Study of the Mechanical & Sound Absorption Properties of Natural Fibre (Corn Husks) as Reinforced Composite

by

Mohamad Aizat bin Mohd Radzman

16273

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical Engineering)

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CERTIFICATION OF APPROVAL

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Approved by.

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(Mr. Kamal Ariff Zainal Abidin)

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SRI ISKANDAR PERAK

MALAYSIA

May 2015

CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(MOHAMAD AIZAT BIN MOHD RADZMAN)

ABSTRACT

Recent years have shown that the increase in noise pollution have become a problem in developing countries. The dependency on fossil fuel products, primarily plastic products is also a concern as environmental awareness and the issues of sustainability is much more discussed.

This research studies the sound absorption and mechanical properties of corn husks fibres as reinforced composites. Cornhusk fibre –Polyporpylene (CHF-PP) composites were made through compression moulding. Tests conducted were following the ASTM standard, C423 Standard Test for Sound Absorption and Sound Absorption Coefficient by the Reverberation Room Method and D638 Tensile Properties of Plastics.

The results shows that CHF-PP composite has an affective sound absorption capability and the tensile strength increases with the increase in fibre ratio.

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CHAPTER 1

INTRODUCTION

1. Background of Study

Natural fibers are in much more use as more awareness for the usage of green technology in the engineering industry has arisen. The following paper will discuss the mechanical properties of the natural fiber specifically, corn husks as reinforced composite and its viability as substitute for fossil fuel-based polymers, as well as its capability as a sound dampening material.

The increase usage of natural fibres such as corn husk and cob, hemp, jute and kenaf, this is especially prominent in the automotive industry where the usage of natural fibers is high. Automobile manufacturers such as Audi have been using natural fibres to manufacture boot lining and the panes for the back and side doors, while BMW uses natural fibres from kenaf to manufacture door, headliner and noise insulation panels. The usage of natural fibers as a replacement for wood or plastic products can provide a more environmentally safe solution to meet the needs of the increasing world population.

Most natural fibers that are plant base are lignocellulosic fibres, i.e. that they comprise of both lignin and cellulose. Lignocellulosic fiber can be considered self-reinforcing, as the lignin is a natural resin and cellulose the reinforcing fibre. A vital point why lignocellulosic fibers are chosen as composites is that it is abundant, cheap and strong. Thus, fibers such as jute are widely used (Thakur & Singha).

Corn husks have been in used to replace synthetic fibres made from petroleum derivatives within the textile industry. The renewability of corn husk makes it a potential substitute for synthetic fibers currently in use, reserving the non-renewable resources that is continually depleting, this include forest reserves and petroleum reservoirs(Reddy & Yang, 2005).

Natural fibres are fabricated as thermosets or thermoplastics. Thermoplastic are made by mixing the fibre with additives to get a composite. Thermosets are made by crosslinking the fibres together through a curing process.

The increase in noise pollution specifically in developing countries due to the huge amount of construction and the increase in traffic on the roads presents an opportunity to look into corn husk fibre as a sound dampening material.

Understanding the mechanical and sound dampening properties of the composite is important as it has the potential to be utilised in multiple industry. Thus, tests will be conducted to determine these properties and a suitable composite must be selected for comparison of data, in this case petroleum based polymer are chosen as the comparative material.

2. Problem Statement

The increase in noise pollution especially in urban areas, due to the high volume of traffic and construction can cause mental health to deteriorate.

Currently the market is dominated by petroleum based materials, that are environmentally harmful are in use. These materials are also costly due to the limited resources of fossil fuels (petroleum).

3. Objective

The research conducted will attempt to answer the following question, "What are its sound absorption properties as well as mechanical properties of a composite made from corn husk fibres and its viability as a substitute for fossil fuel-based composites?" by fabricating a composite made of corn husk and conducting the necessary tests.

4. Scope of Study

The corn husk fibre will be processed and fabricated into a composite through compounding with polypropylene. The material will be tested to determine its sound absorption coefficient to evaluate its effectiveness in noise reduction. Tests that will be carried out will be conducted to determine the aforementioned properties (tensile) and the results will be compared with the mechanical properties of a petroleum based polymer.

CHAPTER 2

LITERATURE REVIEW

This section of the proposal paper will try to discuss previous researches that were conducted on the subject matter.

1. Cornhusk Fibres (CHF)

Corn is one of the grains that Malaysia grows in abundance; in the year 2014 the average produce for corn is about 56000 metric tonne(Agriculture, 2014). Corn husks which are lignocellulosic is usually thrown away or used as compost fertilizer as only the main part of the corn that is processed are either the kernel only or the kernel along with the cob. Thus, huge amount of husks that are thrown away presents an opportunity for it to be recycled into a more useful product. From nearly 24 million tonnes of cornhusks co-produced annually in the United States alone, approximately 5 million tonnes of corn can be produced as fibers to be used in composites with better sound absorption and higher flexural and tensile strength compared with jute/PP composites, although flexural and tensile moduli of the former are inferior. Furthermore there is possibility for improvement wherein the fibres manufactured are of finer quality could enhance the mechanical properties of the corn husk fibre (Huda & Yang, 2008).

The increase usage of natural fiber as a substitute for fibre glass has been seen especially in the automotive industry. Reasons for this is that natural composite fibres are process friendly, does not have a high specific weight, it does not wear out tooling and it provides excellent thermal and acoustic insulation (Huda & Yang, 2008). The drawbacks of natural fibres are that they are susceptible fire and have considerably low durability. The prices of natural fibres are also not stable due to the reliance on the annual yield of crop harvests. Natural fibres also tend to be hydrophilic, thus it absorbs moisture well, but this can be avoided by alkalization (Huda & Yang, 2008).

Thermoplastic uses bio-fibres as reinforcement material, by compounding the fibres with a polymer matrix. The polymer matrices used for example are propylene (PP), polyethylene (PE), and polyvinylchloride (PVC) (Puglia, Biagiotti, & Kenny, 2005).

Table 1 (Thakur & Singha) shows the type of natural reinforcement fibre and the respective thermoplastic polymer matrix that is used.

Table 1 Thermoplastic Matrix-Natural Fibre Composite

Fiber	Thermoplastic Matrix
Cellulose	PP, PE, PA66, PS, PVC
Flax	PP,PE
Jute	PP,PE
Abaca	PHBV
Sisal	PP, PE, PS
Kenaf	PP
Ramie	PP
Broom	PP
Henequén	PE, PVC
Bagasse	PP
Bamboo	PP
Pineapple	PE
Wood Flour/Fibre	PP,PE,PS, PVC

Corn husk composite has already been researched to an extent. According to S.S.Musil composites made of "corn husks show moderate strength and high elongation to failure equating to high work of rupture for a natural fiber which acts as a toughening mechanism for this biocomposite." (Musil, Keane, & Kriven, 2013)

Figure 1 Unprocessed Corn Husk

The strength of a natural composite material comes from the lignocellulosic fibres that make up the natural fibre. The material strength also depends on the chemical interaction between the reinforcement fibre and the polymer matrix. As stated above most natural fibres are hydrophilic in nature, while the polymer matrix is hydrophobic. Through alkalization the treatment of the polymer matrix the hydrophilic nature of the reinforcement and the hydrophobic nature of the polymer matrix can be reduced to get a stronger composite. Through alkalization the number of cellulosic materials can be increased creating a rougher material to be worked with. Table 2 shows the content of corn husk fibre (CHF) before and after alkalization. (Huda & Yang, 2008)

Table 2 Constituent of Corn Husk Fibre (CHF) Before and After Alkaline Treatment

Constituent	CHF	CHT from Alkalization
Cellulose (%)	42.31±0.69	64.52±0.46
Lignin (%)	12.58±0.21	6.40±0.42
Ash (%)	4.61±0.26	0.75±0.06
Other (%)	40.95	28.33

The researches that has been conducted to show the viability of corn husks as fibres has been conducted in recent years. Huda S. and Yang. Y (2008) have chemicaly extracted corn husk fibres and examined its mechanical properties and sound absorption properties. Their research focuses on the ratio of propylene and corn husk fibre to its mechanical properties and sound absorption coefficient. The results were then compared to a jute-propylene composite that has been in used within the automotive industry as a replacement for fibre glass. Table 3 shows the mechanical properties of the corn husk fibre-propylene composite and compared to jute-propylene composite, it can be seen that the cornhusk-propylene composite has a higher flexural strength and lower flexural modulus, higher impact resistance, lower tensile strength and tensile modulus. But they have explained that CHF has a higher percentage of elongation, CHF 15.3% versus jute, 1.1%. The sound absorption properties were evaluated to be decent as shown in figure 2. (Huda & Yang, 2008)

Table 3 Comparison of CHF-PP and Jute Fibre-PP Composites(Huda & Yang, 2008)

Composite Material	Concentration of reinforcing fiber	Flexural strength	Flexural modulus of elasticity	Impact resistance	Tensile strength	Tensile modulus
	wt.-%	MPa	MPa	$J \cdot m^{-1}$	MPa	MPa
CHF/PP	40[a)]	12.0 ± 0.1	1073 ± 96	106.0 ± 12.5	10.0 ± 0.9	301.8 ± 22.7
	30[b)]	9.1 ± 0.9	792 ± 61	75.2 ± 9.9	8.6 ± 0.8	310.4 ± 33.0
	35[b)]	10.9 ± 0.9	953 ± 52	104.0 ± 9.0	8.9 ± 0.8	262.4 ± 29.6
	40[b)]	10.6 ± 0.9	924 ± 40	103.3 ± 9.2	7.3 ± 0.5	223.5 ± 14.7
	50[b)]	7.8 ± 0.9	658 ± 91	68.9 ± 14.5	6.0 ± 0.6	172.7 ± 13.6
	60[b)]	7.0 ± 1.0	614 ± 119	55.3 ± 11.3	3.8 ± 0.3	124.4 ± 7.2
	70[b)]	6.3 ± 0.9	544 ± 108	51.2 ± 11.9	3.1 ± 0.4	101.5 ± 8.3
Jute/PP	40[c)]	8.4 ± 1.6	1280 ± 54	81.2 ± 8.0	10.6 ± 1.0	597.8 ± 30.1
	50[c)]	9.1 ± 0.5	1455 ± 72	123.6 ± 5.4	11.1 ± 0.9	483.3 ± 47.2
	60[c)]	9.0 ± 0.4	1830 ± 95	111.2 ± 9.6	7.0 ± 0.4	466.2 ± 28.6
	70[c)]	7.7 ± 0.3	1677 ± 65	83.8 ± 8.1	4.5 ± 0.4	328.6 ± 24.6

[a)]CHF extracted using caustic and further treated with pulpzyme and cellulase; composites at the optimized condition; compared with jute/PP composite at 60%; [b)]CHF extracted using caustic; [c)]Jute extracted through natural retting process without any chemicals; compared with CHF/PP composite at 40%.

2. Polypropylene (PP)

Polypropylene (PP) is a semi-crystalline thermoplastic, viscoelastic material that is produced by polymerization of propylene molecules. According to Karian(Karian, 2003), PP has excellent physical, mechanical and thermal properties when it is used in room temperature applications. It is relatively stiff and has a high melting point which is at 130 ^{0}C, its crystalline melting point ranges from 160-170 ºC, low density and relatively good resistance to impact. Besides, it provides good fatigue resistance, good chemical resistance, good environmental stress cracking resistance, good detergent resistance and excellent hardness(Addeo, 2005). As the properties of PPs cover an extensive range, thus its applications are quite diverse.

There are two type of polypropylene, which are homopolymer PP (HPP) and copolymer PP. PP that contains only propylene monomer in the semi crystalline solid form is referred to as HPP while PP containing ethylene as a comonomer in the PP chains is referred as copolymer. Homopolymer PP are more rigid and have better resistance to high temperature than copolymers, however their impact strength at temperature below zero is limited. Applications of homopolymer PP include windshield washer tanks, housing for domestic appliances, clothing, medical fabrics and automotive interior fabrics. As for copolymerized PP, it gives softer feel to film and fibre products compared to homopolymer. It is mostly used for battery cases, bumper filler supports, interior trim, gloves box, package trays and window mouldings, office chair, disposable container, boxes and housing appliances.

Furthermore, as PP is considered as semi-crystalline polymer, thus its crystallinity is also one of the concerns. The degree of crystallinity and crystal structure in a polymer depends on its thermal history. The formation of crystals can be suppressed by rapid cooling and give a tough clear product. In other words, slow cooling of the product leads to a brittle and hazy product. However, different degree of crysallinity has different advantages. PP with higher crystallinity has better hardness, modulus, strength, chemical resistance, barrier properties etc. while low crystallinity has better transparency and good processibility.

As for the safety of processing PP, it is claimed that it does not cause hazardous to health, but it can release volatile organic compounds into the surrounding air during high-temperature processing.

3. Mechanical Analysis

Mechanical analysis is performed in order to test the physical properties of the material under variety of testing regimes. Tensile properties such as tensile strength and tensile modulus can be determined using tensile tests. These tests measure the force required to elongate a specimen to its breaking point, material properties such as the material tensile strength, elongation at break and the elastic modulus can be determined. Tensile strength is the maximum force measured divided by the original cross-sectional area. This point is also known as Ultimate Tensile Stress (UTS). The formula is shown as below.

$$Tensile\ Stress = \frac{Load\ at\ Break}{(Original\ Width)(Original\ Thckness)}$$

Elongation at break is the observed strain, percent strain or draw ratio that occurs immediately prior to the sample failure. As for elastic modulus, it is defined as the ratio of tensile stress to tensile strain.

4. Sound Pressure Level and Absorption

The increase of noise pollution in Malaysia is also a concern for the public. As mentioned by S. Yusoff and A. Ishak. Their research show that 60% of interviewees found that the noise pollution surrounding them is disturbing. WHO has determined that sound levels that are considered non-hazardous to human health are 50dB at day and 45 dB at night, while Malaysian law regulates the sound level to be 50dB at both day and night. Current sound levels in urban areas the research focuses on have a sound level of more than 65dB at day and more than 50dB at night. causing concern on the health of the surrounding citizens. (Yusoff & Ishak, 2005)

Sound pressure level or the intensity of noise can have an effect on human's ability to hear(OSHA, 2002). The top limit for noise level exposure is 90dB over an eight-hour period. Table 4 below shows the sound pressure levels, the associated source of the particular noise and the effect of exposure.

Table 4 Sound Pressure Levels Source and Effects(OSHA, 2002)

Sound Pressure Level (dB)	Source(s) of Noise	Effect
80	city traffic, manual machine, tools	
90	subway train, lawn mower, motorcycle, tractor	Prolonged exposure to any noise above 90 decibels can cause gradual hearing loss.
95	Electric drill	.
100	Woodworking shop, factory machinery;	Recommend avoiding more than 15 minutes of unprotected exposure
110	Chainsaw, leaf blower	Regular exposure of more than one minute risks permanent hearing loss.
120	Ambulance siren, pneumatic drill, heavy machinery, jet plane on ramp	
130	Jackhammer, pneumatic drill, air raid	
140	Airplane taking off, rock concert, firecracker	

Sound striking a surface will be partially absorbed and transmitted by the contact surface. Both of these amounts are lost from the room, and the fractional loss is characterized by an absorption coefficient α which can take values between 0 and 1, where 1 being a perfect absorber. The Table 5 below shows the average sound absorption properties of some surfaces.

Table 5 Sound Absorpion Coefficients for Common Surfaces (Hall, 1991)

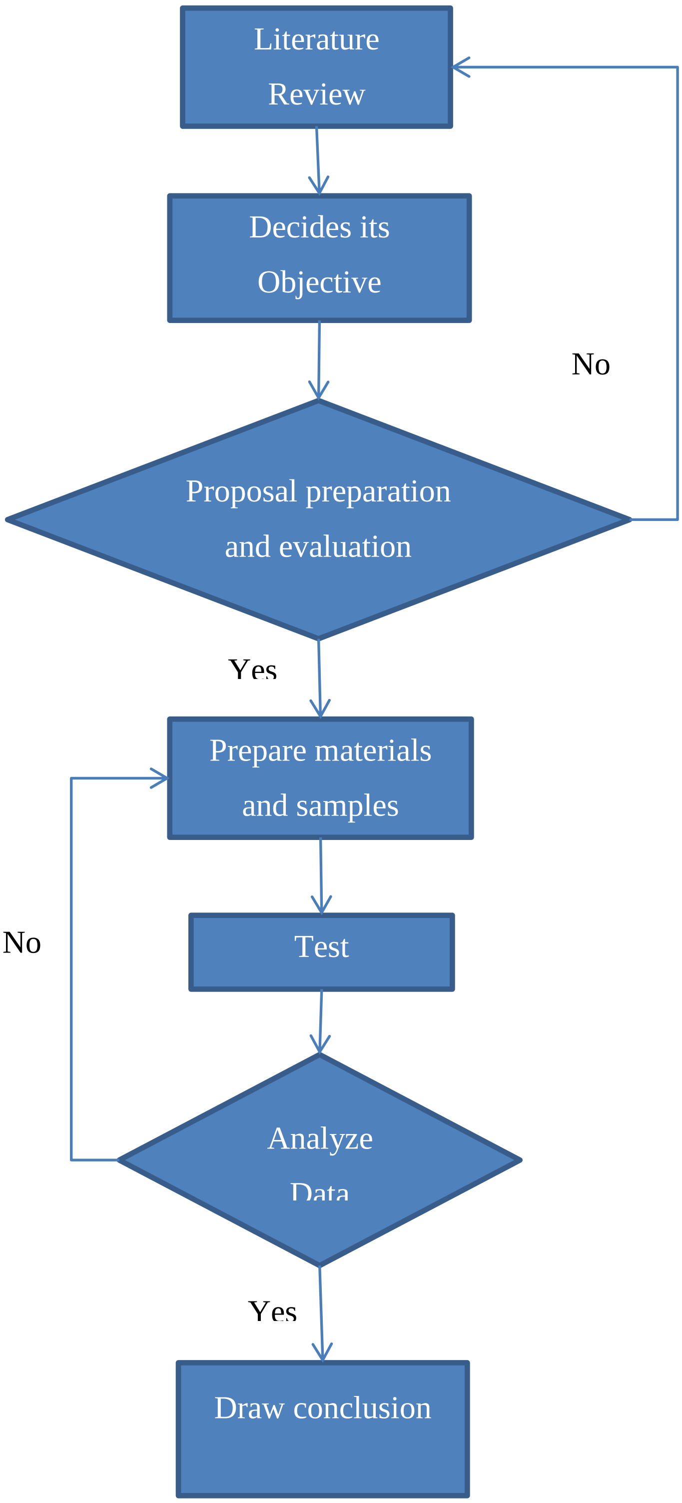
Nature of surface	**Sound Absorption Coefficients at Frequency(Hz)**					
	125	250	500	1000	2000	4000
Acoustic tile, rigid mount	0.2	0.4	0.7	0.8	0.6	0.4
Acoustic tile, suspended	0.5	0.7	0.6	0.7	0.7	0.5
Acoustical plaster	0.1	0.2	0.5	0.6	0.7	0.7
Ordinary plaster, on lath	0.2	0.15	0.1	0.05	0.04	0.05
Gypsum wallboard, 1/2" on studs	0.3	0.1	0.05	0.04	0.07	0.1
Plywood sheet, 1/4" on studs	0.6	0.3	0.1	0.1	0.1	0.1
Concrete block, unpainted	0.4	0.4	0.3	0.3	0.4	0.3
Concrete block, painted	0.1	0.05	0.06	0.07	0.1	0.1
Concrete, poured	0.01	0.01	0.02	0.02	0.02	0.03
Brick	0.03	0.03	0.03	0.04	0.05	0.07
Vinyl tile on concrete	0.02	0.03	0.03	0.03	0.03	0.02

Heavy carpet on concrete	0.02	0.06	0.15	0.4	0.6	0.6
Heavy carpet on felt backing	0.1	0.3	0.4	0.5	0.6	0.7
Platform floor, wooden	0.4	0.3	0.2	0.2	0.15	0.1
Ordinary window glass	0.3	0.2	0.2	0.1	0.07	0.04
Heavy plate glass	0.2	0.06	0.04	0.03	0.02	0.02
Draperies, medium velour	0.07	0.3	0.5	0.7	0.7	0.6
Upholstered seating, unoccupied	0.2	0.4	0.6	0.7	0.6	0.6
Upholstered seating, occupied	0.4	0.6	0.8	0.9	0.9	0.9
Wood seating, unoccupied	0.02	0.03	0.03	0.06	0.06	0.05
Wooden pews, occupied	0.4	0.4	0.7	0.7	0.8	0.7

CHAPTER 3

METHODOLOGY

1. Project Flow Chart



2. Materials

Polypropylene pallets were obtained from the Mechanical Engineering Department supply and raw corn husk were obtained from the local distributor of corn.

The corn husk were first cleaned using water, it was then left to dry under the sun for approximately twelve hours. The corn husks were then heated in the oven to remove moisture for approximately 24hours at a temperature of 40°C.

The cornhusk was then put through a grinder shown in Figure 2 to get the fibres. The ground corn husks were then put through a sieve to get the size of approximately 1mm in length.

Figure 2 Grinder

The corn husk fibres were then compounded with the polypropylene using a compression moulding machine at different weight ratios of corn husk fibres to polypropylene as shown in table. The cast mould used for casting the polymeric specimens and composites, which was shown in Figure 3 made of iron which consists of two plates. The first one acts as a base where the second plate used as a cover putting on the first plate to make sample thickness uniform. Before casting, the iron plates were cleaned to remove the dirt and dust that were presented on the surfaces. Then, the plates were coated with wax so that the sample was easy to remove from casting after compression moulding. The corn husk fibres were sandwiched between two polypropylene plates and moulded at 140°C using 14 tonnes of force.

The composites made was of 20% wt and 15% wt CHF.

Figure 3 Cast Mould for Tensile Testing

3. Mechanical Testing

- Tensile Test

The tensile tests were carried out according to the ASTM D 638-89, Tensile Properties of Plastics. In this method, the specimen is placed into tensile grips and an extensometer is attached to the sample. The test begins when the tensile grips pulls the specimen at a constant rate of 50.00 mm/min. The stress needed to break the sample is the tensile strength of the specimen. Figure 4 shows the approximate size of the samples for the test

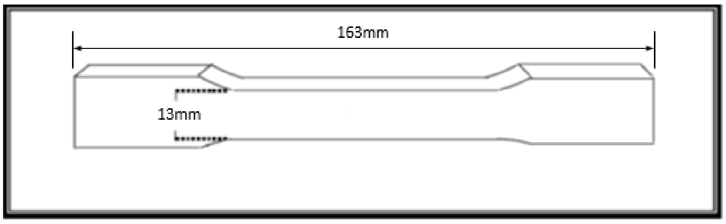


Figure 4 Approximate Size of Dog-bone Test Samples

4. Sound Absorption Test

The CHF-PP composite will be tested for its sound absorption properties using ASTM C423-02 Standard Test for Sound Absorption and Sound Absorption Coefficient by the Reverberation Room Method. The samples were made according to the Figure 5 below with different weight of CHF to PP ratio.

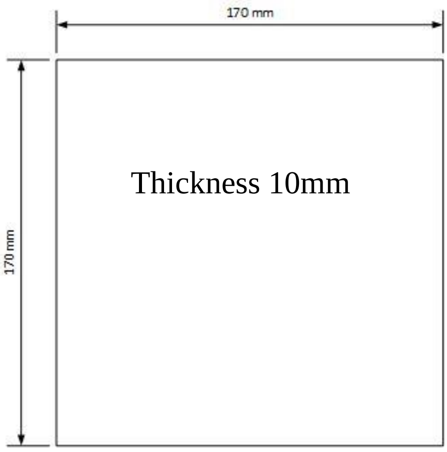


Figure 5 Sample of Plate For Sound Absorbtion Test

The reverberation room was set up as shown in Figure 6.

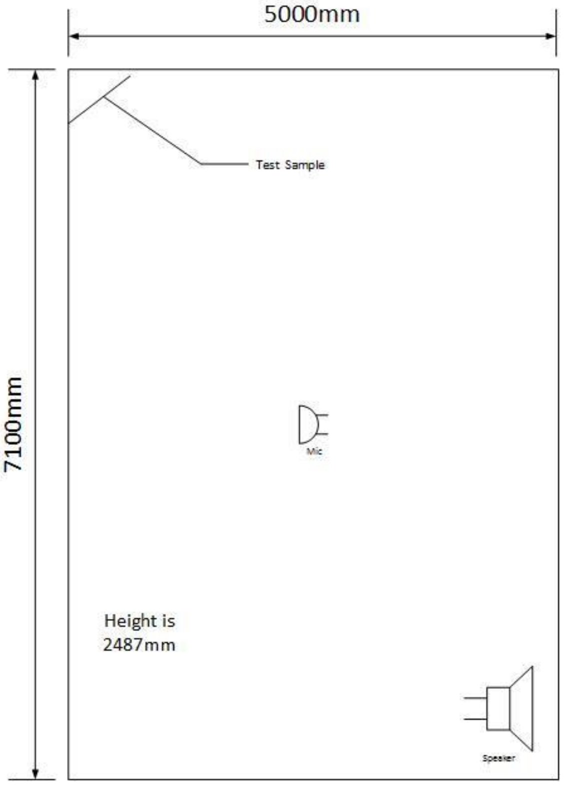


Figure 6 Reverberation Room

The sound source, in this case a portable public announcement (PA) system will be used to emit different frequency bands, which range from 200Hz to 5000 Hz this range and a sound pressure level of no more than 120dB is selected due to it being within the human audible range . The sound samples of differing frequencies as stated previously that will be used were downloaded from the internet and the volume of the speaker was adjusted so that the maximum sound pressure level would not exceed the 120dB.

The decay of the sound will be recorded via a microphone and the data will be analysed using a Real Time Audio Analyser software, in this case Room EQ Wizard, and the decay rate will be obtained.

Based on the data recorded the decay rate can be obtained from the software as shown in Figure 7 and the sound absorption will be calculated using the Sabine formulae shown in equation 1 below.

$$\alpha = 0.9210\frac{Vd}{c} \quad (1)$$

Where α=sound absorption coefficient (Sabine or m^2)

V=Volume of reverberation room (m^3)

d=decay rate of sound(dB/s)

c=Speed of sound=340.29m/s

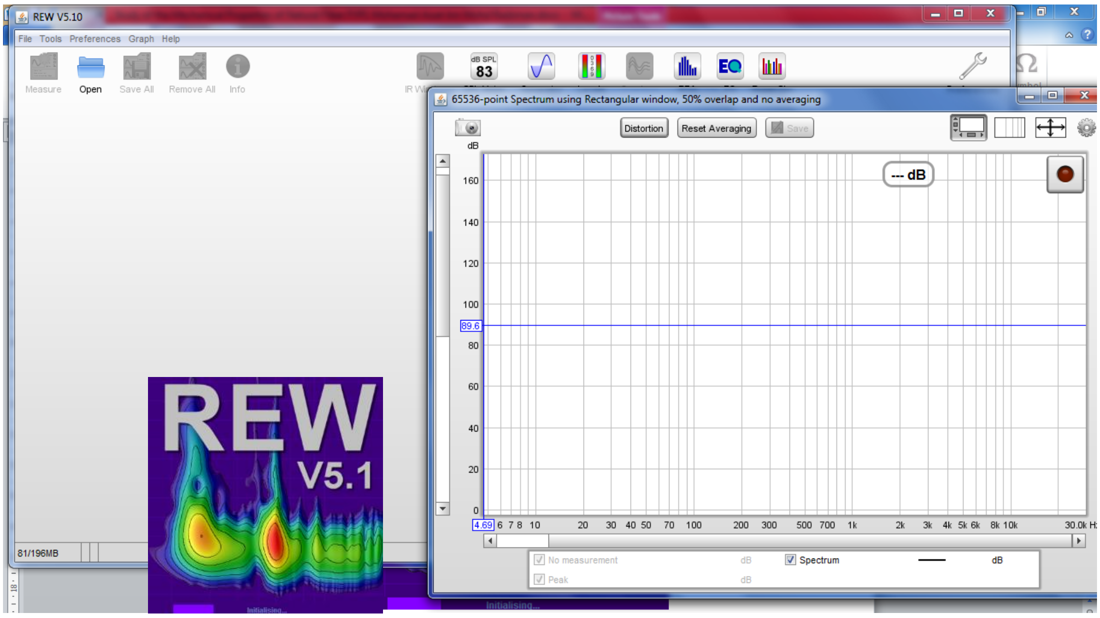


Figure 7 Room EQ Wizard Real Time Analyzer Software

The decay rate of the material is determined by subtracting the sound absorption coefficient of the empty room with the sound absorption coefficient of the room with test sample, as in equation 2.

$$A_{material} = A_1 - A_2$$

Where, $A_{material}$ =Sound absorption coefficient of test sample

A_1 =Sound absorption coefficient of empty room

A_2 =Sound absorption coefficient of room with test sample

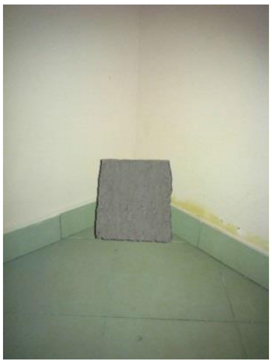


Figure 8 The Test Sample Position

As shown in figure 6 above the test sample was placed in the corner of the room, and not parallel to any of the walls. The, corner was chosen as it reverberates sound the most. The sound source

CHAPTER 4

RESULTS AND DISCUSSION

1. Sound Absorption Properties

The graph of sound pressure level against time was obtained from the real time analyser software. As shown in the figure 8 below.

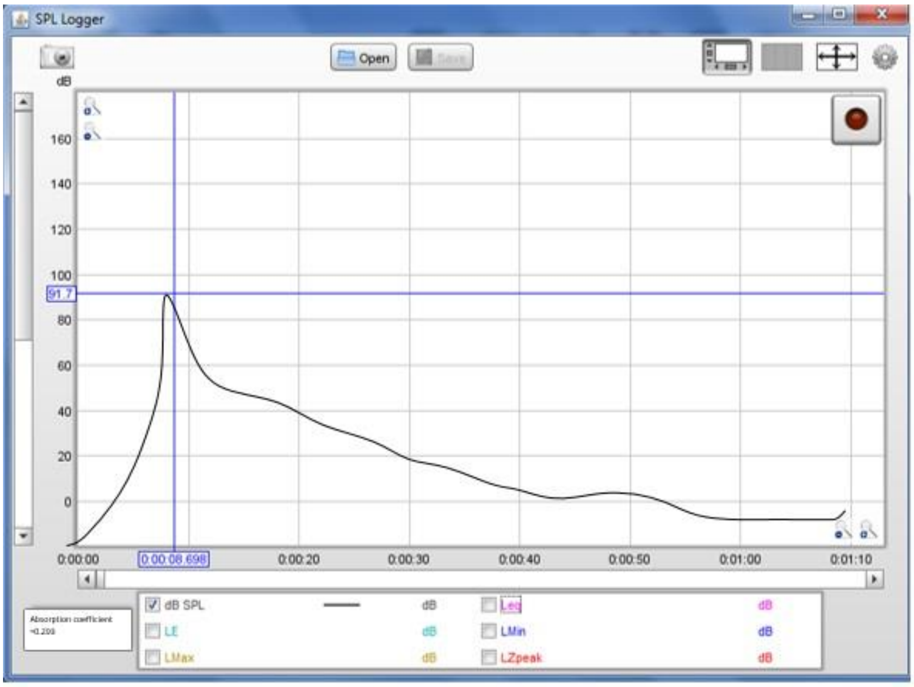


Figure 9 Sound Pressure Level vs Time for 20%wtCHF Sample at 200Hz

The data obtained was then tabulated into table to calculate the sound absorption coefficient of the room and the sound absorption coefficient of the material using equation 1 and 2 (Chapter 3). The Figure 10 and 11 below shows the graph that was plotted showing the relationship of sound absorption coefficient to frequency of sound.

Frequency (Hz)	Room Absorption Coefficient (m^2)			Material Absorption Coefficient (m^2)	
	20%wt	15%wt	Bare Room	20%wt	15%wt
200	0.154	0.149	0.1	0.054	0.049
300	0.257	0.242	0.2	0.057	0.042
400	0.403	0.381	0.35	0.053	0.031
500	0.612	0.535	0.5	0.112	0.035
600	0.634	0.629	0.52	0.114	0.109
700	0.773	0.751	0.65	0.123	0.101
800	0.847	0.834	0.72	0.127	0.114
900	0.888	0.853	0.73	0.158	0.123
1000	0.819	0.791	0.66	0.159	0.131
1200	0.87	0.84	0.71	0.16	0.13
1400	0.739	0.72	0.6	0.139	0.12
1600	0.679	0.66	0.55	0.129	0.11
1800	0.766	0.756	0.65	0.116	0.106
2000	0.655	0.5504	0.54	0.115	0.0104

Figure 10 Absorption Coefficient for CHF-PP Composite

The graph in Figure 10 shows the sound absorption coefficient of the material with respect to the differing noise frequencies. The sound absorption coefficient is significantly better for noises of frequencies between 600 to 1300Hz. The sample with 20wt%CHF has a better sound absorption coefficient as shown in the graph.

The sound absorption of the CHF-PP Composite has better same sound absorption as plywood at frequencies 500Hz or higher.

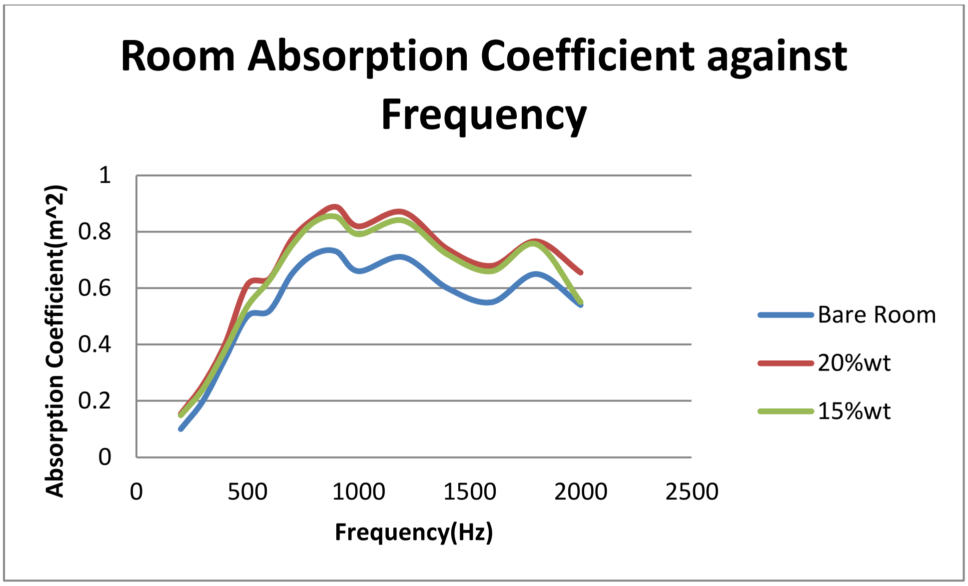


Figure 11 Absorption Coefficient vs Time

The bare room absorption coefficient of the room was quite high for sounds of frequency between 500Hz to 200Hz, in comparison to sounds of lower frequency. With the placement of the test sample the room absorption coefficient increases by an average of 23.75% for the sample with 20wt% CHF and about 17.95% with the 15wt% CHF. This can be attributed to the increase in fibre percentage also increases the porosity within the sample that creates better sound absorbance (Huda & Yang, 2008).

2. Mechanical Properties

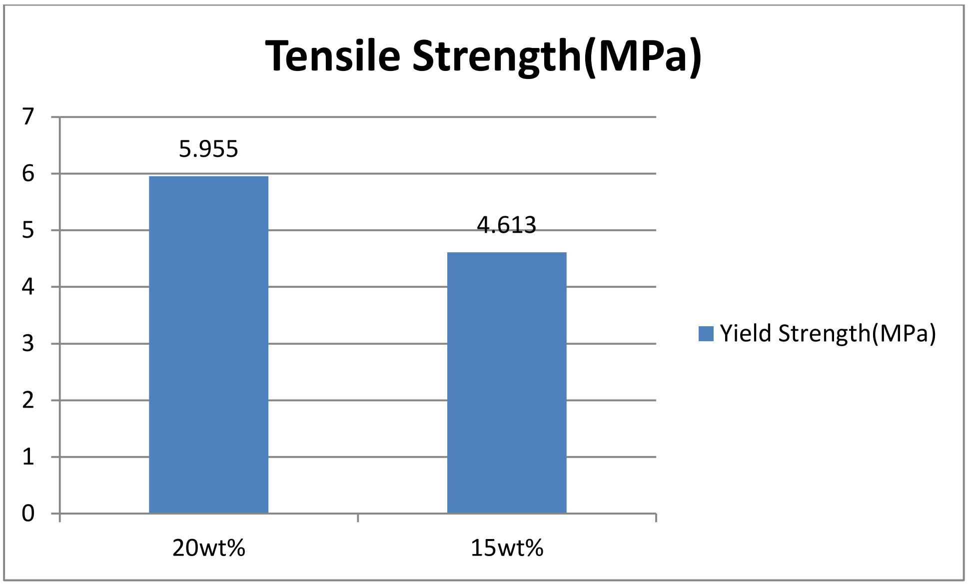


Figure 12 Tensile Streangtth for CHF-PP Composite

Tensile strength increases as the fibre ratio increases.

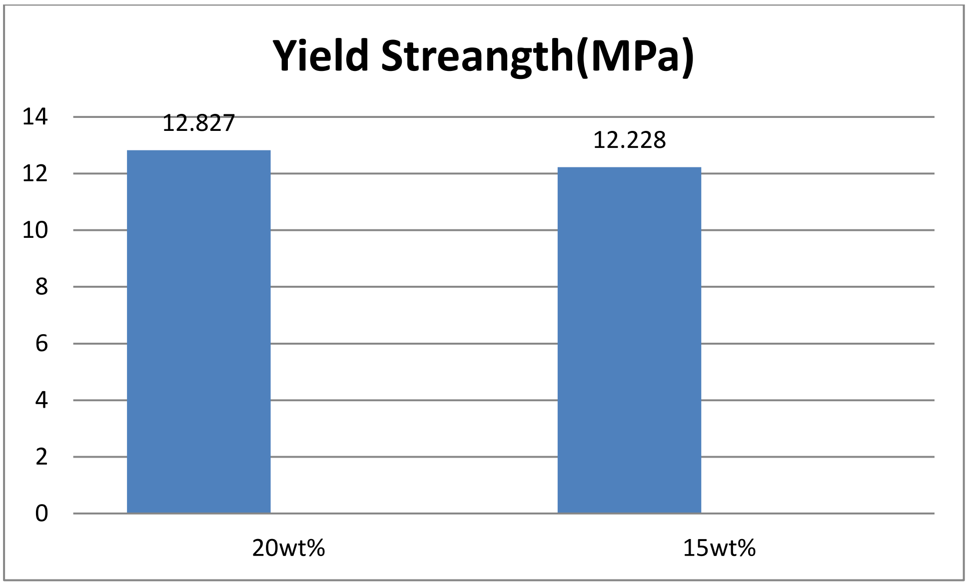


Figure 13 Yield Strength of CHF-PP Composite

Yield strength also increases as the fibre ratio increase.

The Figure 12 and 13 shows the tensile and yield strength of the CHF-PP composite and it shows that with increase fibre ratio it increases the tensile and yield strength of the composite. This is the due to the fibre reinforcing the polymer matrix creating a stronger composite, as shown in previous researches with other composites(Huda & Yang, 2008).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

1. Conclusion

In this project corn husk fibre (CHF) and polypropylene (PP) were used to create a composite and its sound absorption and mechanical properties were studied.

The studies showed that the sound absorption properties of the CHF-PP composite are higher when the fibre ratio is increased. This is due to the increase in the porosity of the material when the fibre ratio is increased. The sound absorption coefficient of the material is not that high, it is only the same as plywood at higher frequencies of noise, but it is still quite effective due to the ratio of the fibre is quite low.

The mechanical properties that was studied was it tensile strength, and it shows that corn husk is viable as a reinforcing polymer since the tensile strength is increasing with the increase in fibre ratio.

Thus it can be concluded that there is potential of CHF as reinforced composite and the objectives of the research has been met.

2. Recommendations

The writer suggests that more studies will be conducted on CHF as composites as it displays potential as an acoustic absorber. More research needs to be carried out with varying CHF ratios and differing polymer matrices, since this research can only focus on one polymer matrix that is polypropylene due to the shortage of time. The acoustical test can also be fine-tuned to determine the acoustical properties of the material, for example using the two tubes method in determining the sound absorption coefficient as the reverberation room method is more suited to field testing than laboratory test.

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APPENDICES

Appendix A

Universiti Teknologi Petronas

MECHANICAL ENGINEERING DEPARTMENT
BANDAR SERI ISKANDAR
31750, TRONOH
PERAK.

Tensile Test Report

Material :PP Composite

Test Method :ASTM D638

Test Speed : 5.000 mm/min

Test No.	Thickness	Width	Max. Load	Elastic Modulus	Tensile Strength	Yield Strength	Elongation@Yield	Elongation@Break
			N	MPa	MPa	MPa	%	%
1	3.899	12.606	888.221	-	5.377	12.091	1.152	0.903
2	3.929	12.660	759.208	1491.901	4.552	11.752	0.872	2.458
3	3.954	12.656	733.964	-	4.385	12.842	0.346	0.502
4	3.873	12.540	686.451	10293.442	4.138	-	0.028	0.100
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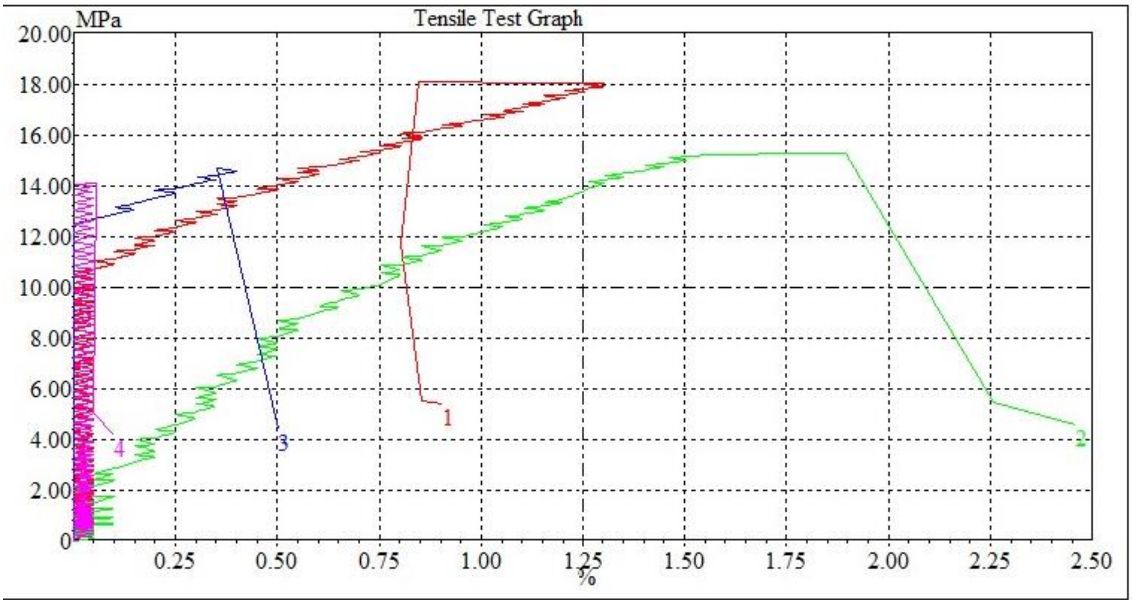
Average	3.914	12.615	766.961	5892.671	4.613	12.228	0.600	0.991
SD(N-1)	0.035	0.056	86.284	6223.629	0.537	0.558	0.507	1.032



Appendix B

Universiti Teknologi Petronas

MECHANICAL ENGINEERING DEPARTMENT
BANDAR SERI ISKANDAR
31750, TRONOH
PERAK.

UNIVERSITI TEKNOLOGI PETRONAS

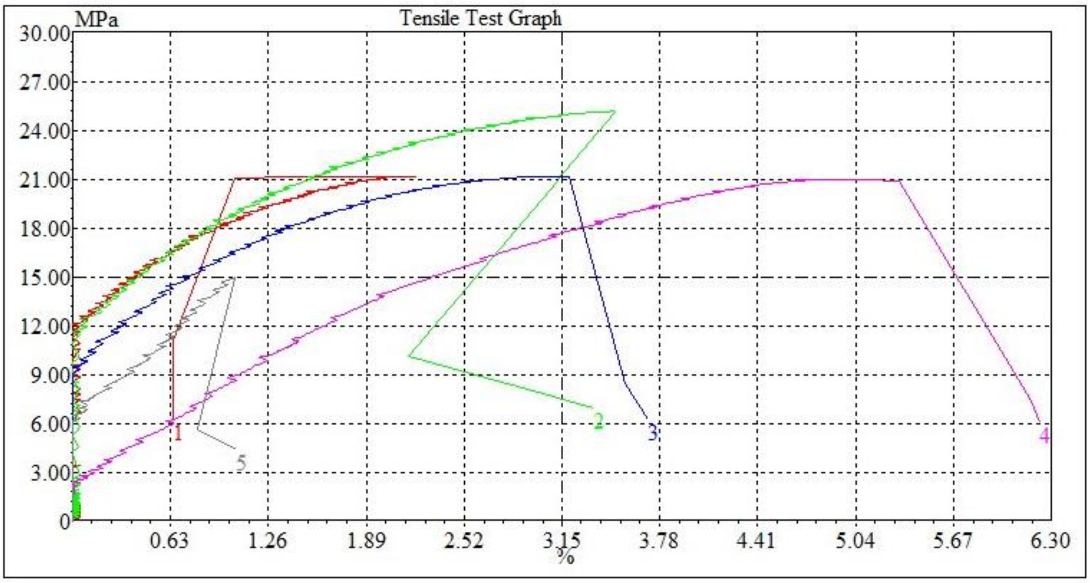
Tensile Test Report

Material :PP Composite

Test Method :ASTM D638

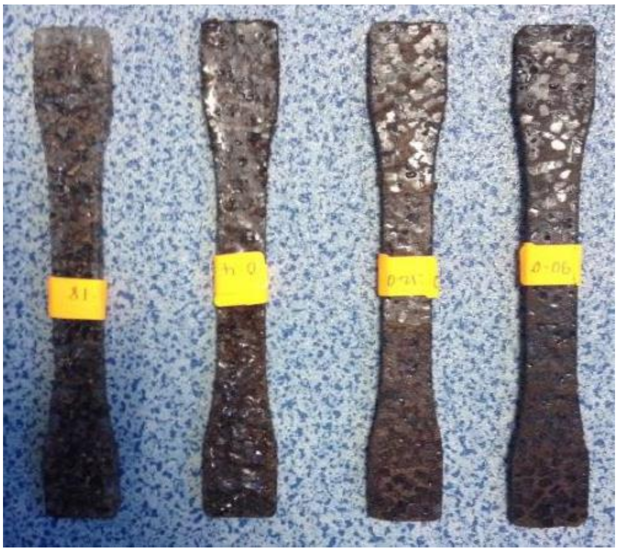
Test Speed : 5.000 mm/min

Test No.	Thickness	Width	Max. Load	Elastic Modulus	Tensile Strength	Yield Strength	Elongation@Yield	Elongation@Break
			N	MPa	MPa	MPa	%	%
1	3.848	12.520	1020.201	-	6.201	13.213	1.172	0.652
2	3.802	12.520	1197.142	4664.978	6.904	14.508	1.036	3.361
3	3.845	12.540	1020.438	2863.219	6.240	12.636	1.309	3.712
4	3.838	12.590	1012.912	622.925	6.050	14.625	3.386	6.220
5	3.861	12.550	725.049	1954.096	4.379	9.152	0.722	1.053
Average	3.839	12.544	995.148	2526.305	5.955	12.827	1.525	3.000
SD(N-1)	0.022	0.029	169.807	1696.832	0.940	2.222	1.063	2.253



Appendix C

Appendix D



Appendix E