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DESIGN & ANALYSIS OF LAWN MOWER

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Abstract: A manually operated apparatus for cutting grass was designed, fabricated and tested. The apparatus was designed with an internal spur gear system which transfers the torque to the mower spiral mechanism. The cutting mechanism is made of a flat blade rigidly fixed to the frame behind the spiral arrangement which is configured to contact at least one reel bar of the spiral blades during the rotation of the spiral mechanism. Its friendly to the environment, because it does not emits carbon monoxide into the environment and the noise level is drastically reduced. The machine is more efficient in a soil with low moisture content.

Keywords: Lawn, spiral blade, mower, field capacity, field efficiency.

1. Introduction: Lawn maintenance and landscaping remain the most important constraints to keeping a clean and fresh looking gardens and yards. Places that experience incessant rainfall throughout the year results in fast and tall growing grasses which are detrimental to the environment and purpose of keeping the lawn landscapes. Land clearing involves the removal of vegetation such as trees, bushes, shrubs grasses etc. but the clearing is done with respect to the purpose of the land utilization. For instance, construction works (highway, dam, building etc.) total removal of vegetation is necessary.

Dakogol et al., (2007), stated that in farming practice, removal of vegetation up to 100mm below ground level is very important. Clearing operation is also done in gardens and surroundings of premises. This involves four different methods which are employed for land clearing, via; physical uprooting of trees and vegetation, cutting the vegetation at ground level and collecting the same for burning or allowed to decay, crushing down the vegetation or ploughing and mixing in the vegetation to a soil depth of about 200mm.

These methods of land clearing can be done manually using axes, machetes, brush hooks, power saws and sickles. This can be done mechanically using bulldozers, tree rake, tree pushers, shear blades and mowers. A lawn mower is an apparatus that has one or more revolving blades to cut grass or other plants of a lawn at an even height.

Lawn mower is an essential tool for the maintenance of yards. They vary in size, mode of operation, and power. The power source riding mowers for example are usually powered by a gasoline engine and are ridden and steered by the operator. Walk behind mowers are designed to be pushed by the operator and typically run on gasoline or electricity. Modern gas powered and electric powered lawn mowers cut grass with a single blade revolving at a high speed parallel to the ground. The blade is slightly raised along its rear edge to create draft that lifts the cutting blades before its cutting operation. Mulching mowers suspends clippings and other debris near the blade shredding them before blowing them straight down in the lawn where they serve as manure for future lawn growth. Okoro, (2010) designed a locally operated engine powered lawn mower. The mower is fitted with horizontal cutting blade attached to a vertical shaft. The mower was tested and the average effective field capacity and efficiency were 0.127 ha/hr and 88.4% respectively. However, all the above mentioned type of mowers are not friendly to the environment, because enough carbon monoxide is emitted into the environment, there is much vibration on the part of the operator, and there is also very serious noise pollution. Jeremy, (2005) designed and fabricated solar charged lawn mower. The machine was dependent on weather since the battery would be charged using photovoltaic panel (i.e. solar panel). The common disadvantage was that the engine runs down easily and the cost of production was high for an average individual to purchase. Victor and Verns, (2003) designed and developed a power operated rotary weeder for wet land paddy. The complex nature of the machine makes its maintenance and operation difficult for the peasant farmers. Generally, in areas like ours, the conventional methods of grass cutting involved the use of cutlasses which never met the maximum satisfaction. More so, it is strenuous, time and labour intensive. Therefore, there is the need to develop a locally, fabricated spiral lawn mower which can take care of this operation easily.

The objective of the study is to design and develop a locally fabricated non engine powered spiral blade lawn mower affordable by peasant farmers

2. REEL MOWER PARTS

There are three main structural members in a reel cutting unit:

1. The REEL consists of varying numbers of helix shaped blades attached to support spiders which are mounted on a rotating shaft.

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2. The BEDKNIFE is attached to the bed bar and the assembly is mounted to the main frame in a manner that allows for paralleling and adjustment to the reel.

3. The FRAME supports the rollers, the bed bar assembly and reel with its drive mechanism, which can be hydraulic, belt driven or ground driven. A reel mower cuts grass with a scissors-like shearing action as the moving helix shaped blades pass over the stationary bed knife.

The cutting action requires that the bed knife and reel blades be sharp, matched, and in close relationship with each other. When properly maintained and operated, reel mowers provide superior quality of cut. It cannot be overstated that reel mowers are precision tools. It is essential that they be adjusted and operated with this in mind.

3. WORKING PRINCILE OF LAWN MOWER

The cutting mechanism is made of a flat blade rigidly fixed to the frame behind the spiral arrangement which is configured to contact at least one reel bar of the spiral blades during the rotation of the spiral mechanism.

To understand reel cutting theory, we must understand the concept of clip and the shear point. A shear point is any single point of contact made between the reel blade and bed knife. Clip is the forward distance traveled between successive blade contacts at one shear point.

The bed knife pushes grass toward the shear point while the reel blade gathers it in front. Each blade path has one-half clip in which to cut all the grass. The pushing force required to move the reel mower is given by the handle bar.

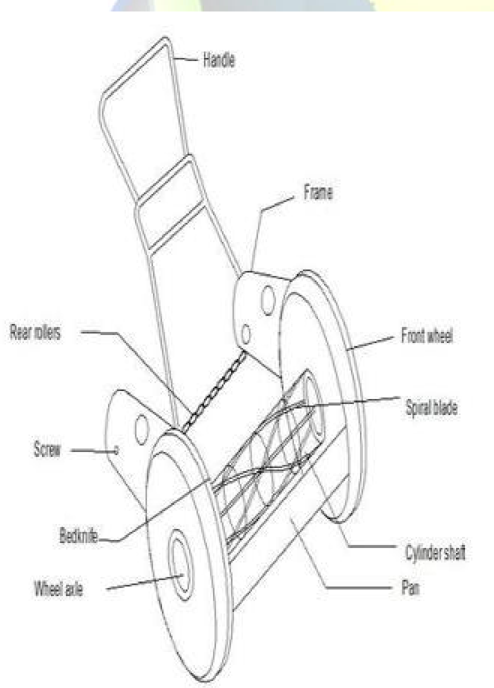

Fig. 1 Lawn Mower

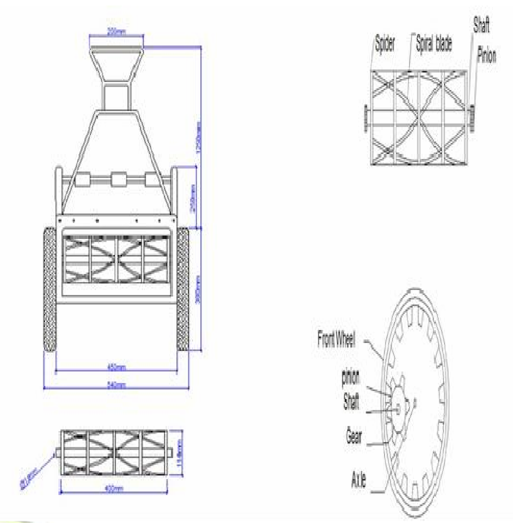

Fig 2 Different views of mower

4. DESIGN CALCULATIONS

SPECIFICATIONS Diameter

of the blade = 20mm Length of

the blade = 200mm

Thickness of the welded portion = 3mm

Blade material – C35 steel

Specific weight = 7.84x10-8 N/mm3

E = 2.06x106 N/mm2

τ = 65 Mpa

WELDING CALCULATION

At one side

Perimeter of the welded portion (P)

P = Aτ

= πdtτ

= πx20x3x65

= 12.15 KN

BENDING CALCULATION

M = Pl

= 12150x200

= 24.5x105 N/mm2

Z = (d2 2

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$+ \pi D2)$ t

= (πx202 2

+ πx202) 3

= 126292.02 mm2

Bending stress (σb1 at one side)

σb1 = M Z

= 24.5x105 12.629x104

σb1 = 19.3 N/mm3

Similarly for other side of welded portion

σb1 = 19.3 N/mm3

Total Bending stress σb

σb = σb1 + σb2

= 19.3 +19.3

σb = 38.79 N/mm3

Maximum normal stress (σb(max))

σb(max) = σb 2 + √σb2−4τ2 2

σb(max) = 38.79 2

+ √(38.79)2+(4x65)2 2

σb(max) = 87.226 N/mm2

Maximum shear stress (τmax)

τmax = 1 2 + √$\sigma b2$ + 4τ2

= 1 2 + √38.792 + 4(65)2

= 33.91 N/mm2

TORQUE AND SPEED OF THE BLADE

Torque T = Fe

= 12500x400

= 4.9x106 N.mm

Speed N = 60P 2πT

= 60x12500 2π(4.9x106)

= 41.8 rpm

GEAR CALCULATION

Internal gear

Z1=63 Z2=12

Gear Ratio (i) = Z2 Z1

i = 0.2

P = 12.25 Kw

i = N1 N2

N1 = 42rpm

N2 = N1 i = 42 0.2

N2 = 210 rpm

Type is internal gear

SELECTION OF MATERIALS:

Pinion = C45 Steel [σc = 5000 kgf/cm2] , [σb = 1400 kgf/cm2]

Wheel = C45 Steel [σc = 5000 kgf/cm2] , [σb = 1400 kgf/cm2]

Min center distance (a):

a ≥ (i-1)√(0.74 σc

E[Mt] iΨ

E = 1.4 kgf/m2

Ψ = 0.3

[Mt] = Mt kd k = 36938.4 kgf.cm

a ≥ 21 cm = 210 mm

Min Module (m) :

m ≥ 1.26 √([Mt] Y[σb]ΨaZ1) 3

Z1 = 63

Mt = 36938.4 kgf.cm

Y = 0.490

Ψa = 10

m ≥ 5.55 mm Std module M = 6 mm

P.C.P

For d1 = m Z1 = 6 x 63 = 378 mm

d2 = m Z2 = 6 x 12 = 72 mm

Corrected Center Distance:

a = m (Z1+Z2 2) = 225 mm

aact > amin

Design is Safe

Ψ = b a = 0.3

36

Ψm = b m

= 10

b = 60 mm

b = 67.5 ≈ 68 mm (highest)

σc = 0.74 i−1 a

√i−1 ib

E [Mt]

Mt = 36938.4 kgf.cm

i = 0.2

b = 6.8 cm

E = 1.4 x 106

a = 22.5 cm

σc = 2294.5 kgf/cm2 ≤ 4500 kgf/cm2

Design is safe and satisfactory

σb = i−1 $aMby$

[Mt]

σb = 656.9 kgf/cm2 < 1400 kgf/cm2

Design is safe

CUTTING BLADE CALCULATION

L = Length of the Blade (m) = 310 mm

r = radius of the cylinder (m) = 50 mm

i = helix angle (degree)

i = Cot-1(L $2\pi r$

)

= 11.08 degree

5. Results and discussion

The performance test of the spiral blade lawn mower is presented in Table 2, indicating the value of the computed effective field capacity (FC_e) and field efficiency(%).The highest effective field capacity is obtained as 0.082ha/hr and Field efficiency (%) as 71.3%, with operating time of 0.00972hr. This may be due to variations in level of moisture contents during the time of field operation. The theoretical field capacity (FC_t) of the machine was calculated to be 0.115ha/hr with forward speed of 0.8m/s and the theoretical width of 0.4m.

The machine was seen to be more effective when working in a dry soil condition, because there is proper gripping of the tyres in a dry condition of the soil.

The field efficiency of plots 1, 2, 4 and 7 are generally low. This is attributed to the wet conditions of these plots as there was poor gripping of the tyres on the soil (.i.e. wheel slip). Figure 4, shows the relationship between the effective field capacity and operational time. There is an increasing linear relationship of effective field capacity with increasing operational time. This is an indication of the effect of more time expended during field operations, resulting to effectiveness in grass cutting. Field efficiency, increases with increase in operational time.

6. CONCLUSION

The helix blade lawn mower was designed, fabricated and analysis. This does not have engine and is powered by the operator. Test revealed that, higher grass cutting efficiency is obtained when the lawn is dry before mowing. The machine is simply powered by manual pushing. Therefore, it can be used by both rural as well as urban dwellers. It is also affordable since the cost of production is low. High moisture content and undulated nature of the field surface affected the efficiency of the machine.

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