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RESEARCH ARTICLE

Performance evaluation of power chaff cutter

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ABSTRACT

The ever increasing energy demand, unemployment in developing countries like India, Increased awareness of people towards the health are some of the driving forces for the development of powered machines. The experimentation has been carried out on a fodder cutter energized by electrical power. Fodder-cutter machines are used every day by farmers and their families in India for preparation of fodder for the livestock they own. This paper discus about the procedure of the testing of fodder cutter machine.

KEY WORDS : Chaff cutter, Performance, Load condition, Power consumption, Fodder

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INTRODUCTION

Nutrition is the foundation of a livestock production system and proper nutrition is imperative for achieving high and sustained livestock productivity. The success of animal reproduction and health programme rests on proper nutrition. The cutting of crop resides into small pieces then feeding to the cattle, increases the consumption and palatability of feed, hence reducing the wastage.

Animal feeding is very important aspect of livestock husbandry. It is very necessary to have effective utilization of available feed sources. Chaff is hay cut into small pieces for feeding to livestock (Mohan and Kumar, 2004); it is a good fodder, and at its best is cleanly and evenly cut, free of dust, of good colour and with a fresh aroma. Chaff can be purchased from commercial chaff cutting mills (Wikipedia, 2009). Cutting chaff can be done by manually operated machine and electric operated one, As far as cutting by manually operated machine is concerned. Traditionally for the operator it is done manually which is physically demanding through it energy and postural requirements and is commonly regarded as source of drudgery (Kumar *et al.*, 2004); many farmers associated with this task reported back, shoulder and wrist discomfort. It may also cause clinical or anatomical disorders and may affect worker's health. By considering the above constraints in chaff cutting machine it is necessary to introduce the power operated chaff cutter looking to the shortage of labour, drudgery involved in manually operated chaff cutter operation. By keeping above facts in to the consideration present investigation has been made an attempt to study the performance evaluation of power operated chaff cutter.

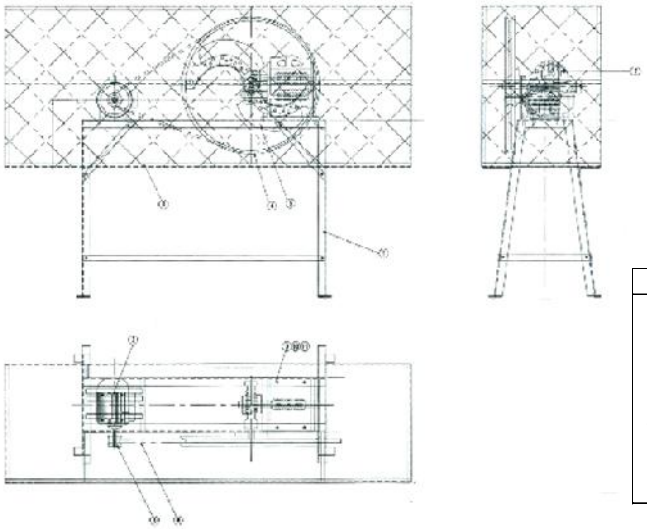
EXPERIMENTAL PROCEDURE

The power operated chaff cuter evaluated for the assessment the performance at Department of Farm Power and

Table A : Details specification of power operated chaff cutter

Sr. No.	Particular	Specifications
1.	**Chaff cutter assembly**	
	Power unit:	
	Type and rating	Single Phase, AC induction motor , 1 hp, 1440 rpm
	Mass , kg	28.8
	Size of mounting base, mm	300x275
2.	**Main power transmission**	
	Type	V belt and Pulley
	Size of motor pulley, mm	Outer 100 φ, inner 80 φ
	Size of fly-wheel pulley, mm	780 φ (thickness-28 mm)
	Type and size of belt	V belt, B-103 (single belt)
	Reduction ratio	1:0.128
3.	**Cutter head:**	
	Fly Wheel:	
	Diameter of fly wheel, mm	780
	Size of 'S' shape for mounting blade, mm	840 (curved length)x 60 (width) and 10(thickness)
	No. and size of holes on the 'S"	3 ; 12.5 φ (For each blade)
	Mass of fly wheel, kg	15.5
4.	**Blades**	
	Type and Number of blades	Two rotating and One fixed blades and 2
	Material of blades	High Carbon Steel
	Method of mounting	Each blade is mounted on as 'S' shaped sitting of flywheel by three nut and bolts of size 3/8" , (sunk headed)
5.	**Shear plate (fixed edge):**	
	Number and Size, mm	One and 219x120x10 (L x B x T)
6.	Feeding assembly:	
7.	Main shaft:	
	Material and dimensions, mm	Cast Iron and 410 x 32 φ
8.	**Gear box**	
	Type	Warm and pinion gear
	Number of worms gear and Number of pinion gear	1 and 2
	Details of worm:	
	Type	Constant mesh spur gear
	No. and depth of teeth, mm	2 and 13 mm
	Details of pinion:	
	Number of teeth on each gear	15
	Pitch, mm	18.7
9.	**Feed rollers:**	
	Number of rollers and types	Two and toothed types
	Length and diameter of roller, mm	205 and 85 φ (upper) and 205x84 φ (Lower)
	Effective length of roller, mm	190 (upper): 190 (Lower)
	No. of teeth on each roller and their configuration	72(8x9 rows) (upper)& 80 (8x10 rows) (lower)
	Type of teeth and pitch, mm	Triangular and 300
	Size of roller shaft, mm	285x25x25 (upper): 425x25x25(lower)
	No. and type of shaft bearing	Two, CI bushes (for each shaft)
	Space between the axes of upper and lower roller shaft, mm	100
	Minimum and maximum, mm	100 and 150
	Speed of feeding rollers corresponding to 1400 rpm of the prime-mover, rpm	6
10.	**Feeding mechanism**	
	Type of feeding	Manual, Chute feed
	Size of feeding trough, mm	595 x 325/200 (front/rear)x110.5/50.5(front/rear) (Length x Width x Depth)
	Height from ground level, mm	997 at rear end and 105 at front end
11.	**Overall dimensions, mm**	
	Length	1200
	Width	925
	Height	1400
	Mass with prime-mover	104.79

Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The details functional components of chaff cutter are chaff cutter assembly, power transmission, fly wheel, blades, shear plate, feeding assembly, feed rollers, feeding mechanism and stand. The Various view of chaff cutter are shown in Fig. A. Details specification of power chaff cutter is given in Table A.



Sr. No.	Name of part	Sr. No.	Name of part
1.	Main frame	7.	Net frame
2.	Head	8.	V belt
3.	Motor	9.	Hexagonal bolt
4.	Fly wheel	10.	Hexagonal nut
5.	Blade	11.	Washer
6.	Motor pulley		

Fig. A : View of power operated chaff cutter

Performance test :

Chaff cutter was tested at no load and on load condition while these test following methodology followed for the assessment of the performance of the power chaff cutter. For the evaluation of the performance of the chaff cutter different test codes referred such as IS: 11459-1985, IS: 7897-1975 and IS: 15542: 2005.

Test at no load conditions:

Power consumption:

The chaff cutter was fixing on firmly on level and preferably hard surface. Then set the clearance between rotating and fixed blade and made other adjustments for proper working of the chaff cutter. After proper functioning of the chaff cutter was attach to an electric motor as shown in the circuit diagram given in Fig. B. The attachment of cutter head with motor done by connecting the motor with the help of flat or V-belt and pulleys with the main axle of the cutter head. The allowances for V-belt drive losses was taken as 8 per cent as per the IS: 7897 (1975).

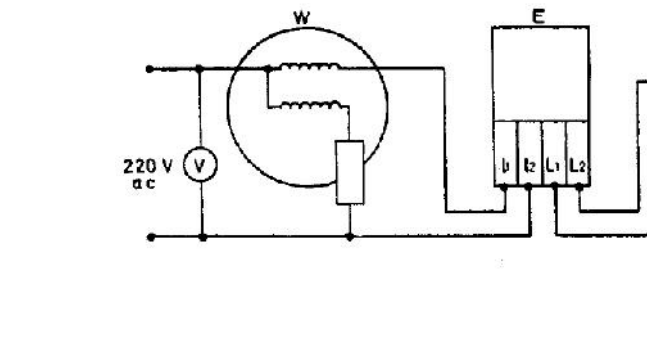


Fig. B : Circuit diagram

V = Voltmeter, 0-300 V, ac moving iron type
E = Energymeter, 3 ampere, single phase, 1600 rev/kWh
W = Wattmeter, 0-230 V, Single phase, dynamometer type
CON= 1.5 kW Speed Controller
M = dc motor shunt wound, 1.5 kW, 220 V
A = Ammeter, 0-10 A

After making of proper connection the motor coupled with chaff cutter and run for about 30 minutes. Then the following parameter was recorded.

- Resistance of the winding of the motor (R ohms),
- Initial reading of the energy meter (El watt-hour),
- Final reading of the energy meter (E_2 watt-hour), and
- Time of run (T_1 minutes).

Then the total power at no load condition (P_1) was calculated by the following formula.

$$\mathbf{P} = \frac{\mathbf{60\,(E_2 - E_1)}}{\mathbf{1000\,T_1}}\ \mathbf{kW}$$

where,
E_2= final reading of the energymeter, watthour
E_1= initial reading of the energymeter, watthour
T_1= time of run, min

Visual observations:

During and after completing power consumption test the observations were recorded and as given in Table 2.

Test at load condition :

Short run tests:

The Chaff cutter was installed as given above procedure. The sufficient quantity of fodder was taken to be cut from the same variety of crop free from roots. The length of the fodder was selected as far as possible be of the same size. The moisture content of the fodder should be, as far as possible to be in the range of 75 to 85 per cent. The fodder was piled near the feeding tray in bundle formation. The mass of the bundles for continuous feeding was calculated by following formula

$$\mathbf{W_3 = 4 \times D}$$

where,
W_3 = mass of the bundle in g, and
D = effective width of the feed roller in mm

Then the chaff cuter operated the cutter head at the speed specified and feed the fodder manually ensure that the feeding is done continuously and covers full width and height of the throat. The feeding was done from root side of the fodder. While feeding, rigid plastic pipe of diameter approximately equal to the diameter of the fodder stalk and 2 meters in length was fed along with the fodder. The duration of the operation was taken for more than 1 hour. The starting and stopping time was recorded carefully. The starting time was noted when the fodder comes in contact with feed rolls.

Parameters taken in consideration of the chaff cutter performance and calculated by the following formulae.

Quality of cut:

Better quality of cut means least deviation of measured length of cut from the theoretical length of cut. But practically there would be some deviation because of feed interference. For getting proper measured length 25 cut pieces selected of plastic pipes and then measure the length of each piece and calculate the quality of work by the following formulae:

$$Q = (1-\pm)$$

where,

Q = quality of work and

σ= standared deviation of length of cut

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_t - x)^2}{n-1}}$$

where,

n = number of pieces plastic pipes taken,

x_t = measured length of cut pieces in mm

x = theoretical length of cut in mm and

i = serial number of cut pieces, (1,2,3……n)

$$x = \frac{\pi D_i N_1}{NR}$$

Where,

D_i = diameter of feed rolls in mm

N_1 = rev/min of feed rolls

N = rev/min of flywheel or cutter head, and

R = mumber of blads used

Quantity of cut :

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

$$W_4 = \frac{60A}{T}$$

where,

W_4 = quantity of cut in kg/h,

A = measured the quantity of cut in kg in T min

T = duration of operation in min

Power requirement:

The power requirement of the chaff cutter was calculated by the following formulae giving due allowances to the type of drive

$$P_2 = \frac{60(E_4 - E_3)}{1000T}$$

where,

P_2 = total power consumed at load in kW

E_4 = final reading of the energymeter in watthour

E_3 = initial reading of the energymeter in watthour

T= duration of operations in min

$$P_3 = P_2 - P_1$$

where,

P_3 = power consumed by chaff cutter in kW

P_2 = total power consumed at load in kW

P_1= total power consumed at no load in kW

Quantity per unit energy consumed :

To calculated the quantity of cut in per kilowatt hour energy consumed (WS) the following formula was used.

$$W_5 = \frac{W_4}{P_2}$$

Corrected quantity of cut:

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

$$W_6 = \left[\frac{W_4\,(100 - M)}{100}\right]\frac{20}{L}$$

where,

W_6 = corrected quantity of cut in kg/h,

W_4 = quantity of cut in kg/h,

M = observed moisture per cent and

L = measured length of cut in mm

$$W_7 = \frac{W_6}{P_3}$$

where,

W_7 = corrected quantity of cut in kg/kWh

Performance index:

For comparison of performance of the chaff cutter, calculate the performance index (PI) by the following formula:

$$PI = \frac{(W_4 \times Q)}{P_3}$$

where,

W_4 = quantity of cut in kg/h,

Q = quantity of work,

P_3 = power consumed by chaff cutter in kW

EXPERIMENTAL FINDINGS AND ANALYSIS

The power operated chaff cutter was evaluated for their measurement performance at Deptt. of Farm Power and Machinery, Dr. PDKV, Akola. The test trials has been carried out at Dairy and Animal Husbandry Department, Dr. PDKV, Akola.

Performance test :

There were four trials were conducted out of which two trials on dry sorghum and two on ginni grass. The details physical parameter of crop and ginni grass are shown in Table 1.

Test at no load:

The chaff cutter was operated for 1.0 hour at No Load and recorded the power consumption and visual observations.

Power consumption:

Chaff cutter was fix firmly on level and hard surface and essential adjustment was made. Chaff cutter was attached to an electric motor as per test code IS: 7897-1975. The No Load power consumption of chaff cutter was recorded as 0.92 kWh.

Visual observations:

During the No Load test, the observations against the following points were made in Table 1.

Table 1 : No load test

Sr. No.	Parameters	Observations
1.	Presence of any marked oscillation during operation	Not found
2.	Presence of knocking or rattling sound	Not found
3.	Frequent slippage of belts	Not found
4.	Smooth running of shaft/shafts in their respective bearings	Not found
5.	Any marked unusual wear or slackness in any component	Not found
6.	Any marked rise in bearing temperature	Not found
7.	Stability of Chaff Cutter	Satisfactory
8.	Other observations	Not noticed

Short run test:

The details of fodder crop parameters and observations made during the test are given in Table 2.

Table 2 : Performance test results of power operated chaff cutter

Sr. No.	Parameters	Test trials			
		I	II	I	II
1.	Name of the crop	Dry Sorgum		Ginni	
2.	Moisture content of fodder ,%	19.15	19.28	34.41	34.81
3.	Avg. length of stalk, cm	252.8	247	256.5	268.75
4.	Avg. dia. of stalks, mm	11.4	9.8	6.44	8.33
5.	Duration of test, h	1.0	1.0	1.0	1.0
6.	Feed rate, kg/h	179.9	181.03	310.38	308.45
7.	Quantity of cut, kg/h	177.00	177.51	304.47	302.32
8.	Quality of cut	0.832	0.827	0.821	0.820
9.	Range of length fodder pieces, mm	8.3-20.2	7.8 -19.8	5.54-18.8	5.7-19.1
10.	Avg. length of fodder pieces, mm	10.8	12	9.90	11.88
11.	Variation in length of plastic cut pieces, %	2.81	3.02	2.54	2.71
12.	Power consumed by chaff cutter ,kW	1.15	1.19	1.03	1.08
13.	Qty. of cut per unit energy consumed, kg/kWh	153.91	149.16	295.60	279.92
14.	Corrected qty. of cut, kg/h	155.95	143.29	237.36	195.23
15.	Corrected qty. of cut, kg/kWh	135.60	120.04	230.45	180.77
16.	Performance index	128.85	122.3	242.68	229.53

Table 3 : Wear of chaff cutter blade on mass basis

Sr. No.	Notation	Initial wt.(g)	Final wt. after 25.0 h of test (g)	% wear	Wear rate (%)
1	Blade	997	986.5	1.053	0.042

Quantity of cut:

The average feed rate was observed as 180.46 kg/hr for dry Sorgum crop and 276.65 for ginni crop respectively. Average quantity of cut was observed 177.25 kg/hr for dry Sorgum and 268.30 for ginni crop. The average quantity of cut per unit energy consumed was found to be 151.53 kg/kWh for dry Sorgum crop and for 287.76 kg/kWh, respectively.

Quality of cut:

The quality of cut was determined from the deviation of measured length of cut from length of cut. The quality of cut was 0.83 for harvested dry sorgum crop and 0.84 for ginni crop.

Power requirement:

The power consumed by chaff cutter was measured at a time of load test and found to be 1.17kWh for dry Sorghum crop and 1.05 kWh for ginni crop.

Long run test:

The power chaff cutter was operated for total duration of 25 hr during the operation of chaff cutter, no breakdown in the cutter head, feeding mechanism, transmission system and other part of chaff cutter was noticed.

Labour requirement:

Two labour are required for operation of chaff cutter one for feeding a fodder crop and one for handling cut materials

Wear of chaff cutter blade :

Wear analysis carried out of chaff cutter blade on mass basis after 25 h operation of chaff cutter. The hourly rate of wear of chaff cutter blade was found 0.042 per cent

Conclusion :

Form the trials of power operated chaff cutter the following conclusions could be drawn

– The feed rate was found higher in ginni crop as compared to dry Sorghum due higher moisture content.
– The quantity of cut is more in ginni crop than dry sorghum.
– The power consumption was found minimum ginni crop than dry sorghum.
– Qty. of cut per unit energy consumed less in dry sorghum as compared with ginni fodder crop.
– The performance index was also found more in ginni crop than dry sorghum crop.
– Over all from the study it can concluded that the performance of chaff cutter is better in high moisture holding crop.

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