Design and Development of Semi Automated Painting booth for Pump Manufacturing Industries

P.Magudapathi,R.Saravanan,K.Murugesan
Department of Mechatronics Engineering.
Kumaraguru College of Technology
Coimbatore,India
magudapathi.p.mce@kct.ac.in saravana.r.mce@kct.ac.in
murugesan.k.mce@kct.ac.in

P.D.Devan,G.Gunalan
Department of Mechanical Engineering.
Kumaraguru College of Technology
Coimbatore,India,
Knowledge Insitute of Technology
Salem,India
devan.p.d.mec@kct.ac.in, gunalan.mts@gmail.com

Abstract— **Industrial painting robots are large and expensive, but today the price of the robots has come down. For this reason every pump manufacturing industry still applies painting process which causes decrease the work time, low quality and hazardous to human health. Painting works in the pump manufacturing industries of Small scale levels are carried out mostly by manual process. Therefore the purpose of this design is to develop the semi-automated painting booth system. It consists of framed structure with the mechanical system for the linear and rotary motions. To proposing this design and development of the paint booth is for easy operation, reduction in man power, decrease in the working time, easy material handling, painting quality and preventing painter from the poisonous chemicals present in the paint pigment.**

Keywords—Robots, paint pigments, automated paint booth

I. Introduction

The purpose of design and development is to automate the paint booth for easy operation, reduction in man power, decrease in the working time, easy material handling, painting quality and preventing painter from the poisonous chemicals present in the paint pigment.

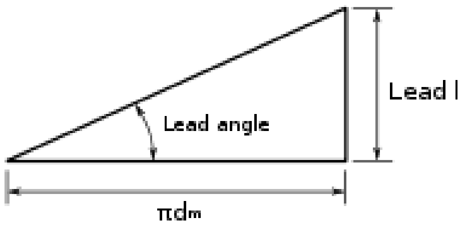
Industrial paint robots are large and expensive, but today the price of the robots have come down to the point that general industry can now afford to have the same level of automation that only the big automotive manufacturers could once afford. In this specially designed robotic system will be developed to paint vertical submersible pump sets. The system comprises of motor, microcontroller and proximity sensor.

Lead screw arrangement actuated by a motor is used for the linear movement of the paint sprayer, and another motor is used in the rotating fixture which is used for the pump rotation. These components are placed in the paint booth. The exhaust and paint purification system is placed behind the paint booth.

The microcontroller is used to control the actuation of the motor, gun motion and the exhaust with purification system is used to purify the paint dissolved in the water. Submersible pump diameter and height are the input for this control system. Based on these inputs microcontroller calculates the total area of the pump to be painted. The motion of each motor is controlled by a driver circuit which is controlled by a microcontroller. The advantages of the paint booth are easy operation, reduction in man power, decrease in the working time, easy material handling and preventing painter from the poisonous chemicals present in the paint pigment.

II. Mechanics and Drives

A. Mechanics



The torque required to lift or lower a load can be calculated by "unwrapping" one revolution of a thread. This is most easily described for a square or buttress thread as the thread angle is 0 and has no bearing on the calculations. The unwrapped thread forms a right angle triangle where the base is πd m long and the height is the lead (pictured to the right). The force of the load is directed downward, the normal force is perpendicular to the hypotenuse of the triangle, the frictional force is directed in the opposite direction of the direction of motion (perpendicular to the normal force or along the hypotenuse), and an imaginary "effort" force is acting horizontally in the direction opposite the direction of the frictional force. Using this free-body diagram the torque required to lift or lower a load can be calculated.

$$T_{raise} = \frac{Fd_m}{2}\left(\frac{l + \pi\mu d_m}{\pi d_m - \mu l}\right) = \frac{Fd_m}{2}\tan(\phi + \lambda)$$

$$T_{lower} = \frac{Fd_m}{2}\left(\frac{\pi\mu d_m - l}{\pi d_m + \mu l}\right) = \frac{Fd_m}{2}\tan(\phi - \lambda)$$

B. Drives

AC INDUCTION MOTOR SPECIFICATION

Speed N	= 1440 RPM
Voltage V	= 230 Volt
Current I	= 0.81 A (full loading condition)
Power P	=V x I=230x0.81= 186.5WATT
P	=0.25 HP
Motor Efficiency	= 80%
Pin = I * V	Pout = T * ω
ω = N * 2π / 60	E = Pout / Pin
Pout = Pin * E	T * ω = I * V * E

T * N * 2π / 60 = I * V * E

TORQUE OF THE MOTOR

The formula for calculating torque will be

T = (I * V * E *60) / (N * 2π)

	= (0.81x230x0.8x60)/(1440x2π)
Torque	= 0.988 Nm= 1 Nm
Torque (T)	= 10 kgcm

DC MOTOR CALCULATION

Speed N	= 30 RPM
Voltage V	= 12 Volt
Loading Current I	= 300 mA
No Load Current I	= 60 mA
Power P	=V x I=12x0.3 = 3.6 WATT
P	= 0.0048 HP
Motor Efficiency E	= 36%
Motor shaft diameter	= 6 mm
Torque (T)	= 4.2kgcm

WORM GEAR CALCULATION

Number of teeth on worm wheel	= 30
Outer diameter of worm	= 32 mm
Inner diameter of worm	= 24 mm
Number of starts on worm	= 7
Motor speed	= N = 1440 rpm
Mild steel shaft shear stress	= f_s =42 N / mm^2
Torque of the motor	= T_1 = P_1 x 60 / 2 x π x N
	= 414 x 60 / 2 x π x 1440
	= 2.74 N - m
Gear ratio (i) = no of teeth in worm wheel / one spiral worm	= 30/1=30:1
(N1) worm shaft speed	= 1440 rpm
(N2) worm wheel speed	= 48 rpm

Torque ratio= reciprocal of speed ratio

T1/T2=N2/N1=48/1440	=0.033
Torque of the worm wheel (T_2)	= T1/0.033=2.74/0.033
	= 83.03 N m
Angular velocity of worm wheel	= 5.026 rad/sec
	= 2 x π x 48 / 60
Maximum torque rate of the worm wheel	= π/16 x f_s x d^3
	= π/16 x 42 x 0.06^3
	= 1.78 N m

Worm wheel torque is limited to the maximum limit. So our design is safe. Hence the worm wheel used here rotates at = 48 rpm.

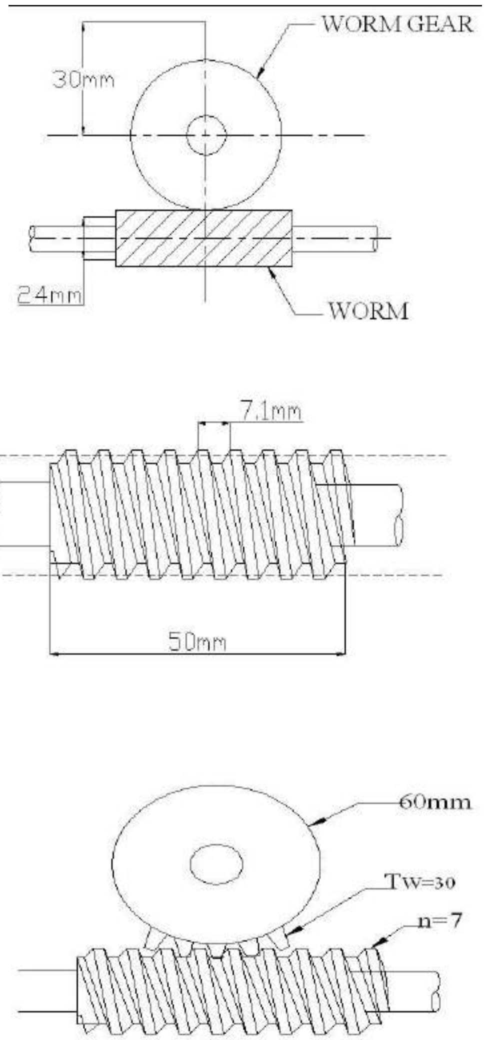


Fig. 1.Worm Gear Arrangements

LEAD SCREW CALCULATION

Pitch of the lead screw P	= 3 mm
Speed of Lead Screw, N	= 48 rpm
The linear velocity of the lead screw	= N x P= 48 x 3
	= 144 mm/min
angular velocity of the lead screw	= 2∏N/60= 2∏ (48)/60
	= 5.026 radian/s

Power of the lead screw, P = 186.5 W

Torque of the lead screw = $P \times 60/2\prod N = 186.5 \times 60/2\prod(48)$

= 37Nm

Maximum withstanding capacity = torque/radius of lead screw

= 37 /0.0125

Maximum withstanding capacity = 2960 N

III. BLOCK DIAGRAM

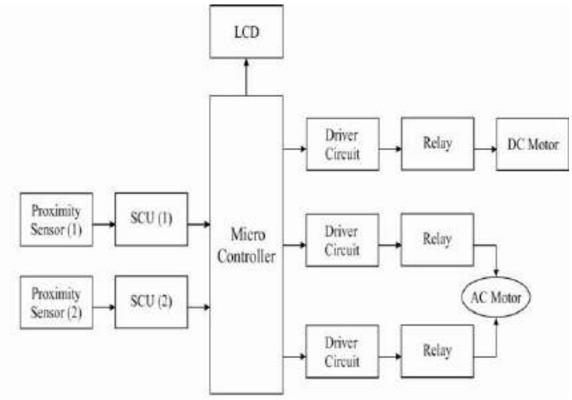


Fig. 2.Lay out of Controller

IV. WORKING PRINCIPLE

In this painting process the using components of proximity sensor and mechanical components such that lead screw, motor, spur gear, worm drive, paint sprayer, rope and hook. Lead screw, worm drive and AC motor setup tends to move the sprayer up and down. Another function is to slowly rotate the submergible pump that is to be painted. Motor is coupled with small spur gear that tends to rotate the large gear. Submersible pump to be painted is hanging on the hook through rope and clamp that tends to be rotated by large gear. Movement of paint sprayer is guided through lead screw. Clock and anti – clock wise rotation of lead screw is done by AC motor and lead screw setup. Up and down motion of sprayer is sense with proximity sensor according to that signal received from sensor motor rotate forward or reverse.

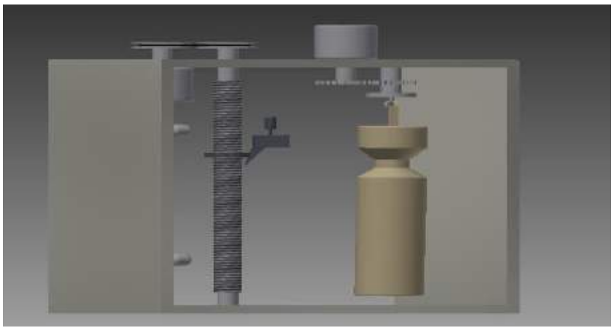


Fig. 3.CAD Model

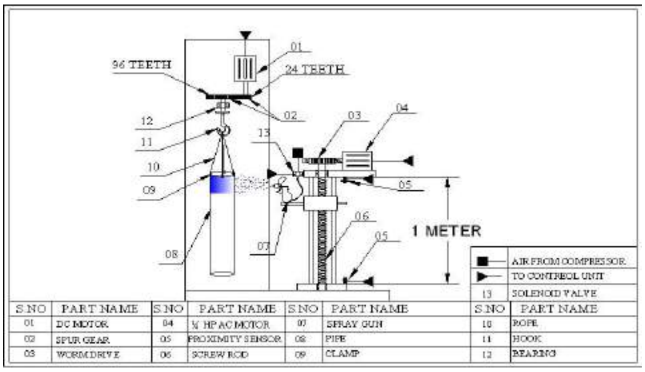


Fig. 4.Experimental Setup

Fig. 5.Working Model

V. CONCLUTION

Thus this work has been developed to provide more flexibility in its operation, to be economical and improved production volume by reducing process time. Semi Automated Painting Automation for Submersible Pump Sets is designed with the hope that it is very much economical and help full in pump industries. This work carried out by us will make an impressing mark in the field of small scale industries. It is very useful for the workers to carry out the operations in a single machine.

References

[1] M.Vincze, A.Pichler, G.Biegelbauer, “Automatic robotic spray painting parts”,2002.

[2] Urbano Nunes, Antonio Batista, Jaoa figueredo, “Spray painting motion planning”,1999.

[3] Eisemann, “Large capacity spray booths”, 2002.

[4] P.S.G.Tech., “Design data book”, vol 1,2009.

[5] Mark freels, “Robotic paint automation”, 2007.

[6] Dong Hoon Lee, Ho Kyeong Kim, Rae Soo Lim, Eun Tae Kimand Hyo Kwan Leem“Development of semi-automatic painting system for longitudinal stiffeners in double Hull blocks”, 2008.