



Addis Ababa University
Addis Ababa Institute of Technology
School of Chemical and Bio Engineering

**Production of Acoustic Material from Chrome Shaving
Wastes and Its Evaluation as Soundproofing**



By: Tesfay Gebregewergs

Advisor: Dr. Shegaw Ahmed

A thesis submitted to the School of Chemical and Bio Engineering of Addis Ababa University in partial fulfilment of the Degree of Master of Science in Chemical Engineering (Leather Technology stream)

Dec, 2021

Addis Ababa, Ethiopia

DECLARATION

I hereby declare that this thesis represents my original work and has not been previously done in the entire thesis study and that all the sources of the materials that are used in this thesis have been acknowledged.

	SIGNATURE	DATE
Tesfay Gebregewergs	_____	_____

This thesis has been approved for submission by:

NAME OF ADVISOR	SIGNATURE	DATE
Dr. Shegaw Ahmed	_____	_____

NAME OF EXAMINERS	SIGNATURE	DATE
Internal Examiner		
Prof. Belay Woldeyes	_____	_____

External Examiner		
Dr. Shimelis S.	_____	_____

Department Head		
Dr. Eng. Abubeker E.	_____	_____

Abstract

In tannery sectors, chrome shaving is one of the most hazardous solid wastes that have a serious impact on public health and the environment when discharged to the land without treatment. Utilization of large amount of chrome shaving waste is very critical to reduce environmental pollution effect. Hence, this research is focused on the production of acoustic material from chrome shaving wastes combining with animal fiber so as to reduce environmental problems of chrome shaving waste and to get value added products which is used as sound absorbing material in building applications. The acoustic material were prepared from chrome shaving waste and animal fiber using hydraulic pressing machine at the temperature of 150°C and pressure of 50bar. Styrene butadiene rubber was used for blending purpose and animal fiber (sheep wool fiber) was chosen as reinforcement due to its excellent sound absorbing capability and it has good fibrous content in nature. The effect of addition of animal fiber to the final product were assessed by varying ratios of concentrations in preparing of acoustic materials. The density and thickness of the acoustic materials were determined using appropriate measurements. The physical testing of the prepared materials were measured by controlling the temperature at 23.2°C and with relative humidity of 45.7%. The acoustic material (30% Cr & 70% W) were found as good material in the results of physical properties which have better tensile strength, elongation at break and tear strength when compared to the other acoustic materials. The sound absorption of the prepared acoustic material were measured using impedance tube with two microphones transfer function method. The results suggested that the acoustic material of (30% Cr & 70% W) and the acoustic material of (70% Cr & 30% W) have better sound absorbance in the lower and higher frequencies, which can be used as sound absorbing panel at home, class room, auditorium and music studio by providing good hearing ability thus making environmental friendly value added products from wastes.

Key words: Chrome shaving, acoustic, sound absorption coefficient, animal fiber, noise pollution

Table of contents

Abstract	i
Table of contents.....	ii
Acknowledgment	v
List of Tables	vi
List of Figures	vii
List of Acronyms	viii
1. Introduction.....	1
1.1 Background	1
1.2 Statement of the problem	3
1.3 Objectives.....	4
1.3.1 General Objective	4
1.3.2 Specific Objectives	4
1.4 Significance and Scope of the study	5
1.4.1 Significance of the study	5
1.4.2 Scope of the Study.....	5
2. Literature Review.....	6
2.1 Natural Fibers Reinforced Chrome Shaving Composites for Sound Absorption Applications	6
2.2 Acoustic characterization of natural fibers for sound absorption applications	7
2.3 Research Gap Analysis.....	10
2.4 Wet blue manufacturing process	10
2.4.1 Beamhouse Processing	10
2.4.2 Chrome Tanning	12
2.5 Mechanical operations.....	13
2.6 Tannery solid wastes and their environmental pollution	13
2.6.1 Chrome shavings	15
2.7 Noise/Unwanted sound and its environmental pollution	15
2.7.1 Sound.....	15
2.7.2 Unwanted sound or Noise.....	16
2.7.2.1 Types of noise	16
2.7.2.2 Health effects of noise	17

2.8	Fibers	19
2.8.1	Classification of Natural Fibers	20
2.8.1.1	Plant Fibers	21
2.8.1.2	Mineral Fibers.....	21
2.8.1.3	Animal Fibers.....	21
2.9	Acoustic material(sound absorbing material)	22
2.9.1	Acoutics	22
2.9.2	Characterization of the acoustic material	23
2.9.2.1	Sound absorption coefficient	23
2.9.2.2	Thickness	23
2.9.2.3	Density	23
2.9.3	Factors that can affects on preparation of the acoustic material.....	24
2.9.4	Chemical used on production of the acoustic material.....	25
2.9.4.1	Styrene butadiene rubber (synthetic rubber adhesive).....	25
2.9.5	Equipment /Machines used on production of the acoustic material	25
3.	Materials and Methods.....	28
3.1	Physico-Chemical Characterization of Raw Materials	28
3.1.1	Materials	28
3.1.2	Methods	28
3.1.2.1	Determination of pH	28
3.1.2.2	Determination of Moisture Content	28
3.1.2.3	Determination of Ash Content	29
3.1.2.4	Determination of Chromium Content	29
3.1.2.5	Determination of Fat Content	29
3.1.2.6	Material Type, Color and Size	29
3.2	Optimization of the acoustic material	30
3.2.1.	Materials	30
3.2.2	Methods	31
3.2.2.1	Preparations of acoustic material from chrome shaving and styrene butadiene rubber	31
3.2.2.2	Preparations of acoustic material from animal fiber and styrene butadiene rubber	31

3.2.2.3 Preparations of acoustic material from chrome shaving, animal fiber and styrene butadiene rubber.....	32
3.3 Characterization of the Product.....	34
3.3.1. Materials	34
3.3.2 Methods	34
3.3.2.1. Thickness and Dimensions of the Product.....	34
3.3.2.2 Determination of Density of the Product	34
3.3.2.3 Sound Absorption Measurements	34
3.3.2.4 Physical testing of the product.....	36
4. Results and Discussion	37
4.1 Physico-chemical characterization of the raw materials	37
4.2. Optimization of Acoustic Material with addition of Animal fiber	40
4.3 Characterization of the Product(Acoustic Material)	41
4.3.1 Thickness and density of acoustic materials.....	42
4.3.2 Sound absorption coefficients of the acoustic materials	45
4.3.3 Physical Characterizations of the Acoustic Material.....	46
5. Conclusion and Recommendation	49
References	51

Acknowledgment

- ✓ Firstly, I would like to thanks the almighty God and his Mother St. Merry for giving me the strength throughout my study work.
- ✓ I would like to express my deep gratitude to my external advisor **Dr. Nishad Fathima**, Sr. Principal Scientist, Central Leather Research Institute (CLRI) and to my internal advisor **Dr. Shegaw Ahmed**, Assistant Professor of Chemical Engineering, Addis Ababa University, for their guidances and advices throughout this research work.
- ✓ My thanks also going to Central Leather Research Institute (CLRI) and Leather Industry Development Institute (LIDI) for giving me the opportunity to pursue my Master's degree
- ✓ I would like also to say thanks to **Mrs. Sivaranjani Chinnadurai** for her help during my laboratory work in Central Leather Research Institute (CLRI), India.
- ✓ I am gratefully acknowledge the help of all staff members of PSG TECHS COE INDUTECH LABORATORY, PSG College of Technology, Avinashi Road, Neelambur, Coimbatore-641062, Tamil Nadu, India, in sound absorpion measurements.
- ✓ I am grateful to all the staff members of School of Chemical and Bioengineering, AAiT and Leather Industry Development Institute (LIDI), Ethiopia and all staff members of Central Leather Research Institute (CLRI), India.
- ✓ Finally, my specials thanks goes to my lovely wife and to my parents and friends for their love, care, support and encouragement throughout my life.

List of Tables

Table 3.1: Proportion of samples for blends	32
Table 4.1: Physico-chemical analysis of raw materials (sheep wool and chrome shaving waste).....	39
Table 4.2: Results of thickness and density of acoustic materials	43
Table 4.3: Physical testing results of the acoustic materials	48

List of Figures

Fig.2.1 Image of raw sheep wool skin	9
Fig. 2.2 Classification of Natural Fibers	20
Fig.2.3 Structure of Styrene -butadiene rubber polymer	25
Fig. 3.1: (a) Chrome shaving waste and (b) animal fiber(sheep.....	30
Fig.3.2 Characterization and processing flow chart of the raw materials and product.....	33
Fig.3.3 Schematic diagram of the impedance tube with the two-microphone transfer-function method	35
Fig. 4.1 Digital images of prepared acoustic materials	41
Fig.4.2 Relationship of density and sound absorption coefficient of acoustic materials at frequency of 2000Hz.....	44
Fig.4.3 Relationship of thickness and sound absorption coefficient of acoustic materials at frequency of 2000Hz.....	44
Fig.4.4 Sound absorption coefficients of the prepared acoustic materials	46

List of Acronyms

ASTM- American Society for Testing and Materials

ISO- International Organization for Standardization

SLC- Standard Methods for Leather Chemical Analysis

FT-IR- Fourier-transform infrared spectroscopy

SEM- Scanning Electron Microscopy

Cr- Chromium or chrome

W- Wool

Rpm- rotation per minute

MIC 1- Microphone 1

MIC 2- Microphone 2

ppm- parts per million

g- gram

mm- Millimeters

Fig, - Figure

RM- Raw material

CLRI- Central Leather Research Institute

LIDI- Leather Industry Development Institute

1. Introduction

1.1 Background

Chrome shaving is the most hazardous tannery solid wastes that have a serious impact on public health and the environment when discharged to the land without treatment. Chrome shavings are tannery solid wastes that are difficult to dispose off due to the presence of the heavy element chromium. Collagen and Cr(III) complexes make up the majority of chrome leather waste, which might be processed to yield protein and chromium resources. Because of chromium is hazardous, the disposal of chrome shavings generated as solid wastes in the tanning sector has been identified as a severe challenge in terms of environmental safety. Chemical-based wastes are typically disposed off in landfills or burned to eliminate organic residues and reduce waste volume. When these wastes are incinerated, gases and soluble hazardous compounds are produced. These substances pollute the air, land and water that causing major environmental issues. Cr (III) can be converted to its more soluble hexavalent form in the air environment when solid wastes containing chromium are incinerated. ^[1,7, 19] Effective utilization of a large amount of chrome shaving waste is important to reduce the chrome shaving waste in the tannery and to get value-added products.

Unwanted sound or noise affects a greater number of people at home or at work. Noise may impact one's ability to learn, work, relax, rest, sleep, and other things. Excessive noise can be harmful to one's mental and physical health. Noise is one of the most common air contaminants that has the potential to harm living beings. Continuous noise exposure has been shown to cause hearing loss, sleep disturbances, and immune system disruption in humans. The desired acoustical impact is produced by using porous materials for sound absorption and insulation as wall and ceiling claddings. Noise pollution has been identified as a key danger that has an impact on people's quality of life all over the world. Noise pollution has reached a disturbing level over the years as a result of rapid advancements in technology, urbanization, industrialization and other communication and transportation systems, and it needs to be studied and controlled to avoid various health effects such as high blood pressure, nausea, sleeplessness, dizziness, heart attack, depression, headache and induced hearing loss. Acoustic materials are used to manage noise by absorbing undesired sound and providing people with good hearing capabilities. Sound-absorbing

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

materials like glass wool, rockwool and mineral wool are routinely used inside buildings. However, because these materials are costly to manufacture and create a variety of health problems such as respiratory disease and skin irritations, their use is prohibited in many countries. Due to the detrimental consequences, researchers are developing porous materials made from various natural fibers derived from plants and trees.^[2,4]

Sheep wool (animal fiber) is a natural substance that can be used to insulate buildings for both thermal and acoustic reasons. Wool naturally clumps into staples as it grows from the sheep's skin, including thousands of fibers of various types. Wool is made up of a variety of amino acids linked together in long strands. The coiled springs in wool molecular chains contribute to fiber robustness, which has been investigated for acoustic applications. Wool is self-extinguishing and does not produce poisonous compounds in the event of a fire; but, this material can be attacked by moths or parasites, necessitating chemical treatments prior to usage in buildings. Sheep wool is a superb sound-absorbing material due to the micro-cavities that make it up. However, Sheep wool is mostly utilized in the textile sector and is not cost effective when used alone to manufacture sound absorption material, but it can be used in composites with other materials as reinforcement.^[3] Wool resists dirt and odors. Wool is a long-lasting and resilient material. Wool fiber is incomparable in terms of flexibility, strength, and shape retention for a lifetime of use.^[20]

Acoustic absorption is the process through which sound waves collide with and reflect off of a surface such as a wall, seats, floors, buildings or other materials. The reduction of sound energy reflected off a surface is referred to as sound absorption. The terms sound absorption and sound insulation were used to differentiate between the two. A portion of the sound wave is converted to heat, while the remainder is absorbed by the materials. When a speaker is installed in a room, the sound wave will move and collide with the walls, with part of it reflecting and some being absorbed by the wall. The most important aspect of soundproofing is acoustic absorption. It entails absorbing as much sound energy as possible and either converting it to heat or sending it away from a particular spot. Soft, flexible, or porous materials absorb sound well, while hard, dense and impenetrable materials reflect it the most.^[9]

This study conducts effective utilization of chrome shavings solid wastes by combining with animal fiber through styrene butadiene rubber as binder to produce environmental friendly acoustic material which is very important for the sound absorption purposes.

1.2 Statement of the problem

Solid wastes generated by tanning industries should be treated in an environmentally acceptable manner because they are highly polluting industrial wastes. Chrome shavings are tannery solid wastes that are difficult to dispose off due to the presence of the heavy element chromium. In the tannery-environment relationship, the disposal of these solid wastes from leather manufacturing is a key concern. Because of chromium is hazardous, the disposal of chrome shavings generated as solid wastes in the tanning sector has been identified as a severe challenge in terms of environmental safety. Chemical-based wastes are typically disposed off in landfills or burned to eliminate organic residues and reduce waste volume. When these wastes are incinerated, gases and soluble hazardous compounds are produced. These substances pollute the air, land and water that causing major environmental issues. Cr (III) can be converted to its more soluble hexavalent form in the air environment when solid wastes containing chromium are incinerated and can cause carcinogenic disease to the people. It is critical to make effective use of a considerable amount of chrome shaving waste in order to reduce pollution and obtain value-added products. Noise, often known as undesired sound, is a pollutant in the air that causes hearing loss, sleep disruptions, and immune system harm in people. Acoustic materials are used to control noise by absorbing unwanted sound and allowing people to hear clearly. In the previous studies, the natural fibers and synthetic fibers reinforced polymer composites were developed for the production of acoustic materials. However, using these materials have also negative impacts on public health and the environment. The synthetic fibers that were used to produce acoustic materials causes many health problems such as respiratory disease and skin irritations, due to this reason their use is limited in many countries. The natural fiber reinforced composites made from natural fiber/ plant trees have also a negative impact on the environment when large amount of plant fibers are used in the manufacturing of the composites, this leads to deforestation on the environment.

In this study, production of acoustic material from chrome shaving wastes with addition of animal fiber as reinforcement by varying the concentrations ratio were being to be done to get the desired purposes. And, characterize and optimize the products and the acoustic materials were expected to have good sound absorption coefficients of the material and gets environmental friendly material when compared to the recent studies. This study also reduces the environmental pollution and producing value-added byproducts which are used for sound absorption's purpose.

1.3 Objectives

1.3.1 General Objective

The general objective of this study was production of acoustic material from chrome shaving wastes and its evaluation as soundproofing.

1.3.2 Specific Objectives

The specific objectives of this study were given below:

- Physico-chemical characterization of raw materials (chrome shaving waste and sheep wool)
- Optimization of the acoustic material with addition of animal fiber
- Characterization of the product produced from chrome shaving waste and sheep wool fiber

1.4 Significance and Scope of the study

1.4.1 Significance of the study

The main significances of this study were: reduction of environmental pollution caused by tannery solid wastes, provide environmental friendly acoustic material for the construction sectors, reducing environmental sound pollution, creating a comfortable atmosphere for people by minimizing environmental pollution, minimizing the legal pressure on the tanneries which is imposed by environmental protection authority related waste disposal and management, generate income from tannery by products and creating suitable working environment for tannery workers by utilizing the chrome shaving waste properly.

1.4.2 Scope of the Study

The scope of this research was limited on the production of acoustic material from chrome shaving waste and sheep wool fiber with styrene butadiene rubber using hydraulic pressing machine by controlling constant temperature and pressure parameters. This study also includes the physico-chemical characterization of the raw materials(sheep wool and chrome shaving waste), the characterization of the product (thickness, density, sound absorption coefficients), optimization of the acoustic material with addition of animal fiber and without animal fiber by varying the ratios of the concentrations and determining of physical properties of the final product (tensile strength, tear strength, elongation at break).

2. Literature Review

2.1 Natural Fibers Reinforced Chrome Shaving Composites for Sound Absorption Applications

Chrome shavings, the solid wastes from tanneries, show disposal difficulties due to the presence of the heavy metal chromium. Because the majority of chrome shavings are disposed of by land filling and cremation, effective reutilization procedures are required to limit pollution. Preparation of colors, manufacture of keratinase using collagen hydrolysate as a source of bacteria after chromium removal, and preparation of leather-like materials for footwear applications are all current uses for chrome shavings. The following approaches, on the other hand, have a number of drawbacks, including a large initial investment cost and many processing phases. As a result, a suitable easy and cost-effective alternative strategy to the use of chrome shaving is required.^[1,2]

Noise pollution has a negative impact on human health since it promotes hearing loss and sleep disruptions. Noise pollution is reduced by using sound absorption materials. When placed between the sound source and the receiver, these materials absorb the sound by dissipating the sound wave energy. Foams, fibers, and perforated plates, among other sound-absorbing materials, have already been developed and are in use. Because of their low cost and high performance, synthetic sound absorption fibers such as fiberglass and rockwool are commonly employed. These materials, on the other hand, are associated with handling issues, and inhaling these mineral fibers can cause lung inflammation and skin irritation. Natural sound-absorbing materials, on the other hand, such as kapok, cotton, and jute, are biodegradable, low-cost, renewable, and pose few health risks during processing and handling when compared to synthetic fibers. The usage of these fibers as sound absorption materials will lower manufacturing costs significantly. The natural fibers' reduced density and porous texture led in effective sound absorption in the mid-frequency band. Natural fiber reinforced polymer composites were developed for acoustics, and they outperform synthetic materials in terms of environmental sustainability. Natural fibers, on the other hand, are more susceptible to fungal and parasite assault and have low moisture resistance. The incorporation of antifungal compounds into natural fibers is a crucial necessity for creating materials. Chrome shavings was used for sound absorption in this study by combining them with

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

natural fibers including cotton, kapok, and jute and using polypropylene as a binder. Natural fibers such as cotton, kapok, and jute were combined with chrome shavings to provide sound absorbent materials with increased sound absorption in the middle range frequencies, making them suitable for acoustics applications.^[2,4]

Kapok Fiber

Kapok fibers are a blend of lignin and cellulose that shine and are yellowish brown in color. Each fiber is around 2.5 cm long, with a large lumen and thin walls that are waxed to keep water out. Kapok is a material that is commonly used in home, cosmetic, and personal care goods. Kapok fiber is light, buoyant, water resistant, and robust, but it is also extremely combustible. Harvesting and sorting the fiber is done by hand using manpower.^[19] The tensile strength and elongation at break of the kapok reinforced chrome shaving composite were found to be 6.18 N/mm² and 4.36% respectively. The sound absorption coefficients of 5.26mm thick kapok fiber reinforced chrome shaving composite at frequency of 2000 Hz was found to be 0.45.^[2]

2.2 Acoustic characterization of natural fibers for sound absorption applications

The materials, which are primarily vegetable fibers, were obtained by crushing plants to obtain basic components, which were then compacted to make sound absorption panels. Kenaf, hemp, wood, cane, and coconut are examples of fibrous materials; for comparison, cork, a cellular structure material, and wool, an animal fiber are also investigated. Natural fibers are gaining popularity for acoustic applications. Although a number of natural fibers for building applications have begun to be commercialized, the majority of the goods studied are still infrequently employed in construction. Natural fibers are a competitive material because of their low density, good mechanical qualities, ease of processing, high stability, occupational health benefits, reduced fogging behavior, high quantity availability, low price, and minimal environmental effect. However, scientists have raised concerns about the long-term viability of natural fibers due to the toxicity of the chemical compounds used in their production or during the material transformation into construction materials. Fiber plants are more susceptible to fungi and parasites, and are less fire resistant than ordinary mineral fibers; also, they frequently require specific treatment before

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

use, reducing the raw materials' natural sustainability. These factors indicate that the environmental implications of all goods employed during the transformation of natural fibers into building materials be taken into account. As a result, whereas natural fibers are frequently commercialized in panels or blocks made with a binder, unprocessed natural fibers were the only ones studied in this recent work. In this approach, the raw fibers were analyzed without being influenced by a binder in this investigation. Compressing the raw material and compartmentalizing it in small acoustically transparent containers provided shape stability.^[2,3]

Wooden Cane

Arundo donax, sometimes known as cane or reed, is a popular plant that thrives near water sources. It has a very rapidly growing process, which usually causes conflicts with agriculture, and as a result, it is regularly cut, resulting in a large supply of raw material. Cane is a natural fiber that fits in well with the environment. Cane has a mellow, warm hue and bends effortlessly into graceful contours. Cane furniture is also light in weight, which is helpful while moving furniture but unfavorable when it is windy. Chairs, tables, and benches are all made of cane. The sound absorption coefficients of 40mm thick wooden cane at frequency of 2000 Hz was found to be 0.43.^[3]

Mineralized wood

When plant woody stems are buried in moist sediments saturated with dissolved minerals, petrified wood is formed. Because there isn't enough oxygen in the air, the degradation of the wood is slowed, allowing minerals to replace cell walls and fill vacant areas in the wood. Mineralized wood fibers are sold in a variety of forms, depending on the binder and manufacturing process used. Crushed wood fibers impregnated with cement are commonly used to make semi-rigid panels. Because the binder may make the material compact and dense; mineralized wood is frequently regarded as a non-fibrous substance. The sound absorption coefficients of 30mm thick mineralized wood at frequency of 2000 Hz was found to be 0.4.^[3]

Sheep wool

Wool is a fiber obtained from the fur of *Caprinae* family animals, primarily sheep. Keratin (33 percent), grease (28 percent), suint (12 percent), different pollutants (28 percent), and water content (1 percent) are all found in wool fiber. Wool resists dirt and odors. Wool is a long-lasting

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

and resilient material. Wool fiber is incomparable in terms of flexibility, strength, and shape retention for a lifetime of use.^[20]

Sheep wool has been used for clothing since ancient times because of its great thermal insulation capabilities. Wool is made up of a variety of amino acids linked together in long strands. The coiled springs in wool molecular chains contribute to fiber robustness, which has been investigated for acoustic applications. Wool is self-extinguishing and does not produce poisonous compounds in the event of a fire; but, this material can be attacked by moths or parasites, necessitating chemical treatments prior to usage in buildings. Sheep wool (animal fiber) is a natural substance that can be used to insulate buildings for both thermal and acoustic reasons. Wool naturally clumps into staples as it grows from the sheep's skin, including thousands of fibers of various types. Because of the micro-cavities that make up sheep wool, it is a great sound-absorbing material. Sheep wool, on the other hand, is mostly utilized in the textile sector and is not cost effective when used alone to manufacture sound absorption material, but it can be used as reinforcement in composites with other materials. Wool fibers are excellent sound absorbing materials. The sound absorption coefficient of 40mm thick sheep wool at frequency of 2000Hz were found to be 0.94^[3]



Fig.2.1 Image of raw sheep wool skin

2.3 Research Gap Analysis

In the recent studies, sound absorbing materials has been developed with natural(plant) fiber reinforced chrome shaving composites for sound absorption applications but using large amount of those plant fibers in production also causes deforestation leads to global warming which have negative impacts on the environment. In the case of acoustic characterization of natural fibers for sound absorption applications, the acoustic material were produced without binder which leads to weaken the strength properties of the material. The recent studies showed that the sound absorption coefficients of wooden cane, mineralized wood and kapok fiber reinforced chrome shaving composite at frequency of 2000 Hz were found to be 0.43, 0.4 and 0.45 respectively.^[3,2]

In this study, an effective production of acoustic material from chrome shaving wastes combined with animal fiber (sheep wool fiber) were done to improve the sound absorption coefficients and enhancements of physical strength of the material and gets environmental friendly material when compared to the recent studies. Characterizations and optimization of the acoustic material by changing the reinforcement fibers and its concentration variations were being to be done to get a novel approach of this research.

2.4 Wet blue manufacturing process

2.4.1 Beamhouse Processing

The beamhouse's basic purpose is to prepare the pelt for tanning. Another way to describe it is that the beamhouse is used to purify the pelt or to 'open up' the pelt structure. The elimination of non-collagenous skin components and the splitting of the fibre structure at the level of the fibril bundles to separate them are two components of the structure opening up.^[5]

➤ Soaking:

This is the first operation, which is carried out in drums, paddles, or pits with the addition of the required amount of water, wetting agent, and bactericides based on the raw material weight to rehydrate and restore the hides/ skins to their natural condition and remove adhering dirt, blood, curing agents, and some soluble proteins. Depending on the condition of the raw stock, the technique and duration of soaking varies. Fresh hides/skins simply need a few changes of water,

preferably cold water, to remove blood, dirt, and other contaminants. Depending on the degree of dehydration, wet salted stocks should be soaked for longer periods of time. Preservatives should be used if the soaking is to be done for an extended period of time. Wetting agents are used to shorten the soaking period. Soaking aids and preservatives must always be used when soaking dry salted stock. For effective rehydration, additives such as sodium sulphide, caustic soda, and soda ash may be necessary. Enzymatic soaking aids have also been found to be quite helpful at cutting down on soaking time. Dried skins require more soaking time than dry salted stock, including the use of proper wetting agents and preservatives, as well as drum rpm control. By folding the skins/hides flesh side out and checking for uniform softness and flexibility, the soaking is complete. These are accepted as proof of proper soaking.^[6]

➤ **Liming:**

This is the process of treating soaked hides / skins in a drum, pit, or paddle with lime, sharpening agent (sodium sulphide, sulphhydrate), surface active agents, and other chemicals. Liming is used to remove hairs, epidermis, natural lipids, and interfibrillary proteins, and thus to swell and separate fiber bundles into fibers, soften the collagen fiber matrix, and make the finished leather non-patchy, flexible and pliable. This operation's pH is maintained between 12.5 and 13. Limed pelt is the name given to the hide/skin after this stage. The method of liming is determined by the raw stock as well as the final leather to be produced. A paint liming procedure is to be used on sheep skins where the wool or hair has some value. Hair pulping technique is used in paddle/drum for cattle hide and goat skins. To achieve tighter leather and reduced looseness in leather, short liming is required. To increase the swelling and splitting of fibres, a somewhat longer liming is used for soft leather when good structure opening is required. The type of source material influences this process. To adjust the appropriate degree of plumping, reliming with soda ash/caustic soda is done.^[7]

➤ **Fleshing:**

Fleshing is the process of mechanically removing undesired loose fleshy pieces with a hand knife or a fleshing machine.^[8]

➤ **Deliming:**

Deliming is the process at which alkalinity of the pelt is reduced by washing it in a paddle or drum with weak organic acids, acid salts, and other chemicals. It is mainly carried out to prevent alkaline swelling and to eliminate physical deposited and chemically bonded lime, as well as capillary lime,

which is harmful to later tanning. After delimiting, the pelt is thoroughly washed to ensure that all of the lime is removed. The phenolphthalein indicator is used to verify that the delimiting is complete.^[5]

➤ **Bating:**

Bating is the process of treating delimited pelts with enzymatic bate powder to remove non-leather-making substances including scud, short hairs, and interfibrillary material, as well as to clean, smooth, and fine the grain surface in order to make the leather soft, flexible, and elastic. Bating efficiency is determined by the temperature, strength, and pH of the bate liquor, as well as the length of the operation. Bating completeness can be verified using an air bubble for skins and a thump press for cow hides.^[6]

➤ **Pickling:**

Pickling is a method of preserving and conditioning scudded pelts in a drum using a salt solution and pre-diluted acids (organic and inorganic) to preserve and condition them for tanning. The pickling process is monitored by measuring the pH of the pelt cross section, which should be between 2.8 and 3.0. Pickling is done to lower the pH of the pelt so that it can be prepared for tanning. The salt content and pH are the most important parameters in pickling.^[7,8]

2.4.2 Chrome Tanning

The conversion of a putrescible organic material into a stable compound that resists decomposition by spoilage bacteria is known as tanning. Other changes are expected by tanners, and the first three on the list, appearance, handle, and smell, are usually present during the tanning process. Most tanners, on the other hand, anticipate an increase in hydrothermal stability, which is often manifested as a rise in shrinkage/denaturation temperatures. Furthermore, there is frequently an assumption that the alteration would not be transient but will have some persistence in conventional usage. The use of chromium (III) salts is the most popular method of tanning at the moment, with about 90% of the world's leather being tanned this way. Until the end of the nineteenth century, almost all leather was produced via 'vegetable' tanning, or the use of plant extracts. The background of chrome tanning dates back to 1858, when Knapp released a tanning book in which he outlined how to utilize chrome alum; due to the steps of infusion and fixing of the chromium(III) species are carried out in the same vessel, this is referred to as the single bath procedure. Chrome tanning is thought to have started commercially around 1884, with the new

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

method patented by Schultz, in which chromic acid was injected through the hides or skins in one bath, the pelts were then removed to enable for equilibration (but not fixation), and the chrome in the second bath was simultaneously lowered and fixed. The creation, according to legend, was a solution to the difficulty of corset construction: iron bracing strips (as a replacement to whale bone) in the garments would interact with vegetable (plant polyphenol) tanned leather under moist heat surrounding the body. The matching of the chromium (III) salt's reactivity with the reactivity of the collagen is the foundation of the chrome tanning reaction. The availability of ionized carboxyls varies across the pH range of 2–6. Because the metal salt only reacts with ionized carboxyls, this is the reactivity range of collagen: the rate of reaction between chromium (III) and unionized carboxyls is so slow that it may be ignored. Chromium (III) salts are stable in the pH range 2–4, where the basicity varies, but they will precipitate at higher pH values. ^[1,5,6,]

2.5 Mechanical operations

Samming

Samming is a mechanical technique that decreases tanned leather's moisture content to around 45 percent. The samming machine, which features squeezing rollers and water-absorbing felts, is used for this process. ^[8]

Shaving

Shaving is the process of adjusting the thickness of leather using a shaving machine's knife cylinder. Both split and un-split leathers must go through this process. It is the shaving of the flesh side with a shaving machine to produce a correct and even thickness (thickness adjustment according to the kind of product). As a result, chrome shaving waste is created by shaving chrome tanned leather (wet blue), which can be used to produce acoustic material when combined with animal fiber by using bonding agent. ^[7]

2.6 Tannery solid wastes and their environmental pollution

Tannery is among the world's oldest industries. In today's world, the demand for leather and leather goods is estimated in millions of dollars. Tannery industries have played a significant role in Ethiopia's economy during the last few decades. Because of the bad smell, organic solid waste, and toxic water produced during the traditional manufacturing process, the tannery sector has been

linked to significant pollution. According to several studies, 1 ton of raw hides and skins yields nearly 200 kg of leather. 35-40 percent chrome shaving, chrome split or buffing dust, 5-7 percent skin trimmings, 56-60 percent fleshing, and 2-5 percent hair make up solid waste. Chrome shavings contain 2.5-5% chromium, depending on the method. In the tanning process, 4 to 6 thousand tons of basic chromium are consumed each year, with 20-40 percent of it thrown as waste. From that, chrome tanning waste water contains 50-60%, while chrome shaving dust created throughout mechanical operations contains 40-50 percent. Hides and skins, which are by-products of the meat and meat products sector, are commonly used as raw materials in the leather industry. Because it handles waste products from livestock processing, the leather industry might have readily been identified as an environmentally good industry in this regard. Thousands of leather factories across the world generate various sorts of waste, both in terms of quality and quantity, during the conversion of hides and skins into leathers., ranging from ancient to modern. The qualities of leather waste created by each type of leather and process are different.^[1,8]

Because of the huge quantity of solid and liquid waste generated, the leather industry is one of the most polluting sectors. Chrome shavings, raw trimmings, fleshing, buffing dusts and keratin wastes are examples of solid waste. The accumulation of these wastes causes a surge problem and blockage of treatment pipes and resulting in a decline in treatment plant efficiency. Treatment of solid wastes is likewise inefficient, putting a financial strain on tanneries. The leather industry in poor countries is challenged by a large amount of solid waste.^[6]

The global leather industry has a bad reputation in society, not only because of its pollution-causing potential but also because of its dirty nature as a result of the massive amounts of solid waste it generates. Tanneries have been forced to close down due to pollution issues not only in developed countries but also in developing countries. Chrome tanning is one of the most widely used tanning techniques in the world. In the tannery-environment relationship, solid waste disposal from leather manufacturing is a serious issue. Wet blue shavings, splits, trimmings, and scraps, as well as those produced in post-tanning activities such as trimming and buffing process, are among the chromium-containing leather wastes. Massive amounts of solid waste created by tanneries' varied processes are deposited without being used and become a source of pollution. As a result, the Ethiopian tanning sector has a major waste disposal challenge.^[8,10]

2.6.1 Chrome shavings

The chrome tanned leather will be shaved once it has been chrome tanned. Shaving evens out the thickness of the skin and for hides, allows for more precision than possible by splitting. The savings and splits will make a significant contribution to the tannery's overall solid waste generation. During the leveling process, chrome shavings are small, thin particles of chromium-tanned collagen fibrous matrix.^[20] Chrome shaving is one of the most toxic tannery solid wastes, with negative consequences for the environment and public health when discharged to the environment. Chrome shavings are tannery solid wastes that are difficult to dispose off due to the presence of the heavy element chromium. Collagen and Cr(III) complexes make up the majority of chrome leather waste, which might be processed to yield protein and chromium resources.^[1,19] Because of chromium is hazardous, the disposal of chrome shavings generated as solid wastes in the tanning sector has been identified as a severe challenge in terms of environmental safety. Chemical-based wastes are typically disposed off in landfills or burned to eliminate organic residues and reduce waste volume. When these wastes are incinerated, gases and soluble hazardous compounds are produced. These substances pollute the air, land and water that causing major environmental issues. Cr (III) can be converted to its more soluble hexavalent form in the air environment when solid wastes containing chromium are incinerated.^[1,7]

2.7 Noise/Unwanted sound and its environmental pollution

2.7.1 Sound

Sound is a sensation that occurs in the ear as a result of changes in air pressure. These pressure changes transfer energy from a vibrating source. A variety of techniques can be used to vibrate air. For example, guitar, loudspeaker, and human voice chords. Sound is a vibration that moves through the air. The vibrations collected by the ears and translated by the brain are what the ears can hear. When sound is created, vibrations move through the air and impact any medium in its surroundings, including floors, walls, ceilings, tables, doors, chairs, and many others. The vibration's impact on the surface is then reflected, absorbed, or diffracted. This is a vibrating item that compresses nearby air particles in one direction and spreads them out in the opposite direction.

In addition, unless obstructed by an object or other material in its pathway, the front of the waves spreads out evenly in all directions^[4]

2.7.2 Unwanted sound or Noise

Unwanted sound or noise affects a greater number of people at home or at work. Noise may impact one's ability to learn, work, relax, rest, sleep, and other things. Excessive noise can be harmful to one's mental and physical health. Noise is one of the most common air contaminants that has the potential to harm living beings. Continuous noise exposure has been shown to cause hearing loss, sleep disturbances, and immune system disruption in humans. The desired acoustical impact is produced by using porous materials for sound absorption and insulation as wall and ceiling claddings. Noise pollution has been identified as a key danger that has an impact on people's quality of life all over the world. Noise pollution has reached a disturbing level over the years as a result of rapid advancements in technology, urbanization, industrialization and other communication and transportation systems, and it needs to be studied and controlled to avoid various health effects such as high blood pressure, nausea, sleeplessness, dizziness, heart attack, depression, headache and induced hearing loss.^[2]

2.7.2.1 Types of noise

Low frequency noise, continuous noise, intermittent noise and impulsive noise are examples of different forms of noise based on their intensity, duration, and frequency.^[9]

➤ Impulsive noise

Impulse noise is commonly characterized as noise that consists of short bursts of less than one second duration with peak levels 15 decibels higher than background noise. The features in the time domain distinguish impulse noise from steady state noise. Rapid sound pressure transients are present in impulse noise. Peak level, rise and decay time, duration and number of impulses, spectrum content, and level distribution are all physical aspects of impulse noise.^[11]

➤ Low frequency noise

Road cars, aircraft, artillery and mining explosions, industrial machinery, wind turbines, compressors, and ventilation or air conditioning systems all contribute to low frequency noise in urban environments. Because low-frequency noise is widespread (effective transmission) in comparison to many buildings, and many constructions (homes, walls, and hearing protection) are

less effective at dampening low-frequency noise than other noises, low-frequency noise has worrying effects. Intense low-frequency sounds appear to cause noticeable effects, such as breathing problems and hearing loss. Due to methodological problems, determining the effect of low-frequency noise is difficult, there are indications that low-frequency noise is responsible for some of the negative effects of noise: for sound pressure levels that are equal, loudness ratings and unpleasant responses are occasionally given. Low frequency noises are louder than other noises, hum or vibration induced by low frequency noise amplify difficulties, and low frequency noise can degrade speech intelligibility more than other sounds, with the exception of noise in the speech's frequency range due to upward propagation of the masking.^[9]

➤ **Intermittent noise**

Intermittent noise is defined as a noise level that rapidly rises and falls. A train passing by, factory machinery that runs in cycles, or airplanes flying above your property could all be the blame. We use a sound level meter to measure intermittent noise in the same way we do continuous noise.^[16]

➤ **Continuous noise**

Continuous noise refers to noise that has the identical intensity, frequency and quantity that provided to the community for longer periods of time, such as machinery operating in the textile sector, which has similar amount, intensity and frequency for 6–8 hours of a working shift. Noise has a negative impact on the health of industrial workers, producing everything from headaches to high blood pressure and other heart issues.^[15]

2.7.2.2 Health effects of noise

Noise pollution is thought to be the cause of hearing, heart disease, discomfort, high blood pressure, sleeplessness, and also immune system consequences. Noise also causes dizziness, headaches and hypertension, in addition to the ailments listed above.^[9]

➤ **On humans:**

Engine noise, horns and tire friction are all part of the complex mix of traffic noise emissions. Traffic noise, loss of communication, learning disabilities and lack of attention are all thought to contribute to noise pollution. Traffic noise, according to epidemiological data, increases the frequency of arterial diseases, strokes, hypertension and vascular dysfunctions. Non-hearing consequences such as sleep, activities, and communication difficulties can cause a variety of

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

emotional reactions, including annoyance and subsequent worry, elevated blood pressure and cholesterol, increased blood fluidity and sugar levels, and blood clotting factor activation. Higher memory problems and oxidative stress were also observed as a result of noise pollution. ^[12]

➤ **On industrial workers:**

Workers' health is harmed by occupational noise exposure, which increases hypertension, sleep problems, cardiovascular problems, blood pressure, exhaustion, and overworking, as well as mistakes made in various operational processes due to noise disturbance, impaired memory, accelerated heart rate, hearing loss and diabetes. ^[13]

➤ **On public:**

Technology, modernity, and residential complexes are typically located near people, resulting in an increase in noise that is documented. Noise's environmental influence is linked to a variety of health issues, including pain, sleep disturbances, and cardiovascular disease. Noise can also have a negative impact on communication, memory, and hearing. ^[14]

➤ **On animals:**

Noise levels are steadily rising over the world, posing a threat to many animal species. Birds' behavior and physiology, as well as their reproductive system, can be affected by short-term exposure, since birds avoid reproducing in noisy environments. Loss of hearing, loss of responsiveness, disorientation, and disruption are all symptoms that animals experience in the same way that humans do. Most bats' foraging effectiveness was lowered by traffic noise. Monkeys also prefer noise-free environments, as evidenced by a studies in which continuous noises was provided in a monkey's habitat in Brazil, and monkeys relocated from that area to a noise-free region, demonstrating that they dislike noise as well. The effects of noise on wildlife have also been extensively investigated, with studies indicating that bears, wolves, ants, lions, and larger species such as elephants and whales prefer to live in quiet environments. ^[9]

2.8 Fibers

Natural fibers and man-made (synthetic) fibers are the two types of fibers. Natural fibers are one of the most abundant and renewable resources available in the world. Natural fibers includes vegetable as kenaf, hemp and wood; animal as wool and fur felt; and mineral as asbestos fibers, whereas synthetic fibers might be mineral such as fiberglass, mineral wool, and glass wool or polymer/ polyester. It mainly refers to wood fiber and agro-based bast, seed, leaf, and stem fibers in the composites sector. When utilized in plastic composites, these fibers can provide significant reinforcement and contribute significantly to the structural performance of the plant. Growing awareness of environmental issues has resulted in an increase in demand for goods made from natural resources, such as natural fibers in recent years. They are biodegradable, making them convenient to use and accept in society.^[3,17]

Natural fibers are becoming more popular in the automobile and packaging industries. The automotive industry, notably in Europe, is one of the major recent development areas in natural fiber plastic composites, where the natural fibers are being used more frequently as a result of their low density and rising environmental concerns. Although a variety of techniques have been examined, the majority of natural fiber composites are currently press-molded. In the European car industry, flax is the most extensively utilized natural fiber, accounting for 71% of all natural fibers used in 2000. India attracts a lot of worldwide interest because it is one of the world's fastest developing countries. When compared to prior years, India is the seventh largest country in the world in terms of natural fiber production. Next to China, India is the world's second largest producer and consumer of fibers, textiles, and manufactured goods.^[18]

2.8.1 Classification of Natural Fibers

Natural fibers are classified into three groups based on where they come from: plant, animal, and mineral fibers.^[17]

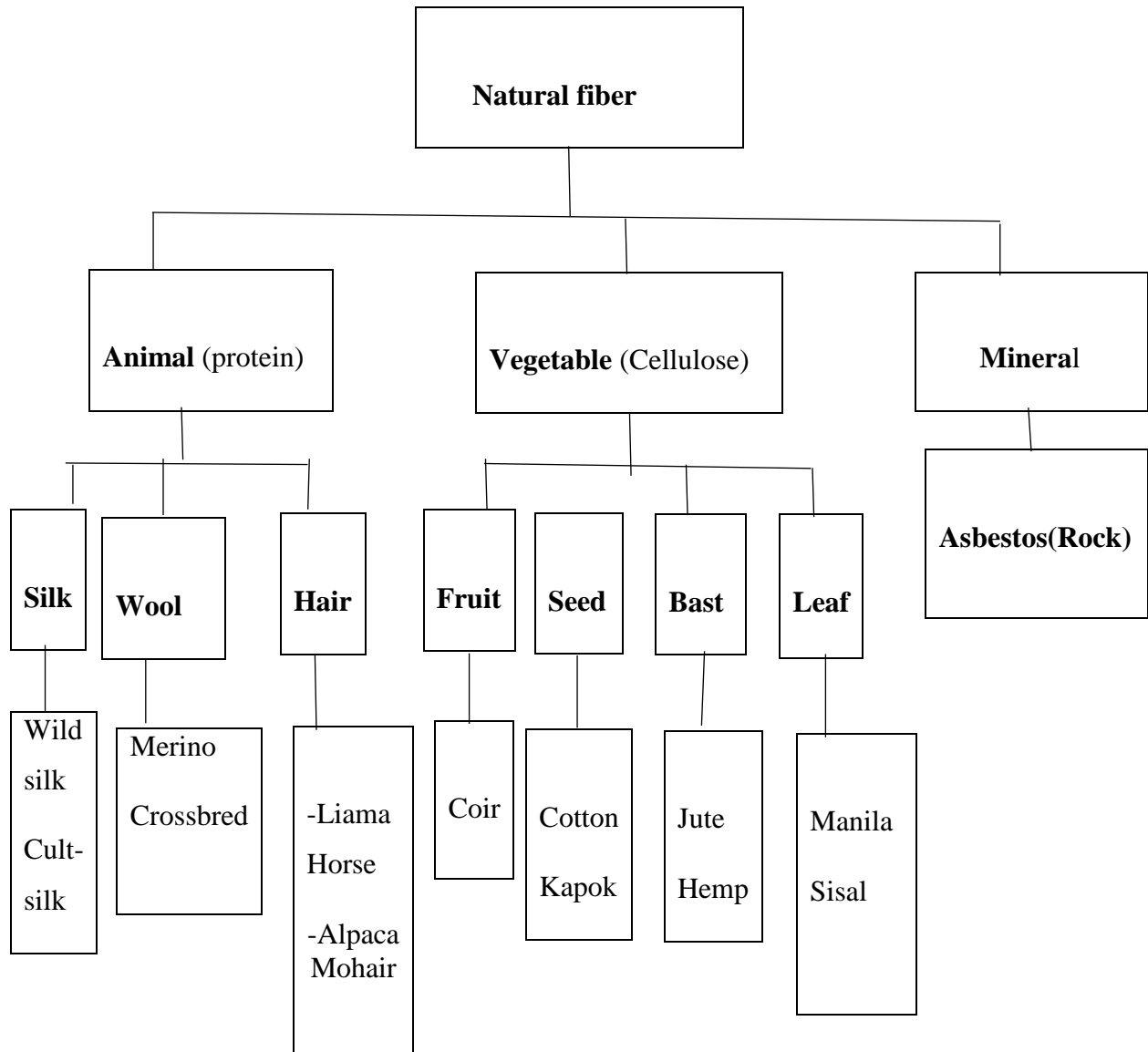


Fig. 2.2 Classification of Natural Fibers ^[17]

2.8.1.1 Plant Fibers

Many raw materials used to make textiles, ropes, twine, and other related goods come from plants. Pineapple, banana, coir, and palm fibers are examples of naturally occurring fruit fibers. The most commonly used plant fibers are: cotton and kapok fibers are seed fibers; and areca, bamboo, hemp, jute, kenaf, and ramie fibers are leaf fibers.^[3]

2.8.1.2 Mineral Fibers

Asbestos, graphite, and glass are examples of mineral fibers. Asbestos fibers are found in nature. Asbestos is the only natural fiber that may be found in many rocks. It is a fibrous magnesium and calcium silicate containing iron, aluminum, and other elements. It is acid, flame, and rust resistant, but its particles are carcinogenic, thus its use is prohibited. It's commonly utilized in fire-resistant materials. Graphite is a naturally occurring mineral fiber with a cheap cost. They have a higher rigidity and mechanical qualities that are acceptable. They will have a higher thermal conductivity, making them very helpful in thermal management systems and satellite constructions. Glass mineral fibers are lightweight that easy to install, and they provide excellent thermal insulation and acoustic performance. Glass mineral wool is the most common type of glass fiber, and it can be utilized in a variety of applications, including lofts and roofs, as well as industrial insulation.^[17]

2.8.1.3 Animal Fibers

Animal fibers are natural fibers mainly made up of certain proteins. Examples include silk, hair/fur or wool, and feathers.. Wool from domestic sheep and silk are the most often utilized animal fibers in the manufacturing industry as well as by hand spinners. Alpaca fiber and Angora goat mohair are also quite popular. Uncommon fibers such as rabbit Angora wool and dog Chiengora are also accessible, but they are infrequently applied in large-scale manufacture. Silk is a natural protein fiber that may be woven into textiles in some forms. Silk is mostly made up of the protein fibroin, which is produced by some insect larvae in order to construct cocoons. The most well-known silk is made from the cocoons of the mulberry silkworm *Bombyx mori* larvae, which are bred in sericulture. Silk's gleaming appearance is due to the triangular prism-like arrangement of the silk strand, where this permits silk to refract incoming light at different angles, resulting in different hues.^[17]

2.9 Acoustic material(sound absorbing material)

2.9.1 Acoustics

Acoustics is a term that is occasionally used to refer to sound science in general. It's most usually associated with a part of that field called architectural acoustics, which works with the building of enclosed spaces to improve speech or music hearing. It might also be considered a field of architecture that works with sound control and emphasizes sound's reflecting and absorptive qualities. The spoken word, music, as well as other auditory experiences that offer us pleasure all rely heavily on sound. In most circumstances, if a sufficient balance of sound-absorbing and sound-reflecting materials is produced, the acoustics of a building will be satisfactory. The degree of sound absorption and the frequencies absorbed by most common acoustic materials are affected by the density and thickness of the material.^[21]

Acoustic absorption is the process through which sound waves collide with and reflect off of a surface such as a walls, seats, floors, buildings or other materials. The reduction of sound energy reflected off a surface is referred to as sound absorption. The terms sound absorption and sound insulation were used to differentiate between the two. A portion of the sound wave is converted to heat, while the remainder is absorbed by the materials. When a speaker is installed in a room, the sound wave will move and collide with the walls, with part of it reflecting and some being absorbed by the wall. Because of the viscosity of the wall, absorption may happen by deformation. Size, shape, and impact angle all influence the amount of sound absorbed. The most important aspect of soundproofing is acoustic absorption. It entails absorbing as much sound energy as possible and either converting it to heat or sending it away from a particular spot. Soft, flexible, or porous materials absorb sound well, while hard, dense and impenetrable materials reflect it the most.^[9]

The architect has two sorts of materials to coating the surface of ceilings, walls, and floors to adjust reverberations; those are sound absorbent and sound-reflecting. Soft materials like cork and felt absorb the majority of the sound they come into contact with, while they may reflect certain low-frequency sounds. The majority of sound that strikes hard objects like stone and metal is reflected. When a huge auditorium is packed, the acoustics are substantially different than when it is empty; empty seats reflect sound, while an audience absorbs it.^[4,22]

2.9.2 Characterization of the acoustic material

2.9.2.1 Sound absorption coefficient

A material's ability to absorb sound is measured by its sound absorption coefficient. It's the ratios of absorbed to incident energy, and it's denoted as α . The sound absorption coefficient of materials is proportional to frequency and varies with different frequency. The frequencies characteristic curves of sound absorption coefficients can be used to precisely describe the sound absorption properties of various frequencies. The sound absorption coefficient is commonly used as a metric to assess a material's sound absorbing capabilities. The mean value of absorbance to sound from all incidence areas is adopted by the sound absorption coefficient, and the frequency of the sound being absorbed must be specific.^[23] In the previous studies, it showed that the sound absorption coefficients of wooden cane, mineralized wood and kapok fiber reinforced composite at 2000 Hz were 0.43, 0.4 and 0.45 respectively.^[2,3]

2.9.2.2 Thickness

Thickness, as opposed to width/height or the attribute of being thick, is the distance through an objects. The composites' thickness can be measured with a screw gauge by measuring thickness at different places and averaging the results. The sound absorption coefficient of a product can be affected by material thickness variation. Several investigations on sound absorption in porous materials have concluded that low frequency sound absorption is proportional to thickness. As the material thickens, sound absorption increases only at low frequencies. But, at higher frequencies, thickness has insignifican effect on sound absorption.^[25]

2.9.2.3 Density

A material's density is calculated as its mass per unit volume. The density of the samples was determined using their mass and volume ($\pi r^2 h$). The ability of a material's sound absorption capacity is influenced by its density.

$$\rho = \frac{m}{V} \text{ where } \rho \text{ represent the density, } m \text{ represent the mass, and } V \text{ represnt the volume.}$$

The density of a material is one of the most critical criteria that determines how well it absorbs sound. As the density of the material increased, the sound absorption value in the midrange and

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

higher frequencies increased. When the apparent density is high, the number of fibers per unit area increases. As the surface friction increases, the energy loss increases, and the sound absorption coefficient increases. Low-frequency sound is absorbed by a structure that is less dense and more open. For frequencies greater than 2500 Hz, a denser structure works better.^[24]

2.9.3 Factors that can affects on preparation of the acoustic material

Particle size

Particle size is a phrase used to compare the dimensions of solids, liquids, and gases. Sieving or direct measuring of individual clasts can be used to assess particle size. Particle size analysis is a critical test that is used in a variety of industries for quality control. Particle size is a significant component in affecting the efficiency of production operations and the performance of the finished product in almost every industry that uses milling or grinding.^[26]

Temperature

The quantity or intensity of heat carried in a material or item, as measured on a scale and displayed by a thermometer or sensed by touch, is referred to as temperature. Temperature can affect the production of the acoustic material when pressing the samples by using the hydraulic pressing machine.^[2]

Pressure

A regular physical force imposed on or against an object by something in touch with it, is referred to as pressure. The perpendicular force per unit surface area, or the stresses at a point within a confined fluid, is also known as pressure. Pressure can affect on preparation of the product when pressing the samples by using the hydraulic pressing machine.^[4]

Time duration

The time duration of a task is the amount of time it takes to perform it. Time duration plays an important role on preparation of the acoustic material when drying the samples by using the oven dryer.^[26]

2.9.4 Chemical used on production of the acoustic material

2.9.4.1 Styrene butadiene rubber (synthetic rubber adhesive)

Synthetic rubbers manufactured from styrene and butadiene are known as styrene-butadiene or styrene-butadiene rubber (SBR). When treated by additives, these materials exhibit good abrasion resistance and aging stability. SBR is widely used in vehicle and truck tires, primarily as an abrasion-resistant alternative to natural rubber. In many cases, SBR rubber polymer substitutes natural rubber since it is more cost-effective and provides numerous benefits. SBR, for example, has good abrasion resistance, crack endurance, and ages well. It also has high water resistance and compression set resistance.^[27]

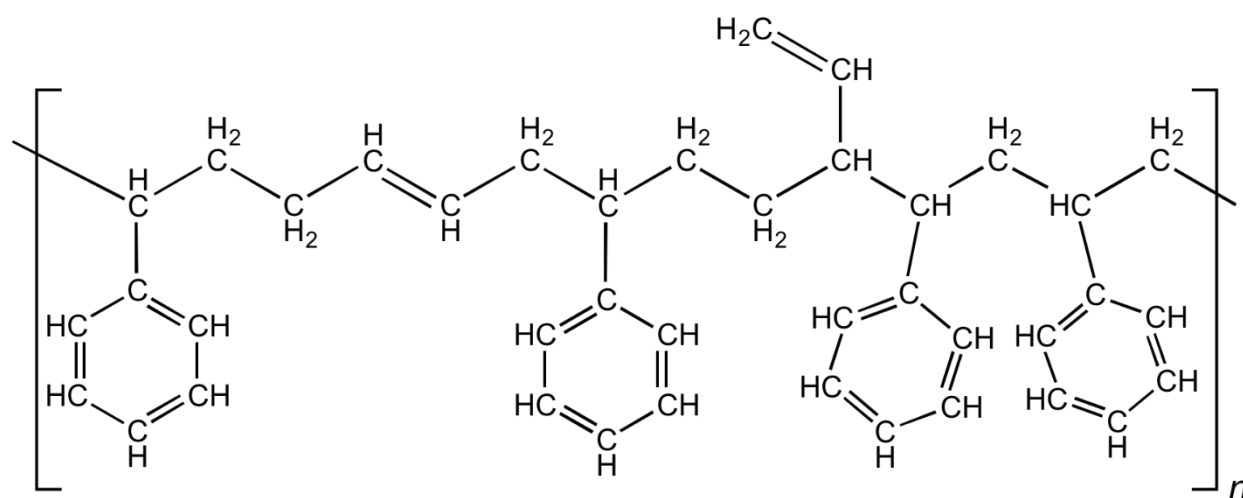


Fig.2.3 Structure of Styrene -butadiene rubber polymer^[27]

2.9.5 Equipment /Machines used on production of the acoustic material

Grinding Machine

A grinding machine, sometimes known as a grinder, is a type of tool or machine tool that is used for grinding, which is a type of machining that involves cutting with an abrasive wheel. In this case grinding machine used in order to grinding the dried chrome shaving waste to reduce its size.^[28]

Milling Machine

The workpiece is generally held in a vise or identical device secured to a table that can travel in three perpendicular directions, and the milling machine rotates a circular tool with a number of cutting blades symmetrically positioned about its axis. Milling is the process of removing material from a workpiece by advancing a cutter into it with rotary cutters. This can be accomplished by changing the direction of one or more axes, as well as the cutter head speed and pressure. In this study this milling machine is used to milling the grinded chrome shaving waste for further uniform reduction of samples size. [29]

Homogenizer/Mixer Machine

A homogenizer is a component of laboratory or industrial equipment that homogenizes a different materials such as tissue, plants, foods, soils, and other things. In this case homogenizer is used for mixing of the weighed chrome shaving , animal fiber and bonding agent. [30]

Hydraulic pressing Machine

A hydraulic press is a machinery press that generates compressive force using a hydraulic cylinder. Many objects are shaped and assembled using hydraulic presses. In this study, the hydraulic pressing machine is used to pressing of the mixed samples by adjusting the pressure and temperature to get desired shape of the material. [31]

Vacuum Dryer

Vacuum drying ovens are frequently used for critical drying tasks such as drying small parts or removing flammable liquids. Vacuum drying is a mass transfer technique that involves removing moisture from a material, usually a wet solids, by creating a vacuum. Drying is an important unit operations in chemical manufacturing industry such as food production, pharmacy, agriculture, and textiles to removing a moisture. Vacuum drying ovens are widely used to dry samples at the lowest temperature possible to prevent degradation. Vacuum ovens are used for a variety of purposes, including curing epoxies, degassing liquids, baking-out, moisture estimation, aging testing, and heat treating, in addition to sample drying. In this study, the vacuum oven dryer was used to drying the blended samples of the acoustic material. [32]

Impedance tube (Transfer function method)

In 1980, Chung and Blaser proposed employing impedance tubes with the two microphones to measure absorption coefficients in the transfer function method. The transfer function technique, like the standing wave approach, is carried out in sonic tubes, but two microphones mounted on the tube wall substitute the sliding microphone. Plane waves are generated in the tubes by the sound source. The wave propagation functions of the two microphone signals could be estimated by placing the two microphones adjacent to the test sample and measuring sound pressure. Complex calculations are used to determine the normal incident absorption coefficient and surface impedance. In comparison to the standing wave method, the transfer function method is more easy and advanced.^[33] The sound source emits a broadband steady noise signal when using the transfer function method. The tube measures the transfer function, which is defined as a ratio of pressures among two microphone positions. As a result, the sample's reflection coefficient for the same frequency band as the wideband signal is calculated. It's also possible to calculate the impedance and absorption coefficient. The second method is accurate, dependable, and produces the surface's absorption coefficient and impedance for a wide range of frequencies (within limits) in a relatively short amount of time.^[34]

3. Materials and Methods

3.1 Physico-Chemical Characterization of Raw Materials

3.1.1 Materials

The raw materials used in this physico-chemical characterization were chrome shaving waste, sheep wool fiber, water, nitric acid, acetylene and dichloromethane which were found in CLRI.

The equipments used in physico-chemical characterization of the raw materials were pH meter, glass reactor, weighing balance, oven, desiccator, furnace, atomic absorption spectrophotometer, ruler, filter paper and extraction flask which were found in CLRI.

3.1.2 Methods

The following methods were performed to determine the physico-chemical parameters (pH, moisture content, ash content, fat content, chromium content, and material type, color, size):

3.1.2.1 Determination of pH

The pH of the raw materials sample were obtained by shaking six grams of sample in 100ml of distilled water for 18–24 hours, then measuring the pH directly using SLC 13's standard techniques.^[8]

3.1.2.2 Determination of Moisture Content

The mass of moisture per unit mass of wet or dry materials is commonly used to express the moisture content of solid waste. To assess the moisture content of solid wastes, samples were weighed and then put in an oven for 18 hours at 105°C. It was cooled for around 40 minutes in desiccator before being weighed and documented. The moisture contents of wet mass were calculated as follows:^[7]

$$\text{Moisture content (\%)} = ((w-d) / w) \times 100$$

Where: w is initial mass of raw sample

d is mass of raw sample after drying

3.1.2.3 Determination of Ash Content

The ash content of the raw sample were obtained after burning the dry solids in a furnace at 700⁰C for 2 hours. The raw samples were then put in to a desiccator for about 40 minutes and weighed.^[35]

$$\text{Ash Content (\%)} = (W1/W2) \times 100$$

Where: W1 is the mass of raw sample left after burning

W2 is the mass of raw sample before burning

3.1.2.4 Determination of Chromium Content

The chromium content of the chrome shaving waste were determined using Atomic absorption spectrophotometer. The raw samples chrome shaving were first treated with an acid digestion techniques and after they reached the room temperature the raw sample solutions were filled up to 100 ml with pure water. Then , the amount of Cr content in the sample solutions were detected using Atomic absorption spectrophotometer at 350.8nm with 0.6 slit intervals by using air plus acetylene (C₂H₂) mixture.^[8]

3.1.2.5 Determination of Fat Content

The fat content of the sample waste were determind by Dichloromethane SLC4 standard methods. 10 g of the raw sample was weighed and pressed evenly into the filter paper thimble. The sample was covered with a thin layer of cotton wool. Drying the extraction flask with two glass beads in it by heating for 30 minutes at 10⁰C in oven. Then its was weighed after cooling in a desiccator.^[7]

3.1.2.6 Material Type, Color and Size

Physical parameters were used to determine the physical characteristics of the raw materials (chrome shaving waste and sheep wool). The type and color of the raw material were identified. The size of the raw material were measured using ruler and taking the average.^[35]

3.2 Optimization of the acoustic material

3.2.1. Materials

Raw materials

Chrome shaving waste and animal fiber (sheep wool fiber) were collected from Model Tannery in Central Leather Research Institute (CLRI), Chennai, India. The styrene butadiene rubber (synthetic rubber adhesive) which used as bonding agent were taken from Footwear Department in CLRI, Chennai, India.

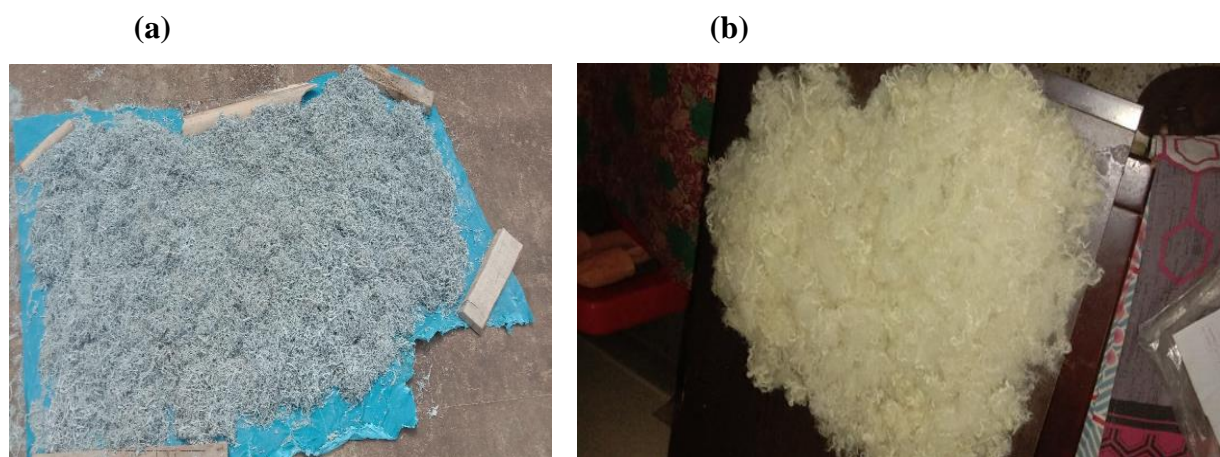


Fig 3.1: (a) Chrome shaving waste and (b) animal fiber(sheep wool)

Equipment

The equipments or machines used in this preparation and optimization of the product were grinding machine, milling machine, homogenizer (mixer), beaker/glass reactor, vacuum dryer, sheet forming material, hydraulic pressing machine, scissors, weighing balance machine, which were found in central CLRI, Chennai, India..

3.2.2 Methods

3.2.2.1 Preparations of acoustic material from chrome shaving and styrene

butadiene rubber

Chrome shavings waste were collected from Model Tannery in CLRI and the styrene butadiene rubber (synthetic rubber adhesive) used as bonding agent were taken from Footwear Department. The collected chrome shaving wastes were dried by sun drying method. After drying, the chrome shavings were grinded to reduce its size using the grinding machine. The grinded chrome shavings were milled uniformly in to 3mm particle size using milling machine. Then, the desired concentrations of samples were weighed using weighing balance. The measured chrome shaving waste and styrene butadiene rubber (synthetic rubber adhesive) in different concentration ratios were blended using homogenizer(mixer) and sheet formation of mixed samples using sheet forming material. The sheet materials were pressed using hydraulic pressing machine at 50bar pressure and temperature of 150°C. Finally the prepared material were dried using oven(vacuum) dryer at 50°C for 6 hours.

3.2.2.2 Preparations of acoustic material from animal fiber and styrene butadiene rubber

Animal fiber (sheep wool fiber) were collected from Model Tannery in CLRI and the styrene butadiene rubber (synthetic rubber adhesive) used as bonding agent were taken from Footwear Department. The collected animal fiber (sheep wool fiber) were dried by sun drying method. After drying, the animal fiber (sheep wool fiber) were cut to reduce its size to get the desired size (approximately to 5mm) using scissors. Then, the desired concentrations of samples were weighed using weighing balance. The measured animal fiber and styrene butadiene rubber (synthetic rubber adhesive) in different concentration ratios were blended using homogenizer(mixer) and sheet formation of mixed samples using sheet forming material. The sheet materials were pressed using hydraulic pressing machine at 50bar pressure and temperature of 150°C . Finally the prepared material were dried using oven(vacuum) dryer at 50°C for 6 hours.

3.2.2.3 Preparations of acoustic material from chrome shaving, animal fiber and styrene butadiene rubber

Chrome shavings waste and sheep wool fiber were collected from Model Tannery in CLRI and the styrene butadiene rubber (synthetic rubber adhesive) used as bonding agent were taken from Footwear Department. The collected chrome shaving wastes and sheep wool fiber were dried by sun drying method. After drying, the chrome shavings were grinded to reduce its size using the grinding machine and the animal fiber (sheep wool fiber) were cut to reduce its size to get the desired size (approximately to 5mm) using scissors. The grinded chrome shavings were milled uniformly in to 3mm particle size using milling machine. Then, the desired concentrations of samples were weighed using weighing balance. The measured chrome shaving waste, animal fiber and styrene butadiene rubber (synthetic rubber adhesive) in different concentration ratios were blended using homogenizer(mixer) and sheet formation of mixed samples using sheet forming material. The sheet materials were pressed using hydraulic pressing machine at 50bar pressure and temperature of 150°C. Finally the prepared material were dried using oven (vacuum) dryer at 50°C for 6 hours.

Table 3.1

Proportion of samples for blends

Samples	Chrome shaving	Sheep wool(animal fiber)
1	10g(100%)	-
2	-	10g(100%)
3	7g(70%)	3g(30%)
4	3g(30%)	7g(70%)

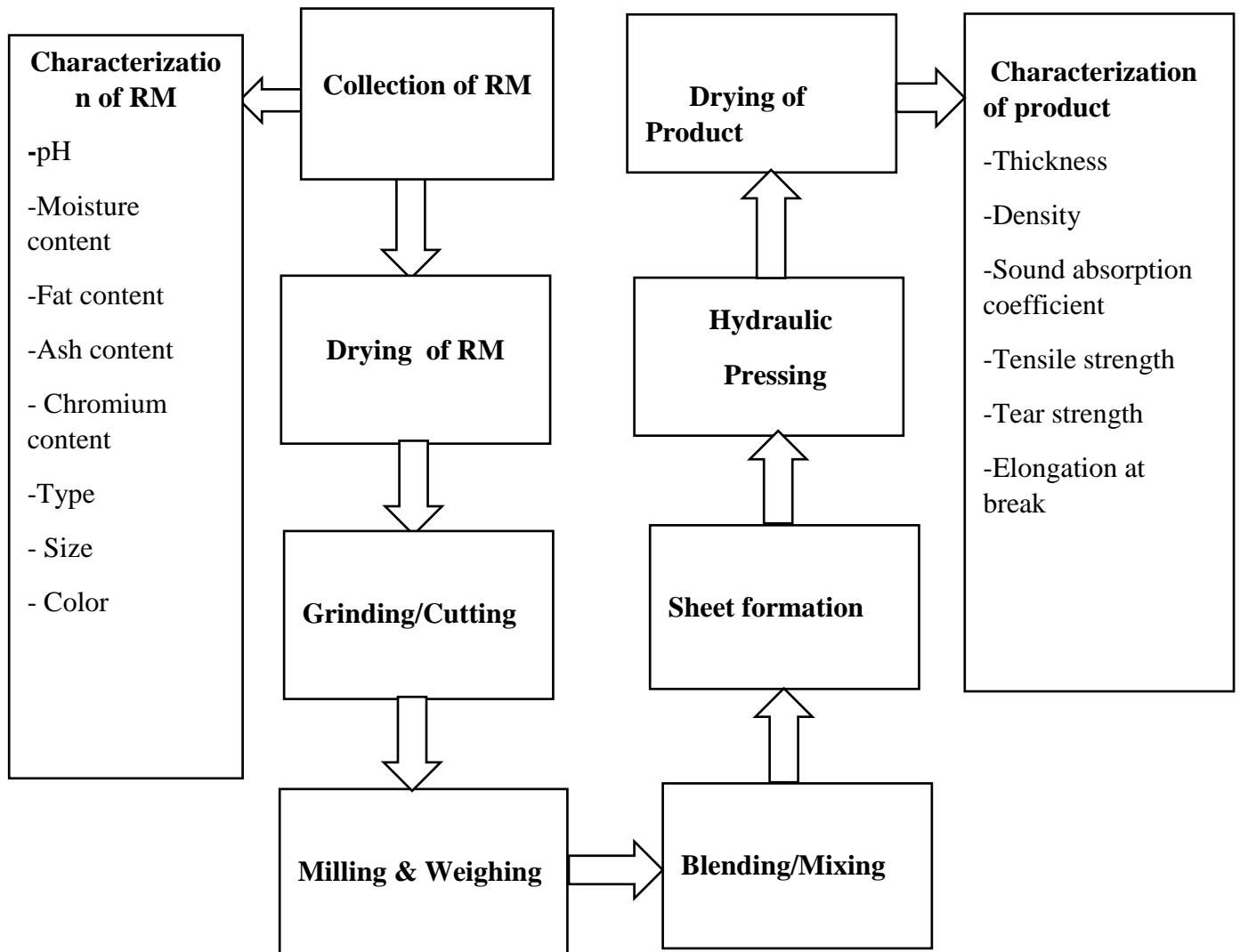


Fig.3.2 Characterization and processing flow chart of the raw materials and product

3.3 Characterization of the Product

3.3.1. Materials

The equipments used in measurement and characterization of the product were screw gauge, ruler for measuring thickness and dimensions of the prepared samples found in CLRI, Chennai, India, the impedance tube that were used to measure the sound absorption coefficient found in PSG TECHS COE INDUTECH LABORATORY, PSG College of Technology, Avinashi Road, Neelambur, Coimbatore-641062, Tamil Nadu, India and physical testing of the product were measured using tensile and tear tester according to ISO methods in CLRI, Chennai, India.

3.3.2 Methods

3.3.2.1. Thickness and Dimensions of the Product

The dimensions of the product were measured by measuring ruler and the thickness of the materials(products) were determined using screw gauge by measuring the thickness at six different places of the material and then taking the average. Thickness is a factor which influencing sound absorbing capacity of the acoustic material. ^[25]

3.3.2.2 Determination of Density of the Product

The density of the acoustic material is determined as mass of the material per unit volume of the material. The volume of the samples were determined using the formula ($\pi r^2 h$) where, r is the radius of the samples and h is the depth of the samples. The ability of a material's sound absorption capacity can be influenced by its density. ^[24]

$$\rho = \frac{m}{V}$$

where ρ represent the density, m represent the mass, and V represent the volume^[24]

3.3.2.3 Sound Absorption Measurements

The sound absorption coefficients of the acoustic material were measured using an impedance tube setup with the two-microphone transfer function method at the range of frequency 250 to 6300 Hz (according to ASTM E1050) at PSG TECHS COE INDUTECH LABORATORY, PSG College

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

of Technology, Avinashi Road, Neelambur, Coimbatore-641062, Tamil Nadu, india. The acoustic material samples with 20mm diameter circles were put into the sample holder. The samples holder placed directly against the backing plate. The signal generator producing sound in to equalizer for equalize the random generated sounds. Then the sound was amplified using the power amplifier. Broadband sounds were generated in to the impedance tube. The software that used in this measurement was based on the Transfer Function Method. The Transfer Function method was done by separating the incident and reflected energy from the measured transfer function and then estimates the sound absorption coefficients of the test sample with respect to frequency ranges.^[22]

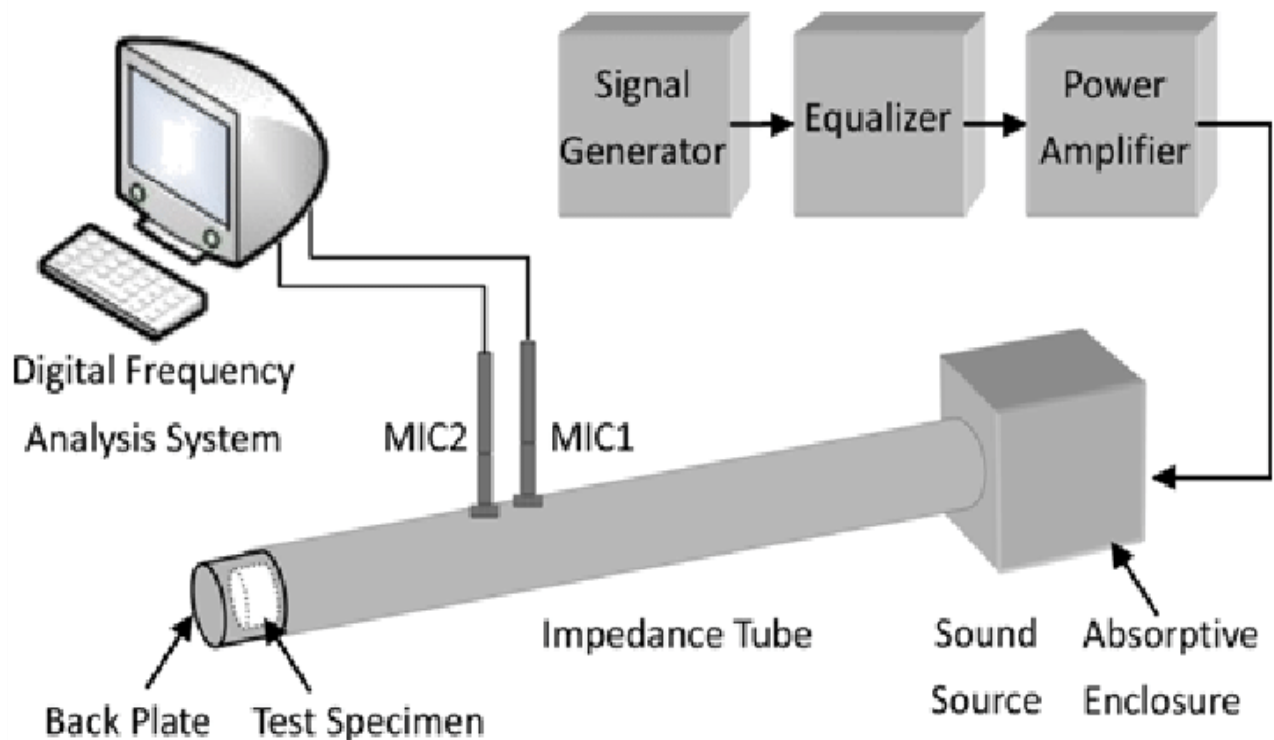


Fig.3.3. Schematic diagram of the impedance tube with the two-microphone transfer-function method.^[22]

3.3.2.4 Physical testing of the product

Tensile strength

Tensile strength of the acoustic materials were measured using universal tensile tester at the temperature of 23.2°C and with relative humidity of 45.7% according to the testing method of ISO 3376:2011.^[38] Tensile strength of the acoustic material is defined as the resistance of acoustic material to breaking under tension. The capacity of a material to endure loads that tend to elongate is known as tensile strength.^[36]

Tensile strength = Maximum breaking load(Nmm⁻² or Kgcm⁻²) / Cross section area

Tear strength

Tear strength of the acoustic materials were measured using tear tester at the temperature of 23.2°C and with relative humidity of 45.7% according to the testing method of ISO 3377-2:2011.^[39] Tear strength or tear resistance of the acoustic material is defined as a measure of how well the acoustic material can withstand the effects of tearing. Tear strength of the material can be determined as the amount of force required to tear a specific sampling subject and proceed through it in a vertical axis.^[37]

Tear strength = Force /thickness

Elongation at break

Elongation at break of the acoustic material were determined by tensile testing at the temperature of 23.2°C and with relative humidity of 45.7% according to the testing method of ISO 3376:2011.^[38] The ratio between the modified length and the initial length following breaking the test sample is determined as elongation at break of the material, also termed as fracture strain. It describes a material's capacity to withstand changes in shape without cracking.^[36]

Elongation at break, % = {(Final free length - Initial free length)/ Initial free length} x 100

4. Results and Discussion

4.1 Physico-chemical characterization of the raw materials

The raw chrome shaving waste and sheep wool/animal fiber were characterized by determining the physico-chemical parameters which were pH, moisture content, ash content, chromium content, fat content, material type, color and size of raw samples. The results are shown below in table 4.1.

pH

The pH value of chrome shaving waste was found as 3.7, which indicated that the chrome shaving waste was found in acidic pH value due to the chrome tanning of the cow hide were carried out at acidic condition. The pH value of sheep wool fiber was found as 8.8, this indicated that the sheep wool fiber was found in basic condition. The pH values of chrome shaving waste and sheep wool fiber were found in acidic and alkaline conditions respectively, so disposal of those wastes to the environment without treatment have negative impact on the public health and the environment.

Moisture Content

The moisture content of the chrome shaving waste and sheep wool fiber were found as 52.30% and 13.23% respectively. The moisture content of chrome shavings was showed higher in comparison to the moisture content of sheep wool fiber. This was happened due to the fact that the chrome shaving waste was generated from wet processing stages while the sheep wool was generated from paint unharing techniques. Due to the high moisture content of chrome shaving waste, infusion of chrome in chrome shaving wastes into soil surface and ground water can affect the natural structures of the environments. Therefore, utilization of chrome shaving waste is important to get value added products and minimize the environmental pollution.

Ash Content

The ash content of the chrome shaving waste and sheep wool fiber were found to be 9.50% and 1.50% respectively. This indicates that more than 90% of chrome shaving waste and 98% of sheep wool fiber were found to be organic content.

Fat Content

The fat content of chrome shaving waste and sheep wool were found to be 0.75% and 0.10% respectively. This indicates that both raw materials have low fat contents in their composition.

Chromium Content

The chromium content of chrome shavings wastes was found to be 16,545ppm, which is much higher than the safe standard limit of chromium metal to be in soil surface (100 – 150ppm).^[8] This was happened due to the fact that chromium sulphate chemical was used in chrome tanning process. Therefore, this chrome shaving waste must to be utilized in to value added product or disposed in secured landfill since the chromium metal is highly toxic.

Material Type, Color and Size

The chrome shaving waste was found from cow hide wet blue leather and the sheep wool fiber was found from merino sheep wool. The color of chrome shaving waste was bulish while the color of sheep wool fiber was white. The average length of chrome shaving waste and sheep wool fiber were found to be 30mm and 25mm respectively. The size of the both raw materials should be reduced to smaller size for the production of acoustic material.

Table 4.1

Physico-chemical analysis of raw materials (sheep wool and chrome shaving waste)

Physico-chemical parameters	Chrome shaving waste	Sheep wool/animal fiber
pH	3.7	8.8
Moisture content	52.30%	13.23%
Ash content	9.50%	1.50%
Fat content	0.75%	0.10%
Chromium content	16,545 ppm	-
Material type	Cow hide Cr shaving	Merino sheep wool
Size (average length)	30mm	25 mm
Color	Bluish	White

4.2. Optimization of Acoustic Material with addition of Animal fiber

The prepared acoustic materials with addition of animal fiber were found as good sound absorbing materials due to the effect of animal fiber to the product which increased the thickness and fibrous content of the material and has good effect on sound absorption capacity. From Table 4.2, thickness of the acoustic material made up of animal fiber/wool- chrome shavings- styrene butadiene rubber blends were higher when compared to the acoustic material that made up of chrome shavings- styrene butadiene rubber blends and the density of the acoustic material decreases due to the addition of the animal fiber/wool fibers to the chrome shavings. The animal fiber/wool fiber has good strength and low pressing ability, due to this reason the thickness of the acoustic material with animal fiber were increased when compared to the chrome shavings blends. From Fig 4.4, the sound absorption coefficient of the acoustic materials of (30% Cr & 70% W) and (70% Cr & 30% W) were higher than the other prepared samples, this effect were shown due to addition of fibrous content rich animal fiber to the blends. The addition of the animal fiber also affects on the density characterization of the acoustic material, as increasing the addition of animal fiber to the material leads to decrease the density which increase the sound absorption coefficients at low frequencies. The addition of the animal fiber to the blends also were leads to have good strength of the final product due its excellent strength properties. From Table 4.3, the acoustic material(30% Cr - 70% W) and (70% Cr - 30% W) were found as good material in the results of physical properties which have better tensile strength, elongation at break and tear strength when compared to the other acoustic materials made from 100%Cr and 100%W. This result were found due to the addition of high amount of animal fiber to the chrome shaving blends which affects in increasing the strength to the materials. The acoustic materials of 70% W -30%Cr and 30%W – 70%Cr with thickness of 4.25mm and 3.86mm and with density of 0.011 g/mm³ and 0.012 g/mm³ and their sound absorption coefficient of 0.54 and 0.46 at frequency of 2000 Hz respectively were found as good sound absorbing materials when compared to the acoustic materials made from 100%Cr and 100%W with sound absorption coefficient of 0.36 and 0.36 at frequency of 2000Hz respectively. Hence, the addition of animal fiber to the blends were shown on optimizing the results related to the thickness, sound absorption coefficient and physical strength of the acoustic materials.

4.3 Characterization of the Product(Acoustic Material)

The prepared acoustic materials were characterized using appropriate characterization methods. The characterization parameters of the product produced from chrome shaving waste and animal fiber were thickness, density, sound absorption coefficient and physical properties (tensile strength, tear strength and elongation at break).



100% Cr shaving



100% Animal fiber(sheep wool)



70% Cr Shaving - 30% Sheep wool



30% Cr shaving – 70% Sheep wool

Fig. 4.1 Digital images of prepared acoustic materials

4.3.1 Thickness and density of acoustic materials

The thickness of the acoustic materials were determined using screw gauge by measuring the thickness at six different places and by taking the average. Density of the acoustic materials were calculated from mass and volume ($\pi r^2 h$) of the samples. Thickness of the acoustic material made up of animal fiber/wool- chrome shavings- styrene butadiene rubber blends were higher when compared to the acoustic material that made up of chrome shavings- styrene butadiene rubber blends and the density of the acoustic material decreases due to the addition of the animal fiber/wool fibers to the chrome shavings. The animal fiber/wool fiber has good strength and low pressing ability, due to this reason the thickness of the acoustic material with animal fiber were increased when compared to the chrome shavings blends. The size variations in the animal fibers/sheep wool fiber also affects for the variation in thickness of the samples due to its compression behaviour. As the thickness of the acoustic material increases, the density of the acoustic material decreases and the sound absorption coefficients of the acoustic material increases in the low and mid frequencies. The results showed that the acoustic material (**30% Cr shaving & 70% wool/animal fiber**) were found as the thick and less dense when compared to the other samples which leads to have good sound absorption coefficients. The thickness and density of the prepared acoustic materials are shown in Table 4.2. The relationship of thickness and sound absorption coefficient of the acoustic materials at frequency of 2000 Hz were shown below in Fig.4.3. From this graph, the sound absorption coefficient of the acoustic material at low frequencies were increased when increasing the thickness of the acoustic materials. The acoustic materials of 70% W -30%Cr and 30% W – 70%Cr were found as good sound absorbing materials with thickness of 4.25mm and 3.86mm and their sound absorption coefficient of 0.54 and 0.46 at frequency of 2000 Hz respectively. The relationship of density and sound absorption coefficient of the acoustic materials at frequency of 2000 Hz were shown below in Fig.4.2. From this graph, the sound absorption coefficient of the acoustic material at low frequencies were increased when decreasing the density of the acoustic materials. The acoustic materials of 70%W -30%Cr and 30% W – 70%Cr were found as good sound absorbing materials with density of 0.011 g/mm³ and 0.012 g/mm³ and their sound absorption coefficients of 0.54 and 0.46 at frequency of 2000 Hz respectively. Generally, the acoustic materials of 70%W -30%Cr and 30%W – 70%Cr with thickness of 4.25mm and 3.86mm and with density of 0.011 g/mm³ and 0.012 g/mm³ and their

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

sound absorption coefficient of 0.54 and 0.46 at frequency of 2000 Hz respectively were found as good sound absorbing materials when compared to the acoustic material made in the previous studies showed that the sound absorption coefficients of wooden cane, mineralized wood and kapok fiber reinforced composite at 2000 Hz were 0.43, 0.4 and 0.45 respectively.^[3,2]

Table 4.2

Results of thickness and density of acoustic materials

Samples	Thickness(mm)	Diameter(cm)	Density(g/mm³)
100% Cr	2.56	2	0.019
100% W	3.34	2	0.014
70%Cr - 30%W	3.86	2	0.012
30% Cr - 70% W	4.25	2	0.011

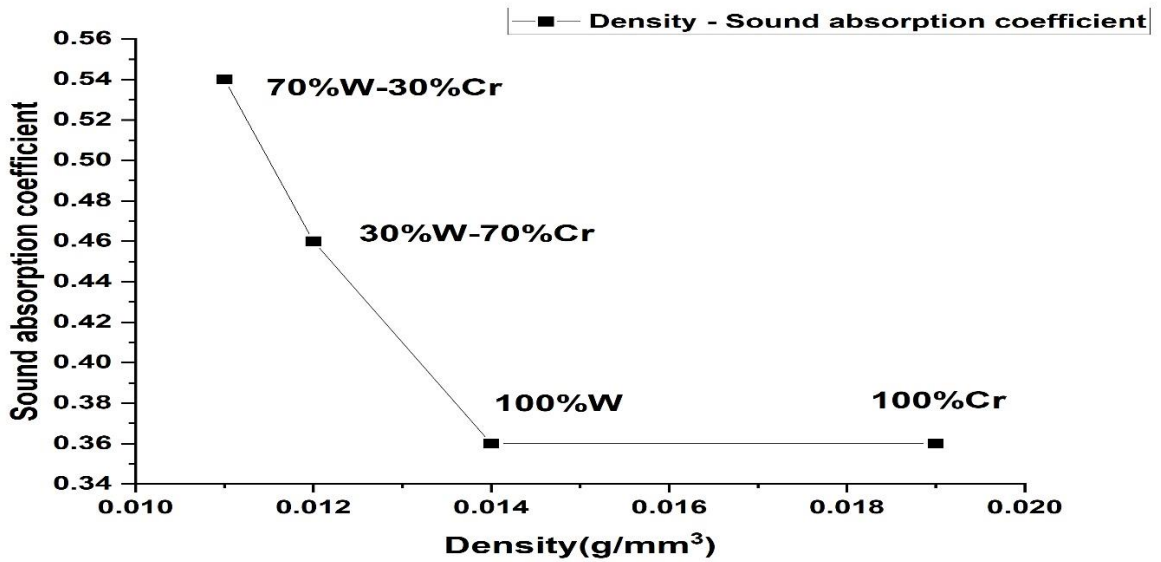


Fig. 4.2 Relationship of density and sound absorption coefficient of acoustic materials at frequency of 2000Hz.

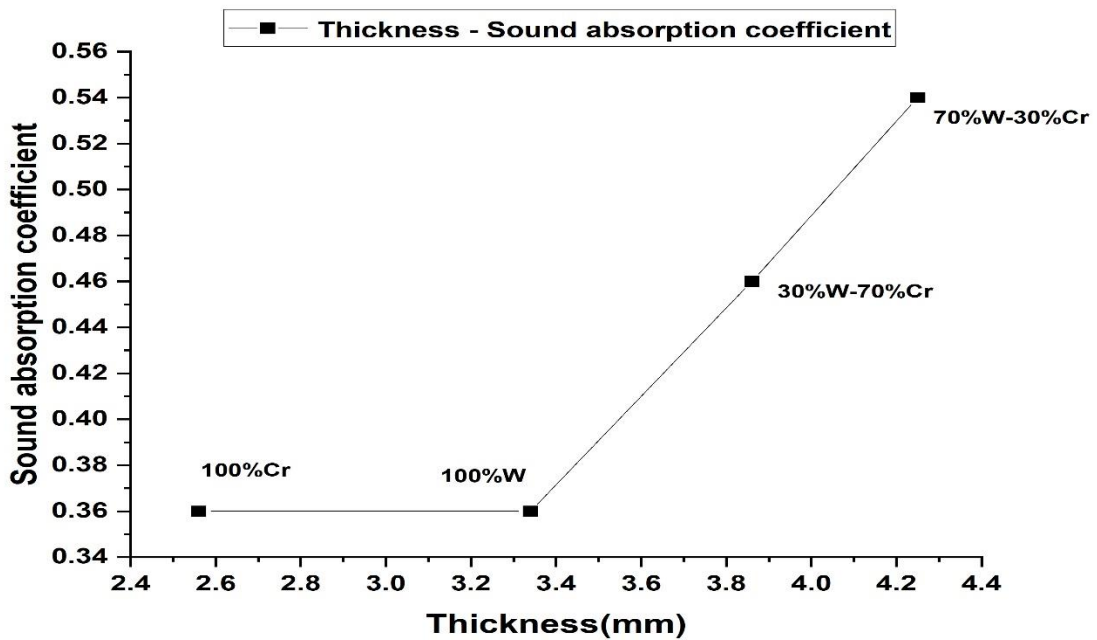


Fig. 4.3 Relationship of thickness and sound absorption coefficient of acoustic materials at frequency of 2000Hz.

4.3.2 Sound absorption coefficients of the acoustic materials

The sound absorption coefficients of the acoustic materials were measured using an impedance tube setup with the two-microphone transfer function method at the range of frequency 250 to 6300 Hz (according to ASTM E1050) and the results are shown in Fig. 4.4.

The sound absorption coefficient of the acoustic material with chrome shavings alone at low frequencies is lower when compared to acoustic material made up of chrome shavings with animal fiber/sheep wool. The sound absorption coefficient of the acoustic material (30% Cr & 70% W) is higher than the other prepared samples. Acoustic material of 70% wool with 30% chrome shaving has good sound absorption coefficient due to the addition of animal fiber to the acoustic material which increased the thickness and fibrous content of the material and has good effect on sound absorption capacity. Acoustic material with mixture of wool fiber and Cr shavings were showed high sound absorption coefficient at both low and high frequencies when compared to acoustic materials of Cr shavings and wool separately.

As reference, the previous studies showed that the sound absorption coefficients of wooden cane, mineralized wood and kapok fiber reinforced composite at 2000 Hz were 0.43, 0.4 and 0.45 respectively.^[3,2] In this study, the sound absorption coefficients of the acoustic material (30% Cr & 70% W) and the acoustic material (70% Cr & 30% W) at 2000 Hz were found to be 0.54 and 0.46 respectively. Thus, this paper suggests a novel approach for effective utilization of chrome shavings to get value added product used as sound absorbing materials by combining with animal fiber (sheep wool fiber), which can be effectively reduce unwanted sound pollution.

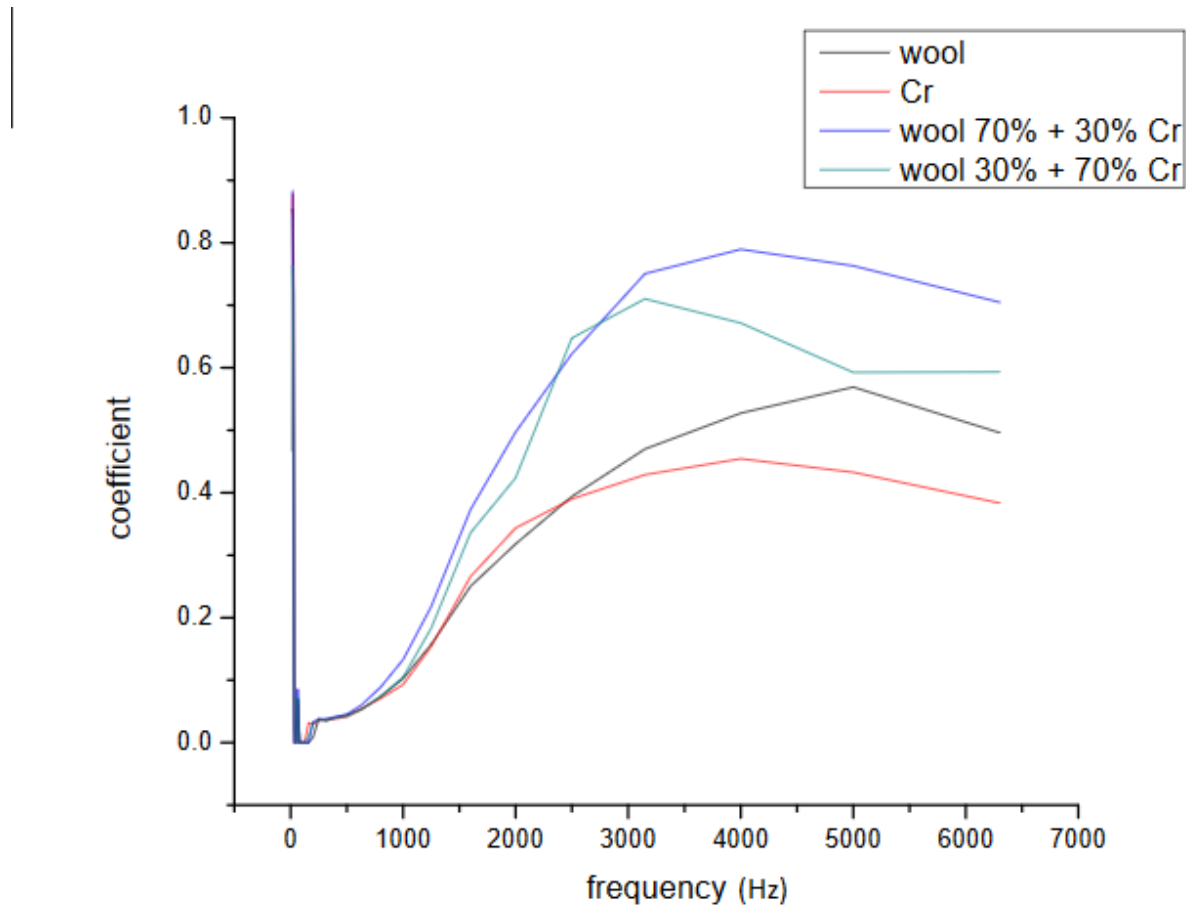


Fig 4.4 Sound absorption coefficients of the prepared acoustic materials

4.3.3 Physical Characterizations of the Acoustic Material

The physical testing of the prepared materials were measured by controlling the temperature at 23.2°C and with relative humidity of 45.7%. Tensile strength (N/mm²) and elongation at break (%) were measured using universal tensile tester according to testing method of ISO 3376:2011 and tear strength (N/mm) were measured using tear tester according to testing method of ISO 3377-2:2011. The results of the physical testing properties of the material are shown in Table 4.3.

The acoustic materials made up of chrome shaving - animal fiber - styrene butadiene rubber have better physical properties when compared to the acoustic material made from chrome shaving - styrene butadiene rubber and animal fiber - styrene butadiene rubber. The tensile strength of the

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

acoustic material (30% Cr & 70% W) were found as 6.64 N/mm^2 which have better tensile strength when compared to the other prepared samples. The acoustic material (70% Cr & 30% W) with the tensile strength of 5.79 N/mm^2 also have good tensile strength relative to the tensile strength of the acoustic materials made up of 100% chrome shaving and 100% animal fiber. The elongation at break of the acoustic materials made of chrome shaving with animal fiber were higher when compared to the acoustic material made up of chrome shaving without animal fiber. The elongation at break of the acoustic materials (30% Cr & 70% W) and (70% Cr & 30% W) were found as 10.85% and 9.57% respectively, which have better elongation when compared to the other prepared samples. The tear strength of the acoustic material made up of 100% chrome shaving were found as 8.74 N/mm which have less tear strength when compared to the other acoustic materials. The tear strength of the acoustic material (30% Cr & 70% W) were found as 15.08 N/mm that have higher tear strength than the other prepared materials.

Generally, the acoustic material (30% Cr & 70% W) were found as good material in the results of physical properties which have better tensile strength, elongation at break and tear strength when compared to the other acoustic materials. This result were found due to the addition of high amount of animal fiber to the chrome shaving blends which affects in increasing the strength to the materials.

Table 4.3

Physical testing results of the acoustic materials

Acoustic material	Tensile strength (N/mm ²)	Elongation at break (%)	Tear strength(double edge tear)			
			Mean tear load in newton(parallel to the back bone) (N)	Mean tear load in newton(perpendicular to the back bone) (N)	Average tear load (N)	Tear load (N/mm)
100% Cr	2.93	7.50	25.23	19.54	22.39	8.74
30%Cr -70%W	6.64	10.85	49.30	78.95	64.13	15.08
70%Cr- 30%W	5.79	9.57	39.32	53.51	46.42	12.02
100% W	5.36	8.14	30.14	41.18	35.66	10.67

5. Conclusion and Recommendation

Conclusion

Chrome shavings is one of the tannery solid wastes that have been utilized to get acoustic material (sound absorbing material) using hydraulic pressing technique by blending with animal fiber (sheep wool) and styrene butadiene rubber. Animal fiber was blended with chrome shavings to produce good sound absorbing materials and good strength due to its high content of fibrous content and thus can be used for acoustics applications. The acoustic material (30% Cr & 70% W) were found as good material in the results of physical properties which have better tensile strength, elongation at break and tear strength when compared to the other acoustic materials. This result were found due to the addition of animal fiber to the chrome shaving blends which affects in increasing the strength to the acoustic materials. The acoustic material of (30% Cr & 70% W) and the acoustic material of (70% Cr & 30% W) have better sound absorbance in the lower and higher frequencies, which can be used as sound absorbing panel at home, class room, auditorium and music studio by providing good hearing ability thus making environmental friendly value added products from wastes.

Recommendation

Based on the results and conclusions of this research, the following recommendations are given:

- It is recommended that tanneries can consider on converting chrome shaving waste in to value added product (acoustic material) as given in this study report, that can helps on minimizing the legal pressure on the tanneries which is imposed by environmental protection authority related to waste disposal and management, reduce cost of elimination of chrome shaving waste dump, create job opportunity to the community, generate income and creating suitable working environment for their tannery workers by utilizing the chrome shaving waste.
- This research also recommended that construction sectors can invest on the production of acoustic material from chrome shaving waste and sheep wool which can be used as alternative sound absorbing material to provide good hearing ability to the peoples inside of room or buildings by reducing sound pollution on public health and environment.

MSc Thesis: Production of Acoustic Material from Chrome shaving waste and Its evaluation as soundproofing

- But, this study needs further characterization and optimization of the product produced from chrome shaving and animal fiber (sheep wool). This product can be characterize and optimize by controlling the factors that affect on acoustic materials like particle size, temperature, pressure, binders, air flow resistance and porosity.
- This study also requires examination of morphology of the acoustic material using scanning electron microscopy (SEM) method to obtain the images of surface composites. And Fourier-transform infrared spectroscopy (FT-IR) also recommended to determine the functional groups found in the chrome shaving waste and sheep wool fiber.

References

1. A. Rahaman, D. Islam, M. Raihan- “Recovery of chromium from chrome shaving dust” EUROPEAN ACADEMIC RESEARCH, Vol. IV, February 2017
2. D. Hemalatha, S. Kowsalya, N. Nishad Fathima,* S. Sowmya and J. Raghava Rao* :“Natural Fibers Reinforced Chrome Shaving Composites for Sound Absorption Applications”: Inorganic and Physical Chemistry Laboratory, Council of Scientific and Industrial Research, Central Leather Research Institute , Adyar, Chennai, India: JALCA, VOL. 113, 2018
3. U. Berardi, G. Iannace, “Acoustic characterization of natural fibers for sound absorption applications”, Building and Environment , sound and vibration, Italy, Elsevier, Vol. 22. July 2015
4. M. R. Kumar, P.S. Alagisamy, M. Sakthivel: A Review Of Building Acoustic Materials, Kumaraguru College of Technology, New Delhi, India, Vol. 303, November 10-15, 2013
5. A. D. Covington, W. R. Wise: Tanning Chemistry 2nd Edition: The Science of Leather: Royal Society of Chemistry, The University of Northampton, UK : 2020
6. G. Andualem: Combination tanning based on tara and sodium metasilicate a new chrome free tanning system, addis ababa , Ethiopian : LAP LAMBERT Academic Publishing, February 8, 2017
7. H. Getahun:VALUE ADDED PROTEIN PRODUCTS FROM CHROME SHAVINGS:, Addis ababa, Ethiopia: Semantic scholar, October, 2017
8. Z. Abajihad: ASSESSMENT OF TANNERY SOLID WASTE MANAGEMENT AND CHARACTERIZATION A Case of Ethio-Leather Industry Private Limited Company (ELICO): Addis Ababa, Ethiopia : Journal of Environmental Protection Vol. VI November 2012
9. Z. R. Farooqi, M. Sabir, N. Zeeshan, G. Murtaza, M. Mahroz and M. U. Ghani : Vehicular Noise Pollution: Its Environmental Implications and Strategic Control, Published: September 9th 2020
10. M. Parisi *, A. Nanni and M. Colonna *: Recycling of Chrome-Tanned Leather and Its Utilization as Polymeric Materials and in Polymer-Based Composites: Department of

Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Italy :
2021

11. J. Starck , E. Toppila , I. Pyykko: Impulse noise and risk criteria: Noise Health : Department of Physics, Finnish Institute of Occupational Health, Helsinki, Finland, Vol.5, Page : 63-73 : 2013
12. M. Franklin: Assessing the contribution of noise to the association between traffic-related air pollution and children's respiratory health. In: ISEE Conference Abstracts; 2018
13. S. Zare :Evaluation of the effects of occupational noise exposure on serum aldosterone and potassium among industrial workers. Noise & Health, 2016
14. J.Hays, M. McCawley , S. Shonkoff: Public health implications of environmental noise associated with unconventional oil and gas development: Science of the Total Environment, 2017
15. J.Han, A. Dimitrijevic: Continuous noise maskers reduce cochlear implant related artifacts during electrophysiological testing:The Journal of Health Science, 2017
16. T. Nichols, W. Anderson, A. Širović: Intermittent noise induces physiological stress in a coastal marine fish, PLoS One, 2015
17. J. PRAVEENKUMARA, R. SUNDER, H. CHANDAN, M. SRIVATHSA, P. MADHU :NATURAL FIBERS AND ITS COMPOSITES FOR ENGINEERING APPLICATIONS: International Journal of Industrial Electronics and Electrical Engineering, Volume-6, Jan.-2018
18. A. Bledzki, V. Sperber and O. Faruk :Natural and Wood Fiber Reinforcement in Polymers, (University of Kassel), 2017
19. M. SHAHARUD: ACOUSTIC PANEL: USING KAPOK AND SAWDUST AS ABSORBENT MATERIAL, ACADEMIA, MAY 2016
20. L. Nostro, L. Fratoni, W. Ninham and P. Baglioni: Water absorbency by wool fibers: Hofmeister effect, Biomacromolecules, 2012
21. I. Olufunto, O. Mobolaji, O. Olawale : ACOUSTIC PROPERTIES OF BUILDING MATERIALS: 2012
22. R. Wang, R. Yan, C. Lou, and J. Horng*: Characterization of Acoustic-absorbing Inter/intra-ply Hybrid Laminated Composites Under Dynamic Loading: Fibers and Polymers, Vol.17, 2016

23. L. Peng :Sound absorption and insulation functional composites :in Advanced High Strength Natural Fibre Composites in Construction, 2017
24. A. Nandanwar, M. Kiran, K. Varadarajulu: Influence of Density on Sound Absorption Coefficient of Fibre Board: Journal of Acoustics, 2017
25. H. Qui, Y. Enhui: EFFECT OF THICKNESS, DENSITY AND CAVITY DEPTH ON THE SOUND ABSORPTION PROPERTIES OF WOOL BOARDS, AUTEX Research Journa, Vol.18, Jun 11, 2018
26. S.H. Seddeq, “Factors Influencing Acoustic Performance of Sound Absorptive Materials”: Housing & Building Research Center, Acoustic Department, Egypt.: Australian Journal of Basic and Applied Sciences, 2009
27. S. Mohd , M. B. Bakar*, N. H. Rosdi , I. N. Sabri , M. H. Amini , R. M. Nordin and J. Intapun: Effects of Styrene Butadiene Rubber on Physical and Mechanical Properties of Kenaf Core Fiber Reinforced Polypropylene Composites, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan, Jeli Campus, Kelantan Malaysia: 2020
28. V. Gunasegaran, Assistant Professor : GRINDING PROCESS: Department of Mechanical Engineering, School of Mechanical Sciences : 2013
29. K. Shrivastava: Milling Machine: Parts, Types, Operations, Milling Cutter: March 16, 2020
30. P. Dhankhar: Homogenization Fundamentals: May, 2014
31. T. Patel, V. Panchal, S. Sheth, P. Chauhan: Design and Development of Hydraulic Press with Die : May, 2015.
32. D. M. Parikh: Vacuum Drying: Basics and Application: April, 2015.
33. L. Peng :Sound absorption and insulation functional composites :in Advanced High Strength Natural Fibre Composites in Construction, : ScienceDirect, 2017
34. F. Setaki, M. Tenpierik, A. Timmeren, M. Turrin :Comparison of standing wave ratio method and transfer function method for measuring sound absorbing properties of 3d-printed samples: Faculty of Architecture and the Built Environment, ResearchGate, 2016
35. S. Ponsubbiah, S. Suryanarayana, Dr. S. Gupta: Composite from Leather Waste: Institute of Leather Technology, CLRI, India, International Journal of Latest Technology in Engineering, Management & Applied Science, Vol. VII, March 2018
36. S. Petroudy: Physical and mechanical properties of natural fibers :in Advanced High Strength Natural Fibre Composites in Construction, Elsevier, 2017

37. B. Witkowska: Protective clothing – test methods and criteria of tear resistance assessment:
The Institute of Textile Material Engineering, researchgate, Vol.17, 2012
38. ISO 3376:2011 [IULTCS/IUP 6] :Leather — Physical and mechanical tests —
Determination of tensile strength and percentage extension
39. ISO 3377-2:2011 [IULTCS/IUP 8] :Leather — Physical and mechanical tests —
Determination of tear load: Double edge tear