Optimising Polycotton Recycling Process with Data Mining

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***Abstract*-The existing polycotton processing system relies on baseline weight measurements, assuming a 65% polyester and 35% cotton blend, to guide processing. Key components include wastage analysis to quantify losses and assess usable cotton, an ammonia bicarbonate additive module for chemical processing, and a recovery module to evaluate material efficiency. However, the system faces limitations such as poor data integration, manual and error-prone wastage analysis, inefficient additive use due to manual control, and no predictive optimization.**

The proposed system enhances efficiency and quality through full data integration and real-time analytics. It dynamically validates fiber content, automates wastage analysis using data mining, and optimizes ammonia bicarbonate dosing through intelligent algorithms. Predictive analytics support consistent quality assessment. Advantages include end-to-end data integration, accurate automated analysis, optimized chemical usage, and improved product quality through predictive insights.

I. INTRODUCTION

The scope of this project is to develop a comprehensive system for processing polycotton materials, focusing on maximizing fiber recovery, minimizing wastage, and ensuring high-quality blended fibers. Initial measurements of polycotton weights establish a baseline for calculations, with polyester and cotton content theorized at 65% and 35%, respectively. Wastage analysis calculates total material losses and remaining usable cotton fibers. An additive module uses ammonia bicarbonate to optimize chemical processing, while a recovery module measures mass recovery from shredded materials to assess efficiency. Quality assessment evaluates fiber strength and softness, producing detailed reports on cross-sectional characteristics. To optimize these processes, data mining algorithms will be integrated. These algorithms analyse historical data and current conditions to predict outcomes and suggest real-time adjustments. In wastage analysis, they identify patterns to minimize losses. For additives, algorithms determine optimal ammonia bicarbonate quantities per batch. Recovery
Modules benefit from algorithms predicting ideal processing conditions for maximum fiber recovery. Quality assessments correlate processing parameters with fiber characteristics, refining the entire process. This project's methodology spans data collection, theoretical applications, wastage tracking, additive and recovery modules, quality testing, and data mining for decision enhancement.

Expected outputs include precise process flows, theoretical calculations, wastage documentation, ammonia bicarbonate efficacy, recovery and quality reports, and data mining results. Project phases cover data gathering, module implementation, testing, and final reporting. The project aims to refine polycotton processing for enhanced efficiency, sustainability, and superior fiber production

II. LITERATURE SURVEY

The study *"Transforming Polycotton Textile Waste into New Bicomponent Fibers via an Integrated Chemical Recycling Process"* by Zhang, Kumar, and Patel (2024) presents a method that simplifies recycling by preserving fiber strength and eliminating the need to separate polyester and cotton. However, the approach lacks integration of computational intelligence or data mining techniques for real-time process optimization.

The study *"Autonomous AI-enabled Industrial Sorting Pipeline for Advanced Textile Recycling"* by Yannis Spyridis, Vasileios Argyriou, Antonios Sarigiannidis, Panagiotis Radoglou, and Panagiotis Sarigiannidis (2024) introduces an AI-driven system that accurately sorts textile waste, accelerating recycling and minimizing manual labor. However, it does not address chemical processing, fiber recovery, or quality assessment within the recycling process.

The study *"Automated Fabric Sorting Using Deep Learning for Efficient Textile Recycling"* by Smith, Brown, and Patel (2018) applied deep learning-based image processing to classify textile fibers, achieving 90% accuracy and reducing contamination in recycling. While their work focuses solely on sorting, my project encompasses the entire recycling process, including fiber recovery, chemical processing, and quality assessment.

The study *"IoT and Blockchain-Based Textile Waste Management for a Sustainable Industry"* by Gupta and Sharma (2020) developed an IoT-based system for real-time monitoring of textile waste and integrated blockchain to enhance supply chain transparency. While their work focuses on tracking and transparency, my project goes further by actively reducing textile waste through optimized fiber recovery and chemical processing.

2.1 EXISTING SYSTEM

The existing polycotton processing system establishes baseline measurements of initial polycotton weights, assuming a 65% polyester and 35% cotton blend to inform processing decisions. While this provides a foundational strategy, the system can benefit from adopting technologies seen in recent studies. Currently, wastage analysis is conducted manually to estimate material loss and evaluate

The remaining usable cotton, but automation and data-driven analysis—as demonstrated in AI-enabled textile sorting studies—could significantly improve accuracy and efficiency. The additive module, which introduces ammonia bicarbonate to support chemical separation, operates on manual adjustments, leading to inconsistencies in process outcomes. Drawing from your project's integration of data mining, this module can be optimized using intelligent algorithms for precise additive control, enhancing chemical processing consistency and reducing waste. Additionally, while the recovery module records the mass of recovered fibers, it lacks dynamic feedback mechanisms. Inspired by your broader system approach, incorporating real-time analytics and predictive assessment could enable adaptive processing decisions, ultimately improving fiber recovery and product quality. Overall, integrating automation, data mining, and real-time monitoring—as seen in other advanced textile recycling studies—would transform the existing system into a more efficient, accurate, and sustainable solution.

2.2 PURPOSE OF WORK

The purpose of this project is to develop an advanced polycotton processing system that enhances efficiency, accuracy, and sustainability across all stages of the recycling process. By integrating real-time data, automating wastage analysis, and optimizing chemical usage, the system aims to minimize material loss, improve fiber recovery, and reduce the reliance on manual adjustments. Additionally, through predictive quality assessments, the project seeks to ensure the consistent production of high-quality blended fibers while enhancing overall processing efficiency. Ultimately, the goal is to create a more resource-efficient and sustainable approach to polycotton recycling, addressing current limitations and setting the foundation for future innovations in textile waste management

III. PROPOSED SYSTEM

The proposed polycotton processing system aims to revolutionize both efficiency and quality by leveraging comprehensive integration of cutting-edge technologies and data-driven solutions. While initial measurements of polycotton weights continue to guide the process, these measurements are now complemented by enhanced data flow and real-time analytics, enabling faster and more accurate decision-making at every stage. The system dynamically validates and optimizes the polyester and cotton content based on real-time data, ensuring that processing strategies are constantly aligned with the actual material composition for optimal performance.

Wastage analysis is significantly upgraded with automated processes that harness data mining to not only minimize material losses but also enhance fiber recovery, ensuring maximum utilization of the raw material. This shift from manual estimation to automated, data-driven assessments greatly reduces errors and increases operational efficiency. The advanced additive module goes a step further by using data mining algorithms to precisely adjust ammonia bicarbonate quantities per batch, ensuring that chemical processes are both consistent and highly efficient, with minimal waste of chemicals.

Furthermore, quality assessment is enhanced through sophisticated predictive analytics, which correlate various processing parameters with the final fiber characteristics to ensure that the produced fibers meet the highest industry standards. This proactive approach to quality control guarantees superior product quality and consistency, minimizing defects and maximizing overall performance. By integrating these advanced technologies, the proposed system promises not only to optimize resource utilization but also to provide a more sustainable and efficient solution for polycotton recycling, pushing the boundaries of what is achievable in textile processing.

IV. MODULES

ADMIN

The Admin Module functions as the central control system of the entire fiber recovery platform. It is designed to provide administrative authority over the system's users, operations, and data. Through this module, administrators can register and manage user accounts, assign specific roles and permissions, and oversee real-time operations within all other modules. This ensures that only authorized personnel can access critical functions and sensitive data. Additionally, the admin dashboard allows for tracking daily workflow, monitoring batch processing, and analysing statistical data related to chemical usage, fiber recovery efficiency, and production trends. This module also generates automated reports, logs all activities for audit purposes, and ensures that the system operates under proper supervision with a high degree of accountability. It provides complete visibility and control over the recovery process and ensures secure, centralized data management, making it a backbone for decision-making and process optimization.

SEGREGATION

The Segregation Module is responsible for the initial stage of the fiber recovery process, where incoming polycotton waste is identified, classified, and weighed. It automates what was traditionally a manual and error-prone step, using sensors or scanning systems to determine the composition of fabrics, particularly the polyester-to-cotton ratio. This classification is crucial because the chemical treatment in later stages relies heavily on the accurate understanding of the material's makeup. After identification, the module measures the weight of each sorted batch using precision sensors, and this data is forwarded to the Additive Module for chemical calculation. The accuracy in segregation ensures that each batch is processed under optimal conditions, reducing the risk of overuse or underuse of chemicals. It improves the quality of recovery, reduces waste, and prepares the input for the next stages with precision. Automating this stage eliminates human errors, enhances speed, and ensures consistency in handling different types of fabric waste.

ADDITIVE

The Additive Module is the core of the chemical treatment stage, where polyester is separated from cotton through controlled chemical reactions. Based on the input weight and fabric composition data received from the Segregation Module, this module intelligently calculates the exact amount of chemicals—such as ammonium bicarbonate and water—needed for each batch. These chemicals are then automatically dispensed and injected into the system with high precision. It also maintains strict control over environmental conditions such as temperature and timing, which are critical to achieving the desired reaction without damaging the cotton fibers. This module reduces reliance on manual estimation, thereby avoiding over- or under-treatment, and ensures worker safety by minimizing direct contact with chemicals. Automation in this stage results in consistent output, efficient chemical usage, and high-quality fiber recovery. It is one of the most sensitive and essential modules, as the accuracy of chemical processing directly affects the success of polyester removal and the integrity of the recovered cotton.

RECOVERY

The Recovery module is a pivotal system that meticulously tracks and records the amount of material recovered during the chemical processing of shredded polycotton. It quantifies the effectiveness of solvent treatments by capturing precise data on the recovered polyester and cotton fibers, providing critical insights into the efficiency of each processing cycle. Through continuous monitoring and real-time data collection, the module evaluates the process effectiveness, identifying opportunities for improvement in fiber separation and recovery. It also assesses the material reuse potential, determining how much of the recovered fiber can be reintroduced into the production process. By offering detailed analytics on recovery rates, this module helps optimize the overall recycling process, enhancing both resource efficiency and sustainability while ensuring the maximization of usable materials for subsequent stages.

QUALITY BLEND

The Quality Blend module is an advanced system designed to rigorously evaluate the strength, softness, and overall quality of the recycled fiber blend's cross-section. It performs in-depth analysis of fiber properties post-processing, ensuring that the blend composition accurately reflects the desired ratios of polyester and cotton. The module continuously monitors key characteristics such as fiber strength, flexibility, softness, and uniformity, providing real-time feedback on the quality of the polycotton fibers produced. By assessing these properties, it ensures that the final product meets industry standards and is suitable for a wide range of applications, from textiles to industrial materials. Furthermore, the system optimizes the balance between fiber durability and comfort, guaranteeing a high-quality end product that is both functional and aesthetically appealing. Through continuous monitoring and precise adjustments, the Quality Blend module plays a critical role in ensuring the production of polycotton fibers that meet or exceed performance expectations, while enhancing the overall sustainability of the recycling process.

V. ALGORITHM

The Wastage Minimization Algorithm implemented within the Additive Module intelligently calculates the minimum effective quantity of chemical additives—such as ammonia and bicarbonate—required for efficient polycotton processing. By analyzing the initial fabric composition and leveraging predictive logic, the algorithm ensures that only the necessary amount of chemicals is used to achieve optimal fiber separation and recovery. This approach not only reduces material loss and chemical waste but also enhances processing efficiency by maintaining fiber quality while minimizing environmental impact. Additionally, it continuously adapts based on real-time data, ensuring consistent performance across varying fabric types. The result is a smart, sustainable system that improves resource utilization while preserving output quality.

VI. SYSTEM ARCHITECTURE

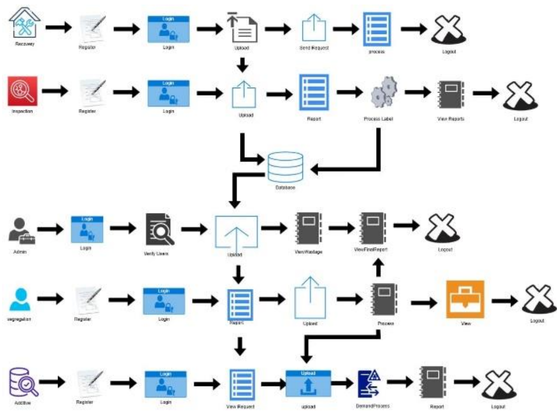

Figure 1: System Architecture

This system is designed to reduce waste and improve the production process. It includes five main parts: Recovery, Inspection, Admin, Segregation, and Additive. In each part, users register, log in, upload data, perform tasks like processing or creating reports, and then log out. All the data from these parts is stored in one central database. The Recovery section handles sending and processing requests. The Inspection section uploads data and creates reports. The admin section verifies users, uploads important data, and views reports. The Segregation section prepares and processes reports, while the Additive section manages requests and uploads data for further processing. All parts of the system work together to save materials and make the production process more efficient.

VII. RESULT AND CONCLUSION

The proposed polycotton processing system is designed to fundamentally transform the way polycotton materials are processed, pushing the boundaries of efficiency, sustainability, and fiber quality through the seamless integration of cutting-edge technologies, real-time analytics, and advanced automation. While initial polycotton weight measurements remain a crucial starting point, they are now part of a broader, dynamic system that leverages continuous data integration to make processing decisions more responsive and accurate. Through the incorporation of real-time data analytics, the system dynamically validates and adjusts assumptions regarding polyester and cotton content, allowing for continuous optimization and ensuring that the processing parameters are always aligned with actual material characteristics.

The shift from traditional, manual wastage analysis to automated, data mining-driven processes marks a significant leap forward. By utilizing sophisticated algorithms, the system minimizes material losses and enhances the recovery of usable fibers, improving overall resource efficiency and minimizing waste. This not only ensures that more fibers are recovered but also reduces the environmental footprint of the recycling process, making it more sustainable.

Furthermore, the advanced automation introduced throughout the system enhances every stage of the process, from fiber segregation and chemical processing to fiber recovery and quality control. The introduction of intelligent additive optimization and predictive quality assessments ensures consistent product quality while also allowing for adaptive adjustments based on real-time feedback. By correlating processing parameters with fiber characteristics, the system guarantees the production of high-quality polycotton fibers that meet or exceed industry standards, suitable for a wide range of applications, from everyday textiles to industrial materials.

Ultimately, this next-generation polycotton processing system not only enhances operational efficiency and quality control but also promotes a more circular and sustainable approach to textile recycling. Through its integration of smart technologies, data mining, and data-driven decision-making, the system stands poised to set a new benchmark in polycotton recycling, offering unprecedented levels of automation, optimization, and resource utilization that will significantly contribute to the future of textile recycling and the global sustainability movement.

VIII. FUTURE ENHANCEMENTS

Association Rule Mining for Process Improvement

Identify patterns between different waste types and successful recycling outcomes to optimize sorting and processing strategies.

Clustering for Material Classification

Use advanced clustering (e.g., DBSCAN, hierarchical clustering) to group similar fabric

waste types based on properties like texture, color, or fiber mix

Hybrid Data Mining Models

Combine multiple techniques (e.g., classification + clustering) to improve prediction quality and identify hidden patterns in textile waste

Incremental Learning

Implement algorithms that can learn from new data continuously, improving accuracy over time without retraining from scratch

Integration with External Data

Use external datasets like market demand or environmental data to enhance decision-making in the recycling process

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