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Development of a Gasoline Powered Cutter

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ABSTRACT

The design and construction of the gasoline powered cutter is presented. The objective here is to reduce the time and mechanical energy exerted in during the machine use, to increase the power of the engine from 6.5 HP to 25 HP in other for task to be performed easily and smoothly. The gasoline power cutter was designed and assembled to give a better performance that satisfies the need of the people, and to equally overcome the problems that the existing technological development faced due to less power output. This was accomplished by providing a shaft known as the flywheel power multiplier which helped to boost the performance of this machine. The methods adopted includes the design stage, fabrication and testing. The engine of this machine produces a speed of 3000rpm. The machine has a circular saw that is being powered by the engine that cuts through or cross cuts any type of wood within a limited time. All materials used for the fabrication or construction of this machine were sourced locally.

KEYWORDS: *Gasoline, Power, Cutter, Energy, Machine*

INTRODUCTION

The use of gasoline powered cutter cannot be overemphasized particularly in an environment where the issue of electricity generation is problematic. Moreover the idea of saving generated energy for use by the powered cutter gives it an edge over other available types. This energy storage capability helps to rectify the mismatch between generation and demand at any loading condition.

One distinct characteristic of flywheels is the huge numeral of charge/discharge cycles, which can reach hundreds of thousands, self-governing of the depth of discharge DOD). The lifetime expectancy of 20 years or more is much longer than other energy storage devices. Monitoring the state of charge in flywheels is simple and reliable as the rotational speed is only required as the rotational speed is only required.

The aim of the study is to design and construct a gasoline power cutter, inculcating in it the flywheel power multiplier system (FPMS) that will help to store electrical energy, as well as increase the electricity supply quantity.
The objectives of this study include;

i. To identify the essential components of the system.
ii. To design the gasoline power cutter
iii. To construct the gasoline power cutter
iv. To achieve an increase in power from 6.5horsepower to 25horse power of the machine.

The existing electric grid systems (systems of interconnected network for delivering energy from producers to consumers) are not designed to meet the requirements of the modern society, such as small scale independent generation units, increasing use of digital equipment etc. The traditional electric grid consists of large generation units far from end users, and power is transferred in a main high voltage transmission grid to local low voltage distribution grids. The FPMS will meet the requirement of today's society, it will bring about large scale use of renewable energy source, reduction in peaks in electricity demands, more active consumers, and increased efficiency in the use of electrical energy.

LITERATURE REVIEW

One of the first modern dissertations in analyzing the flywheel rotor was the seminal work done by Stodola (1997). Millenson and Manson (1948) extended the method to include plastic flow and creep. These methods have been widely used and extended by industry. Wahl et. al. (1954) conducted the creep test in a rotating disc made of steel and simulated the results theoretically using von Mises and Tresca yield criteria describing creep behavior by power law relation and noticed that the creep deformation based on Mises criterion yielded slightly lower values compared to the experimental values, however, the theoretical results based on maximum shear theory, was found to be in a better agreement with the test values.

The 1960s and 1970s lead to numerous other serious efforts in analyzing the rotor, and introducing different designs for the flywheel, with the onset of composite material development giving added impetus. A detailed review of the rotating disk problem up through the late 1960s is given by Seireg (1970). The past 50 years showed a tremendous amount of work done concerning the rotating disc. Several investigators (Arya (1979), Bhatnagar et. al. (1986), Biner (2002), Bueno et. al. (1992), Gupta (2008), Sharma (2008), Singh and Ray (2001), Cao and Pollock (2009) etc.) used Norton's power law to describe creep behavior of metal matrix composites. Arya and Bhatnagar (1979) carried out creep analysis of rotating orthotropic disk using constitutive equations as obtained by Bhatnagar and Gupta (1966) and a time hardening law. The analysis was based on the theory of Tresca criterion and its associated flow rule, and used the exponential function creep law for steady−state conditions. Guven (1998) investigated the deformations of constant thickness rotating annular disks with rigid inclusion in the fully plastic state and obtained analytical solution using Tresca yield condition assuming linear strain hardening. Elastic−plastic deformations of rotating hyperbolic disks with rigid inclusion were studied by Guven (1998) to obtain exact solution for linearly hardening disks using Tresca yield criterion and its associated flow rule, considering small reductions in disk thickness and small values of the hardening parameter.

In summary, the previous work conveys the complexity of the problem, in that a very large number of conditions and factors must be considered. In particular, each of the listed investigations have necessarily focused on some specified conditions, particular material behavior and related conclusions.

Flywheel Power Multiplier

Most Flywheel power multiplier use electricity to accelerate and decelerate the flywheel. The rotational pace of the flywheel is condensed as a consequence of the code of protection of energy, adding power to the system likewise results in an add to in the speed of the flywheel. Recently the devices that directly use mechanical energy is being developed. (Wayback Machine, 2007).

Figure 1: NASA G2 flywheel

Components of the Flywheel Power Multiplication System

This design is a modification of the flywheel power multiplication system, and it has the following parts:

Saw Shield – The saw shield is used to protect the circular saw from corrosion, and also for safety purposes.

Circular Saw - The circular saw is used to cross cut through the wood.

Supporting Frame Or Table - The supporting frame or table, helps to hold the work piece in position.

Bolt And Nut - The bolt and nut helps to hold the work piece firmly in position.
Shock Absorber - The shock absorber is either a mechanical or hydraulic device used to absorb and damp the shock impulses.
Washers - The washers ensures that the nut is pressed against a smooth surface, reducing the chance that it will gradually loosen because its in contact with an even surface.
Flywheel Power Multiplier - The flywheel power multiplier is used to increase the power transmitted from the engine.
GX 200 Engine - This engine is used to burn or consume fuel to perform mechanical work by exerting a torque or linear force (usually in the form of thrust).
Welding Electrode - This welding electrode is used to join two metal pieces together.
Coupling-The coupling in this machine helps in balancing the shaft of the engine with the shaft of the flywheel, it also ensures proper alignment of the engine with the flywheel.

METHODOLOGY

The following procedures or measures were undertaken during the construction or fabrication of the machine. Different parts were put in place, measurements of these parts were carried out, machining operations were carried out and assembly processes were equally carried out.

During construction, four pieces angle iron was cut out measuring 22 inches length angle bar each, to make a stand. For a table in between the two legs, a cross member was put to make the four vertical legs more rigid and firm, then another 29 inches length of angle iron was cut, using it to create another cross member from the leg on the left side of the table, thereby further creating a reinforcement. After the construction of the table, three inches length of angle bar or iron was cut out and welded to the top right side of the table, three on the left and three on the right side of the table, after which a basement was created on which the engine is to seat upon. This same basement served as a base for the flywheel to seat upon, and also a base for the blade to seat upon. This base also created a flat surface that will allow the operator or user of this machine to put in the work piece (wood) into the blade for cutting, either to be sawed straight or to be cross-cut.

The flywheel used in this machine was to increase the power output of the multi-purpose engine. The flywheel is a 25kg round heavy metal without any form of shaft on it to allow us use the flywheel. For this machine on project, we constructed a shaft on each side of the machine with support bearings on the shaft to allow for free and smooth rotation of the flywheel. The flywheel and the shaft were bolted together, creating a shaft on the left side of the flywheel, and also a shaft on the right side of the flywheel. The bolt and nut on the shaft were all welded together to keep them firmly in position, after which they were taken to the machine shop for machining. The machining was also carried out on the shaft that was on the flywheel to all a 2063 gearing to go into the shaft thereby serving as a support bearing allowing for smooth rotation.

The other end or one end of the flywheel was further machined to a small stored, to allow the saw that is to be driven go into the stored, thereby creating a small shaft with thread on it and a nut that is going to hold the saw in place. With this mechanism, as the multi-purpose engine produces its own rotation, the rotation is transmitted to the flywheel through shaft. The flywheel therefore rotates at high speed (3000rpm), the flywheel at that speed becomes the source of power with the 6.5 horse power the multi-purpose engine is able to produce and the power the flywheel is able to produce.

These two powers were put together and used to drive the circular saw thereby giving off up to twenty-five horse power. This twenty-five horse power ascertained can only be made possible electrically with a three phase induction motor. A three phase induction motor, requires so much power to operate from a three phase power source, whereas in this project, the same power with lesser input has been ascertained.

The component parts of the design, their dimensions, calculations and their equations were determined.

DESIGN CALCULATIONS

The Supporting Frame or Table Design

The supporting frame or table, helps to hold the work piece in position.

a) For tensile stress induced on the table,

Stress σ = P/A

P = Force or load acting on the body

A = Cross-sectional area of the body

Where P = 1200KN

A = length x breadth (l x b)

Length of the table from the ground to the base of the (6 x 200 engine) = 1115mm

Breadth of the supporting table = 558mm

A = 1115mm x 558mm = 622170mm^2 or 0.62217m^2

Stress σ = 1200KN = 1930KB/m^2 = 0.62217m^2

b) For tensile strain induced on the table

ε = δL/L or δL = ε.L

δL = change in length of the body

L = Original length of the body

Overall length of the table after deformation = 1114mm

Tensile strain ε = 1115mm/114mm = 1.008

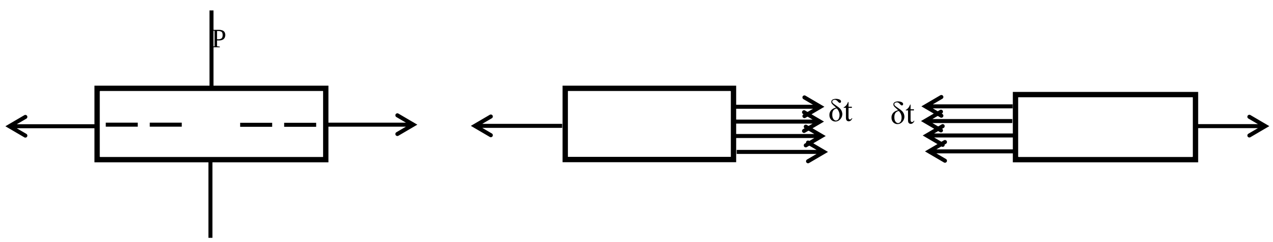


Fig. 2: Tensile Stress and Strain Diagram

Angle Iron Design

a) Resistance offered by the angle Iron

R = ρL/A

Where R = Conductor resistance at temperature (T)

ρ= Resistivity = 1 x 10^{-7} Ω-cm width = 2 inches

L = length of the iron = 125inches

A = cross sectional area = 250sq inches

R = 1 x 10^{-7}125inches

250sq inches

R = 5.00 x 10^{-6} Ω

b) Thickness of the angle iron

Thickness = Volume (v)

Area (a)

Volume of the angle iron = 80 cubic centimeters i.e 80cm^3

Cross Sectional Area of the angle iron = 12cm^2

Thickness = 80cm^2 = 6.67cm

12cm^2

Circular Saw Design

The circular saw is a cutting tool, used to cross cut through the wood producing wood chunk, wood pellet, shredded wood and sawdust as raw materials.

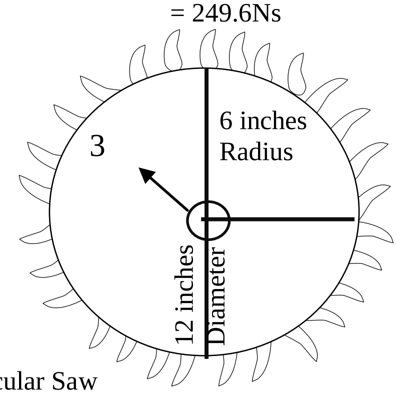
a) Area of the circular saw (A) = πr^2
where π = 22/7 or 3.142
Radius (r) = 6 inches
Diameter = 12inches
Cross-sectional area (A) = 22/7 x 6 x 6 = 792/7
Cross-sectional area (A) = 113sq inches

b) Perimeter of the circular saw (P) = $2\pi r$, π = 22/7, r = 6 inches
2 x 22/7 x 6 = 264/7 = 37.714 inches

c) Cutting force of the circular saw (F) = $m\frac{(v - u)}{t}$; where a = $\frac{v - u}{t}$
m = mass of the saw = 50g
u = initial velocity = 0
v = final velocity = 5m/s
t = time = 2 mins
The circular saw moves at a velocity of 5m/s in 2mins (120sec).
$F = \frac{250 - 0)}{120} = \frac{250}{120}$
Hence, cutting force (F) = 2.08N

d) Impulse of the force exerted by the circular saw
impulse = force x time (F x t)
impulse = Change in momentum
Hence, Force x time = change in momentum = f x t
Buth change in momentum = MV – MU = M(V-U)

Therefore, F x t = m(v – u)
Cutting force exerted by the circular saw (F) = 2.08N
Time = 120 sec
Impulse (I) = f x t
= 2.08 x 120
= 249.6Ns



No. of teeth = 47 teeth

Fig. 3. Circular Saw

e) Resistance offered by the circular saw (R)
Since the circular saw is made of vanadium steel, resistivity for the steel is 7 x 10^{-7} Ω-cm
R = ρL/A
Where ρ = resistivity
L = length or diameter of the saw = 12 inches
A = cross sectional area of the saw = 113sq inches
ρ = 7 x 10^-7 x12 inches

113 sq inches

$R = 1x\ 10^{-7}\ \Omega$

It is usually advisable to keep this circular saw in a cool dry place to prevent corrosion.

Bolt And Nut Design

This helps to hold the work piece firmly in position.

a) Cross-sectional area = πr^2, $\pi = 22/7$

Diameter of the bolt and nut (n) = 1.5cm

Radius of the bolt and nut = 0.75cm

Cross-sectional area (A) = $\frac{22 \times 0.75 \times 0.75}{7}$

$= 1.76cm^2$

b) Perimeter = $2\pi r$ i.e of the circular section

= $\frac{2 \times 22 \times 0.75}{7}$

= 33/7 = 4.71cm

c) Resistance offered by the bolt and nut

$R = \rho L/A$

Where ρ = resistivity

L = length or diameter of the bolt and nut

A = cross sectional area

ρ = 6.9 x 10^-7Ω-cm

Since the bolt and nut is made of stainless steel, the resistivity is given as 6.9×10^{-7}

Diameter of the bolt and nut (D) = 1.5cm

Cross-sectional area (A) πr^2 = 1.76cm2

Therefore, Resistance (R) = $\frac{6.9 \times 10^{-7} \times 1.5}{1.76}$

Resistance (R) = 5.88 x 10^-7Ω

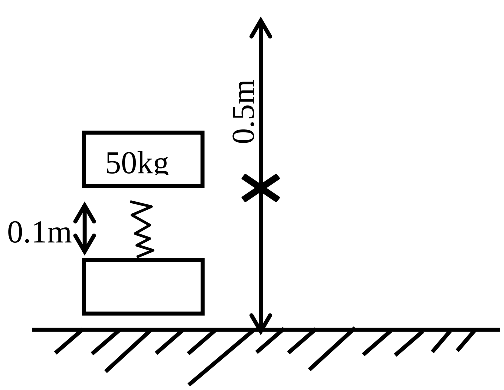
Shock Absorber Design

A shock absorber is either a mechanical or hydraulic device used to absorb and damp the shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) (JS70R, 2012).

a) Maximum force resulting from use of the spring.

Spring Stroke – 0.1m

The spring is rated to absorb all of the energy resulting from the load.



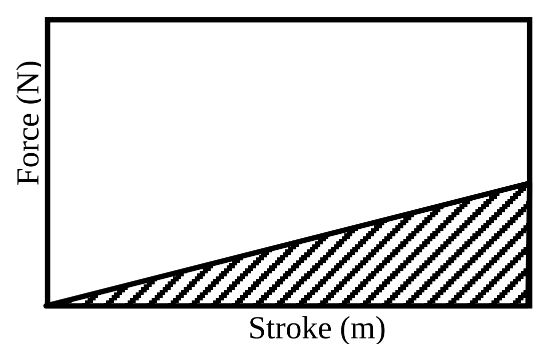


Fig. 4: Force Diagram for the Spring

The resulting maximum force is determined as follows;
Energy to be absorbed = E = m.g.h
Mass (m) = 50kg (resting on the spring)
g = acceleration due to gravity = 9.81
Height (H) = 0.5m
E_1 = 50 x 9.81 x 0.5
E_1 = 245.25Nm
Strain energy of the spring = Fmax. δ spring/2
Therefore maximum force Fmax = 2 m.g.h/δ spring
= 2 x 50 x 9.81 x 0.5/0.1 = 490.5/0.1
Maximum force, Fmax = 4905N

Design for Sheet Metal

These are metals formed into thin pieces.

a) Bending allowance

To determine the bending allowance, we determine the distance from bend line to mold line;

$D = \frac{(R + T) \times \text{Tan } a}{2}$ or $D = \frac{(R + T)}{\text{Cot } a/2}$

Where D = Distance from bend line to mold line
R = Inside bend radius
T = Material thickness
a = Angle in degrees

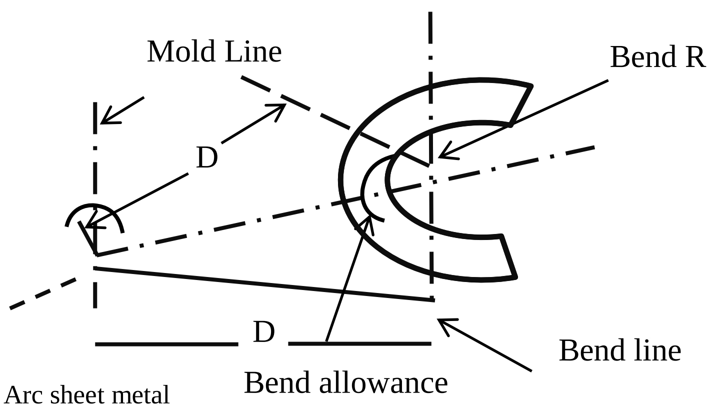


Fig. 5: Arc sheet metal

Where R = 0.25m; a = 150◦
T = 0.125m
D = (R + T) x (Tan a/2)
D = (0.25 + 0.125) x (Tan 150^0/2)
D = 0.375 x Tan 75^0
D = 0.375 x 3.732
D = 1.400

b) Bend allowance per degree of bend
(0.0078T + 0.174R) x (No of Degrees)

Where R = 0.25 (inside bend radius)
T = 0.125 (Thickness)

Bend Angle = No of Degrees = 90^0
(0.0078T + 0.174R) x No of Degrees
([0.0078] [0.125] + [0.174] [0.25]) x 90^0
(0.000975 + 0.00435) x 90^0
0.005325 x 90^0 =0.479

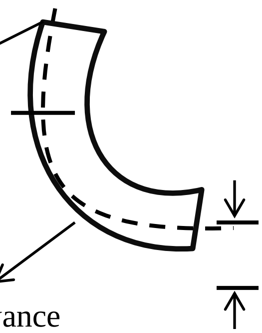


Fig. 6: Angle of arc sheet metal

Design for Engine with 6.5 Horse Power Rating

a) Mean piston speed: This is the average speed of the piston in a reciprocating engine.
Mean Piston Speed (MPS) = 2* stroke *RPM/60
Engine stroke = 90mm
Mean speed = 3000rpm
Mean piston speed (v) = 2* (90/1000)* 3000/60
(v) = 9m/s

b) Calculation for Horse Power rating

$$\text{Horse power} = \text{weight x} \left[\frac{velocity}{234}\right]^3$$

Weight of the engine = 11.4436kg
Velocity = 9m/s

$$\text{Horse power (HP)} = 11.4436 \text{ x } \left[\frac{9^3}{234^3}\right]$$

Horse power (HP) = 11.4436 x 0.00005689
= 6.5 Horse Power (HP)
The weight of the engine was ascertained using a scale balance

Design for Washers

a) Resistance offered by the washers (R)
R = ρL/A, the washers being a conductor
Resistivity ρ = 6.9 x 10^-7Ω-cm(i.e the washers are made of stainless steel)
L = length or Diameter of the washer = 1.5cm radius = 0.75cm
A = cross-sectional area of the washers = πr^2 = 22/7 x 0.75 x 0.75 = $1.76cm^2$

The Resistance (R) = $\left[\dfrac{6.9x10^{-7}x1.5}{1.76}\right]$

Resistance (R) = 5.88 x 10^-7Ω

Design of the Flywheel Power Multiplier

The flywheel power multiplier used in this project helps to increase the power transmitted from the engine, from 6.5 horse power (hp) to 25 horse power (hp). It stores energy when the supply of energy is excess and then releases this energy when the need or requirement arises.

a) Sizing of Flywheel

Coefficient of speed fluctuation Cs = 0.02,
Stroke length (l) = 90mm = 0.09m
Maximum size of the flywheel diameter (D) = 500mm
Mass moment of inertia = I
Kinetic energy of the system (ke)
Work done = w
Engine power rating = 6.5hp
Rated capacity of the machine = 22kN
Workdone (w) = 22*10^6.5* 0.09* 0.15
(Assumed rated load delivered during 15% of power stroke)
Therefore W = 939,196Nm
Thus energy absorbed is 939,196Nm = 939.196kNm
Engine speed = 3000rpm = flywheel speed

- Mean torque acting on the shaft, T mean =
  6.5* 10^6.5/2*π* (3000/60)
  Therefore, T mean = 65,419Nm = 65.419knm
- Workdone per cycle is (Energy supplied)
  WC = 2 π* x 65,419*5
  This machine is powered by a motor with set of 5.1
  WC = 2055464.98Nm = 2055.46kNm

Therefore, kinetic energy of the system is

Ke = W – Wc*0.08 (Energy absorbed – Energy Supplied x factor for loss).
Ke = 939.196 – 2055.46* 0.08
Ke = 939.196 – 164.437
Ke = 774.76kNm or 774760Nm

Therefore, mass moment of inertia is

$I = 774760/0.02\ (2\ \pi \text{ x } 3000/60)^2$

$I = 774760/1974.4328 = 25.2\text{kg}.m^3$

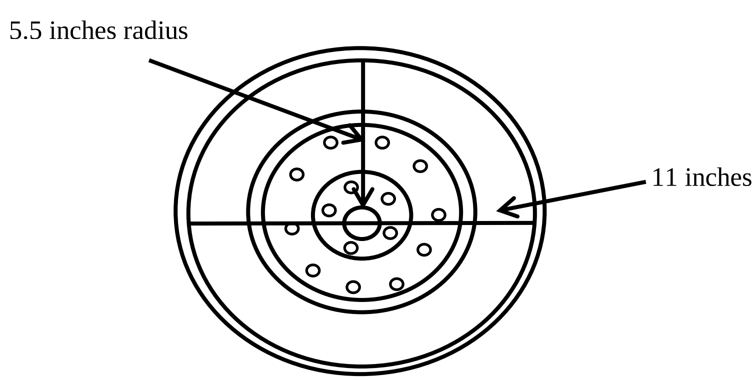


Fig. 7: Flywheel Power multiplier

RESULTS AND DISCUSSION

From the test carried out on the machine during operation, the machine produced a lot of mechanical sound because of the weight of the flywheel. As the teeth of the saw bites and cuts into the wood, this further increased the sound produced by the machine. As a result of this, the operator has to operate this machine with ear covering. The heat around the machine reaches high temperature quickly and when the machine is in operation, saw dust tends to build around the body of the machine. This can cause a disturbance to the cooling effect of the machine. So for proper cooling, the saw dust building around the machines should be blown off the body of the machine everyday after work with the help of high pressure air blower to give a good cooling effect, thereby preventing the engine from overheating.

Table 1: Table of Values Obtained From the Test

Engine Name	**Increased Engine Rating**	**Engine Top Speed Rev/Min**	**Flywheel Top Speed Rev/Min**	**Wood Used**	**Cutting Speed Rev/Min**	**Cutting Time (Time Taken) Seconds**	**Raw Materials Obtained**
Henry Max (Gx 200)	From 6.5 horse power to 25 horse power	3000rpm	3000rpm	Softwood Hardwood Softwood Hardwood	3000rpm 3000rpm 1000rpm 1000rpm	5 secs. 30secs 10secs 40secs	Wood chunk Wood pellet Shredded wood Saw dust Wood chips

Fig. 8: Performance evaluation graph

CONCLUSION

A modified flywheel power multiplication system has been designed, constructed and tested to handle problems arising from low power output. This design modification was achieved using parts such as the Gx200 engine, the rotating belt, the flywheel power multiplier, the circular saw. The Gx 200 engine suppliers the power, the rotating belt then transmits this power to the flywheel power multiplier, the flywheel power multiplier then increases the horse power produced by the engine, transmitting this power to the circular saw which can do work very easily cutting through any log of wood. This would enable the operator to even choose to stand far away from the machine when bringing a wood to the teeth of the circular saw. This flywheel power multiplication system has been able to conquer problems arising from a machine due to increased mechanical energy, in performing a task, it has also been able to conquer problems related to time consumption, increased labour due to less power output.

The early machines of this category operated without the use of the flywheel power multiplier which made increase in production of no effect. These early machines were not safe to be used in powering a disk grinder or a disk cutter because it would require the operator coming very close to the rotating part where all the power out put are, and that can be very dangerous to the operator of this machine, resulting to sustained injuries or even death in some cases. But due to this new modification, powering a disk grinder or a disk cutter has become very easy. Our design has been able to tackle problems resulting from excessive vibration and tension when a machine is in operation. The system is very unique because of the speed at which cutting is done. The speed of the flywheel being 3000rpm transmitted to the circular saw can produce high yield returns and can beat a production time of 60 minutes in just 20 minutes. Without doubt, the market overview of this machine or system cannot be overemphasized, due to its trending result it would be able to win the market and many consumers would be able to play their role in purchasing this machine.

This machine would be able to stand the test of time due to the high quality materials used during production. It is electrically safe and very safe to operate hence it can serve as a mini saw mill or can be used for wood processing application purpose. This machine can be for wood cross-cutting purpose and sawing, raw material like wood pellet, saw dust, shredded wood, wood chunk can be obtained or gotten with the use of this machine. The cutting speed at 3000rpm of this machine, obtained from the test, can be able to perform cutting operations within a short period of time which makes it very productive in the wood manufacturing industry.

RECOMMENDATIONS

From the engineering point of view, any new design produced always forms a basis for further development of an advanced model of the same machine. Therefore, in subsequent work, the use of the machine should not just only be restricted to wood cutting but also to metal cutting using the circular cutting disk. A more advanced flywheel can be used to increase the power rating of the engine far beyond the power rating produced by this new design. Also a switch can be used to start up the machine instead of the starting cord. In order to minimize noise, a soundproof can be used for future development.

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