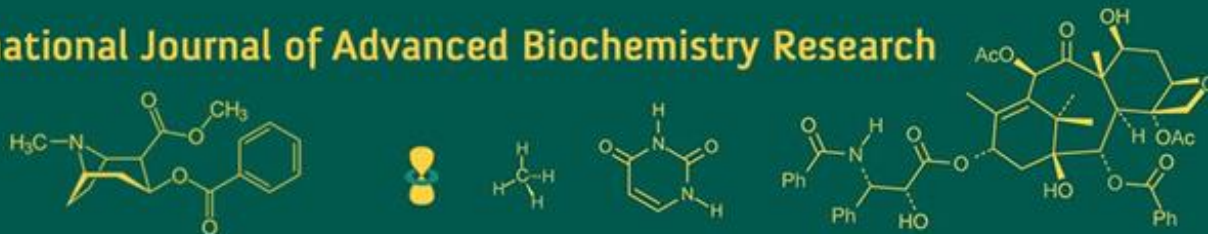


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## Development and performance evaluation of semi-automatic feeding and conveying system

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### Abstract

Feeding management in dairy farms is a labour-intensive operation that requires considerable time, manpower, and effort. Traditional feeding practices often lead to higher labour costs and feed wastage. To overcome these limitations, a semi-automatic feeding and conveying system was developed to improve feeding efficiency and reduce labour requirements. The developed unit mainly consists of a hopper, conveying tray, belt conveyor, power transmission mechanisms, micro-controller, and LiDAR sensor, including pulley, chain, and gear drives for efficient feed movement and distribution. Performance evaluation of the developed system was carried out by comparing it with the conventional feeding method. The results showed that the developed unit saved 55.46 per cent fodder, reduced manpower requirement by 50 per cent, and decreased feeding time by 93.34 per cent compared to traditional practices. The system also reduced labour drudgery and improved feeding management. The developed unit is easy to operate, requires low maintenance, and is suitable for small and medium dairy farms.

**Keywords:** Feed management, labor saving, micro-controller, semi-automatic, sensor

### 1. Introduction

In livestock management feeding is a basic activity and it directly impacts on the health, productivity, and economic viability of cattle farming operations. Farmers given feed to the animals by hand, by spreading fodder on wheel borrow or cart. This feeding by hand is labour-intensive, time-consuming, and highly dependent on the labour availability and work effort. In most of cases feed provided to the animals at irregular intervals or unequal quantities, which can result in underfeeding or overfeeding to the animals. This will be given impact on animal health, lower productivity, and increases the disease risk. Large number of livestock farm operations, feeding manually is challenging.

Farmer offer the feed to the animal on the open floor without feeding in manger which may cause heavy losses of fodder and does not maintain clean and hygiene in the cattle shed. Cattle shades are constructed with available space and material which is not maintain properly, feeding mangers are not constructed properly. To avoid wastage of fodder feeding continuously to the cattle there is need to develop semi-automatic fodder feeding system to the animals.

Automation in dairy farming has become increasingly important due to labour shortages, rising labour costs, and the need to improve farm efficiency and animal welfare. Farms using automatic feeding systems distributed feed more frequently compared to conventional feeding systems, which improved feeding management while reducing labour requirement from 33.2 s per cow per day to 16.4 s per cow per day (Bisaglia *et al.* 2013) [6]. Feeding management is one of the most labour-intensive activities in dairy farms, particularly in farms with a large herd size. The working time requirements for automatic feeding systems (AFS) on European farms and reported that farms with 60 animals required about 50.6 manpower minutes (MP min) per day, while farms with 120 animals required 65.2 MP min per day. In comparison, feeding the same herd using a conventional feeder mixer wagon required significantly higher working time (Grothmann *et al.* 2010) [5]. (Arul Prakash *et al.* 2015) [7] emphasized that automation in feeding operations such as forage, silage, concentrate, or total mixed ration (TMR) distribution can significantly reduce labour costs and feeding time, especially in farms with more than 50–100 animals. Oberschätzl *et al.* (2015) [8] also reported that automated systems consume electrical energy, they can reduce feeding costs compared to conventional feeding methods.

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Therefore, the adoption of automated feeding systems has gained attention as an effective solution to reduce labour requirement and improve feeding efficiency.

Recent studies have focused on microcontroller-based automated feeding systems using technologies such as Arduino, sensors, conveyors, and IoT to ensure precise feed distribution and reduce manual intervention (Karn *et al.*, 2019; Mali *et al.*, 2022; Bachhav *et al.*, 2023) [9, 12, 13]. These developments highlight the growing importance of automation in improving feeding efficiency and overall dairy farm management. Considering these facts and mechanization gap in feeding of fodder to animals and heavy losses and wastage of fodder, the aim of this study to design and development of semi-automatic feeding and conveying system for small dairy farms was necessary.

## 2. Material and methodology

A survey of 22 small dairy farms in the Parbhani district revealed that most farmers rear non-descript breeds of cows and buffaloes but expect higher milk yield from them. However, standard management practices related to housing, cleanliness, sanitation, feeding, and health care are not properly followed. Many cattle sheds lack adequate space for standing and feeding, and feeding mangers and water tanks are often poorly maintained, affecting hygienic feeding and drinking conditions. Farmers generally feed fodder without proper physical treatment such as chaffing, mixing green and dry fodder, or providing total mixed ration (TMR), resulting in significant fodder wastage and economic loss. The survey indicated that 54% of farmers feed only dry fodder, 18% provide both dry and green fodder, 14% offer dry, green, and concentrate feed, while only 13% use TMR. Although 63% of farmers provide chaffed fodder, a large proportion still feed unchaffed fodder. Only about 32% of farmers have feeding mangers, and none use automatic feeding and conveying systems. The major constraints identified were lack of technical knowledge and financial limitations in adopting improved dairy management practices.

### 2.1 Design consideration of semi-automatic feeding and conveying system (SAFCS) for small dairy farm

The Semi-Automatic Feeding and Conveying System is a mechanized solution developed for efficiently feed livestock, especially in small and large cattle sheds. The system is designed and developed to automate the process of transporting feed and fodder, minimizing labour efforts and ensuring uniform feed and fodder distribution. The machine was designed and developed with following components:

- Feed hopper
- Conveyor system
- Electric motor / Drive motor
- Feeding Trough / Channels
- Support Frame / Base
- Control Panel
- Discharge Gates or Outlets
- Chaff cutter

### 2.2 Design formulae for different components of feeding and conveying system:

#### 1. Design of Hopper

Hopper is a funnel shaped the formula used is

$$V = \frac{h}{3} (L \times W) + (l \times w) + \sqrt{h}$$

Where,

- L, W = Length and width of the top
- l, w = Length and width of the outlet
- h = Vertical height of the slope section.

#### 2. Design of belt capacity

$$Q = A \times v \times \psi \times 3600 \text{ (J. Sahay)}$$

Where,

- Q = Capacity m<sup>3</sup> / hr
- A = Cross sectional area of the trough
- v = Velocity of the belt
- $\psi$  = Filling coefficient (usually 0.3 to 0.45 for fodder)

#### Conveyor Capacity

The mass of fodder (live load) l M<sub>m</sub> per metre (kg/m) loaded on a belt conveyor is given as

$$M_m = C / (3.6 \times V) 50$$

Where,

- C= Conveyor capacity (tonnes/hr)
- V= belt speed (m/s).

**Table 1:** Specification of Semi-automatic feeding and conveying system

| Sr. No.          | Particulars                           | Dimensions         |
|------------------|---------------------------------------|--------------------|
| Feeding Hopper   |                                       |                    |
| 1                | Feeding Hopper size (L x W x H), mm   | 1070 X 610 x560    |
| 2                | Feeding Hopper output size(L x W), mm | 200 x 380          |
| 3                | Shaft Dia., mm                        | 20                 |
| 4                | Shaft Length, mm                      | 635                |
| 5                | Pedestal Bearing, mm                  | 20                 |
| Conveying system |                                       |                    |
| 1                | Cattle shed size, mm                  | 7620 x 3658 x 2793 |
| 2                | Conveying Tray, mm                    | 7440 x 400 x 215   |
| 3                | Sliding belt, mm                      | 9146 x 400         |
| 4                | Belt conveyor roller, mm              | Ø430, Width 420    |
| 5                | Sprocket 1, mm                        | Ø200               |
| 6                | Belt Pulley, mm                       | Ø91, 25            |
| 7                | Transmission system, mm               | 200 x120           |
| 8                | Rope Conveyor Pulley, mm              | Ø120, L- 420       |
| 9                | Electric Motor                        | 1hp                |
| 10               | Sprocket 2, mm                        | Ø90                |
| 11               | Pedestal Bearing                      | P.120              |
| 12               | Sensor                                | TF LUNA LIDAR      |
| Chaff cutter     |                                       |                    |
| 1                | Gearbox                               | Reverse Forward    |
| 2                | High carbon steel Blade               | 4 Nos.             |
| 3                | Output capacity, kg/h                 | 400- 600           |
| 4                | Electric motor, hp                    | 3                  |
| 5                | Weight, kg                            | 150                |
| 6                | RPM                                   | 720                |

## Conceptual designs

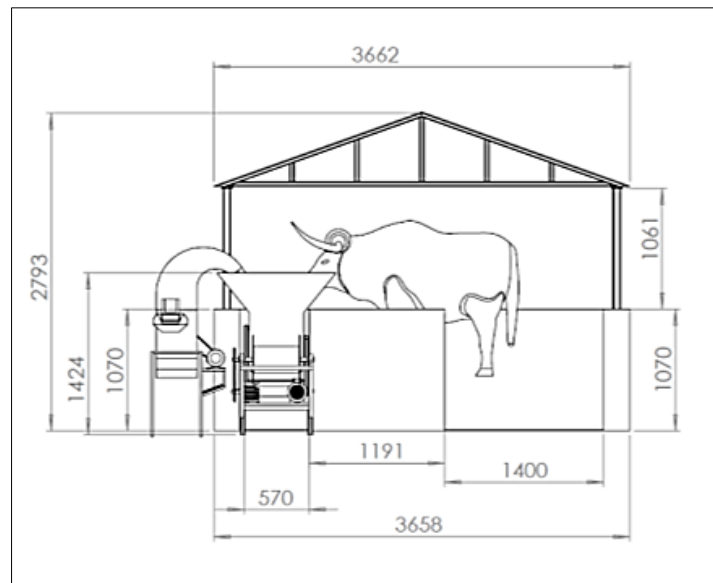


**Fig 1:** Pictorial view of SAFCS

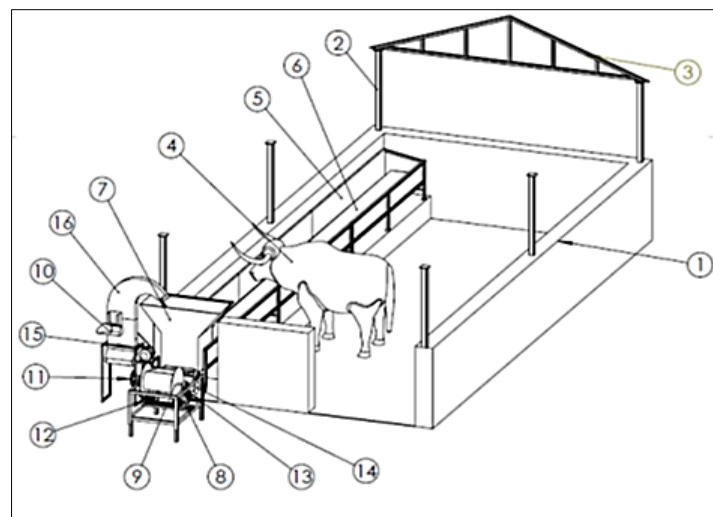


**Fig 2:** Schematic view of cattle shed

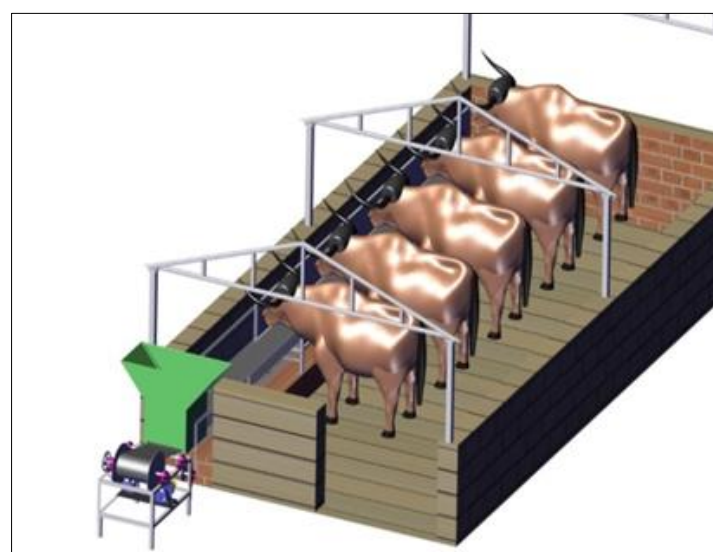


**Fig 3:** Isometric view of SAFCS

### 2.3 Atomization in feeding and conveying system:

A motor-driven conveyor belt feeder powered by a 1.0 HP electric motor is used in the system, depending on herd size and feed load. The control unit consists of an Arduino UNO microcontroller connected with a TF-LUNA LIDAR sensor to detect the physical presence of animals or obstacles. Based on the sensor input, a relay driver circuit automatically turns the motor ON or OFF to ensure accurate fodder dispensing. The entire system operates on 12 V DC, improving energy efficiency and safety.

Relay modules, the Arduino UNO, and the TF-LUNA LIDAR sensor control the conveyor mechanism and detect obstacles. This simple stop-and-resume logic allows the feeding system to respond automatically to obstructions without human intervention. LIDAR technology provides reliable real-time obstacle detection in agricultural applications. Similar integration of LIDAR with microcontrollers for agricultural robots was demonstrated by Zhang *et al.* (2020), showing high responsiveness and adaptability in real-time systems.

#### Atomization components

In the upgraded unit some sub units are given as per following:

##### a) Power unit

The power unit serves as the central source of electrical supply for all components of the semi-automatic feeding and conveying system.

##### b) Sensing unit

The sensing unit is responsible for detecting physical obstacles, specifically cattle, within the barn up to a range of 1 meters. This unit uses a TF-Luna LiDAR sensor to perform real-time object detection and distance measurement. The data sensed by the LiDAR is communicated to the Arduino Uno microcontroller, which acts as the processing hub for further action. The TF-Luna is a single-point ranging sensor based on the Time of Flight (ToF) principle. It is engineered for stability, high accuracy, and fast frame rate detection. With multiple configurable parameters and adaptable algorithms, it delivers precise and consistent performance even in complex agricultural environments, making it an ideal choice for this application.

**c) Controlling Unit:** The controlling unit consists of an Arduino UNO fig. 5, a relay module (SPDT) fig. 6, two

automatic starters, and an MCB switch. It receives power from the power unit and acts as the main control system. The sensing unit sends information to the Arduino UNO through jumper wires. The Arduino processes this data and sends commands to the relay module, which in turn triggers the starters to operate the connected devices.

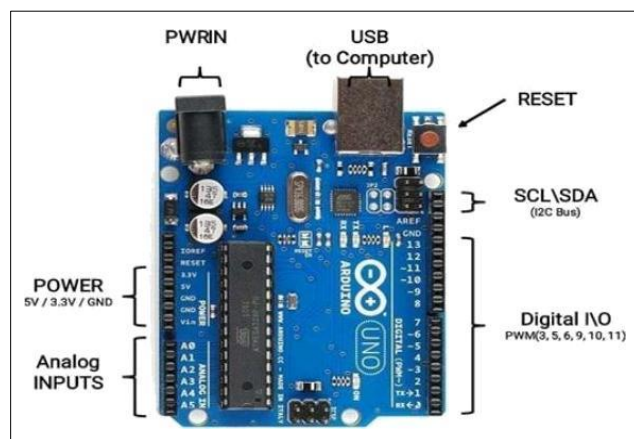


Fig 4: Arduino UNO

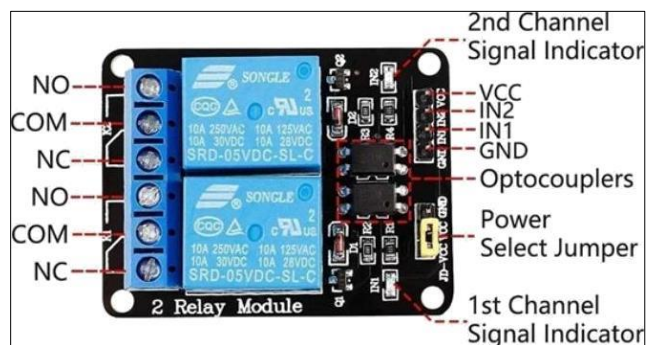


Fig 5: Components of Relay module

### 2.4 Parameters observed

1. Feed offered (kg/day)
2. Feed residue (kg/day)
3. Percent Feed Wastage (%) =  $\frac{\text{Feed residue (kg)}}{\text{Feed offered (kg)}} \times 100$
4. Feed Conveying Efficiency (%) =  $\frac{\text{Feed convey (kg)}}{\text{Total feed in hopper(kg)}} \times 100$



Fig 6: Trials of semi-automatic feeding and conveying system

### 3. Result

Arduino UNO microcontroller is programmed as per requirement and steps for working of sensor:

#### For dry, green fodder and concentrate mixture

**Step 1:** LIDAR sensor senses the obstacle up to 1 meter according to the code given to Arduino UNO.

**Step 2:** If obstacle is detected for 5 seconds Arduino gives command to Relay 1 to turn-on for 40 seconds then turn-off. When the Relay 1 turns on starter 1 (for forward motion of motor) will turn on for 40 seconds. Then belt will moves forward for 40 seconds then turn off.

**Step 3:** Now both Relays 1 & 2 will turn off for 2 h for dry, 1.30 h for green and 0.3 h for concentrate for feeding of the cattle.

**Step 4:** Again the LIDAR sensor will sense for obstacle if the obstacle is not detected for 5 seconds then Relay 2 will turn on for 40 seconds then turn off (If the obstacle is detected Relay 2 will not turn on). When Relay 2 turns on starter 2 (for reverse motion of motor) will turn on for 40 seconds. Then belt will moves reverse for 40 seconds then turn off.

#### Step 5

The machine will turn off for 2 hours for next cycle. As per the thumb rule of feeding the adult bullocks offered 10 kg dry fodder, 20 kg green fodder and 2 kg concentrate feed. Bullock feed with dry, green and concentrate feed in developed unit ( $T_2$ )

showed higher feed consumption than those under the traditional practices ( $T_1$ ) for all three types of feed. Semi-automatic feed conveying system resulted in significantly higher feed intake and lower feed residue by 55.30% as compared to traditional feed conveying method, while feed offered remained constant. Feed conveying efficiency of developed unit is higher as compared to traditional system.

#### 3.1 Performance evaluation of animal feeding trials under developed unit and traditional practice

The performance of animal feeding with dry, green and concentrate feed for six animals was taken. It was observed that time required to pass the feed material to the tail end feed offered is 40 sec in developed unit which is very less as compare to traditional practices. Also wastage of fodder observed more in traditional practice i.e. 19 per cent as compared to 8 per cent wastage observed in developed unit. Hence, semi-automatic feed conveying is more efficient in reducing wastage and improving feed utilization in cattle.

**Table 2:** Statistical comparison of traditional and developed feeding systems

| Sr. No. | Parameter                         | Traditional (Mean $\pm$ SD) | Developed (Mean $\pm$ SD) | % Reduction |
|---------|-----------------------------------|-----------------------------|---------------------------|-------------|
| 1       | Feeding Time, (h)                 | 1.78 $\pm$ 1.35             | 1.17 $\pm$ 0.91           | 34.58       |
| 2       | Residue leftover, (kg/animal/day) | 2.04 $\pm$ 1.13             | 0.91 $\pm$ 0.77           | 55.30       |

The mean feeding time under the traditional system reduced by 34.58% as compared to developed unit. This indicates improved operational efficiency and reduced time consumption. Similarly, the mean residue leftover decreased by 55.30%, indicating better feed utilization.

#### 4. Conclusion

The developed semi-automatic feeding and conveying system showed significant improvement over the traditional feeding method. The unit saved 55.46 per cent of fodder, which indicates better feed utilization and reduced wastage during feeding operations. In addition, the system reduced the requirement of manpower by 50 per cent, thereby lowering the labour demand on dairy farms. The long-term use of the semi-automatic feeding and conveying system can improve animal husbandry management practices in dairy farming. Furthermore, the system helps in reducing labour costs, minimizing the drudgery involved in manual feeding operations, and optimizing manpower utilization. The developed unit also requires less maintenance and is easy to operate, making it suitable for practical use in dairy farms.

#### 5. Acknowledgments

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