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# Recycled Leather and Sawdust Composite Sheets

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## ABSTRACT

**This study explores the innovative combination of leather waste and sawdust with polyurethane (PU) to fabricate composite sheets. The utilization of leather waste and sawdust addresses the environmental concerns associated with their disposal while harnessing their potential as sustainable resources. The composite sheets offer a promising alternative to traditional materials, showcasing desirable properties such as enhanced durability, flexibility, and eco-friendliness. The abstract highlights the significance of this research in advancing sustainable material development and promoting circular economy principles. The present work provides immense potential for a new approach to make composite sheets by recycling of leather waste and sawdust to safeguard the environment and maintain ecology. This composite sheet can be a good substitute as a sustainable alternative to synthetic leather which affects the environment adversely.**

**Keywords:** Wood cutting dust, sustainable leather, leather dust, leather and environment, eco-system.

## INTRODUCTION

In recent years, the pursuit of sustainable solutions in material science has gained significant traction owing to escalating environmental concerns and the pressing need for resource conservation. One promising avenue in this endeavor involves the integration of waste materials into novel composite structures, thereby mitigating environmental burdens while fostering resource efficiency. This paper introduces the innovative amalgamation of leather waste, sawdust, and polyurethane (PU) to fabricate eco-friendly composite sheets, mitigating both environmental harm and health risks associated with traditional synthetic leathers.

Leather processing and woodworking industries generate substantial amounts of waste in the form of leather scrap and sawdust, respectively. For example, leather industry globally produces 1.7 billion $m^2$ of leather per year and generating various forms of solid waste, including leather scrape [1]. Also the waste ratio regarding leather manufacturing process is given in Table 1. The heavy bovine finished leather weights about 3 $kg/m^2$ and a sheep/goat finished leather measures about $0.75m^2$ were considered in calculating the waste. Leather wastes are produced in various regions world-wide is shown in Fig. 1. In woodworking, sawdust can account for 10-30% of the total wood volume processed, depending on the type of machinery and techniques used [2]. The disposal of these byproducts poses considerable environmental challenges, including landfill accumulation, pollutant leaching, and greenhouse gas emissions. Addressing these challenges necessitates the development of sustainable strategies to utilize these waste materials effectively. Concurrently, the versatile properties of polyurethane have rendered it a ubiquitous material in various industrial applications, ranging from construction to automotive engineering. By harnessing the inherent characteristics of leather waste, sawdust, and PU, a synergistic approach emerges to create composite materials with enhanced functionalities and reduced environmental footprint.

**Table 1: Waste ratio regarding leather manufacturing process**

| | Ratio of heavy bovine leather (t/t finished leather) | Ratio of light bovine leather (t/million $m^2$ finished leather) | Ratio of sheep goat leather (t/million $m^2$ finished leather) |
|---|---|---|---|
| Unusable wet blue splits, wet blue shavings and wet blue trimming | 171.0 | 513.0 | 180 |
| Dry leather wastes (trimming, dust...) | 27.7 | 83.2 | 151.3 |

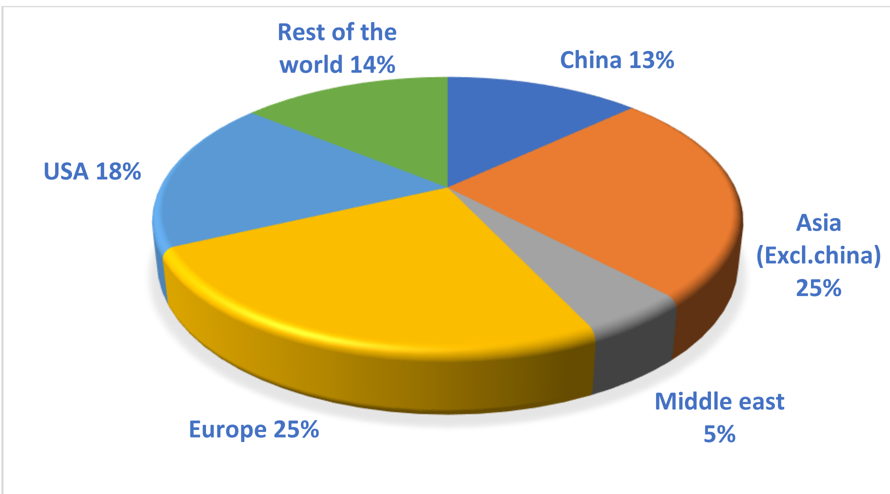


**Fig 1: Leather Waste Produced by leather manufacturing – worldwide [2].**

By valorizing waste streams and repurposing them into value-added products, this paper contributes to the optimization of resource utilization and the reduction of environmental burdens. Furthermore, the versatility of the composite sheets opens avenues for innovative applications across multiple sectors, ranging from construction and automotive to consumer goods and packaging. Consequently, this research paves the way for the proliferation of sustainable materials in mainstream industrial practices, fostering a more ecologically conscious and resilient future. In summary, the integration of leather waste and sawdust with PU to form composite sheets represents a pioneering initiative towards sustainable material development. By elucidating the synthesis process, characterizing the properties, and elucidating the potential applications of these composites, this paper seeks to catalyze a transition towards more sustainable and environmentally responsible manufacturing practices.

## LITERATURE REVIEW

***Nelissa et.al.*** [3-4] explored the effects of incorporating leather waste into natural rubber to create an expanded composite, presenting a novel and eco-friendly material and recycling approach.

The study emphasizes that an increase in leather shavings within the mixture enhances the hardness of the composite, thereby requiring greater force to strengthen it. This finding not only highlights the versatility of the composite but also underscores the potential for tailoring its properties based on the desired application.

Marek et.al. (2021) discussed the leather waste gasification process for thermal power production [5]. Rethinam et.al. (2014) recycled finished leather waste to prepare composite sheet using plant fiber [6] and improve circular economy [7-9].

The waste management can be done in the following steps:

1. Reduction – This is an important step, in which the wastage is minimized by proper optimizations process to utilize the leather.
2. Re-use – From the step 1, whatever the waste comes out from the industry will be re-used to make other items from it.
3. Re-cycle – If it can't be re-used then it will be recycled to get some useful product.
4. If step 4 also not able to utilize the waste, then it is decomposed in other forms to get energy eg. in leather converted into gaseous state and energy is produced.
5. Some special treatment is given to manage the waste.
6. Landfill – finally if it can't be used in above steps then it is buried or used in land fill.

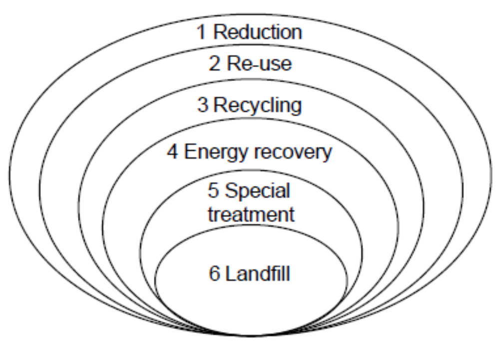


**Fig 2: Steps involved in waste management**

## DEVELOPMENT OF COMPOSITE SHEET USING LEATHER WASTE AND SAW DUST

- **Step – 1:** Begin by cutting waste into small pieces and grind it in a grinder.
- **Step – 2:** Transfer the grind material onto a cotton cloth and place it in the dryer of a washing machine for 3-4 minutes.
- **Step – 3:** Soak newspapers in water for half an hour and grind it also in the grinder.
- **Step – 4:** In a container, combine 100 gm waste and 100ml PU. Ensure thorough stirring for a homogeneous mixture.
- **Step – 5:** Prepare a working surface by laying polythene on the floor. Lightly spray oil drops over the polythene.

- **Step – 6:** Once the paste is well-mixed, carefully pour it over the polythene and press firmly to achieve a thin sheet fusing it with net cloth to get good results.
- **Step – 7:** Place the prepared sheet in direct sunlight for 2 days, allowing it to cure and dry effectively.

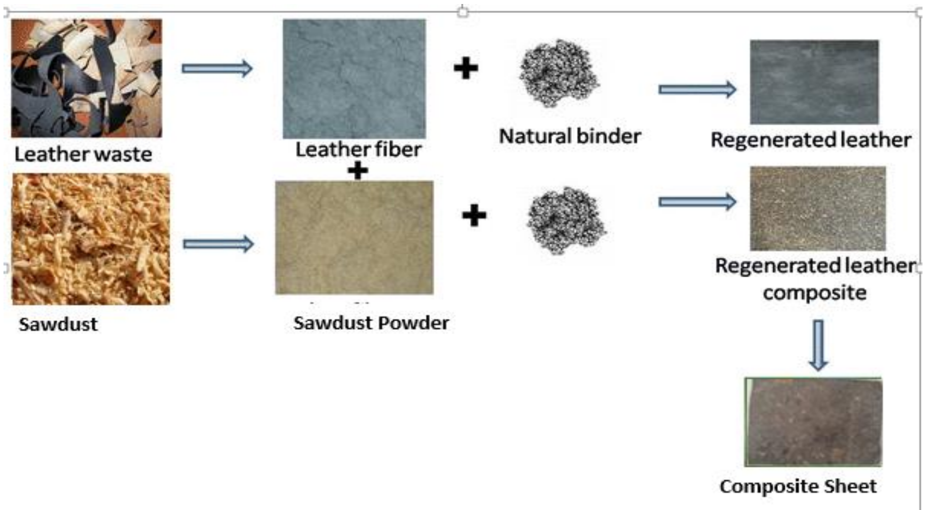


**Fig 3: Composite sheet preparation using leather dust and sawdust**

## Results Obtained

The composite sheet prepared through this process as shown in Fig. 3, exhibits the following distinctive properties:

- **Adequate Bonding:** The material displays sufficient bonding, indicating a well-connected and coherent structure.
- **Moderate Flexibility:** The material demonstrates a balanced level of flexibility, allowing for adaptability within certain limits without compromising structural integrity.
- **Fold-Induced Cracking:** Under folding conditions, the material experiences cracking. This characteristic underscores the need for further exploration to enhance its fold resistance.
- **Uniform Strength via Proper Drying:** Through meticulous drying, the material achieves uniform strength distribution, contributing to its overall durability and stability.
- **Improved Surface Uniformity:** Significantly, the material's surface is more uniform compared to the previous trial. This suggests advancements in the manufacturing process, resulting in a refined and consistent external appearance.

## TESTING

## Creation of Specimen for Tensile Strength Testing

Assessing the tensile strength of leather specimens is pivotal for understanding the material's capability to withstand stretching forces. This involves subjecting a standardized leather sample to gradual tension until it reaches the point of rupture. By measuring the force applied and the corresponding elongation, one can calculate the tensile strength—providing essential insights into the material's durability and suitability for applications requiring resistance to pulling forces, such as in belts or load-bearing components. This testing process is fundamental in ensuring the reliability and performance of leather products across diverse use cases.

**Procedure**

- **Material Selection:** Choose defect-free, uniform leather.
- **Sample Dimensions:** Use a cutting tool for standardized length and width as shown in Table – 2 and Fig. 4.

**Table 2: Sample Dimensions (mm)**

| Size | A | B | C | D | R |
|---|---|---|---|---|---|
| Standard | 110 | 20 | 30 | 10 | 5 |
| Large | 190 | 40 | 45 | 20 | 10 |

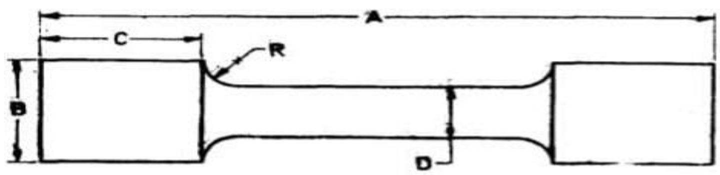


**Fig 4: Dumbbell shape test specimen**

- **Gauge Length** Mark the portion for tensile testing.
- **Edge Care** Ensure straight, parallel edges to prevent premature failure.
- **Moisture Content** Standardize to maintain consistent properties.
- **Mounting** Secure one end in the fixed grip, attach the other to the movable grip.
- **Alignment** Properly align the specimen for even force distribution.

**Fixing the Sample:** The leather strip is securely clamped in a testing machine, with one end held in place while the other is pulled.

**Application of Force:** A controlled force is applied to the leather strip using UTM as shown in Fig. 5, gradually increasing until the strip begins to stretch and eventually breaks.

**Measurement:** The testing machine records the maximum force applied (tensile strength) and the point at which the leather strip broke as shown in Fig. 7.

**Analysis:** The results as mentioned in Table 3 are analyzed to determine the leather's tensile strength, which is crucial for assessing its durability and suitability for various applications, such as in manufacturing leather products.

This test helps ensure that leather meets quality standards and can withstand the stresses it may encounter in its intended use, such as in the production of garments, accessories, or upholstery.

**Fig 5: Testing Machine**

**Fig 6: Test Specimen for Tensile Testing**

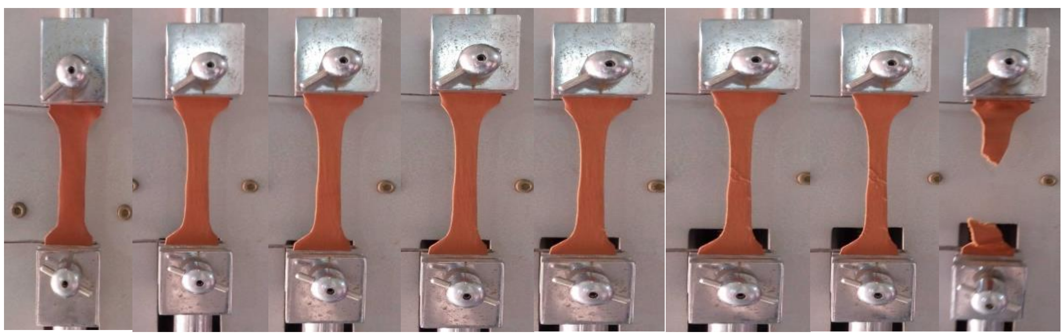

**Fig 7: Process of Tensile Testing**

**Table 3: Measurement of Tensile Strength**

| Trials | Final Thickness | Breaking (kg) | Area ($mm^2$) | Tensile Strength (kgf) |
|---|---|---|---|---|
| 1 | 1.28 | 8 | 10.24 | 12.9 |
| 2 | 1.28 | 7.5 | 9.6 | 15.27 |
| 3 | 1.12 | 7 | 7.84 | 13.06 |
| 4 | 1.14 | 8 | 9.12 | 9.38 |
| 5 | 1.16 | 8 | 9.28 | 9.26 |
| 6 | 1.24 | 8 | 9.92 | 19.07 |
| 7 | 1.28 | 7 | 8.96 | 19.88 |
| 8 | 1.21 | 8 | 9.68 | 19.57 |

## Flexing Endurance Test on Upper Materials

The flexing endurance test is a crucial step in evaluating the durability and quality of footwear upper materials. It simulates the repeated bending and flexing that occurs during normal wear, helping predict how well the material will hold up over time.

## Method

There are several standardized methods, but a common one is based on ISO 20344. In this method

- A square sample of the material as shown in Fig. 8 is clamped between two V-shaped plates.
- The plates move back and forth, repeatedly flexing the sample at a specific angle and speed (usually 90° at 60 cycles per minute).
- This process continues until the material breaks, shows visible damage like cracks, or reaches a predetermined number of cycles. The results are tabulated in Table 4 and shown in Fig. 9.

**Fig 8: Specimen for flexing endurance**

**Table 4: Readings of Flexing Endurance**

| S. No. | No. of Cycles | Result Obtained |
|---|---|---|
| 1 | 10000 | After 10000 cycles there was no change found in the texture and in their grain structure |
| 2 | 20000 | After 20000 cycles there was no change found in the texture and in their grain structure |
| 3 | 30000 | After 30000 cycles there was no change found in the texture and in their grain structure |
| 4 | 40000 | After 40000 cycles there was no change found in the texture and in their grain structure |
| 5 | 50000 | After 50000 cycles there was no change found in the texture and in their grain structure |
| 6 | 60000 | After 60000 cycles there was no change found in the texture and in their grain structure |
| 7 | 70000 | After 70000 cycles there was no change found in the texture and in their grain structure |
| 8 | 80000 | After 80000 cycles there was no change found in the texture and in their grain structure |
| 9 | 90000 | After 90000 cycles there was no change found in the texture and in their grain structure |
| 10 | 100000 | After 100000 cycles there was no change found in the texture and in their grain structure |
| 11 | 110000 | After 110000 cycles there was no change found in the texture and in their grain structure |
| 12 | 120000 | After 120000 cycles there was no change found in the texture and in their grain structure |

| | | |
|---|---|---|
| 13 | 130000 | After 130000 cycles there was no change found in the texture and in their grain structure |
| 14 | 140000 | After 140000 cycles there was no change found in the texture and in their grain structure |
| 15 | 150000 | After 150000 cycles there was no change found in the texture and in their grain structure |

## RESULTS AND DISCUSSION

The results of tensile strength test of composite sheets developed in this paper are shown in Table - 4 and Fig. 7. These results demonstrate the feasibility and efficacy of harnessing waste materials to create value-added products with enhanced properties and reduced environmental footprint.

**Table 5: Final Results of composite sheet**

| Trials | Tensile Strength (kgf) |
|---|---|
| 1 | 12.9 |
| 2 | 15.27 |
| 3 | 13.06 |
| 4 | 9.38 |
| 5 | 9.26 |
| 6 | 19.07 |
| 7 | 19.88 |
| 8 | 19.57 |

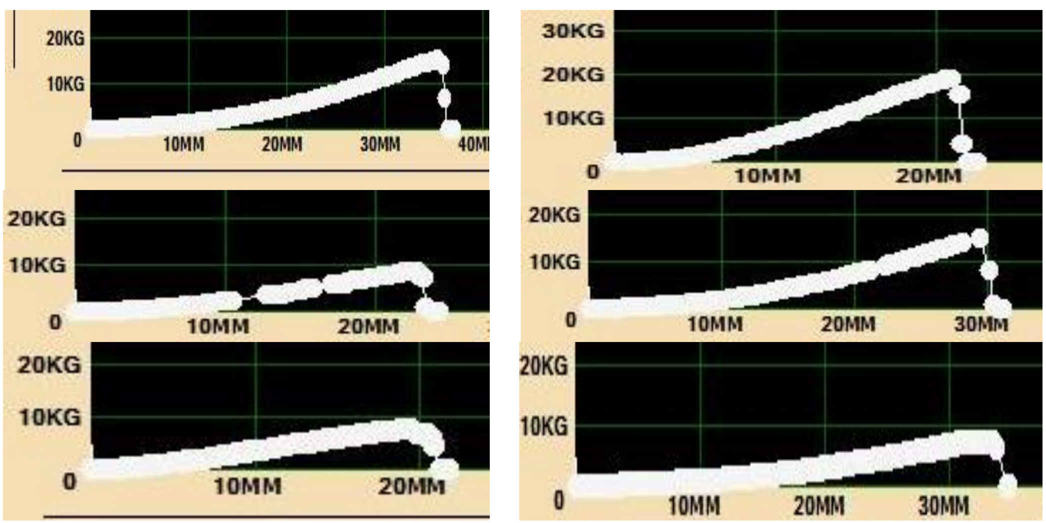


**Fig 9: stress-strain curve of various trials of composite sheets**

## CONCLUSIONS

The integration of leather waste and saw dust with polyurethane (PU) using net cloth as a reinforcement medium to form composite sheets represents a significant advancement in sustainable material science. Through meticulous experimentation and characterization, this study has demonstrated the feasibility and efficacy of harnessing waste materials to create value-added products with enhanced properties and reduced environmental footprint. The developed composite sheets exhibit desirable tensile strength and flexible properties, highlighting their potential for diverse industrial applications. By encapsulating leather waste and sawdust within a PU matrix reinforced with net cloth, the composites offer improved durability, flexibility, and sustainability compared to conventional materials. Moreover, the utilization of waste streams mitigates environmental burdens associated with landfill accumulation and resource depletion, contributing to the promotion of circular economy principles and resource efficiency.

Future research on leather tensile strength and its impact on footwear and garments should focus on global variations, including diverse tanning practices, processing methods, and animal breeds, to enhance the generalizability of findings. Exploring advanced materials like bio-based and conductive leathers is crucial for understanding their suitability and durability.

## Declaration

D.K. Chaturvedi conceptualize the problem and design and develop the composite sheet for sustainable mater in footwear industry. Tipu Sultan helped in experimentation and manuscript preparation.

There is no conflict among the authors. Also there is no financial support obtained from any source.

## Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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