

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

Design of Shoe Sole Cleaning with Polishing Machine

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Abstract: In this work, it is proposed to design a shoe sole cleaning machine, incorporating shoe polishing facility with this machine. As all the employees, faculty etc required to wear clean shoes before entering their laboratories, as these laboratories have highly précised instruments, sensors etc and the air inside should be very clean.

Thus shoe sole cleaner with shoe polishing machine is designed, considering all the parameters with respect to customer need in terms portability and also economically available to them, thus providing not only clean environment but also provide the style quotient to the person with polishing effect.

I. INTRODUCTION

There is a famous proverb “*Cleanliness is next to godliness*”. The machine which we have designed and fabricated implicates this, called as “shoe sole cleaner with shoe polishing machine”, here the shoes sole can be cleaned and polished in much less time with no effort.

Most of the industries, hospitals and educational institutions having the most preserved laboratories like computer labs, instrumentation labs operational theatre and various production, assembly sites in chemical, pharmaceutical industries etc, have to be free from dust and dirt which would be carried through the shoe of the employees to the work area, causing untidy environment and also sometimes hazardous to the working environment.

As prime importance given to the shoe selection nowadays, its maintenance is also being taken care and in some regions or areas tidy environment is preferred, hence cleaning of shoe, upper and lower part of it and also to have a elegant look to the human, polishing of the shoe is necessary, considering all these factors wide range of machines for shoe sole cleaning machine and shoe polishing machine has been evolved from the earlier centuries and also the project introduces a variety of concepts of the product and helps in selecting a better model for shoe sole cleaning and shoe polishing machine.

II. CONCEPT DEVELOPMENT

A Concept development process is the sequence of steps or activities which an enterprise employs to conceive, design, and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe the processes. Furthermore, every organization employs a process at least slightly different from that of every other organization. In fact, the same enterprise may follow different processes for each of several different types of development projects.

The Concept development process includes the following activities as shown in block diagram,



Fig2.1: Concept development process block diagram.

III. SYSTEM LEVEL DESIGN (CONCEPT GENERATION)

A: Concept 1:

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The schematic representation of the conceptual model A for Shoe sole cleaning with polishing machine is as shown through a 3-D CAD model in Fig 3.1

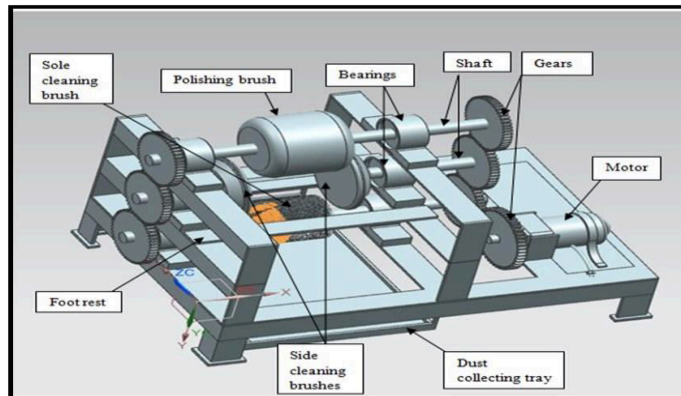


Fig 3.1: First conceptual model (A) for shoe sole cleaning with polishing machine

In the figure3.1, the machine relates to shoe sole cleaning (removing of dust, sand and any other unwanted material attached to the sole) and also helps in polishing the shoe.

B: Concept 2:

The schematic representation of the conceptual model B for Shoe sole cleaning with polishing machine is as shown through a 3-D CAD model in Fig 3.2.

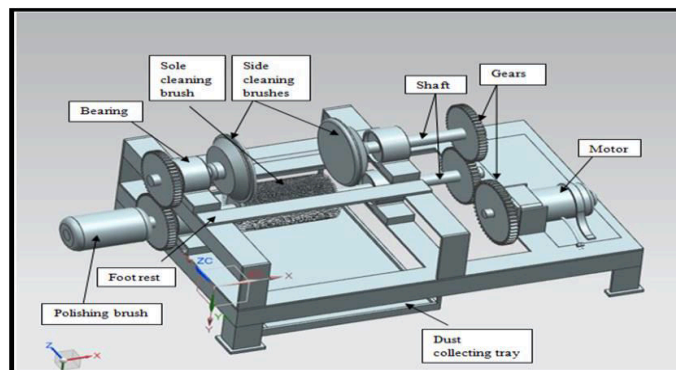


Fig 3.2: Second conceptual model (B) for shoe sole cleaning with polishing machine

The conceptual model B is designed in order to overcome the disadvantages of the conceptual model A. In the Figure 3.2, the machine relates to shoe sole cleaning (removing of dust, sand and any other unwanted material attached to the sole) and also helps in polishing the shoe.

Concept B provides easy operation of both shoes sole cleaning and polishing where in polishing operation is provided exterior of the machine which helps the user to freely move the shoe over the rotating brush. The polishing liquid is applied manually to the shoe during the polishing operation. Entire gears, shaft and bearings mounts are rested on the L iron bar base arranged according to the space needed to carry out the operation, at the bottom a tray is provided in order to collect the dust particles obtained during the operation of sole cleaning.

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IV. GEOMETRICAL CONFIGURATION

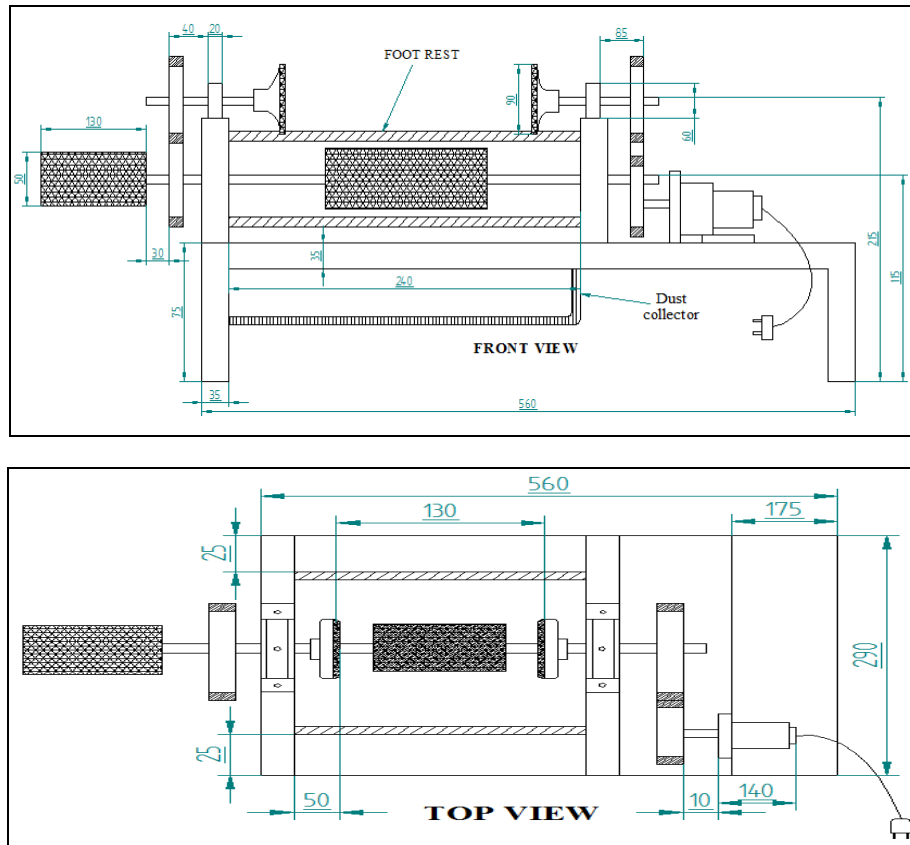


Fig 4.1: Detailed 2-dimensional view (FV and TV) of the assembled model

V. DESIGN CALCULATION

We have used single shaft, which carries the sole cleaning brush and polishing brush, and the shaft is supported with bearings at respective positions. Necessary gear train for the rotation of shaft are arranged in order to achieve the motion and the process of the machine to clean the shoe and polish it. In order to have a safe action of the machine the shaft has to be designed, considering the loads and forces acting on it. Thus the shaft designed to its safety.

A self weight of 1.5 kg, total weight of 14.71N for the shaft is assumed.

Material of the shaft: SAE 1040 annealed is considered.

From Design data hand book volume 1 (DDHBv1) we have,

$F_s = 2$, $\sigma_{ed} = 137.96$ Mpa, $\sigma_y = 309.9$ Mpa.

Speed available at the shaft:

We know that

$$\frac{n_1}{n_2} = \frac{z_2}{z_1}$$

Where $n_1 = 219$ rpm, $z_2 = 96$, $z_1 = 96$

$\therefore n_2 = 219$ rpm.

The shaft is subjected to combined bending and torsion. Therefore the shaft diameter is given by,

$$\therefore D = \left\{ \left(\frac{16}{\pi * \tau_{ed}} \right) \{ (K_b * M_b)^2 + (K_t * M_t)^2 \}^{1/2} \right\}^{1/3}$$

Assuming steady or gradually applied load from DDHB v1 table 14-2 we have,

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$$K_t = 1, K_b = 1.5$$

Loads acting on shaft

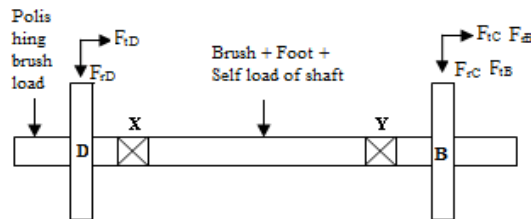


Fig 5.1: Various loads acting on the shaft

From the Fig.5.1, 'B' and 'D' is gear mounted on shaft, 'X' and 'Y' are bearing support for the shaft, the load of brush, self load and foot load is concentrated at centre of the shaft considering at point 'C', \$F_r\$ and \$F_t\$ are radial and tangential tooth load acting, considering the forces acting and resolving it to obtain the maximum bending moment, and hence the diameter of the shaft.

Power received by the shaft

Torque transmitted,

$$M_t = \frac{9550 * N * 1000}{n}$$

Where \$M_t\$ in N-mm, Power \$N = 15W\$, Speed of motor \$n_1 = 200\$ rpm.

$$\therefore M_{t1} = \frac{9550 * 0.015 * 1000}{200} = 716.25 \text{ N - mm}$$

Consider the gear drive at B

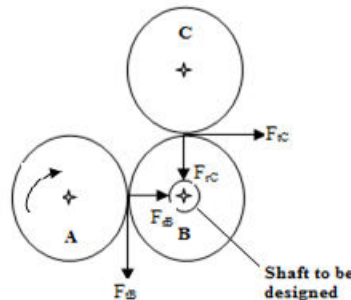


Fig 5.2: Free body diagram of the loads on gear B

Where gear 'A' rotating in clock wise direction, driving gear 'B' in counter clockwise direction.

$$r_{gB} = \frac{d_{gB}}{2} = \frac{100}{2} = 50\text{mm}$$

We have,

$$M_{t1} = F_{tB} * r_{gB}$$

$$716.25 = F_{tB} * 50$$

$$\therefore F_{tB} = 14.32 \text{ N}$$

$$\therefore F_{rB} = F_{tB} * \tan \phi = 14.32 * \tan 20 = 5.21 \text{ N, for } 20^\circ \text{ pressure angle}$$

Then, the torque transmitted from gear C, as shown in Fig 5.2 given by,

$$M_{t2} = \frac{9550 * N * 1000}{n_2} = \frac{9550 * 0.015 * 1000}{219} = 654.10 \text{ N - mm}$$

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Hence,

$$r_{gB} = \frac{d_{gB}}{2} = \frac{100}{2} = 50\text{mm}$$

We have,

$$M_{t2} = F_{tC} * r_{gB}$$

$$654.10 = F_{tC} * 50$$

$$\therefore F_{tC} = 13.08 \text{ N}$$

$$\therefore F_{rC} = F_{tC} * \tan \varphi = 13.08 * \tan 20 = 4.76 \text{ N}$$

Consider the gear drive at D

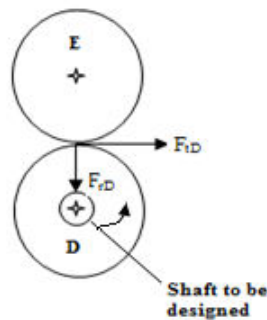


Fig 5.3: Free body diagram of loads on gear D

Where gear 'D' rotating in counter clockwise direction, driving gear 'E' in clockwise direction.

$$r_{gD} = \frac{d_{gD}}{2} = \frac{100}{2} = 50\text{mm}$$

We have,

$$M_{t1} = F_{tD} * r_{gD}$$

$$716.25 = F_{tD} * 50$$

$$\therefore F_{tD} = 14.32 \text{ N}$$

$$\therefore F_{rD} = F_{tD} * \tan \varphi = 14.32 * \tan 20 = 5.21 \text{ N}$$

Therefore,

Horizontal forces acting on the shaft due to gear drive B and D are

$$F_{tD} = 13.08 \text{ N}, F_{tC} = 13.08 \text{ N}, F_{tB} = 5.21 \text{ N}.$$

Vertical forces acting on the shaft due to gear drive B and D are

$$F_{rD} = 4.76 \text{ N}, F_{rC} = 4.76 \text{ N}, F_{rB} = 14.32 \text{ N}.$$

Consider the vertical load diagram

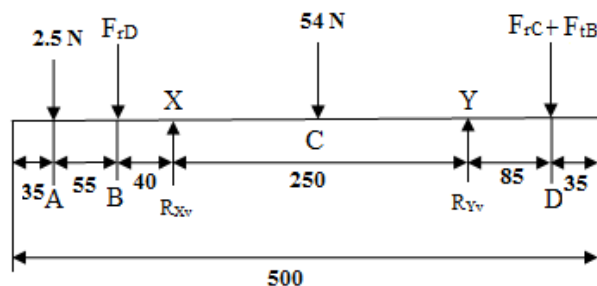


Fig 5.4: Vertical loads acting on the shaft

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Let R_{Xv} and R_{Yv} be the bearing reactions due to vertical loads, and forces acting are as shown in Fig. 5.4, where, $F_{tD} = 4.76$ N,

$F_{tC} + F_{tB} = 4.76 + 14.32 = 19.08$ N, at points B and D.

Also at point B = gear D and at point D = gear B is placed, Self weight of the shaft = 1.5 kg = 14.71 N,

Weight of the sole cleaning brush = 1 kg = 9.81 N, load acting due to foot placed on the brush (assumed) = 3 kg = 29.43 N.

Total load acting on shaft due to brush, self load of shaft and foot load = $14.71 + 9.81 + 29.43 = 53.95 \sim 54$ N at the centre 'C'.

From the Fig,

Moment about 'X'

$$R_{Yv} * 250 = 125 * 54 + 165 * 4.76 + 220 * 2.5 + 19.08 * 335$$

$$R_{Yv} = \frac{14477.2}{250}$$

$$\therefore R_{Yv} = 57.90 \text{ N}$$

Also,

$$R_{Yv} + R_{Xv} = 2.5 + 4.76 + 54 + 19.08$$

$$\therefore R_{Xv} = 22.44 \text{ N}$$

To find vertical bending moment (BM)

BM at X = 0.

BM at Y = 0.

BM at A = $R_{Xv} * 95 = 2131.8$ N-mm.

BM at B = $R_{Xv} * 40 = 897.6$ N-mm.

BM at C = $R_{Yv} * 125 = 7237.5$ N-mm.

BM at D = $R_{Yv} * 85 = 4921.5$ N-mm.

Consider horizontal load diagram

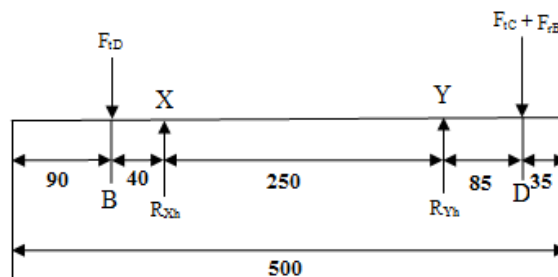


Fig 5.5: Horizontal loads acting on the shaft

Let R_{Xh} and R_{Yh} be the bearing reactions due to horizontal loads, and forces acting are as shown in Fig 5.5, where $F_{tD} = 13.08$ N,

$$F_{tC} + F_{tB} = 13.08 + 5.21 = 18.29 \text{ N, at points B and D.}$$

Also at point B = gear D and at point D = gear B is placed.

From the Fig,

Moment about 'X'

$$R_{Yh} * 250 = 18.29 * 335 + 13.08 * 40$$

$$R_{Yh} = \frac{6650.35}{250}$$

$$\therefore R_{Yh} = 26.60 \text{ N}$$

Also

$$R_{Yh} + R_{Xh} = 18.29 + 13.08$$

$$\therefore R_{Xh} = 4.77 \text{ N}$$

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To find horizontal bending moment (BM)

BM at X = 0

BM at Y = 0

BM at B = $R_{Xh} * 40 = 190.8$ N-mm.

BM at D = $R_{Yh} * 85 = 2261$ N-mm.

Resultant bending moment

BM at X = 0

BM at Y = 0

BM at A = 2131.8 N-mm.

BM at B = $\sqrt{2131.8^2 + 190.8^2} = 2140.32$ N-mm.

BM at C = 7237.5 N-mm.

BM at D = $\sqrt{2261^2 + 897.6^2} = 2432.65$ N-mm.

From above values we have,

∴ Maximum bending moment $M_b = 7237.5$ N-mm.

∴ Maximum twisting moment $M_t = 716.25$ N-mm.

Diameter of the solid shaft subjected to combined bending and torsion is given by,

$$D = \left\{ \left(\frac{16}{\pi * \tau_{ed}} \right) \{ (K_b * M_b)^2 + (K_t * M_t)^2 \}^{1/2} \right\}^{1/3}$$

Substituting the values in above equation we get,

$$D = \left\{ \left(\frac{16}{\pi * 82.776} \right) \{ (1.5 * 7237.5)^2 + (1 * 716.25)^2 \}^{1/2} \right\}^{1/3}$$

$$\therefore D = 8.74 \sim 9 \text{ mm}$$

The adopted diameter is 20mm, obtained is 9mm. Hence $9\text{mm} < 20\text{mm}$, so the design is safe.

VI.CONCLUSIONS

The high speed rotation of the brush helps in cleaning the sole of the shoe effectively and the rotating brush attached to the same shaft helps in polishing the shoe, where the liquid polish is manually applied to the shoe by the user. Hence the shoe sole cleaners are extremely useful in places where the dust due to the footwear is a major problem. The shoe sole cleaning with polishing machine is a complete set up produced for cleaning the shoe in order to maintain dust free environment and also polishing the shoe to give an elegant look to the shoe as well as to the user. Thus we can conclude from the above that the usage of shoe sole cleaning with polishing machine is a must for all the industries (chemical, food processing etc) and institutions where cleanliness and dust free environment is a primary requirement.

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**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

BIOGRAPHY



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