Automatic Sheet Cutter Drum for Sun Dry Mill Board

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Abstract -This project focuses on automating the cutting mechanism of a semi-automatic Sundry Board Machine used in cardboard manufacturing. The current system relies on manual intervention, causing inefficiencies and inconsistencies. The proposed solution replaces manual cutting with a fully automated process using an Arduino Mega 2560 microcontroller, pneumatic cylinders, photoelectric sensors, solenoid valves, and solid-state relays. A redesigned cutting drum and integrated air nozzles enable precise sheet cutting and transfer. The system includes a TFT display for user interaction and offers remote operation, automatic production tracking, and enhanced cutting accuracy. This automation significantly improves productivity, reduces human error, and modernizes cardboard production with an efficient, low-cost, and scalable solution.

Key Words: Sundry board machine ,Cardboard cutting Automation, Paper mill Card board mills

1.INTRODUCTION

The Sundry Board Machine processes wet pulp from a pulper into cardboard sheets through a series of automated steps, culminating in a semi-automatic cutting stage. Initially, the wet pulp is shaped into a continuous sheet using a former and mould arrangement. This wet sheet then passes over a felt conveyor where a vacuum pump removes excess water, reducing the moisture content to a suitable level for further processing.

Following water removal, the sheet is wound onto a large cutting drum. The number of revolutions around this drum dictates the final thickness of the cardboard, with each revolution adding a consistent thickness increment. Simultaneously, the circumference of the drum determines the length of the cardboard sheet. The machine automatically controls the drum's revolutions to achieve the desired thickness.

However, after reaching the intended thickness, the cutting of the cardboard sheet to a standard size requires manual intervention to separate it from the drum. While the length is predetermined by the drum's circumference, the cutting process is not automated, classifying the machine as semi-automatic. The cut sheets then undergo final processing stages of drying and calendaring to remove remaining moisture and improve the surface finish. The text highlights that while fully automatic machines exist in India, they are imported, underscoring the need for designing an automated cutting mechanism for locally manufactured machines.

problem statement:

The primary issue is the **obstruction in the paperboard making process** caused by the manual cutting and transferring of sheets. This necessity for human intervention creates bottlenecks, slowing down the overall production rate and reducing the machine's efficiency.

The **manual cutting** process itself is a significant problem. It introduces variability and the potential for human error, directly impacting the speed and precision of production. Consequently, the quality of the final product can be inconsistent.

The **limited automation** of the current system is a key concern. The reliance on manual labor for the critical cutting step prevents the achievement of a fully automated system. This lack of complete automation hinders efforts to increase production volume and maintain consistent product quality.

Ultimately, there is a **need for increased quality and quantity of production**. To meet growing demand, a fully automated system is required. Reducing reliance on manual labor and minimizing human errors through automation is crucial for achieving higher production volumes and improved product quality.

Objectives

The following objectives are set:

1. Automation for without skill labour work.
2. Increase in Accuracy.
3. Increase in productivity.
4. Precision in output product.

2 LITERATURE REVIEW

The literature review highlights key considerations for automating the cutting process in cardboard manufacturing. Studies emphasize the influence of pulp consistency and couch roll pressure on material properties, which in turn affect the required cutting forces. The arrangement of rollers supporting the felt is also crucial as it impacts fiber bonding and the ease of blade movement. Research has analyzed the stress distribution of cutting blades with varying angles relative to paper GSM.

Furthermore, the review covers technologies applicable to automation. PLCs are discussed for their role in controlling continuous processes, with advancements in programming and simulation tools explored. The integration of Arduino and fuzzy logic for safety in industrial automation, as well as the implementation of fully automated systems based on Industry 4.0 principles, are presented as relevant approaches.

Cost-effective automation through microcontrollers, the precision of pneumatic actuators, IoT-based predictive maintenance, user-friendly HMI design using TFT displays, dynamic balancing of rotating machinery, energy-efficient pneumatic control with Arduino, and hybrid PLC-Arduino architectures for scalable automation are also examined. This body of work provides a foundation for developing an automated cutting mechanism by considering material properties, cutting mechanics, and various control and automation technologies.

3. PROJECT METHODOLOGY

The project employs a systematic and iterative approach integrating both quantitative and qualitative methods to ensure comprehensive analysis and robust outcomes. Our methodology begins with a thorough requirements analysis phase, followed by a structured design process where system specifications are developed based on stakeholder input. Implementation follows a phased approach with continuous integration and testing to verify functionality against established criteria. Regular progress reviews and stakeholder consultations allow for refinements based on feedback. Risk management procedures are embedded throughout the project lifecycle, with contingency plans established for identified vulnerabilities. This methodical framework ensures alignment with project objectives while maintaining the flexibility to adapt to emerging challenges or changing requirements. A project methodology flow chart design

4. AUTOMATION COMPONENTS SELECTION

This section details the selection of automation components required to automate the cutting and transferring process of cardboard sheets in the Sundry Board Machine. The core objectives of this automation include: cutting the sheet to the desired length after achieving the target thickness, transferring the cut sheet from the drum to a transport mechanism, ensuring the final length considers edge allowances, and establishing a control system for these mechanisms.

The chosen components for this automation are: a Microcontroller (Arduino Mega 2560) for synchronized control of actuators based on sheet position and thickness; a Display TFT screen (3.5 inch) for a user-friendly interface for monitoring and control; SSR Relays (SSR-25 DA) for reliable, high-speed switching of high-power electrical loads; an FRL Unit (AL4000-04) to provide clean, regulated, and lubricated compressed air for pneumatic components; Solenoid Pneumatic Direction Control Valves (5/2 way and 3/2 way) to control the direction of airflow to pneumatic cylinders based on microcontroller signals; Pneumatic Cylinders (single-acting, 63mm bore, 50mm stroke) to provide linear motion for the cutting blade; Photoelectric Sensors (IR Photoelectric Sensor E18-D80NK) to measure sheet thickness and count drum revolutions; and Air Nozzles to assist in transferring the cut sheet from the drum to the conveyors.

The selection of each component is justified based on its specific functionality and specifications. The Arduino Mega 2560 offers sufficient I/O pins, memory, and communication ports for the control system. The TFT screen provides a user-friendly interface. SSR relays ensure reliable switching of electrical loads. The FRL unit guarantees clean air for the pneumatic system. Solenoid valves precisely direct airflow. Pneumatic cylinders provide the necessary linear force for cutting. Photoelectric sensors enable thickness measurement and revolution counting. Air nozzles aid in sheet transfer. Detailed specifications for each component, including model numbers and key parameters, are provided in tables and figures.

5. DESIGN

Old cutting drum machine :

The data of the sheet produced and the specification of machine are noted, in order to be used for further design. The all data is given from old machine .

1. Length of the drum : 1100 mm
2. Length of the shaft : 380 mm
3. Width of the Shaft : 140 mm
4. Width of the drum : 292 mm = 11.4 inch
5. Circumference of the circle = π * Diameter

Circumference = 3.14 * 11.4 inch

Circumference = 36 inch = 914 mm

Fig 1 : Previous cutting drum image

Design of the New cutting Drum:

In this project, a new cutting drum was designed using AutoCAD software to meet specific operational requirements for cutting machinery. The objective was to ensure precision in dimensions, optimal strength.

Software Used:

- **AutoCAD 2D** was utilized for drafting the cutting drum design.
- Detailed dimensioning and scaling were carried out to ensure accuracy.

- **Initial Concept Sketch**: A rough hand-drawn sketch of the drum was created based on initial technical requirements.
- **Drafting in AutoCAD**: A precise **Front View** and **Side View** of the cutting drum were designed to represent all critical dimensions and geometry clearly.
- **Dimensioning and Detailing**: Accurate dimensioning was performed for all views, including lengths, diameters, and thicknesses, using AutoCAD's dimensioning tools.
- **Review and Optimization**: The design was carefully reviewed for manufacturability, structural integrity, and operational performance.
- **Finalization**: The final 2D drawings Fig.14: Front view of the new cutting drum And Fig.15: Side view of the new cutting drum were saved and exported for fabrication and project documentation.

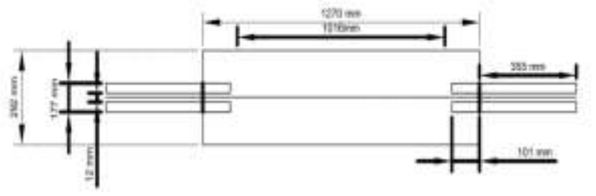

Fig.2: Front view of the new cutting drum

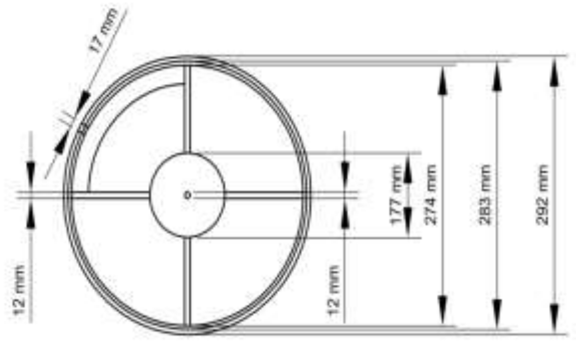

Fig.3: Side view of the new cutting drum

6. ARCHITECTURE OF MICROCONTROLLER AND COMPONENTS.

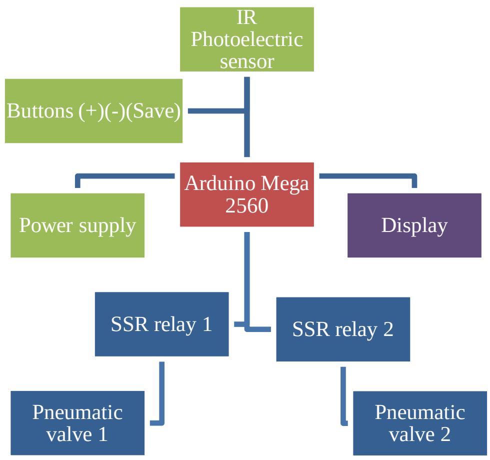

Fig.4: Block Diagram of Architecture of microcontroller

This section details the architecture and programming of a microcontroller-based pneumatic control system, utilizing the Arduino Mega 2560 as its core. The system integrates a power supply, input devices (IR photoelectric sensor and tactile push buttons), output devices (SSR relays and pneumatic control valves), and a TFT display for user interaction.

The Arduino Mega 2560 reads input from the IR sensor (for object detection) and three push buttons (+, -, Save) for user configuration. Based on the programmed logic, it sends control signals to the SSR relays, which in turn switch the high-power AC supply to the pneumatic control valves. These valves regulate the flow of compressed air to mechanical actuators. A 3.5-inch TFT LCD screen provides a real-time graphical user interface, displaying system status and allowing user interaction.

The Arduino is programmed to count events detected by the IR sensor, allow users to adjust a limit value using the push buttons (with visual feedback on the TFT), and trigger the pneumatic valves when the event count reaches the set limit. The system also includes functionality to save the adjusted limit value to the Arduino's EEPROM, ensuring it persists across power cycles. The TFT screen displays the current count, limit value, and the on/off status of the air and blade valves, along with user feedback messages for actions like incrementing/decrementing the limit or saving the value.

7. ANALYSIS

Speed of old machine:

The components are in machine speed control motor, pullys, gear box, all this works with speed of machine. While calculating the speed given data is

Motor speed – 1440 rpm

Motor pully size (OD) – 4 inch

Gear box pully size (OD) – 11 inch

Gear box input speed - ?

For calculating the speed of gear box input speed formula is

Motor speed × motor pully size (OD) = Gear box pully size (OD) × gear box input speed

Putting given data in formula

$1440 \times 4 = 11 \times x$

$x = \frac{1440 \times 4}{11}$

$x = \frac{5760}{11}$

x = 523 rpm

Gear box input speed = 523 rpm

A worm and wheel gearbox with a 40:1 ratio means that:

The worm (input shaft) must make 40 full rotations to turn the worm wheel (output shaft) just 1.

Output speed of the gear box = Gear box input speed rpm ÷ 40

X = 523 ÷ 40

X = 13 rpm

Output speed of the gear box is 13 rpm.

Speed of New machine:

The speed of the new machine is high because it operates without the need for human intervention. We can adjust the speed to a level that the machine can handle more efficiently. The components are in machine speed control, motor, pullys, gear box, all this works with speed of machine. While calculating the speed given data is

Motor speed – 1440 rpm

Motor pully size (OD) – 5 inch

Gear box pully size (OD) – 11 inch

Gear box input speed – x

For calculating the speed of gear box input speed formula is

Motor speed × motor pully size (OD) = Gear box pully size (OD) × Gear box input speed

Putting given data in formula

$1440 \times 5 = 11 \times x$

$x = \frac{1440 \times 5}{11}$

$x = \frac{7200}{11}$

x = 654 rpm

Gear box input speed = 654 rpm

A worm and wheel gearbox with a 40:1 ratio means that:

The worm (input shaft) must make 40 full rotations to turn the worm wheel (output shaft) just 1.

Output speed of the gear box = Gear box input speed rpm ÷ 40

X = 654 ÷ 40

X = 16 rpm

Output speed of the gear box is 13 rpm.

Fig.5. Image of worm and wheel gear box

The gear box rotates the coach roll and the cutting drum is placed over the coach roll ,The coach roll rotates clockwise and cutting drum rotates anticlockwise.

8. CONCLUSIONS

The project successfully automated the cutting and transferring processes of a Sundry Board Machine, transitioning it from a semi-automatic to a fully automated system. This achievement eliminated the need for manual intervention, enabled remote operation, automated production measurement, increased productivity, enhanced precision of the final product, and improved operator safety. The systematic design approach, careful component selection (including Arduino Mega 2560, pneumatics, and sensors), and effective control system architecture were key to this success, contributing to local manufacturing capabilities in India.

Looking ahead, the automated Sundry Board Machine presents numerous opportunities for future development. These include integrating Industry 4.0 technologies (IoT, data analytics, cloud connectivity), enhancing the control system with PLCs and advanced algorithms, implementing mechanical improvements like automated stacking and quick-change mechanisms, integrating quality control systems (vision systems, real-time thickness measurement), improving energy efficiency, expanding the scope of automation to upstream and downstream processes, enhancing safety and ergonomics, ensuring scalability and flexibility for different production needs, addressing environmental considerations, and focusing on economic benefits through cost optimization and commercialization. These future directions aim to evolve the machine into an intelligent, efficient, and sustainable manufacturing solution, aligning with modern industrial trends and bolstering technological self-reliance.

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