

Energy consumption pattern in manufacturing of different types of broiler feeds

V. P. Sakthivel¹, P.Vasan^{2*} and C. Kathirvelan³

Department of Animal Nutrition
Veterinary College and Research Institute
Tamil Nadu Veterinary and Animal Sciences University
Namakkal, Tamil Nadu, India

ABSTRACT

The present study was carried out to determine the specific energy consumption pattern in the manufacturing of different type of broiler feeds with different process conditions and thereby analyze the gaps between the benchmarking and actual energy usage pattern. The study was conducted in three commercial feed plants located at different locations. This was achieved by conducting energy analysis for the specific energy consumption for different type of the broiler feeds. The actual consumption was recorded from the electricity board department's energy meter readings. The results indicated that the gap between actual consumption and benchmarking was lesser at one plant whilst, it was considerably higher at other two plants. The gap was observed to be higher in the pre-starter feed and lesser in the finisher pellet feed. The gap between actual power consumption and benchmarking observed for pre-starter feeds at different locations viz., Muzaffarpur, Kanpur and Ambala was 2.70, 2.43 and 0.85 kwh units respectively. The gap analysis for starter feed was 1.71, 1.46 and 0.59 kwh units and for finisher feed 1.37, 1.81 and 0.92 kwh units respectively. The cost saving per metric tonne of feed ranged from Rs. 16.00 to Rs. 22.00. Among the three feed manufacturing plants, the gap between benchmarking and actual power consumption was very minimal at Ambala plant due to better production efficiency. From the boiler's fuel cost point of view, coal was found to be cheaper than wood due to its high calorific value and hence it was suggested to replace fire wood with coal at Ambala plant for further improvement of fuel efficiency. The present findings also revealed that the timely replacement of press roller of pellet mill and reduction in pellet fines recycling leads to better efficiency and cost control.

Key words: energy efficiency, boiler fuel, coal, wood, fuel efficiency

INTRODUCTION

Feed milling industry is one of the most energy consuming industries in the world. Like capital, labor and materials, energy is also one of the major production factors which are used to produce final product. In economical terms, energy

is demand-derived goods and can be regarded as intermediate good whose demand depends on the demand of final product. Electricity is the main energy source for these feed mills which is imported from the state electricity board grids. Electricity is

¹PG Diploma scholar

^{2*}Professor, Corresponding author Email: drpvasan@yahoo.com

³Assistant Professor

used to run motors, pumps, blowers, conveyors, fans, lights, etc. The variations in the consumption rate of energy through the use of utilities during processing must also be accounted for final cost of the finished product. The feed milling consumes significant quantity of fuels and electricity. The major energy consuming equipments in the feed milling units are; pellet mill, hammer mill, boiler and steam distribution units, blowers, pumps, conveyers, elevators, motors, transmission systems, weighing, etc. Energy, its utilization and conservation, may be the greatest challenge facing management in the feed industry today and in the years ahead. All forms of energy are increasing in cost and diminishing in supply; yet effective energy management, or conservation, can reduce the cost impact and make better use of available energy supplies. As energy is used more effectively, product costs can be reduced and profits improved.

Energy is one of the most critical input resources in the manufacturing industries. In most cases, energy cost outweighs the costs of other resources such as raw material, labors, depreciation and maintenance (Fadare, 2003). Energy is one of the most important material bases for the economic growth and social development of a country or region. Scientific forecasts and analysis of energy consumption will be of great importance for the planning of energy strategies and policies. Nowadays, energy usage in agriculture has been intensified in response to continued growth of human population, tendency for an overall improved standard of living and limited supply of arable land; thus, the farmers use their inputs in excess and inefficiently, particularly when the inputs have low price or are available in plenty. The enhancement of energy efficiency not only helps in improving competitiveness through cost reduction, but also results in minimized energy-related environmental pollution, thus positively contributing towards sustainable development (Kizilaslan, 2009 and Ghorbaniet. al., 2010).

Improvement of energy efficiency in our facility improves the bottom line; increases productivity and market competitiveness; lessens the impact and protects the business from fluctuations in energy prices and reduces carbon emission and stay ahead of government regulations.

Though, wide variety of technologies has been evolved for efficient use of energy for various equipments of feed mills, so far, only a few have improved their energy efficiency levels. Most of the feed mills use old and locally available technologies and are also completely dependent on locally available technical personnel. In this pretext the present investigation was carried out at three different commercial feed mills located at Muzaffarpur (Bihar), Ambala (Haryana) and Kanpur (UP) to determine energy consumption pattern during different stages of feed manufacturing process for each type of feed viz., pre-starter, starter and finisher feed with different type boilers and work out the economic impact of energy utilization on feed production.

MATERIALS AND METHODS

The determination of the energy consumption in manufacturing of different types of broiler feeds (crumbs and pellets), was the main target of this study. This was achieved by determining the energy consumed in each stage of processing to assess the most consumable stage in the different types of feed. The bench marking study is done for specific energy consumptions of major sections in the feed milling process viz., intake, batching & grinding, pelleting and boiler and other utilities.

Energy benchmarking for industry is a process in which the energy performance of an individual plant or an entire sector of similar plants is compared against a common metric that represents 'standard' or 'optimal' performance. As a benchmarking standard "Specific Energy Consumption" energy analysis was conducted by

measuring running amps of the individual motor load. Load factor of each motor is calculated. From the input Volts and measured current (amps), individual motor power consumption unit has been calculated. The benchmarking energy analysis was studied for all of three plants for different types of feeds of prestarter, starter and finisher feeds. Actual energy consumption data was taken from the electricity meter installed in the feed mill.

Methodology Used

Electrical power consumption was estimated from the measured electric current and voltage values and estimated according to Kurt (1979) as follows from equation:

The amount electricity (kwh) used to produce one tonne of feed (kwh/T) is calculated as follows as specific energy consumption of the individual motor by using the following formula :

$$\text{Power (kwh)} = \frac{A \times \text{voltage} \times \sqrt{3} \times \text{power factor}}{1000} \quad \text{MT/ Hour}$$

(power factor has been taken as 0.95)

Specific energy consumption in terms of kwh \ MT of feed was calculated for Pre-Starter, Starter and Finisher feed and the benchmarking data has been arrived under standard process conditions. The specific energy consumption bench mark data was compared with the actual energy consumption data which were being recorded from energy meter installed by the electricity department.

Method of Motor Load measurement

To estimate the motor load factor power measurement was carried out in induction motor as a part of work during the detailed energy studies. The power measurements were used to calculate the actual load factor of induction motor at site conditions. The power measurements were done

with the help of a Class 1 accuracy clamp-on power meter.

Actual power consumption was arrived from the data collected from the EB meter installed at the respective plants and it was calculated as per MT of prestarter, starter and finisher feed.

Boiler Fuel Consumption

Coal is being used for the boilers located at Muzaffarpur and Kanpur and wood is used at the Ambala plant's boiler unit. Fuel usage per MT of feed was calculated from the daily consumption record.

$$\text{Fuel Consumption per MT of feed} = \frac{\text{Total Consumption in Kgs}}{\text{Qty of feed produced in MT}}$$

Table 1. Technical specifications of boiler unit at three feed plants

S.No.	Particular	Details		
		Muzaffarpur	Kanpur	Ambala
1	Firm Name	Ugraya foods and feeds pvt. Ltd.	Prime avian feeds pvt. Ltd.	Ugraya foods and feeds pvt. Ltd.
2	Type of Boiler	Horizontal Multi Tubular Fully Wet back Three pass smoke tube Boiler	Horizontal Multi Tubular Fully Wet back Three pass smoke tube Boiler	Horizontal Multi Tubular Fully Wet back Three pass smoke tube Boiler

3	Design, Fabrication	IBR 1950 with latest Amendments. inspection & testing code	IBR 1950 with latest Amendments. inspection & testing code	IBR 1950 with latest Amendments. inspection & testing code
4	Model	IFB-20D -THERMAX MAKE	IFB-10D -THERMAX MAKE	IFB-10D -THERMAX MAKE
5	Evaporation Capacity	2000 Kg/hr (F&A 100°C)	1000 Kg/hr (F&A 100°C)	1000 Kg/hr (F&A 100°C)
6	Max. Working Pressure	10.54 Kg/cm ² (g) (Safety valve set off)	10.54 Kg/cm ² (g) (Safety valve set off)	10.54 Kg/cm ² (g) (Safety valve set off)
7	Efficiency	72%	72%	72%
8	Fuel	Coal	Coal	wood
9	Gross Calorific Value	3500 kCal/kg	4500 kcal/kg	4500 kCal/kg
10	Mode of combustion	Mechanical Draught	Mechanical Draught	Mechanical Draught
	Type of feeding	Manually through fire door	Manually through fire door	Manually through fire door

RESULTS AND DISCUSSION

The process condition under which energy consumption study was conducted is given in Table 2. The pelleting process conditions are different from one another at each plant. Conditioner design is different from one another at all of the three plants and the moisture addition is maintained in the range of 2.0- 2.5% by adjusting steam flow valves. Different hole diameter and thickness of the die has been used at all the three plants. It has been observed that there is variance in the electrical consumption at all the three plants.

The comparative details of benchmarking of specific energy consumption analysis per MT of feed of pre-starter crumbs (PSC), starter crumbs (SC) and finisher pellet (FP), produced at muzaffarpur, kanpur and ambala respectively are depicted in Table 3. The specific energy

consumption benchmarking analysis was done for the different processes such as intake, batching and grinding, pelleting, boiler and other utilities. From the individual process study values, total power consumption in kwh units were calculated. The actual power consumption units were calculated from the energy meter's initial and final readings. From the total benchmarking and actual power consumption data, the gaps were identified. The gap between benchmarking and actual observed was more at muzaffarpur plant and lesser gap was observed at ambala plant. The electrical energy utilization efficiency was found to be better at ambala plant and less efficient at muzaffarpur plant, followed by kanpur plant. Overall, high cost impact per MT of feed was observed at Kanpur due to high power cost. The potential cost saving per month by considering average production volume at respective plants has been calculated as Rs. 79,459 at muzaffarpur, Rs. 21,091 at kanpur and Rs. 17,158 at ambala.

Table 2. Process design Variables

S.No	Pelleting Variables	Plant		
		Ambala	Kanpur	Muzaffarpur
1	Ground Particle Size passing on 0.71mm (%)	65-70	65-70	65-70
2	Moisture Addition at Conditioner (%)	2.0	2.5	2.0
3	Added Fat (%)	0.5 -0.9	0.5 -0.9	0.5 -0.9
4	Steam Pipe Size from Boiler (NB)	40	40	50
5	Die Hole diameter (mm)	3.2	2.8	3
5	Pellet Die L/D Ratio	01:10.5	1:12	1:13
6	Die Material	Chrome	Chrome	Chrome
7	Retention Time at Conditioner (Seconds)	10	15	30
8	Conditioner Type	Two Stage	Single	Two Stage
9	Moisture Addition at the Conditioner (%)	2.00- 2.5	1.8-2.2	2.0- 2.5
10	Conditioner Length (mt)	2.0	3.0	2.5
11	Retention time (Seconds)	20	10	30
12	Steam Pressure (Kg/cm ²) at PRV	2.5	2.5	2.5

The boiler fuel consumption pattern is presented in Table 4. Fuel consumption quantity per MT of feed was calculated from the boiler operators log book. The fuel consumption usage per MT of feed was arrived. Coal was used as a fuel at two boilers at Muzaffarpur and Kanpur and fire wood was used at Ambala. From the fuel consumption volume and actual fuel price, the fuel cost per MT of feed was calculated as Rs 94.15 at Ambala, Rs 73.98 at Kanpur and Rs 88.57 at Muzaffarpur. Coal has been identified as cheaper source of fuel as compared to firewood and up to Rs 20 can be saved per MT of feed, if coal is used as a fuel.

Table 3. Data on boiler design and operation for three different feed plants

S.No	Description	Plant Locations		
		Ambala	Kanpur	Muzaffarpur
1	Make	Thermax	Thermax	Thermax
2	Model. No	IFB-10D	IFB-10D	IFB-20D
3	Efficiency (%)	73	73	78
3	No of Passes	Three	Three	Three
4	Steam Generation Capacity (Kgs/ Hr)	1000	1000	2000
5	Year of installation	2012	2014	2013
6	Design Pressure (Kg/cm ²)	10.54	10.54	10.54
7	Max Working Steam Pressure (Kg/cm ²)	10.5	10.5	10.5

8	Operational Pressure (Kgs/cm ²)	8.5	9	8.5
6	ID (Induced Draft Fan)	Available	Available	Available
7	FD (Forced Draft Fan)	Available	Available	Available
8	Water Pre heater	Available	Available	Available
10	Fuel Type Used	Wood	Coal	Coal
11	Net Calorific Value (Kcal /kg)	3500	4500	4500
12	Production per hour (MT)	10	10	20
13	Fuel Consumption (Kgs) /Hr	207.13	82.2	208.4
14	Fuel Consumption (Kgs) / MT of feed	18.83	8.22	10.42
15	Fuel Cost per kg (Rs)	5	9	8.5
16	Fuel cost per MT of feed (Rs)	94.15	73.98	88.57

Table 4. Data on Electricity Consumption Analysis - Benchmarking of specific energy consumption Vs Actual Consumption Units

S. NO	Particulars	Muzaffarpur			KANPUR			Ambala		
		PSC	SC	FP	PSC	SC	FP	PSC	SC	FP
1	Intake Bench Marking Units (kwh)	1.75	1.75	1.75	1.36	1.36	1.36	1.11	1.11	1.11
2	Batching & Grinding Bench marking units (kwh)	9.25	9.25	9.25	7.23	7.23	7.23	7.68	7.68	7.68
3	Pelleting bench marking units (kwh)	20.14	18.13	15.47	20.54	20.5	17.46	18.2	16.5	15.17
4	Boiler & other utilities benchmarking units (kwh)	1.16	1.16	1.16	1.44	1.44	1.44	1.12	1.12	1.12
5	Total Benchmarking Units (kwh)	32.3	30.29	27.63	30.57	30.5	27.49	28.2	26.4	25.1
6	Actual Power Consumption Units (kwh)	35	32	29	33	32	29.3	29	27	26
7	Gap between standard and Actual (kwh)	2.7	1.71	1.37	2.43	1.46	1.81	0.85	0.59	0.92
8	KWH Cost (Rs) /Unit	6.15	6.15	6.15	9.06	9.06	9.06	8.37	8.37	8.37
9	Cost impact per MT of feed (Rs)	16.61	10.52	8.43	22.02	13.23	16.4	7.11	4.94	7.7
10	Average Production Qty .Month (MTs)	1090	4048	2230	162	762	454	296	946	1348
11	Cost Impact per month (Rs)	18099	42571	18789	3567.2	10081	7445	2106	4672	10380
12	Total potential Cost Savings / Month (Rs)	79459			21091			17158		

PSC – Prestarter crumbles; SC – Starter crumbles; FP – Finisher pellets

The actual power consumption units (kwh) for pre-starter feed were 35, 33 and 29 at Muzaffarpur, Kanpur and Ambala plants respectively which is of 2.7, 2.45 and 0.85 more than bench marked specific energy consumption units. For pre-starter feed, power consumption was high at muzaffarpur plant and lower at ambala plant. For Starter feed, the actual power consumption were 32,32 and 27kwh, which is of 1.71, 1.46 and 0.59 units more than the bench marked specific energy consumption units at muzaffarpur, kanpur and ambala plants respectively. For finisher feed, the actual power consumption were 29, 29.3 and 26kwh, which is of 1.37, 1.81 and 0.92 units more than the bench marked specific energy consumption units at muzaffarpur, kanpur and ambala plants respectively. From the boiler's fuel consumption study, coal consumption was 8.22 Kg and 10.42 kg/MT of feed and fuel cost was Rs 73.98 and Rs 88.57/MT for Kanpur and Muzaffarpur boilers respectively. Fire wood was used at Ambala boiler plant. The fuel consumption per MT of feed was 18.83 kg and cost per MT of feed was Rs. 94.15.

Kilborn *et. al.*(1982) found that the total specific milling energy ranged from 46 kJ·kg⁻¹ for soft wheat cultivars to 124 kJ·kg⁻¹ for durum wheat. Dziki, (2008)reported that the specific grinding energy of uncrushed kernels ranged from 72.3 to 146.7 kJ·kg⁻¹ and from 67.0 to 114.4 kJ·kg⁻¹ for Turnia and Slade, respectively. The crushing caused a decrease of specific grinding energy in both cultivars. The total specific grinding energy of crushed kernels (the sum of crushing energy and grinding energy) ranged from 47.6 to 100.5 kJ·kg⁻¹ and from 44.6 to 85.3 kJ·kg⁻¹ for hard and soft wheat, respectively. Dziki, (2008)presented the results concerning the influence of grain mechanical properties on wheat grinding energy requirements. The investigations were carried out on 10 wheat varieties (grain moisture was 15%). The results showed that the specific grinding energy ranged from 22 to 37 kJ.kg⁻¹. The grinding efficiency index ranged from 0.215 to 0.342 m².kg⁻¹.

Kulig and Laskowski (2005) reported that an increase in fat concentration in feed material from 2 to 5.5% reduces energy consumption during pelleting by 30%. In general, the specific energy required for pelleting (i.e., energy consumed by the pellet mill motor) may range from 4 to 40 kwh/t (Stevens, 1987; Israelsen *et. al.*, 1981 and Tabil *et. al.*, 1997). In addition, steam conditioning/preheating the feed may require considerable energy. For example, Skoch *et. al.* (1981) estimated that steam conditioning to increase the temperature from 27 to 80°C consumed about 26 kwh/t. Steam addition in pelleting operations improves pellet durability. Added steam provides heat and moisture and it also helps to reduce energy consumption during pelleting.

There is no known report in the literature on the energy requirements of feed processing operations. Such information is vital so as to enable the management of this industry to develop strategies for better control of their production operations and modify areas of waste. It will also enable the management to properly appraise their energy consumption for effective planning of production network.

From the electric energy consumption study, it has been observed that ambala plant was more energy efficient as the gap between actual power consumption and bench marked data is lower which was highest at muzaffarpur followed by kanpur plant. The present study revealed that the power consumption was higher at muzaffarpur due to lack of efficient pelleting output followed by kanpur plant due to installation of high capacity motor. If the actual energy efficiency is achieved to benchmarking data, the power cost per MT of feed can be saved to the tune of Rs 16.61, 10.52 and 8.43 for Pre-starter, starter and finisher feed respectively at muzaffarpur, Rs 22.02, 13.23 and 4.94 at kanpur and Rs 8.43, 7.11 and 7.7 at ambala plant .The overall cost saving per month can be Rs 79,459, Rs 21,091 and Rs 17,158 at muzaffarpur,

kanpur and ambala plants respectively. If energy is used more effectively, product costs can be reduced and profits improved.

REFERENCES

- Dabbour, A and Bahnasawy, S Ali. (2014). Energy consumption in manufacturing of different types of feeds . (2nd International Conference on Biotechnology Applications in Agriculture (ICBAA), Benha University, Moshtohor and Hurghada, 8-12, April 2014, Egypt; <http://www.bu.edu.eg/portal/uploads/Agriculture>)
- Dziki, D. (2008). The crushing of wheat kernels and its consequences on the grinding process. *Powder Technology*, 185: 181– 186. (<https://www.researchgate.net/>)
- Fadare, D.A. (2003). Development of an organo-mineral fertilizer processing plant. Ph.D. thesis of Department of Mechanical Engineering, University of Ibadan. Ibadan, Nigeria. (<https://www.academia.edu>)
- François Lucas FabricePutier. (2012). Energy benchmarking for the animal feeds sector in France. (https://www.ecee.org/library/conference_proceedings/ecee_Industrial_Summer_Study)
- Ghorbani,R., Mondani, F., Amirmoradi, S.,Feizi, H.,Khorramdel, S and Teimouri, M. (2010). A case study of energy use and economical analysis of irrigated and dryland wheat production systems. *Applied Energy*, 88:283–288.
- Gupta, S.,Handa, K.,Saxena, S. K and Bandyopadhyaya, S. (2000).Assessment of energy conservation potential in petroleum refineries through benchmarking and targeting techniques (http://www.ese.iitb.ac.in/~santanu/Ref_Benchmark_152.pdf)
- Indian Animal Feed (Poultry, Cattle & Aquaculture) Market. (2017). Industry Analysis, Size, Share, Growth, Trends and Forecast by 2022 (<http://www.digitaljournal.com/pr/3584516>)
- Israelsen, M., Busk, J and Jensen, J. (1981). Pelleting properties of dairy compounds with molasses, alkali-treated straw and other byproducts. *Feedstuffs*, 7:26–28.
- Jahangeer, K Abdul Halim. (2015). Energy efficiency benchmarking study of food manufacturing plants in Singapore. (<http://www.e2singapore.gov.sg>)
- Kilborn, R. H., Black, H. C., Dexter, J. E and Martin D. G. (1982).Energy consumption during flour milling. Description of two measuring systems and influence of wheat hardness on the energy requirements. *Cereal Chemistry*, 59:284–288.
- Kizilaslan, H. (2009). Input–output energy analysis of cherries production in Tokat Province of Turkey. *Applied Energy*, 86:1354– 8.
- Kulig, R and Laskowski.(2005). Wpływ zawartości tłu s zczuna process granulowania materiał ł ów paszowych. *Inżynieria Rolnicza*, 7(67):59-68.
- Kurt, G. (1979). *Engineering formulas*. 3rd. Ed. McGraw – Hill book Co.
- McElhiney, R.R. (1980). “The Economics of Feed Manufacturing Processes,” In: proceedings of thirty-fifth Kansas Formula Feed Conference, Kansas State University, Manhattan, KS, Jan.
- Metwally, K. A. (2010). Study the effect of some operational Factors on hammer mill. AMSC thesis of Department of Agricultural Engineering, Faculty of Agriculture,

- Zagazig University. Egypt. (<http://www.mjae.eg.net/pdf/jan2010/4.pdf>)
- Mokhtar Ibrahim Dabbour. (2014). Role of feeding rate in energy consumption and mechanical properties for different types of feed pellet (www.researchgate.net/publication/275518848)
- Odigboh, E. U. (1997). Machines for crop production. In: Stout BA, editor. Handbook of agricultural engineering-plant production engineering. American Society of Agricultural Engineers. (<http://www.cigr.org/documents/CIGRHandbookVol3.pdf>)
- Robinson, Roy, "Pelleting – Introduction and General Definitions." In Feed Manufacturing Technology, American Feed Manufacturers Assn., Arlington, VA 1976 (book Feed manufacturing technology IV Robert R McElhiney) Published in 1994 in Arlington (Va.) by American feed industry association
- Skoch, E. R., Behnke, K. C., Deyoe, C. W and Binder, S. F. (1981). The effect of steam-conditioning rate on the pelleting process. *Animal Feed Science and Technology*, 6:83–90. (<https://www.sciencedirect.com/science/article/pii/037784018190033X>)
- Stevens, C. A. (1987). Starch gelatinization and the influence of particle size, steam pressure and die speed on the pelleting process. Ph.D. Dissertation. Kansas State University, Manhattan, KS.
- Tabil, L.G., Sokhansanj, S and Tyler, R.T. (1997). Performance of different binders during alfalfa pelleting. *Canadian Agricultural Engineering*, 39(1):17-23.