Design and Evaluation of Portable Compound Cattle Feed Pelleting Machine for Farm-level Feed Production

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Imbalanced nutrition, besides shortage of feed is one of the major factors responsible for low livestock productivity in conventional feeding. But, as time elapsed, there has been gradual shift from traditional pattern to compounded cattle feed (CCF), either in mash or pellet forms. The pellet form is the most preferred form of CCF among other due to its various advantages. In India, compound feeds are produced at industrial level and there is about 57% of gap between demand and supply. Any disruption in trade may cause cattle pellets expensive and unaffordable for the average dairy farmer. Feed pellet production at farm level by using locally available feed resources (which are within easy reach of the farmers and at low cost) is an alternative to the high cost feed pellet available in the market. The feed pelleting machines available in the market are expensive and individuals are unable to own them. Considering this, an attempt was made to design and develop the portable feed pelleting machine for farm level compound cattle feed pellet production. The physical properties of the feed mixture (viz. particle size, moisture content, bulk density, coefficient of friction and angle of repose) were determined and used/considered for design of feed pelleting machine wherever found necessary. The developed feed pelleting machine consists of the die plate, die shaft, pelleting chamber, press rolls, clearance adjustment mechanism, hopper, V-belt and pulley drive mechanism, electric motor and main frame. The outcome from evaluation of the pelleting machine has demonstrated a pelleting efficiency of 91.40%. The prototype feed pelleting machine produced a throughput capacity of up to 55 kg/h and pelleting capacity of 54 kg/h.

Keywords: Compounded cattle feed, Development, Pelleting capacity, Portable Pelletizer, Throughput capacity

Introduction

Global annual ruminants feed production is estimated to be 213.3 million metric tons[1] (including alone 131.2 million metric tons of dairy animals feed) and out of which 31% is produced domestically by local traders.[2] Global commercial feed manufacturing generated an estimated annual turnover of over USD 460 billion[2] in 2014 and grew by a strong overall 3 per cent.[1] The industry continues to expand in volume and value in response to increases in world population, urbanization and growing consumer purchasing power.

The Asia-Pacific region is home to several of the top-10 feed-producing countries, including China, India and Japan. China maintains its hold as the global leader in feed production and India stood at 2nd with 34.2 million metric ton after China in Asia-Pacific.[1] India witnessed 7% growth in the feed production, among the countries of Asia-Pacific region (Table 1).

Owing to largest livestock population in the world, India accounts for about 57.3% of the world's buffalo population and 14.7% of the cattle population[4] and total number of workers involved in animal husbandry is 20.5 million (according to NSSO 66th round survey). Most of them are marginal, small and semi-medium operational holdings farmers (< 4 ha) and agricultural labourers who own about 87.7% of the milch animals and dairying is an important source of

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Table 1 — Global top 7 leading feed producer in 2017
(*Source*: Global Feed Survey-2018)[3]

Sl. No.	Country	Number of mill	Feed production, million tons	% growth
1	China	6000	186.9	-0.4
2	USA	6241	173	2
3	Brazil	1572	69.9	1
4	Russia	569	37.6	19
5	Mexico	501	34.4	2
6	India	1201	34.2	7
7	Spain	845	33	2

subsidiary income to them. Overall contribution of livestock sector in total GDP is nearly 4.11% at current prices.[5]

Cattle feeding practices are very traditional and the most of the feed comes from grazing. Imbalanced nutrition, besides shortage of feed is one of the major factors responsible for low livestock productivity in traditional feeding practices. But, as time elapsed, there has been gradual shift from the age-old traditional pattern to Compounded Cattle Feed (CCF).[6] In this respect, the technology for making Densified Total Mixed Ration Blocks or Pellets based on straw, stover and oilseed meals is an innovative approach. The feeding of total mixed rations has also been shown to have several advantages such as decrease in feed loss, higher nutrient availability and higher animal performance over feeding ingredients separately[7,8], which is conventionally practised in many countries. As far as the experts are concerned, pellet form is the most preferred form of CCF with specified advantages like balanced diet, convenience to use and better yield.[9]

With one of the highest livestock population, India's cattle feed industry is not really tapping the entire potential of manufacturing feed for its animals even though it stood globally at 6th position for its annual feed production[1]. Thus, India has remained in chronic deficit of feed and milch animals have been traditionally underfed. The estimates of demand and supply of feeds by Department of Animal Husbandry, Dairying & Fisheries, Govt. of India, is 53 Mt and 29 Mt (57% gap), respectively.[5,10] Most of the feed pellets are being produced at industrial scale in all regions.[11] Any disruption in trade or increase/extreme volatility in cost of produced cattle pellets could be expensive and unaffordable for the average dairy farmer[12], thus lower productivity of dairy animals. Besides these, both price and quality together of the feed available in market affects the buyer decision by 38.88% among the price, convenience, availability and quality of feed.[13] Hence, there is a need for the country to enlarge indigenous feed resource base and rely more on locally available feed resources and their efficient use to produce cattle feed at low cost with quality preferred by the users.[9,12] Although the major essential raw materials required for the formulation of complete feeds from the locally available feed resources are within easy reach of the farmers and at low cost, but the major limiting factor to take the full advantage is the lack of available appropriate equipment to convert the identified raw materials into the required feeds.[14]

To meet the demand of dairy farmers at both commercial and subsistence level, the use of portable, readily affordable feed pelleting machines becomes necessary. Thus, the objective of this study was to design and develop portable feed pelleting machine and evaluate its performance in terms of its throughput capacity, pelleting capacity, pelleting efficiency and unit pellets cost, to test its suitability for individual dairy farmers.

Materials and Methods

Design and Development of Portable Feed Pelletizer

The pelleting machines are broadly categorized as screw extruder type and roller - die type.[15] The roller-die type (driven die with roller type design) is the most commonly recommended pelleting machine for animal feed production.[16] The pelleting chamber (consists of die plate, die shaft and rollers), hopper, pellet outlet, drive mechanism, speed reduction unit, power source, bearings and necessary controls, main frame are the major components of the roller-die type pelletizers.[14,17]

Determination of Physical Properties of the Feed Mixture

Before began design and development of feed pelleting machine, the determination of feed mixture's physical properties (viz., particle size, moisture content, bulk density, coefficient of friction and angle of repose) becomes necessary as they affects the design of portable feed pelletizer.[18,19]

The feed mixture used for physical properties determination consists of maize (50%), groundnut cake exponent (20.86%), gram-chuni (12.07%), wheat bran (14.03%), mineral mixture (2.00%) and salt (1.00%). Physical properties determined were as follows.

Particle size is an important feedstock variable which influences the quality of densified pellets and briquettes.[20] Studies have demonstrated that agriculture biomasses are usually ground to reduce particle sizes so as to increase the surface area, to produce denser pellets and enhance the pelleting capacity. As for the National Dairy Development Board (NDDB), Anand, Gujarat, India, for the compound cattle feed production, the different feed ingredients must be mixed to required proportions and mixed rations are then ground into uniform particle size of ≤ 3 mm. In this study, to ensure the particle size of the ground mixture, the ANSI/ASAE Standard

Method S319.3 (ASABE Standards 2008) was performed by sieving with screen size of 3 mm. The average maximum size of feed mixture particles recorded was 2.17 mm (Table 2).

The *moisture content* is crucial as it affects the physico-chemical and stability of the pellets.[21] The density, angle of repose and coefficient of friction of feed mixture rely on the moisture content of feed mixture and is very essential to know the right moisture content of the raw feed mixture which helps in moistening the feed mixture while pelleting. ASAE Standard was followed for moisture content determination of feed mixture. The measured mean initial moisture content of feed mixture was 9.60% (Table 2).

Bulk density is the mass per unit volume of the material. Fig. 1 (A) shows a container of known mass and volume, loosely filled with feed mixture to measure bulk density. Mixture was poured into the container from a height of 15 cm to facilitate the free flowing of the samples until the container was overflowed. By striking a straight edge across the top, the excess material was removed.[22] The weight of the material with the container was recorded. The net weight of the sample was obtained by subtracting the weight of the empty container. Bulk density was calculated by dividing the mass over the container volume.[23,24] From Table 2, the recorded average value of bulk density, 426.00 kg/m³ can be seen. This bulk density was used to determine the volume of hopper of the pelleting machine.

One critical factor that influences efficiency and motion of surfaces in contact is friction and heat generated between particles in motion caused by friction increases power requirement. In order to choose magnitude of power source for portable feed pelleting machine, one must know the *coefficient of friction* that feed mixture experience over SS material. Hence, coefficient of friction of feed mixture was measured using coefficient of friction apparatus (Fig. 1 (B)), which consisted of a frictionless pulley fitted on a frame, a bottomless square container of negligible weight, loading pan and test surfaces. The experiment was performed on test surface of stainless steel with feed mixture of different moisture content. The measured mean value of coefficient of friction (Table 2) was 0.25. The coefficient of friction measured as follows[22] was used to determine the
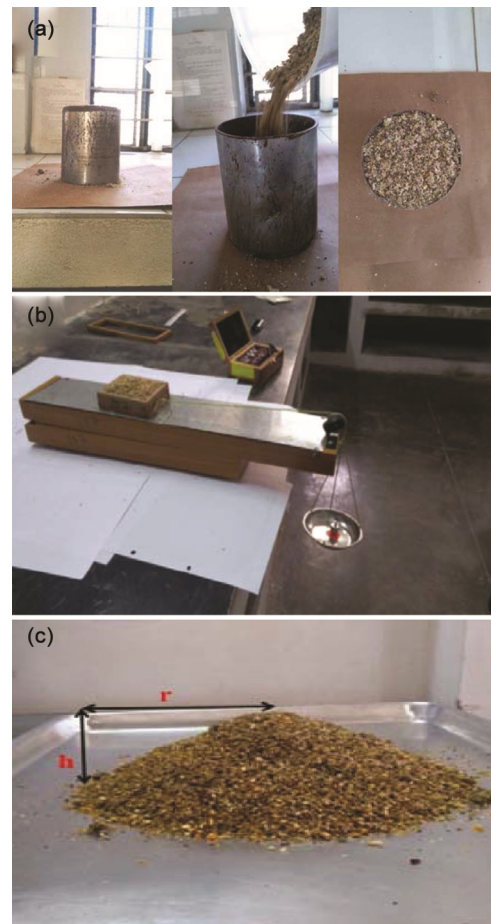

Fig. 1 — Measurement of physical properties of feed mixture (*A*: bulk density; *B*: coefficient of friction and *C*: angle of repose)

Table 2 — Physical properties of feed mixture

Sl. No.	Particle size, mm	Moisture content (w.b.), %	Bulk density, kg/m³	Coefficient of friction	Angle of repose, degree
				10% MC	40% MC
1	2.10	9.65	426.00	0.25	36.12
2	1.80	10.30	422.00	0.22	35.37
3	2.2	9.22	431.00	0.28	36.00
4	2.30	9.40	420.00	0.24	36.35
5	2.60	9.28	433.00	0.25	35.50
6	2.00	9.75	424.00	0.26	35.00
Avg.	2.17	9.60	426.00	0.25	35.72
SD	0.27	0.40	5.10	0.02	0.51
CV	12.61	4.17	1.20	7.62	1.44

thickness of die-plate and power required for the pelleting machine as well.

The coefficient of static friction, $\mu = \dfrac{F_2 - F_1}{N}$ … (1)

where, F_1 = Force to cause the sliding of empty container, N; F_2 = Force to cause the sliding of filled container, N and N = Weight of the sample, N.

When a granular product is dumped through a circular opening on a level horizontal surface, the product takes a shape of inverted cone. The angle between the horizontal and inclination of heap is called the natural *angle of repose*[25] and it range from $0°$ to $90°$.[26] The angle of repose is an indicator of the product's ability to flow and was determined (Fig. 1 (C)) as follows for given feed mixture. The average value of $35.72°$ was recorded and same was used in pelleting machine hopper design.

Angle of reposes $= \tan^{-1}\left(\dfrac{h}{r}\right)$ … (2)

where, r = radius of heap (mm) $= \dfrac{\text{perimeter of heap}}{2\pi}$ and h = height of heap, mm.

Design Criteria

Thereafter determination of feed mixture's physical and engineering properties, criteria were established for the portable feed pelleting machine based on available information from past work and pellets quality requirements. The machine should:

i) Have capacity of 50 kg/h or above, be movable and easy to transport anywhere.

ii) Be adaptable for wide range of ingredients to produce pellets and should have high pelleting efficiency.

iii) Total cost and daily service requirement of machines should be such that an individuals can afford it and as low as possible respectively.

Machine Components

The feeding unit (hopper), pelleting chamber (die-plate and press-roller encased in cylindrical chamber), pellet discharging and power transmission unit with accompanying frame combined together forms a rotating die and roller type portable pelleting machine. Feeding of thoroughly mixed ground feed ingredients to the pelleting machine was achieved manually. Feed mixture was extruded through die plate to form pellets while passing between the flat-die and press roller. A small knife to cut the pelleted feed as they formed was also provided beneath the die

plate. The clearance between the die and the press roller was kept to 0.5 mm, with provision for adjustment if required. The un-pelleted feed, if any, are separated from pelleted feeds within the pelletizer (through perforated screen which screens the pellets from un-pelleted feed, before it is discharged) and were used for re-feeding. Some assumptions were made from past work done on the pelleting machines design and are quoated wherever needed while designing of machine components hereafter.

Feeding Unit

Feeding unit (Fig. 2(A)) was designed to feed the mixture to the pelleting chamber. The feeding unit consists of inverted truncated cone, gravity flow type hopper. The hopper volume of the pelleting machine is the function of pelleting capacity, bulk density of feed and number of loading of the
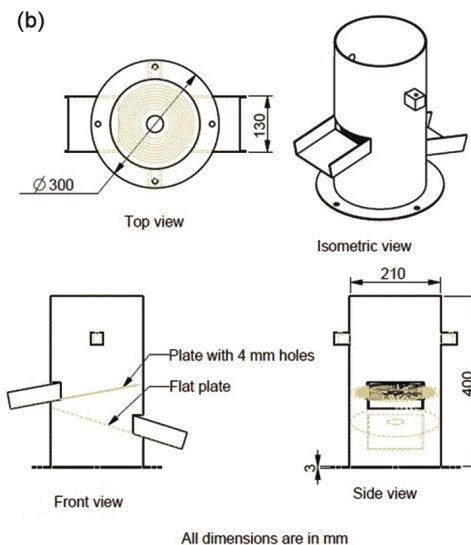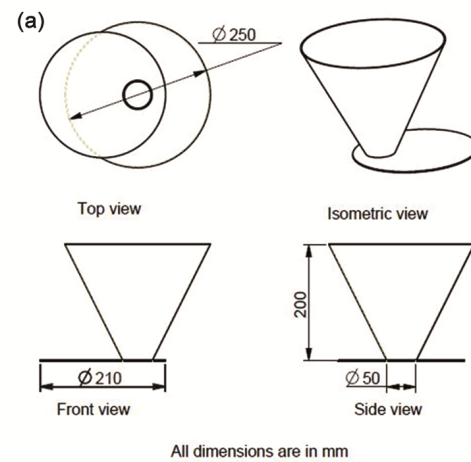

Fig. 2 — Schematic diagram: (A) Feeding hopper and (B) Pelleting chamber

machine. The hopper volume and its top radius were calculated as follows.[27] The 2 mm thickness truncated cone shaped hopper with 200 mm height and 250 mm diameter (hopper top) was made using stainless steel (SS). The bottom diameter of the hopper was kept to 50 mm.

$$V_h = \frac{C_p}{\rho \times l_t} \qquad \dots (3)$$

$$r = \sqrt{\frac{V_h \times 3}{\pi \times h}} \qquad \dots (4)$$

where, V_h = hopper volume, m³; C_p = pelleting capacity, kg/h (was taken as 50 kg/h); ρ= bulk density of the materials, kg/m³; l_t = number of loading /h (was taken as 30); r = radius of hopper, m and h = height of the hopper, m (taken as 0.20 m).

Pelleting Chamber

The pelleting chamber is the hollow cylinder which houses the die plate, press-rollers, clearance adjustment mechanism (between die plate-roller), pellet cutting knife, perforated pellet separator plate & pelleted and un-pelleted feed outlets (Fig. 2(B)). The die plate is considered as the heart of the pelleting machine. The die plate selection is a function of quality & production rate and die speed (rpm) is a function of the feeds to be pelleted. The diameter and thickness of die plate was determined as follows.[17]

$$D_d = \frac{V_d \times 60}{\pi \times N_d} \qquad \dots (5)$$

$$t = \mu \times D_d \times \sqrt{\frac{P}{\sigma_t}} \qquad \dots (6)$$

where, D_d = diameter of die, mm; V_d = velocity of die, taken as 6 m/sec[28]; N_d = speed of die, taken as 600 rpm[29]; t = thickness of die, mm; μ = coefficient of friction between the stainless steel (SS-304) and the material; P = extruding pressure intensity, taken as 2 N/mm² [30] and σ_t = allowable design stress, (the allowable design stress is assumed to be 5 times of extruding pressure intensity), N/mm².

The die plate was made from SS-304 of 200 mm diameter and 23 mm thickness. It was provided with number of 10 mm diameter holes on it (as shown in Fig. 3(A)), hence length to diameter ratio of these holes was kept 2.3. The feed mixture was forced to pass through these holes by a pair of press rolls (cylindrical rollers with rough outer surfaces) to form pellets by extrusion. This plate was then placed on

keyed die shaft and bolted. The diameter, speed and velocity of the roller were calculated as follows.[17]

$$D_R = \frac{D_d}{VR} \qquad \dots (7)$$

$$N_R = N_d \times VR \qquad \dots (8)$$

$$V_R = \frac{\pi \times D_R \times N_R}{60} \qquad \dots (9)$$

where, D_R = diameter of roller, mm; N_R = speed of roller, rpm; VR = velocity ratio between roller and die, taken as 2.5[14] and V_R= velocity of the roller, m/s.

Two SS press rollers of each 100 mm diameter and 65 mm length were placed on the 20 mm diameter, 270 mm length shaft (as shown in Fig. 3(B)) with ball bearings to enable rollers to rotate freely on shaft and the desired clearance (0.5 mm) between the rollers and the die plate were maintained by lifting or forcing the rollers against the die plate through clearance adjustment mechanism which consists of blunt edged bolts (provided at outer two sides of the chamber wherein roller shaft projects out from the chamber), screwed through fixed nut has to cause roller shaft to
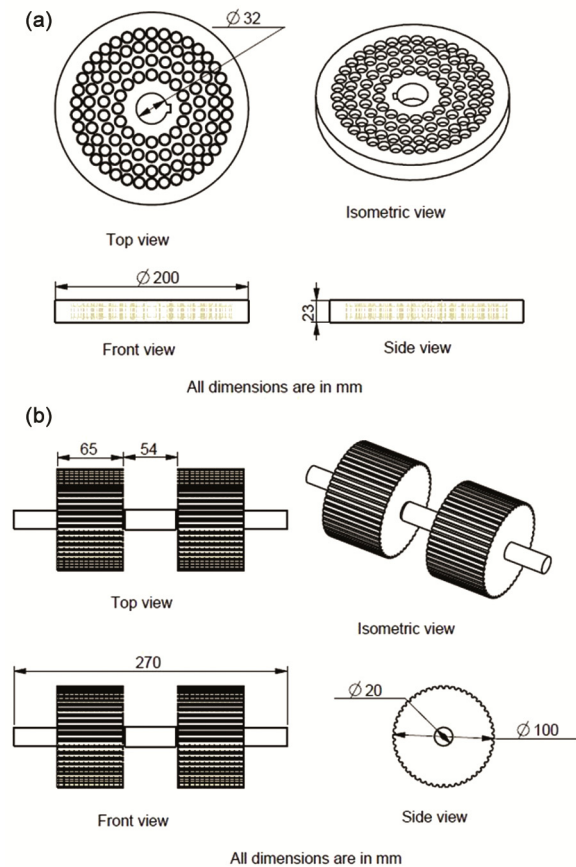

Fig. 3 — Schematic diagram: (A) Die plate and (B) Press rollers

lift or force against the die plate (as shown in Fig. 6 & 7(A)).

The pelleting chamber wall should have sufficient clearance from the die plate to allow it to rotate freely; hence its diameter was kept to 10 mm larger than the die plate diameter (200 mm) and length to 400 mm and was placed on the platform (as shown in Fig. 4(A)). This in turn is bolted to the main frame as shown in Fig. 6 & Fig. 7(A). The whole weight of the pelleting chamber was transferred to the main frame through platform. A small sharpened knife to cut the pellets formed as they reach 25 mm of length, was also provided just beneath the die-plate at 25 mm apart in the chamber. The pellet outlet was placed underneath the knife, and inclined perforated plate screens the pellets from un-pelleted feed and directs them towards the outlet. The un-pelleted feed then gets collected at outlet below the pellet outlet and can be used for re-feeding.

Power Source and Drive System

The power required by the pelletizer for pelleting mainly comes from the extruding deformation area

(a)

Top view

Isometric view

Front view

Side view

All dimensions are in mm

(b)

Top view

Isometric view

Front view

Side view

All dimensions are in mm

Fig. 4 — Schematic diagram: (A) Pelleting chamber flat form and (B) Die shaft

and the extruding formation area.[28] The selection of motor for power supply to the pelleting machine depends on the choice of capacity, motor type (2 or 3 phase), voltage, speed, and so on.[31] It is found from Gemco (2016)[(32)] that the electric motor of 2.2 to 7.5 kW is required for the pelleting capacity of up to 80 to 120 kg/h. In this study, the power required by the pelletizer was calculated as follows.[17]

$$P_p = \frac{V_R \times F_R}{1000} \qquad \qquad \ldots (10)$$

$$F_R = \mu \times P \times A \qquad \qquad \ldots (11)$$

where, P_p = power required by the pelletizer, kW; V_R = roller velocity, m/sec; F_R = force acting on the roller, N; μ = coefficient of friction between the stainless steel (SS 304) and the feed material; A = extruding area, mm^2 (or area of the roller causing shear of the material) and it was taken as 1/10th of the die plate area, i.e.

$$A = \frac{\pi \times D_d^2}{4} \times 0.1$$

A 3 phase AC motor of 2 hp, 950 rpm with 2 way on-off switch was used as power source. In this pelletizer, the power was given to die plate rather than press rolls through die shaft. The diameter of the shaft was calculated as follows.[33]

$$d^3 = \frac{16 \times 30}{\pi \times N \times 10^{-3}} \times \frac{H}{\tau_d} \qquad \qquad \ldots (12)$$

where, d = diameter of shaft, mm; N = rpm of shaft, rpm; H = power transmitted by the shaft, W and τ_d = permissible shearing stress of shaft, taken as 4.9 MPa.[33]

A circular shaft (made of SS) of 38 mm diameter and 460 mm length (Fig. 4(B)) was used to transmit power from motor to pelleting unit through belt-pulley mechanism. Diameter of shaft from both the ends was reduced to 32 mm for a length of 50 mm. The length of the pelleting chamber was considered for length of the shaft. The one end of the die shaft was connected to the die plate and other end to the V-sheave pulley which in turn was coupled with another pulley (on motor shaft) by V-belt drive mechanism. A variable frequency drive was used during initial testing to drive the pelletizer at different speed in order to decide the range of operational speed and size of pulleys was determined accordingly. Diameter of the pulley placed on die shaft and length of the belt were determined by calculating as Eq. 13
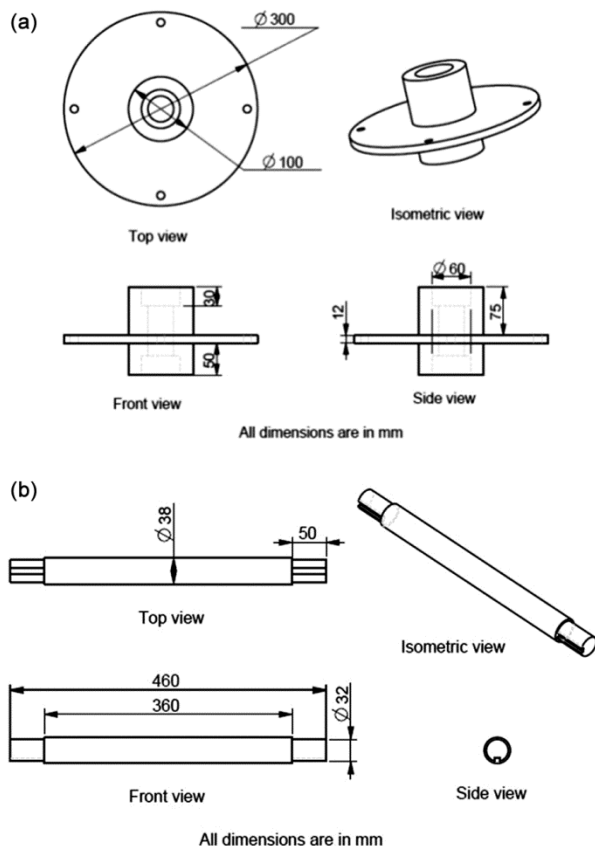
and 14. A 75 mm diameter pulley on motor shaft was kept constant and diameter of the die plate shaft was changed accordingly to the speed required. The power to be transmitted by the belt and its length were considered for the selection of belt.

$$D_2 = \frac{N_1 \times D_1}{N_2} \qquad \ldots (13)$$

$$L = 2c + \frac{\pi}{2}(D_2 + D_1) + \frac{(D_2 - D_1)}{4c} \qquad \ldots (14)$$

where, N_1 = speeds of motor shaft, rpm; N_2 = speed of pelletizer shaft, rpm; D_1 = diameters of motor pulley, mm; D_2 = diameters of pelletizer shaft pulley, mm; L = length of belt, mm; and c = distance between centre of pulleys, mm.

Main Frame

The main frame, which provides rigid support and space for the electric motor and pelleting unit, was fabricated by using square MS (mild steel) pipe. The width, length and height of main frame for pelleting machine were based on the geometry of pelleting chamber and motor. A rectangular frame (length and width of 600 mm and 300 mm respectively) was made (Fig. 5) with 3 mm thickness square MS pipes (50 × 50 mm). The height of frame was 450 mm at one end and 585 mm at other end (where motor was mounted). The provision was given to frame for lateral/vertical

adjustment of motor with pelleting unit. Four legs of the frame were also provided with lockable transport wheel to make this developed machine portable. The complete assembled schematic diagram of portable compound cattle feed pelleting machine is shown in Fig. 6.
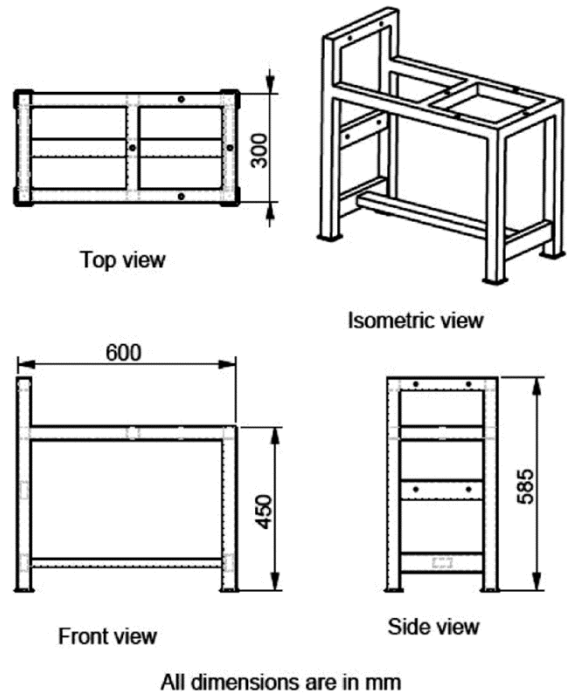

All dimensions are in mm

Fig. 5 — Schematic diagram of the main frame

1. Feed hopper
2. Pelleting chamber
3. Die plate-roller clearance adjustment mechanism
4. Pelleted feed outlet
5. Non-pelleted powder outlet
6. Main frame
7. Die plate shaft pulley
8. Electric motor
9. Motor on-off switch
10. Motor shaft pulley
11. Transport wheels
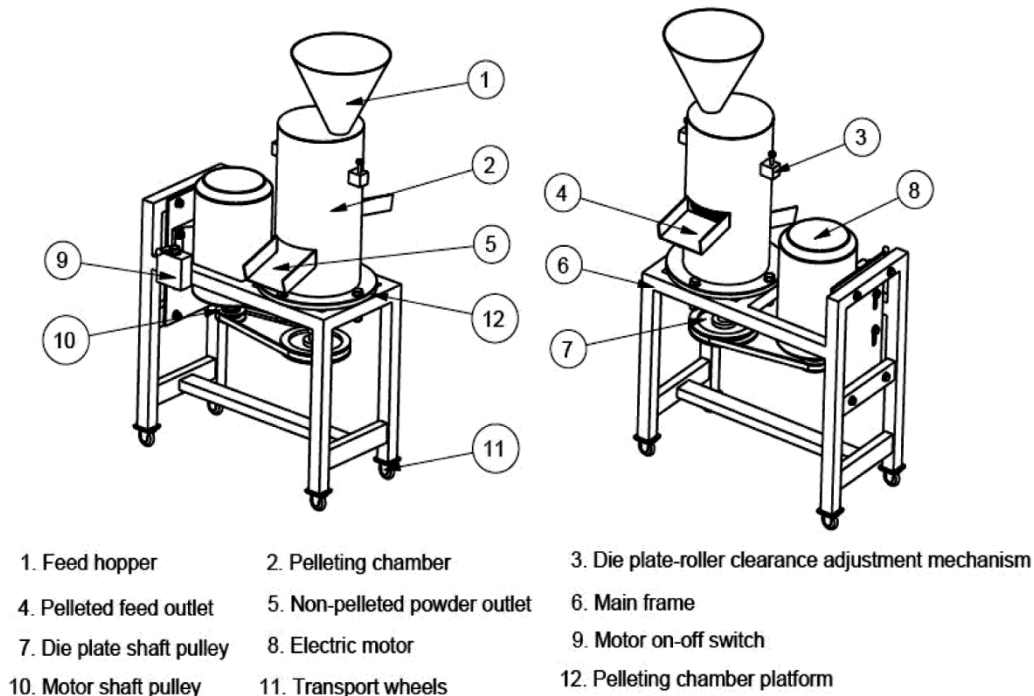12. Pelleting chamber platform

Fig. 6 — Isometric view of the complete portable feed pelleting machine

Testing and Evaluation of Cattle Feed Pelletizer

The performance test of feed pelleting machine (Fig. 7) was carried out to assess its pelleting capacity and pelleting efficiency at different feed mixtures moisture content and speed of die plate. Prior to start of actual experiments, the feed mixture were prepared and moisturized to a desired selected level and kept aside for a while (about 15–20 minutes) before fed into pelleting machine in order to facilitate nearly uniform moisture content within the ingredients. The type and their proportion of feed mixture ingredients used for pelleting were same as mentioned elsewhere in this article while physical properties measurement. The experiment was conducted at the Maharana Pratap University of Agriculture and Technology, CTAE campus, Udaipur.

Evaluation of Pelleting Capacity of Pelletizer

The pelleting capacity of machine was assessed as throughput capacity and pelleting capacity. The former represents the ratio of total mass of input to the time taken by pelleting machine[27] and the later one indicates the ratio of the quantity of actual feed pelleted to the time taken by pelleting machine to pelletize the specified feed.[9]

Fig. 7 — (A) Performance evaluation of developed feed pelleting machine; (B) 23 mm length and 10 mm Dia feed pellets produced

The throughput capacity and pelleting capacity were calculated as given in Eq. 15 and 16 for three different die plate speeds and three feed mixture moisture content. The speed of the die was changed by changing size of the pulley on die shaft, and the moisture content of the feed mixture was varied by adding calculated amount of moisture to bring it to desired level.

$$TC = \frac{W_i}{T} \qquad \qquad \dots (15)$$

$$PC = \frac{W_p}{T} \qquad \qquad \dots (16)$$

where, TC = throughput capacity, kg/h; W_i = weight of the input feeds, kg; T = time taken, h; PC = pelleting capacity, kg/h; W_p = weight of pellets collected, kg.

Evaluation of Pelleting Efficiency of Pelletizer

Pelleting efficiency is the ratio of quantity of actual feed pellets obtained at the main pellet outlet to the total feed input for a given unit time.[9] The feed mixture retained in pelleting chamber was manually removed and weighed at the end of every experiment. The quantity of feed pelleted as well as retained, in comparison with the total mass of feed mixture fed to pelletizer, was used to calculate pelleting efficiency of the pelletizer. Efficiency of the pelleting machine was determined using the following equation.

$$PE = \frac{W_p}{W_m} \times 100 \qquad \qquad \dots (17)$$

where, PE = pelleting efficiency, per cent; W_p = quantity of actual feed pelleted, kg and W_m = total feed mass input, kg.

Results and Discussion

The pelleting machine produced a throughput capacity of up to 55 kg/h, ranging from 43.18 to 55.27 kg/h and pelleting capacity of up to 54 kg/h, ranging from 42.38 to 54.04 kg/h (Table 3) depending

Table 3 — Throughput capacity, pelleting capacity and efficiency of pelleting machine at different die speed and input feed moisture content

Die speed (rpm)	Feed moisture content (%)	Throughput capacity (kg/h)	Pelleting capacity (kg/h)	Pelleting efficiency (%)
407	25	43.18	42.38	90.18
	30	50.54	49.70	91.11
	35	52.38	51.51	91.23
475	25	44.52	43.65	91.40
	30	52.40	51.45	89.03
	35	53.83	52.88	89.32
570	25	44.21	43.40	91.34
	30	52.02	51.07	88.90
	35	55.27	54.04	89.13

on the moisture content of feed and die speed. The variation in throughput and pelleting capacity for varied moisture content of input feed mixture was statistically significant at 1% level, and highest throughput and pelleting capacity were achieved at feed mixture moisture content of 35% and die plate speed of 475 rpm. The lowest moisture content of feed mixture produced the lowest throughput and pelleting capacity and was significantly different from a moisture content of 35% and 1% level. A feed mixture moisture content of 35% gave optimum combination of throughput (55.27 kg/h) and pelleting (54.04 kg/h) capacity. Feed mixture at higher moisture content, as is pressed by press roller extruded at faster rate may be the fact behind this higher throughput and pelleting capacity at 35% moisture content. These results are in accordance with the results of Romallosa & Cabarles (2011); Aremu *et al*. (2014).[14,27] It was also observed while pelleting that the un-pelleted feed material received at the un-pelleted feed outlet was higher at lower feed moisture content, that too at higher die speed and was found only at the beginning of the each trail.

The pelleting machine had maximum efficiency of 91.40% at feed moisture content of 30% and die-plate speed of 475 rpm (Table 3). However, differences in pelleting efficiency among different die-plate speeds were not statistically significant at 1% level. The possible reason for highest efficiency at 30% moisture content was that the less amount of input material retained in the pelleting chamber unless pelleted, but also due to sufficient wetness that feed mixture had to hold the particles each other and did not let them separated after pelleting. Most of the inefficiencies (un-pelleted feed) resulted from feed being retained in the chamber, which demonstrated the need to further investigate pelleting chamber design. The efficiency of pelleting machine was decreased as working length of machine decrease, though the feed rate was maintained constant. Chikwado (2013)[34] reported similar results and concluded that the machine performance (efficiency) can be increased if quantity to be pelleted per test is more. It was due to the fact that the amount of input material retained in the chamber was independent of duration of working.

The produced pellets were compared with the pellets available in the market in terms of their nutritional value (crude fat and crude protein), and found superior (higher by 1.52% and 3.76% respectively) than the pellets available in market and within the limits of standard (BIS). The price per unit mass of pellets produced was also less (by about 2.5 INR/kg) against the commercially available pellets.

Conclusions

The feed pellets available in the market are unaffordable for the small and medium dairy farmers, thus reduces productivity of dairy animals in India. The feed pellets produced traditionally/domestically will be superior to the feed pellets available in the market in terms of both price and quality as are produced by locally available feed ingredients. But producing feed pellets traditionally at low cost is a challenging task unless a simple low cost pelleting machine is available for the same (as feed pelleting machines available commercially are expensive and unaffordable by individual dairy farmers). In this regard, a portable feed pelleting machine was designed and developed for cattle feed production. The outcome from the development and evaluation of the pelleting machine has demonstrated a pelleting efficiency of 91.40%. The prototype feed pelleting machine produced a throughput capacity of up to 55 kg/h and pelleting capacity of 54 kg/h. The pelleting capacity and the efficiency of the machine can be increased by minor modification on the die-plate to facilitate unblocked and reduced friction for the feed material. Further modification of power unit and drive system for provision of IC engine instead of electric motor is essential to increase its utility in rural area especially in remote area where continuity of electricity is an issue. Overall this study has demonstrated that it is possible to significantly reduce the dependency on commercially available high cost feed pellets, as the produced feed pellets are lower in cost (around 2.5 INR/kg) with superior nutritional quality as compared to commercially available feed pellets.

Reference

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