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Fabrication and Simulation of Multi-Purpose Agriculture Machine

Mullu Pavani, Peda Baliyara Simhuni Indhu, Yendamuri Venkataramana, Potnuru Dileep, Thota Tirumala Srinivas Manjunath, Assistant Professor Dr. Gorti Janardhan
Department of Mechanical Engg.
GMR Institute of Technology Rajam, India

Abstract- The machine is a double-purpose unit proposed to chop and crush forage crops in an efficient way, to cut down on waste and inefficiency in agricultural practices. It discusses evaluation related to the performance of the machine, with emphasis on its productivity in trimming different forages. The study discusses the advantages the use of this machine would bring about, such as minimum labor costs and efficient crop management. Testing results show that the machine achieves the basic standards of operation for agricultural purposes. The main objective of the project was to develop a machine that efficiently performs chopping and crushing work simultaneously with the ability to overcome the weaknesses of machines that can only perform the two functions separately. This multi-purpose functionality aims at increased productivity and saving on operational costs. An increased need for environmentally friendly economical machines capable of delivering agricultural needs effectively, therefore, is essential to achieve economic sustainability.

Index Terms- Forage crops, chopping and crushing, Agricultural efficiency, small-scale farms, productivity, and specific energy.

I. INTRODUCTION

Small-scale and marginal farmers are, for instance, raising poultry, goats, buffalo or dairy farming to ensure supplementary income, especially during crop failure. With the global energy crisis, there has been a thrust to use livestock for bio-energy and convert waste into organic manure.

This is part of an integrated approach to managing waste from agriculture and adding both economic and environmental value to the process. It is widely acknowledged that the principles of lean manufacturing have been very effective in eliminating unnecessary waste and improving processes to bring about betterment of operational and economic outcomes.

Crop residues and agro-industrial by-products are the greatest feed sources for ruminants and also occupy a significant position in their nutrition. On an average, an adult bullock consumes 10-15 kg of fodder a day, whereas cows and buffaloes consume 8-10 kg a day.

Agricultural residues include wheat straw, maize stalks, and rice straw; India produces about 30 million tons per year. Residues ranked by percentage: Wheat straw, 58.7%; Rice straw, 28.3%; and Maize stalks, 3.8%. The residues are choped or ground to improve their quality as well as to make them more digestible for the animals.

Chop, shred, and grind fodder for a higher exposure to microbial breakdown for easier digestibility with less energy usage by animals in the chewing of the fodder. Crops may be chopped by hand, by diesel-powered, or electric machine. A newly designed power machine with a capacity of 1.5 kW was constructed for cutting fodder and grinding grains for easier operation.

This machine was used for cutting both wet and dry fodder with high efficiency, cutting grain sorghum, and grinding maize. Based on this, the similar machine was modified to chop agricultural residues in the form of rice straw and stalks of corn while reducing energy consumption. It was experimented with performance in terms of productivity, cutting efficiency, and energy utilization at various speeds and moisture levels.

Most of them now use manual chopping machines such as sickles, which are laborious and take a lot of time. In addition, any imported agriculture equipment is expensive, and thus many small- and medium-scale farmers cannot acquire them. However, the paper endeavored to come up with and test a locally fabricated, low-cost machine that would easily execute both chopping and grinding operations, and suit the small and medium farms.

II. LITERATURE REVIEW

1. Overview of Relevant Literature

More studies were carried out on agricultural machinery, which focused on efficiency and sustainability. Of major importance include harvesting machines for specific agricultural needs such as wheat harvesting machines, straw collection rice harvesting, low-cost choppers, and fodder processing devices. Innovations based on improving efficiency in operations, cost-cutting, and use of energy inputs with a minimum effect on the environment were paramount. There is recurrent failure in previous studies in terms of integrating multi functionality. Most of the machines carry out chopping or crushing activities. Most traditional machines were also made to consume these fuels and hence emitted more greenhouse gases. This paper fills the gap by introducing a dual-purpose, electric-powered machine on a small and medium scale for use on small farms. It is a low-energy consumption and low-cost operational device.

2. Key Concepts

Agricultural Efficiency: multiple functions from one machine: comprises low labor, time and costs especially to the small-scale farmers. Important measures include chopping efficiency and throughput.

Sustainability: From using diesel engines to electric power to reduce greenhouse gas emissions and work closer towards an environment-friendly form of farming with minimum energy usage.

Material Chopping and Crushing: Optimize the selection of knife type, angle, and speed for better chopping and crushing effect.

Improvement of Energy Efficiency: Reduction of power usage and continued production of productivity that would ensure that machines are cost-effective and suitable for usage in farming practices at the country end.

Structural Design: Durables are to be considered as a basis of selection and structural analysis are held, which will make balance durability, performance, and cost.

3. Gaps in the Literature

- Most of the earlier machines were either chopping machines or crushing machines. Separation itself incurs an increase in costs and also labor; therefore, a single-purpose machine that could be efficient in both operations is required.
- Machines developed in the earlier works ran on diesel or gasoline engines, which generated more greenhouse gases, thereby causing harm to the environment.
- The studies undertaken in the previous studies used a high amount of energy, owing to the crushing of crops.

III. METHODOLOGY

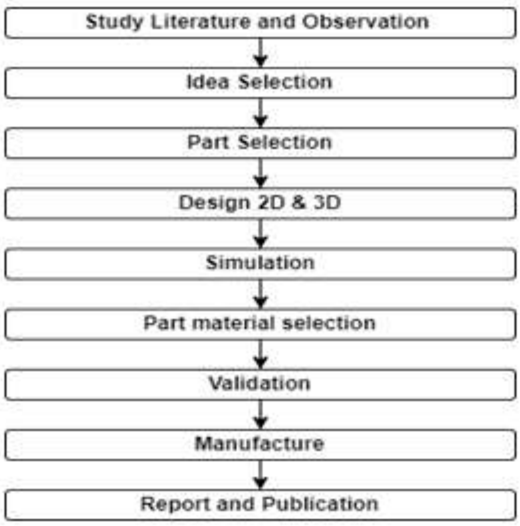

Fig. 1: Research design

1. Data Collection Methods

Maize Plant Characteristics Survey: The following plant characteristics, among others such as the plant height, stalk diameter, ear length, ear diameter, and mass of the plant, were recorded using 50 samples randomly selected from the field. The major measurements were that the plant had a height of 2480 mm, a stalk diameter was 36 mm, and whole plant mass was 2135 g.

Measurement of Moisture Content: Moisture content of maize stalk samples was measured as the samples were dried in the oven for 24 hours at 105°C; this is a critical measurement in terms of studying the impact that moisture has on the chopping process.

Machine Productivity Test: Productivity was defined as the ratio of the mass of output (in tons) to machine operating time (in hours), which should, thus, measure the efficiency of the machine.

Estimation of Specific Energy to Chop and Crush: Since specific data were not provided, energy to chop and crush was estimated for assessment of efficiency.

Evaluation of Operational Parameters: Performance was evaluated at multiple rotational speeds of 1200 to 1800 rpm with several moisture levels between chopping, besides changes in the speed of crusher and diameters of sieve holes during crushing.

IV. MATERIALS AND METHODS

The chopping and crushing machine

1. The Machine's Frame

- **Material:** Angular rods
- **Welding Used:** Arc Welding with 95v
- **Stand Dimensions:** (600*500*300) mm

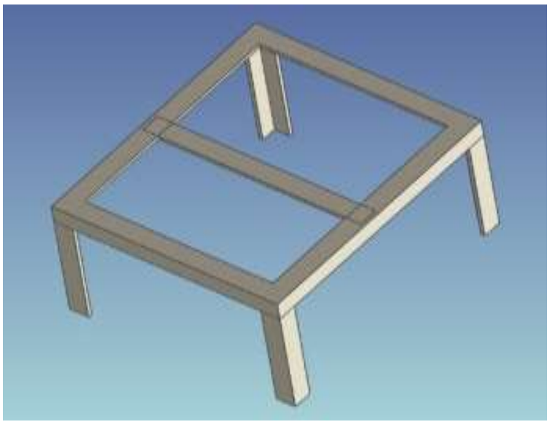

Fig. 2: Isometric view of machine's frame

2. Bottom Body

- **Material:** Metal Sheet (3mm thickness)
- **Welding Used:** Arc Welding with 95v
- **Stand Dimensions:** (180*600*600) mm

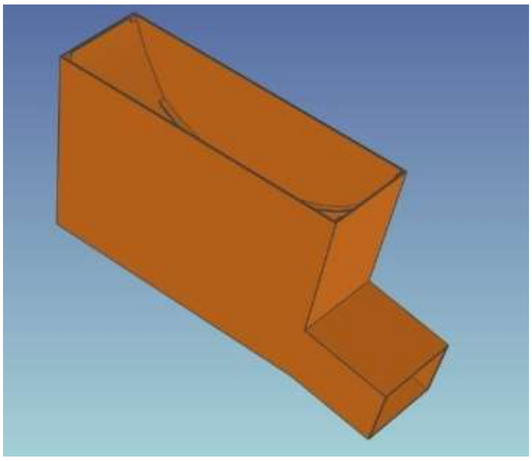

Fig. 3: Bottom body

3. Top Body

- **Material:** Metal Sheet (3mm thickness)
- **Welding Used:** Arc Welding with 95v
- **Stand Dimensions:** (180*600*400) mm

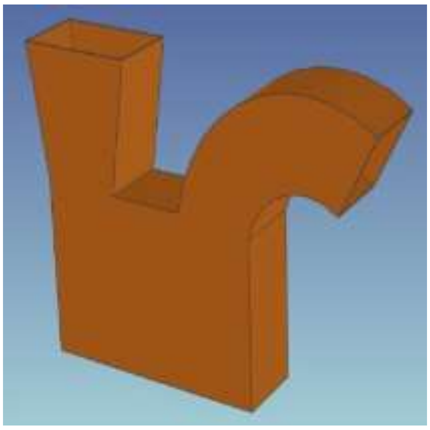

Fig. 4: Top body

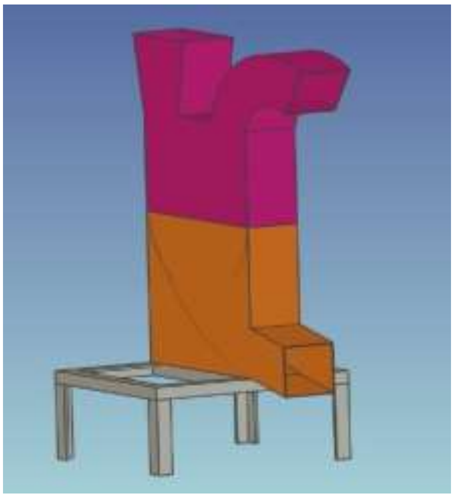

Fig. 5: Isometric view of chopper and crusher

Cost Estimation

Name of the Material	COST
Multiple Cutting Blade	2000
Wheels(4)	2000
Frames(2)	1500
Motor(3hp)	8000
Metal Sheet	3000
Angulars(L Bends)	1000
Dust Collecting Frame	300
Motor Belt & Pulley	500
Total Estimated Cost	2500

V. RESULTS AND DISCUSSION

1. Machine Productivity

The ranges of chopper rates of rotation in the range between 1200 and 1800 rpm and moisture content in the range of 22.5 to 60% as shown in figures 5 and 6 and also the crushers' rotational speeds and diameters of sieve holes, which were within the ranges of 6 to 10 mm. Fig.5 On the scope of influence of a rotatable chopper's angular velocity on machine's performance, it indicates that any level of moisture content does not hinder the rise of machine productivity with the increase of chopper rotational speed. It was also found that for better productivity, the rotational speed of the chopper must be increased from 1200 rpm to 1800 rpm, with the moisture level being decreased from 61% to 0% whereby productivity reduces from 2.24 ton.hr-1 to 1.61 ton.hr-1 respectively. This might probably be due to the fact, at high speeds, the elapsed time spent on chopping was reduced thus resulting in more yield from the machine.

Fig 6 depicts the case when the speed of the crusher was high and its effect on the efficiencies of the machine altogether. The same was noticed whenever the crushing spindle was fast, henceforth resulting in giving the machine higher efficiencies at all the tested screens. Thus, this work established the fact that at higher crusher speed from 1200 to 1800 revolutions per minute, the productivity of the machine at the screen size of 10 mm changed from 0.3 to 0.4 ton/hr-1. Perhaps because of that fact, as a result of an increase in the rotational speed, the time of breaking with the crusher became smaller, thus the improvement of productivity of the machine.

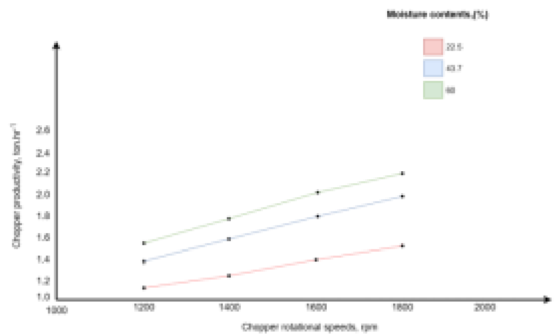

Fig. 6: Copper productivity

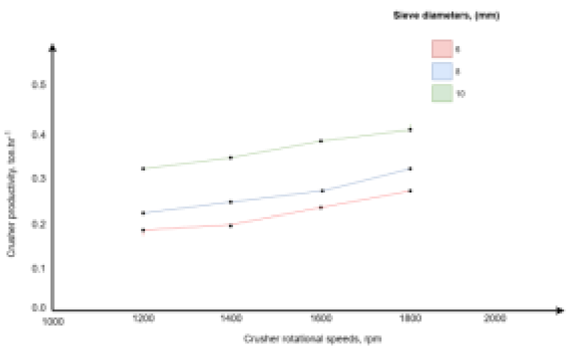

Fig. 7: Crusher productivity

2. Machine Efficiency

Fig. 7 shows the effect of chopping speed of the torso chopper on the torso. Higher speed of chopper rotation gives the chopper an increased chopping efficiency of raw material for any moisture content. From the same figure, it is seen that an increase of speed of chopper by 600 rpm increased efficiency of chopper from 75.12 to 85.34%, and from 70.23 to 78.14% as well as from 65.26 to 73.25% at moisture contents at 22.5, 43.7, and 60%, respectively. Most probably, this is connected with chopper blades beats in more in number per unit time, associated with higher mass of the optimal forage cutting length. Figure 8. Efficiency of the crusher against different sets of diameter of sieves with the rotational speed of the crusher.

The results clearly indicated that the increase in the rotational speed of the crusher also resulted in the corresponding reduction in the efficiency at any sieve holes, diameter. Fig. 8 indicates that a variation in the crusher speed from 1200 to 1800 rpm reduced the crusher efficiency from 62.05% - 50.24%, 74.68% - 57.43% and 89.86% - 75.83% at 6, 8 and 10 mm sieves hole diameters, respectively. It can be either that speeding up the crusher be should the crusher the rotational speed to enlarge the maize particles of maize ears under the required size that yet the crusher efficiency decreases.

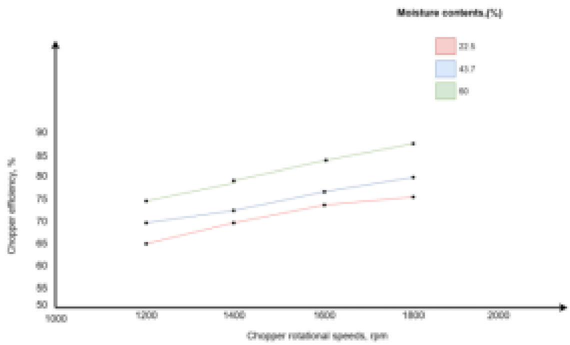

Fig. 8: Chopper efficiency

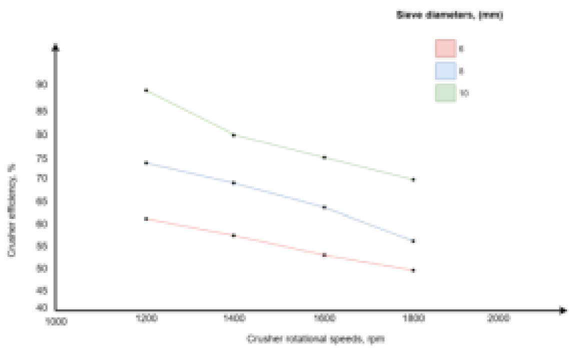

Fig. 9: Crusher efficiency

VI. CONCLUSION

Experiments were conducted and designed, evaluating a chopping and crushing device, based on local material, involving minimal factors of cost involved and easy use. The chopper operated at percent efficiency, whereas, when its working speed and condition of work were appropriately set, the crusher operated efficiently at 92 percent. The productivity rate achieved by the chopper was about 2.24 tons per hour. The crusher will, therefore, consume 3.22 kWh per ton while consuming 4.5 kWh per ton, respectively. Despite this, the device still has disadvantages; it is not yet ready for large-scale production because production of such a machine requires specialists who have to be trained first, then the materials available locally for the manufacturing are limited, and it is immobile, so raw materials cost more in transportation. The device is most efficient at present for to-sized farms. With future developments, it could be suitable for large-scale operations with the option of integrating power thereby making it much more adaptable to any kind of crop cultivation in open fields.

REFERENCES

1. Khairy, M. F. A., Abd El-Tawwab, I. M., & El-Bediwy, A. R. A. (2015). Development of a locally made chopping machine for rice straw. In The 20th Annual Conference of Misr Soc. Of Agric. Eng. Benha University, Egypt (pp. 65-78).
2. Muhammad, K., Walusimbi, K. H., Jimmy, K., & Swidiq, M. (2018). Design and performance evaluation of a NARO forage chopper prototype for smallholder dairying systems. Design and performance, 5(11), 547-551.
3. Nipa, J. F., Mondal, M. H. T., & Islam, M. A. (2021). Design, development and performance evaluation of small-scale fodder chopping machine for farmers.
4. Mr. Kumbhar S. J, Mr. Mali S. M . (2020). Design of Multi-Purpose Crushing Machine for Processing of Food Grains an Overview.
5. Smirnov, N. A., & Smirnov, R. A. (2020, August). Improving the technology of crushing root crops. In IOP Conference Series: Earth and Environmental Science (Vol. 548, No. 8, p. 082044). IOP Publishing.
6. V.-D. Vu, T.-T. Nguyen, N.-H. Chu, Q.-H. Ngo, K.-T. Ho, V.-D. Nguyen, Multiresponse optimization of cutting force and cutting power in chopping agricultural residues using grey-based taguchi method, Agriculture 10 (2020) 51.
7. M.M. Abo-Habaga, I. Yehia, G.A. Abo-Elasaad, Study some factors affecting the Design of rice straw bales chopper, J. Soil Sci. and Agric. Eng., Mansoura Univ. 10 (2019) 471–475.
8. A.M. El Shal, M.I. El Didamony, Performance of a maize chopping machine with an attached sharpener unit, J. Soil Sci. and Agric. Eng., Mansoura Univ. 9 (2018) 793–798.
9. Y. Ushakov, E. Asmankin, D. Naumov, A. Kolpakov, Experimental study results of the grinding process in a hammer-type shredder with side separating sieves, Int. Sci. J. 66 (2020) 55–58. “Mechanization In Agriculture & Conserving Of The Resources”.
10. Ramulu, C., Pateriya, R.N., Naik, M.A., 2020. Comparison of straw chopper cum incorporator with existing paddy residue management technologies in combine harvested paddy field at north western region of India. Current J. of Applied Sci. and Tech 39, 31–40.
11. Zheng, Z., He, J., Wang, Q., Li, H., Li, W., Chen, W., 2017. Design and experiment on straw pickup-chopping and ditch-burying integrated machine. Trans. Chin. Soc. Agric. Mach. 48, 87–96.
12. Abdrabo, A.F.A., Abdalh, S.E., 2013. Development of a pickup baler for chopping and compressing crop residues for processing nonconventional forages. J. Soil Sci. and Agric. Eng., Mansoura Univ. 4, 375–389.
13. C.C. Onyonagu, O.L. Njoku, Crop residues and agro-industrial by-products used in traditional sheep and goat production in rural communities of Markudi LGA, J. Tropic. Agric. Food Env. Ext. 9 (2010) 161–169.
14. R.A.A. Ahmed, Evaluation of local machine performance for faba bean crushing, Misr J. Agric. Eng. 34 (2017) 1167–1178.
15. Dauda, S. M., Ahmad, D., Khalina, A. and Jamarei, O (2015). Effect of Cutting Speedon Cutting Torque and Cutting Power of Varying Kenaf-Stem Diameters at Different Moisture Contents, 38 (4): 549 - 561 (2015).