Acoustic absorptive properties of Kapok fiber, Kapok fiber layered tricot fabric and Kapok fiber layered double weave fabric

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Abstract. Kapok fiber was one of the natural cellulosic fiber that can be found widely in Asia’s forest especially in Indonesia. Kapok fiber was short and smooth surface causing poor interfiber cohesion that could not be processed in spinning. This fiber could be utilized to be acoustic sound proofing material. This research investigated about absorptive properties of non woven kapok fiber (SK) and its layered combination with tricot knitted fabric (TC) and double weave fabric (DWK). Combination of various kind of fabric’s type improved thickness and air cavity that impact absorptive properties of fabric. Impedance tube were used to characterization sound absorptive properties at low until normal frequency on 100 until 5000 Hz. The optimum sound absorptive were showed by combination of non woven kapok fiber with double weave fabric with thickness 11.25 mm. It shows thickness impact to air cavity and gave significant effect to sound absorptive properties.

1. Introduction
Prolonged exposure to noise pollution has harmful effect for human health. Noise exposure could cause cognitive decline and health problem such as high stress level, sleep disturbance, hearing impairment and cardiovascular effect. According to WHO, more than 30% of the population in EU countries is exposed to noise exposure at night. The growing awareness towards engineering and research to obtain sound absorbing material as noise control. Sound absorbing material are generally made from synthetic fiber that consumes high energy level on production process. In contrast, sustainable material have good potency as sound absorbing materials [1]. The previous research shows that natural kenaf fiber [1] and Pineapple leaf fiber [2] gave good results as sound absorber material. Kapok fiber is one of natural fiber that have good potency as sound absorber material. Kapok fiber have good potency as sound absorbing material due to its special properties that increase the chance of friction between sound wave and fibers [3]. Kapok fiber is a buoyancy material, combining kapok fiber with low melting fiber can improve the buoyancy characteristic of kapok fiber assemblies [3]. The previous research shows kapok fiber with smaller bulk density compared with glass wool gave similar absorbancy coefficient [3]. The recent research shows that combining kapok fiber with polypropilene fiber provide very good sound absorption behaviour in 250 – 2000 Hz [4]. Production of kapok fiber as sound absorber material required less energy and less chemical compound.

Textile plays important role in sound absorber material. There was some factor that give significant impact on sound absorbing material such as bulk density, thickness and arrangement of fiber [1]. Knitted and woven are potential for sound absorbing material, although, both of them have microperforated acoustic absorption panel, they have different acoustic absorption mechanism[5]. Sound absorption properties of knitted fabric are highly influenced by fabric structure [6]. In the other hand,
Non woven fabric contains micron and submicron pores making them preferred as sound absorbing material [7]. There is many factors that can improve sound absorptive properties of non woven fabric, such as fiber parameters, process parameter and physical parameters [8]. This paper focuses on assessment kapok fiber and its layered combination to absorbance properties.

2. Methods Research

This research were used three types of fabric: tricot knitted fabric, double weave fabric, and non woven fabric from kapok fiber. All fabric were made in Polytechnic STTT Bandung. Tricot knitted fabric were produced on Double Needle Knitted Fabric RD7/2-12 EN/119740 (Karl Meyer, Germany) using polyester fiber 100%. Structure of tricot knitted fabric shows on Fig. 1.

Double weave fabric were produced on Toyoda Machinery using 1/3 twill effect on top surface and 3/1 twill effect for bottom surface as seen on Fig. 2. Cotton fiber are used as materials on double weave fabric.

3. Result and Discussion

3.1. Morphological Structure

Sound absorption properties is highly influenced by morphological structure of fiber. The cross sectional of kapok fiber as shown in figure 3, denote irregular oval to round shape. The longitudinal
view shows a hollow morphological structure, a special structure on natural fiber that play role on sound absorption properties.

![Figure 3. Morphological structure of Kapok fiber](image)

Buoyancy behaviour on kapok fiber are affected by hollow structure. These characteristic makes kapok fiber has high porosity resulting improvement on sound absorption properties. Large diameter of cross sectional kapok fiber increases friction resistance between air and fibre, resulting dissipation of energy [13]. This unique structure enabled the air of sound wave diffuse between and into the fibre.

3.2. Thickness

Thickness was observed in each sample as shows in Figure 4. Data in figure 4, indicates thicknes on this research was not give significant impact. Although TC Fabric was the highest thickness, DWK fabric absorb sound more effective than other fabric. This phenomena conducted due to Tricot fabric and non woven kapok fiber have high thickness because of spacer apart the fabric, but the space area was highly loose and open structure. The sound energy could through the fabric easily, caused sound energy transmitted. This phenomenon are suitable with previous research, that explain the fabric with loose open structure has lowest sound absorption properties [14].

![Figure 4. Relation between Thickness and Sound Absorption Coefficient](image)

3.3. Density

Sound Absorption coefficient on various sample was observed. Graphic in Figure 5 shows all sound absorber material give similar coefficient absorbancy, 0.98, at High frequency 5000Hz. Otherwise non woven kapok fiber layered by double weave fabric (DWK) give the best results at frequency between 1600 - 3160Hz compared with single non-woven kapok fiber (SK) and kapok fiber layered by tricot fabric (TC), there was 0.95, 0.89, 0.90 respectively. This phenomenon due to complex pores structure on DWK cause the sound wave trapped on the fabric and absorb to the fabric. Twill effect on double
layer woven fabric obstruct sound energy to release. In the other hand, Tricot fabric have perforated structure with big pores it cause the energy are released easily.

![Figure 4. Sound Absorption Coefficient on Various Fabric](image)

Density is the most important factor on sound absorption properties. Dense properties of sound absorber were affected by material and web formation of material, as shown in Figure 6.

![Figure 5. Relation Density of Fabric to Sound Absorption Coefficient](image)

Figure 5 shows relation between density of various fabric to sound absorption coefficient on the range frequency 500 – 5000 Hz. DWK fabric have high density however the density is still can absorb the sound energy. Double weave fabric has open structure forming flexible complex pores between warp and weft. This structure impact to high friction and resistance between air and fiber. DWK were composed by cotton and kapok fiber. Both of this fiber have good absorption properties resulting good absorption properties on DWK fabric.

4. Conclusion

Textile has potential properties as sound absorber material. Woven, knitted and non woven fabric are most commonly textile product that could be used as sound absorber material. This material could absorb the sound energy and convert into heat energy. Fiber material, thickness, and density of sound
absorber material are major factors that impact significantly to sound absorption properties. Non woven kapok fabric layered by double weave fabric give good result in absorbing sound at range frequency 100 – 5000 Hz.

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