

Design of Portable Crop Reaper

Tejas Kakade¹, Darshan Hindocha², Pankaj Rithe³, Hrishikesh Gosavi⁴, M.J.Naidu⁵

¹Student, Department of Mechanical engineering, SKNCOE, tejas.kakade12@gmail.com

²Student, Department of Mechanical engineering, SKNCOE, vallabhkuti@gmail.com

³Student, Department of Mechanical engineering, SKNCOE, pankaj.rithe11@gmail.com

⁴Student, Department of Mechanical engineering, SKNCOE, hgosavi2091@gmail.com

⁵Assistant Professor, Department of Mechanical Engineering, SKNCOE, mnj2979@gmail.com

ABSTRACT

India being an agricultural country, Farming is most widely followed profession in India. Agricultural products contribute a major portion to our economy. Recently India seen a shortage of skilled labour available for agriculture. Because of this shortage the farmers have transitioned to using crop reaper. These agricultural crop reapers are available for purchase but because of their high Costs, they are not affordable for small scale farmers. Existing machine are more costlier and inconvenient for the agricultural fields in India, so we there's a need of machines which targets the small scale farmers who have land area of less than 2acres. The history of agriculture contains many conventional agricultural methods and tools such as **plough sickle, scythe etc.** In traditionally harvesting technique, harvesting of field is done manually with the help sickle. To overcome the problem of harvesting for small scale farmers designing and optimization of heavy harvesting machine to compact crop reaper is required. This machine is compact and can cut up to two rows of plant. It has cutting blades which cut the crop in a scissoring type of motion. This machine is compact and can cut up to two rows of plant. It has cutting blades which cut the crop in a scissoring type of motion. There are no cutter on two metal strip (plate) upper cutter plate will be reciprocate by scotch yoke mechanism, It runs on electrical AC motor with 1Hp capacity or engine, this power, is provided through pulley and gear box arrangement to the cutter. A collecting mechanism is provided for the collection of crops to one side after cutting. This mechanism is also powered by pulley arrangement, two sprockets and chain arrangements given for collection of crops. This compact harvester is manufactured using locally available spare parts and thus, it is easily maintainable. This harvester might be the solution to the problems faced by a small scale farmer regarding cost and labour implementation. After testing this machine in farm it is found that the cost of harvesting using this harvester is considerably less as compare to manual harvesting.

Keywords: Reaper, Harvester, Farming.

1. INTRODUCTION

Farming is most widely followed profession in India. Agricultural products contribute a major portion to our economy. Engineering science has brought tremendous changes in traditional methods of agriculture viz. sowing, planting, irrigation, fertilizer spraying, harvesting, etc. However to increase our economic condition, we must increase the productivity and quality of our farming activities. Nowadays very few skilled labors are available for agriculture. Because of this shortage the farmers prefer to use reaper harvesters.

These reapers are costly and only available of very large scale farming. However, agriculture groups make these available for rent on an hourly basis. But the small holding farm owners generally do not require the full-featured combine harvesters. Also, these combine harvesters are not available in all parts of rural India due to financial or transportation reasons. Thus, there is a need for a smaller and efficient combine reaper which would be more accessible and also considerably cheaper.

The mission is to create a portable, user-friendly and low cost mini harvester taking into account the requirements of current situation; the idea was created to prepare a machine which is cheap and will reduce the labor required to cut crops. This machine has the capability and the economic value for fulfilling the needs of farmers having small land holdings. This machine is cost effective and easy to maintain and repair for the farmers. The machine model is designed based on the demand for a compact and economical reaper. This demand is taken into consideration by consulting farmers in person, for their problems and requirements.

1.1 Problem Statement

- DESIGN and DEVELOP the crop reaper.
- Also to fabricate the model of the same which would able to show the characteristics of systems and working according to need.

1.2 Objectives

- To formulate an idea to suit our required functionality that is to reap the crops.
- To formulate an idea to suit our required functionality that is to reap the crops.
- To develop the idea to suitable mechanical principles and to design the idea to practice.
- To fabricate the design with the knowledge and the selected material which are cost effective.

1.3 Scope of work

1.4 Methodology

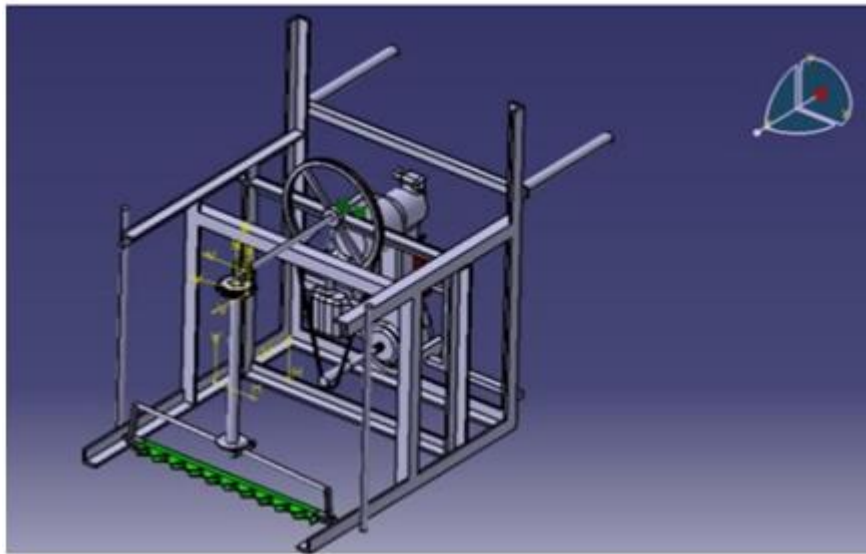
Study of conventional Harvesters for various crops

- I. Selecting the Drive for machine.
 - Motor
 - Engine
- II. Selecting the crops for which our machine is to be manufactures.
- III. Calculating the force exerted by crops and various parameters of crops.
 - Diameters
 - Height of cut
- IV. Assuming the machine Compact the transmission should be at least in 2 stages
 - Belt drive
 - Gear Drives
 Scotch yoke mechanism
- V. Designing the gear drive and belt drive with the structure analysis in ansys and Catia.
- VI. Validating the Design with theoretical Calculations
- VII. Manufacturing the Machine

Results in form of experimenting at stationary conditions and comparing our machine with conventional system

2. WORKING

The crop reaper is used to reap the crop like wheat, maize and rice type of crops. The crop reaper has four wheels to move and there is an engine to power the whole device. The power from the engine transfer to the v- belt drive and it goes to the centre shaft. There is a bevel gear attached to the central shaft transfer power to perpendicular direction. There will be a belt drive system attached to the chain drive assembly and there is some blades present to reap the crop properly. The rotary motion of the belt drive helps to move the scotch yoke mechanism to sideways along with it the reaper blade also move to cut the crops. The completion of harvesting marks the end of the growing season, or the growing cycle for a particular crop, and the social importance of this event makes it the focus of seasonal celebrations such as harvest festivals, found in many religions. Reaping is usually distinguished from mowing, which uses similar implements, but is the traditional term for cutting grass for hay, rather than reaping cereals. The stiffer, dryer straw of the cereal plants and the greener grasses for hay usually demand different blades on the machines. The reaped grain stalks are gathered into sheaves (bunches), tied with string or with a twist of straw



3. CALCULATIONS

Engine Specification

Mileage:	67 Kmpl
Engine Displ.:	99.7 cc
Speed	6000 rpm max
Max Power:	4.35 PS
Weight:	5 Kg
Starting:	Kick Start Only
Standard Warranty (Years):	1 Year

Step 1

Calculation of Torque

1ps = 735Watt
 4.35 ps = 3310 Watt
 Max RPM = 6000
 $P = \frac{2\pi nT}{60}$
 $3310 = \frac{2\pi * 6000 * T}{60}$
 $T = 5.27 \text{ N-M}$

Step 2

Calculation

Selection of Belt Drive

Engine RPM = N1
 = 2400RPM
 Output of belt drive required = N2
 = 2100 RPM
 Diameter of input pulley = D1 (From table no. 21-4 B)
 = 75mm
 Diameter of output pulley = D2
 = 280mm
 Selection of belts
 Power to be transmitted = 1.8KW
 Service factor = Fa = 1.2 (Service factor = 1.1 to 1.4 from table 21.1)
 Therefore
 Design power = Fa x Power to be transmitted [13.12.i.]
 = 1.2 * 1.8
 = 2.16kw
 Hence the Engine output power is safe

Pitch length of belt:

Center distance = $2x D2$

$$= 2 * 280$$

$$= 560 \text{ mm}$$

$$L = 2C + \pi(D+d)/2 + (D-d)^2 / 4C \quad [13.12.]$$

$$= 2(560) + \pi(75+280)/2 + (280-75)^2 / 4 * 560$$

$$= 1120 + 258 + 18.76$$

$$= 1396.76 \text{ mm}$$

$$= 1397 \text{ mm}$$

Cutting blade types = V edge section

V section = standard Blade type

Rectangle Width = 38 mm

Thickness = 3 mm

Angle between cutting edge and axis of knife section = 31°

Material - High carbon steel

Determine number of blades on reel Deflection angle $\theta = 54^\circ$ (constant angle)

Reel rotational speed = 100 Rpm

Rotational velocity of the reel

$$\omega = 2\pi N / 60$$

$$= 2\pi * 100 / 60$$

$$= 10.47 \text{ Rad/sec}$$

Gear Calculation

Peripheral speed of the reel

Decide upon the pitch, face, N_g , material, and heat treatment of a pair of straight Bevel gears to transmit continuously and indefinitely a uniform loading of 2.5 hp at 1200 rpm of the pinion, reasonable operating temperature, high reliability; $m_g \approx 1.75$; $D_p \approx 86 \text{ mm}$. Pinion overhangs, gear is straddle mounted.

1. Length of Pitch Cone Element (L):

$$L = (r_p^2 + r_g^2)^{1/2}$$

Pitch cone angle of bevel pinion:

$$\tan \gamma_p = 1/m_g = 1/1.75$$

$$\gamma_p = 29.7^\circ$$

$$L \sin \gamma_p = r_p$$

$$L \sin 29.7^\circ = 3.333/2$$

$$L = 3.86 \text{ in (convert into mm)}$$

$$L = 98 \text{ mm}$$

2. Tangential Force (Ft):

$$F_t = P/V_m$$

Where P = Power Transmitted,

V_m = Mean Pitch line velocity in m/s

$$F_t = (33,000 \text{ hp} / V_m)$$

$$V_m = (\pi * D_p * n_p / 60) = (\pi * 86 * 1400 / 60) = 32 \text{ m/s}$$

$$F_t = (33,000 * 2.5 / 32) = 11474 \text{ N}$$

3. Dynamic Load (Fd):

$$F_d = (V F) * N_s f * K_m * F_t$$

Where K_m = Load distribution Factor = 1.2, (One gear straddle, one not)

$N_s f$ = Application Factor = 1, (From table no. 22.24)

V_f = Velocity Factor

$$\text{Velocity Factor: } V F = (50 + V_m^{1/2}) / 50 \\ = (50 + 32/2) / 50$$

$$V F = 21.48$$

Dynamic load

$$F_d = (21.48) \cdot (1.0) \cdot (1.2) \cdot (11474) = 295.75 \cdot 10^3 \text{N}$$

4. Wear load (F_w):

$$F_w = D_p \cdot b \cdot I \cdot (s_{cd}^2 / C^2) \cdot (C_l / K_t \cdot C_r)^2$$

$$D_p = 86 \text{mm}$$

$$b = 0.6L = 0.3(84) = 25 \text{mm}$$

Temperature factor

$K_t = 1.0$, reasonable operating temperature

Life factor for wear

$C_t = 1.0$ for indefinite life (from table no. 22.15)

Reliability factor for wear

$C_r = 1.25$ high reliability

Steel on steel, $C_e = 2800$

Assume $I = 0.080$

$$F_w = F_d$$

$$(86) \cdot (1.0) \cdot (0.08) \cdot \left\{ \frac{s_{cd}^2}{(2800)^2} \right\} \cdot [1.0 / (1.0) \cdot (1.25)]^2 = 295.75 \cdot 10^3$$

$$s_{cd} = 465 \cdot 10^3$$

5. Strength of bevel gears (F_s):

$$F_s = (s_{bbj} / P_d) \cdot \{ K_t / (K_s \cdot K_t \cdot K_r) \}$$

Size factor, assume $K_s = 0.71$

Life factor for strength

$K_l = 1$, for indefinite life

Temperature factor,

$K_t = 1$, good operating condition

Reliability factor

$K_r = 1.5$ high reliability

Assume $J = 0.240$

$$b = 25 \text{mm}$$

s_d = design flexural stress

Min. BHN = 300

$s_d = 19 \text{ksi}$

$$F_s = F_d$$

$$(19,000) \cdot (1.0) \cdot (0.240) / P_d \cdot \left[1 / \{ (0.71) \cdot (1) \cdot (1.5) \} \right] = 295$$

$$P_d = 14.68$$

$$b = 10 / P_d$$

$$b = 10 / 14.68$$

$$b = 0.68 \text{in}$$

$$b = 18 \text{mm}$$

$$D_g = D_p \cdot m_g = (86) \cdot (1.75) = 147 \text{mm}$$

Material = steel,

BHN = 300

Design of shaft

Specification of shaft

Material of shaft (MS-low Carbon Steel)

Grade (40C8)

Max Power = 2.5HP

Speed = 1400rpm

Tensile strength (s_{ut}) = 640 N/mm²

Yield strength (s_{yt}) = 380 N/mm²

$$t_{\max} = 0.18 \cdot s_{ut}$$

$$= 0.18 \cdot 640$$

$$= 115.2 \text{MPa}$$

$$t_{\max} = 0.3 \cdot s_{yt}$$

$$= 0.3 \cdot 380$$

$$= 114 \text{MPa}$$

$t_{\max 1}$ is greater than $r_{\max 2}$

Hence the design is done by $t_{\max 2}$,

Now considering keyway effect on shaft:-

$$t_{\max} = 0.75 \times 114$$

$$= 85.5 \text{ MPa}$$

Taking Bevel Gear Torque 180 Nm

$$t_{\text{actual}} = 16 \times T_d / (\pi \times d^3)$$

$$85.5 = 16 \times 180 \times 10^3 / (3.14 \times d^3)$$

$$d = 22.45 \text{ mm}$$

As per the standard diameter is 28 mm.

But while doing production we consider the diameter of shaft as 30mm.

Now, checking shear stress for diameter 28 mm.

Design Torque (W): 180 N-m.

$$\text{Actual} = 16 \times T_d / (\pi \times d^3)$$

$$= 16 \times 180000 / (3.14 \times 28^3)$$

$$= 41.76 \text{ MPa}$$

$$t_{\text{actual}} < t_{\max}$$

Hence the design for shaft is safe.

Design of key

Material used for key - Mild Steel standard properties

Shear stress = 56 MPa

A Crushing stress = 112 MPa

for diameter $d = 28 \text{ mm}$ of shaft

Width and thickness of key (From Table no.17-1)

$$w = 10 \text{ mm}$$

$$t = 8 \text{ mm}$$

length of key can be obtained by considering shear stress and crushing stress

By shearing, torque transmitted is given by -

$$T = L \times w \times t \times (d/2)$$

$$T = L \times 10 \times 56 \times (25/2)$$

$$T = 7000 \times L$$

$$L = 24.54 \text{ mm}$$

Tensional Shearing Strength,

$$T = \pi / 16 \times t \times d^3$$

$$T = 171805.84 \text{ N/mm}$$

$$T = 1 \times t / 2 \times \sigma \times (d/2)$$

$$T = L \times (8/2) \times 112 \times (25/2)$$

$$T = 5600 \times L$$

$$L = 30.67 \text{ mm}$$

Approximate dimensions of Key

$$L = 32 \text{ mm}$$

$$W = 10 \text{ mm}$$

$$t = 8 \text{ mm}$$



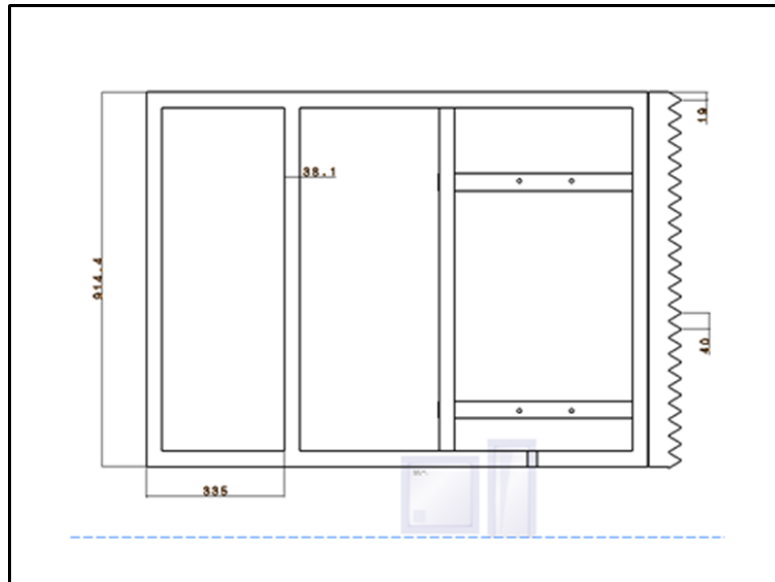


Fig. drafting of base frame

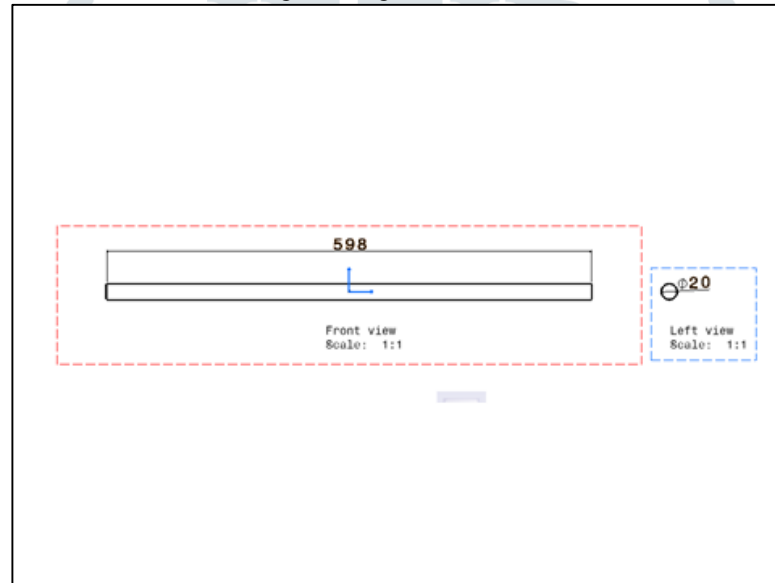


Fig. drafting of shaft

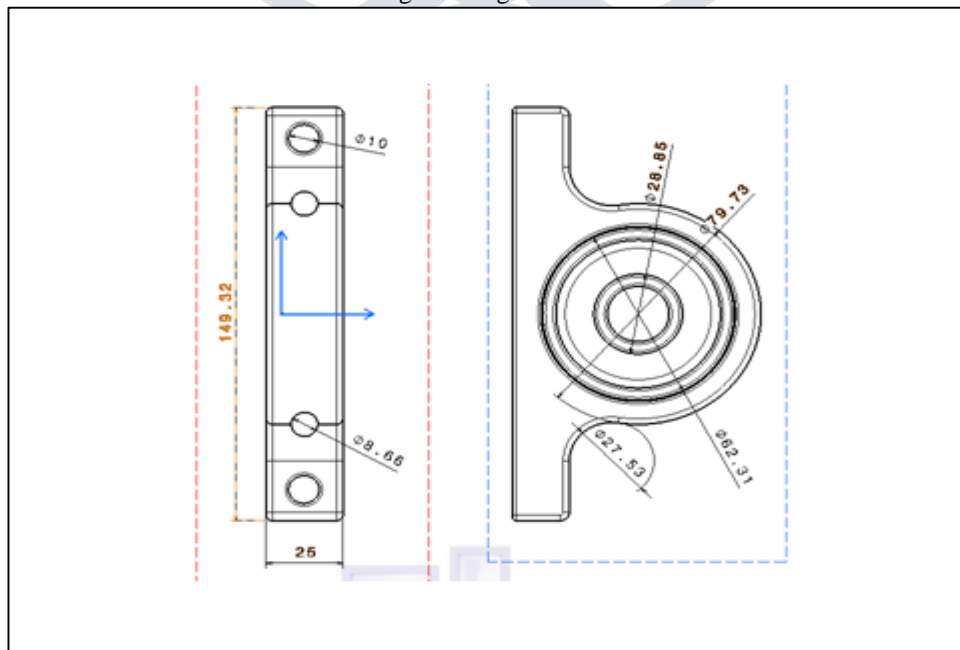


Fig. drafting of pedestal bearing

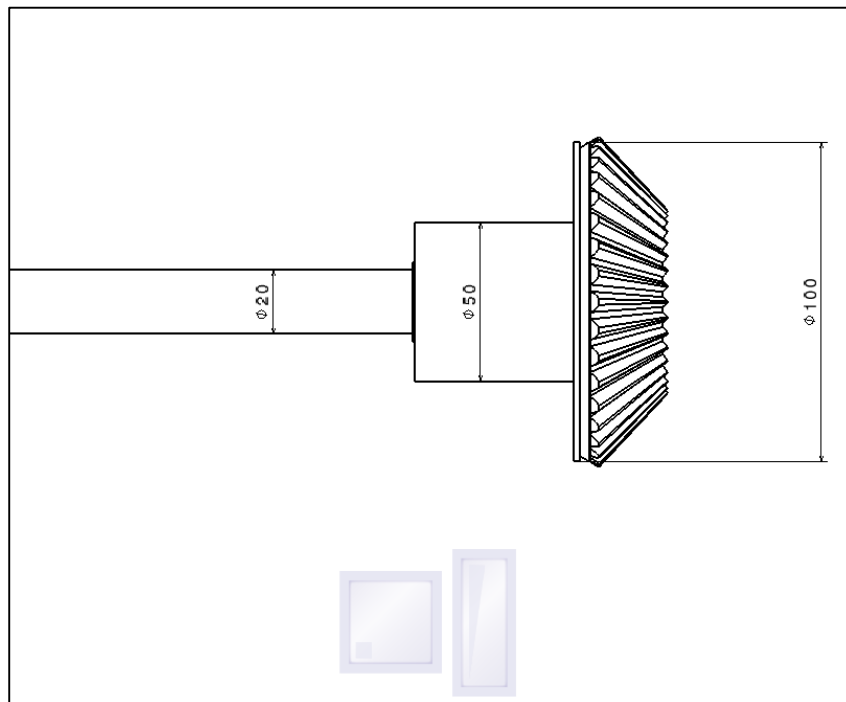


Fig. drafting of bevel gear

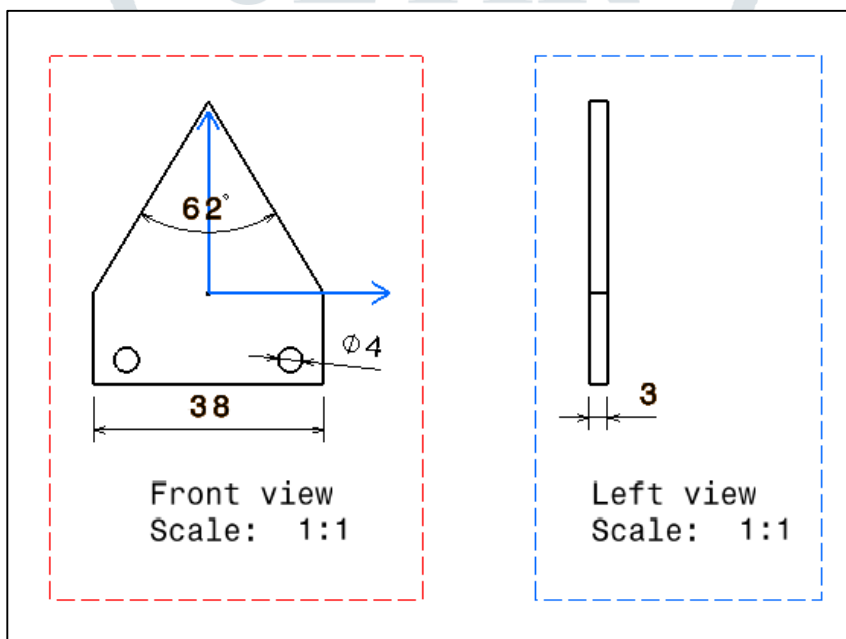


Fig. drafting of harvester blade

4. ADVANTAGES

After the design of portable crop reaper, the cost of harvesting using this machine will be considerably less as compare to manual harvesting. The design of machine Simple as well as easy to construct and machine will be easily maintained.

As very few farmers in our country are educated , so the uneducated farmers will be able to handle this portable machine easily.

Many farmers are either below poverty line or very poor and won't be able to keep on investing their money or spend for any reason again and again so this machine will help them in cutting their power consumption cost as well as the motor used are low capacity with good fuel mileage.

As well as the design of machine is such that the Noise of operation is reduced.

5. CONCLUSION

The designed machine will be used to trim heavy crops like corn and sugarcane easily. As well machine also can be automatically driven with the trimming.

The cost of harvesting using this machine is considerably less as compare to manual harvesting. Poor farmers can easily afford this economical crop reaper.

REFERENCES

- [1] P.B.Chavan, D .K. Patil, D .S. Dhondge, “Design and Development of manually Operated Reaper” IOSR Journal of Mechanical and Civil Engineering (IOSR- JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 3 Ver. I (May. - Jun. 2015), PP152
- [2] R. A. Ghumadwar, MR. V. H. Bankar, “Design and analysis of crop cutter” International journal of pure and applied research in engineering and technology, ISSN: 2319-507X, 2016; Volume 4 (9): 242-246
- [3] Tejaskumar Patel, Chetan Vora and Vipulkumar Rokad, “Design and Analysis of Arm of Reaper and Binder Machine” International Journal for Scientific Research & Development, Vol. 4, Issue 01, 2016 | ISSN (online): 2321-0613
- [4] Shalini P. Shivankar, Ashish. M. Wankhade, Mansur. N. Syed, “Design and fabrication of crop reaper” International journal for engineering applications and Technology, ISSN: 2321-8134
- [5] P. Chakaravarthi, Abuthaker. A, Arun. S, Karthikeyan. U, “Design and performance analysis of handy harvester” Vol-2 Issue-2 2016 IJARIE-ISSN (O)-2395-4396
- [6] Muhammad Nadeem , Muhammad Iqbal , Aitazaz Farooque, Anjum Munir, Manzoor Ahmad, Qamar Zaman, “DESIGN AND EVALUATION OF SELF PROPELLED REAPER FOR HARVESTING MULTI CROPS” , Paper Number: 152189141 , DOI:10.13031/aim.20152189141
- [7]Shravan U. Burade¹, Rohit S. Ghatule², Varad G. Kannadkar³, Neel V. Sonawane⁴, “Design and Fabrication of Agricultural Crop Reaper” , International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072
- [8]Mr. R. A. Ghumadwar¹, Mr. V. H. Bankar, “DESIGN AND ANALYSIS OF CROP CUTTER” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 07 | July-2016 www.irjet.net p-ISSN: 2395-0072
- [9]Aravind C, Shivashankar V, Vikas R, Vikas V, “Design & Development of Mini Paddy Harvester” International Journal for Scientific Research & Development| Vol. 3, Issue 05, 2015 | ISSN (online): 2321-0613
- [10] V B Bhandari , “Design of MACHINE ELEMENTS”.IVth Edition, Page No: 328-378, 494-536,699-717.