A Low Cost Oil Extraction Machine for Extraction of Oil from Gears

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Abstract

This work illustrates a low cost mechanical system manufactured for extraction of oil which is present on gears when the gear is under manufacturing process. The sedimentation principle under centrifugal force is used as a basic principle in this system for removal of oil. The gear is spun at 1440rpm for 4 seconds for extracting oil. The centrifugal forces acts tangentially to the gears and is responsible for the removal of oil from the gears. This oil is collected in the oil pot and then supplied by tubes to the oil filter. Oil filter is used for filtration of oil coming from the oil pot. The filtered oil is again supplied for hobbing and shaving machines thus recycling and making it reusable. Similar setup with different dimensions can be used for different gears.
Keywords: Hobbing, Spindle, Shaft, Centrifugal force, R cube, Gear

I. INTRODUCTION

Nowadays R cube (Recycle, Reuse, Reduce) is a need for better environment, therefore it is always researched where recycling or reduction or reuse can be done and various techniques are thought of for the same. This work presents a machine with similar aim of recycling and reuse.

Gear manufacturing process involves basically hobbing of a blank [1]. Firstly, the gear blanks are passed to ID checking machine for internal diameter checking. After verification, these gears are passed to hobbing machine where gear cutting operation is done. During gear cutting operation, oil is sprinkled on the gear blanks for the reason of heat dissipation, precision cut, flowing out the burr and appropriate gear cutting. After gear cutting, these gears are passed to the DOP (Diameter Over Pin/ Dimension Over Pin) checking machine for measurement of diameter over pin [2]. For this measurement, the oil present on the gears is being removed by using cotton threads or waste cloths; sometimes gears are thoroughly washed. Thus, there is wastage of oil. Instead, this oil can be collected and reused by recycling it in appropriate processes like hobbing and shaving of gears. By installing this gear spinning machine and using it immediately after the hobbing process, the oil can be collected and thus recycled for further use; resulting in reduction of oil consumption, thus leading to reduction in overall cost of production and also improving the process efficiency and environmental harm.

II. EXPERIMENTAL SETUP

The experimental setup consists mainly of, a main frame, barrel, fixture, spindle, oil pot, motor shaft, electric motor, supply lines, filter as shown in Figure. This setup extracts and collects the oil from the surface of the mounted gear and filters it for further usage and can also calculate the quantity of the oil.

The main frame supports every part of the machine. The barrel is situated on top of the main frame and houses the fixture. The fixture is attached to the base plate. The spindle is placed in the spindle housing. One end of the shaft/spindle is attached to the fixture while other to the motor. The motor is attached to the motor mounting plate, which is attached to the spindle housing. Two bearings are incorporated inside the spindle housing for supporting the shaft; one above the coupling and one below the fixture

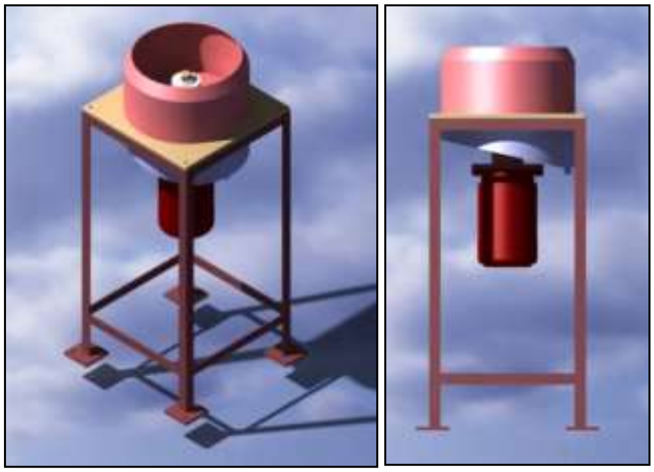


Fig. 1: Experimental Setup of Oil extraction by Gear Spinning machine

Detail of the Setup is provided in the CAD drawing below.

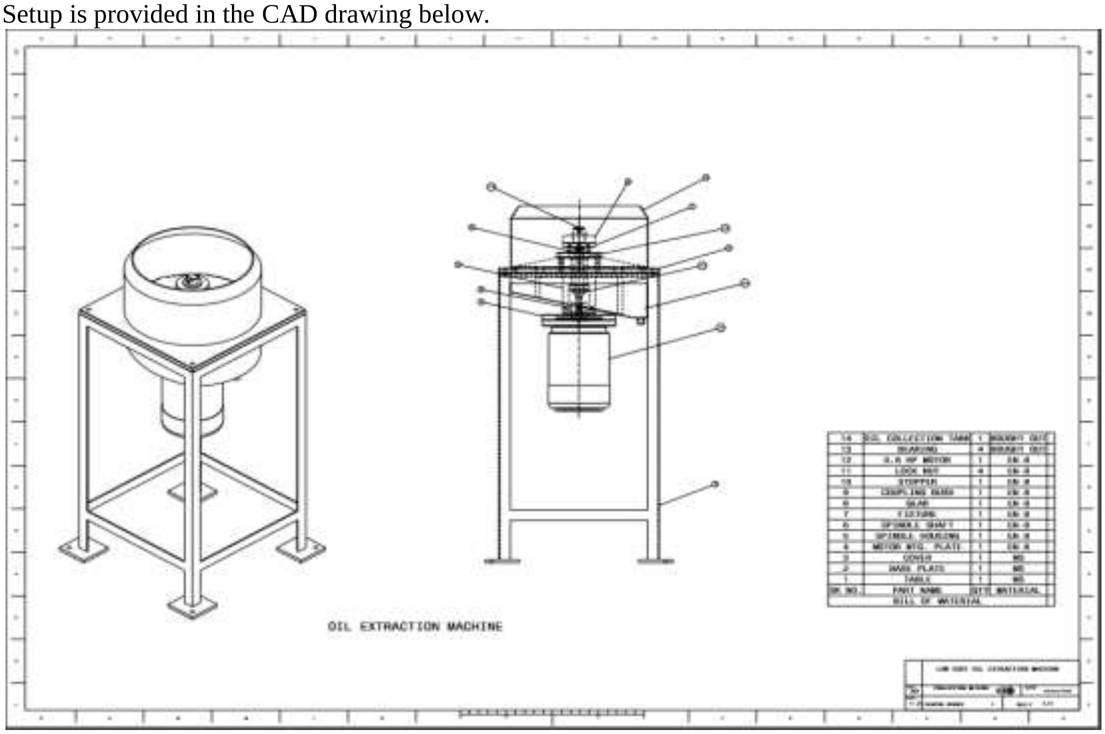


Fig. 2: CAD drawing of the setup

III. PARTS

A. Main Frame

The main frame has the function of supporting all the components and absorbing the vibrations produced during operation of the machine. The main frame has to be rigid enough to support all parts and withstand the different forces acting on the system such as rotating force of shaft and spindle, vibrational forces, etc; thus made of Cast Iron [4]. Rubber pads are placed at the bottom of the pillars of the main frame to provide grip to the structure and for absorbing vibrations.

B. Oil Pot

Oil pot is a reservoir whose function is to collect oil coming from barrel surface. Oil pot collects oil coming from the barrel surfaces and supplies it to the oil filter

C. *Fixture*

Fixture is a work-holding device used in manufacturing industries. A fixture's primary function here is to create a secure mounting point for the gear, helping for support during operation and increased accuracy [5]. Fixture needs to be designed or selected as per the size of the gear to be used.

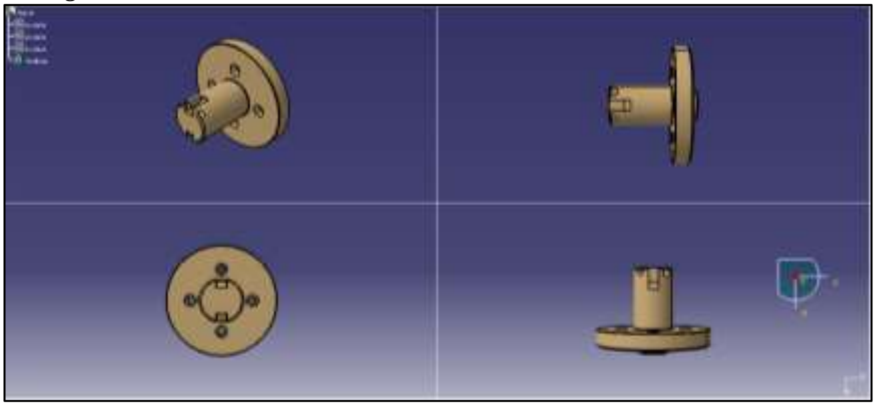


Fig. 3: CAD Drawing of Fixture

D. *Base Plate*

The base plate is fixed to the frame. The base plate acts as a base for the fixture and the cover and these both components are fixed to the base plate. The upper side of the base plate is coated with polytetrafluoroethylene.

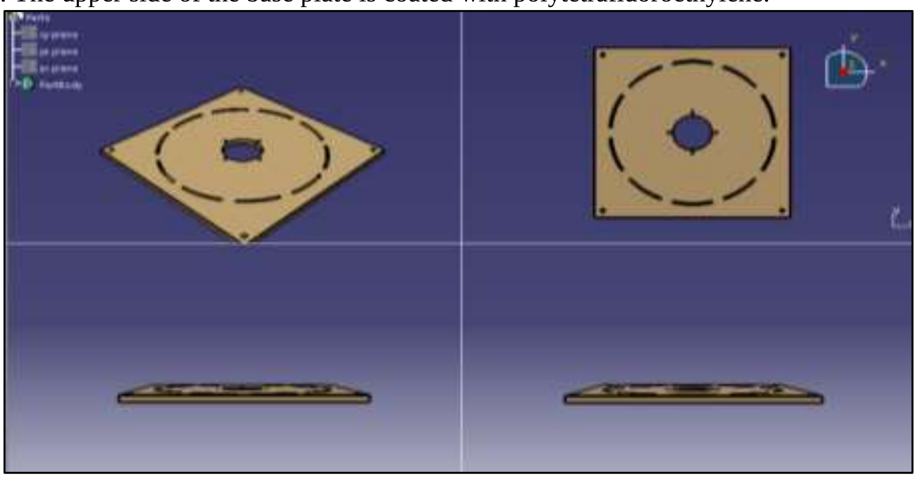


Fig. 4: CAD Drawing of Base plate

E. *Gear Spinning Cover*

The Gear Spinning Cover is a cover for the fixture and the gear. When the gear rotates, the oil will splash and stick to this cover and then flow down to the oil pot. Inner side of the cover is coated with polytetrafluoroethylene, due to its properties like low friction, adhesiveness etc. [6]

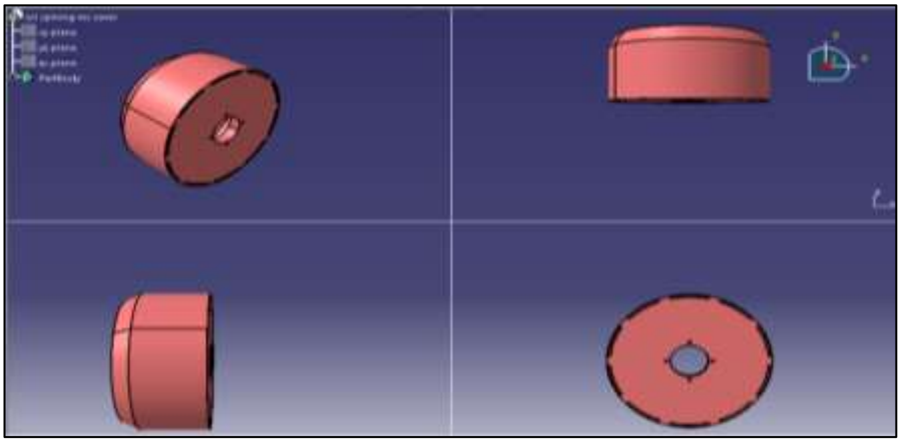


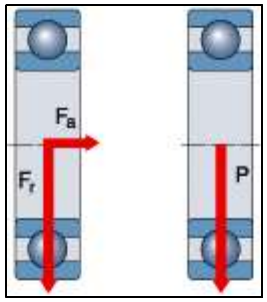
Fig. 5: CAD Drawing of Gear Spinning Cover

F. Indusction Motor

Motor is an electrical machine that converts electrical energy into mechanical energy. In normal operating mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. Electric motors are used to produce linear or rotary force (torque) and should be distinguished from devices such as magnetic solenoids. Induction motor used for this machine is rated at 0.5hp at 1440 rpm. Reason for using 0.5hp motor is that it has enough torque to spin a gear and fixture for the time it takes to clean gear completely and it also efficient to work with. Total load induction motor has to bear is less than 1kg

G. Bearing

A mechanical element that constrains relative motion to only the desired motion, and reduces friction between moving parts
Bearing calculations:-



$$P = X F_r + Y F_a$$

Neglecting self-weight of carrier and gear assembly
Where,
$F_r = 250$ N and $F_a = 40$ N
As, $F_r < e$, X = 1, Y = 0
P = 250 N
Calculating dynamic load capacity of bearing [7],

$$L = \frac{(C)^n}{(P)^n}$$

Where,
n=3 for ball bearings.
For m/c used for eight hr of service per day;
L_H = 15000 hr
But;

$$L = \frac{60 \text{ N } L_H}{10^6}$$

Where,
N = 1440 rpm, $L_H = 15000$
L= 1296 million rev
Now;

$$1296 = \frac{(C)^3}{(250)^3}$$

C= 2725.68 N
As the required dynamic capacity of bearing is less than the rated dynamic capacity of bearing; Bearing is safe.

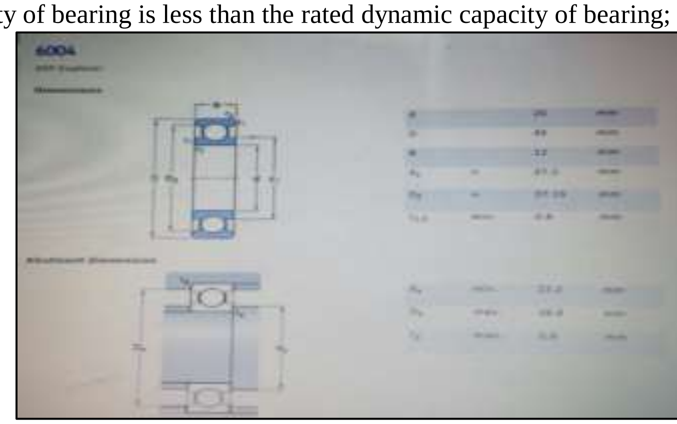


Fig. 6: Bearing details

H. Bush Coupling

The Bush coupling is used to connect the spindle to the motor, helping the spindle to transmit torque to the fixture.

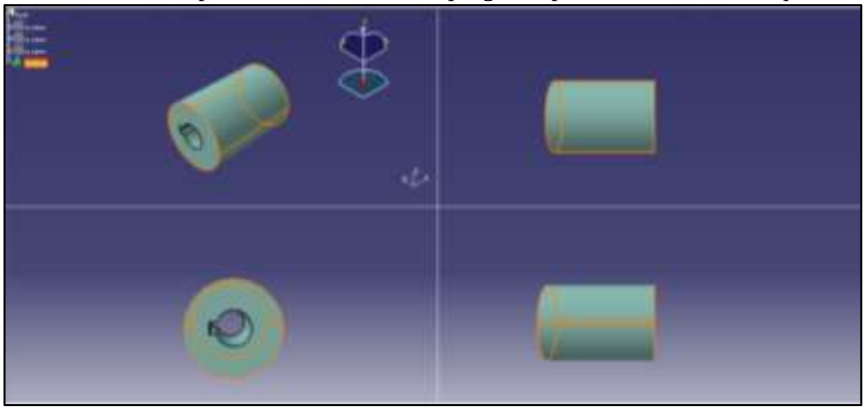


Fig. 7: CAD drawing of coupling bush

I. Spindle

Spindle/Shaft is used to transmit torque from the motor to the fixture. Thus,
Shaft Calculations:
Axial Stress [8],

$$\sigma = \frac{4\alpha F}{\pi d^2(1 - K^2)}$$

$$\sigma = \frac{1}{1 - 0.0044(\frac{L}{K})}$$

$$\sigma = 1.0965 \text{ N/mm}^2$$

Where,
K- Ratio of inner to outer dia. of shaft
d- Outer dia. of the shaft
F- Axial force (tensile or compressive)
α- Column action force
Stress due to torsion,

$$\tau = \frac{16T}{\pi d^3(1 - K^4)}$$

Where,
T = Torque on the shaft

$$T = \frac{60 \times 0.5 \times 746}{2\pi \times 960}$$

= 3710 N-mm

$$\tau = \frac{S_{sy}}{F.O.S.}$$

$$= \frac{0.9 \times 380}{3}$$

$$= 63.33 \text{ N/mm}^2$$

The shafts are normally acted upon by gradual and sudden loads. Hence, the equation is modified in ASME code by suitable load factors,

$$\tau_{allowable} = \frac{16}{\pi d_0^3(1-k^4)}\sqrt{\left\{C_{bm}M + \frac{\alpha F d_0(1+k^2)}{8}\right\}^2 + (C_t T)^2}$$

Where, C_{bm} and C_t are the bending and torsion factors.

Table - 3.1.1
Values of factors

	C_{bm}	C_t
For stationary shaft:-		
Load gradually applied	*1.0*	*1.0*
Load suddenly applied	*1.5-2.0*	*1.5-2.0*
For rotating shaft:-		
Load gradually applied	*1.5*	*1.0*
Load suddenly applied [minor shock]	*1.5 - 2.0*	*1.0 - 1.5*
Load suddenly applied [heavy shock]	*2.0 - 3.0*	*1.5 - 3.0*

$$66.33 = \frac{16}{d^3\pi}\sqrt{(2.03d)^{2+}(3710)^2}$$

d=13mm

Therefore, selecting standard d = 20 mm.

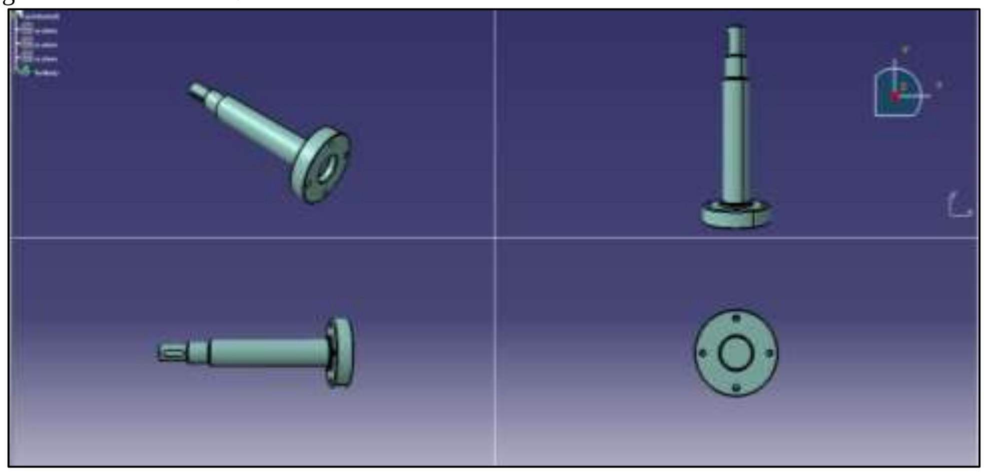


Fig. 8: CAD drawing of Spindle

J. *Motor Mounting Plate*

The motor is mounted and fixed on this plate which is in turn connected to the spindle housing.

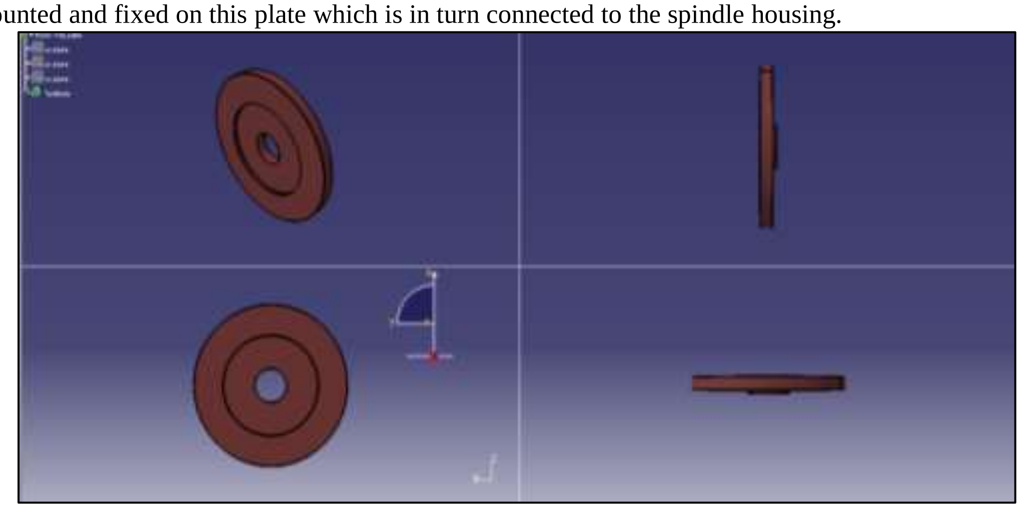


Fig. 9: CAD Drawing of Motor Mounting Plate

IV. WORKING

1) The gear after the hobbing process is taken as it is and fixed on the fixture.
2) The gear is then rotated at 1440 rpm for 4 seconds and the oil thus splashes on to the cover.
3) This oil then flows down through the perforations and gets collected into the slotted oil pot.
4) This oil is then drained to a filter through supply lines and gets filtered and is collected for further use. 80- 90% of the oil from the gear is extracted.

V. CONCLUSION

The machine will help reduce the oil usage for gear manufacturing by extracting and collecting it from the gear, recycling and reusing it; and will improve the process efficiency. The reduced oil consumption leads to reduction of the manufacturing cost of the gears. As the oil is recycled, the need for new oil is reduced which leads to conservation of natural oil resources. Similar setup can be substituted for gear of any appropriate dimensions.

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