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Design and Fabrication of Semi-Automatic Road Reflector Stud Installation Machine

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ABSTRACT: *Automation is an essential component nowadays to eliminate the requirements of labour in any industries. Road reflector stud is the important component that mainly prevents the major accidents during night time. But, Manual road reflector stud installation adds up to the major challenge of labour shortage in public work departments. Moreover the manual process is time consuming and not suitable for large volume installations in the roads. The main objective of this work is to design a semi-automated machine for the installation of road reflector studs. The conventional method employs four different processes includes drilling of hole on to the roads, pouring of epoxy resin, placing and stamping of studs, all these process done one back another manually. The present work consists of four stations to do these four processes and employs simple station transfer mechanism. Pneumatic power is fruitfully utilized in this project and the system is controlled by a microcontroller. This paper brings out the detail design procedure, hand calculations, fabrication procedure and system assembly of the machine.*

Keywords: *labour, microcontroller, pneumatic, reflector studs, station transfer*

INTRODUCTION

In today's world increase in urbanization demands a large volume of road construction projects to maintain good communication between cities. This change is accompanied by number of road safety systems and one such system is the road reflector studs, commonly called as Cat's eye [1]. Road studs are retro reflective markers on the road surface to supplement longitudinal road markings, aiding visibility at night. Road studs have a retro reflective surface which reflects the light from vehicle headlights providing drivers with effective lane delineation, particularly during the hours of darkness and in adverse weather conditions [2] [3].It has been reported that with the introduction of cat's eye, road accidents are reduced by a large number.

There is no current system that is being tried for automating the installation of the reflector studs on to the roads and manual effort is fully utilized for it. In recent years Public Works Department faces acute labour shortage problems and road stud installation adds up to it. Also manual installation consumes more time and are not efficient. This paper aims to design and fabricate a semi-automated machine for the installation of road reflector studs. This system once developed into a real time model will have the key to shape the future of road construction and safety and greatly reduces the relying of construction field on man power.

II. SETUP DETAILS

A real time semi-automated road reflector stud installation machine is designed and fabricated. The setup is capable of performing four different processes [4] which includes 1) Drilling of hole on to the roads; 2) Filling up of hole with strong adhesives like epoxy resin; 3) Placing of road studs from the hopper storage, such that their legs are in to the holes; 4)Stamping of studs to fix it tightly on the roads. The setup is broadly divided in to two major parts; one is the mechanical setup involving the driller setup, lead screw arrangement, cylinder setup, gumming station and the hopper setup, the most important being the base setup above which the magazine is capable of rotating. While the other part is the electrical circuit involving AC-DC converter, relays, microcontroller, solenoid DCV, solenoid valves and more. The two parts work with synergy to perform the reflector stud installation process semi- automatically. Once the human being places the machine at the desired location and when it is switched on, the four processes are done sequentially to fulfil the objective of road stud installation.

The proposed setup is a tetra-stationed body made up of L angles of 1'' and channels of 2'' width, uses rotary indexing mechanism indexes for every 90 degrees. The tetra stationed body seats over the shaft connected with the base motor [10]. The motor is held by the base body and the entire setup is movable with the help of wheels.The drive for the rotation is provided by 12V DC Wiper motor rotates at about 45 RPM having 20Kgf-cm torque through gear transmission [11]. Indexing is achieved with the help of an inductive type proximity sensor.

On the first station, a driller is attached to a lead screw which brings about the drilling process [6]. The lead screw is driven by the same 12V DC Wiper motor having the same specifications. A limit switch is provided to limit the depth of the drill. In the second station,a channel for the storage of epoxy resin provided with a solenoid valve is assembled.The studs are stacked on to the hopper made of steel. One pneumatic cylinder of stroke length 200mm is used to place the studs from the hopper to the drilled hole and are placed horizontal at the base [5]. Another pneumatic cylinder of same stroke length is placed parallel to the hopper and is used for stamping of studs.

Specifications of Machine

3.1Mechanical

Lead Screw	Mild steel 7/8 ” diameter
Drilling capacity	25 mm
Stroke Length	100 mm
Hopper	5’ x 4 ‘’ wide , 300 mm height
Solenoid Valve	10mm

3.2 Pneumatic

Cylinder [5]	Double acting
Stroke Length	200mm
DCV	5/2 ,Solenoid 230 V
FRL	5µ filter, 20 bar
Compressor	12 bar

3.3 Electrical

DC Motor	12 V, 20 Kgf-cm, 45 RPM
Microcontroller	AT89C51
Relay	6V DC
Motor Driver	ULN 2003
Proximity Sensor	Inductive type

III. WORKING

The road studs are initially stacked in to the hopper [7]. Once the machine is placed on the desired location and switched on, the four processes included in the road stud installation are carried out sequentially. On the first station a hole is drilled on the road for the depth of the stud’s leg. This can be achieved by a driller setup and lead screw arrangement. Provision of blower setup from the compressor ensures clearing the hole of sand and stone particles. The motor used here is of high torque enough to withstand the back pressure exerted while drilling on the road. Stability of the setup can be maintained while drilling with the help of pneumatic stability legs as seen in earthmovers. Once the drilling is completed the base motor rotates for 90 degrees and the pouring of epoxy resin in to the hole is carried out in this station. Epoxy resin is highly adhesive in nature which firmly fixes the road studs on to the roads and are not affected by any atmospheric conditions like sun’s heat. On another 90 degree rotation the 3rd station starts to do its job. Here from the hopper one stud is made to fit into the hole with the help of a pneumatic cylinder. Once this is accurately done with the provision of proper guide ways, in the next station a pneumatic cylinder stamps the stud that tightly fits them on to the roads. The entire sequence is controlled by a microcontroller and it is programmed such that [9]. With the availability of small sized portable compressors and battery power supply adds the features of less weight and low cost to this machine.

Design Calculations

The design calculations utilized for the present work is reported in this section.Selection of Pneumatic Cylinders[8] is given below

Stroke Length - 200mm
Dia of the cylinder - 400mm
Operating pressure - 4 to 10 bar
Dia of the rod - 200 mm

Force Calculations are based on the following values and it will be around 880N.

Pressure = 700 kPa (assuming)
Cylinder Diameter = 40mm

Force F = P * A (1)
Selection of Motor [12] is based on the following
Torque = Force * Distance (2)
Required torque for the motor is around 36.7875 Nm, also maximum power required for the motor is 192.52 W, and required current will be 16.043A

Fabrication Process

6.1Mechanical Section

Product Design is the most important stage which is iterative and complex in nature till the visualization comes into real picture. This machine is designed using Pro-E creo software. Initially the part drawings are made to the dimension specified and then the parts are assembled as shown in Fig1. Once the design meets the requirement, the real time setup is fabricated. For the body making steel L angles of size 1'' is used. They are cut in to specific dimensions and are arc welded. The motors and cylinders are screwed or fastened in appropriate places, motors are coupled to the shafts held in bearings. The entire rotating setup is laid over a base attached with wheels. The fabricated real time setup is shown in Fig 2.

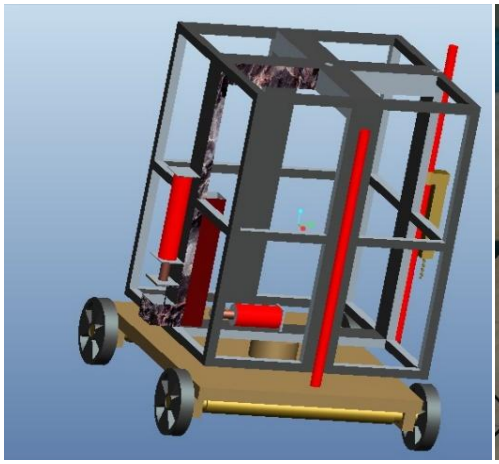
Fig 1 Pro-E Model


Fig 2 Fabricated setup

6.2 Electrical Section

The electrical section consists of microcontroller circuit, relay circuit and rectifier circuit. All the circuits are built on a dot board except the microcontroller circuit which is built using a microcontroller development board. Relay board has relays which converts the signals from the microcontroller through ULN 2003 to actuating components. Software implementation of the electrical section is carried out using RIDE for programming [9], PROTEUS for simulation which is shown in the Fig 3 and WILPRO for microcontroller dumping. Once this is done and output of simulation meets the objective of the project, real time implementation is carried out. The real time electrical circuit is shown in the Fig 4. The conversion of AC voltage to DC voltage is achieved by a rectifier circuit. The AC voltage is stepped down using a step down transformer and it is fed to the rectifier. The rectifier, thus, converts 230V AC into 12V DC which is given as input to DC motor.

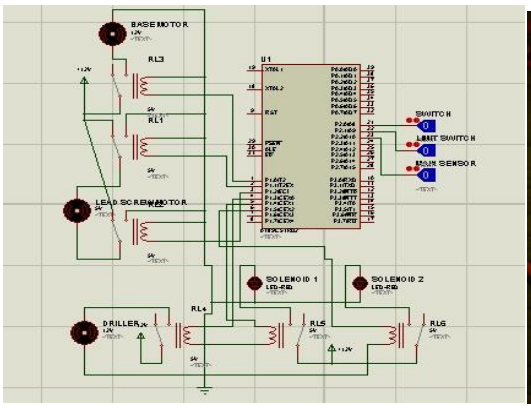

Fig 3 Proteus diagram

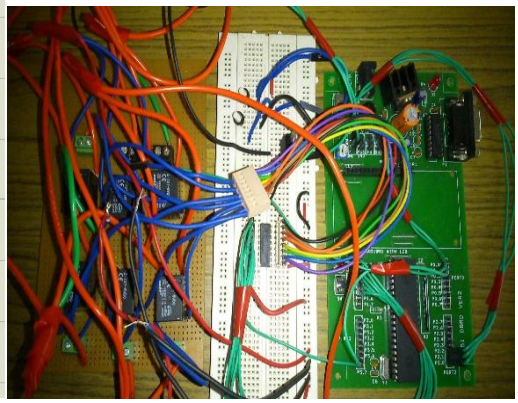
Fig 4 Electrical Section

6.3 Machine Assembly

Once the mechanical and electrical sections are fabricated, they are assembled together to achieve the semi-automatic installation process. The proximity sensor is placed in the centre shaft and are used to achieve the indexing mechanism. The signal from the sensor and the limit switch are given to the respective ports of the microcontroller as created in the program. The cylinders are connected to the compressors through FRL Unit and 5/2 DCVs with 6mm hoses. AC supply is given to the driller and the solenoid actuated DCVs through the signal from the microcontroller to the relays. DC supply is fed through relays on signal from the microcontroller for the DC motors. All the wirings are properly insulated and tagged.

IV. CONCLUSION

In the present work, a semi- automated system for road stud installation is developed. Usage of pneumatic components proves to be cost-effective without satisfying the performance of the machine. This system greatly reduces the problem ofman power shortage in public works department. Also it increases the productivity and efficiency in laying of road reflector studs. In future the machine can be improved by making it to work as a fully automated one by eliminating the present intervention of human beings for moving the machine to each location. The potential of hydraulic power can also be visualized for this work. The idea that have chosen is a completely new dimension that surely will open up innovative minds to move forward in this direction.

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