Design and Development of Paint Viscosity Controller

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Abstract - *This dissertation concentrates on designing a fully automatic paint viscosity controller closed loop system. If the paint has high thickness it takes more time to dry out which results in less productivity. Similarly, very thin paint results in bad quality of work. How the specific amount of thinner can be added into the paint and the viscosity can be controlled automatically is explained here. The newly designed system gives a perfect layer of paint which reduces the rejection rate of products and helps to increase the profit amount. The manual interface is totally removed in the new design to avoid human errors and. The automation of system is achieved by using Programmable Logic Controller (PLC).*

Key Words: automatic, paint, viscosity controller, productivity, quality, rejection rate, errors, PLC.

1. INTRODUCTION

Existing system is having multiple problems like; open tank of thinner which results the thinner to get evaporated as it has vicinity to the air, uneven layer of paint is generated because of uncontrolled viscosity of the paint, extra thick layer results in excess time requirement to dry the paint out, extra thin paint results in a very poor quality of paint layer generation and an open system needs human interface to operate the machine. The newly designed system overcomes each problem of this list.

The objective of the new machine is to provide completely closed loop system for proportionate mixture of paint and thinner, save the cost and material, ensure proper quality of the paint layer, minimise the product rejection rate and increase the profit.

2. DESIGN

This machine is specifically designed to achieve an exact viscosity value of the paint which will be used for painting various objects according to need. Measurement and control of viscosity of paint is done by using viscosity sensor. Viscosity of the paint is one of the important parameters that give a perfect layer of paint on the product. The rotating spool of the viscosity sensor is operated by the servomotor which runs in the paint and thinner mixture.

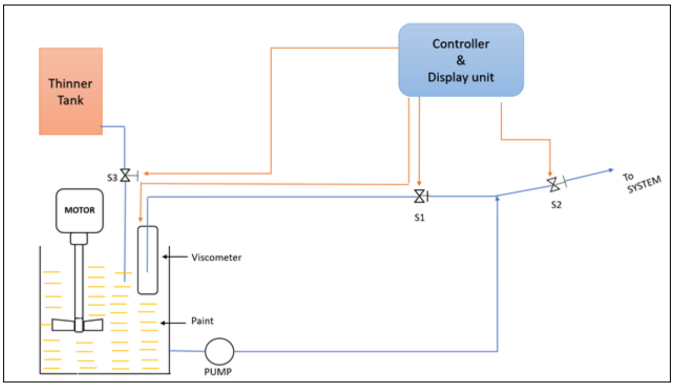

Fig – 1: Proposed model

The pipe which connects the pump and sensor has a normally open type solenoid valve SV1 which controls the flow to the sensor. Another pipe which is between pump and the place of use is controlled by normally closed type solenoid valve SV2. The intention behind keeping such arrangement is to check the mixture before actual use. Mixture flows through SV1 to the sensor where viscosity of the mixture is checked.

Indication of green light by sensor gives the certification of meeting the required viscosity. This happens because the PLC is programmed to satisfy this condition according to needs. PLC triggers the system and then SV1 closes with opening SV2 which makes the mixture to flow to the painting unit. This opening and closing cycle of SV1 keeps on running to continuously have a check on viscosity of the mixture as it may change during the working conditions.

When the viscosity of the mixture is not as per the requirements, the sensor gives an indication of red light. As well as sensor display actual viscosity of the mixture. The programming of the system is such that, it calculates the difference between actual and required values of viscosity and then adds the amount of thinner/paint as per the requirements. SV3 is operated to add the amount of thinner to the mixture to achieve the exact viscosity as per the requirements. The mixer mixes the mixture of paint and thinner continuously. Blades are placed to complete the task of mixing. In the actual model, the force exerted by the mixture on the mixing blades is used to determine the viscosity of the mixture. The load on the blades increases with increase in viscosity and vice versa. It is little challenging to calculate the load accurately. Servo motor is used to determine this load. RPM of the motor is kept constant and then the load is calculated according to the consumption of current by the motor. PLC records the readings and compares it with different reading at specific intervals of time.

3. MATERIAL SELECTION

1. Motor

Given = 220 volts, 0.0018 ampere.

i. Power

P = V * I

= 220 * 0.0018

= 0.3987 KW

= 0.4 KW

ii. Torque

P = (2*π*N*T)/60 W

400 = (2*3.14*3000*T)/60 W

T = 1.273885 Nm

2. Shaft

For 400W, 0.4KW Delta ECMA – C30604FS 60mm motor, shaft diameter available is 12mm. So we need to select the shaft with outer diameter 12mm.

Length of shaft is taken as 40mm, according to the height of mixing tank.

Blades

Blades size is decided according to the amount of colour in litres.

Sr. No.	Blade Size (Diameter*Thickness in mm)	Paint quantity (Liters)
1.	40 * 1.5	5-10
2.	70 * 1.8	15-40
3.	120 * 2.2	50-250
4.	145 * 2.2	200-700

Table – 1: Standard Blade Sizes

3. Couplings of Shaft.

Diameter = 40mm.

Inner Diameter = 12mm.

Length = 30mm.

4. WORKING

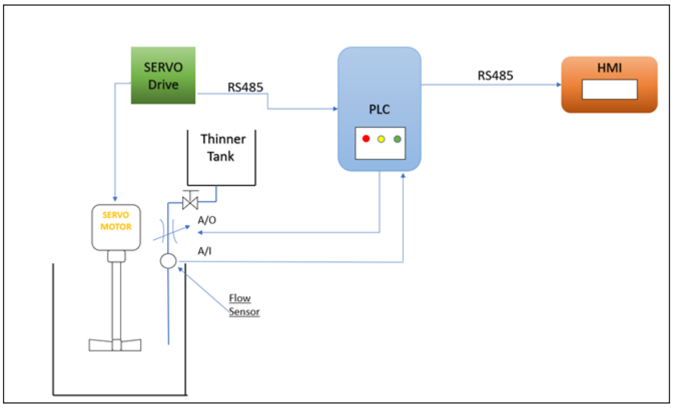

Fig – 2: Working setup

The setup consists of Servo Motor, Servo Drive, Thinner Tank, Programmable Logic Controller, Human Manual Interface, Solenoid Valve, Flow Sensor and Variable Flow Control Valve. Initially the raw paint with extremely high velocity is poured into the mixing tank. Now the servo motor is turned ON which is operated by servo drive. The thick paint exerts pressure on the mixing blades attached to the motor shaft. The current consumption by the motor is identified and RS485 command is sent to the PLC by the servo drive. The force exerted by the paint on the blades is very high initially because of high viscosity and therefore high load on the motor take more current consumption.

PLC compare the value with pre-set required value and send the command to variable flow control valve. The thinner is added to the mixing tank through solenoid valve, variable flow control valve and flow sensor. After adding thinner into the paint, viscosity of the paint starts reducing. This results in less force acting on the mixing blades and further less consumption of current by the motor which shows reduction of viscosity via command RS485.

The flow sensor works as a feedback loop. It gives the data to PLC which is related exact amount of thinner added into the mixing tank. Exact value of the Viscosity of the paint is calculated in the Programmable Logic Controller and then further it is displayed on the Digital Screen at Human Manual Interface (HMI).

In case if the tank is open to the environment and paint is stored in the mixing tank only then high vicinity of thinner to the environment results in automatic increase in the viscosity of the paint. In this case we need to turn on the servo motor once again before using that paint for painting the required objects.

5. ANALYTICAL METHOD TO CALCULATE VISCOSITY

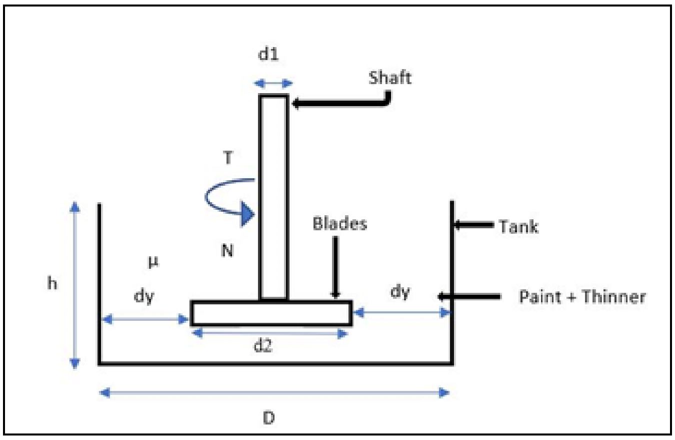

Fig – 3: Dimensions of Tank

The shaft which is connected to the blades is rotating at 1000rpm. Diameter of shaft and blade is 12mm and 90mm respectively. Torque of the motor used to rotate the blades is 1.27Nm. The task of mixing is carried out in a cylindrical tank of diameter 300mm and height 400mm. Paint is filled up to height 304.8mm. Calculate the dynamic viscosity of the paint.

Given:

N	= 1000 rpm	
T	= 1.27 Nm	
d1	= 12 mm	= 0.012m
d2	= 90 mm	= 0.09 m
D	= 300 mm	= 0.3 m
H (fluid height)	= 304.8 mm	= 0.3048 m

To Find: μ =?

1) Velocity of mixing blades

Du = [(3.14*d2*N)/60]

= [(3.14*0.09*1000)/60]

= 4.712388 m/s

2) Remaining distance of fluid around the blades

Dy = D-d2

= 0.3-0.09

= 0.21 m

3) According to Newton's Law of Viscosity, rate of Shear stress is directly proportional to rate of Shear strain.

Shear Stress = μ*[Du/Dy]

Shear Stress = F/A

Therefore;

F = Shear stress * Area

= T/r1 (motor give speed to shaft first)

= 1.27/ (0.012/2)

= 211.6666N

Area = 2*3.14*R*H (cylindrical tank)

= 2*3.14*0.15*0.3048

= 0.28726 sq. m

F = Shear stress * Area

211.66 = {μ*[Du/Dy]}*0.28726

= {μ*[4.712388/0.21]}*0.28726

736.84 = μ*22.4399

μ = 32.8363 Poise

= 32.8363*10^3 cP

The dynamic viscosity of the paint is 32.8363*10^3 cP.

5. CONCLUSIONS

From the above results, conclusions drawn are;

1. The current paint mixing machine has manually interfered thinner and paint mixing systems, which results in uneven mixture, play with the required viscosity value and high product rejection rate. All these problems are eliminated by introducing a fully automatic unit.

2. Continuous monitoring of the viscosity of paint and thinner mixture is done at regular intervals by using PLC.

3. Exact viscosity of the paint is achieved by adding a specific amount of paint and thinner in the tank by using different solenoid valves and this viscosity is compared to the pre-set value by using sensors and PLC to achieve the accuracy.

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