International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 10 | Oct 2022 www.irjet.net p-ISSN: 2395-0072

# Performance Evaluation of Power Operated Corn-Sheller

**Dr. J P Yadav[1] and Pratyush[2]**

[1]*Professor, Faculty of Agril Engg & Tech, (C.S.A. Univ of Agri & Tech, Kanpur) Campus Etawah, U.P.*
[2]*Faculty, Department Civil Engineering, Kamla Nehru Institute of Technology, Sultanpur, U.P.*

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**Abstract -** *Corn has been called the "Queen of Grains" and "King of Fodder" which is used for industrial products and for human and animal feed. Traditionally, corn shelling was done mechanically by small and marginal farmers in the corn-prone region of Uttar Pradesh in India, either by rubbing corn on each other or shelling the grains by using fingers. Sometimes cylindrical tools with wire mesh are used for shelling the corn grains. All these methods are tiresome and time consuming. Here in this paper power operated Corn-Sheller is developed and its performance is evaluated for its shelling capacity and shelling efficiency. The corn shelling machine consists of a hopper, cylinder and a concave with chain spikes that rotate inside the cylinder to separate the grain from the cob. The shelling capacity of machine is reported to be 973kg/h with a shelling efficiency of 97.37%. The output rate of the corn shelling machine was around 577 kg/h. This corn-sheller is robust, cost effective and can be easily made by local artisans.*

***Key Words***: Corn, Corn-sheller, corn shelling efficiency.

## 1.INTRODUCTION

Corn is a rich source of starch (60–80%), protein (8–12%), fat (3–5%) and minerals (1–2%) (Hosmani et al., 2000). India is the fifth largest producer of maize in the world contributing 3% of the global production. With genetically improved varieties and production/conservation technologies through All India Coordinated Research Project (AICRP) since 1957, maize is now grown in India in all seasons i.e., Kharif, Rabi and Summer. The major maize producing states of India, which contribute more than 80% of the total maize production, are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%, Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), and Himachal Pradesh (4.4%).

Maize yields for varieties like Hybrid (Navjot, Naveen, Shweta, Azad Uttam, Kanchan, Gaurav) and Hybrid (Prakash, JH3459, Pusa Agatei Hybrid Maize, Deccan-115, MMH-133, Pro-4212, Malvian Hybrid Maize-2, HQPM-15) varies from 35-40 Q/ha for Sankul and 35-50 Q/ha for hybrids. (Source: Agriculture Department, Uttar Pradesh). District Kannauj in Uttar Pradesh is the leading district in corn production accounting for 9.75% of India's corn production. The top five other regions are Mainpuri, Bahraich, Bulandshahr, Farrukhabad and Etawah districts. (Source: Krishi Vigyan Kendra, Etawah, Uttar Pradesh) Mechanization of threshing is gaining more importance in recent times. Due to the increasing importance of mechanized threshing, several types of threshers were introduced and evaluated across the country. These include spike tooth type, chaff cutter type, syndicator type and beater type commonly used in Indian farms for threshing of specific crops. Electric powered corn-shellers have been popularized to take care of corn crops grown by small and marginal farmers to reduce the cost of operation and time. Corn kernels are difficult to break or cut from the cob when moisture is more than 25 percent. With this moisture content, the grain separation efficiency is very poor, with high operating energy and mechanical damage to the kernels. When the grain has a moisture content of 13 to 14%, more efficient shelling is achieved. In order to get better performance from shelling machine, a certain relationship exists between sheller speed, concave and cylinder clearance with respect to crop type. Considering the above factors, a study was conducted to survey the various threshing/shelling methods used by farmers for corn and the suitability of various power operated corn-shellers in the context of the prevailing socioeconomic conditions in Uttar Pradesh was evaluated. Here in this paper the corn shelling machine is designed and manufactured with the necessary safeguards for its performance evaluation following power threshers – safety requirements (IS 9020:2002), Indian Standard Test code for power maize-shellers (IS:7052-1973 – reaffirmed 2012) and RNAM Test codes & procedures for farm machinery.

## 2. MATERIALS AND METHODS

The shelling is accomplished by shearing by rotating pegs on the cylinder, which lift the grain out of the corn cobs holding it. Different grain crops and different varieties of the same grain crop have different characteristics, which require different speed of the cylinder to achieve the best result of shelling, so the adjustment of cylinder speed and appropriate feeding of cob is necessary. For comparison of power operated corn-shellers, different shelling methods were adopted such as hand-sheller, hand-held-sheller and pedal operated corn-sheller. The Power Operated Corn-Sheller consisted of a hopper that was fabricated into a trapezoidal shape of mild steel sheet of 18-gauge thickness and had dimensions of 508 mm in length, 508 mm in width and 228.6 mm in height. Hopper is a main important part of the machine which is provided in the machine to feed the corn to shelling. Main frame structures are generally used to overcome the large moments developed due to applied loading. The main frame is made of angle iron of 5mm thickness. The dimensions of the frame are 1000×541×767

mm. The shelling tool used is six to six chain spikes on both sides of the main shaft as shown in Figure 1 for high production rates and uniform shelling. The chain spikes have a length of about 158 mm. As shown in Figure 2, the flats of cylinder and bearings were mounted on the rotor shaft. The standard size and length of the shaft was selected based on the design of the shaft. A pulley was installed to give drive from the motor to the shaft. Two ball bearings were mounted in the bearing housing on the machine. The inner diameter of the bearing is 25.4 mm. It runs over a pulley having a V-shaped groove. The B62 v-belt is selected according to the size of the requirement. The required length, width, height is 1660 mm (62 inches' inner circumference), 17 mm, 11 mm. The 1 HP single phase and 1440 rpm electric motor is used to operate the machine. The collecting tray is the lower part of the machine which is used to collect the corn grains after the shelling process. This is made of GI sheet. Safety guard is the upper right part of the machine which is made by fiber sheet supported on iron frame. The specifications of corn-sheller are shown in Table 1 and Annexure A. The required important formulae and parametric relations are given at Annexure B.

**Fig -1**: Shelling Tool (having chain spikes)

## 3. EXPERIMENTATION AND EVALUATION

Locally available corn was taken and its moisture content was assessed in laboratory with ambient temperature on variable dates and corn-sheller was tested on various parameters such as feed rate, production rate and shelling efficiency at variable speed of motor as shown in Table 2. It has been observed that both the feed rate and the production rate increase as the motor speed increases, but the shelling efficiency is variable which is dependent on the ambient temperature and moisture content.

**Table -1:** Specifications of Corn Sheller

| Serial No. | Particulars | Specifications |
|---|---|---|
| 1. | Type of machine | Corn Sheller |
| 2. | Overall Dimension | |
| | Length(mm) | 1368.00 |
| | Width(mm) | 541.02 |
| | Height(mm) | 769.20 |
| | Weight (Kg) | 150.00 |
| 3. | Power unit | |
| | Power unit | Electric Motor |
| | Horse Power (HP) | 2 |
| | Revolution per minute(rpm) | 1440 |
| 4. | Pulley | |
| | Number of Pulley(mm) | 2 |
| | Diameter of driving Pulley(mm) | 90 |
| | Diameter of driven Pulley(mm) | 228.6 |
| 5. | Perforated concave | |
| | Length(mm) | 635 |
| | Width(mm) | 297 |
| | Clearance b/w rods(mm) | 22.6 |
| 6. | Bearing | |
| | Type of bearings | Ball Bearing |
| | Number of bearings | 2 |
| | Diameter of bearings(mm) | 22.86 |
| 7. | Shaft | |
| | Number of shafts | 1 (main transmission shaft) |
| | Diameter of main shaft(mm) | 31.75 |
| 8. | Belt | |
| | Size(m) | 1.6 |
| 9. | Hopper | |
| | Capacity(kg) | 10-12 |
| 11. | Shelling Tool | |
| | Type | Cylindrical bar having twelve chain spikes |
| | Length of chain spikes(mm) | 157.48 |
| 12. | Collecting tray | |
| | Length(mm) | 800 |

**Fig -2**: Rotor shaft

**Table -2:** Observation of shelling parameters

| Observations | Quantity of dry corn (kg) | Speed of motor (rpm) | Time taken (sec) | Threshed grains (kg) | Weight of cobs (kg) | Unbroken grains, kg | Broken grains, kg | Feed rate, kg/h | Production rate, kg/h | Unbroken efficiency, % | Un-threshed grains, kg | Shelling efficiency, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Obs.1: with 28% moisture content and 42.4$^0$C, dtd 21.5.2019 | 0.5 | 1000 | 3 | 0.350 | 0.130 | 0.344 | 0.006 | 600 | 420.00 | 98.40 | 0.020 | 98.28 |
| Obs.2: with 31% moisture content and 39.2$^0$C, dtd 22.5.2019 | 1.0 | 1100 | 5 | 0.720 | 0.240 | 0.708 | 0.012 | 720 | 518.40 | 98.11 | 0.040 | 97.50 |
| Obs.3: with 26% moisture content and 40.3$^0$C, dtd 25.5.2019 | 1.5 | 1200 | 7 | 1.170 | 0.280 | 1.125 | 0.045 | 772 | 602.00 | 96.15 | 0.050 | 99.50 |
| Obs.4: with 34% moisture content and 38$^0$C, dtd 28.5.2019 | 2.0 | 1300 | 8 | 1.416 | 0.460 | 1.358 | 0.058 | 900 | 637.20 | 95.90 | 0.124 | 95.40 |
| Obs.5: with 23% moisture content and 42.4$^0$C, dtd 28.5.2019 | 1.0 | 1440 | 4 | 0.758 | 0.180 | 0.748 | 0.010 | 900 | 682.20 | 99.07 | 0.062 | 96.19 |
| Average value | | | | | | | | 973 | 571.96 | 97.53 | 0.059 | 97.37 |

**Table -3:** Performance parameters under various treatments

| Treatments | No. of Labor required | Wages per day of 8 h | Total amount (Rs) | Shelling capacity kg/h | Output capacity (Kg/h) | Shelling efficiency (%) | Moisture content (%) | Visual damage (%) | Unshelled cobs (%) | Cost of operation (Rs/qtl) |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 1 | 250 | 250 | 12.50 | 12.40 | 100.00 | 13 | 0.0 | 0.00 | 250.00 |
| $T_2$ | 1 | 250 | 250 | 18.30 | 17.90 | 100.00 | 13 | 0.1 | 0.00 | 168.92 |
| $T_3$ | 2 | 250 | 500 | 74.60 | 74.10 | 95.92 | 13 | 0.5 | 0.55 | 83.78 |
| $T_4$ | 2 | 250 | 500 | 973.00 | 576.91 | 97.37 | 13 | 1.0 | 0.12 | 06.42 |

T1 - Hand shelling, T2 – Hand-held-sheller, T3 - Pedal operated corn-sheller, T4 - Power operated corn-sheller

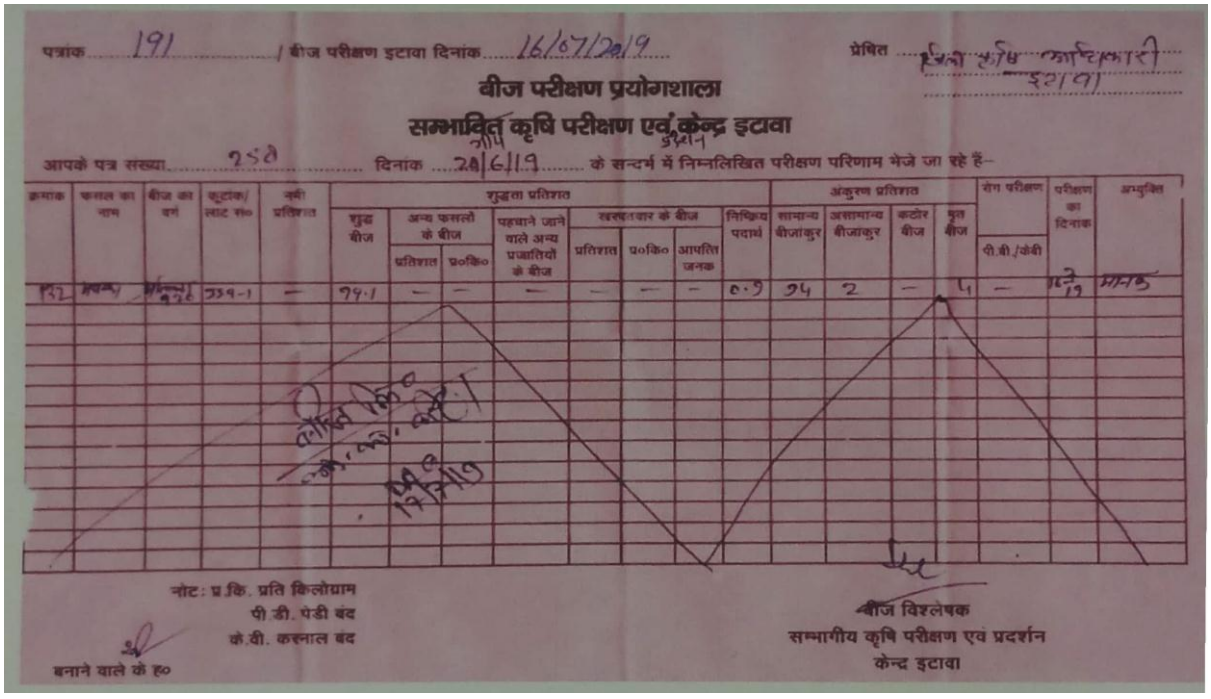
## 4. COMPARISON WITH DIFFERENT SHELLING METHODS

Trials were conducted for four different treatments with the same sample size as mentioned. The results of the effect of treatment on shelling efficiency (%), output capacity (kg/h), visible damage (%), unshelled cobs efficiency (%) and cost of operation (Rs/qtl) are presented in Table 3. Parametric observations reveal significant variations in parameters such as shelling capacity (feed rate), output capacity (production rate) and cost of operation under different treatments. The power operated corn-sheller's shelling capacity is many times higher than that of other treatments. Although the shelling efficiency of hand-sheller and hand-held-sheller is 100%, it is drudgeries and time consuming compared to power operated corn-sheller which has an efficiency of 97.37%. The cost of operation of shelling corn has been gradually reduced from Rs 250 per quintal to Rs 6.42 per quintal while switching from hand-sheller to hand-held -sheller, pedal operated sheller to power operated corn-sheller ignoring other inputs like electricity consumption charges while going for economic analysis.

**Fig -3**: Inner view of Corn-Sheller

**Fig -4**: Completely threshed unbroken grains

The sample of corn grain shelled out by the power operated corn-sheller was sent to Seed Testing Laboratory, Regional Agri-Testing and Breeding Centre, Etawah, India, for germination testing. The test report is attached below with the purity of the seed being 99.1% and 0.9% impure seed.



पत्रांक 191 / बीज परीक्षण इटावा दिनांक 16/07/2019 प्रेषित

बीज परीक्षण प्रयोगशाला

सम्भावित कृषि परीक्षण एवं केन्द्र इटावा

आपके पत्र संख्या 258 दिनांक 28/6/19 के सन्दर्भ में निम्नलिखित परीक्षण परिणाम भेजे जा रहे हैं–

| क्रमांक | फसल का नाम | बीज का वर्ग | थैला/लाट सं० | थैली प्रतिशत | शुद्धता प्रतिशत | | | | | | | अंकुरण प्रतिशत | | | | रोग परीक्षण | परीक्षण का दिनांक | अभ्युक्ति |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | शुद्ध बीज | अन्य फसलों के बीज | | पहचाने जाने वाले अन्य प्रजातियों के बीज | खरपतवार के बीज | | | निष्क्रिय पदार्थ | सामान्य बीजांकुर | असामान्य बीजांकुर | कठोर बीज | मृत बीज | पी.बी./केबी | |
| | | | | | | प्रतिशत | प्र०कि० | | प्रतिशत | प्र०कि० | आपत्ति जनक | | | | | | | |
| 1 | | | 339-1 | — | 99.1 | — | — | — | — | — | — | 0.9 | 94 | 2 | — | 4 | — | 16/7/19 | |

नोट: प्र.कि. प्रति किलोग्राम
पी.डी. पेंडी बंद
के.वी. कस्नाल बंद

बनाने वाले के ह०

बीज विश्लेषक
सम्भागीय कृषि परीक्षण एवं प्रदर्शन
केन्द्र इटावा

## 3. CONCLUSIONS

The performance of Power Operated Corn-Sheller was found to be better during testing with the following findings as compared to conventional hand shelling, hand held-shellers and pedal operated shellers:

- The germination test by the State Government Seed Testing Laboratory shows the purity of the seed as 99.1% and 0.9% as impure seed.
- The performance of the power operated corn-sheller was better than other traditional shelling

methods as the productivity increased with negligible total loss (damaged + unpeeled grains).

- The shelling efficiency of power operated corn-sheller was 97.37%.
- The feed rate of power operated corn-sheller was about 973 kg/h.
- The output rate of the corn-sheller was around 577 kg/h.
- No un-shelled cobs were left in the corn-sheller as it is best suited for low moisture corns.
- The use of chain spikes is beneficial for better removal of corn grains from the cobs.

## ACKNOWLEDGEMENT (Optional)

The author is thankful to Shri Sarvesh Tripathi, Lab Technician (welding) and B. Tech. students, viz. Ajay Kumar, Akanksha Upadhyay, C.P. Singh, Prashant Kumar, Gargi Awashthi and Akash Singh, for their contribution in designing and fabrication of prototype power operated corn-sheller for its performance evaluation under my supervision. The author also gratefully acknowledges the UPCAR, Lucknow, for financial support under "Central of Excellence in Farm Machinery". We acknowledge Seed Testing Laboratory, Regional Agri-Testing and Breeding Centre, Etawah, India, for their kind support and help in germination testing of corn shelled samples.

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## Annexure A

A. Specifications

1. Type of machine – Corn-sheller
2. Manufacturer's address – B. S. Dr. B. R. A. C. A. E. T., Etawah - 206001
3. Market price – US$ (292.50) (Local currency 20,352) Year 2018-19
4. Name of crops for which the machine is suitable – Corn
5. Weight in kg. (i) Overall: 150 kg (ii) at transportation: 150 kg
6. Power source – Electricity
7. Power transmission system – Pulleys and belt
8. Threshing drum or cylinder
    i. Type – Chain spikes type
    ii. Diameter of drum – 457.20 mm
    iii. Length of drum – 635.00 mm
    iv. Rated revolution speed of drum – 560 rpm
    v. Number and size of wire loop – 12 chain spikes and 5 mm thickness &157.48 mm length.
9. Labour requirement for feeding, supply of crop to feeder(s), collecting and bagging grain, disposal of other outlets – 1 Persons (max. 2 persons).
10. Output capacity (announced) kg/hr. –577 kg/h

Power operated Corn-Sheller


| Date of verification: 25 May 2019, Venue: Etawah, U.P. | | | | | |
|---|---|---|---|---|---|
| Particulars | | | | Performance tests | |
| Date of test | | | | 25 May 2019 | 27 May 2019 |
| Location of test | | | | Etawah | Etawah |
| A. | Test conditions | | | | |
| | I. | Condition of corn | | Dry | Dry |
| | | (1) | Name of corns | Mallika | Mallika |
| | | (2) | Variety of corns | NMH 920 | NMH 920 |
| | | (3) | Length of corn (cm) | 15-20 | 15-20 |
| | | (4) | Moisture content (%) | 26 | 32 |
| | | (5) | Percentage of broken grains | 1.16% | 3.02% |
| | II. | Condition of machine | | | |
| | | (1) | Revolution speed prime mover no load (rpm) | 1440 | 1440 |
| | | (2) | Threshing drum, no load (rpm) | 560 | 560 |
| | | (3) | Peripheral speed of threshing drum (rpm) | 520-530 | 520-530 |
| | III. | Condition of operation | | | |
| | | (1) | Name of prime mover and fuel | Electric motor, & Electricity | Electric motor, & Electricity |
| | | (2) | Feeding method | Manual feeding | Manual feeding |
| | | (3) | Number and role of labourers | Two labours for feeding and collecting | Two labours for feeding and collecting |
| | IV. | Condition of labour | | | |
| | | (1) | Skill of labour | Less skilled | Less skilled |
| | | (2) | Wages of labour (local currency/day) | Rs 250-350 | Rs 250-350 |

| | | | | | |
|---|---|---|---|---|---|
| | V. | Ambient conditions | | | |
| | | (1) | Temperature | 40.1$^0$C | 38$^0$C |
| | | (2) | Relative humidity (%) | 45% | 48% |
| | | (3) | Wind velocity (m/s) | 4m/s | 4m/s |
| | | (4) | Weather (sunny, cloudy, hot, cold, etc.) | Sunny | Sunny |
| | VI. | Method of measuring power consumption | | P = 2πNT/60 | P = 2πNT/60 |
| B. | Performance test | | | | |
| | | (1) | Actual operating time (min) | 60 min | 60 min |
| | | (2) | Time lost owing to | | |
| | | | a) Adjustments (min) | 05 min | 05 min |
| | | | b) Others (min) | 05 min | 05 min |
| | | (3) | Power required | | |
| | | | a) For no load (kw) | 0.5 – 0.6 kw | 0.5 – 0.6 kw |
| | | | b) For load (kw) | 0.7 - 1.5 kw | 0.7 - 1.5 kw |

**Discussion:**

Machine aspect: The handling of machine is quite easy. It does not require any educational skills for its operation.

1. Crop aspect: The machine is suitable for only corn shelling.
2. Field operation: The machine requires minimum one or maximum two labour at a time to do the operations. The working capacity of machine is approximately 900 kg/hour. The machine requires an electric motor of 1hp.
3. Machine Cost: The total manufacturing cost of machine is Rs 20,352/-
4. Summary and conclusions

   a. The performance of power operated corn-sheller was better than manually operated Corn-Sheller because the productivity has increased and the total losses (damaged + un-threshed grains) had decreased.
   b. The threshing/ shelling efficiency of power operated corn-sheller is 97.37%.
   c. The feed rate kg per hour of power operated corn-sheller is approximately 900 kg/h.
   d. The un-threshed grain % by power operated corn-sheller was lower than manually operated corn shelling machine.

**Annexure B:** Important formulae and parametric relations

| | | | |
|---|---|---|---|
| 1. | Capacity of machine, C=W/t, kg/h<br>where W= weight of corn cob fed in the hopper, kg; and t= time taken for shelling, h | 2. | Shelling efficiency, $\eta_t = [W_g/ (W_g + W_u)] \times 100$<br>where $W_u$= weight of unshelled corn, kg; and $W_g$ = weight of grain, kg |
| 3. | Percentage of unshelled grain =<br>100 (Quantity of unshelled grain obtained from all outlets in kg)/ Total grain inputs in kg | 4. | Specific energy requirement, E = K/W,<br>where E = energy requirement per kg of corn cobs, kWh/kg; K = energy meter reading, kWh; and<br>W = weight of corn shelled, kg. |
| 5. | Energy consumption, $E_{sp} = \frac{1}{Q}[(P_L \times n_L) - (P_{NL} \times n_{NL})]$<br>where $E_{sp}$ = specific energy for shelling, Wh/kg; Q = throughput of the machine, kg/h, $P_L$ = watt meter reading(average) at load, W; $n_L$ = efficiency of prime mover at load (assume 0.9); $P_{NL}$ = watt meter reading (average) at no-load, W; and $n_{NL}$ = efficiency of prime mover at no-load (assume 0.5) | 6. | Volume of shelling chamber = $\pi r^2 h$<br>Determination of speed of driven pulley,<br>$N_1 D_1 = N_2 D_2$<br>Angles of lap,<br>$\alpha_1 = 180^0 - 2\sin^{-1}[228.6-88.9)/2560]$<br>Length of the belt, $L=2x+\frac{\pi}{2}(D_1 + D_2) + \frac{(D_1 - D_2)^2}{4x}$<br>Velocities of driving and driven pulley,<br>$V_1 = \pi D_1 N_1/60$, $V_2 = \pi D_2 N_2/60$ |
| 7. | Diameter of shaft, $D^3 = 16/\pi S_s[(K_b \times M_b)^2 + (K_t \times M_t)^2]^{1/2}$<br>Assuming, $K_b$, $K_t$ as 2 and factor of safety 2 | 8. | Power required to drive the threshing bar,<br>$P_D = T \times \omega$ |
| 9. | Power requirement of machine, $P_T = T \times \omega$ | | |