame spread rate decreases as the angle increases. Experiments also have been conducted to study the flame spread behavior over the combined fabric of cotton/polyester and cotton/nylon [8]. For θ = 0°, a significant difference is seen between these two combined fabrics in the shape of burning front. However, the shape of the burning front is the same for both fabrics at θ = 90°. From the research, it is also seen that both fabrics have a similar angle dependency; the flame spread rate decreases as the angle increases.

Recently, several industries have used kenaf as natural thread. Mohd Azahari *et al.,* [9-10] have been examining the effect of weft thread angle on flame spread behavior over kenaf/polyester fabric. From the results obtained, it is seen that thread angle has some influence on the flame spread shape of fabrics. Instead of the comprehension of the flame spread over fabric, it is also essential to understanding influence of the combined fabric structure on flame spread behavior since data are still insufficient. This information is important in selecting material for interior furniture such as bedclothes, clothing, etc. Thus, in this study, the preliminary experiments are conducted in order to study the effect of distance between threads on angle dependency of flame spread behavior over combined fabrics. Kenaf is used as the natural material, and polyester as the synthetic material.

2. Methodology

Fabric samples are made by means of a weaving machine. Plain weave is chosen as the structure of the fabric. The plain weave has warp threads perpendicular to weft threads. Figure 1 shows the illustration of the sample. The fabric composed of different materials is referred to as a combined fabric. In this research, kenaf is used as the warp thread and polyester as the weft thread. The diameter of kenaf thread is approximately 0.56 mm and polyester thread is 0.62 mm. Distance between polyester threads of all samples have been controlled for approximately 3.0 mm. Samples are cut with different weft thread angle of 0°, 45° and 90°.

Before the burning test, the fabric sample is dried in a desiccator for more than 48 hours. The humidity in the desiccator is controlled to below 40%. Figure 2 shows the experimental setup. During the experiment, the fabric sample is clamped by the holder on both sides. It is made of two thin aluminum plates. The fabric is ignited at the top of the sample and the flame spreads from upward to downward. Flame spread is recorded by using a high resolution camera. The light source is used to illuminate the sample from in front. This experimental procedure is also similar as one from previous studies [7-12].

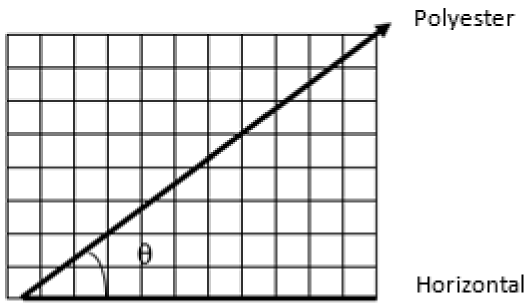


Fig. 1. Illustration of sample

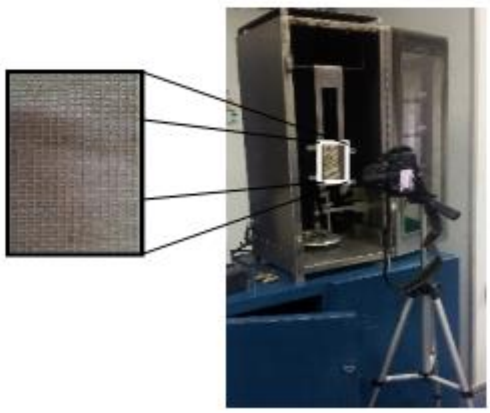
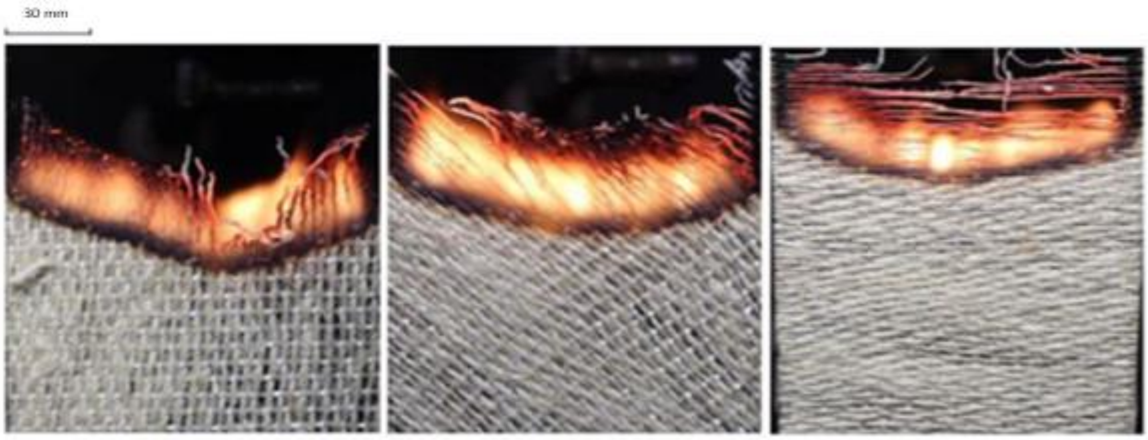


Fig. 2. Experimental setup

3. Results

Figure 3 and 4 show the shape of flame front at every weft thread angle for kenaf distance of 0 mm and 20 mm, respectively. From Figure 3(a), it is seen the flame spread in 'V' shape. As seen in Figure 3(b), the flame front shape changes from 'V' to 'U' shapes by changing of the weft thread angle from 0° to 45°. For weft thread angle 90°, the flame front shape is in flat shape as seen in Figure 3(c).



(a) $\vartheta = 0°$ (b) $\vartheta = 45°$ (c) $\vartheta = 90°$

Fig. 3. Shape of flame front at every weft thread angle for kenaf distance 0mm

Similar flame front shape is seen also sample with a kenaf distance of 20 mm. Figure 4(a) shows the shape is in 'V' shape when the weft thread angle is 0°. The shape then changes to 'U' shape and flat shape for the thread angle of 45° and 90°, respectively, as seen in Figure 4(b) and 4(c).

(a) $\vartheta = 0°$ (b) $\vartheta = 45°$ (c) $\vartheta = 90°$

Fig. 4. Shape of flame front at every weft thread angle for kenaf distance 20mm

Figure 5 shows the relation between the flame spread rate and the weft thread angle. The white circle '○' and the black circle '●' represent the sample for kenaf distance of 0 mm and 20 mm, respectively. It is seen that, for all conditions, the flame spread rate for kenaf distance 0 mm is slower than a kenaf distance of 20 mm. However, both samples exhibit a similar angle dependency of flame spread rate. The flame spread rate decreases as weft thread angle increases. This phenomenon is also seen in previous studies [7 – 9].

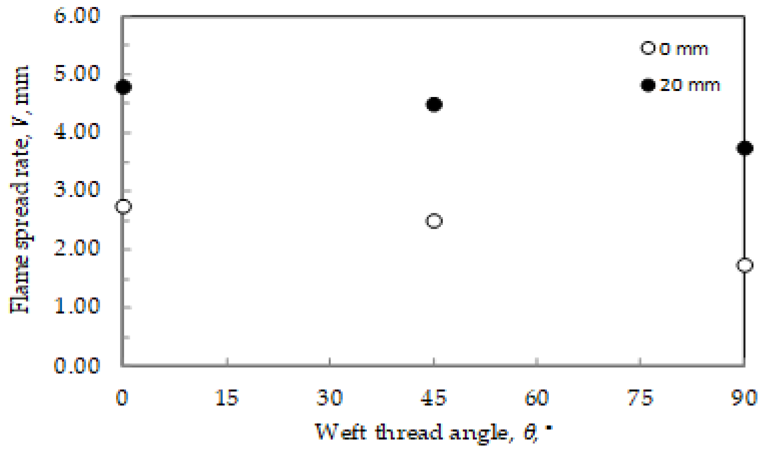


Fig. 5. Relation between flame spread rate and weft thread angle

In order to explain the angle dependency of flame spread rate, it would be necessary to present by using the ratio of V_θ/V_0. Figure 6 shows the relation between V_θ/V_0 and the weft thread angle for different distance of kenaf thread. The result shows the sample with a kenaf distance of 0 mm has a greater angle dependency of the flame spread rate compared to the one with kenaf distance 20 mm. However, the additional experiments are needed in order to describe details about the effect of distance between natural threads on the angle dependency of flame spread rate. It is also essential to describe the detail analysis about the reason of this phenomenon.

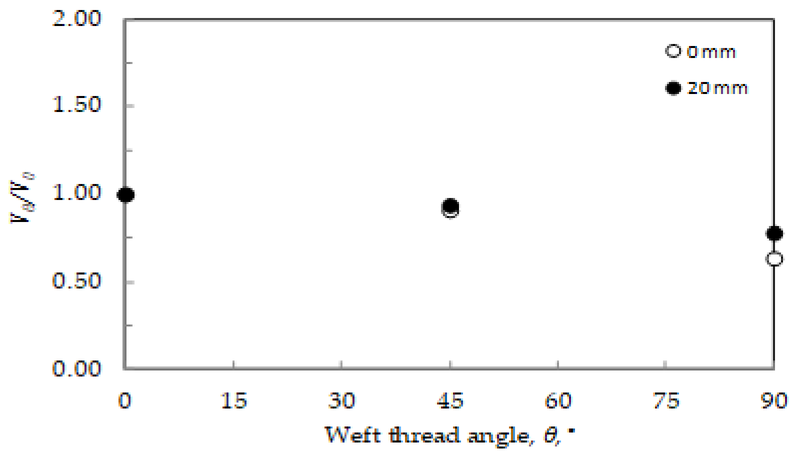


Fig. 6. Relation between V_ϑ/V_0 and weft thread angle

4. Conclusions

In this study, flame spread over combined fabrics of kenaf/polyester is examined and the following results are obtained

i. Flame front shape changes due to the weft thread angle.
ii. Both samples of fabric exhibit a similar shape of flame front for all types of the weft thread angle.
iii. The flame spread rate for fabric with a kenaf distance of 0 mm is slower than the one with kenaf distance of 20 mm for all thread angle.
iv. The sample with a kenaf distance of 0 mm has a greater angle dependency of the flame spread rate compared to the one with kenaf distance 20 mm.

Acknowledgement
The authors would like to thank Universiti Tun Hussein Onn Malaysia (UTHM) and Ministry of Higher Education Malaysia (MOHE) for their financial support of the present work through GPPS Grant Scheme (U802) and Fundamental Research Grant Scheme (FRGS-1465 and FRGS-1545), respectively.

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