EFFECT OF STITCHING ON TENSILE PROPERTIES OF KENAF FABRIC REINFORCED POLYPROPYLENE

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ABSTRACT: Nowadays, an increased interest in environmental awareness and use of eco-friendly composites towards the natural fibre such as kenaf fibre usage as reinforcement in composites have been shown by the researchers and industry. In this study, an experimental investigation was conducted to discover the effect of stitching patterns on woven kenaf fabric. The woven kenaf fibre and epoxy resin was used as a reinforcement and matrix. The composite samples was prepared by using hot press technique. It was found that the V and T60 samples was improved the tensile performance about 69.91% and 41.37%, respectively. It was also shown that the highest specific strength is V stitch pattern with the increment of 34.60% compared to unstitched sample. This can be concluded that, the angle of stitch direction gave significant effect on specific strength performance. Implications of the results and future research directions are also presented.

KEYWORDS: *Stitching; Woven Kenaf; Natural Fibre; Polymer; Composite*

1.0 INTRODUCTION

Nowadays, natural fibre composites are humongous used in many applications, interest area of scientific research and product development due to it exhibition with combined behaviour of low density, stiff and strong fibrous reinforcement. In additional, natural fibre reinforced composites also give the benefits such as environmental friendly, corrosive resistance, chemical resistance, high mechanical performance and thermal properties. These natural fibres included sisal, pineapple, jute, banana, oil palm, kenaf and coir fibres [1-4].

In addition, the textile structure such as woven, knitted or braided are usually used for reinforcement in fibre reinforced polymer composite. This is because woven fabric provides high stiffness, strength, stable and easy to handle [5]. Knitted reinforcement provided better impact strength but poor in tensile properties while woven reinforcement gave the higher modulus value [6]. Alavudeen et al. [7] had studied the mechanical properties of banana and kenaf fibre reinforced composite with the effect of weaving pattern and random orientation. They found that plain woven hybrid composite gave the higher mechanical strength compared to random orientation composite. This showed that the mechanical properties of the composite also affected by the woven structure.

Moreover, stitching is a process to bind two components together by using thread and needle. In the modern technology, it can be performed advanced from sewing machine. Lock stitch, modified lock stitch and chain stitch are the common stitching types used by many researchers on the composite material. The use of stitching in the composite is to join the composite structure to improve through-thickness strength and interlaminar fracture toughness and impact damage tolerance [8-9]. According to Pingkarawat and Mouritz [10], stitching will cause fibre breakage in the composite. They highlighted that stitching on mendable composite reduced mechanical properties due to the increasing of areal density or the size of stitched. In contrast, the stitch density and stitch size will influence the performance of the composite. Suhaimi et al. [11] also agreed with this claimed. They mentioned that the stitch density with different stitching pattern contribute different strength on the composite.

In summary, many interesting results indicating the effect of stitching on woven fabric composites have been reported. However, most of the studies in the open literature did not simultaneously examine the effect of stitching on woven kenaf fabric. Therefore, this study aims to experimentally investigate the effect of different stitching patterns on woven kenaf fabric reinforced polypropylene composite. The findings of this study will help our understanding on the effect of stitching towards woven kenaf fabric.

2.0 MATERIALS AND METHODS

In this study, kenaf fibre was as a reinforcement and epoxy auto-fix 1345-A and auto-fix 1345-B as the matrix. The epoxy auto-fix 1345-A and auto-fix 1345-B were obtained from Chemibond Enterprise Sdn. Bhd while kenaf fibre was purchased from Lembaga Kenaf dan Tembakau Negara, Malaysia (LKTN). The kenaf fibre was supplied in long fibre form. Before the weaving process, kenaf fibre was cleaned and divided according to the size of 4 to 5mm (±0.1). The weaving process was done manually as shown in Figure 1 (b). After that, kenaf fibre was stitched by using sewing machine brand SINGER, model 8280 with capacity of machine of 240 V, 50 Hz and 85 W. There were four types of stitching patterns which were Vertical, Horizontal, Tilt 30° and Tilt 60° as shown in Figure 2. The unstitched (O) composite sample also was fabricated as a benchmarking. All of these design were stitched on the woven kenaf fabric with distance of 5mm between each stitch.

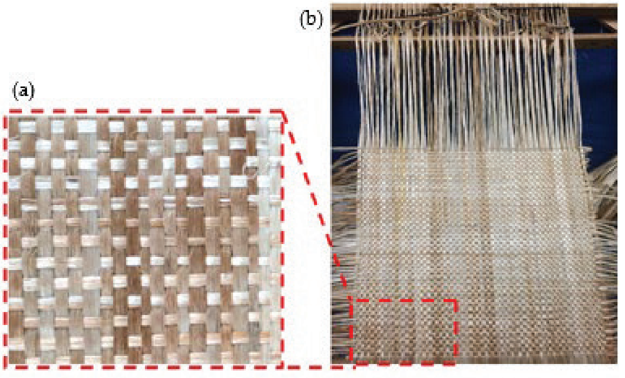

Figure 1: (a) woven kenaf fabric and (b) weaving process [20]

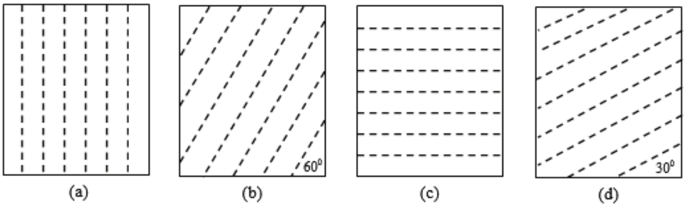

Figure 2: Types of stitching patterns: (a) Vertical, (b) Tilt 60°, (c) Horizontal and (d) Tilt 30°

The stitching wove kenaf fabric (SWKF) with the dimension of 300mm x 220mm was prepared then followed hot press technique. For the easy removal of sample, the SWKF was arranged between two Teflon sheets. The PP pallets was placed on SWKF. Before performing hot press technique, a pre-heat of PP pallets for 20 minutes at 170°C was done to ensure all the pallets melted, then further carried out with compressing the SWKF with 2 Tonne pressure for 20 minutes. This allows all the PP to propagates towards the SWKF itself. After the compressing process for 20 minutes, a quickly releasing of air bubbles is performed within 30 seconds then will continuously press again for 15 minutes. Lastly, the cooling process takes time for about 20 minutes and then samples were removed from the mold after complete cooling at room temparature. Next, the samples were cut according to ASTM D3039 standard with a dimension 250mm (length) x 25mm (width) for tensile test.

3.0 RESULTS AND DISCUSSION

The performance of composite samples can be seen in Figure 3. From the figure, the highest tensile performance was observed in the V stitches pattern which is 32.69 MPa and followed by T60 at 27.2 MPa. The lowest tensile performance was observed in the H stitch which recorded at 14.23 MPa. From the data in Figure 3, what is interesting in this data is that the tensile performance improved only in samples V and T60 respectively. The V and T60 samples was improved the tensile performance about 69.91% and 41.37% respectively. The V sample, which is in 90° of stitching angle direction significantly affected the tensile performance. This indicates that the SWKF reinforced composite will produce better performance of tensile strength when the direction of stitching is parallel to the loading direction as in the composite with the stitching at V sample. As referred to in [12-15] therefore, the effect of fibre in various direction on tensile strength. They also observed that the composite reinforced with fibre aligned in parallel to the loading direction will give superior performance.

In addition, from the data in Table 1, the sample of T30 and H stitching patterns demonstrated that the values of tensile strength was decreased about 24.43% and 26.04% respectively compared to O sample. This indicates that the tensile performance will decrease with the changes in orientation of stitching angle direction, if the stitching angle direction is approaching the horizontal direction as occurred on the samples of T30 and H, respectively. The present finding also supported [13,16] which noted that the composite reinforced with fibre aligned in one direction have high modulus and strength in the fibre direction and inadequate mechanical properties in horizontal direction.

Table 1: Properties of single stitch and unstitch composite

Patterns types	Tensile strength (MPa)	Mass (g)	Specific strength (MPa/g)	Young's modulus (MPa)
O	9.24	5.64	3.41	1.17
V	2.69	7.12	4.59	1.69
T60	27.2	6.82	3.99	1.45
T30	4.54	3.68	3.95	0.78
H	14.23	5.90	2.41	0.92

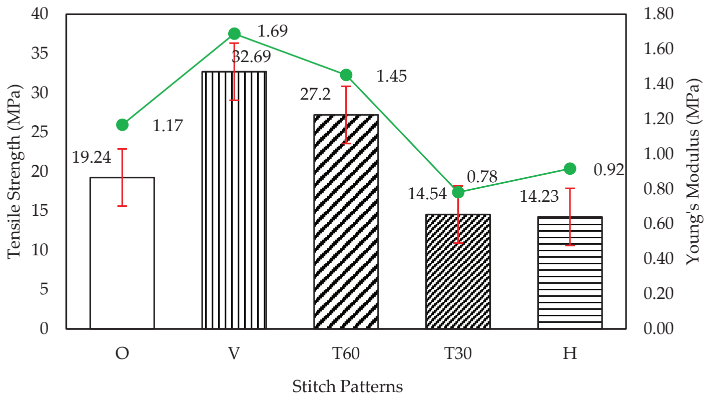

Figure 3: Tensile strength of single stitched and unstitched composite

Moreover, the use of specific strength is important when comparing the performance of composite material which made from different mass. Generally, the higher value of specific strength is, the higher value of strength and lighter weight the material is. In this case, the data of specific strength can be seen in Figure 4 and Table 1. Figure 4 showed that the highest specific strength is V stitch pattern with the increment of 34.60 % compared to O sample. This indicates that the V stitch pattern is more consistent and stable to withstand load due to stitching direction which is parallel with the direction of load given. Furthermore, SEM images of V sample after fracture under tensile test were shown in Figure 5. The mechanical performance of SWKF composites depends on not only the properties of fibre constituent but also the interfacial interactions established between the reinforcing agent and the matrix material as well. Moreover, fracture analysis reveal that the PP melt viscosity achieved at two Tonne pressure for 20 minutes with 170°C temperature assisting PP migration and deeper penetration into the woven fabric to provide good mechanical interlocking and bond line performance as shown in Figure 5. Therefore, it can be noted that by using right pressure and temperature in composite reinforced thermoplastic, it will produce good mechanical interlocking and bonding between reinforcement and matrix which is in agreement with the previous studies [17-18].

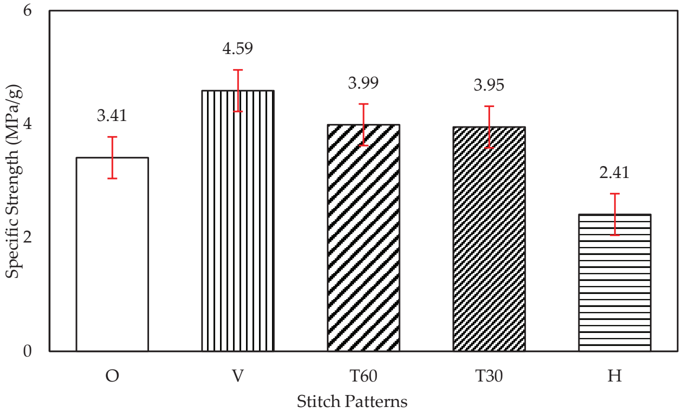

Figure 4: Specific strength of single stitched and unstitched composite

On the other hand, H sample exhibited lower specific strength compared to all samples. From Figure 4, it was observed that the specific strength values of H sample are lower than O sample by 29.33%. Menon et al. [14] demonstrated that the composite in the vertical is higher than horizontal direction, which showed a similar agreement in this current study. Hence, based on the previous and current findings, this confirmed that the stitching angle in horizontal will be the lowest tensile performance. Moreover, the fracture analysis of H sample can be seen in Figure 6. The failure of H sample was occurred at stitch line on SWKF as illustrated in Figure 7. Due to the attraction of bobbin yarn and needle yarn at stitch point, it has tighter the fibre and made it easy to break during the force applied as illustrated in Figure 8. This area works mostly as a crack initiator that can reduce composite performance [19].

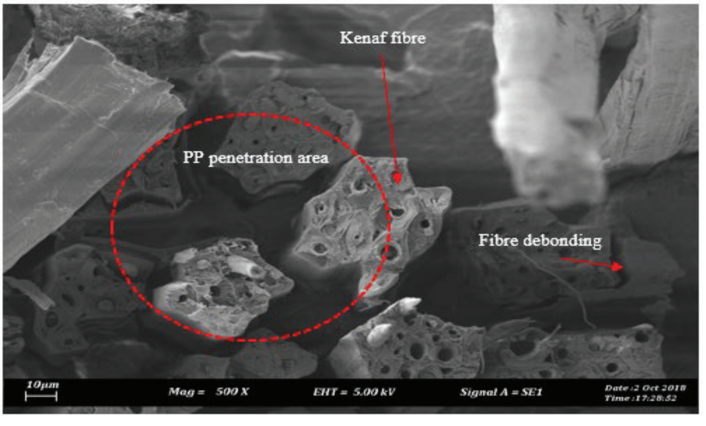

Figure 5: SEM image of V stitch sample

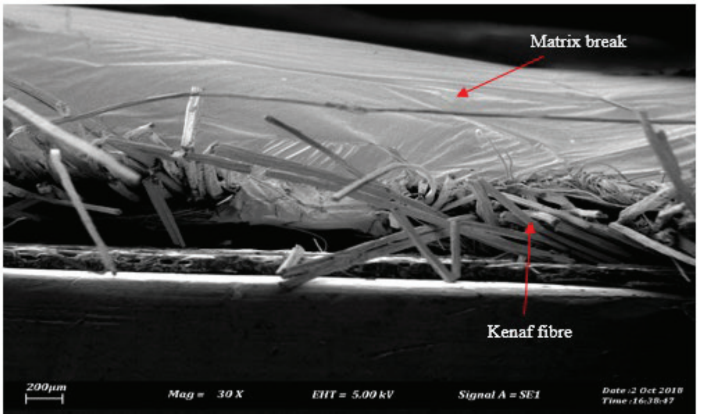

Figure 6: SEM image of H stitch sample

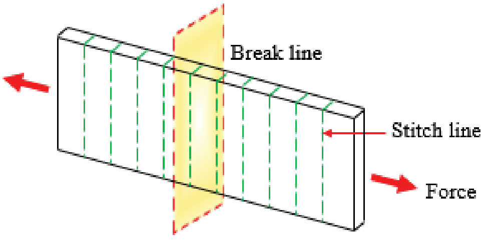

Figure 7: Illustration of H sample failure at stitch line

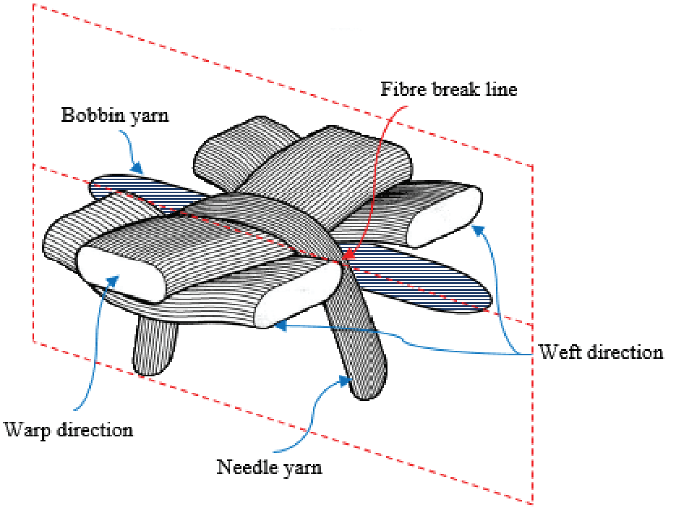

Figure 8: Illustration of tighter fibre on H sample

By irrespective O sample, it was clearly showed that by increasing the angle of stitch direction, it will increase the tensile performance [14]. This can be concluded the angle of stitch direction gave significant effect on specific strength performance.

4.0 CONCLUSION

The purpose of the current study was to determine the effect of stitching patterns on woven kenaf fabric. The results show that the tensile performance improved only in samples V and T60 respectively. The V and T60 samples was improved the tensile performance about 69.91% and 41.37%, respectively. It was also shown that the highest specific strength is V stitch pattern with the increment of 34.60% compared to unstitched sample. It was clearly showed that by increasing the angle of stitch direction, it will increase the tensile performance. This can be concluded that, the angle of stitch direction gave significant effect on specific strength performance. The current findings add substantially to our understanding of the effect of different stitching patterns on woven kenaf fabric. Further research might explore investigate the effect of stitching technique on laminated woven kenaf fabric.

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