

Analysing the Effects of Thread Pitch and Angle on the Combustion Characteristics of Cotton/Nylon Fabrics: Implications for Fire Behaviour and Safety

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This study examines the effects of thread pitch and thread angle on the combustion characteristics of cotton/nylon blended fabrics, focusing on flame spread rate, heat release behaviour, and fire performance. Fabric samples were produced using a plain weave structure with cotton as warp fibres and nylon as weft fibres, with thread angles ranging from 0° to 90° and thread pitch from 0 mm to 5 mm. Flame spread experiments were conducted under controlled conditions, and combustion behaviour was analysed by observing and measuring flame propagation. The results show that increasing the thread angle reduces flame spread rate due to fibre misalignment, reduced heat transfer, and the melting behaviour of nylon fibres. In contrast, a larger thread pitch enhances flame spread by improving airflow and oxygen availability within the fabric structure. Cotton fibres exhibited charring and sustained combustion, while nylon fibres melted and evaporated, influencing overall flame behaviour. The combined effects of thread angle and pitch demonstrate that fabric geometry plays a significant role in combustion performance. These findings provide valuable insights for designing textile materials with improved fire safety and energy efficiency.

Keywords: Cotton/Nylon Blended Fabric, Flame Spread Rate, Thread Angle, Thread Pitch, Combustion Characteristics, Heat Release Rate, Fire Behaviour

1. INTRODUCTION

The increasing demand for energy-efficient and fire-safe materials has become a critical concern in modern engineering applications, particularly in the textile, construction, and transportation sectors. Textile-based materials such as cotton and nylon fabrics are widely utilised for their lightweight nature, flexibility, and cost-effectiveness. However, their inherent susceptibility to combustion poses significant challenges for fire safety and energy performance.

Complex interactions between material composition, thermal degradation mechanisms, and structural configuration govern the combustion behaviour of textile materials. In particular, flame spread behaviour plays a crucial role in determining fire hazards, as it directly influences the rate of fire propagation and heat release. Previous studies have

shown that fibre type significantly affects combustion characteristics: natural fibres such as cotton tend to ignite easily and sustain combustion due to their cellulose content, whereas synthetic fibres such as nylon exhibit melting, dripping, and thermal shrinkage when exposed to elevated temperatures [1]. In blended fabric systems, these contrasting behaviours interact, resulting in complex flame propagation dynamics.

In addition to material composition, fabric structural parameters such as thread orientation and spacing have been shown to significantly influence combustion behaviour. The angle of threads relative to the direction of flame spread affects heat transfer pathways, airflow permeability, and flame front geometry. Experimental studies have reported that flame spread rates decrease as the thread angle increases from 0° to 90° in combined fabric systems [2-3]. At lower angles (0°), flame propagation is more rapid and aggressive, whereas at higher angles (90°), the flame spread rate is reduced due to the melting and shrinking behaviour of synthetic fibres such as nylon [2],[4]. Furthermore, thread orientation also affects the shape of the flame front, where a V-shaped flame structure is typically observed at lower angles, while a more stable and uniform flame profile develops at higher angles [3],[5]. These findings highlight the importance of fabric geometry in influencing fire behaviour and suggest that structural design can be optimised to improve fire safety performance [6]. Conversely, while the findings emphasise the importance of thread angle and material composition in fire behaviour, it is also essential to consider other factors such as environmental conditions and fabric treatments that may influence combustion characteristics.

From an energy perspective, combustion characteristics are closely associated with heat release rate, thermal degradation, and energy dissipation mechanisms. Materials with high heat release rates contribute to rapid fire growth and increased energy loss, thereby reducing overall energy efficiency and compromising safety [7-8]. The heat release rate is a key parameter in fire hazard assessment, as it quantifies the intensity of combustion and its potential impact on surrounding environments [9]. In addition, thermal degradation behaviour plays a crucial role in determining ignition characteristics, flame propagation, and residual mass formation. A comprehensive understanding of thermal degradation mechanisms is essential for improving both fire resistance and energy efficiency in textile materials [10]. Moreover, inefficient or incomplete combustion results in significant energy losses and may produce hazardous by-products, further increasing environmental and safety risks [11].

Despite extensive research on textile flammability, existing studies have predominantly focused on material composition, chemical treatments, and flame-retardant additives [12-14]. Comparatively, the influence of structural parameters, particularly thread pitch and thread angle, has received limited systematic investigation. While some studies have explored the effect of thread angle on flame spread behaviour in combined fabrics [15-17], the combined influence of thread pitch and thread angle in cotton/nylon blended systems remains insufficiently understood. In particular, there is a lack of comprehensive analysis linking fabric geometry to key combustion parameters such as flame spread rate, heat release behaviour, and flame propagation mechanisms, especially in hybrid natural synthetic fibre systems.

Therefore, this study aims to investigate the effects of thread pitch and thread angle on the combustion characteristics of cotton/nylon blended fabrics. The research focuses on evaluating flame spread rate, heat release behaviour, and flame propagation under varying structural configurations. By establishing the relationship between fabric geometry and combustion performance, this study seeks to provide new insights into the design of textile materials with improved fire safety and energy efficiency. Additionally, the findings contribute to the development of safer and more sustainable textile systems, considering the environmental implications associated with flame-retardant materials and end-of-life treatment [18-21].

2. MATERIAL AND METHODS

2.1 Materials and Sample Preparation

Cotton/nylon blended fabric samples were prepared for the experimental investigation. The fabrics were produced using a weaving machine with a plain weave structure, where cotton fibres were used as the warp threads and nylon fibres as the weft threads. Variations in weft thread angle were introduced, ranging from 0° to 90°, to examine their influence on combustion behaviour. All fabric samples were cut into uniform dimensions and conditioned under ambient laboratory conditions before testing to ensure consistency. The structural parameters, including thread pitch and thread angle, were carefully controlled during the fabrication process to maintain uniformity across all samples.

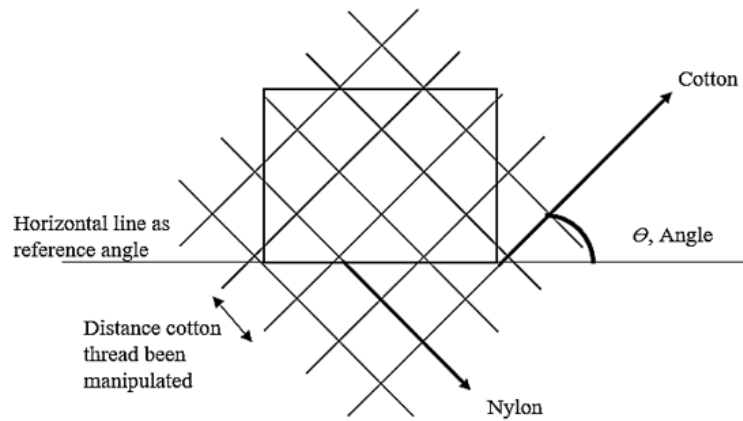


Figure 1. Method for calculating the angle distance on a sample

2.2 Experimental Setup and Procedure

The combustion behaviour of the fabric samples was evaluated using a flame spread test. Each sample was vertically mounted on a clamping holder to ensure stability and consistent positioning throughout the experiment. The samples were ignited at the top edge using a controlled burner, allowing the flame to propagate downward along the fabric.

A standardised ignition flame with controlled height and exposure time was used to ensure repeatability. The flame spread behaviour was observed as it travelled across the fabric surface, with particular attention given to the influence of thread angle on flame propagation characteristics.



Figure 2. Combustion chamber

2.3 Equipment used

The experimental setup consisted of a weaving machine for fabric preparation, a vertical clamping frame for sample positioning, a burner for ignition, a measuring scale for flame distance measurement, and a digital recording system for capturing flame propagation.

2.4 Measurement of Flame Spread Rate

The flame spread rate was determined by tracking the position of the most advanced point of the burning front over time. This was achieved through the analysis of recorded videos and captured images, allowing precise measurement of flame progression along the fabric surface.

The relationship between flame spread rate and weft thread angle was analysed by comparing the distance travelled by the flame over a specific time interval for each sample configuration. This approach enabled the evaluation of how structural variations influence combustion characteristics.

2.5 Data Analysis

The collected data were analysed using graphical and comparative methods to evaluate trends in flame spread behaviour. The variation in burning rate with respect to thread angle was examined to identify key relationships between fabric structure and combustion performance. The results were further interpreted to understand the underlying mechanisms governing flame propagation in cotton/nylon blended fabrics.

3. RESULTS AND DISCUSSION

3.1 Introduction

This section presents and discusses the experimental findings on the combustion behaviour of cotton/nylon fabric samples. The analysis focuses on flame spread characteristics, heat release behaviour, and the influence of structural parameters such as thread angle and thread pitch. The results are interpreted to establish the relationship between fabric geometry and fire performance.

3.2 Combustion Behaviour of Different Materials

The combustion behaviour of cotton/nylon fabric samples was investigated by analysing flame propagation patterns, material response, and structural variations under different thread spacings and orientations. The results highlight clear differences between the combustion characteristics of natural fibres (cotton) and synthetic fibres (nylon).

The experimental observations were categorised based on cotton thread spacing of 0 mm, 2.5 mm, and 5 mm, with varying thread angles of 0°, 30°, 45°, 60°, and 90°. The flame propagation process was recorded at consistent time intervals, allowing for a detailed assessment of combustion development and pattern formation.

Distinct combustion behaviours were observed between cotton and nylon fibres. Cotton, being a natural fibre, exhibited charring behaviour during combustion. As the burning process progressed, the cotton fibres underwent thermal degradation, forming a carbonaceous residue that remained visible after combustion. In contrast, nylon, as a synthetic material, demonstrated thermoplastic behaviour. Upon exposure to heat, nylon fibres melted and gradually evaporated, leaving minimal visible residue. This difference is attributed to the fundamental material properties of natural and synthetic fibres.

The combustion patterns observed in the fabric samples evolved and were strongly influenced by thread angle and spacing. At the beginning of combustion, the flame pattern typically appeared in a “U” shape. As the burning progressed, the pattern transformed into “V” or horizontal shapes depending on the structural configuration of the fabric. These pattern transitions show changes in heat distribution and flame propagation pathways across the material.

The thread angle was found to significantly influence combustion behaviour. An increase in thread angle resulted in noticeable changes in flame shape and propagation characteristics. In general, larger angles produced wider and less

pointed flame patterns, indicating a reduction in directional flame intensity. Conversely, smaller angles tended to promote sharper and more concentrated flame fronts.

Thread spacing also played a critical role in combustion behaviour. Fabrics with smaller spacing (0 mm) exhibited more compact and concentrated flame patterns, while larger spacings (2.5 mm and 5 mm) resulted in more dispersed combustion. In some cases, samples with larger spacing did not achieve complete combustion, leaving partially unburned regions of the fabric.

Additionally, the results show that flame spread rate varies with both spacing and angle. Fabrics with moderate spacing (2.5 mm) often exhibited faster combustion compared to those with very small or large spacing. This suggests that an optimal structural configuration exists where heat transfer and oxygen availability are balanced, leading to enhanced combustion efficiency.

Overall, the combustion behaviour of cotton/nylon fabrics is governed by the interaction between material properties and fabric geometry. Cotton contributes to sustained combustion through char formation, while nylon influences flame behaviour through melting and material loss. The combined effects of thread spacing and angle determine the overall flame propagation pattern, combustion completeness, and fire performance of the fabric.

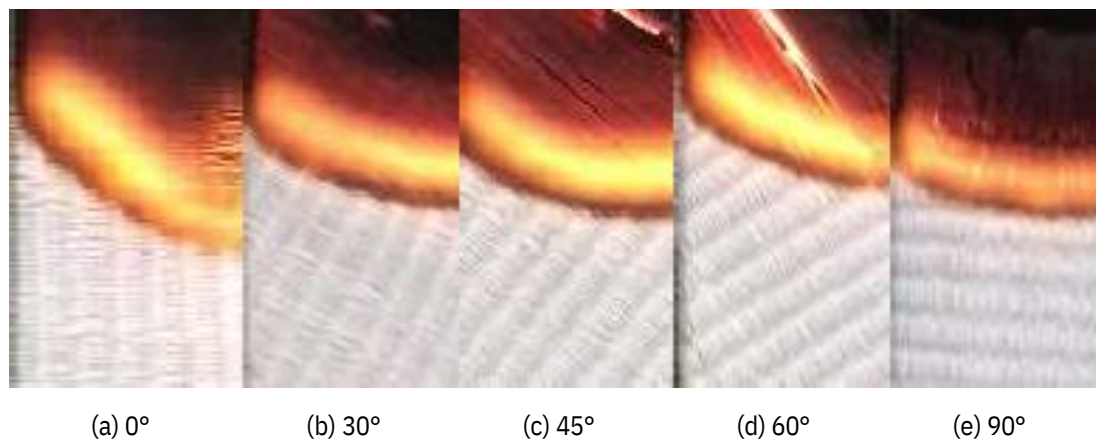
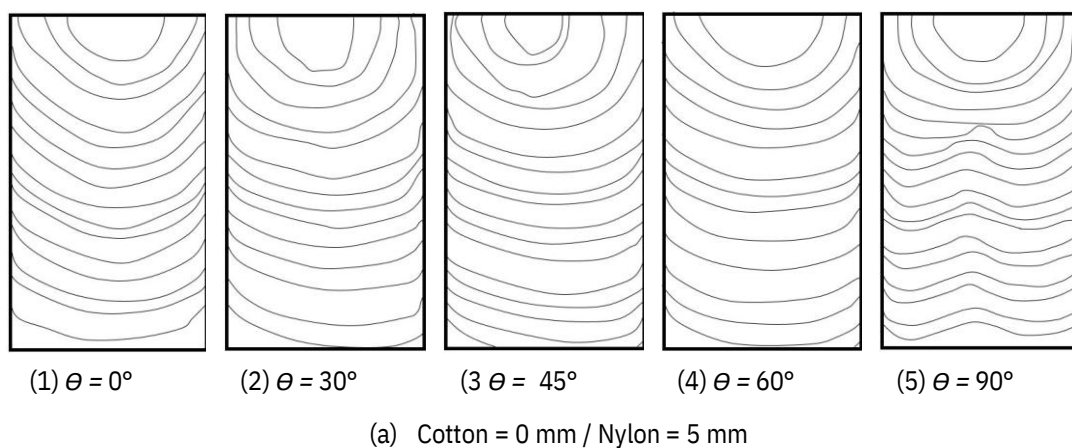
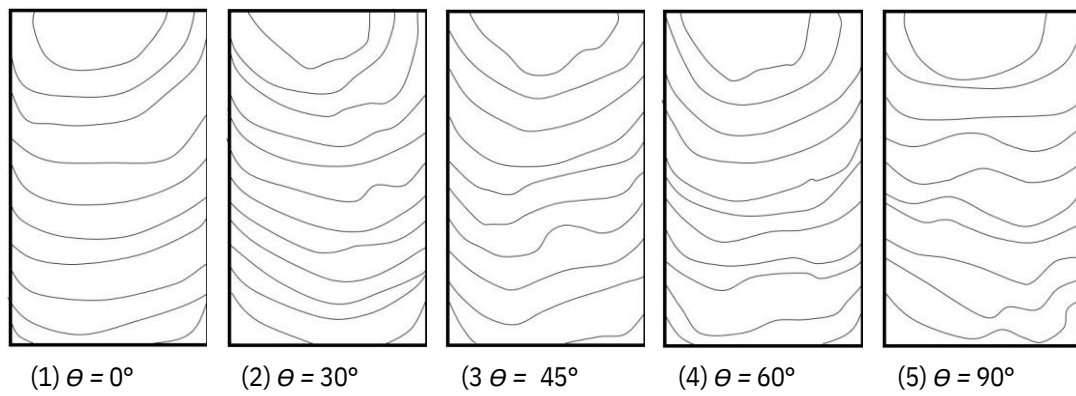
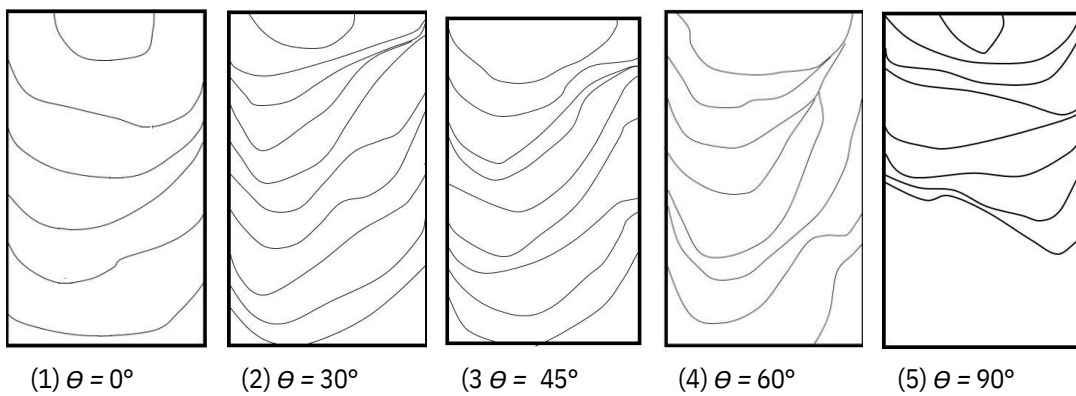


Figure 3. Burning pattern from each angle of the thread





(b) Cotton = 2.5 mm / Nylon = 5 mm



(c) Cotton = 5 mm / Nylon = 5 mm

Figure 4. (a), (b) and (c) Combustion pattern taken every 5 seconds

3.3 Flame Spread Rate of Fabric Samples

The flame spread rate of cotton/nylon fabric samples was evaluated under varying thread pitch (0 mm, 2.5 mm, and 5 mm) and thread angle (0° to 90°) to determine the influence of fabric structural parameters on combustion behaviour. The results, summarised in Table 1, clearly show that both thread angle and thread pitch significantly affect the rate of flame propagation.

Table 1. Summary of cotton and nylon threads spacing on the speed of combustion.

Spacing between cotton thread at 0 mm					
Angle ($^\circ$)	0	30	45	60	90
The flame spread rate (mm/s)	0.3549	0.3949	0.3505	0.3817	0.3617
Spacing between cotton thread at 2.5 mm					
Angle ($^\circ$)	0	30	45	60	90
The flame spread rate (mm/s)	0.5488	0.5143	0.5020	0.3897	0.3802
Spacing between cotton thread at 5 mm					
Angle ($^\circ$)	0	30	45	60	90
The flame spread rate (mm/s)	0.7368	0.5788	0.4778	0.4274	0.3992

3.3.1 Effect of Thread Angle

For all thread pitch configurations, a general decreasing trend in flame spread rate was observed with increasing thread angle. At lower angles (0°), the flame spread rate was relatively high, indicating rapid combustion. For instance, at 0 mm thread pitch, the flame spread rate was approximately 0.3549 mm/s at 0° , with comparable values observed across other pitch configurations.

As the thread angle increased to 30° and 45° , slight fluctuations in flame spread rate were observed; however, the overall trend remained decreasing. At higher angles (60° and 90°), the flame spread rate consistently reduced across all samples. This behaviour can be attributed to the misalignment between fibre orientation and flame propagation direction, which reduces heat transfer efficiency and slows down the combustion process.

Additionally, the presence of nylon fibres contributes to this trend. At higher angles, nylon fibres undergo melting and shrinkage, which disrupts the structural continuity of the fabric and reduces oxygen accessibility, thereby inhibiting flame propagation.

3.3.2 Effect of Thread Pitch

Thread pitch also plays a significant role in determining flame spread behaviour. The results show that increasing the thread pitch from 0 mm to 5 mm leads to a noticeable increase in flame spread rate. For example, at 0° thread angle, the flame spread rate increased from 0.3549 mm/s (0 mm pitch) to 0.7368 mm/s (5 mm pitch).

This trend shows that fabrics with larger thread spacing (lower density) promote faster combustion. The increased spacing allows greater airflow through the fabric structure, enhancing oxygen availability and facilitating more efficient combustion. In contrast, fabrics with smaller thread pitch (higher density) restrict airflow, limiting oxygen supply and reducing the rate of flame spread.

3.3.3 Combined Effect of Thread Angle and Thread Pitch

The interaction between thread angle and thread pitch reveals a combined effect on combustion behaviour. The highest flame spread rates were observed at low thread angles combined with large thread pitch, where fibre alignment and oxygen availability both favour rapid combustion.

Conversely, the lowest flame spread rates occurred at high thread angles combined with small thread pitch. In this configuration, both fibre misalignment and restricted airflow contribute to reduced combustion efficiency.

3.4 Heat Release Behaviour at Ignition Point

The heat release behaviour at the ignition point of cotton/nylon fabric samples was analysed through visual observation of thermal decomposition and flame initiation. The results demonstrate distinct differences in combustion response between natural (cotton) and synthetic (nylon) fibres, particularly during the early stages of ignition at angle 30° .

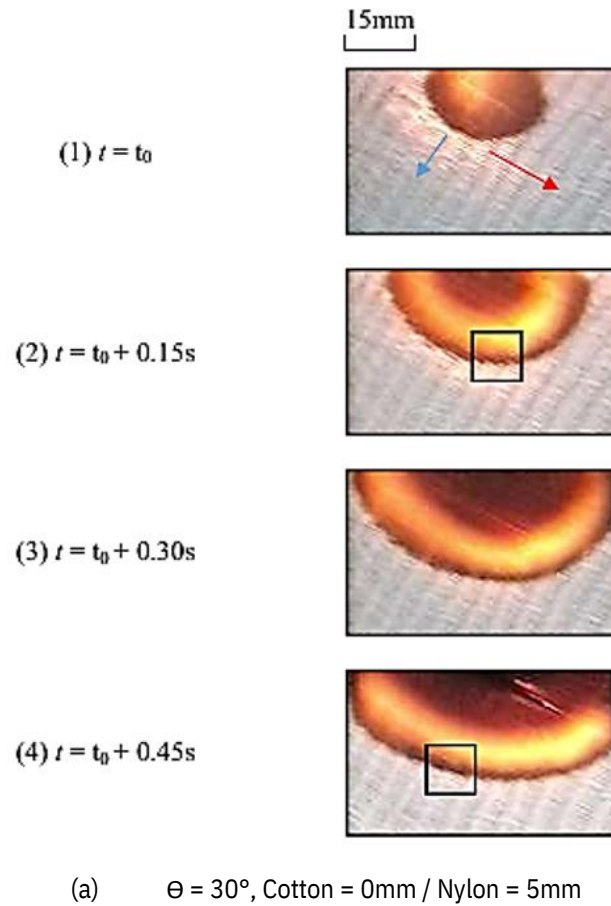
At the onset of heating, cotton fibres exhibited a gradual colour transformation from their original state to a darker, charred appearance prior to ignition. This behaviour shows the formation of a carbonaceous layer, which is characteristic of natural fibres undergoing thermal degradation. In contrast, nylon fibres did not show any significant colour change before ignition but instead underwent rapid melting, followed by volatilisation. This confirms the thermoplastic nature of nylon, where heat exposure leads to softening and eventual evaporation rather than char formation.

The ignition point was consistently observed at a localised region (vertex), from which flame propagation began. The heat release at this point was highly dependent on the structural arrangement of the fabric, including thread spacing and orientation. At a smaller thread spacing (0 mm), the heat was more concentrated, resulting in a more defined ignition point and continuous combustion. As spacing increased (2.5 mm and 5 mm), the heat distribution became less uniform, leading to intermittent ignition behaviour and occasional flame extinction before re-ignition.

Time-based observations further revealed that heat release evolved dynamically. Within the first 15 seconds, ignition was initiated, and localised burning was evident. By 30 seconds, the heat distribution expanded across adjacent fibres, while at 45 seconds, the combustion pattern stabilised or, in some cases, diminished due to loss of the heat source at the centre of the sample.

Additionally, the direction of heat propagation differed between materials. Cotton facilitated sustained heat release due to its ability to retain thermal energy through char formation, whereas nylon exhibited directional heat flow influenced by melting and dripping behaviour. The accumulation of molten nylon along cotton threads also contributed to localised heat concentration, affecting the ignition behaviour in subsequent stages of combustion.

Overall, the results show that heat release at the ignition point is governed by both material properties and fabric geometry. Cotton enhances sustained combustion through char formation, while nylon modifies heat distribution through melting. The interaction between these materials plays a critical role in determining ignition stability and early flame development.



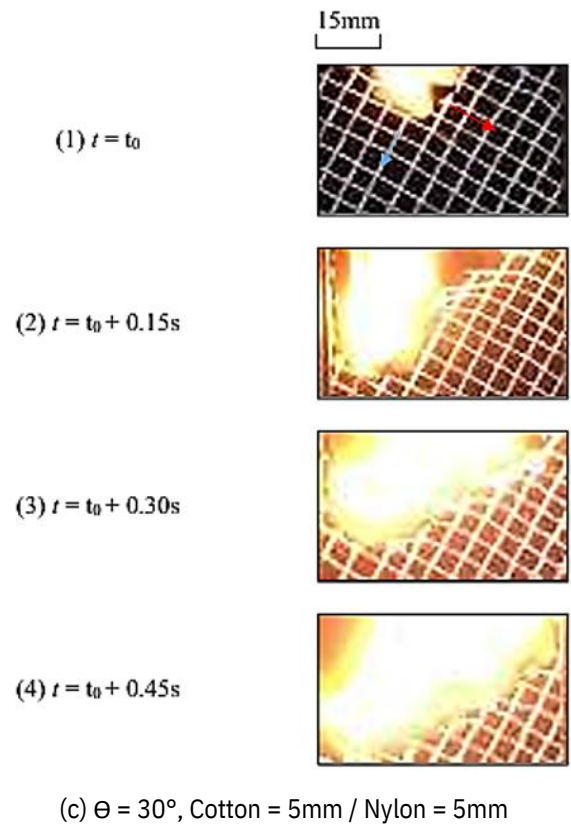
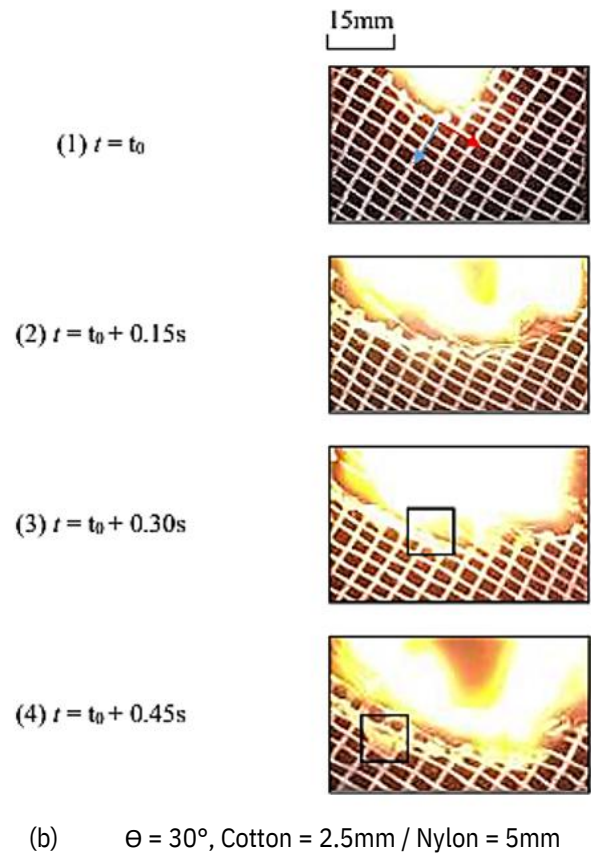


Figure 5. (a), (b) and (c) Heat release behaviour at ignition point for angle 30°

3.5 Relationship Between Flame Spread Rate and Thread Angle

The relationship between flame spread rate and thread angle for cotton/nylon fabric samples is illustrated in Figure 6. The results show that both thread angle and cotton thread spacing significantly influence flame propagation behaviour.

The flame spread rate (V , mm/s) was evaluated at different thread angles (0° , 30° , 45° , 60° , and 90°) for three levels of cotton thread spacing: 0 mm, 2.5 mm, and 5 mm, while the nylon thread spacing was kept constant. Overall, the findings show that variations in thread angle affect both the rate and pattern of flame spread across the fabric surface.

At a thread angle of 0° , the flame spread rates for all cotton spacings were relatively similar, showing that spacing has minimal influence at this orientation. However, as the thread angle increased to 30° , 60° , and 90° , the sample with a cotton spacing of 5 mm consistently exhibited the highest flame spread rate. This suggests that larger thread spacing enhances flame propagation at higher angles, possibly due to reduced resistance to heat transfer along the fabric structure.

At 45° , a different trend was observed, where the sample with 2.5 mm cotton spacing showed the highest flame spread rate. This shows that at intermediate angles, the interaction between thread orientation and spacing produces a more complex combustion response, likely due to differences in heat distribution and fibre alignment.

In general, the results demonstrate that the effect of thread angle on flame spread rate is non-linear. The flame spread rate does not vary uniformly with increasing angle but depends on the combined influence of thread spacing and fabric geometry. The structural arrangement of fibres governs heat transfer across the material, thereby controlling both the speed and direction of flame propagation.

Overall, it can be concluded that thread angle and cotton thread spacing are key factors influencing flame spread behaviour. Fabrics with larger thread spacing tend to exhibit higher flame spread rates at larger angles, while intermediate spacing may result in peak behaviour at specific angles such as 45° . These findings highlight the importance of fabric structural design in determining combustion performance and fire safety characteristics.

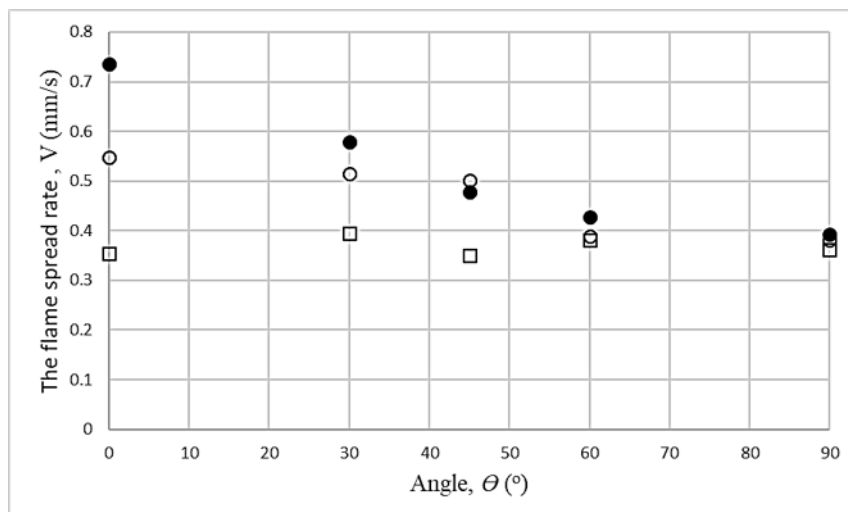


Figure 6. The flame spread rate vs angle

4. CONCLUSIONS

This study has demonstrated that the combustion characteristics of cotton/nylon blended fabrics are strongly influenced by structural parameters, particularly thread angle and thread pitch. The experimental results show that flame spread rate decreases with increasing thread angle, primarily due to reduced fibre alignment with the flame direction and the thermoplastic behaviour of nylon, which disrupts heat transfer and limits oxygen accessibility.

In contrast, increasing thread pitch results in higher flame spread rates, as larger spacing between fibres enhances airflow and promotes more efficient combustion. The combined effect of these parameters reveals that fabrics with low thread angles and large thread spacing exhibit the most rapid flame propagation, whereas high angles and dense structures contribute to reduced combustion rates.

The study also highlights the distinct roles of cotton and nylon in combustion behaviour. Cotton contributes to sustained burning through char formation, while nylon influences flame dynamics through melting, shrinkage, and material loss. Furthermore, heat release behaviour at the ignition point is governed by both material composition and structural configuration, affecting ignition stability and flame development.

In conclusion, the findings confirm that fabric geometry plays a crucial role in controlling fire behaviour. By optimising thread angle and pitch, it is possible to design textile materials with improved fire resistance and reduced fire hazards. This research provides a foundation for future studies on structural optimisation of hybrid fabrics and contributes to the advancement of safer and more energy-efficient textile systems.

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REFERENCES

- [1] Levchik, S. V., & Weil, E. D. (2004). "A Review on Intumescent Flame Retardants in Polyolefins and Related Polymers." *Journal of Fire Sciences*, 22(6), 469-498.
- [2] Azahari BM, Suzuki M, Masuda W, Hamidon BS, Azwan BS, Nizam BA, Faisal HM, Amir BK. Effect of synthetic material on angle dependency of flame spread behavior over combined fabric. In AIP Conference Proceedings 2017 Apr 21 (Vol. 1831, No. 1, p. 020014). AIP Publishing LLC. <https://doi.org/10.1063/1.4981155>
- [3] Razali MA, Sapit A, Hushim MF, Khalid A, Masataro S, Wataru M. Flame spread behavior over combined fabric of cotton/polyester. In the International Engineering Research and Innovation Symposium 2015.
- [4] Razali MA, Sapit A, Mohammed AN, Hushim MF, Sadikin A, Ja'at MN, Peraman H, Suardi M. Flame spread behavior over kenaf fabric, polyester fabric, and kenaf/polyester combined fabric. In *Engineering applications for new materials and technologies 2018* Jan 26 (pp. 67-75). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-72697-7_5
- [5] Azahari Razali M, Sapit A, Nizam Mohammed A, Anuar Mohamad MN, Nordin N, Sadikin A, Faisal Hushim M, Jaat N, Khalid A. Thread angle dependency on flame spread shape over kenaf/polyester combined fabric. In *IOP Conference Series: Materials Science and Engineering 2017* Sep 1 (Vol. 243, No. 1, p. 012027). IOP Publishing. DOI: 10.1088/1757-899X/243/1/012027
- [6] Razali MA, Sapit AB, Mohammed AN, Hushim MF, Salleh HB, Peraman HB. Effect of thread angle on flame spread behaviour over combined fabric of kenaf/polyester. In AIP Conference Proceedings 2017 Apr 21 (Vol. 1831, No. 1, p. 020016). AIP Publishing LLC. <https://doi.org/10.1063/1.4981157>
- [7] Horrocks, A. R., & Price, D. *Burning Behaviour of Textiles*. In *Fire Retardant Materials 2008* (pp. 214-250). Woodhead Publishing.
- [8] Alongi, J. Recent Advances in Flame Retardancy of Textiles. *Polymer Degradation and Stability*, 2015. 121, 34-46.
- [9] Magalhaes L, Conde O, Mesquita L, Briga-Sá A, Ferreira DM. Evaluating the fire behaviour of cement-based lightweight materials with textile waste incorporation using a cone calorimeter. *Case Studies in Construction Materials*. 2024 Jul 1;20:e02798. <https://doi.org/10.1016/j.cscm.2023.e02798>
- [10] Qi P, Zhang J, Liu J, Li Y, Chen F, Sun J, Li H, Gu X, Zhang S. Fabrication of sustainable flame retardant cotton fabrics via foam finishing with sodium polyborate. *Polymer Degradation and Stability*. 2024 Feb 1;220:110647. <https://doi.org/10.1016/j.polymdegradstab.2023.110647>
- [11] Milovanovic D, Babic M, Jovicic N, Gordic D. Energy efficiency in buildings, industry and transportation. In AIP Conference Proceedings 2012 Nov 20 (Vol. 1499, No. 1, pp. 71-82). American Institute of Physics. <https://doi.org/10.1063/1.4768971>
- [12] Kandola, B. K. "The Effect of Thermally Stable Additives on the Combustion Behaviour of Textiles." *Polymer Degradation and Stability* 2006 (91(10), 2439-2451).

- [13] Razali MA, Sapit A, Mohammad AN, Salleh H, Madon RH. Effect of baggase physical properties and composition on flame spread behavior. *International Journal of Integrated Engineering*. 2020 Feb 3;12(3):271-7.
- [14] Sahabudin MA, Razali MA. Effect of Material Composition Towards Flame Spread Behavior of Flammable Materials from Pineapple Fibre and Paper. *Fuel, Mixture Formation and Combustion Process*. 2019 Nov 14;1(2).
- [15] Zhang, Y. Influence of Yarn Structure on Fabric Flammability. *Textile Research Journal*, 2012 (82(5), 456-467).
- [16] Ramli A, Razali MA, Madon RH, Hushim MF, Khalid A, Ja'at MN, Salleh H. Influence of Material Composition on Flame Spread Behaviour over Combustible Solid of Paper/Bagasse. *International Journal of Integrated Engineering*. 2018 Dec 31;10(8).
- [17] Ramli A, Razali MA, Sapit A, Hushim MF, Nordin N, Khalid A, Mohammad MN. Flame Spread Behaviour over Combustible Solid of Paper, Bagasse and Paper/Bagasse. In *MATEC Web of Conferences 2017* (Vol. 135, p. 00012). EDP Sciences. <https://doi.org/10.1051/mateconf/201713500012>
- [18] Yasin S. An alternative for the end-of-life phase of flame retardant textile products: Degradation of flame retardant and preliminary settings of energy valorization by gasification.
- [19] Razali MA, Sapit A, Hushim MF, Khalid A, Masataro S, Wataru M. Flame spread behavior over combined fabric of cotton/polyester. In *International Engineering Research and Innovation Symposium 2015*.
- [20] Sahabudin MA, Razali MA. Effect of Material Composition Towards Flame Spread Behavior of Flammable Materials from Pineapple Fibre and Paper. *Fuel, Mixture Formation and Combustion Process*. 2019 Nov 14;1(2).
- [21] Razali MA, Sapit A, Batcha MF, Madon RH, Khalid A, Ja'at MN, Mohammed AN, Salleh H, Hushim MF, Hadi UA. Preliminary study of effect of natural thread distance on angle dependency of flame spread behaviour over kenaf/polyester fabric. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*. 2019;62(2):250-5.