Experiment No: **9** **Date:**

Aim:

Study of flow control using PID controller.

Theory:

Control system:

The block diagram of feedback control system is as shown below. The basic concept in feedback control system is to vary the I/p to the process depending on the I/p as well as O/p of the system. The goal is to maintain the O/p at desired value independently of the variation in system parameter, environmental parameter, and noise.

The value at which the O/p is to maintain constant is given as I/p to the system in some form. This I/p are called as **set point**. The difference between set point & feedback is called error. The O/p of controller is called **control output** & is then given to controlling element, called as controller. The quantity which is to be controlled is called as control variable.

There are different types of controllers.

1. ON-OFF controller
2. PI controller
3. PD controller
4. PID controller.

Proportional Control (P Action):

In above equation if ki and Kd are made zero, the controller is proportional controller, here the output proportional to the instantaneous value of error for output to be non zero. For output parameter to be maintained at different from natural level. Some controller o/p is must. According to basic definition of proportional control, for some o/p some error is must, hence controller with only P action will never sets the o/p exactly at the set point but will always have some error i.e. there will always be some difference between desired & actual value of o/p.

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Integrals action:

The contributions of integral action are the second term in the PID eq. given earlier. This is proportional to the integral of error. Thus is dependent on the history of the o/p & not only the current value. Thus the value of integral action is not as obvious from the apparent o/p plot as in case of proportional contribution.

The effect of action is to reduce the average value of the steady state error. Note that if steady state error is not constant then PI controller reduces the dc part to zero & now sinusoidal variation about zero dc value remains.

The disadvantage of integral action is that it increases the system settling time. A typical o/p plot with PI action is shown below. For this Kd is set to zero.

$$P(t) = K_i \int_{o}^{t} ep \, dt + p(0)$$

Derivative action:-

The third term of PID controller transfer eq. contributes proportional to the time derivative of error. This part is introduced to compensate against the o/p variation with respect to time. The D action depends on few past & current error value & not the complete history in case of integral action.

This also responds to the o/p variation that may rise due to noise in the sensing conditioning, feedback network which is unnecessary & hence this part must be precision type.

$$p(t) = K_D \, de_p/dt$$

Composite control mode:

It is common in the industrial process to find control requirement that do not fit the application norms of any of the previously considered controller modes. It is possible to combine several basic modes, there by gaining the advantage of each mode. Here some of them are discussed below.

Proportional – integral control:-

This is control mode that results from a combination of the proportional mode & the integral mode. The equation for this control process is given as,

$$P = K_p e_p + K_p K_i \int_0^t e_p \, dt + p_i(0)$$

Pi (o) = integral term value at = 0(initial value)

The main advantage of this composite control mode is that the one to one correspondence of the proportional mode is available & integral mode eliminates the inherent offset. Note that P gain also changes net I gain through Ki can be independently adjusted.

Characteristics:-

1. When the error is zero the controller o/p is fixed at the value that the integral term had when the error went to zero. This o/p is given by pi (o) in eq. simply because we chose to define the time at which observation starts as t = 0
2. If the error is not zero, the proportional term contributes a correction, & the integral term begins to increase or decreases the accumulated value depending on the sign of the error sign of the error & the direct or reverse action.
3. The initial term can not become negative. Thus it will saturate at zero.

Proportional – derivative control mode:

A second combination of control modes has many industrial application. It involves the serial use of proportional & derivative modes. The analytic expression for this mode is found from combination of P & I eq.

$$P = K_p e_p + K_p K_D \left[de_p / dt \right] + p_o$$

Where the terms are all defined inters given by previous equation.

It is clear that this system can not eliminate offset of proportional controller. It can however handle fast process load changes as long as the load change offset error is acceptable.

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PID Controller (P +I +D):-

PID stands for proportional + integral + derivative. In PID controller the o/p of controller is the sum of three parts.

I. Proportional To Error

II. Proportional To Integral Of Error

III. Proportional to derivative of error.

From this it is very clear that the o/p of controller does not depend only on the instantaneous difference between i/p & feedback generated from o/p, but also depend on the history of error hence some sort of memory or storage is necessary.

The PID controller equation is given as,

$$\mathbf{Un(t) = Kp\ Es(t) \quad + \quad \int Ki\ Es(t)dt \quad + \quad Kd\ d\ Es(t)\ /dt}$$

Un (t) = Up (t) + Ui(t) + Ud(t)

Where,

Un (t) = total PID o/p as a function of time

Kp = proportional constant

Es (t) = error ass function of time

Ki = integral constant

Kd = derivative constant

Up = proportional action contribution

Ui = integral action contribution

Ud = differential action contribution

Sometimes Ki & Kd are expresses in terms of time constant Ti & Td respectively. I is inversely proportional to Ti & Kd is directly proportional to Td .

Conclusion:

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