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RESEARCH ARTICLE

Comparative Study on the Mechanical Properties of Weft Knitted and Warp Fabric Reinforced Composites

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ABSTRACT

Knitted fabric composites occupy a special interest in the field of engineering and materials science because of their easy to form complex component and high impact energy absorption. Mechanical tests were carried out in the course, wale and slanting directions of the knitted fabric reinforced composites. The stress-strain curves and failure modes of warp and weft knitted fabrics were investigated and compared. The test results revealed from the composite structure fabricated from warp knitted fabric shown better mechanical properties than weft knitted fabric because of the warp knitted fabric distinct by the process of overlap between the stitches that gave better resistance.

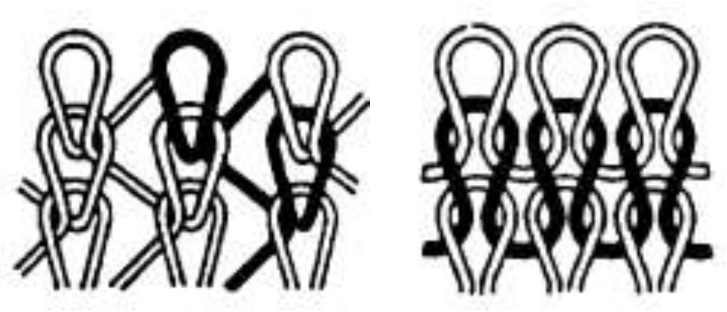
Keywords: Warp Knitting, Interloping, Mechanical properties

1 Introduction

Knitting refers to a technique for producing textile fabrics by intermeshing loops of yarns using knitting needles. When one loop is drawn through another loop a “stitch” is formed. Stitches may be formed in a horizontal or in a vertical direction. A continuous series of knitting stitches or intermeshed loops is formed by the needle catching the yarn and drawing it through a previously formed loop to form a new loop. In a knit structure, rows, known in the textile industry as courses, run across the width of the fabric, and columns, known as wales, run along the length of the fabric. The loops in the courses and wales are supported by, and interconnected with, each other to form the final fabric as shown in Figure 1[1]. Depending on the direction in which the loops are formed, knitting can be broadly classified into one of two major types i.e., warp knitting and weft knitting. The terms weft and warp knitting have come from the technique, wherein the threads running at right angle to the selvedges are called weft and the threads running parallel to the selvedges are called warp. Warp knitting is characterized by loops forming through the feeding of the warp yarns, usually from warp beams, parallel to the direction in which the fabric is produced shown in Figure 1a. Whereas weft knitting is characterized by loops forming through the feeding of the weft yarn at right angles to the direction in which the fabric is produced illustrated in Figure1b. More precisely, warp knitting is affected by interloping each yarn into adjacent columns of wales as knitting progresses. The basic structure of the warp (i.e., single tricot) and weft (i.e., plain knit) knitted fabrics. Generally, weft-knit structures are less stable and, hence, stretch and distort more easily than warp-knit structures [1-3]. General comparison between warp and weft knitted structure was summarized in Table1.

In recent years, use of composite materials supported by textile fabric is increased, because the intermingling between the inorganic fibers and organic materials gives the new ecofriendly material with good properties. Knitted fabric composites occupy a special position in the field of engineering materials because of their easy to form complex component and high impact energy absorption. But Knitted fabric composites have low in-plane tensile strength because the yarns are in a loop structure in the materials. To improve the tensile stiffness and strength, the axial yarns can be inserted in both wale and course direction of knitted fabric. This kind of knitted fabric has both good mechanical properties and good forming characteristics for straight fibers and knitting component.

With inserted yarns, the anisotropy of the knitted composite can be manipulated to make it suitable for a particular requirement [4-6]. Good mechanical properties and conformal properties, the biaxial weft knitted fabrics have been used more and more widely in the field of industrial textiles [7-11].



(a) Warp knitting and *(b) Weft knitting*

Figure 1. *Basic type of knitted structures*

Different scholars have been done a lot of research work on knitted fabric reinforced composite and they were said that; knitted composites are inferior to many of their more traditional counterparts with respect to in-plane strength and stiffness, they are generally superior in terms of energy absorption, bearing and notched strengths, and fracture toughness. In addition, knitted fabrics also have low resistance to deformation, and hence exceptional formability [12-16]. The aim of the research study was a comparative study in warp and weft knitted fabric and their composite structure, also to find out the effect of supportive reinforcing knitted fabric types i.e. warp and weft knitted reinforced textile materials on their composite materials on the physic-mechanical properties of manufactured textile based composite materials.

Table 1. *Comparison of warp and weft knitting*

Warp knitting	Weft knitting
Only filament yarns can be successfully worked	Usually staple fiber yarns (cotton, wool, jute) as well as continuous filament yarns (silk, filament, viscose: nylon, polyester: polypropylene filaments) can be worked
A variety of goods can be knitted on a warp knitting machine	Only one class of goods, with very, little modification, can be knitted on a weft knitting machine. It means versatility is less with weft knitting machines.
The quality of the fabric obtained on warp knitting machines is consistent and uniform due to the type of collective movement given to the needles. Warp-knit loops are very uniform.	Not like warp knitting
Warp-knit fabrics usually stretch in widthwise direction in contrast to weft-knit structures which possess extensibility in both, widthwise and lengthwise.	Not like warp knitting
Superior dimensional stability and Strength	Not like warp knitting
Warp knits will not ravel or run	Not like warp knitting
Less susceptible to snagging	Not like warp knitting

Moreover, this research work was to find out a new possible alternative composite reinforcing material in Geo textile and Agro-textile sectors having light weight and low cost of production as compared with other fabric manufacturing techniques such as non-woven and weaving technology.

2 Materials and Methods

Knitted fabric composite structures were manufactured by using PP resin and warp and weft knitted fabric with weight percentage of 60:40 wt. % as shown in Figure 2. Hand lay-up techniques were used for composite manufacturing. Then the samples were dried in oven for 2 hours at a temperature of 100 ± 2 ^{0}C before cooling at room temperature. The samples were prepared according to ASTM-D638-10 standards and SHIMADZU Strength tester.

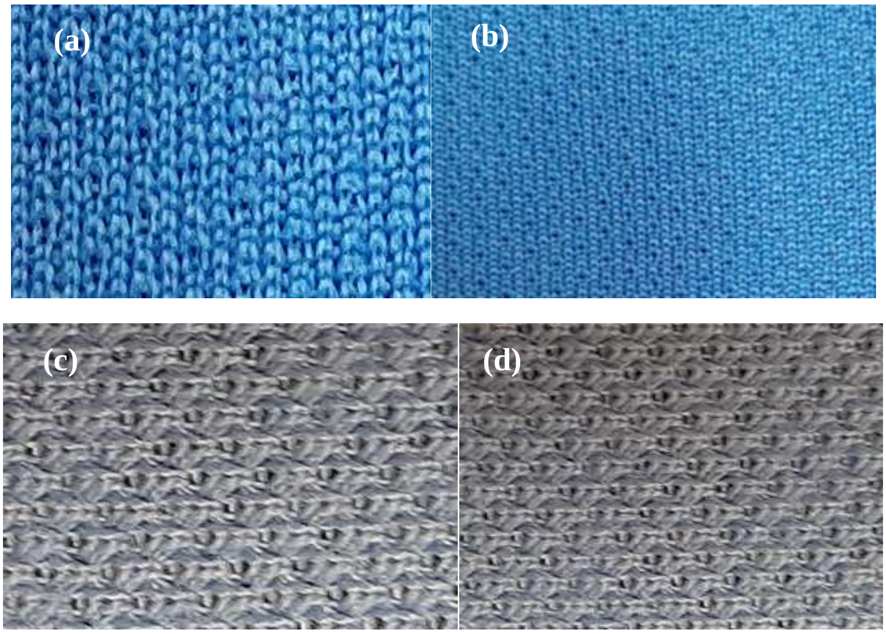


Figure 2. *Plain weft knitted textile (a) Fabric, (b) its reinforced composite structure; Warp knitted textile (c) Fabric (d) its reinforced composite structure*

2.1 Tensile strength test

Tensile strength of warp and weft knitted fabrics were done by using Shimadzu strength tester having a 10KN load cell with a speed of 2 mm/min. (A force of 10kN and speed of 2mm/minute) was used for analysis the mechanical strength of composite structures having 5 cm wide and 20 cm effective length of samples. The mechanical strength measurements were carried out from 5 different samples and the tests were conducted in warp direction. All the test specimen preparations and tests were conducted based on the ASTM standards and in warp direction. The average values were used as the measured value.

3 Results and Discussions

Tensile properties of warp and weft knitted fabric reinforced composites were summarized in the Table 2, Figure 3 and 4.

Table 2. *Comparison of tensile strength for warp and weft knitted fabric reinforced composites*

Type of reinforced knitted fabric	Elongation (%)	Strength (MPa)	Modulus (GPa)
Warp knitted fabric	6.02	96.68	3.9
Weft knitted fabric	7.36	83.09	3.2

The test results revealed that, composite structure reinforced with warp knitted fabric had better tensile properties compared to weft fabric reinforced composite due to their interlocking of the yarns from the consecutives yarns. The tensile strength of composite structure reinforced by basket warp was enhanced by 15% as compared with warp knitted within similar composite elongation range. In the case of weft knitted structure, yarns movement in the warp and weft direction is straight and uniform. These yarns movements in the knitted structure and orientation of fabric in the warp and weft directions were influenced the tensile properties of composites fabricated from knitted fabrics. Similarly, warp knitted fabric pattern reinforced composite had higher modulus compared to weft knitted fabric as shown in Table 2 and Figure 4. The tensile strength measured values are higher than the estimating values in wale-wise directions of the knitted fabric composite structures. The in-plane mechanical properties of knitted fabric reinforced composite structures are usually anisotropic. These are due to a difference in the relative proportion of fibers oriented in the knitted fabric. Resultant stress of composite material with weft knitted fabric is greater than the stress of warp knitted fabric, that because of warp fabric drooping less than weft knitted fabric drooping, due to the structure of weft knitted fabric had better flexibility than warp knitted structure as shown in Table 2.

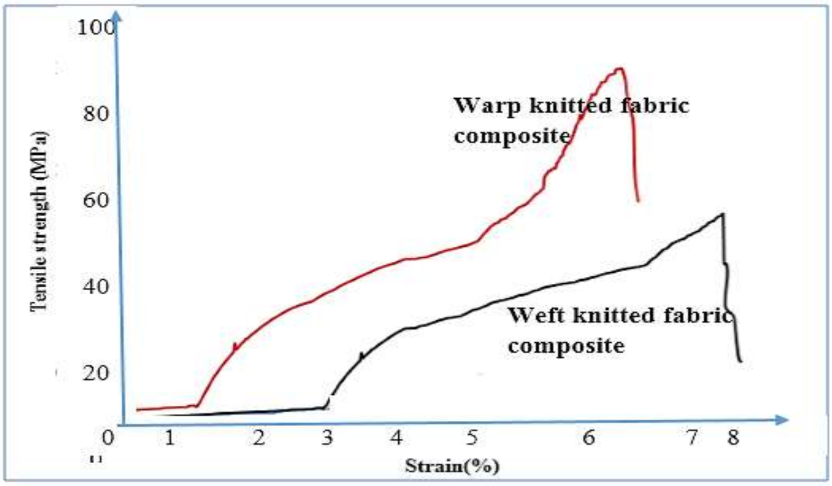


Figure 3. *Stress- strain analysis of warp and weft knitted fabric reinforced composite tensile strength test*

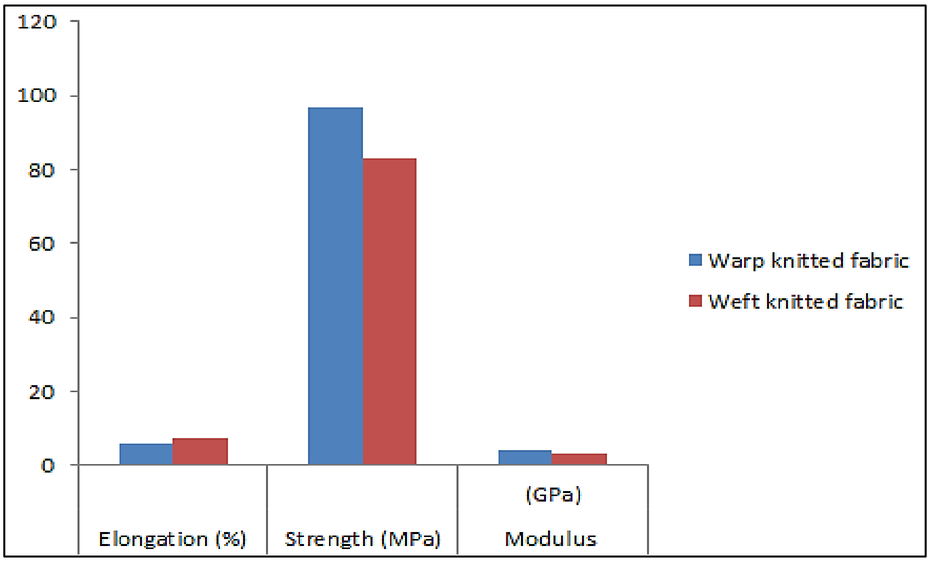


Figure 4. *Mechanical properties of warp and weft knitted fabric reinforced composite*

The difference between in wale directions of the composite structure regarding the linearity of stress-stain curves of the warp knitted fabric reinforced composite had better performance than weft knitted fabric reinforced composite materials as shown in Figure 3. During the fabric cation of knitted fabrics structures, the interlacements of yarns in the wales and course-wise directions, a certain amount of unevenness is imparted to the warp and weft –wise threads of both warp and weft knitted fabrics, this waviness is called crimp. Denser weave packing actually causes more void in the knitwear architecture and thus more matrix material and a lower fiber volume fraction in the composite, especially for weft knitted fabrics. Crimp is expressed as percentage and it vary from 2% to as high as 30% depending on various parameters like threads/cm, Tex of yarns, characteristics of raw materials [17, 18]. The test result confirmed that lower crimp means straighter yarns, which translates into better composite mechanical properties in warp knitted structure as shown in Figure 4. Also, the percentage of crimp varies widely in weft knitted fabric reinforced composite and type of knitwear structure which were directly related to the amount of reinforced fabrics (yarns) and resins used in composite manufacturing [19].

4 Conclusion

Composite materials fabricated from warp knitted fabric shows better tensile resistance than composite materials fabricated from weft fabric. The difference between large is in wale directions of the composite structure regarding the linearity of stress-stain curves of the warp knitted fabric reinforced composite had better performance than weft knitted fabric reinforced composite materials. Because the buckling degrees of yarns in warp knitted fabric reinforced composites were lager and the axial yams utilization of warp knitted fabric reinforced composite was better than that of the weft knitted fabric reinforced composite.

5 Declarations

5.1 Competing Interests

The Authors declare that no conflict of interest exists in this publication.

5.2 Publisher's Note

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