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Design and Development of Tractor Operated Spin Groomer

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A B S T R A C T

Tillage is major operation for seedbed preparation and defined as the physical, chemical and biological manipulation of soil to obtain an optimized plant growth. Tillage requires about 60 % of time and energy during the total crop production. A study was taken to design and develop a power less self-propelling vertical axis rotary spin groomer. The purpose of the implement development was to cover more filed in a single pass for reducing the operational time, collect the uprooted residues and to leave it in one end of the ground. Spin groomer designed by using a "solid work 2018 software" and developed in a workshop. Major component of the developed implement is Mainframe, 3-point hitch, circular wheel, pegs and rake. A frame is for holding the different component of the implement. The pegs tightened on circular wheel with the help of suitable nut and bolts. Since the implement converts the forward motion of tractor into rotary motion, hence an axle provided at the rear end of the implement, which holds the bearing assembly and circular wheel. The implement designed to match the any kind of tractor having a power range of 35-horse power or more.

Introduction

The recent seedbed preparation practices used by the farmers and the equipment used to conduct various operations require detailed research and study. It is required to minimize the operational cost and improve the efficiency of the system by studying the best alternative, either operation wise or equipment wise for farmer's benefit. Mechanization plays a vital role in agriculture through timely operation for increased productivity and profitability. In Chhattisgarh, most of the tillage operation was done either animals or by traditional methods. Traditional methods and animal power increases the time of operation and increases the dependency on labors. Thus, there is need to shift towards the mechanical power which are more economical than

conventional methods of tillage.

In the view of the above statements, there is a need to develop a tillage implement, which is more economical, and consumes less energy as compared to the conventional methods.

A rotary till opts to be the best implement for tillage operation, and can carry out work such as uprooting of weeds, breaking of big clods, and carrying of uprooted grasses and crop residue outside the field. The machine, which is developed, carries out various works such as uprooting and carrying the grasses of the field. The wheel's spinning motion leaves the straws and the grass outside the ground. Similar to a plough and a harrow, the machine also breaks large clods and soil lumps that is a necessary step for seedbed preparation.

Materials and Methods

Tractor operated spin groomer was designed and developed by using Solid Works software and fabricated at IGKV Raipur. Designing of implement consists of following design considerations:

The developed implement should be simple in design.

The implement should be optimally efficient in every load condition.

The machine should be economical.

The machine designed in such a way that it requires less maintenance.

The cost of operation of the implement should be less.

The various components that are required to design for development of spin groomer:
Power requirement

Development of frame

Development of 3-point hitch

Development of circular wheel

Selection of proper size of bearing

Design of pegs

Design of rake

Power requirement

Power required to pull an implement draft force was measured by pull force and weight of the implement. It was calculated by formula given in IS 7640-1975.

Draft force was calculated by using the following formula

$$P = \frac{F \times S}{1000} \ldots (1)$$

Where,

F = Force on implement, N; and

S = Speed of operation, km/h;

Pull force was calculated by using the following formula

$$D = p\cos\Theta \ldots (2)$$

Where,

D = Draft, N;

p = Pull, N; and

Θ = Angle between line of pull and horizontal;

Weight of the implement was found to be 165 kg

Development of mainframe

Mainframe consists of following two assemblies' *viz.* 3-point hitch and circular wheel. The 3-point hitch were designed by using the solid works 2018 software. Centre-to-center distance of rear wheel of tractor (New Holland 3630) taken as the diameter of the circular wheel.

AutoCAD view of both the assemblies shown in Fig. 1 and 2.

Selection of proper size of bearing

The proper selection of bearing was essential to bear the entire axial and thrust load. Following formula was used before the selection of bearing and given by Khurmi and Gupta, (2005)

Basic dynamic load is calculated by

$$F = X \times V \times Fr + Y \times Fa \quad \ldots (3)$$

Where,

X = Radial load factor;

Y = Axial load factor;

V = Rotation factor, 1 for all type of bearing when the inner face rotating;

Fr = Radial load, N; and

Fa = Axial load, N;

Design basic dynamic equivalent radial load is calculated by

$$F = F \times Ks \quad \ldots (4)$$

Where,

Ks = service factor, for heavy shock load 1.5; and (Varshney *et al.*, 2004)

F_e = basic dynamic equivalent load;

Calculate the basic dynamic load rating

$$C = F_e\left(\frac{L}{10^6}\right)^{\frac{1}{k}} \ldots (5)$$

Where,

L = Rating life of bearing in no. of revaluation; and

F_e = maximum load acting on the bearing;

Design of pegs

The pegs designed by using following formula given by Varshney *et al.,*

The sectional modulus of pegs was calculated by classical flexure formula

$$\sigma = \frac{MC_1}{I} \ldots (6)$$

Where,

M = Maximum bending moment, N-mm;

C_1 = distance from natural axis to point at which stress is determined, mm = t/2; and

I = moment of inertia of the section, mm^4 = $1/12(bt^3)$;

The thickness of the peg was calculated by below formula

$$b = \sqrt[3]{6Z} \ldots (7)$$

Where,

b = Thickness of the peg; and

Z = Sectional modulus;

Design of rake

The rake designed by using solid works software and depicted in fig. 4.

Computer aided design of spin groomer

Selection of material for fabrication of different component of spin groomer

Fabrication of different component of spin groomer, the BIS test code IS: 6813-2000 was followed for selection of materials.

Result and Discussions

The tractor operated spin groomer consists of following component: i.e. Mainframe having 3-point hitch and circular wheel, Pegs, Axle, Bearing assembly and Rake.

Mainframe was fabricated out of 1219.2×70×70 mm³ (L×W×T), mild steel angle bar which acts as a strut. The bottom section of the3-point hitch system connected with strut and supported by MS angle bar of 50×10 mm².

At the rear end of the strut an axle having 50 mm diameter and 500 mm, length made by mild steel of grade Fe 410-s, attached to hold the bearing assembly. A circular wheel of 152.4 cm diameter made by 70×70 mm² hollow square MS angle iron on which the pegs were attach by nut and bolts. At the centre of the wheel these is a provision for assembling of bearing hub and bearing. A tapered roller bearing selected for smooth rotation of the wheel and to withstand entire axial and thrust load. By all the calculation of basic dynamic equivalent load, referring the bearing number of 6210 having dimension 50 mm bore-dia., 90 mm outside dia., and 20 mm thick bearing was selected.

A 20 mm diameter rod (Carbon steel of grade 60) used to fabricate the pegs by tapering the lower end, which is tightened on the circular wheel with the help of nuts. Pegs had dimensions of 203 mm length, 20 mm diameter and 3 mm tip diameter so it can easily penetrate into the soil during field operation. There are 54 pegs were fabricated to attach on the circular wheel.

A rake was fabricated by 152×70×70 mm³ (L×W×T) of hollow square MS pipe. At the bottom end of the rack, 15 pegs was welded to collect the weeds during operation and level the ground (Fig. 1–6 and Table 1).

Fig.1 CAD view of 3-point hitch

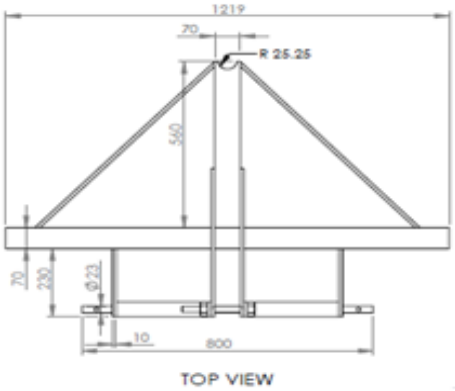

Fig.2 CAD view of circular wheel

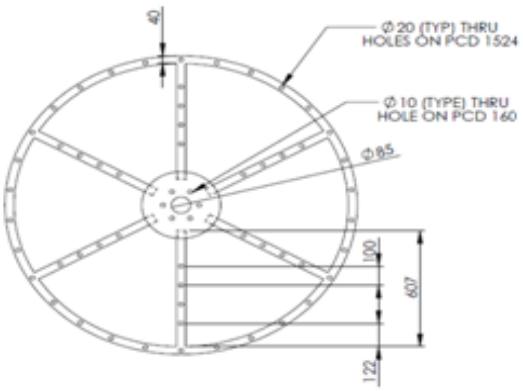

Fig.3 CAD view of peg

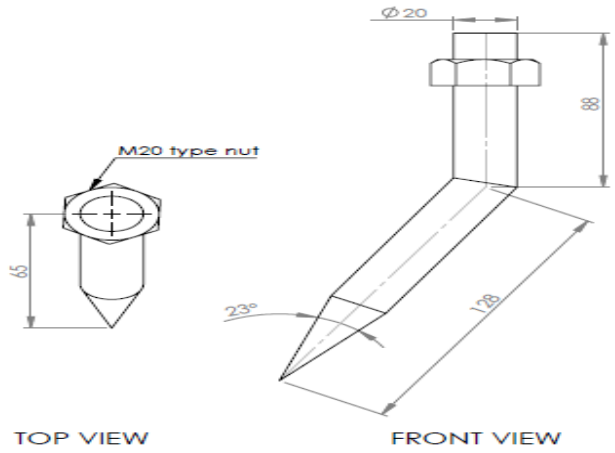

Fig.4 CAD view of rake

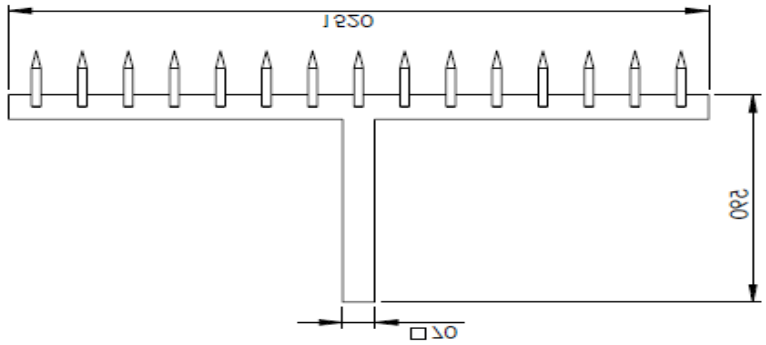

Fig.5 CAD view of spin groomer

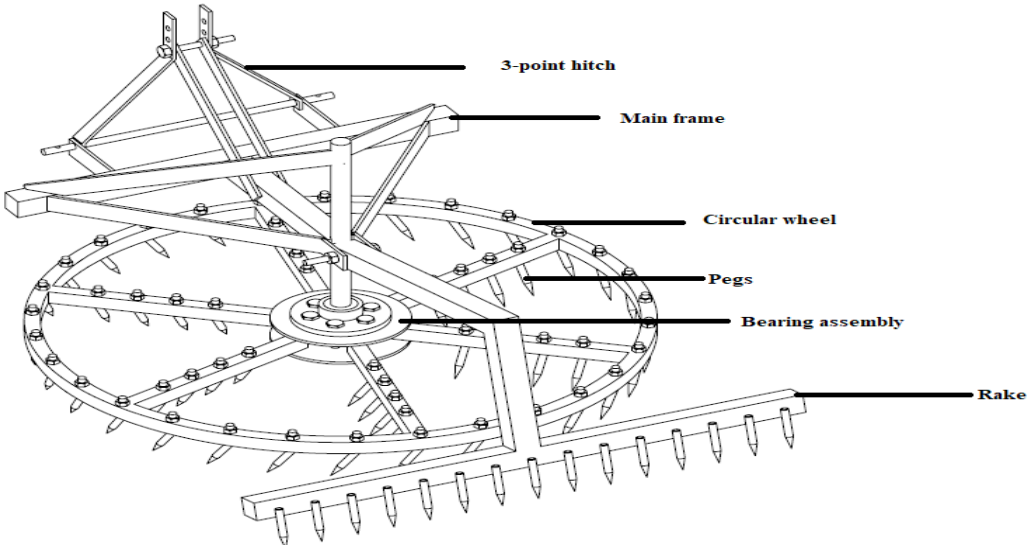

Fig.6 Developed spin groomer

Table.1 Specification of material used for fabrication of different parts of spin groomer

Component	Particulars	Material
Axle	Axle diameter should be of 50mm	Mild steel of grade Fe 410-s
Frame	It is made of mild steel angle iron Circular wheel in made by 50×50 mm square hollow pipe rounded at 154.4 cm diameter	Mild steel square pipe
Pegs	Pegs used in spin groomer Length of peg, mm: 203 Peg diameter, mm: 20 Diameter of tip, mm: 3	Carbon steel of grade 60 C6
Bearing used	6210 bearing number is selected having 50 mm bore dia., 90 mm outside dia., and 20 mm thickness	Chrome SAE 52100 bearing steel
Rack	The frame of the rack is made of MS square pipe having 70×70 mm No. of spikes: 15 Size of the rake or working width of rake	Mild steel

Table.2 Specification of the developed spin groomer

S. No.	Specification	Dimensions
1	Location of implement	Rear end of tractor
2	Hitch type	Category–I type 3-point hitch, 1219.2×70×70 mm³
3	Pegs	54 no. of pegs, 203 mm long, 20 mm thick and 3 mm tip diameter.
4	Angle of pegs, °	40
5	Diameter of circular wheel, cm	154.4
6	Bearing	Tapered roller bearing, 50 mm bore dia., 90 mm outside dia., 20 mm thick
7	Rake	1520 mm, 590 mm and 70 mm
8	Power required, hp	35

The specification of the developed spin groomer depicted in the table 2.

A spin groomer was successfully developed and it was tested in the field. It is helpful for both pulverising the soil as well as collection of weeds in the field. The spin groomer cover more filed in a single pass for reducing the operational time, collect the uprooted residues and to leave it in one end of the ground with a effective field capacity of 0.5 ha/h.

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