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Design and development of an industrial shredding system for corn stalks and forage crops

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Abstract
Efficient handling of agricultural biomass, such as corn stalks and forage crops, is critical for livestock feed preparation and bioenergy applications. This paper presents the design, development, and evaluation of an industrial-scale shredding system tailored for processing corn stalks and forage materials. The system incorporates a rotary cutting mechanism driven by a 75 kW motor, with automated feeding and discharge. Performance tests demonstrated a throughput of 12 tons/hour with an average particle size of less than 20 mm, suitable for silage and pelletizing. The system shows promise for large-scale agricultural use due to its efficiency, safety, and ease of maintenance.
Keyword*: Corn stalk shredder, forage processing, agricultural machinery, biomass handling, industrial shredder*

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I. INTRODUCTION

Agricultural residues such as corn stalks and grasses are increasingly utilized as feedstock for livestock and as raw material for renewable energy. However, their high volume and fibrous nature present challenges in handling, transportation, and storage. Shredding or chopping these materials into smaller particles enhances their bulk density and digestibility for livestock, and improves combustion or fermentation characteristics for energy applications.Traditional shredders often fail to meet the demands of high-volume processing in industrial farms. Therefore, developing an efficient, robust, and cost-effective shredding system for these biomass materials is essential.This paper describes the design and functional testing of an industrial shredding machine optimized for corn stalks and forage crops. The system aims to achieve high throughput, uniform particle size, and long operational life with minimal maintenance.

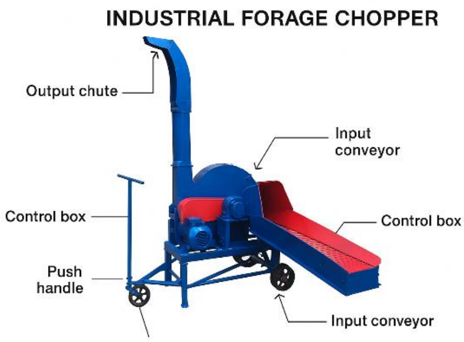

Fig 1.1 Image of the forage shredding system

II. MATERIALS AND METHODS

Design Requirements

The machine was designed to meet the following criteria:
Material types: Corn stalks, Napier grass, elephant grass, and similar forage.
Processing capacity: ≥ 12 000 kg/h.
Output particle size: ≤ 20 mm.
Power source: Three-phase electric motor (75 kW).
Portability: Mounted on a wheeled steel frame.
Safety: Integrated emergency stop and overload protection.

System Components
The shredding system consists of:
Cutting chamber: Housing a rotor with 30 hardened steel blades (SKD-11).
Feeding conveyor: A belt-type conveyor with rubber paddles to feed material steadily.
Discharge chute: Ejects shredded material into a collection bin or conveyor.
Motor and drive: Powered by a 75 kW motor connected via a V-belt transmission to a gear-reduced shaft.
Control panel: Includes overload relay, soft starter, and safety interlocks.

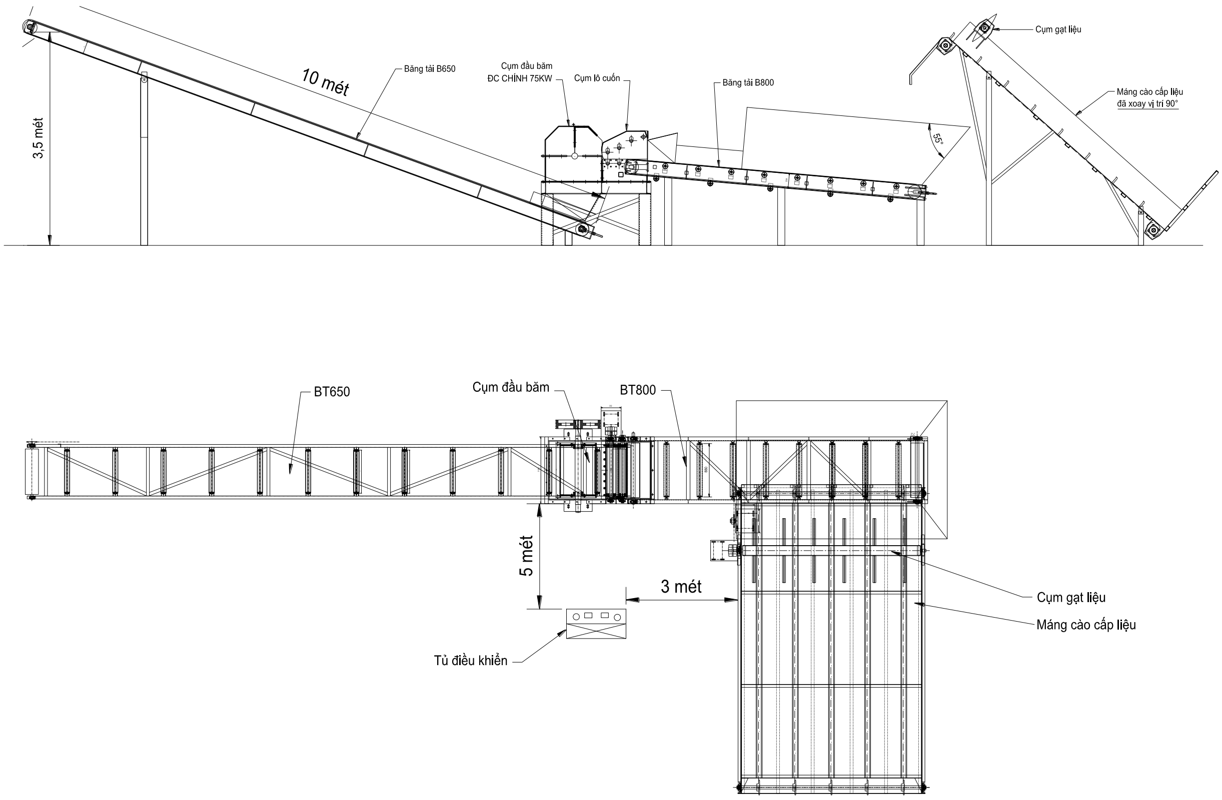

Fig 2.1 Diagram of the industrial chopper system

Fabrication

The frame and housing were constructed using mild steel (SS400), while the blades were fabricated from wear-resistant SKD-11 tool steel, heat-treated to a hardness of 58–60 HRC. The rotor was dynamically balanced to minimize vibration during operation.

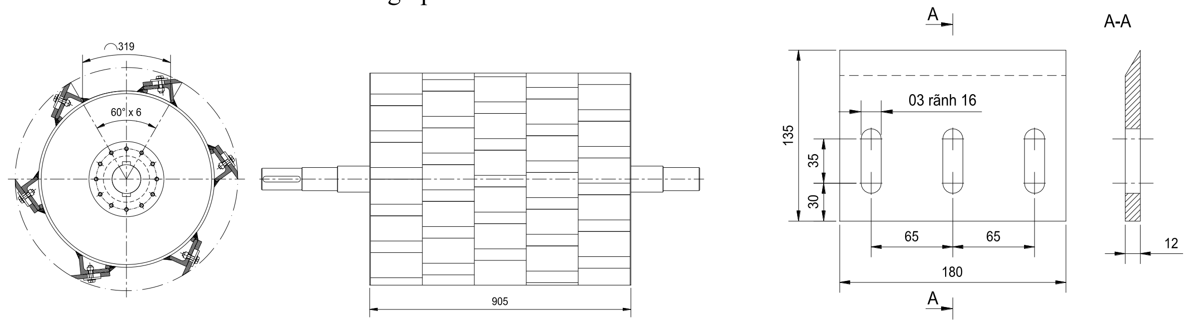

Fig 2.2 Structure of the grass/corn shredder system.

Performance Testing

The machine was tested with fresh and dry corn stalks and elephant grass. Key parameters recorded:
Input and output mass (kg): 50 000kg
Processing time (minutes): 180 minutes
Motor current and temperature: 180A and 35^{o}C
Average particle size (mm): 20 mm
Tests were conducted in triplicate to ensure reliability.

Fig 2.3 Processed biomass.

III. RESULTS AND DISCUSSION

Performance Metrics

Material Type	Throughput (kg/h)	Avg. Particle Size (mm)	Power Consumption (kWh/ton)
Fresh corn stalks	12 000	16.5	6.5
Dry corn stalks	10 500	19.8	8.2
Elephant grass	13 500	17.2	7.1

Tab 3.1 Table of Experimental Results.

The results indicate the shredder met and exceeded design specifications. The output size was consistent and suitable for both silage fermentation and briquetting processes.

Energy Efficiency, Safety and Maintenance

The specific energy consumption was within acceptable limits for industrial shredding. Power usage increased slightly with drier materials due to higher shear resistance.

No mechanical failures or blade damage occurred during 10 hours of continuous operation. Blade replacement is modular and requires less than 35 minutes. The emergency stop system functioned effectively during simulated overload scenarios.

IV. SUMMARY AND PROSPECT

The developed industrial shredding machine for corn stalks and forage crops successfully met its design objectives. It provides:

High throughput (≥12 ton/h),

Uniform output suitable for multiple downstream applications,

Reliable and safe operation,

Low maintenance needs.

This system has strong potential for adoption in agricultural cooperatives and medium-to-large-scale farms aiming to mechanize their forage preparation or biomass processing operations.

Future work will focus on integrating moisture sensors and automation for feed rate control, as well as exploring hybrid power options (diesel-electric).

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