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Investigation of Warp and Weft Knitted Fabric Acoustic Structures Derived from Garment Waste

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Abstract

The mechanical performance of knitted fabric was significantly affected by loop density and geometries. Knitted fabric composites occupy a special position in the field of engineering materials because of their easy to form complex components 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. Sound insulation requirements in automobiles, manufacturing environments, and equipment, generating higher sound pressure drive the need to develop more efficient and economical ways of producing sound absorption materials. The knitted fabric based acoustic materials were produced from cut wastes from different garment industries for their sound absorption property test as per the method described in ASTM E 1050. The acoustic performance of knitted fabrics was measured by independent tube methods for sound waves of 1000-6000 Hz. It is observed that the knitted fabrics acoustic materials prepared from waste materials showed high sound absorption than woven fabrics made from the same synthetic fibers. Moreover, the test revealed that blended knitted fabric had a better sound absorption property.

Keywords

Knitted fabric, Acoustic Properties, Independent Tube, Garment Waste

1. Introduction

Knitted fabric is the form of fabric manufacturing by interloping of a single yarn in the horizontal as well as vertical directions by using a knitting machine. Based on the inter looping direction of the looped structure, knitted fabrics are clas-

sified as warp and weft knitted fabric as shown in **Figure 1(a)** and **Figure 1(b)** [1] [2] [3] [4] [5]. Weft knitting is a method of forming a fabric by knitting means in which the loops are made in a horizontal way from a single yarn and intermeshing of loops takes place in a circular or flat form on a course-wise basis [6] [7] [8]. While Warp knitting is a method of forming a fabric by knitting means in which the loops are made in a vertical way along the length of the fabric from each warp yarn and intermeshing of loops takes place in a flat form on a length-wise basis. So Warp knitting is characterized by the structural threads of the fabric running along the length of the fabrics [9] [10] [11]. According to Wadje 2009 report, the mechanical performance of knitted fabric was significantly affected by loop density and geometries as shown in **Table 1**. Until recent time, knitted fabrics have been not effectively utilized as composite reinforcing materials. Similarly, Gommers in 1998, Pamuk and Çeken in 2008 reported that most manufactures focused on using woven and braiding textile materials in composite fabrications. There are two basic reasons why knitted fabrics did not attract researchers and manufacturers for a long period of time is that knitted fabric reinforced structures cannot carry heavy loads (lose their structure) and the required level of fiber contents is not achieved in the composite structures. Gommers in 1998 reported that for the last 10 years, these two assumptions are disproved by various research work and investigators. Knitted fabric manufacturing is one of the most versatile techniques for the textile fabrics fabrication processes. This is one of the most desirable properties for textile materials used as reinforcing structures. For knitted fabric reinforced composite, the knitted fabric structures are selected by three major criteria, the first criteria are knitted structure deformations, the second criteria is that physical and mechanical properties of the knitted fabrics and the third selection criteria are the curl nature of knitted structure. Composite materials reinforced by knitted fabrics have special properties and advantages: 1) Knitted fabrics having super drapability and deformation properties help for the formation of complex and interacted shapes without creating folds. 2) Advanced knitting machines are used for manufacturing the desired shapes. 3) Their versatility. These major properties have played a significant role in the overall properties of composite materials reinforced by knitted fabrics, to have better impact resistance, flexibility, excellent inter-laminar performance, lower fabrication periods and high fabrication rates [12] [13] [14].

A recently large amount of small scale garment industries has been generated. These garment industries are generated a large amount of cut pieces of cloths into the environments, are commonly called garment wastes. These huge amounts of waste materials had their own effect on global warming. Using wastes as raw materials have both economic and environmental advantages. Noise is a form of air pollution and like other forms of pollution, it affects the quality of the life [15] [16]. Noise accompanies distraction in the working place with consequent reduction in production, efficiency, accuracy and safety. The acoustic properties

of knitted fabric structures were influenced by several factors such as porosity of the yarn, orientation, distribution, quality of waste garment, volume of fiber fraction and the type of knitted fabric manufacturing (warp or weft knitting) used for sound absorption [17] [18] [19] [20]. This research work was focused on the effect of type of knitting mechanism and utilization of garment waste materials to generate additional income and also reduced industrial waste materials.

2. Materials and Methods

2.1. Materials

Warp and weft types of knitted fabrics were collected from different garment factories. Weft and warp kind of knitted fabric structures are used as reinforcing materials as shown in Table 1. Inter looping direction of the looped structure, knitted fabrics are classified as warp and weft knitted fabric as shown in Figure 1(a) and Figure 1(b). The knitted fabric structures were interloped from different fibers such as natural fibers, manmade fibers and blended fibers. Knitted fabric wastes have a significate effect on the acoustic properties due to their high loop length and these loops would hold the spikes while opening.

2.2. Method

The collected knitted waste fabrics were opened and the acoustic structure was

Table 1. Characteristics of weft and warp knitting fabric.

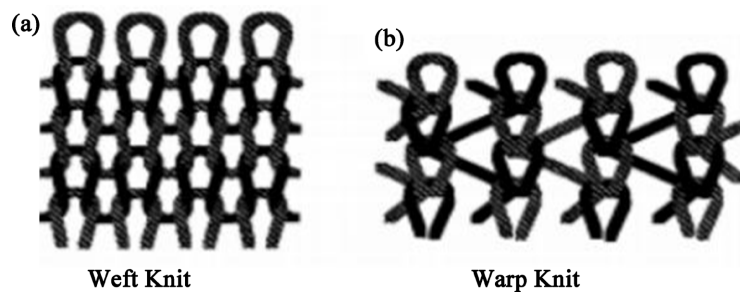| Weft knitted fabrics	Warp knitted fabrics
Threads are run in vertical direction	Threads are runs in horizontal direction
Highly elongation	Less elongation
Required one yarn	One thread is required for each needle
The course is equal to the pattern	Higher course is needed for a pattern
Elongated in width direction	Elongated lengthwise
Appropriate for thin fabric production	Appropriate for fabrication of course materials
Has a Problem of shrinkage	Good shrinkage resistance
Thread is feed from a single cone	Yarns are feed from beams

Figure 1. Type of knitted fabric structure.

processed through sequence of mechanism by the principles of mechanical web laying technique and aero dynamic principle and chemical bonding (like non-woven manufacturing techniques) as shown in **Figure 2**. The impedance tube method was used to determine sound absorption coefficients of the knitted fabric reinforced composite structures as shown in **Figure 3**. ASTM 1050 standard was used for these studies. The specimens were prepared based on the standard and the test was conducted. The average test result was used for test results interpretation.

Impedance Tube (50 Hz - 6000 Hz) consists of:

- A 100 mm diameter tube (large tube);
- A 29 mm diameter tube (small tube);
- Sample holders (29 and 100 mm);
- Extension tubes (29 and 100 mm).

3. Results and Decisions

3.1. Acoustic Properties of Warp Knitted Fabric from Garment Waste

The test result revealed as **Figure 4** shown below was summarized as the samples of 30 mm diameter of retrieved weft knitted fabric produced by chemical bonded mechanism with large tube impedance tube in the frequency range of 1000 Hz to 6000 Hz. The non-laminated sheet reaches 0.96 of sound absorption at the frequency of 4000 Hz, which is porous natured, the laminated sample shows 0.96 of sound absorption at the same frequency due to blocking of pores,
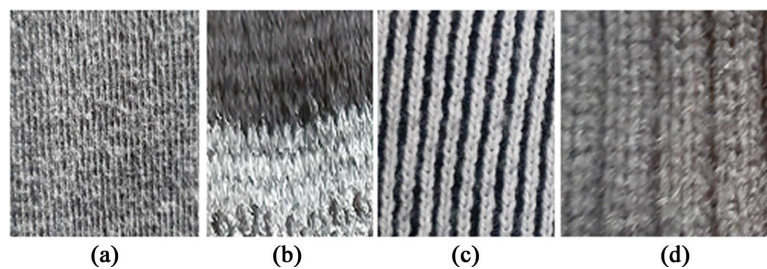

| (a) | (b) | (c) | (d) |

Figure 2. Specimens used for acoustic test (a) nature fiber, (b & c) manmade fibers and (c) blended fibers.
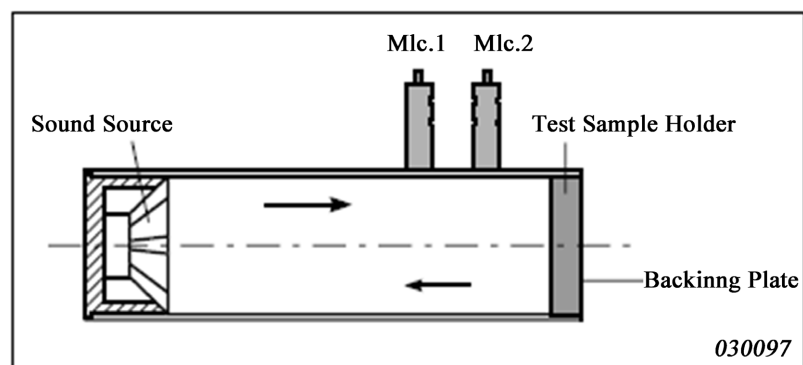

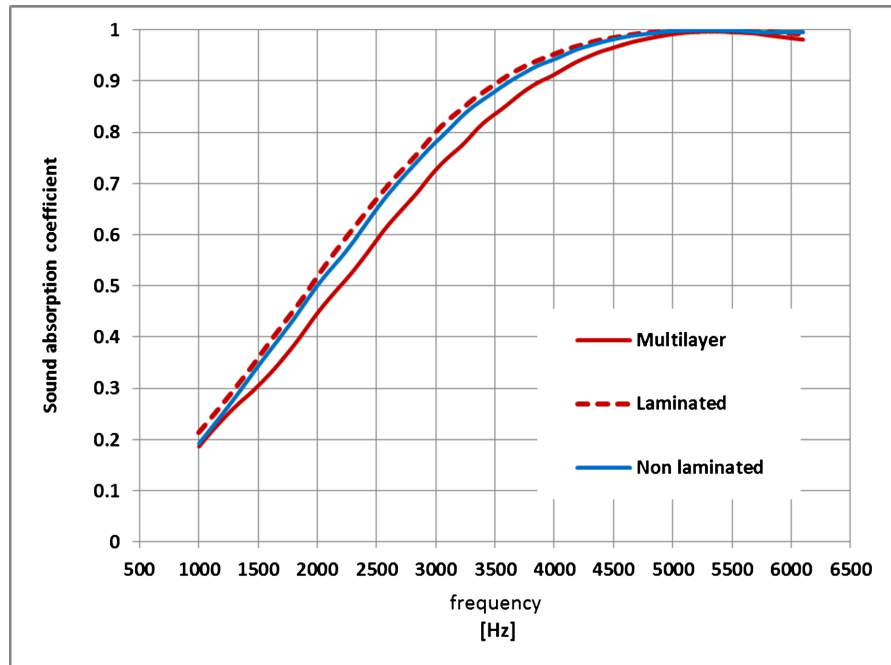**Figure 3.** Acoustic properties test with impedance tube.

Figure 4. Non laminated, laminated and multilayer weft knitted fabric sound absorption properties.

whereas the multilayer samples shown due to calendar compression of the sheet reach the sound absorption at the level of 0.91%.

3.2. Acoustic Properties of Weft Knitted Fabric

The needle punched Warp knitted fabric samples produced from blended three different fibers, these are Enset, jute and cotton with 30 mm diameter and the sample were prepared by the needle punched fabric manufacturing mechanism like nonwoven. The test result was summarized in Figure 5. The coir/jute [50/50] and the coir/enset [50/50] shows near 40% in sound absorption, rather the jute/enset with a ratio of 50/50 had sound absorption coefficient values of 0.92, 0.86 and 0.63 at the frequency of 3000 Hz respectively.

3.3. Sound Absorption Properties of Garment Waste from Knitted Fabric Made of Viscose, Wool, Cotton and Their Blend

The four knitted fabric specimens made from cotton, wool, viscose and their blend having 30 mm diameter where tested for their acoustic properties as shown in Figure 6. The test results revealed that all the specimens had nearly similar sound absorption coefficient values at lower, medium and higher frequency regions, the maximum sound absorption coefficient values were recorded 0.98 at the frequency of 5500 Hz.

4. Conclusion

The test results revealed that the acoustic materials made from knitted fabric produced from short fiber yarns such as cotton, wool, jute, enset as well as continuous
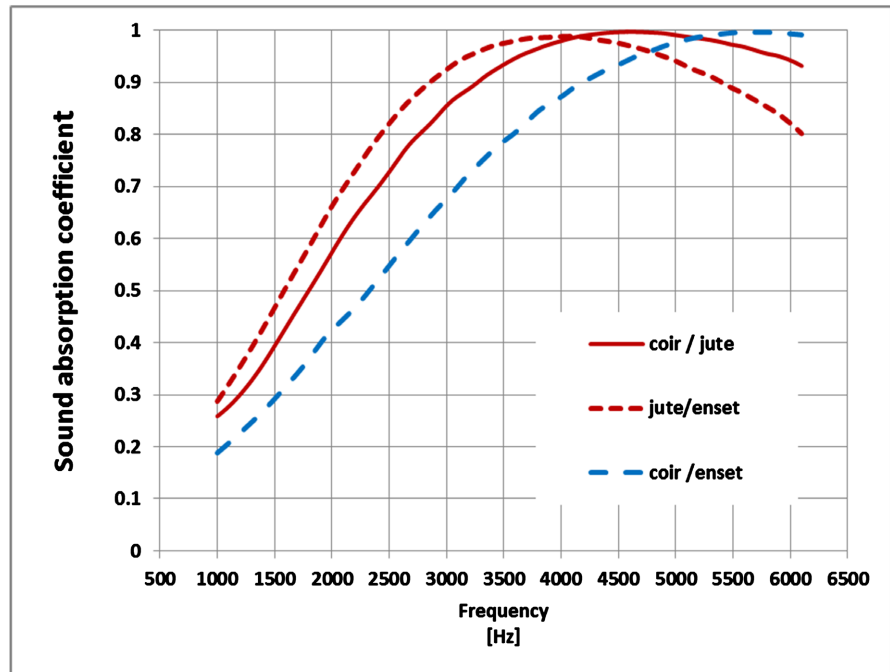
Figure 5. Acoustic properties of blended warp knitted structure coir/jute, coir/enset and jute/enset.
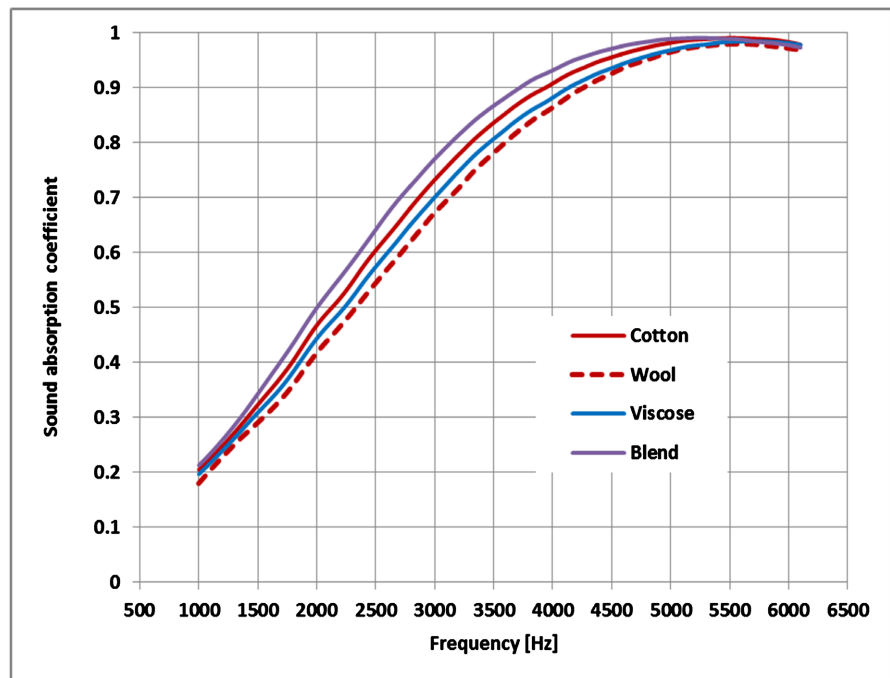

Figure 6. Acoustic properties of knitted fabric made from cotton, wool, viscose and Blended fiber.

filament yarns like viscose were effective for weft knitted fabric while only fila-ment yarns can be effective in warp knitted fabric. It is observed that the knitted fabrics acoustic materials prepared from waste materials had a promising future as a cost-effective sound absorbs orbing material. Moreover, the test revealed

that blended knitted fabric had a better sound absorption property. Many efforts are currently being made to limit the environmental impact of textile production: well-known brands have lately supported strategies devoted to the use of recycled materials, the reduction of solid waste, and the wastage of raw constituents; non-profit institutions have really been formed to certify companies that use pre- or post-consumer waste in their products; and, finally, scientific research has investigated the potential valorization of textile waste.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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