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Design and Fabrication of a Semi- Automatic Shoe Polishing Machine for Small Scale Business

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Abstract*. Shoe is generally made from leather which requires extreme care and regular polishing to maintain its shiny appearance. This work attempts to develop a semi-automatic shoe polishing machine for small scale enterprises. The machine is intended to grip the shoe at the right place, apply a layer of polishing wax all around the shoe and perform buffing action to obtain a shiny and assure minimum damage to the shoe. This semi-automatic shoe polishing machine is designed to consist of screw mechanism, a shaft, two bearings, two pulleys, belt, two fibred brushes, an electric motor and springs for gripping the shoe. It is 710mm x 500mm x 650mm in dimensions. The developed machine is limited to standard shoe sizes and capable of polishing a pair of shoes in 175 seconds*.

Keywords – *Shoe, polishing, machine, buffing, semi-automatic*

INTRODUCTION

In view of global economic recovery and self sufficiency, local materials are readily available for tapping which could enhance our technological advancement. Shoes are so important in the life of man that, for years he has to change them through the act of polishing. When looking at the history of shoe making, the essence of polishing cannot be compromised, because the glory of shoe making is better appreciated from its overall appearance after it has been manufactured and in use which is the result of polishing process [1].

Few researchers have developed various types of shoe polishing machines using different techniques. Screenivas et al [2] designed a shoe sole cleaning with polishing machine. This machine provides easy operation of both shoes sole cleaning and polishing in the exterior of the machine. It helps the user to freely move the sole over the rotating brush. The polishing liquid is applied manually to the shoe during the polishing operation. Entire gears, shaft and bearing mounts are rested on the L- iron bar base arranged according to the space needed to carry out the operation at the bottom a tiny is provided in order to collect for dust particles obtained during the operation of sole cleaning. The machine also focuses on the automation of the shoe cleaning process without human involvement. Thorat [3] designed and fabricated a shoe polishing machine whose shoe polishing operation is entirely mechanical. The machine consists of a shoe support, a conveyor mounted for movement about shoe support, a plurality of shoe engage able brushes, first drive means for conveyor, second drive means for brushes and support mounting. Kanna et al [4] developed an automatic shoe shining device. The primary objective of this invention is to provide an improved machine which may effectively polish shoes through the use of mechanical and electronics means. Campbell [5] also invented foot-support for shoe-polishing machines. This foot-support device consists of drive pulleys in vertical alignment and mounted on a common drive shaft which is supported at its end in a bearing member carried by the bottom wall. The central rear portion of the drive belt is entrained over a drive pushing which is mounted on a vertical drive shaft. The lower end of the drive shaft is journalized in a support bracket extending forwardly from the rear wall and the upper end of the drive shaft is rotatable journeyed in a suitable bearing member depending on the top wall. Harver et al [6] also designed and constructed an automatic shoe cleaning and polishing machine. It consists of a shoe support, a conveyor mounted for movement about shoe support, a drive means connected to brushes for rotating the brushes and means for mounting the brush on conveyor for longitudinal movement over a toe portion of a shoe. Cam is also connected to other support for retaining brush out of engagement with a shoe when the toe of a shoe is disposed rear worldly. Neermarga et al [7] designed and fabricated an automatic shoe polishing machine that focused on automation of the shoe polishing and shining process without any human involvement. Similarly, Viswanath et al [8] designed and fabricated a smart automatic shoe polishing machine. This machine is equipped with a sensor that performs the required operation with a high degree of accuracy. A semi-automatic sole cleaner was also designed and fabricated by [9]. Kujur et al [10] also designed a coin operated shoe polishing machine requires less human involvement. An Indian coin based automatic shoe polishing machine using Raspberry pi with open cove was also developed by [11].

Figure 1 depicts typical model of shoe cleaning and polishing machine adapted from previous works on shoe cleaning and furnishing machine. This work primarily developed a semi-automatic shoe polishing machine that can

be used by shoe polishing business owners. It provides a power operated shoe polisher mechanism that can satisfactorily perform the functions required of it. This work also attempts to develop a compact unit which will successfully combine factors of structural simplicity and durability and yet be economical to manufacture for small scale shoe polishing business owners.

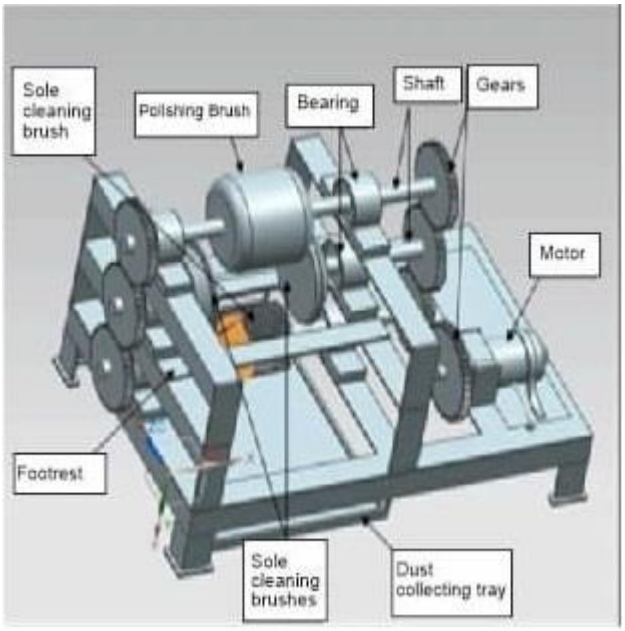


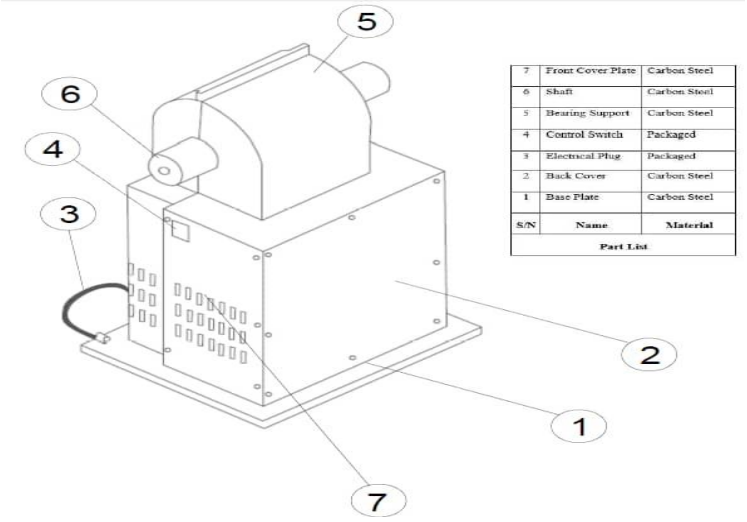
Figure 1. A typical model of shoe sole cleaning and polishing machine

METHODS

In designing and simulation, software that supports technically is used so that the design results can be displayed visually without first being realized. The design process is carried out using a computer with solid work software [16–18]. The stages carried out in this study include:

Design Consideration

Polishing of a shoe involves two steps of applying polish to the shoe and buffing or brushing the polish-coated surfaces of the shoe. The developed semi-automatic shoe polishing machine consists of a shaft, two bearings, two pulleys, belt, two fibred brushes and an electric motor. The criteria for choice of the materials for the various components of the machine are based on the local availability, applicability, operating and environmental conditions in which they will operate. A single shaft was used 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 shoe and polish it. In order to have a safe action of the machine the shaft has to be designed, considering the forces acting on it. The machine was designed in such a way that, the flange on the shaft can be disassembled and replaced with the type of brush to suit the colour of the shoe. The polish brush is driven by a V-belt through pulley, which is fitted to the shaft by prime mover (electric motor) rated at 1.5 kw. The operator is not exposed to any form of danger because the electric motor is enclosed in the machine housing. Finally, the machine is provided with a base, holes are made to the base to accommodate foundation bolts so that the machine could be bolted to the ground. Figure 2 shows the isometric view of the developed semi-automatic shoe polishing machine.



S/N	Name	Material
7	Front Cover Plate	Carbon Steel
6	Shaft	Carbon Steel
5	Bearing Support	Carbon Steel
4	Control Switch	Packaged
3	Electrical Plug	Packaged
2	Back Cover	Carbon Steel
1	Base Plate	Carbon Steel

Part List

Figure 2. Isometric view of the semi- automatic shoe polishing machine.

Design for the Diameter of the Shaft

A single shaft was used 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 shoe and polish it. In order to have a safe action of the machine the shaft has to be designed, considering the forces acting on it.

The determination of the diameter of the shaft is in line with the method used by [12] and evaluated with the aid of equation (1).

$$D = \{[\frac{16}{n*\tau ed}]\ \{(K_b * M_b)^2\ 1+ (K_t * M_t)2\}½\ \}^{1}/_{3} = 23\ mm \quad (1)$$

Where:

$K_t = 1$, $K_b = 1.5$

A total weight of 14.71N is assumed for the shaft.

Permissible shear stress is assumed to be , σy = 309 Mpa and factor of safety, $F_x = 2$ in line with the method used by Khurmi and Gupta [13].

$F_x = 2x$, σ_{ed} = I 137.96 Mpa, σy = 309 Mpa.

Speed available at the shaft is calculated using equation (2) as used by [14]:

$$\frac{n_1}{n_2} = \frac{Z_1}{Z_2} \quad (2)$$

Therefore, $n_1 = 200\ rpm$,Where n_1 = 219 rpm, z_2 = 96, z_1 = 105

Electric Motor

Electric Motor provides motive power to a wide variety of domestic and industrial machinery. It converts electric motor rotating into mechanical energy for use by such devices as pumps, fans and compressors. Their versatility, reliability and economy cannot be equaled by any other form of drive.Successful motor application which depends upon selecting a type of motor which satisfies the kinetic starting, running and stopping requirement of the driver machinery.

The power required to drive the shaft was evaluated as indicated by Rajput [15] and computed using the expression outlined in equation (3)

$$P = 2\pi NT = 0.985\ kW \quad (3)$$

where, P, T and N are the required power (kW), torque, 43.6Nm and maximum speed of the shaft, 150rpm.

The rating is referred to as the capacity of electric motor. Having gone through various types of electric motors taking into consideration the load, capacity and speed of the machine as calculated above a 1.5kW electric with a revolution of 1500rpm was chosen for the design. The nature of the speed required a constant type, therefore it requires no speed reduction. The power is transmitted from the electric motor to the brush spindle by means of Vee belt.
Length of belt = 1. 82m, Lap angle = 5.67° and Distance between centres = 0.7 m as calculated.

Brushes
This work uses cylindrical type of brush for polishing action. Brushes are devices with hair, bristle or other fibres set in a handle. They are used for cleaning or to spread paints or other coatings. Brushes come in various sizes, ranging from that of a toothbrush, to the standard household version. They perform a multitude of cleaning tasks but specific brushes are used for diverse activities. Other brushes include hair brushes, tooth brushes, shaving brushes and wire brushes. Brush handles are made of wood, metal, plastic or rubber. Hairs and bristle come from pigs, camels and squirrels. Brushes are also made of Palmetto or cane fibres or of synthetic fibres. The type of brush used on the machine is made of bristle fibres.

Roller Bearings
Roller bearings are used for this work. Bearings come in different shapes and sizes. Bearings are mechanical assemblies that consist of rolling elements and usually inner and outer races which are used for rotating or linear shaft applications.

Belt
Belt drives provide positive driving, allow flexibility in location of driver and driven. It also reduces vibration, shock transmission and are relatively quiet.They are made of rubber cover with impregnated fabric and reinforced with nylon, decron, rayon, glass fibre or steel tensile cords.

Pulley
Pulleys are devices use with rope, chain or belt as its run. The axis is secured in a casing which may be removable or fixed. They could be found in drive transmission such as pulling of head upward or belt drive as it is used in the above machine.

Polishing Procedures
The polishing procedure is very simple. Unlike polishing of metals or finished product which involves feeding the metal to the rotating wheel, the shoe is moved in between the brush and the support. The shoe is moved linearly or tilted depending on the operator's desire in order to polish the whole surface of the shoe.

RESULTS AND DISCUSSION

Table 1 depicts the component specification for the semi-automatic shoe polishing machine. The performance of the machine was evaluated using polishing force and the distance of the shoe surface from the machine. Some standard shoe sizes weights that ranged from 0 to 4N were moved towards and away from the polishing brush at varying polishing distances from zero up to 6mm. The values obtained were plotted as shown in Figure 3.

Table 1. Component Specifications

S/N	Parameters	Quantity	Specifications
1	Mild steel bar	1	25mmx 80mm
2	Roller bearing	2	SKF 6305
3	Stainless steel sheet	1	Gauge 7 (4.75mm)
4	Electric motor	1	Single phase 1.5HP
5	Eletric switch	1	One gang way
6	Electric wire	2m	Two line
7	Nut	2	10mm
8	Grease nipple	2	H1 straight10x1mm
9	Belt	1	1800mm x 15mm x 10mm

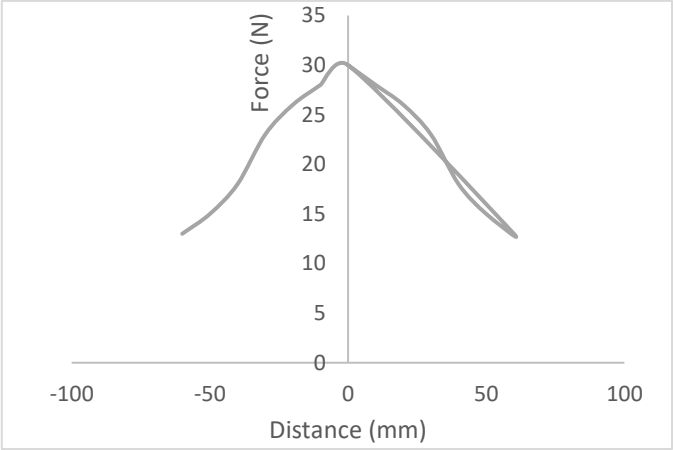


Figure 3. Polishing force against distance.

It was observed that the machine was at its best when the polishing distance is between 0 and 20mm. The time taken to polish some pairs of standard shoe sizes were also taken and compared with manual method. It was observed that it took an average of 175seconds to polish a pair of standard shoe size by the machine. This is similar to the result obtained by Viswanath et al.

CONCLUSION

This work developed a semi-automatic shoe polishing machine for small-scale business that will operate for long periods without substantial maintenance. It can be concluded that the shoe polishing machine:

- Performs buffing action to give the shoe a shiny appearance
- Helps to reduce the rigor of manual means of polishing shoes.
- Reduces the time required to perform the task when compared to manual process.

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