ωn: undamped natural frequency.

It represents how well the system can respond to fast changing input. Higher ωn means the system will respond quickly.

ζ: damping ratio

It represents the friction of the system which controls the size of oscillation and how quick they decrease or die out.

t_{res}: respond time

time taken for the system output to rise from 0% to the first over 100% of the final steady value.

tr: rise time

time taken for the system output to rise from 10% to 90% of the final steady value.

ts: settling time

time taken for the system output to reach and remain within a certain percentage tolerance of the final steady value.

what the purpose of the inner loop(velocity loop)?

In the position control system, the inner loop is a velocity loop. It can compares the desired or commanded velocity to the actual motor velocity and issues the command to adjust the motor's speed accordingly.

Control strategies

On Off control

On off control action results in either full power or zero power being applied to the process under the control.

PID control

Proportional control

Proportional control is where the output from the controller is proportional to the error input. The output voltage of the proportional controller is proportional to the error voltage input. But it only can make the system respond quickly, it can't estimate the error.

Proportional band control

The proportional band is defined as the amount of change in input, as a percent of span, required to cause the control output to change from 0% to 100%. In proportional control, the the manipulated variable(操纵变量) is lowered as the controlled variable rises, which gives a sluggish response. The proportional band control will narrow the band to get a fast response at the beginning.

Integral control

Integral control could estimate the steady state error of the system. The output of integral controller is integral of the error over time. As the equation below shows,

$$\text{Integral controller output(t)} = \frac{1}{T_i}\int e(t)dt$$

Derivative control

Derivative control is based on the rate of change of the error. It could improve the stability and reduce the overshoot of the system. As the equation below shows,

$$\text{Derivative controller output(t)} = T_d\frac{de(t)}{dt}$$

What conditions are required for the 'tuning' process?

First, the controller should be switched to manual.

Second, the controller settings should be set to a minimum. The integral and derivative control are switched off (Td=0, Ti=∞). And the value of the proportion control K is small.

Third, the input should be set to a normal condition, the output should reach a desired setpoint value.

Then set the controller to automatic. Once it stabilizes at the setpoint value, give the system a disturbance.

1. for closed loop continuous cycling method, change the gain to get a sustained oscillation. Then get the gain for Ku and T.
2. for open loop reaction curve, after the disturbance the parameters required can be derived from the S curve.

Explain why the proportional gain can be increased under the PID option.

The derivative controller will damped the oscillation of the system but the proportional controller will increase the oscillation of the system. So, with the aid of derivative control, we could increase the proportional gain to make system response faster.