Performance evaluation of power operated chaff cutter

Abstract

The study was conducted to evaluate the performance of power operated chaff cutter for three types of fodder crops, *viz.,* jowar, maize, and sorghum, under load and no-load conditions during *kharif* (July to October, 2022) at Farm Machinery Testing Centre (FMTC), University of Agricultural Sciences, Raichur, Karnataka (16.2051°N,77.3303°E). The hardness of the blade was recorded to be 54 HRC, and the rate of wear of blades on a mass basis and a dimensional basis was recorded as 0.013% - 0.026% and 0.028% - 0.047% per hour, respectively. The power consumption of the chaff cutter at no load was recorded as 0.42 kWh. Similarly, the quantity of cut fodder received was measured as 621 - 623 kg h^{-1} and 1710 - 1816 kg h^{-1} for dry and wet fodder, respectively. The maximum specific energy consumption was recorded as 1123.21 - 2396.0 kg kWh^{-1} in dry and wet fodder, respectively. The quality of cut ranged from 0.38 - 0.42 and 0.41 - 0.43 in dry and wet fodder, respectively. The performance index of chaff cutters was recorded as 471.37 and 1006.34 for dry and wet fodder, respectively. The maximum efficiency was recorded as 96.62 - 97.87% and 97.50 - 98.10% for dry and wet fodder, respectively. The power-operated chaff cutter was operated for a long-run test (23.00 h) for cutting jowar (dry), maize, and sugarcane crops in both wet and dry conditions was done. No breakdown in the cutter head, feeding mechanism, transmission systems, body of the chaff cutter was noticed.

Key words: Chaff cutter, efficiency, fodder, load condition, power requirement, specific energy

1. Introduction

India has a vast resource of livestock and poultry, with about 65.1 million sheep, 135.1 million goats, and 10.3 million pigs as per the 19th livestock census (Somvanshiet al., 2016). Animal feeding is a very important factor in animal husbandry, and it will be more suitable when fodder is cut into small pieces. Chaff is hay cut into small pieces for feeding to livestock (Mohan and Kumar, 2004). On dairy farms, chaff cutters are used to cut the chaff, dry grass, and green grass on a very large scale. Some farmers are using the chaff cutter to cut the chaff and feed types that are fed to domestic animals. Cutting chaff can be done manually or with a power-operated machine. Most of the farmers chop the fodder into small pieces with the use of sharp knives or sickles for feeding the animals, which may intensify the utilization and digestion ratio (Karunya et al., 2016). Manual chaff cutters demand physical energy and postural requirements and are commonly regarded as a source of drudgery; many farmers associated with this task reported back, shoulder, and wrist discomfort. So, to increase productivity and reduce the physical effort required for running the machine, motorized machines came into existence, which is best for dairy farmers.

The implementation of this technology in the field of agriculture has brought about a wide range of changes in manual procedures, which are now replaced by advanced technical procedures (Anand, 2016).To meet the growing demand from livestock farms, high-efficiency, safe forage processing chaff cutters are the need of the hour. An increase in cutting speed results in maximum efficiency and chopper capacity when using serrated edge blades (Ismail et al., 2009). Traditionally, for the operator, it is done manually, which is physically demanding through its energy and postural requirements and is commonly regarded as a source of drudgery (Kumar et al., 2004).

Barrington et al. (1971) modified the design of the chaff cutting machine, which cuts the fodder uniformly, which is ideal for the livestock, and it is a durable, long-lasting, and low-maintenance machine. The length is adjusted by changing the speed of the feed mechanism or the number of knives on the cutter head. By increasing the moisture content of chaff, the cutting efficiency of the chaff cutter increased and the power required decreased (Metwelliet al., 1995). Similarly, decreasing moisture content, increasing the number of knives, and increasing the speed ratio produced finer bagasse, which produces high-quality silage (Mareyetet *al.*, 2007). The cut length of residues depends on the feeding drum speed, moisture content, and knife clearance (Arif et al., 1999). Energy consumption can be decreased by increasing the cutting speed (Elfatihet al., 2010). The Government of India has specified power-operated chaff cutters as dangerous machines under the provisions of the Dangerous Machines (Regulation) Act 1983 (35 of 1983). The mechanization of agricultural practices has resulted in increased agricultural productivity in India, but at the same time, the incidence of traumatic injuries among agricultural workers seems to have increased.

The government of India's programmes like "Gopala Mitra" and the emerging dairy farms step up the "white revolution" in the country. The growing milking animal strength utilises a large quantity of fodder. The power chaff cutters alone can serve the purpose of growing livestock farms under large-quantity consumption under a critical labour crisis prevailing in the country. Keeping all these in view, the present study was taken up to evaluate power-operated chaff cutters for three types of fodder crops.

By considering the above constraints in chaff cutting machines, there was a need to introduce the power-operated chaff cutter, which helps overcome the shortage of labour and drudgery involved in manually operated chaff cutter operation. By keeping the above facts into consideration, the present investigation has been made in an attempt to evaluate the performance of a power-operated chaff cutter for jowar, maize, and sorghum fodder.

2. Materials and Methods

2.1 Power operated chaff cutter

The study was conducted to evaluate the performance of a power-operated chaff cutter. A 3.7 kW three-phase electric motor was used as a power source and mounted on a 520 x 260 mm frame with the help of nuts and bolts. Two B-62 type V belts were used to transmit the power from the electric motor pulley to the cutting unit roller with 1:0.33 speed reduction ratios. Power is transmitted to the feeding roller with the help of a five-number cast iron spur gear system. A 290 x 210 x 12.85 mm size M.S. flat single cutter head was used. A 920 x 500 mm size hopper was made up of M.S. sheet and mounted on head unit side plates by nuts and bolts with a 25-degree angle of inclination. When the fodder is entered through the hopper, it is moved to the corrugated feed roller, which further moves the fodder, and finally, to the cutting head. A 290 x 219 x 12.85 mm rectangular-shaped cutting blade made of EN 31% material was used and mounted on a rectangular cutter head to cut the fodder into uniform small pieces by the action of impact and shearing, and at the same time it throws the final product outside the machine, which will be helpful for cattle. The overall dimensions, viz., length, width, and height of the power-operated chaff cutter, were 1575, 590, and 1200 mm, respectively. The average weight of a power-operated chaff cutter machine with and without a prime mover was measured at 188 and 140 kg, respectively. The schematic view and working chaff cutter are shown in figure 1. The detailed specifications of the chaff cutter assembly and feeding assembly of the power-operated chaff cutter are given in Tables 1 and 2, respectively.

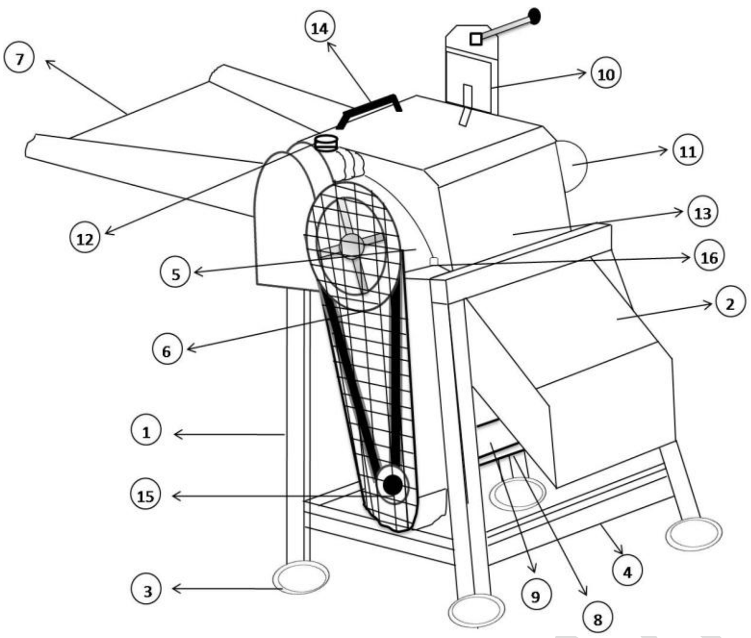

Fig.1:Schematic view of power operated chaff cutter (5HP 3 Phase, Electrical)

1. Main frame	7. Feeding hopper	13. Blade cover plate
2. Main outlet	8. Motor adjusting stud	14. Handle
3. Base plate	9. Motor	15. Small pulley
4. Body support	10. Starter	16. Pedicel
5. Large pulley cover	11. Main shaft drive gear cover	
6. Large pulley	12. Oil cap	

Fig.2: Working diagram of power operated chaff cutter

Table 1. Specification of chaff cutter assembly

Sl. No.	Particular	Specifications
1	**Power unit**	
	Type and Rating	3 Phase, 5 Hp electric motor, 1440 RPM
2	**Main power transmission**	
	Type	2 B-62V belt and pulley
	Reduction ratio	1:0.33
3	**Cutter head**	
	Number and Material	One and mild steel
	Size of cutter head, mm	290 X 219
4	**Blades**	
	Type and Number of blades	Rectangular shaped and three
	Dimension of blades, mm	296 X 46 X 8
	Material of blades	EN 31
5	**Shear Plate (Fixed edge)**	
	Number, size and Material	One, 300 X 48 X 8 and EN31

Table 2. Specification of feeding assembly

Sl. No.	Particular	Specifications
1	**Gear Box**	
	Number of gears, Type and Material	Five, Spur gear and Cast Iron
2	**Feed Rollers**	
	Number of Rollers, Material and Type	Two, Steel and Corrugated
	Length and Diameter of roller, mm	300, Φ 68.11
	Effective length of roller, mm	280
	Number of teeth on each roller	Six
	Size of roller shaft, mm	28 Φ x 507
	Speed feeding rollers corresponding to 1450 rpm of prime mover, rpm	57
3	**Feeding mechanism**	
	Type of feeding and Size of feeding trough, mm	Manual and 920 X 500
	Angle of inclination	25°

Evaluated for the assessment of the performance of a power-operated chaff cutter used for three crops, *viz.*, jowar (dry), maize, and sugarcane (wet), at the Farm Machinery Testing Centre (FMTC), College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka. The following methods of laboratory and field performance tests were followed for the assessment of the performance of chaff cutters.

2.2 Laboratory test of cutting blade

2.2.1 Hardness test

The Rockwell hardness tester utilizes the measurement of the surface hardness of the blade within a range of 35 to 50 HRC up to two thirds of the way from the tip of the beveled edge as per IS: 8811–98 (RA 2006). The hardness value shall not differ from the maximum hardness found in the same blade by more than 10 percent.

2.2.2.Chemical composition test

Determining the exact chemical composition of a cutting blade is extremely important to verify that a critical component is made from the correct metal. The chemical composition of metals can be measured by using an X-ray spectroscopy method or by mass spectrometry as per IS: 8811–98 (RA 2006). The measurement reports include the chemical composition of major alloying elements such as carbon, silicon, and manganese. Sulphur, phosphorus, and chromium are measured in terms of EN 31 (%).

2.2.3.Wear analysis

The measurement of the wear analysis of the cutting blade was done by marking three different point positions on the blade. The dimensions of the cutting blade were measured before and after 23 working hours of operation, as shown in figure 3. Also calculated on a weight basis were the initial weight of the blade before operation and the final weight after 23 working-hour operations.

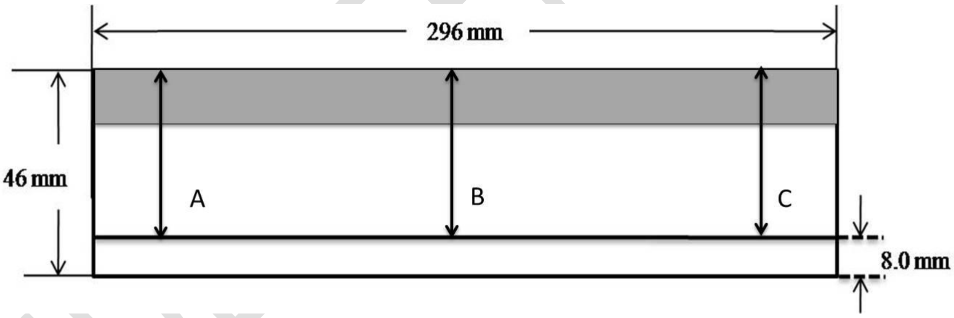

Fig.3:Notations are marked on cutting blade of chaff cutter

2.3.Performance test of power operated chaff cutter

The performance evaluation of the power-operated chaff cutter was carried out at no load and load conditions. The different test codes are referred to as IS: 11459-1985, IS: 7897-1975, and IS: 15542: 2005. The following methodology was followed for the assessment of the performance of a power-operated chaff cutter.

2.3.1.Test at no load conditions

The power-operated chaff cutter was placed on a zero-level ground surface. After that, the recommended clearance between the fixed and rotating blades was set, and other adjustments were made for the proper working of the chaff cutter.

2.3.2.Power consumption

A 3-phase, 5-HP electrical centrifugal motor was used to rotate the main axle of the cutter head shaft and feed roller through a double V belt and pulley system. For measurement of the power consumption by the chaff cutter using an energy meter connection with an electrical motor (Kankal *et al.,* 2016). A digital voltammeter and ammeter were also provided to measure the voltage and current consumed during operation. Also provided is a reverse/forward switch to change the direction of the electrical motor in an emergency or for safety purposes. A circuit diagram of the electric motor connection along with an energy meter, A/V digital meters, and reverse/forward switch is shown in figure 4.

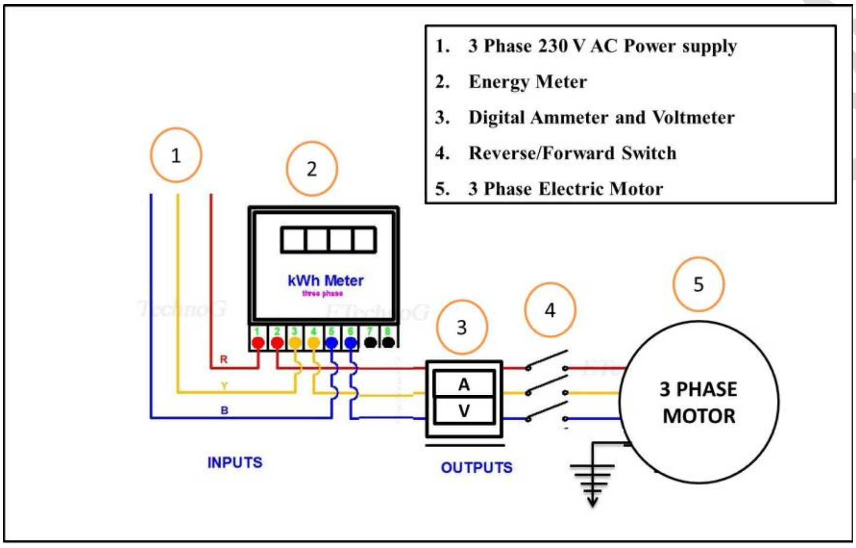

Fig.4:Electrical circuit system for power consumption measurement

2.3.3.Power at no load condition (kW)

After proper connection of the electrical motor with the energy meter, run the chaff cutter for 1 hour, and the total power consumed at no load was calculated by the following formula:

$$\boldsymbol{P_1 = \frac{60 \times (E_2 - E_1)}{1000 \times T_1}} \qquad \ldots 1$$

Where, P_1= Power at no load condition (kW), E_2= Final reading of the energy meter (Wh), E_1= Initial reading of the energy meter (Wh) and T_1= time of run (min).

2.3.4. Speed of prime mover, cylinder and feed roller

Use of a digital tachometer to keep at the tail end centre point of the prime mover, cutting blade cylinder, and feed roller shaft for measurement of different speeds in terms of revolutions per minute, as shown in figure 5.

Fig.5:Measurement of the speed of the prime mover, cylinder, and feed roller using a digital tachometer during no load and load conditions

2.3.5. Visual observations

After running for 1 hour at no load for power consumption measurement and under load condition testing, the observations were recorded in accordance with IS: 7897-1975.

2.3.5.1. Test at load condition

A sufficient quantity of jowar, maize, and sorghum fodder was taken to be cut. The average length and diameter of the fodders were measured using a digital scale meter, and the average moisture content of the fodders was measured using a digital moisture meter probe. The details of crop parameters are presented in Table 5. The duration of the operation was more than an hour. The starting and stopping times were recorded carefully. The starting time was noted when the fodder came into contact with the feed rolls. The performance of a power-operated chaff cutter in wet and dry conditions is shown in figures 6 and 7. The following methodology was followed for the assessment of the performance of the chaff cutter under load conditions:

Fig.6:Performance of a power-operated chaff cutter for wet and dry fodder

Fig.7:Performance of power operated chaff cutter

2.3.5.2. Feed rate of fodder

The jowar, maize, and sorghum fodder were made in bundle formation and kept near the feeding tray unit of the chaff cutter. The weight of the fodder bundles for continuous feeding was measured using a digital weighing machine, and the feed rate of fodder cut per hour of operation was calculated using the following formula:

$$W_1 = \frac{60 \times F}{T} \quad \ldots 2$$

Where, W_1= Feed rate of fodder (kg/h), F = measured the weight of fodder (kg) and T = duration of operation (h).

2.3.5.3. Theoretical length of cut

The theoretical length of the plastic pipe or fodder operation is calculated by using the following formula:

$$X = \frac{\pi \times D_f \times N_f}{N \times R} \quad \ldots 3$$

Where, D_f = diameter of feed rolls (mm), N_f= Feed roller speed (rpm), N = Flywheel/cutter head speed (rpm) and R = number of blades used

2.3.5.4. Standard deviation of length

Feeding of a two-meter length of rigid plastic pipe into the cutting unit and the standard deviation of the length of plastic pipe/fodder operation calculated by using the following formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(xt - x)^2}{n-1}} \quad \ldots 4$$

Where, xt = measured length of cut pieces (mm), i = serial number of cut pieces, (1, 2, 3…n), n = number of pieces plastic pipes taken and x = theoretical length of cut (mm)

2.3.5.5. Quality of cut

A better quality of cut means the least deviation of the measured length of cut from the theoretical length of cut. Practically, there would be some deviation because of feed interference. The quality of the cut was calculated using the following formula:

$$\boldsymbol{Q = (1 - \sigma)} \quad \ldots 5$$

Where, Q = Quality of work and σ = Standard deviation of length of cut

2.3.5.6. Quantity of cut

For calculating the quantity of fodder cut per hour of operation by using the following formula,

$$\boldsymbol{W_4 = \frac{60 \times A}{T}} \quad \ldots 6$$

Where, W_4= Quantity of cut (kg/h), A = Measured quantity of cut (kg), and T = duration of operation (h).

2.3.5.7. Power requirement

The power requirement of the chaff cutter was calculated by the following formula:

$$\boldsymbol{P_2 = \frac{60 \times (E_4 - E_3)}{1000 \times T_2}} \quad \ldots 7$$

Where, P_2= Total power consumed at load (kW), E_4= Final reading of the energy meter (Wh), E_3= Initial reading of the energy meter (Wh) and T_2= Time of run (min)

The power consumed by a power-operated chaff cutter was calculated by the following formula:

$$\boldsymbol{P_3 = P_2 - P_1} \quad \ldots 8$$

Where, P_3 = Power consumed by chaff cutter (kW), P_2 = Total power consumed at load (kW) and P_1 = Total power consumed at no load (kW)

2.3.5.8. Quantity per unit energy consumed

The following formula was used to calculate the quantity of cut per kilowatt hour of energy consumed:

$$\boldsymbol{W_5 = \frac{W_4}{P_3}} \quad \ldots 9$$

Where, W_5= Quantity of cut per unit energy consumed (kg/kWh), W_4= Quantity of cut (kg/h) and P_3 = Power consumed by chaff cutter (kW)

2.3.5.9. Corrected quantity of cut

To avoid the variation in moisture content of fodder and the length of cut, the quantity of cut shall be corrected at 0 percent moisture and 20 mm length of cut by the following formula:

$$\boldsymbol{W_6 = \frac{W_4(100 - M)}{100} \times \frac{20}{L}} \qquad ...10$$

Where, W_6 = Corrected quantity of cut (kg/h), W_4 = Quantity of cut (kg/h), M = Observed moisture (%) and L = Measured length of cut (mm)

2.3.5.10. Corrected quantity of cut

The corrected quantity of cut of chaff cutter was calculated by the following formula

$$\boldsymbol{W_7 = \frac{W_6}{P_3}} \qquad ...11$$

Where, W_7= Corrected quantity of cut (kg/kWh), W_6 = corrected quantity of cut (kg/h) and P_3= power consumed by chaff cutter (kW)

2.3.5.11. Performance index

For comparison of the performance of the chaff cutter, calculate the performance index using the following formula:

$$\boldsymbol{PI = \frac{W_4 \times Q}{P_3}} \qquad ...12$$

Where, PI= Performance index, W_4= Quantity of cut (kg/h) and P_3= Power consumed by chaff cutter (kW)

2.3.5.12. Efficiency

The efficiency of power-operated chaff was calculated by the following formula:

$$\boldsymbol{\eta = \frac{A_c}{T_c} \times 100} \qquad ...13$$

Where, η=Efficiency (%), A_c= Actual capacity (kg/h) and T_c= Theoretical capacity (kg/h)

3. Results and Discussion

The Performance evaluation of the power operated chaff cutter was operated under laboratory conditions and the test results were discussed in the following subheadings.

3.1.Hardness of cutting blade

A Rockwell hardness tester was used to measure the surface hardness of the cutting blade. The hardness of the blade was recorded at 54 HRC, against the requirement of 35–50 HRC as per IS: 8811–98 (RA 2006).

3.2. Chemical composition of cutting blade

The chemical composition of metals was measured by using an X-ray spectroscopy method or mass spectrometry, and the results are presented in Table 3.

Table 3. Chemical composition of cutting blade

Sr. No.	Element	EN 31 (%)	Observed	Confirmed to IS: 8811
1	Carbon	0.90-1.20	0.98	Confirmed
2	Silicon	0.10-0.35	0.28	Confirmed
3	Manganese	0.30-0.75	0.68	Confirmed
4	Sulphur	0.05 Max.	0.022	Confirmed
5	Phosphorus	0.05 Max.	0.015	Confirmed
6	Chromium	1.00-1.60	1.250	Confirmed

From Table 3, the chemical composition of the blade was confirmed to be IS: 8811–98 (RA 2006).

3.3. Wear analysis of cutting blade

The wear analysis of the chaff cutting blade was done for both mass and dimension basis methods. The weight and dimensions of the blade were measured before and after 23 working hours of operation of the chaff cutter, and the results are presented in Table 4.

Table 4. Wear analysis of cutting blade

A. On mass basis					
Sl. No.	**Notations**	**Initial mass blade (g)**	**Final mass of blade after 23.0 h of test (g)**	**Rate of wear (%)**	
				Total	**Per hour**
1	A	688	685	0.44	0.019
2	B	690	688	0.29	0.013
3	C	681	677	0.59	0.026
B. On dimensions basis					
Sl. No.	**Notation**	**Initial width (mm)**	**Final width of blade after 23.0 h (mm)**	**Rate of wear (%)**	
				Total	**Per hour**
1	A	46.1	45.6	1.08	0.047
2	B	45.4	45.0	0.88	0.038
3	C	46.2	45.9	0.65	0.028

From Table 4, the hourly rate of wear of blades on a mass basis and a dimensional basis was recorded as 0.013 to 0.026 and 0.028 to 0.047%, respectively. The hourly rate of blade wear is considered normal.

3.4. Performance test results of power operated chaff cutter at field condition

Three cops, viz., jowar (dry), maize, and sugar cane (wet) fodder, were selected to be evaluated for their measurement performance by a power-operated chaff cutter. Six trials were carried out, two on each crop fodder. The details of the physical parameters of the jowar, maize, and sorghum crops are shown in Table 5.

Table 5. Details of crop parameters results

Sr. No.	Parameter	Observation		
		Dry fodder	Wet fodder	
1	Name of fodder	Jowar	Maize	Sugarcane
2	Variety of fodder crop	PROAGRO-296	GANGA- II	VSI - 434
3	Average length of stalk, mm	1050 - 1100	1120 - 1280	1180 - 1310
4	Average diameter of stalk, mm	16.2 - 26.1	18.9 - 21.2	25.1 - 28.9
5	Average moisture content, %	10.1 - 11.3	79.2 - 81.7	71.2 - 73.4

3.5. Test at no load

The chaff cutter was operated for 1.0 hours at no load and recorded the power consumption and visual observations.

3.6. Speed of prime mover, cylinder and feed roller

A digital tachometer was used to measure the average speed of the prime mover, cutting blade cylinder, and feed roller shaft, which is presented in Table 6.

Table 6. Speed of prime mover, cylinder and feed roller during no load condition

Sl. No.	Parameters	Observations
1	Average prime mover speed, rpm	1497
2	Average cylinder speed, rpm	512
3	Average feed roller speed, rpm	57.76

From Table 6, the average speeds of the prime mover, cutting blade cylinder, and feed roller were found to be 1497, 512, and 57.76 rpm, respectively.

3.7. Power consumption

A power-operated chaff cutter was placed on a level and hard surface. The chaff cutter was attached to an electric motor. The average power consumption at no load conditions for the chaff cutter was recorded as 0.42 kWh.

3.8. Visual observations

The chaff cutter was operated at no load in accordance with IS 7897-1975. During the no load run, the visual observations against the following points were made and presented in Table 7.

Table 7. Results of visual observation during no load test condition

Sl. No.	Parameters	Observations
1	Presence of any marked oscillation during operation	Not observed
2	Presence of any knocking or rattling sound	Not observed
3	Frequent slippage of belt	Not observed
4	Smooth running of shafts in respective bearings.	Not observed
5	Any unusual wear or slackness in any components.	Not observed
6	Any marked rise in bearing temperature	Not observed
7	Stability of Chaff Cutter	Satisfactory

3.9. Test at load

Six short-run tests were carried out for cutting three fodder crops, viz., jowar (dry), maize, and sugarcane (wet). A summary of fodder crop parameters and performance test results of a power-operated chaff cutter is presented in Table 8.

Table 8. Summary of performance test results of power operated chaff cutter

Sr. No.	Parameter	Observation		
		Dry fodder	Wet fodder	
1	Name of fodder	Jowar	Maize	Sugarcane
2	Feed rate, kg h^{-1}	643 - 650	1744 – 1784	1837 - 1841
3	Quantity cut, kg h^{-1}	611 – 628	1700 – 1746	1791 - 1806
4	Quality of cut	0.38 - 0.42	0.41 - 0.43	0.42 - 0.43
5	Avg. length of fodder pieces, mm	13.71 - 14.1	15.7 - 16.6	15.2 - 16.1
6	Power consumption, kW	0.56 - 0.59	0.60 - 0.72	0.76 - 0.78
7	Specific energy requirement, kg kWh^{-1}	1081.3 - 1123.2	2450.0 - 2856.6	2316.6 - 2396.0
8	Corrected quantity of cut, kg h^{-1}	802.7 - 824.9	414.85 - 442.06	601.72 - 653.84
9	Corrected quantity of cut, kg kWh^{-1}	1360.5 - 1473.0	613.97 - 691.40	791.73 - 838.26
10	Performance Index	410.9 - 471.3	1004.5 - 1199.8	949.8 - 1006.34
11	Efficiency, %	95.0 – 96.6	97.48 – 97.87	97.50 – 98.10

From the above table 8, the average feed rate was observed as 629 to 638 and 1717 to 1821 kg h^{-1} for dry and wet fodder, respectively. Similarly, the quantity of cut fodder received was measured as 621 to 623 and 1710 to 1816 kg h^{-1} in dry and wet fodder, respectively. The corrected quantity of cut was recorded as 802.70 to 824.90 kg h^{-1} and 414.85 to 653.84 kg h^{-1} in dry and wet fodder, respectively. The specific energy requirement was recorded as 1081.3 to 1123.21 and 2450.0 to 2396.0 kg kWh^{-1} in dry and wet fodder, respectively. The corrected quantity of cut per unit of energy consumed was recorded as 1360.50 to 1473.0 and 613.97 to 838.26 kg kWh^{-1} in dry and wet fodder, respectively.

The quality of cut was determined from the standard deviation of the measured length of cut of plastic pieces, which ranged from 0.38 to 0.42 and 0.41 to 0.43 in dry and wet fodder, respectively. The power consumed by the chaff cutter was calculated after deducting the no-load power consumption of the chaff cutter from the consumption on load, and it was measured as 0.56 to 0.59 and 0.60 to 0.78 kW in dry and wet fodder, respectively.The overall performance of the chaff cutter was determined by the performance index, which was calculated as 410.91 to 471.37 and 1004.5 to 1006.34 in dry and wet fodder, respectively. The average efficiency was calculated, and it ranged from 95.02 to 96.62%, 97.48 to 97.87%, and 97.50 to 98.10% in dry and wet fodder, respectively.

The power-operated chaff cutter was operated for a long-run test. The total duration of 23.00 hours for cutting jowar (dry), maize, and sugarcane crops in both wet and dry conditions was done. No breakdown in the cutter head, feeding mechanism, transmission systems, or body of the chaff cutter was noticed. No repairs occurred during the entire course of the test.Three labourers were required for the continuous operation of the chaff cutter. Two labourers are required for feeding and supplying the fodder crop and one for handling the chaff. Most of the parameters of this machine confirm the requirements of IS 11459:1985 (reaffirmed 2012), IS 1511:1979 (reaffirmed 2012), and IS 15542:2005.

4. Conclusion

The overall performance of the power-operated chaff cutter machine was found satisfactory. The feed rate was found to be higher in wet maize and sugar cane crops due to the higher moisture content. The quantity of cut is higher in maize and sugar cane crops. The power consumption was found to be lower in dry sorghum crops. The quantity of cut per unit energy consumed and performance index is lower in dry jowar. Overall, from the study, it can be concluded that the performance of chaff cutters is better in high moisture-holding crops.

References

Anand T. Design and modal formulation of power operated chaff cutter. International Journal on Emerging Technologies (Special Issue on ICRIET-2016) 2016;7(2), 181-187.

Arif R, Theriault, Savoie P. Compost processing of agricultural residues. Journal of APPLIED Sciences Research, 1999;8(4), 445-450.

Barrinton GP, Berge OI,Finnor MF. Effect of using a re cutter in a cylinder type forage harvester for chopping low moisture grass silage. American Society of Agricultural Engineers., 1971;14 (2), 232-233.

Elfatih A, Arif EM, Atef AE. Evaluate the Modified Chopper for Rice StrawComposting. Journal of Applied Sciences Research, 2010;6(8), 1125-1131.

Anonymous - Specification for Power Operated Chaff Cutter (IS: 11459-2000)

Anonymous - Specification for blades for Manually Operated Chaff Cutter (IS: 1511-2000)

Anonymous - Power Operated Chaff Cutter - Safety Requirements (IS: 15542: 2005)

Anonymous - Test Code for Chaff Cutter (IS: 7897-2001)

Anonymous - Method for Emission Spectrometric Analysis of Plain Carbon and Low Alloy Steels Point to Plane Technique (IS: 8811 - 2006)

Ismail Fouad, Sayed-Ahmed, El-DesoukeyN, El-NagarAB. Development Of A Chopping Machine For Agriculture Residue (a Case Study on Grape Trashes), Agricultural mechanisation in Asia, Africa, and Latin America, 2009;40(1), 13-24.

Somvanshi SPS, Singh HP, Singh PP. Ethno-veterinary medicine plants for animal therapy in Madhya Pradesh, India: A Review, Society for Scientific Developmentin Agriculture and Technology, 2016;11(9),5699-5702

Kankal US, Karale DS, Khambalkar VP, Thakare SH. Performance evaluation of power chaff cutter, Engg. & Tech. in India, 2016;7(1), 2016 18-25.

Karunya1 M, Gowthami E, Rami Reddy, Pavani.Performance studies on power operated chaff cutter with paragrass (brachiariamutica), International Journal of Agricultural Science and Research, 2016;6(1), 105-112.

Kumar P, Nag A, Drudgery P. Accidents and Injuries in Indian Agriculture Industrial Health, 2004;42 (3), 149– 162.

Marey SA, Drees AM, Sayed-AhmedIF, El-Keway AA. Development a feeding mechanism of chopper for chopping sugarcane bagasse.Misr J. Ag. Eng., 2007;24(2), 299-317.

MetwalliSitkeiG. Effect of moisture content on the performance of mechanical methods for cutting and chopping cotton stalks. Agricultural mechanisation in Asia, Africa, and Latin America, 1995;20(4), 25-29.

Mohan D, Kumar A. Development of safer fodder-cutter machines: a case study from north India. Safety Sci. 2004;42(1), 43-55.