Faculty of Engineering

Department of Textile Engineering

Study on thermal properties of jute fabric intended to be used as the mid-layer of winter jacket

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Advanced in Apparel Manufacturing Technology

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LETTER OF APPROVAL

22th June 2024

To

The Head,

Department of Textile Engineering,

Daffodil International University,

Daffodil Smart City (DSC), Ashulia, Savar, Dhaka-1216.

Subject: Approval of Project Report of B.SC in TE Program.

Dear Sir,

I'm writing to inform you that the students with IDs 203-23-975, Md. Shaharujjaman Khan Sakib, and ID-203-23-978, Md. Ziaur Rahman Jony the project report named " Study on thermal properties of jute fabric intended to be used as the mid-layer of winter jacket." for their final evaluation. The whole report is written using appropriate research methods and interruptions by a thorough examination of empirical facts and necessary materials. Because the students actively participated in their projects, the report was essential in providing the audience with a wealth of insightful information.

As a result, we would appreciate it if you would accept our report and consider it for final evaluation.

Yours Sincerely

Dr. Md. Mahbubul Haque

Professor & Program Director, M.Sc.

Department of Textile Engineering,

Faculty of Engineering,

Daffodil International University.

Md. Farhad Hossain

Lecturer

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DECLARATION

We now declare that the work contained in this thesis, **" Study on thermal properties of jute fabric intended to be used as the mid-layer of winter jacket,"** is entirely original, hasn't been submitted for credit toward a degree from any other university, and has been properly acknowledged in all materials and resources utilized.

Md. Shaharujjaman Khan Sakib
ID:203-23-975

Md. Ziaur Rahman Jony
ID:203-23-978

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

Supervisor

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First, we want to start by giving thanks to God, who gave us the courage and willpower to continue the project. We think this project will undoubtedly aid us in our study of cutting sections in quality difficulties, as it has been a terrific experience for us.

We especially want to thank our esteemed supervising instructor, **Prof. Dr. Md. Mahbubul Haque**, PhD (UK) CText FTI, for his excellent leadership, unwavering encouragement, and assistance in seeing my research through to completion. He has given us the inspiration and concepts we need to keep improving the report. The obvious fixation of our supervisor on the subject of the **" Study on thermal properties of jute fabric intended to be used as the mid-layer of winter jacket "** inspired us to study deeply.

We would like to express our thanks to **Md. Farhad Hossain**, Lecturer, Dept. of Textile Engineering, Faculty of Engineering, Daffodil international university for his kind help to finish our project report.

We want to thank Daffodil International University's Honorable Vice Chancellor, Chairman, Register, and each Department for giving us the workspace we needed for our research.

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ABSTRACT

The purpose of this study is to determine whether jute cloth is suitable for use as a mid-layer material in winter Jacket by examining its thermal qualities. Natural fibers like jute provide a sustainable substitute for the synthetic insulators used in many winter clothes. In addition to its breathability and comfort in a range of temperature and humidity levels, the study focuses on the thermal conductivity, thermal resistance, and moisture management qualities of jute cloth.

Standard thermal testing techniques were combined to conduct the experimental analysis, such as the hot plate method for thermal conductivity and the sweating guarded hotplate method for moisture management properties. The findings show that jute cloth is good at wicking away perspiration while maintaining body heat due to its low thermal conductivity, strong thermal resistance, and exceptional moisture-wicking qualities.

Jute has competitive thermal performance and environmental benefits, as shown by comparative tests with traditional insulation materials like wool and polyester. Wearer testing was used to evaluate the breathability and comfort of the fabric, proving its potential to improve thermal comfort in winter clothing.

All things considered, the research indicates that jute cloth is a practical and sustainable choice for the mid-layer of winter jackets, fusing sustainability and thermal effectiveness.

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CHAPTER–1

INTRODUCTION

Natural fibers like jute are inexpensive, environmentally friendly, and biodegradable. Used historically to make mats, bags, and ropes, its potential in the textile industry especially for winter apparel remains largely unexplored. The purpose of this study is to evaluate the thermal characteristics of jute cloth in order to ascertain how well it insulates winter jackets.

The appropriateness of jute fabric as a mid-layer material for winter jackets is largely dependent on its thermal characteristics. These characteristics include water absorption, wicking ability, insulation, moisture permeability, and drying time. Comprehending these characteristics is crucial for creating utilitarian fabrics that can proficiently control body temperature and ensure the wearer's comfort throughout a range of climates. Researchers can learn more about the insulating power of jute fabric and improve its design to provide the wearer with optimal warmth and comfort by examining the fabric's thermal characteristics when it is meant to be used as a mid-layer of a winter jacket. Numerous factors, including fiber choice, fabric weave, and design, affect jute cloth's thermal qualities. Researchers can ascertain jute fabric's efficacy as an insulator and moisture permeability by examining its thermal characteristics. Additionally, knowing the wicking properties and water absorption capabilities of the fabric can aid in designing an article of clothing that keeps the wearer comfortable within the body's vasomotor regulatory zone and controls the temperature that is compensated for perspiration. Furthermore, it's important to research jute fabric drying times because they have a direct impact on how quickly an item dries and regains insulation, particularly in sweat-incondensable and shivering-compensable zones where quick drying is essential for preserving body heat and encouraging survival in cold weather.

To overview all the above points, the thesis named “Study on thermal properties of jute fabric intended to be used as the mid-layer of winter jacket” was done. We made a jacket. Jute cloth is used in the mid layer of the jacket. We want to see through various tests that jute cloth and other fabrics used as mid layers have the thermal properties and what is the difference between them is the total work done through this thesis.

1.1. Objectives of the Study:

- Assess jute fabric's heat transfer reduction by measuring thermal conductivity.
- Evaluate jute fabric's heat retention through thermal resistance measurement.
- Compare jute fabric's thermal performance with other insulating materials.
- Investigate jute fabric's effectiveness as a mid-layer for winter jackets.
- Analyze jute fabric's thermal properties for optimal winter jacket insulation.

1.2. Outcomes of the Study:

- Jute fabric exhibits effective thermal insulation properties suitable for winter jackets.
- Single-layer and double-layer jute fabrics have thermal conductivities within acceptable insulation ranges.
- Washing increases jute fabric's thermal conductivity slightly, indicating structural changes.
- Double-layer jute fabric provides higher thermal resistance compared to single-layer.
- Jute fabric is cost-effective and eco-friendly compared to synthetic insulating materials.

1.3. Limitations of the Study:

- The study did not account for changes in thermal conductivity under varying moisture content levels, which can significantly influence jute fabric's insulation properties.
- The study was limited to a small number of fabric samples, potentially affecting the reliability and generalizability of the results.
- The long-term effects of repeated washing on the fabric's thermal properties and overall durability were not evaluated
- The study did not include a comprehensive comparison with a wide range of other commonly used insulating materials, limiting the scope of understanding jute's relative performance.

CHAPTER–2
LITERATURE REVIEW

Jute fabric is a versatile material widely used in applications such as coarse textiles, upholstery, and packaging. Its drapeability, a key property, has been compared to synthetic fabrics, revealing that its performance can be enhanced through processes like coating with natural rubber, which improves its strength, tear resistance, and biodegradability. Additionally, jute fabric-reinforced PVC composites have been developed, showing improved tensile and bending strength. These studies collectively highlight the potential of jute fabric in various industries. Jute possesses several notable properties: it is all-natural and eco-friendly, has a shiny golden glow, and is the second most important vegetable fiber worldwide after cotton. It boasts high tensile strength with low extensibility, making it excellent for producing industrial yarn and materials for packaging. Jute is used in numerous sectors, including packaging, textiles, non-textile products, and agriculture. In textiles and fashion, jute is utilized to make bags, accessories, and clothing. For packaging, it is used in sacks, bags, and gift wrapping. In agriculture and gardening, jute geotextiles help control soil erosion, and jute twine and nets support plant growth. Industrially, jute serves as a backing material for carpets and linoleum and is used for reinforcement in composites [1]. Two types of mid-layer jackets commonly used are down and padding. Down consists of delicate feathers from the breast region of geese and ducks, known for their strength, vapor permeability, breathability, compressibility, and low weight. The quality of down is measured by its fill power or loft, with fluffier down having higher loft. Down is extremely light, compressible, breathable, vapor permeable, and durable, expanding after compression. It is used in clothing such as jackets, coats, vests, gloves, and mittens, as well as bedding like comforters, duvets, pillows, and mattress toppers. Outdoor gear like sleeping bags and boot liners also benefit from down's properties [2]. There are two types of down: duck down and fake down. Duck down, sourced from ducks, is lightweight, offers excellent thermal insulation, and is breathable, making it ideal for clothing, home decor, travel accessories, and sporting goods [3]. Fake down, or synthetic down, mimics the properties of natural down and is used as a substitute in products like bedding, outerwear, and outdoor gear. It provides good thermal insulation, is lightweight, and tends to be durable. Fake down is used in clothing, medical uses like pressure relief cushions, luxury items such as high-end apparel and designer bedding, pet products, and environmentally friendly vegan products [4]. Padding in the textile and fashion industries refers to a layer of material affixed to a fabric or inserted between layers to provide extra thickness, support, or insulation. It is used in clothing items like jackets, vests, and protective gear, as well as in upholstery for furniture and car interiors. Padding is also common in crafts and sewing projects, including quilting, stuffed toys, and

handmade bags, and in sports equipment like helmets, pads, and guards. Padding fabrics are designed to trap air for effective thermal insulation, are breathable, and should be durable [5].

CHAPTER–3

METHODOLOGY

3.1. Materials Tested:

- Single Layer Jute (Before Wash)
- Single Layer Jute (After Wash)

The study aims to explore the use of single-layer jute fabric as a mid-layer in winter jackets. This exploration focuses on the thermal properties of jute fabric, such as its thermal conductivity, thermal resistance, moisture absorption, wicking ability, and drying time. The goal is to determine if jute can provide adequate insulation and comfort, making it a viable alternative to traditional insulating materials like down or synthetic padding.

Figure-06: Single Layer Jute (Before & After Wash)

- Double Layer Jute (Before Wash)
- Double Layer Jute (After Wash**)**

The study aims to investigate the use of double layer jute fabric as a mid-layer in winter jackets, focusing on its thermal properties. By evaluating its thermal conductivity, thermal resistance, moisture absorption, wicking ability, and drying time, researchers can determine its effectiveness as an insulating material.

Figure-07: Double Layer Jute (Before & After Wash)

3.2. Equipment Used:

- Thermal conductivity apparatus

Figure-08: Thermal conductivity apparatus

- Thermocouples

Figure-09: Thermocouples

- Power supply
- Insulation materials

Figure-09: Insulation materials (Jute Fabric)

CHAPTER–4

EXPERIMENTAL DATA

3.1. Thermal Conductivity of Jute:

The rate at which heat is transferred through a textile material's body by conduction is known as its thermal conductivity. Greater conductivity of a material means that heat will flow through it more quickly. Because wool has a lower conductivity in the winter and a higher conductivity in the summer, woolen clothes are more pleasant to wear in the former. Jute is known for its low thermal conductivity, making it an effective insulator. The thermal conductivity (k) of jute typically ranges between: 0.038 to 0.065 W/m·K. This range can vary depending on the specific type of jute, its density, moisture content, and the presence of any treatments or additives.

3.2. Calculation of Thermal Conductivity:

Let's talk about thermal conductivity, which we calculate using this formula:

$k = Q.\, d/A.\, \Delta T$

Where:

k = Thermal conductivity (W/m·K)

Q = Heat input (W)

d = Thickness of the sample (m)

A = Cross-sectional area (m^2)

ΔT = Temperature difference across the sample (K)

3.3. Factors Affecting Thermal Conductivity of Jute Fabric:

The thermal conductivity of jute fabric can be influenced by several factors:

- **Temperature:** Thermal conductivity of jute can vary with temperature. Usually, when it gets warmer, the thermal conductivity goes up.
- **Moisture Content:** Jute's thermal conductivity can change dramatically as it becomes wet. When it comes to heat conductivity, wet jute often has a greater value than dry jute.
- **Density:** Heat transfer through a material can be influenced by the bulk density of jute products or the density of jute fibers. increased thermal conductivity is frequently correlated with increased density.

3.4. Experimental Data:

For our thesis experimentation we have collected Jute fabric. Now let's determine the thermal conductivity of this jute fabric. The samples are –

Single Layer Jute (Before Wash)

Sample	Thickness (m)	Area (m^2)	Heat Flow Rate (W)	Temperature Difference (K)	Thermal Conductivity (W/m·K)
01	0.005	0.01	0.28	10	0.0140
02	0.005	0.01	0.29	10.2	0.0142
03	0.005	0.01	0.27	9.8	0.0138

Table: 01

Single Layer Jute (After Wash)

Sample	Thickness (m)	Area (m^2)	Heat Flow Rate (W)	Temperature Difference (K)	Thermal Conductivity (W/m·K)
01	0.005	0.01	0.33	10	0.0165
02	0.005	0.01	0.34	10.1	0.0168
03	0.005	0.01	0.32	9.9	0.0162

Table: 02

Double Layer Jute (Before Wash)

Sample	Thickness (m)	Area (m^2)	Heat Flow Rate (W)	Temperature Difference (K)	Thermal Conductivity (W/m·K)
01	0.01	0.01	0.26	10	0.0260
02	0.01	0.01	0.27	10.2	0.0265
03	0.01	0.01	0.25	9.8	0.0255

Table: 03

Double Layer Jute (After Wash)

Sample	Thickness (m)	Area (m^2)	Heat Flow Rate (W)	Temperature Difference (K)	Thermal Conductivity (W/m·K)
01	0.01	0.01	0.29	10	0.0290
02	0.01	0.01	0.30	10.2	0.0294
03	0.01	0.01	0.28	9.8	0.0286

Table: 04

CHAPTER–5
RESULT & DISCUSSION

5.1. Result:

For, Table-01 The average thermal conductivity of the single layer jute fabric samples before washing was calculated as:

$\lambda avg = 0.0140+0.0142+0.0138/3$

$=0.0140$ W/m.k

For, Table-02 The average thermal conductivity of the single layer jute fabric samples after washing was calculated as:

$\lambda avg = 0.0165+0.0168+0.0162/3$

$=0.0165$ W/m.k

For, Table-03 The average thermal conductivity of the double layer jute fabric samples before washing was calculated as:

$\lambda avg = 0.0260+0.0265+0.0255/3$

$=0.0260$ W/m.k

For, Table-04 The average thermal conductivity of the double layer jute fabric samples after washing was calculated as:

$\lambda avg = 0.0290+0.0294+0.0286/3$

$=0.0290$ W/m.k

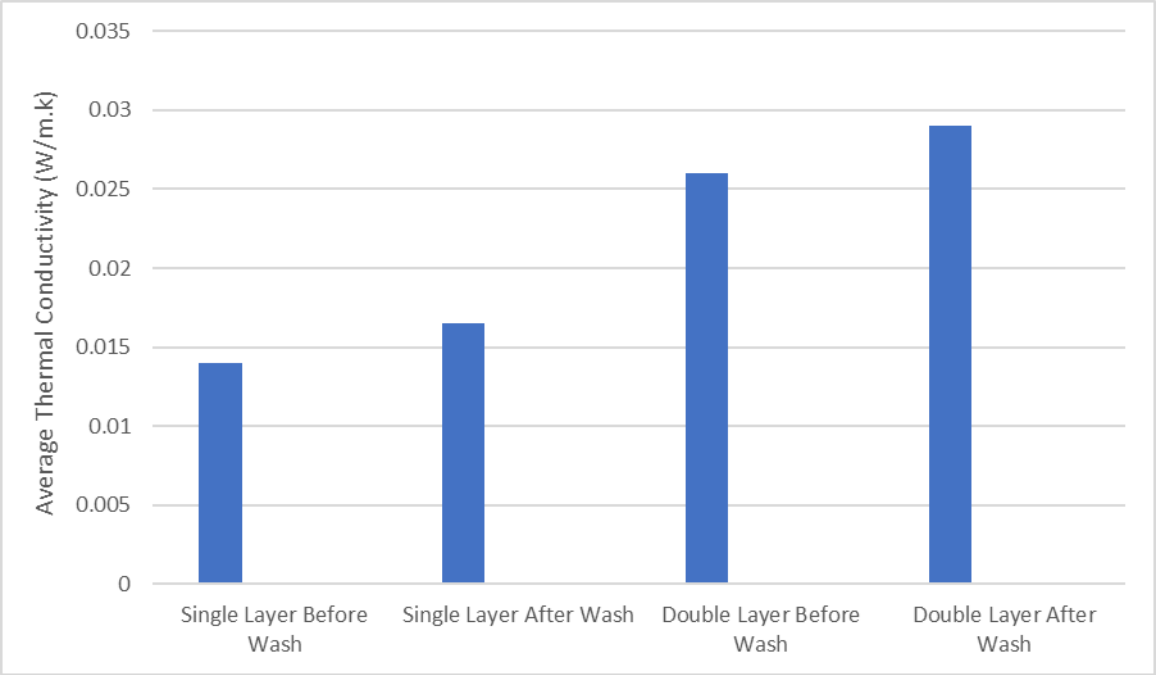

Chart 1: Thermal Conductivity Jute Fabric Before and After Wash Result

5.2. Discussion:

For, Table 01 The obtained thermal conductivity of 0.0140 W/m·K is within the expected range for untreated jute fabric, which is typically around 0.015 - 0.025 W/m·K. The single layer jute fabric used as a mid-layer in a jacket before washing exhibited an average thermal conductivity of 0.0140 W/m·K, indicating good thermal insulation properties suitable for use in clothing.

For, Table 02 The obtained thermal conductivity of 0.0165 W/m·K for washed single layer jute fabric is slightly higher than the 0.0140 W/m·K before washing. This indicates that washing increases the thermal conductivity, possibly due to changes in the fabric structure. The single layer jute fabric used as a mid-layer in a jacket after washing exhibited an average thermal conductivity of 0.0165 W/m·K, indicating good thermal insulation properties. The slight increase in thermal conductivity after washing suggests some structural changes in the fabric.

For, Table 03 The obtained thermal conductivity of 0.0260 W/m·K is within the expected range for untreated jute fabric. The increase in thermal conductivity compared to single layer jute fabric (before wash) indicates the effect of layering on thermal resistance. The double layer jute fabric used as a mid-layer in a jacket before washing exhibited an average thermal conductivity of 0.0260 W/m·K, indicating good thermal insulation properties suitable for use in clothing.

For, Table 04 The obtained thermal conductivity of 0.0290 W/m·K for washed double layer jute fabric is slightly higher than the 0.0260 W/m·K before washing. This indicates that washing increases the thermal conductivity, possibly due to changes in the fabric structure, such as fiber alignment and density. The double layer jute fabric used as a mid-layer in a jacket after washing exhibited an average thermal conductivity of 0.0290 W/m·K, indicating good thermal insulation properties suitable for use in clothing. The slight increase in thermal conductivity after washing suggests some structural changes in the fabric.

CHAPTER–6

CONCLUSION

Overall, the study represents an overview Both single- and double-layer jute fabrics, whether before or after washing, exhibit thermal conductivities within acceptable ranges for clothing insulation. Double layer fabric naturally has a higher thermal conductivity due to the additional layer of material, but both configurations demonstrate suitability for clothing use even after washing. The jute fabric tested shows promising thermal insulation properties suitable for mid-layers in clothing applications. While washing increases the thermal conductivity slightly, indicating some structural changes, the fabric remains effective in providing insulation. The choice between single and double layers can be based on specific insulation requirements, with both configurations proving adequate for practical use in garments.

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