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Design, Development and Manufacturing of Pedal Operated Metal Cutting Machine

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ABSTRACT: The pedal operated machine has been designed and fabricated for cutting of different metals. The 12"hacksaw blade (HSS, 12 mm and 0.5mm) is used to cut materials like M.S, copper, brass, etc. The rotary motion of the pedal is being converted to reciprocating motion (to and fro) by using four bar mechanism. Bicycle like structure is developed and manufactured ergonomically. Using this mechanism a normal average human can cut 20 work pieces (of average 20mm diameter) in 30 minutes. The machine has been tested with different metal shafts of 16mm diameter. Cutting time was recorded at various rpm (100,150 and 200) for different metals. The data obtained was analyzed and compared with the cutting time required for electric hacksaw machine and hand operated hacksaw. The machine has a mechanical advantage of 0.45(less than one) and mechanical efficiency of 79 % which indicates that this manually operated hacksaw machine is beneficial than electrical operated machine or hand operated one as it does not consumes any electricity and works without much human input as compared hand operated hacksaw. Advantages of this machine are saving electricity, easy cutting, reliable, cost effective, exercising, etc.

KEYWORDS - Pedal operated machine, energy saving, reciprocating motion, cutting.

I. INTRODUCTION

The pedal operated hacksaw machine is a cutting machine which runs without electricity and consumes less human power as compared to hand operated hacksaw. It is used for cutting different metals; ferrous and non ferrous materials. It has been observed that if the machine is designed ergonomically to suit human comfort, more power output can be obtained out of the same input. The energy from the pedal is transferred to the hacksaw blade via a slider crank mechanism

An individual can generate four times more power (1/4 HP) by pedaling than by hand-cranking. But, at the rate of ¼ HP, continuous pedaling can be served for only short periods, approximately 10 minutes. However, if pedaling is done at half of this power (1/8 HP), it can be sustained for close to 60 minutes [1]. Power capability depends upon age too.

The reciprocating rod moves to and fro and the hacksaw moves with the rod. The light material to be cut is placed under the hack saw. By pedaling the pedal the sprocket rotates and it will make the connecting rod move to and fro which is further connected to the hacksaw blade. Thus the light material can be cut without any external energy like fuel or current. Since this uses no electric power and fuel, this is very cheap and the best.

The system also uses the flywheel which reduces the fluctuations in speed caused by the non uniform pedaling. Also the flywheel serves as an energy reservoir that stores energy when it is in excess and releases it when the input is cut off. The main aim is to reduce human effort for machining various materials such as wooden blocks, steel, PVC, etc.

II. EXPERIMENTAL METHODS

Figure No. 1: Pedal Operated Machine

The machine was operated at different speeds of 100,150 and 200 rpm. The cutting operation is done during the backward stroke of the blade. 16 mm diameter materials were used for cutting. These materials are fitted in the bench-vice during cutting. Materials like MS, brass and copper were used for testing. The cutting time was measured for this material and it is shown in Table No. 1 and 2. The speed v/s time graph is been showed in Fig. No.2

The machine consists of a foot pedal, chain drive, M.S. Frame, crankshaft and connecting rod, flywheel, bearings, operator seat etc.

Initially pedal was operated by human effort of approximately 94 W (0.12 HP). This power can be maintained for 60 minutes or more. [2] The above power was utilized to rotate the chain drive mechanism. Thedriver and driven sprockets have 44 and 18 teeth respectively. The driven sprocket generally rotates at 180-240 rpm which is mounted on the crankshaft. Aflywheel of 15 kg is mounted on this shaft. The connecting rod is connected to the crank disc at an eccentric distance of 85mm from the center of crank while the other end is connected to the hacksaw frame.

When the pedal is operated the rotational energy gets stored in the flywheel which is then transmitted tothe crankshaft. The crank rotates and makes the hacksaw connected to it move to and fro which cuts the work piece underneath it.

MS C35 material is used for the entire manufacturing of the machine due to its ease of availability (Density= 7850kg/$m^{3,}$ UTS 700MPa)

Specifications of the machine are: Base area 134000mm^2,Distance between the two sprockets615mm, Cutting stroke length350mm, Eccentricity of the disk(adjustable) 85 mm used, Height from pedal to seat 390mm, Diameter of driver and driven sprocket are 210mm and 95 mm respectively, Length of crank pedal =150mm, Velocity ratio 0.57, Ideal Mechanical Advantage(IMA) of the machine 0.45. The standard lubricant SAE 40 has been selected to maintain proper lubrication.

By taking input of 1/8th HP Human power i.e. 94 Watt for a speed of 100 rpm and material properties forC35 materials from Design Data book. The generated torque has been calculated as 8.97 N-m [3][4].

III. DESIGN IN SOLIDWORKS

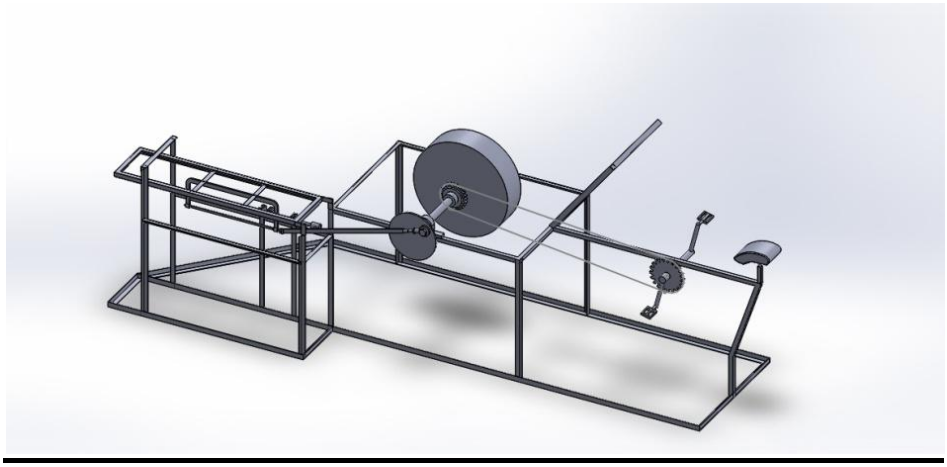

Figure No.2: Design in SOLIDWORKS

RESULTS AND DISCUSSION:

Table No.1: Comparison of cutting time of different materials of 16mm diameter shaft

Speed (rpm)	Time (in seconds)		
	Mild Steel	Brass	Copper
100	76	66	65
150	50.2	42	42.5
200	35.6	27.7	29.4

Mild Steel: Density= 7850kg/m^3; Hardness= 120 BHN
Brass: Density= 8550kg/m^3; Hardness= 60 BHN
Copper: Density= 8960kg/m^3; Hardness= 35 BHN

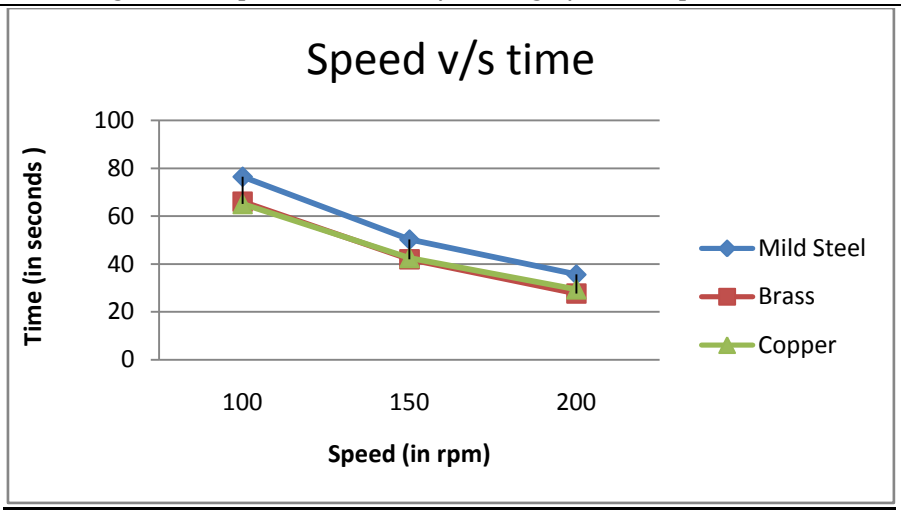

Figure No. 3: Graph of Speed v/s time for different materials

Table No.2: Comparison of cutting time required for different materials by simply hacksaw, hacksaw machine and power hacksaw for average speed

	Time in seconds		
Material	Simply with hacksaw	Hacksaw machine	Power hacksaw
Brass	103	42	4
Copper	190	42.5	5
Mild steel	457	50.2	12

Ideal Mechanical Advantage (IMA) of the machine = Diameter of the driven sprocket/Diameter of the driver sprocket [5]

= 95/210 = 0.45 (less than one)

Mechanical efficiency of the machine = (IMA X 100)/ Velocity ratio [5]

= (0.45 *100)/0.57 = 78.94%

It can be observed that as the hardness of the material increases the time required to cut the work piece increases. Also if the densities of the materials are almost similar (in case of copper and bronze) then the cutting time required is almost equal. The time required to cut the same work piece with hacksaw machine is less than half of that time required to cut directly by hacksaw. Also, the fatigue developed is comparatively much less. One important observation is that the finishing obtained by cutting the metal on hacksaw machine is much better than that obtained by cutting the work piece directly by hand. Also, it was observed that the teeth of the hacksaw did not wear off even after the entire experiments were conducted for three times. This shows that if operated and maintained properly, the machine has a long life of more than 10 years.

IV. CONCLUSION

It can be concluded that

- The hacksaw machine was successfully tested for the speed of 100,150 and 200 rpm and shows cutting time 70% less than that of human time.
- The machine is cost effective compared to power hacksaw machine. Also, the machine consumes no electricity at all, which is a major plus point.
- Machine is simple in design, reliable, and can be used where electric supply is not available, particularly in rural areas.
- The machine operates with the mechanical efficiency of 78.94% and mechanical advantage of 0.45
- The only maintenance required is lubrication.
- Teeth blunt rate and wear rate is very slow.
- If maintained properly, the life of the machine is more than 10 years

V. REFERENCES

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