International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 12, December - 2017

Design of Mechanically Actuated Diaphragm Type Dosing Pump

Vaibhav Rathod*, Bhalchandra Sakhare*, Bhuvanesh Rasal*, Atul Vazratkar*,
*Student,
Department of Mechanical Engineering, RMD Sinhgad School of Engineering, Pune.

Sharayu Ratnaparkhi#
#Assistant Professor,
Department of Mechanical Engineering,
RMD Sinhgad School of Engineering, Pune.

***Abstract*— The main purpose of research is to develop a control scheme for automatic control of dosing pump for a laboratory based water treatment plant. The chemical dosing pump delivers the alum with different flow rates depending on the dosage requirement for the laboratory based water treatment plant. The alum flow rate is controlled by an intelligent controller, which includes knob controller. The intelligent controller is a steady state feed forward controller. The result shows that the steady state feed forward controller will be able to control the flow rate accurately. The purpose of dosage control is to reduce the turbidity of the drinking water below accepted standard. Conventional controllers like Proportional Integral and Derivative controllers cannot be used because of the nature of water treatment process. Alum dosage reduces the turbidity of the water. At the same time excess alum dosage leads to health hazards. Hence the conventional feedback control is not suggested in this research. In dosage control systems, especially in the water treatment process knob controller is preferred.**

Keywords*— *Dosing, Control, Laboratory, Water Treatment.

I. INTRODUCTION

A bendable metal or polymeric diaphragm seals a small capacity of volume at one end. At the other end are two spring-tensioned valves, the valve one open when the volume pressure falls down than the outside pressure and the other opens when its pressure becomes excess than outside pressure. A cam fitted on a motor shaft rapidly reciprocates the diaphragm forward and backward, causing matter transfer in one valve and out the second valve. While in all rotary vane type pumps, matter from the chamber enters the inlet port and is trapped between the rotor vanes and the pump body. The eccentrically fitted rotor compresses the matter and sweeps it toward the discharge port. The exhaust valve opens and matter is expelled when matter pressure exceeds atmospheric. Oil is used as a lubricant, coolant, and matter sealant for the vanes. Single-step rough rotary vane pumps have final pressures about 10^{-2} Torr range while two-step medium vacuum vane pumps reach 10^{-3} Torr. Rate of pumping lies between 1–650 cfm, depending on whether the pump is a coarse vane or rough vane pump. While hybrid pumps were constructed to accept the poor fore line pressure diaphragm pumps produce. The various purpose of Diaphragm pumps are for simple thin film evaporation, distillation, gel drying applications, and as sample movers for gas analyzers, vacuum filtration, membrane filtration, and sample extraction.

II. WHAT IS DOSING ?

The word dosing is incredibly normally employed by engineers in thermal power stations, in water treatment, in any trade wherever steam is being generated, and in building services for heating and cooling water treatment. Dosing procedures also are in textile and similar industries wherever chemical treatment is concerned. business swimming pools conjointly need chemical dosing so as to regulate pH scale balance, atomic number 17 level, and different such water quality criteria. Trendy natatorium plant can have bulk storage of chemicals command in separate dosing tanks, and can have machine-controlled controls and dosing pumps to prime up the varied chemicals as required to regulate the water quality. In building services the water quality of varied tense fluid systems, together with for heating, cooling, and condensation water, are going to be frequently checked and lidded up chemically manually as required to suit the desired water quality. Most ordinarily inhibitors are going to be superimposed to safeguard the pipe work and parts against corrosion or a biocide are going to be superimposed to prevent the expansion of bacterium in lower temperature systems. The desired chemicals are going to be superimposed to the fluid system by use of a dosing pot; a multi-valve chamber within which the chemical will be superimposed, so introduced to the fluid system during a controlled manner. The feeding of chemicals in agriculture has conjointly become common attributable to technology developments. But agricultural dosing is completed by suggests that of handheld pressure spray pumps.

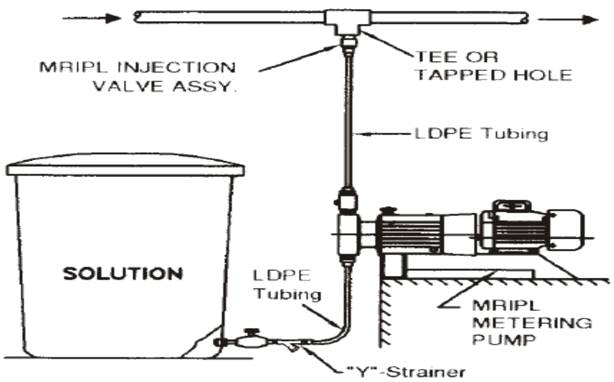

Fig 1. Principle of operation

III. PROBLEM STATEMENTE

According to conventional method the chemicals are mixed or added wherever required manually by hands without any standard equipment so there is disadvantage that the Chemical may not properly get mix and quantity of chemical cannot be

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 12, December - 2017

control accurately. If we are designing chemical dosing pump for various application is very costly and time consuming. If we are designing pump for specific discharge then we can't use the same pump for varying discharge. While designing pump for varying discharge applications we need to design gear box and diaphragm which can control discharge according to the need of application.

IV. OBJECTIVES

Automatic dosing of chemicals gives clean and clear water in the pool. With a stroke length control installed in the system, water quality is continuously monitored and a suitable dose of chemicals supplied, leading to better profitability since need for expensive chemicals is reduced. An optimum solution results in lower cost. Chlorine is the most common disinfectant used in drinking water purification system because it is inexpensive and destroy a large number of pathogens. The impurities are removed by a coagulant dose, which must change according to the change in the quality of raw water inflow in water purification system. Dosing pump are also used in the aerospace and defense, automotive, machine tool, mining, medical, pharmaceutical, semiconductor, and paper industries.

V. LITERATURE REVIEW

[1] Rutuja Mahadik, Sumedha Rapkal, Amita A Shinde, "Automation In Chemical Dosing At Water Treatment Plant Using Plc Scada", International Journal For Technological Research In Engineering Volume 1, Issue 8, April-2014.

At present raw water is pumped and feed to aeration fountain and then added with chemical. The chemical is added manually in water. Water samples are collected every hour and tested and dose of chemical is calculated and that amount of dose is injected in water. In unsuitable weather conditions, sudden increase in turbidity occurs and it is not detected and uneven dosage of chemical and wastage of chemical occurs and that is why automation was required and this project is developed. Now this project automates the existing manual system. In this project chemical dose is calculated with reference to turbidity and flow of water. And that amount of chemical is added to water by using pump. The proportion of dosing the chemical is decided from the previous data of chemical dosing done with manual calculations. Due to this technique, wastage of chemical is reduced and human errors are negligible. Appropriate chemical dosing reduces expenses on chemical.

The metering pump is a positive displacement chemical dosing device with the ability to vary capacity manually or automatically as process conditions require. It features a high level of repetitive accuracy and is capable of pumping a wide range of chemicals including acids, bases, corrosive or viscous liquids and slurries

The goal of this project was to develop chemical based software for controlling a chemical dosing system in water treatment plant. The designed controller successfully compensates the disturbances that directly affect the turbidity such as the flow rate and the influent turbidity. The designed controller automatically adjusts the chemical dosage, therefore the filter operator's work is greatly simplified and a reliable operation is achieved. The control performance is better than the existing dosing system in filter run time, filtered water, and chemical usage. Since turbidity is analyzed by controller, the optimum chemical usage is achieved.

[2] J. Satheesh Kumar And P. Poongodi, "Intelligent Feed Forward Control Of Chemical Dosing Pump Using Pulse Width Modulation", Journal Of Chemical And Pharmaceutical Research, 2013, 5(10):218-222.

The purpose of dosage control is to reduce the turbidity of the drinking water below accepted standard. Conventional controllers like Proportional Integral and Derivative controllers cannot be used because of the nature of water treatment process. Alum dosage reduces the turbidity of the water. At the same time excess alum dosage leads to health hazards. Hence the conventional feedback control is not suggested in this paper. In dosage control systems, especially in the water treatment process feed forward controller is preferred. The quality of the water is to be measured at the input side of the water treatment plant and the desired amount of alum must be added to take corrective action. Normally alum is available in the form of solid. Controlling the flow rate of solid alum is difficult. Hence saturated solution of alum is prepared by mixing known quantity of alum with known quantity of distilled water. This saturated solution is fed to the water treatment plant by a pump. As per the laboratory based water treatment plant requirement the pump must be operated between 2.37×10^{-7} to 2.13×10^{-6} cubic meter per second. The pump speed is controlled by pulse width modulation. This paper focuses only on the development of an intelligent control of the alum dosing pump using a steady state feed forward controller, which uses a neural network and pulse width modulator.

Dosing Control Feed forward controller is suitable for water treatment process since it is a very slow system. The changes in the treated water turbidity from the above mentioned laboratory based water treatment plant for a particular alum dosage can be observed only after one and a half hours. The controller cannot wait for a long time to take decision, hence the changes in the input water quality parameters are measured and the required alum dosage is added at the input raw water immediately.

VI. GEAR BOX DESIGN

A. Design of Worm Gear:

Given parameters,

N_1= 1440 rpm ………………. (Input speed from motor)

N_2= 144 rpm………………… (Worm wheel speed)

Hence,

$$G=N_1/N_2$$
$$G= 10$$

As speed reduction ratio G is very high, single stage worm and worm wheel gear box issued.

The number of start of worm,

$Z_1 = 3$ ………. (As speed reduction ratio is between 7-12)

The number of teeth on worm wheel is equal to,

$$Z_2=G\times Z_1$$
$$Z_2= 30$$

Material of worm screw is Case hardened alloy steel (16Ni80Cr60)

Where,

BHN is Brinell hardness number and S_{ut} is ultimate tensile strength.

$$S_{ut}= 700MPa$$
$$BHN = 170\text{-}311$$

Material of worm wheel is Phosphor Bronze

$$S_{ut}= 240MPa$$

In worm gear pair always worm gear governs the design

B. Beam Strength of Worm Gear Tooth:

d_w and d_g are diameter of worm and gear, Z_w and Z_g are number of teeth on worm and gear, m is module of worm and worm wheel, Y is Lewis form factor, b is breath of worm and q is diametric quotient.

$$\sigma bg= S_{ut}/3$$
$$\sigma bg= 80MPa$$
$$q = 10$$
$$b = 0.73d_w$$
$$b= 7.3m$$

For 20° full depth involute tooth profile

$$Y= 0.484 – 2.87/Z_g$$
$$Y= 0.3883$$
$$\tan \lambda = Z_w/q$$
$$\lambda= 16.69$$
$$F_b= \sigma bg\times b\times m\times Y\times \cos\lambda$$

Where,

Bending force = F_b

$$F_b=217.046m^2, N$$

C. Estimation of Module:

In order to avoid wear failure,

$$F_W=N_f \times F_{eff}$$

Where,

F_W = wear strength

F_{eff} = effective force

N_f = Factor of safety

We have,

$$F_W= 150m^2, N$$

Assume factor of safety = 1.5

$$m=2.79$$

Take m= 3 …….. (Next standard value)

Hence, the designation of worm gear pair is: $Z_w/Z_g/$ q / m.

i.e. 3 / 30 / 10 / 3

Dimensions of worm and worm gear,

$$m =3 \text{ mm}$$
$$Z_w= 3$$
$$Z_g =30$$
$$d_w=m \times q =30 \text{ mm}$$
$$d_g= m \times z_g= 90 \text{ mm}$$
$$p_a= \pi \times m =10mm$$
$$L= p_a\times z_w= 30 \text{ mm}$$

Where,

L = Lead of Worm, mm

p_a = Axial Pitch of Worm

$$\lambda = 16.69°$$
$$b = 7.3 \times m, \text{ mm}$$

Where,

b = Face width of worm wheel gear, mm

$$b = 22 \text{ mm}$$
$$L_w= \pi \times m[4.5+zg /50], \text{ mm}$$
$$L_w=50 \text{ mm}$$
$$h_a =1 \times m =3 \text{ mm}$$

Where,

h_a=addendum, mm

$$h_f =1.2 \times m, \text{ mm}$$

Where,

h_f = dedendum, mm

$$h_f = 3.6 \text{ mm}$$
$$a = d_w+d_g\ 2, \text{ mm}$$

Where,

a = Center distance, mm

$$a = 60 \text{ mm}$$

Now,

$$F_{eff} =329.19 \times (6 +0.22m)/m, N$$
$$F_{eff} = 730.08 N$$
$$F_W =1350N$$

In order to avoid wear failure,

$$1350=N_f \times 730.08$$
$$N_f = 1.85$$

As available factor of safety is greater than assumed (1.5) factor of safety, hence design is safe.

D. Components of Force Acting on Worm:

Where,

Tangential force or tangential component on worm= F_{wt},

The tangential force acting on the worm can be determined by knowing the input power. Its magnitude is given by,

$$F_wt = P_i\ V_w$$

Where,

P_i = input power, W

V_w = pitch line velocity of the worm, m/s

$$F_wt = 165 N$$

Where,

Axial force on worm = F_wa

$$F_wa= F_wt \tan \Phi_v+\lambda$$

Where,

λ = lead angle of worm

Φ_v= virtual friction angle

$$\Phi_v= \tan\text{-}1\mu_v$$

μ_v = virtual coefficient of friction

$$\mu_v= \mu\cos\Phi_n$$

μ = Coefficient of friction between worm and worm gear teeth

Φ_n= normal pressure angle

Put the values of F_wt,Φ_v, λ in equation

We get,

$$F_wa= 493.06 N$$

Where,

Radial force on Worm = F_wr

The radial force acting on the worm is given by,

$$F_wr=F_wt\times\tan\Phi_n\sin\lambda\ [\tan\lambda\tan\Phi_n +\tan\lambda]$$

By putting the values of Fwt, Φ_n, λ in equation

We get,

$$F_wr= 189.11 N$$

E. Force Acting on Worm Gear:

Tangential force on worm gear = F_gt

The tangential force acting on the worm gear can be determined by knowing the output power.

Its magnitude is given by,

$$F_gt =P_o/Vg$$

Where,
P_o= Output Power Acting on Worm Gear,

$$W = 331.83$$

$$F_{g}t= 510.76\ N$$

Where,
Axial force on worm gear = $F_{g}a$
The axial force acting on the worm gear is equal to the tangential force on the worm in magnitude, but opposite in direction.
Hence in magnitude,

$$F_{g}a = F_{w}t$$

$$F_{g}a= 165.04\ N$$

Where,
Radial force on worm gear = $F_{g}r$
The radial force acting on the worm gear is equal to the radial force on the worm in magnitude, but opposite in direction.
Hence in magnitude,

$$F_{g}r = F_{w}r$$

$$F_{g}r = 189.11\ N$$

F. Design of worm input shaft:

Where,
Yield strength = S_{yt}
Material for worm input shaft is case hardened alloy steel (16Ni80Cr60)

Shaft length (l) =90mm

$$\rho =7892\ kg/m^3$$

$$\text{Weight of the worm} = \pi/4\times d_w^2 \times b \times \rho \times g,\ N$$

Weight of worm is = 1.210 N

$$S_{ut}= 760\ MPa$$

$$S_{yt} = 385\ MPa$$

Using ASME code,

$$\tau = 0.18 \times S_{ut}$$

$$= 102.60\ MPa$$

Or

$$\tau = 0.30 \times S_{yt}$$

$$= 86.62\ MPa$$

Hence,
$\tau_{m\,=}$ maximum torque

$$\tau_m = 86.62\ MPa$$

G. Worm Gear Output Shaft:

Shaft length (l) =90mm

Material for shaft is =50 C4
For worm gear (50 C4),

$$\text{Weight of the worm gear} =\pi/4\times d_g^2 \times b \times \rho \times g,\ N$$

For (50C8),

$$S_{ut} = 660MPa$$

$$S_{yt} = 460MPa$$

Using ASME code,

$$\tau = 0.75 \times 0.18 \times S_{ut}$$

$$= 89.1MPa$$

Or

$$\tau = 0.75 \times 0.30 \times S_{yt}$$

$$= 103.5MPa$$

Hence,

$$\tau_m = 89.1\ MPa$$

VII. CATIA MODELS

A. Worm gear:

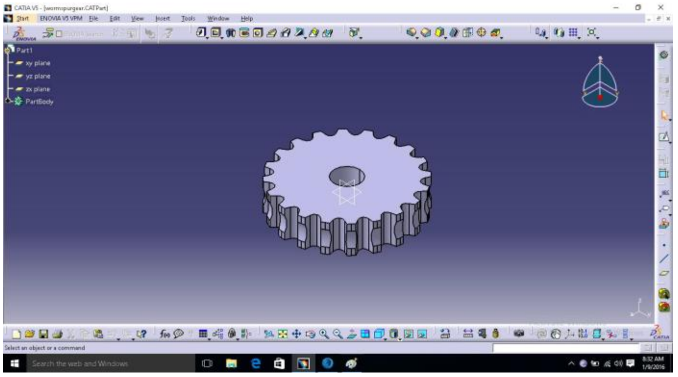

Fig 2. CATIA model of worm gear.

B. Worm:

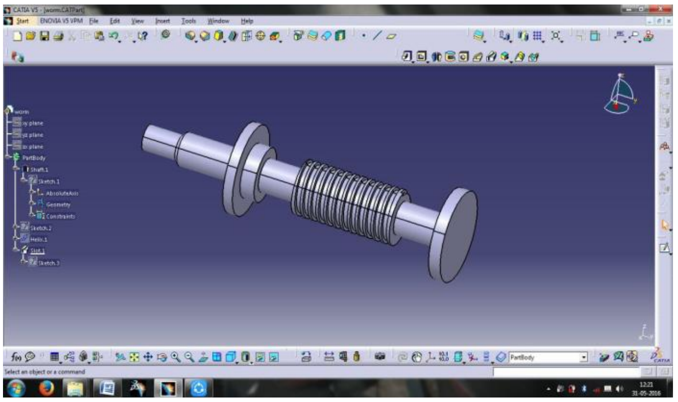

Fig 3. CATIA model of worm.

C. Cam shaft:

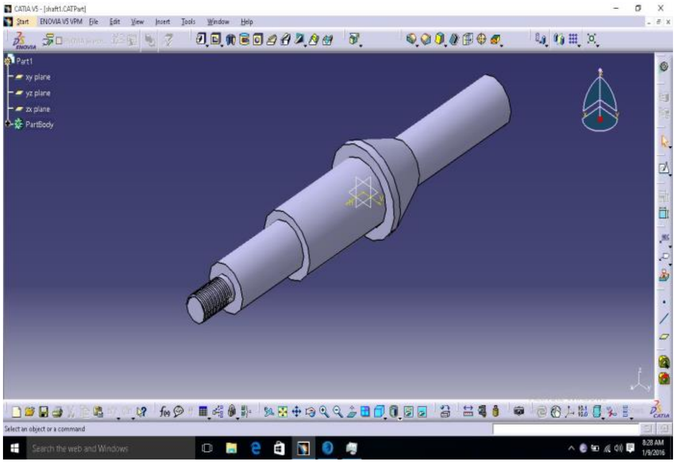

Fig 4. CATIA model of cam shaft.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 12, December - 2017

D. Knob:

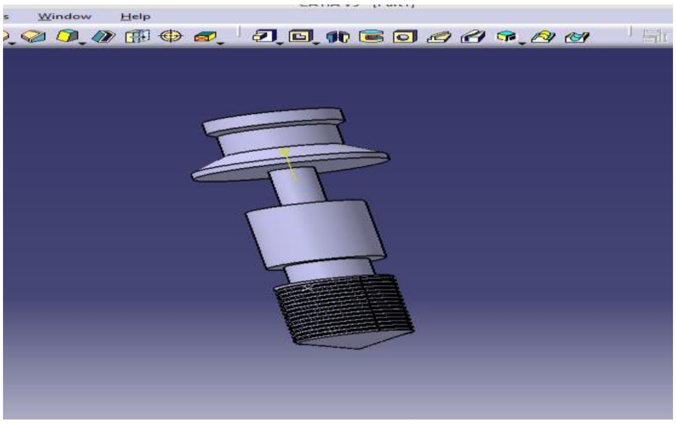

Fig 5. CATIA model of knob.

VIII. Component Fabricated

A. Worm gear – phosphor bronze:

Fig 6. Actual worm gear.

B. Worm-Case hardened alloy steel:

Fig 7. Actual worm.

C. Cam shaft-SS306:

Fig 8. Actual cam shaft.

D. Follower knob-SS306:

Fig 9. Actual knob.

IX. Gear Box Assembly

Fig 10. Gear box assembly.

X. MAIN ASSEMBLY

Fig 11. Pump set up.

XI. TEST RESULTS

Stroke knob set point (In %)	Achieved flow (In LPH)	Max. pressure (In Bar)	Stroke length(In mm)
100	50	5	4
75	37.5	5	3.2
50	25	5	2.4
25	25	5	1.6
10	5	5	0.8

XII. ADVANTAGES, LIMITATIONS AND APPLICATIONS

A. Advantages:

Proper amount of chemical can be dosed, Low noise and vibration so no need of vibration isolator, Required less maintenance, Low cost due to less number of accessories, Able to work in any chemical industry, It achieves various chemical properties and dilute solution is obtained, It is energy efficient, Designed for various types of application.

B. Limitations:

Able to work in particular range of viscosity, Limited capacity.

C. Applications:

Water treatment plant, Blending chemical stocks, Sugar industries, food processing industries, In ice plant to make the brine solution, Pharmaceutical industries, Paper mill.

XIII. CONCLUSION

Efficiency of dosing Pumps is greater than Centrifugal Pumps and Rotary Pumps. Dosing pump speed adjustments are the most efficient means of controlling flow. Reducing the speed means less energy is imparted to the fluid and less energy needs to be throttled or by- passed. There are two primary ways of reducing the speed: Multiple-speed pump motors and using Adjustable speed drives (ASDs).Multiple-speed motors contain a different set of windings for each motor speed; consequently, they are more expensive and less efficient than single- speed motors. Multiple-speed motors also lack suitable speed-changing capabilities within discrete speeds. By using this research, different flow rates can be achieved at constant speed. So there is no need of multiple speed motors or adjustable speed drives.

XIV. FUTURE SCOPE

A variety of chemicals area unit treated to modern chemical action plants to realize specific functions needed for economical plant operation then the topic of systems critically necessary. The chemical dosing facility on the common chemical action plant typically tends to be unnoticed, till plant issues caused by its malfunction become apparent. It ought to be remembered that, for all chemicals, dosing level is of prime importance. Every chemical has an optimum dose level at that the specified performance is obtained while not inflicting plant injury and while not inflicting excessive value. In some ways in which, there's a similarity between dosing chemicals to a chemical action plant and dominant the gasoline metering during a motor automobile. No-one expects their motor automobile to run with efficiency if it's out of tune. Nice efforts are created to line the mixture management in order that the proper quantity of gasoline is treated to the engine over a large vary of operative conditions. During this approach, value effectiveness is optimized and probably harmful facet effects are avoided. Likewise, a bit additional attention paid to the proper dosing of chemical action chemicals can quickly procure itself in optimizing chemical usage and achieving economical and hassle free plant operation. This chapter reviews the history of dosing systems as well as the requirement for chemical dosing and also the style of the systems. It then seeks to spot the key factors for every chemical influencing the planning of contemporary systems to make sure the simplest attainable performance for every chemical treated.

REFERENCES

[1] Rutuja Mahadik, Sumedha Rapkal, Amita A Shinde, "Automation In Chemical Dosing At Water Treatment Plant Using Plc Scada", International Journal For Technological Research In Engineering Volume 1, Issue 8, April-2014.

[2] Romesh Makwana, Prof. Rajnish Katarne, "Analysis of Auto-Gear Shifting Mechanism on Different Load Conditions", International Journal of Engineering Sciences & Research Technology.

[3] Faisal.S.Hussain, "Optimization Of Gear Reduction Unit Through Ray Diagram", International Journal Of Advanced Engineering And Global Technology Vol-1, Issue-4, November 2013.

[4] Das, C. R.; Albert, S. K.; Bhaduri, A. K. and Ray, S. K., "Failure analysis of a pinion", Engineering failure analysis, Vol. 12, pp 287-298, 2010.