Design and Fabrication of Automatic Shoe Polishing Machine

1,2,3,4UG scholar, NMAM Institute of Technology, Karkala Taluk, Udupi Dist. Karnataka State, India
2Asst. Professor, Dept. of Mechanical Engg., NMAMIT, Nitte, Karkala Taluk, Udupi Dist. Karnataka State, India

Abstract — In this work an attempt has been made to design and fabricate an automatic shoe polishing machine to make the shoe polishing process simpler. This project focuses on automation of the shoe polishing and shining process without any human involvement in the process. This machine uses lead screw mechanism, dc motors for actuation, springs for gripping the shoe, Arduino UNO ATMega-328 microcontroller and L298 motor driver circuit.

Keywords — Lead screw mechanism, dc motor, motor driver circuit, roller brush, arduino, shoe.

I. INTRODUCTION

A shoe is an item of footwear intended to protect and comfort the human foot while doing various activities. Shoe is generally made from leather which requires extreme care and regular polishing to maintain its shiny appearance. This requires a waxy paste or cream known as the shoe polishing wax which is first applied to the shoe evenly using a cloth or a brush. Buffing is then carried out by vigorously rubbing it in order to obtain a shiny surface. This also extends the life of the shoe. The application of this wax is a manual and time consuming process.

This 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 in order to obtain a shiny effect and to assure minimum damage to the shoe.

Gouda et al. designed a shoe sole cleaning and shoe polishing machine. In this study authors explained about shoe sole cleaning and polishing machine which uses gear train mechanism [1].

Liu et al. did research on control system for ceramic polishing machine. In this study, authors explained about automated ceramic polishing machine with gantry type structure instead of pre-existing cantilever structure [2].

Gohil and Patel designed a lead screw mechanism for vertical door wrapping. In this study, authors explained mainly about designing an automated machine which works on lead screw mechanism for wrapping of door [3].

Abdullahi Badamasi analyzed the working principle of arduino. In this study, the author mentioned about the softwares being used as C and C++ for programming of arduino and an easy interface with the board is possible by means of the USB slot provided [4].

Hari Sudhan et al. discussed about Arduino ATMEGA-328 Microcontroller. In this study, the authors explained that Arduino UNO ATMega-328 is most suitable microcontroller for various applications such as industries, laboratory and robotics [5].

Ranjan et al. explained about controlling the speed of dc motor by Pulse Width Modulation (PWM) using Labview and microcontroller. In this study, authors explained about using L298 motor driver circuit board to drive induction loads such as dc motors and stepper motors at different speeds and also at the same speed [6].

Kumar Dewangan et al. explained about PWM based automatic closed loop speed control of dc motor. In this study, the authors examined about controlling speed of the dc motor at varying load condition by means of PWM method, using Atmega-8L microcontroller as feedback system. It was concluded that constant speed can be maintained at varying load condition by PWM [7].

From the literature, it is seen that fewer efforts have been made in developing a fully automatic shoe polisher. Generally the process of shoe polishing is time consuming and involves human interaction. This project focuses on automation of the shoe shining process which could be operated by any person and does not involve any human involvement in the process.

II. DESIGN & FABRICATION

Fig. 1 shows the design of an automatic shoe polisher. The design has been made using Solid Works software. It has a wooden base which supports the whole structure of the setup. The shoe can be mounted on the carriage which is fixed firmly to a gripper. The gripper helps to position the shoe at the right place. The wooden base cut to the required dimensions and the aluminium frame is mounted on the base. The carriage is mounted on the aluminium frame via guide rails. The lead-screw is coupled to the carriage by the nut assembly and it is supported by roller bearings at its extreme ends. Arm is fabricated by cold forging and welding. All mounting brackets are made from aluminium channels and are clamped to the arm. The roller brush is fabricated on a PVC base, attaching the bristles by an adhesive. The wax dispenser is made on a PVC base, layered with sponge. All motors are coupled to respective components by means of
metallic sleeves fabricated by turning and drilling. Electronic circuit assembly separately assembled is connected to respective components. The entire system is automated by use of a programmable Arduino Microcontroller. The completed working model of an automatic shoe polisher is shown in fig. 2.

Fig.1 Design an automatic shoe polisher using Solid Works

Fig.2 Working model of an Automatic Shoe Polisher

III. WORKING

The shoe is placed on the carriage using a gripper that facilitates shoes of different sizes to be placed firmly. Pressing the start button on the console will provide input to the microcontroller which actuates the lead screw. Thus the carriage starts moving in the forward direction. Simultaneously the wax roll comes in contact with the roller brush and hence a layer of polish is applied to the shoe. When the carriage moves to the extreme end in the forward direction and actuates a push button switch, the direction of lead screw will be reversed thus moving the carriage in opposite direction. Simultaneously wax roll gets detached and the roller brush rotates at a higher rate in the opposite direction performing buffing action in order to provide the necessary shiny effect. The push button switch is once again actuated when the carriage moves to the extreme end which stops the operation. The complete automation has been controlled by Arduino UNO ATMEGA-328 microcontroller and L298 motor driver circuit.

IV. RESULTS AND DISCUSSIONS

A. Carriage Speed Calculation

The total time required for the entire cycle is predominantly dependent on the speed with which the carriage is driven form end to end. Thus the time required for the carriage movement is calculated as follows:

- Total travel distance of the carriage possible = 400mm
- (Since: Total length of guide way – length of carriage = 780-380 = 400mm)
- Lead screw used = M12x1.5 i.e. Pitch of the screw = 1.5mm
- Advance of the carriage/revolution of the lead screw = 1.5mm
- No. of revolutions required for a travel of 400mm =266.66mm ≈267mm
- The speed of the motor driving the lead screw being 150rpm,
- Time required for the carriage to travel a distance of 400mm is = 267150 = 1.78min = 106.8sec
- Therefore speed of carriage = 224.71mm/min

B. Spring Calculation for the Helical Tension Spring Used in the Arm Assembly:

The arm assembly of the polisher is driven away from its mean position by the shoe during the process of polishing. The tension spring serves as the retraction mechanism. The specifications of the spring required are calculated as follows:

- Mean diameter of the spring D = 3mm
- Assume spring index C=Dd = 6
- Diameter of the wire d = 0.5mm
- Therefore Stress concentration factor, K=4C−14C−4−0.615C = 1.2525
- Possible extension of the spring y = 20mm
- Assuming Cr-Va Steel Material for the spring: Modulus of rigidity G = 80GPa and Max shear stress τmax = 690MPa (For y = 690MPa and FOS = 1)
- No of active coils require i = yGdπD2τ = 51.36 ≈ 52
- Load on spring F = yGd48D3i = 8.9031N
- Solid length of the spring (Plain and ground ends) ls= (i+1)d = 6mm
- Free length of the spring(Ends are bent before grinding) lo = (i+2)d+y+a = 16.638mm (Assuming a = 0.25y)

C. Spring Calculation for the Helical Compression Spring Used in the Shoe Gripper and Switch Actuator:

The shoe to be polished has to be effectively gripped during the process. The polisher uses a gripping mechanism to achieve it. This mechanism
uses compression springs whose specifications are calculated as follows:

- Mean diameter of the wire \( D = 4 \text{mm} \)
- Assume spring index \( C = 8 \Rightarrow \) Diameter of the wire \( 0.5 \text{mm} \)
- Therefore Stress concentration factor \( K = 1.184 \)
- Assume max deflection possible \( y = 10 \text{mm} \)
- Assuming Cr-Va Steel Material for the spring: Modulus of rigidity \( G = 80 \text{GPa} \) and Max shear stress \( \tau_{\text{max}} = 690 \text{MPa} \)
- (For \( \tau_y = 690 \text{MPa} \) and FOS =1)
- Load on spring \( F = 7.15 \text{N} \)
- No of active coils \( i = 10.92 \approx 11 \)

The equations mentioned in this paper have been taken from the Design Data Handbook [8].

**D. Analysis**

Fig.3 Static displacement analysis on arm

Fig.4 Factor of safety analysis on arm

Fig.5 Static strain analysis on arm

Fig.6 Static nodal stress analysis on arm

Fig. 3 to fig. 6 shows the various types of analysis done on arm assembly namely static displacement, factor of safety, static strain and static nodal stress to know the weight carrying capacity of arm. The analysis is carried out on the arm as it supports most of the heavier components and is susceptible to failure due to the weight of the components mounted on it. The analysis is carried on Solid Works platform. The arm is fabricated out of 1020 Steel rod of 3mm thickness. 4 major loads acting on the arm are considered for analysis viz., the weight of the 10rpm motor, the weight of the high speed motor, the weight of the mounting plate, the weight of the sleeve and the weight of the roller brush. The component is analyzed for the static condition. The maximum Von Mises stress which the arm can bear is \( 1.575e+007 \text{ N/m}^2 \), maximum static displacement in the arm is \( 1.387 \text{mm} \), Factor of Safety of the arm is 22 and maximum strain subjected in the arm is \( 4.590e-005 \). From the results of the analysis it can be observed that the stresses in the component are within the yield limit, ideal case displacement is negligible and FOS is extremely high. This concludes that the design is safe. By using this machine, a shoe can be polished in 107 seconds and the process can be made faster with the fine tuning.
V. CONCLUSIONS

This study focuses on the design and fabrication of a fully automatic shoe polishing machine. The following conclusions can be drawn from the study.

- This machine is able to grip the shoe perfectly and apply a layer of polish.
- It performs buffing action to give the shoe a shiny appearance.
- The machine assures minimal damage to the shoe being polished.
- It reduces the time required to perform the task significantly when compared to manual process.
- It reduces human involvement to a considerable level.
- This machine is economical when compared to the available semi-automatic machines.

REFERENCES


