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Chindi Machine - A Textile Waste Recycling Innovation

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Abstract: The Chindi Machine project addresses the escalating problem of textile waste by providing an innovative mechanical solution for recycling cloth scraps, commonly known as "chindi", into useful products. Globally, the textile industry generates over 100 million tonnes of waste annually, much of which ends up in landfills or incineration, causing environmental harm. In India, traditional practices have long repurposed torn cloth strips into inexpensive mats and rugs, but these methods are labor-intensive and limited in output. This project designs, prototypes, and evaluates multiple variants of a Chindi-processing machine (hand-crank, pedal, bicycle- driven, and motorized models) to automate shredding of fabric waste. The methodology included stakeholder consultation, iterative prototyping, and performance testing with various fabric types. Results demonstrate that the motorized model achieves a throughput of around 10kg/hr, significantly higher than human-powered versions (2–4 kg/hr), while producing uniform chindi strips suitable for weaving.

I. INTRODUCTION

Textile waste management remains a major global challenge, driven by fast fashion, limited recycling infrastructure, and inefficient processing technologies. Industrial shredders typically cost between 1.5–6 lakhs and require considerable space and technical expertise. These constraints restrict deployment within small Textile Recovery Facilities (TRFs), Dry Waste Collection Centres (DWCCs), and tailoring units. To address these limitations, this work proposes a low-cost Chindi Machine designed to efficiently shred waste textiles into chindis suitable for reuse in insulation materials, weaving, and cushioning. The proposed system emphasizes affordability, portability, gender-neutral usability, and social impact

II. LITERATURE REVIEW

Global reports indicate rising textile waste generation, with only limited fractions reaching structured recycling systems. Traditional chindi production relies on manual tearing or industrial shredders. Manual methods are slow and labor-intensive, while industrial machines remain inaccessible to small units due to cost and maintenance demands. Circular Economy frameworks encourage innovations that enable decentralized recycling. Previous studies highlight that recycling one ton of textile waste saves up to 20,000 liters of water. However, affordable and scalable technologies for fabric shredding remain insufficiently explored.

III. SYSTEM ARCHITECTURE

The system architecture is organized into four major functional modules: Feeding Layer, Shredding Layer, Separation Layer, and Output & Control Layer, each engineered to address specific challenges encountered in decentralized textile-recycling environment.

A. Feeding Layer

The feeding layer ensures controlled insertion of textile waste into the shredding mechanism. A hopper or manual feed platform guides fabric sheets into the system while preventing accidental hand contact with the blades. For pedal-driven and motorized variants, linear guide rails are incorporated to maintain fabric alignment and reduce jamming during continuous operation.

B. Shredding Layer

The shredding unit constitutes the core of the system. It utilizes a rotating drum fitted with serrated carbon-steel blades engineered to withstand varying fabric thicknesses. The drum operates at approximately 60–80 RPM, providing sufficient torque to process cotton, polyester, denim, and mixed fabrics. Depending on the variant, torque is supplied through: Manual crank mechanism Pedal-driven bicycle-chain transmission 12 VDC motor with V-belt drive, offering uninterrupted shredding capability.

C. Separation Layer

Once shredded, the fabric passes through a vibrating mesh that filters out non-textile elements such as buttons, hooks, and zippers. These foreign objects are collected in a separate bin to prevent blade damage and maintain uniform output quality. Optimized mesh apertures ensure effective separation without restricting shredded chindi flow.

D. Output & Control Layer

Shredded chind is are collected in a designated output chamber positioned below the separation assembly. All machine variants incorporate safety enclosures around rotating components and provide access to an emergency stop mechanism in motorized units. Ergonomically positioned handles, low vibration mounts, and noise-dampening structures improve operator comfort during extended use.

E. Variant Configuration

To accommodate diverse user requirements, the system is implemented in three distinct configurations: Manual Variant: Operated through a hand-crank mechanism; ideal for small-scale users with minimal infrastructure. Motorized Variant: Employs a 12V, 250W DC motor enabling higher throughput and reduced operator involvement.

IV. PROPOSED METHODOLOGY

The workflow is divided into five core stages: material intake, shredding operation, separation and filtration, output processing, and continuous improvement, ensuring that the system delivers efficient, safe, and scalable textile- waste recycling.

A. Working Principle (Sequential Workflow)

The overall operation of the machine is driven by a sequential flow of tasks designed to minimize user effort while maximizing shredding efficiency.

Material Feeding:

Discarded textile materials are introduced through a hopper or guided feed tray. The design ensures stable fabric alignment and prevents overloading or accidental contact with moving parts.

Shredding Operation:

The rotating drum equipped with serrated carbon-steel blades cuts the fabric into uniform chindi strips. Torque is supplied via the selected operating mode manual crank, pedal-drive chain system, or a 12V DC motor with V-belt transmission. Gear reduction enhances torque for thicker fabrics.

Separation of Non-Textile Debris:

Shredded fabric passes through a vibrating mesh that separates buttons, hooks, zippers, and other foreign objects. These are diverted into a separate bin to avoid output contamination and mechanical damage

Collection of Chindis:

The filtered chindis fall into an output chamber, ready for packaging, weaving, or downstream recycling applications.The chamber is designed for easy removal and cleaning.

Power & Operation Management:

Manual and pedal models are human-powered, while the motorized variant uses a low-voltage DC motor powered by battery or mains. Safety guards, ergonomic grips, and optional emergency-stop switches ensure safe and continuous operation with minimal fatigue.

B. Mechanical Assembly Methodology

The prototype development involved a structured assembly process:

Chassis Fabrication:

Recycled plastic sheets and aluminum extrusions were cut, shaped, and assembled to form a lightweight yet durable frame.

Blade & Drum Integration:

Bearings, shafts, and serrated blades were mounted in precise alignment to ensure smooth rotation and uniform shredding.

Installation of Hopper & Output Chamber:

Designed for controlled feeding and efficient collection.

Safety Enhancements:

Guards, covers, and vibration-damping mounts were added following initial trials to improve stability and operator comfort

C. Testing and Validation

Extensive trials were conducted using cotton, polyester, denim, and blended fabrics to assess performance

Processing Time:

Manual mode required ~20 min/kg, pedal mode ~12 min/kg, and motorized mode ~10 min/kg.

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Torque & Vibration Analysis: Blade spacing and drum balance were optimized to reduce jamming and mechanical vibration.

Failure Resolution: Issues such as jamming, vibration, and mesh clogging were resolved through improved blade spacing, chassis reinforcement, and mesh redesign

V. RESULTS AND DISCUSSION

Performance metrics were measured using fabrics such as cotton, polyester, denim, and blended materials. The motorized model delivered the highest throughput, with the pedal and manual variants offering energy-efficient alternatives suitable for low- resource environments.

A. Throughput analysis Motorized Variant: ~3 kg/hr Manual Variant:~1–1.2kg/hr

The 12V, 250W motor provided stable rotation, enabling efficient shredding of thick fabrics such as denim without significant RPM drops.

B. Torque and Mechanical Behaviour

Torque measurements indicated approximately 58.4 N·m at the shredding drum, adequate for processing multilayered and dense textile materials. Mechanical balancing of the drum and optimized blade spacing minimized vibration levels during continuous operation. Reinforcement of the chassis with recycled plastic sheets reduced flex under load, while anti-vibration mounts contributed to a quieter and more stable operation.

C. Wear and Maintenance Performance

Blade edge wear was observed after extended usage. As documented:

Blade sharpening interval: 40–120 operating hours

Bearing and drive train inspection: Every50–100 hours

D. User Studay and Ergonomics

Auser evaluation studyinvolving15 volunteers highlighted the following:

Ease of Operation: 4.5/5 average rating

Physical Effort: Least fatigue reported in pedal-driven variant Safety: No incidents observed during the testing period

Comfort: Improved after addition of handles, guards, and damping mounts

E. Cost Efficient and Parctial Impact

The final manufacturing cost of the prototype was recorded at 10500–12000, significantly lower than existing industrial shredders priced between 1.5–6 lakhs. The cost advantage, combined with portability and low energy requirements, positions this solution as a viable option for: Textile Recovery Facilities (TRFs) Dry Waste Collection Centres (DWCCs) Rural micro-industries

V1. CONCLUSION

This report has presented the concept, design, and evaluation of the Chindi Machine an innovation for recycling textile waste. Through thorough research and engineering methodology, we developed four practical machine models that transform scrap fabric into reusable strips, ready for weaving or other reuse. The design was guided by real-world inputs: stakeholder consultations ensured relevance to end- user needs, and iterative prototyping ensured technical feasibility.

Key findings include: Technical Feasibility: All machine models performed successfully. The motorized version achieved industrial-level throughput (10+ kg/hr), while the human-powered versions provided significant productivity gains over fully manual processes. The shredding mechanism produced consistent chindi suitable for traditional applications. Economic Viability: Cost estimates show that machines can be produced relatively inexpensively ($100–$160 range), and maintenance costs are low. Operating the machines enables users to generate added value from waste that was previously lost. Business models ranging from B2B sales to community co-ops appear viable. The payback period for a machine is expected to be on the order of months through increased product yield. Social and Environmental Benefits: By empowering local artisans and reducing waste, the Chindi Machine contributes positively to communities. It leverages traditional skills while introducing appropriate technology. Environmental benefits include less landfill waste and more efficient resource use.

VII. FUTURE SCOPE

The Chindi Machine presents several opportunities for further enhancement and large-scale deployment. Future improvements can focus on increasing operational efficiency, expanding functionality, and integrating modern technologies to support broader textile-recycling systems

Automation and Smart Control: Incorporating basic electronics such as load sensors, emergency cut-off switches, and RPM monitoring can improve safety and consistency. Low-cost microcontroller integration may also support semi-automatic operation in the motorized model.

Advanced Blade Optimization: Further refinement of blade geometry and material can increase shredding speed, reduce wear, and enhance the machine's ability to handle thicker fabrics such as denim and multilayered textiles.

Noise and Vibration Reduction: Additional damping components and improved mechanical balancing can make the machine more comfortable to operate, especially for long-duration use in community or cottage-industry settings.

Modular Attachments: Add-on units such as pre-cutting rollers, mesh filters of variable sizes, or automated chindi collectors can expand the usability of the machine for different textile categories.

Sustainable Power Options:

Introducing solar-powered or pedal-assisted hybrid versions will make the machine ideal for rural areas with limited access to electricity, increasing adoption among micro-entrepreneurs.

Scaling for Industry Use:

Larger models with multi-drum mechanisms can be developed for small and medium-scale textile recycling units, improving throughput while maintaining cost efficiency.

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