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TEXTILE MATERIAL FORMS FOR REINFORCEMENT MATERIALS – A REVIEW

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ABSTRACT

This paper intended to give an insight of the textile material utilization as reinforcement in the composite materials. The discussion on textile definition and categorization will give some ideas for the reader to recognize textile materials and its role in this system. Simple categorization is referred to which textile materials are clustered into fibre, yarn and fabric regardless whether it is made synthetically or naturally. For every basic textile material form, few selected recent works have been discussed to show the utilization of textile material in research and industry. Composite made of textile fibres form is limited to low and medium load bearing application due to the difficulties of controlling the alignment, dispersion and distribution of fibres. Whereas yarn reinforcement gives more control on the composite materials due to the fibres is aligned in a yarn but the issue is more on the limited fabrication method. Utilization of textile fabric in composite as reinforcement is well recognized for high performance fabric so it is with natural fabric. Nonetheless, there is a limit of work considering fabric properties or parameters when characterize its composite to understand the fabric contribution in composite material.

Keywords: Composite; textile material; fibre; yarn; fabric.

INTRODUCTION

It is well known that engineering material is divided into four clusters which are metals, polymers, ceramics and composites. The first three classes are always been categorized as homogenous materials, and this is the main thing that differentiates them with material. Early definitions of material are rather simple, for instance, Rowell (1990) defined a composite as "a reconstituted product made from a combination of two or more substances using some kind of mastic to hold the components" and Maloney (1996) defines a composite "as materials that have the commonality of being glued or bonded". These two definitions are somewhat general for wood product since they were discussed about wood pulp and wood industries in their papers. Misnon (2007) concluded the definition of materials as a select combination of dissimilar materials with an internal structure and with an external shape or which results to heterogeneous and anisotropic materials. The word heterogeneous and anisotropic make the definition of composite is difficult to achieve because the three classes mentioned (metals, polymers and ceramics), to some extent, are sometimes anisotropic at submicron dimensions. Therefore, some other good definition, more specific and emphasize the general composite structure is needed. Bader (1997) in his work came out with useful and neat definition for composite as a material is characterized by being multiphase materials (one or more substances, including matrix) within which the phase distribution and geometry have been deliberately tailored to optimize one or more properties.

This is clearly an appropriate definition for textile composite or textile-reinforced composites (TCRM) for which there is one phase, called the matrix, reinforced by a fibrous reinforcement in the form of a textile. Due to a major of textile material involvement in composite material, regardless whether it is synthetic or natural derivation, utilization various versions of materials in the form of fibres, yarns, fabrics, their hybrids and many other combinations since about millennia ago has established their own cluster and definition. Textile composite can be defined as a combination of fibrous material (textile) either fibre, yarn, or fabric embedded in a resin system, and it can be in the form of flexible or quite rigid materials (Scardino, 1989).

Properties of textile composites are strongly influenced by the properties of their reinforcement distribution and the interaction among them (reinforcement and matrix). The geometry of the reinforcement may be described by the shape, size, and size distribution. The reinforcement in the systems may differ in concentration, distribution and orientation. Therefore, all of these factors may be important in determining the properties of the textile composites. To understand the reinforcement concentration, distribution and orientation of textile composite, knowledge of textile material should be taken into account.

The intention of this paper is to give insight of the textile material utilization as reinforcement in the composite materials. Definition of textile material has been discussed in order to give some ideas to the reader of what textile is all about and how these materials were clustered into basic categories. Simple categorization is referred to which textile materials are clustered into fibre, yarn and fabric regardless whether it is made synthetically or naturally. Some figures have also been included to provide a better understanding of the forms of the material being discussed. For each basic textile material form, several research or recent research has been discussed to show the utilization of textile material in research and industry and then followed by the authors' opinion and suggestion related to the textile materials' utilization.

TEXTILE MATERIALS

This term applies to product forms (fibre, yarn and fabric), either they are from natural or synthetic sources as well as the products derived from them. Which includes all types of yarns or ropes (threads, cords, ropes and braided); all types of fabrics (woven, knitted and nonwoven); hosiery (knitwear and garments); household textiles, furnishing and upholstery; industrial and technical textiles (e.g. geotextiles, medical textiles and textile composites). Fibre is a basic unit of textile material and it can be clustered into two big groups, natural and synthetic/man-made fibres. These fibres are not only differed in properties among natural and synthetic, but also differ in their cluster depends on the chemical composition (Kadolph & Langford, 2001). Figure 1 shows some types of textile fibres and its classification while Figure 2 shows some example of fibres.

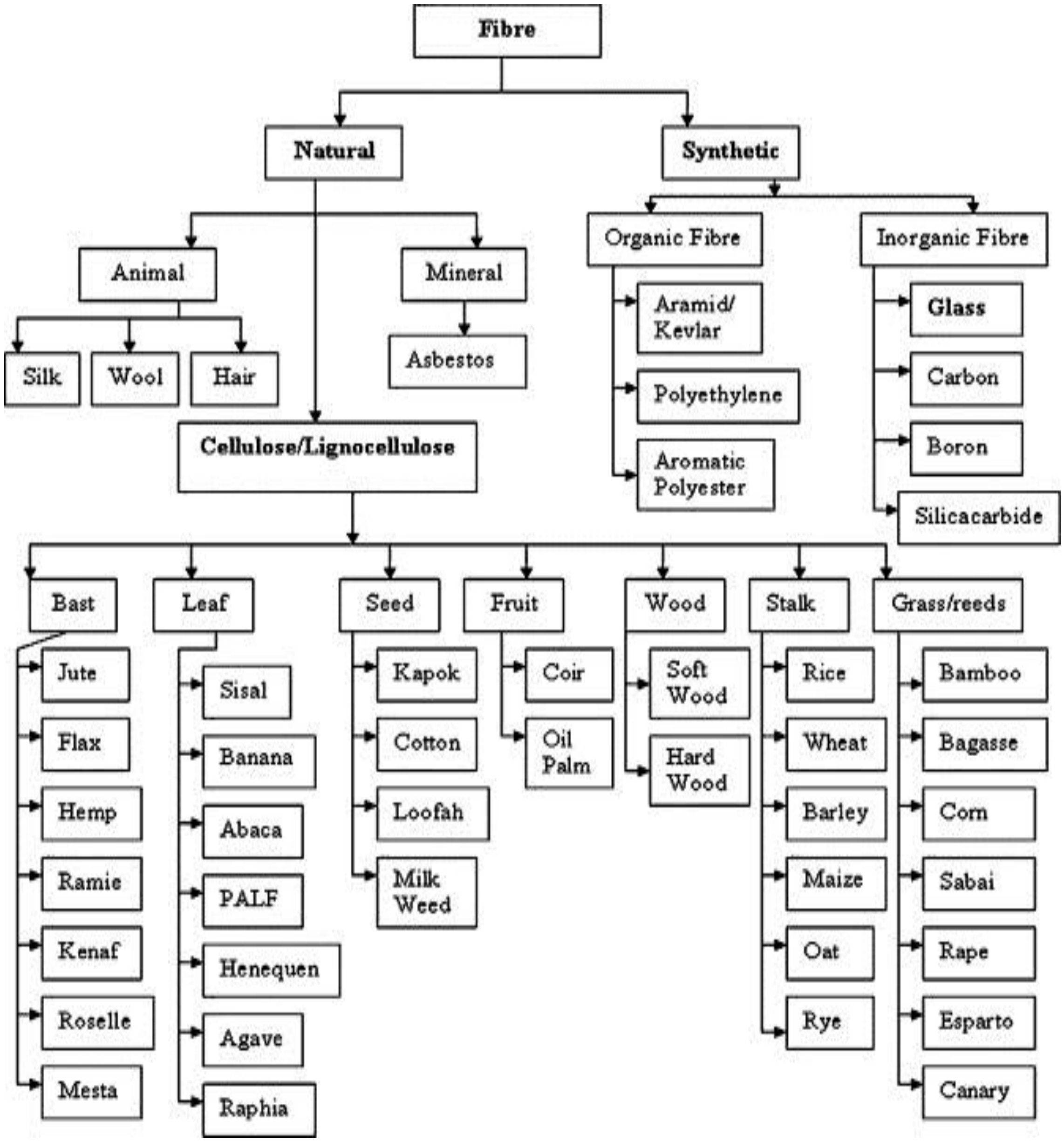

Figure 1. Textile fibre types and their classification (Kadolph & Langford, 2001).

A group of fibres with or without twist is called yarn and it has substantial length and relatively small cross-section. Monofilament is the yarn containing only one fibre for example, nylon. Untwisted, thick yarns are termed tows and this term is usually applied for high performance yarn such glass, aramid and carbon. In twisted yarns, the friction resulting from twist consolidates fibres. A twist is introduced to a continuous filament yarn by twisting. For a twisted yarn made of staple fibres, the process is called spinning and involves a long chain of preparatory operations. There is different yarn spinning processes (ring spinning, open-end spinning, friction spinning) leading to yarns with distinctive internal distributions of fibres. Figure 3 shows some example of yarns.

(c) (d)

Figure 2. Examples of textile fibre; (a) Aramid, (b) Glass, (c) Cotton and (d) Wool (Kadolph & Langford, 2001).

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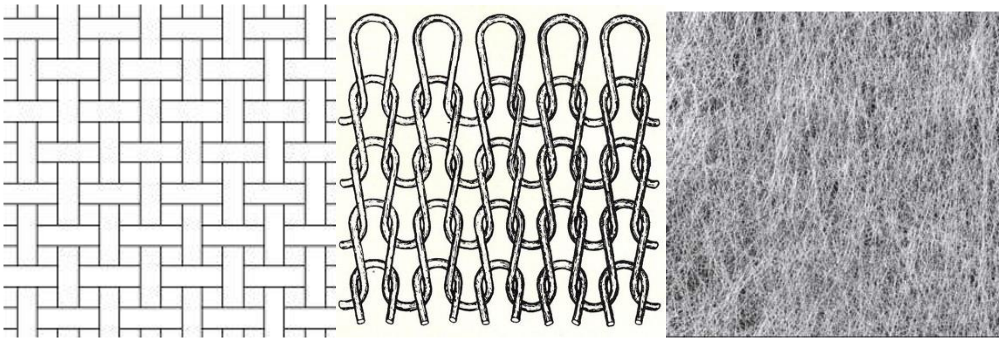
Next transformation of textile fibres after being a yarn is fabrics. Three distinctive common fabric types are woven, knitted and non-woven fabrics produced by weaving, knitting and various non-woven processes respectively. Figure 4 shows different types of fabric structure. Woven fabrics generally consist of two sets of yarns that are interlaced and lie at right angles to each other. The threads that run along the length of the fabric are known as warp ends whilst the threads that run from selvedge to selvedge, that is from one side to the other side of the fabric, are weft picks. Frequently they are simply referred to as ends and picks (Sondhelm, 2000). Knitted fabric consists of interloping yarns either weft (weft knitting) or warp (warp knitting) directions. Warp knitting is a method of manufacturing a fabric by standard knitting means, in which the loops made from each warp are formed substantially along the length of the fabric while weft knitting is a method of making a fabric by normal knitting means, in which the loops made by each weft thread are formed considerably across the width of the fabric (Anand, 2000).

(a) (b)

Figure 3. Example of yarn, (a) Carbon tows and (b) Dyed cotton yarns (Kadolph & Langford, 2001).



(a) (b) (c)

Figure 4. Types of common fabric; (a) woven, (b) knitted and (c) non-woven fabrics (Sondhelm, 2000).

A nonwoven is a textile structure produced by the bonding or interlocking of fibres, or both, accomplished by mechanical, chemical, thermal or solvent means and combinations thereof. It has to be admitted that this definition is not very precise, but it has been chosen because it includes many important fabrics which most people regard as nonwovens. One of the major advantages of nonwoven manufacture is that it is generally done in one continuous process directly from the raw material to the finished fabric, although there are some exceptions to this (Smith, 2000). Fabric types mentioned are the usual single plane structures also known as 2-D fabrics which high performance fibres are available. However, beyond of that, fabric in multi-plane structures or 3-D fabrics can as well be manufactured by weaving, warp knitting, braiding, non-woven and other specially modified techniques. The diverse techniques on fabric manufacturing allow more flexibility on tailoring the textile material which could be used in diverse of applications.

Considering the broad definition of textile and various type of textile material in three different form (fibres, yarns and fabrics), no wonder if textile material can be found not only for apparel and garment but also in technical industry such as automotive, aeronautic, infrastructure, composite etc. Textile can be also defined according to their hierarchical and several notations for broaden the scope of textile materials (Lomov, Verpoest, & Robitaille, 2005). However, this topic is not the main concern, thus it will not be discussed in this paper.

COMPOSITE REINFORCEMENT

Fibres

Fibre is the basic textile material form for composite reinforcement and with the various types of textile fibre ranging from synthetic and natural, with ranges of properties, ranges of polymers as well as several methods of processing, they offer more possibilities to suit the purposes of end products. Table 1 shows the mechanical properties of some common synthetic and natural textile fibres (Bledzki & Gassan, 1999; Dittenber & GangaRao, 2012; Faruk, Bledzki, Fink, & Sain, 2012). Synthetic fibres are meant for high performance and load bearing application while utilizations of natural fibres are more to serve non-load bearing applications. As for natural fibres, even though they possess lower mechanical properties than traditional fibres (high performance fibres), for some type of natural fibres, their young's modulus range can be considered high. For instance, young's modulus of jute, flax, hemp and ramie are within the range of aramid and carbon. Therefore, they are presumably can be used to replace traditional performance fibres in some of the application which need for similar young's modulus (Dittenber & GangaRao, 2012; Koronis, Silva, & Fontul, 2013; Schuh & Gayer, 1997; Ticoala, Aravinthan, & Cardona, 2010).

Application of textile fibres embedded in polymer has long ago been established and there are many workers worked and still working on it. Akonda, Lawrence, and Weager (2012) used short recycled carbon fibres embedded in polypropylene thermoplastic matrix. Their composites possess high tensile and flexural strength, which were 160 and 154 MPa respectively, and this is good enough to be used as low cost material for much non-structural application. Bao, Liang, and Tjong (2012) worked also on short carbon fibre to reinforced polymer to investigate its fracture behaviour.Serna Moreno, Martínez Vicente, and López Cela (2013) fabricated a composite from chopped glass and polyester resin to study its failure strain and stress fields under biaxial loading. From this study, they came out with several failure models, which are taken as a reference. Employing pre-peg and vacuum bagging, Choi and Lee (2013) used short aramid fibres to reinforced carbon/epoxy composite to find a cheaper composite manufacturing process while Sun, Hu, Sun, and Chen (2013) used short aramid reinforced carbon-fibre aluminium foam sandwich to study the energy absorptions and peak loads sandwich beam. It is clear, that even with the short/chopped of high performance fibre, the workers' intention is to use them in medium and high performance applications.

Due to world population awareness on the environmental issues, there is an interest of research which focusing on the developing, creating and innovating eco-friendly materials. Natural textile fibres offer a good opportunity to be used as reinforcements in composite materials. Several natural textile fibres such as cotton, wool and silk are established for producing garment and apparel, thus, the usage of these fibres as composite reinforcement is minimal. However, there are numbers of publication on using them or their wastes in composite/hybrid compote material and for respecting their role in textile garment and apparel, they are not going to be discussed in this paper (Alomayri, Shaikh, & Low, 2013; Aluigi, Vineis, Ceria, & Tonin, 2008;

Bajwa, Bajwa, Holt, Coffelt, & Nakayama, 2011; Bertini, Canetti, Patrucco, & Zoccola, 2013; Cheng, Lin, & Huang, 2011; Conzatti et al., 2013; Dobircau et al., 2009; Hardy & Scheibel, 2010; S.-J. Kim, Moon, Kim, & Ha, 2008; G. Li, Yu, Zhao, Li, & Li, 2003; J. Li et al., 2009; Mahdi, Mokhtar, Asari, Elfaki, & Abdullah, 2006; Paiva Júnior, de Carvalho, Fonseca, Monteiro, & d'Almeida, 2004; Prachayawarakorn, Sangnitidej, & Boonpasith, 2010; Reddy & Yang, 2009; Rockwood et al., 2011; Shubhra & Alam, 2011; Shubhra, Alam, & Beg, 2011; Sionkowska & Płanecka, 2013; Sutivisedsak, Cheng, Dowd, Selling, & Biswas, 2012; Yuan, Yao, Chen, Huang, & Shao, 2010; Zou, Reddy, & Yang, 2011).

Table 1. Mechanical and physical properties of natural fibres.

Fibre	Density (g/cm^3)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at Break (%)	Length (mm)	Diameter (µm)
Synthetic						
E-glass	2.5-2.59	2000 – 3500	70	2.5	-	-
Aramid	1.4	3000 – 3150	63.0 – 67.0	3.3 – 3.7	-	-
Carbon	1.4	4000	230.0 – 240.0	1.4 – 1.8	-	-
Natural						
Bamboo	0.6–1.1	140–800	11–32	2.5-3.7	1.5-4	25-40
Jute	1.3-1.49	320–800	8-78	1.5–1.8	1.5-200	20-200
Kenaf	1.4	223-930	14.5-53	1.5-2.7	-	-
Flax	1.4-1.5	345–2000	27.6-103	1.2–3.3	5-900	12-600
Sisal	1.33-1.5	363–700	9.0–38	2.0–7.0	900	8-200
Hemp	1.4-1.5	270-900	23.5-90	1.0-3.5	5-55	25-500
Coir	1.15-1.46	95-230	2.8–6	15-51.4	20-150	10-460
Ramie	1.0-1.55	400-1000	24.5-128	1.2-4.0	900-1200	20-80
Abaca	1.5	400-980	6.2-20	1-10	-	-
Baggase	1.25	222-290	17-27.1	1.1	10-300	10-34
Cotton	1.5 – 1.6	287 – 800	5.5 – 12.6	3.0 – 10.0	10-60	10-45

More commercially natural fibres used for composite material are flax, jute, hemp and ramie which have traditionally taken a secondary role in terms of consumption, functional and technical requirements. Barkoula, Garkhail, and Peijs (2010) worked on the utilization of flax fibre to reinforce polyhydroxybutyrate (PBH) employing injection moulding to investigate how the fibre and copolymer hydroxyvalerate (HV) would affect the mechanical properties of fabricated material. Bodros, Pillin, Montrelay, and Baley (2007) used flax fibre as a reinforcement for Mater-Bi®, Bionolle PBS, Ecoflex PBAT, polylactic acid (PLA), L-polylactide acid (PLLA) and polyhydroxybutyrate (PHB) using film stacking method to study the best fibre loading for the composite. Ouagne, Bizet, Baley, and Bréard (2010), had tried to refine the film stacking fabrication method by using flax reinforced PLLA as his products. He studied the parameters involved in this processing such as temperature, time, compressibility and permeability.

Ma and Joo (2011) studied on the effect of different fabrication conditions, such as fibre content, processing temperatures and alkali treatment on the mechanical properties and structure of jute fibre reinforced PLA using the film-stacking method. Goriparthi, Suman, and Mohan Rao (2012) also working with jute fibre to reinforce PLA but their focus was to improve the adhesion of jute fibre by surface modification using alkali, permanganate, peroxide and silane treatments. Reddy and Yang (2011) developed biodegradable composite using jute fibre and soyprotein using water without using any chemical as plasticizer using prepeg method to produce their composite. Many researches have been conducted by using sisal fibre as the reinforcement for biodegradable composites (Alvarez & Vazquez, 2004; Cyras, Vallo, Kenny, & Vazquez, 2004; Mishra, Tripathy, Misra, Mohanty, & Nayak, 2002). There are also a number of reports that focus on using one type of fibre such as hemp (Hu & Lim, 2007; Lopez et al., 2012), ramie (D. Chen, Li, & Ren, 2010), silk (Yuan et al., 2010), coir (Nam, Ogihara, Tung, & Kobayashi, 2011), kenaf (Ibrahim, Yunus, Othman, Abdan, & Hadithon, 2010), baggase (Cao, Shibata, & Fukumoto, 2006), flax (Ouagne et al., 2010) and bamboo (Huang & Netravali, 2009; Shih, Huang, & Chen, 2010).

Utilization of textile fibres in composite material has long been established. However, even utilization of high performance fibre is meant for medium load bearing. Even there is research used this high performance in high performance application, the distribution and contribution of this high performance fibre is just small. More so if the natural fibres use in composite material, it is usually catered for the low and medium load bearing application. A factor that could lead to this scenario is because the dispersion and distribution of fibre in composite material. The method of fabrication usually does not take into account the alignment of fibre which the fibres are not interconnected. It is also difficult to control the uniformity of fibres' distribution, which could lead a failure when a place with less fibre is subjected to any destruction force. There are still researches carried out to improve the properties of composite material reinforced with fibre forms so it can be used in many applications.

Yarns

Usual fabrication method of applying fibre in the form of yarn is filament winding. This process is primarily used to produce hollow, generally circular or oval sectioned composites such as pipes and tanks. For this purpose of fabrication, thermoset resin like polyester and epoxy is preferred.

Kaddour, Al-Salehi, Al-Hassani, and Hinton (1996), studied the burst strength of thin filament wound with 75º angle ply using aramid yarns to reinforced epoxy resin as subject matter, while Rousseau, Perreux, and Verdière (1999) investigated the influence of winding patters on the damage behaviour of filament wound pipes. W. Chen et al. (2007) worked on the new epoxy to investigate its adhesive properties. Using filament winding fabrication method, carbon fibre was selected to reinforce this new epoxy system. It is found that the interfacial properties in this composite system improved as well as its toughness. Arvin and Bakis (2006) studied the optimal design of press-fitted, cylindrical, filament wound composite flywheel rotor for producing composite. Utilizing carbon yarns and epoxy resin, they found that by using 5 – 8 press-fitted carbon/epoxy rings and tip speeds of 800-900 ms^{-1} they established the specific energies of 40-50 W.h/kg. He feels that this filament winding is quite costly method, Abdalla et al. (2007) in his work tried to design a low filament winding machine. His new fabricated machine, a lathe-type and wet winding method were used in the design of the machine and this machine able to produce glass, carbon and aramid yarns/tows reinforced polymer.

Recent works have also shown the utilization of natural textile yarn as reinforcement in composite material.. Huang and Netravali (2007) in their research to fabricate environment-friendly ‘green’ composite used flax yarn to reinforced soy protein concentrate. During composite fabrication, they used metal frame to wind the hemp yarns and applied small tension to minimize the yarn shrinkage and misalignment during the drying of resin. J. T. Kim and Netravali (2011) used similar method of fabrication with Huang and Netravali (2007). However, they used hemp yarn to reinforced soy protein concentrate resin processed at various pH values, and they intended to study the effect of pH on mechanical and interfacial properties. George et al. (2012) investigated the fabrication process of jute yarn reinforced, bidirectional thermoplastic commingled composite for treated and untreated samples. Using polypropylene yarn as a resin, jute yarn were wound onto a metal plate in a specific layer pattern using a fibre winding machine specifically designed for commingling. This commingled jute and polypropylene were then pressed under hot presser in different parameters. Even though, these workers using a different method of composite fabrication when dealing with yarns and tows, their method principle is quite similar with filament winding. In both method, yarns have to be straight and this could only be achieved by applying small tension on it. This is important to make sure the uniformity of fibres/yarns distribution and density in the composite material.

Other methods than filament winding can also be used for yarn form reinforcement which believably needs some alteration and assumption. For example, Shah, Schubel, Clifford, and Licence (2013) fabricated his sample by employing vacuum infusion to produce composite made of jute, hemp and flax yarns. Using unsaturated polyester resin as a matrix, he studied the fatigue data on natural fibre composites and this is an important parameter which limits their prospective use in fatigue critical components. From this study, he established the fatigue data of fabricate materials and compared with the e-glass/polyester composites. Utilization of textile yarn gives more control of the properties of composite materials. This is because the scattered fibres are combined and aligned in a group with or without twist given. Nevertheless, there is less of work considering the effect of yarn parameters such as yarn size, yarn twist and twist angle on composite material. Working with these parameters will gives us more input and knowledge on how the composite will react because the yarn properties change with the change of its parameters.

The existence of yarn form in reinforcement is very useful to manufacture circular and hollow material. However, the well-known and establish method of fabrication for employing this yarn limited only for filament winding in which the yarn will be wound onto a shape core before the resin is applied on it. Based on the discussion above, some other works try to use other methods of fabrication such as by winding this yarn onto the metal plate. However, this method is basically similar in principle with filament winding. Therefore, some works are needed to vary the processing method of composite material using textile natural yarn (even for high performance yarn) in order to enhance the potential of this kind form of reinforcement to its optimum performances.

Fabric

Scardino (1989) divided the textile structures or reinforcement forms into four categories; discontinuous chopped fibres, continuous filament yarns, simple fabrics (2-D) and advanced fabrics (3-D) systems. An interesting part to be discussed here is the usage of simple fabric and advanced fabric systems as reinforcement in composite materials. These kinds of reinforcement are preferably used by manufacturer or researcher due to it physical which easy to handle. Figure 5 shows some common textile fabric used as composite reinforcement (Lomov et al., 2005). Producing simple or 2-D fabrics of high performance fibres is commonly used either interlacing (weaving) or interloping (knitting) method. In weaving method, the fabric consists of interlacement of warp (length wise) and weft yarn (width wise). Knitted fabric consists of interloping yarns either in weft (weft knitting) or warp direction (warp knitting) directions.

There are a lot works done on using 2-D fabrics as reinforcement in composite material either for thermoset or thermoplastic resin. High performance fabrics usually dominate high performance application. Choi, Kim, Lee, and Seo (2011) used aramid fabric to replace E-glass for low-observable radomes since it has lower dielectric constant and higher strength than E-glass and it should have better electromagnetic wave transmission characteristics. This material is usually used in aircrafts, warships and missiles functioning to protect the radar antennas. In his work low-observable radome was constructed with a sandwich construction composed of aramid/epoxy. The mechanical properties were measured by means of 3-point bending test and then compared to those of the conventional which made of e-glass/epoxy.

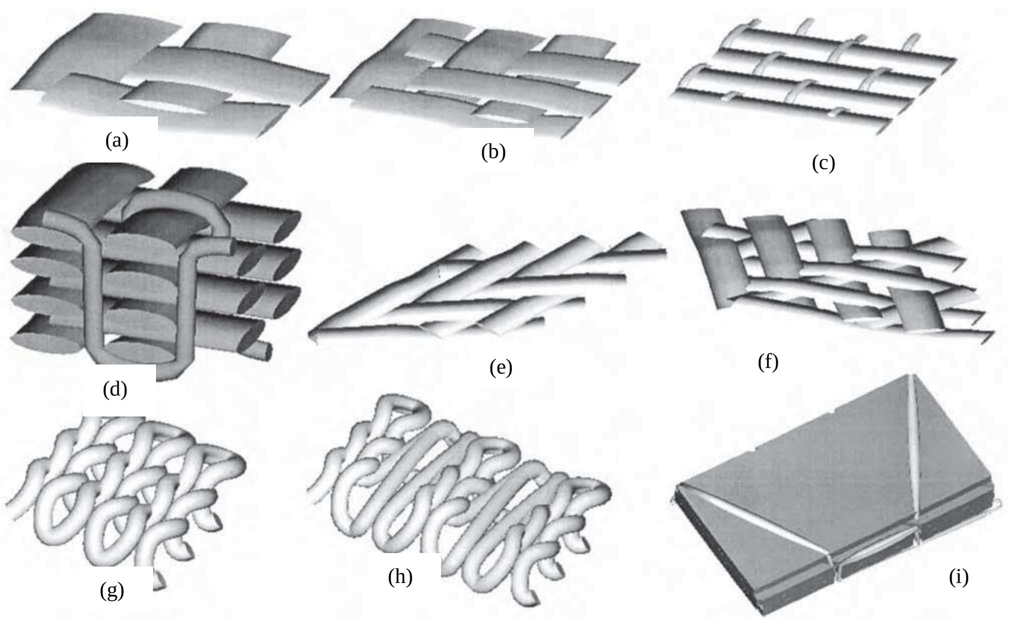


Figure 5. Structure of textile fabric; (a-c) 2-D woven fabrics, (d) 3-D fabric, (e-f) braided fabrics, (g-h) knitted fabric and (i) multiaxial multiply warp-knitted fabrics (Lomov et al., 2005).

Aramid fabric is very well known in protective industries due to its high strength and high impact resistance. It is also light and suitable to be used as lightweight ballistic protection or soft armour. Carrillo, Gamboa, Flores-Johnson, and Gonzalez-Chi (2012) in his work used aramid fabric reinforced polypropylene in composite laminate form as a new material for soft armour. He found that the thermoplastic polypropylene increases the ballistic performance of composite laminates. This is due to the existence of polypropylene which has good elongation properties when it subjected to tensile force. This enables Carrillo's material to have additional energy to absorbance hence improve its performance. In another work, Othman and Hassan (2013) investigate the role of aramid layer in soft armour emphasized on the different direction (0º and 90º) on fabric alignment. He found that the cross-ply aramid laminates could dissipate the impact energy up to 17% and also have the capability to stop the projectile at the minimum layer compared to the aramid which layered in one direction. There is a lot more researches in his area, yet there is still no assessment on the internal injury for the wearer. Aktaş, Aktaş, and Turan (2013) study the effect of stacking method of woven/knitted fabric of glass /epoxy hybrid composites on its impact behaviour while Russo, Acierno, Simeoli, Iannace, and Sorrentino () studied on the flexural and impact response of woven glass fabric reinforced polypropylene employing stacking film method fabrication. Glass fabric was also been used in construction fields. Gopinath, Iyer, Gettu, Palani, and Murthy (2011) used glass fabric to study its confinement effect when bonded with cementitious and organic binders. It was found that the existence of glass fabric enhances the load carrying capacity and ductility for both bonding materials (cementitious and organic binders). This material could be used as a confining system for retrofitting applications.

Fei, Li, Huang, and Fu (2012) studied the effect of phenolic resin on friction and wear performance of the composites using four kinds of carbon fabric using impregnation technique. His analysis has very close relation to the resin content of the composite fabricated and he found that the dynamic friction coefficient decreased with the increase of resin content, but the friction coefficient ratio increased. The sample with 25 wt% resin content possessed the best wear resistance due to the moderated combination between the carbon fibres and the matrix and good friction surface formation. This is one of the researches to enhance the performance of the carbon composite especially in automotive industry since this material has been used widely in a clutch system.

In sports fields, application of carbon fabric reinforced polymer had been studied by Ullah, Harland, and Silberschmidt (2013). This type of material is always exposed to various modes of damage and fracture under impact bending loads. Therefore, they studied these failure modes using experimental material characterization and numerical simulations and managed to developed numerical models which capable of simulate all damage mechanisms as well as their subsequent interaction observed. This is good research and it should be expanded to other high performance materials such as glass and aramid which could lead to very interesting results. Application of 3-D fabric is quite common for synthetic fibre especially in high performance fibre and this structure with natural fibre is almost none may be due to high cost on fabricating 3-D fabrics. Weaving, warp knitting, braiding, nonwoven and other specially modified techniques can manufacture a fabric with multi-plane structures. Woven fabric in the form of 3-D architecture employs multilayer and pile structures. However, it cannot produce thick structures as its shedding limits the number of layers possible. Thick structures are usually made using braiding technique, but it is limited in width. Knitted structures are normally made using warp knitting, but again, it is limited in thickness (Lomov, Verpoest & Robitaille 2005).

3-D fabric usually used in structural application, and it offers cost advantages to replace other isotropic which is usually more expensive. Interest in research and application of thick 3-D orthogonal weave reinforcement is fast growing. Bogdanovich et al. (2011) studied to enhance the performance of 3-D orthogonal woven e-glass composite's joint. A comprehensive experimental study was performed to determine the strength of several co-cured and adhesively bonded joints of composite panels. He found that stitching and stapling dry preforms resulted in a significant increase of the co-cured single-lap joint strength and tapering strap ends to as a small angle as possible was found to be the most effective method of increasing break force of double butt-strap bonded joints.

Carvelli, Pazmino, Lomov, and Verpoest (2012) worked on deformability a single-ply E-glass non-crimp 3D orthogonal woven reinforcement by comparing its properties to 2-D fabrics obtained from several deformation test modes while Cherif, Krzywinski, Lin, Schulz, and Haasemann (2013) suggested new process chain for producing complex 2-D/3-D weft knitted fabrics using glass yarn for thermoplastic composite applications. By using flatbed knitting that usually used for producing weft knitted fabric, he managed to produce near-net-shape or fully fashion multilayer weft knitted fabrics. This is very interesting work, since; the shapes of composite are limited and follow the available 2-D planar material. Using this knitting method, the reinforcement could be designed according to shape that we want seamlessly and this could result to good properties of composites.

Application of natural fibre (except those that are used for garment and apparel) in fabric form is also well established aligned with high performance fabric. However, their utilization is limit for non/low load bearing and semi structural application. There are many researches done on using natural fabric as composite reinforcement. However, there is a limit of choices on natural fabric because not all types of fibre can be converted into fabrics, especially in woven and knitted fabric. In order to convert a natural fibre into fabric, the diameter and length of fibre play important roles. This is because most of the weaving and knitting machine cannot process a fibre that too coarse and too short. Even it can be done, the method could not offer cost advantage and this remain a challenge for fabric manufacturers. Another way on converting natural fibre into fabric is by turn it into non-woven fabrics. A famous method on fabricating this is by using needle punch machine. A product from this method also calls fleece or felt but the real problem with this method is on how to make sure the homogeneity of fibre distributions because the uneven distribution will results to uneven mechanical properties of fabric and to some extent, to composite properties as well.

Jute fabric was used by Huang and Netravali (2007) to reinforced soy protein concentrate resin in their efforts to innovate fully environment-friendly, sustainable and biodegradable green composite. Their green composite exhibits excellent flexural properties in warp and weft directions. Unlike Huang and Netravali, Behera, Avancha, Basak, Sen, and Adhikari (2012) used jute felt o reinforced soy milk based resin and he found that composite having 60 % jute felt possessed the best mechanical properties and the novelty of his work is the resin preparation. Jawaid, Abdul Khalil, Hassan, Dungani, and Hadiyane (2013), by employing hand lay-up, prepared a composite made of epoxy resin reinforced with hybrid jute fabric and oil palm fibre and he expected this material to have a good potential in automobiles and building industry in near future. Barkoula et al. (2010) focused on short flax fabric reinforced composites based on polyhydroxybutyrate (PHB) and its copolymer with hydroxyvalerate (HV) employing compression moulding to study its biodegradability.

Hemp is another type of fibre that can be converted into fabrics. It popularity is getting higher lately due to its availability in different sizes and structures. Song et al.

(2012) examined the physical behaviour of hemp/poly(lactic acid) (PLA) composites, particularly the thermal properties and viscoelastic behaviour. He used twill and plain woven hemp fabrics as reinforcements by stacking film method. The twill structure was found to be suitable for reinforcing a PLA resin with higher impact strength and better mechanical properties than the plain woven. Hemp fabrics were also been used by Kabir, Wang, Lau, Cardona, and Aravinthan (2012) to form composite skins while short hemp fibres with polyester as a core for making composite sandwich structures, while Christian and Billington (2012) fabricated hemp fabric composite to reinforce poly(b-hydroxybutyrate) biopolymer in order to evaluate its feasibility for construction applications as replacements for wood or petroleum based composites. Michel and Billington (2012) claimed that biobased polymer composites have been shown to have suitable initial specific strength and stiffness for use in commercial applications yet the long-term performance of these materials under variable environmental conditions is largely unknown. Therefore, using fabricated composite made of hemp fabric poly-hydroxybutyrate (PHB) they performed accelerated weathering test.

There are a lot of work on using natural fabrics that have been published in many journals and academic writings. The work that was discussed above is just a small part in natural fabric composites. Nevertheless, there is a limit of work which considering the fabric parameters when dealing with natural fabrics such as, fabric density, fabric structure, arial density etc. These factors are very important to determine as the fabric properties will change with the changes of its parameter. Basically, fabric parameters are used to determine fabric properties which relate to its fibre direction, orientation as well as the fibre mass. Therefore, a work on considering these factors is necessary in order to understand their relationship with composite properties.

CONCLUSION

The definition of textile gives the understanding of the types and forms of textile materials. This is very important to understand and acknowledge the contribution of textile material as composite reinforcement. Even for fibre, yarn and fabric, the research is still carried out to enhance its composite material thus suit various applications. It is good to highlight several matters regarding to usage of textile material as reinforcement. The application of composite material reinforced with textile fibres forms basically limit to low and medium load bearing applications. Thus, research emphasized to improve the fibre reinforced composite to suit the purpose of application should be and will be continued. Whereas yarn reinforcement gives more control on the composite materials due to the fibres is aligned in a yarn regardless the twist is given or not. However, the established method of fabrication limits the usage of yarn and there is a need of fabrication process using this kind of textile material other than filament winding to ensure the varieties of end product of yarn reinforced composite. Utilization of textile fabric in composite as reinforcement is well recognized for high performance fabric so it is with natural fabric. Nonetheless, there is a limit of work considering fabric properties or parameters when characterize its composite to understand the fabric contribution in composite material.

On top of all research using natural textile materials, apparently, there is less research done on the assessment of the product life cycle for natural textile materials reinforced composites. This is important to put all the product concepts into the perspective in order to determine the product's survival and suitability for particular/designed purposes. Even though there are hundreds or thousands of work, as far as anisotropic material is concern, research and development of this kind of material will keep continuing due to variation of possibilities when utilizing textile reinforcement forms, matrices and applications.

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