Process Control(PID)

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Why do we need process control?

- Propose: find the most stable and fastest way to reach the setpoint.

- Limits:

  1). Process always have response delay

  2). Unknown force from outside reservoir

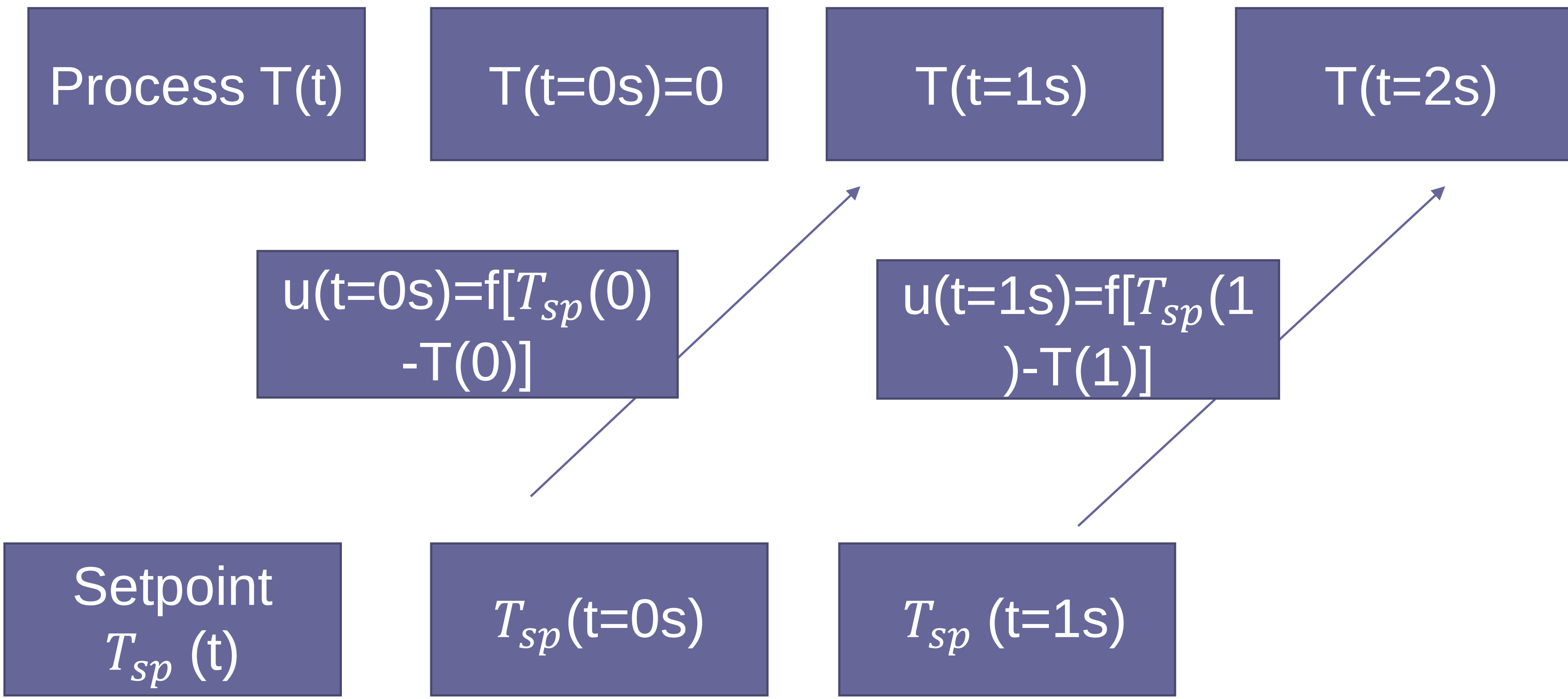
What is PID?

Heating process

$$u(t) = K_P e(t) + K_I \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt}$$

- u(t) is the output power, e(t) is the error between the process temperature T and the setpoint T_{sp}. K_P, K_I, K_d are three variables, adjusted by time.
- According to the temp error between process temp and setpoint, we can calculate the output value, and the output power decides the speed of heating, which leads to cost time from initial temp to setpoint temp.
- However, if the speed of heating is too fast, the overshoot will appear; if it is too slow, the process temp will never reach the setpoint. So the speed of heating need to be changed by time, which adjusted by PID variables.

How to control process?



Temperature function

Process temperature

$$u(t)=\frac{dQ}{dt}=K_P e(t)+K_I\int_0^t e(\tau)d\tau+K_d\frac{de(t)}{dt} \qquad Q \quad the \quad heat$$

$$Since \qquad u(t)=\frac{dT}{dt}=\frac{1}{C}\frac{dQ}{dt} \qquad C \quad heat \quad capacity$$

$$=\frac{1}{C}\left(K_P e(t)+K_I\int_0^t e(\tau)d\tau+K_d\frac{de(t)}{dt}\right)$$

$$Set \qquad K_d=0,$$

$$From \quad differential \quad eqn. \quad T(t)=\exp\left(\frac{K_p}{C}t+i\sqrt{\frac{K_I}{C}}t\right)+\alpha_1 t+\alpha_2 \qquad \alpha_1,\alpha_2 \quad cons\tan t$$

Setpotint temperature

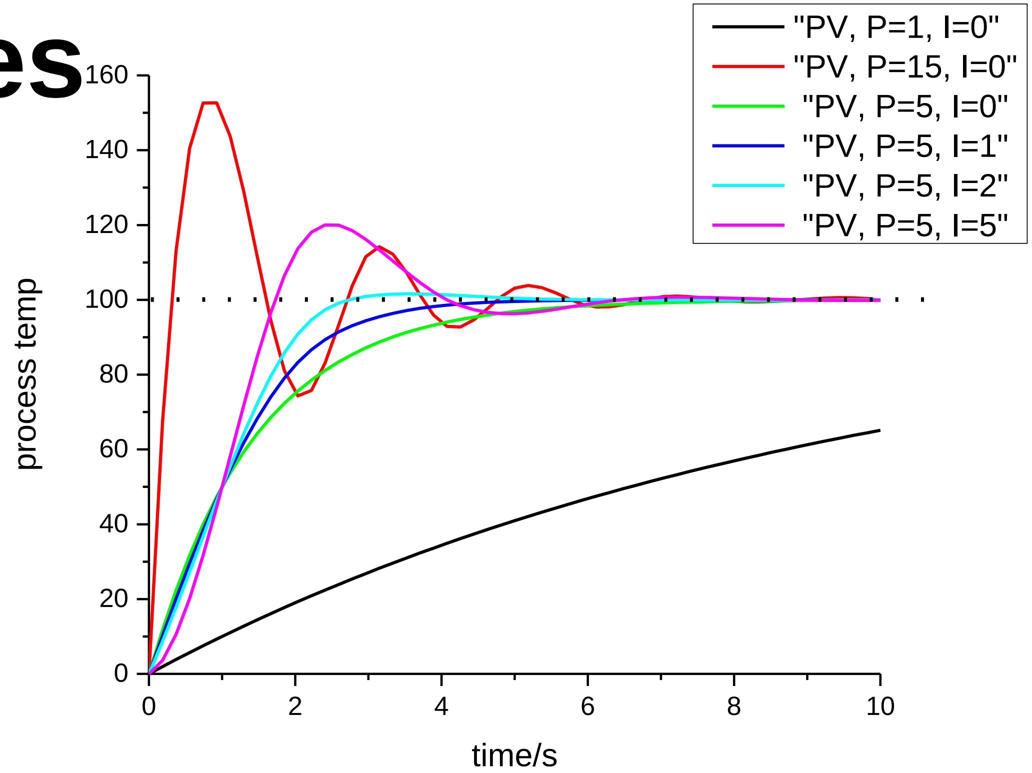
$$T_{SP}(t=0s)$$

Operation

1). Set I=0, double P until the oscillation around setpoint appears, then take the half of that value, set that to be P. The good P will lead the process temp to be within 5% less than setpoint;

2). Double I until the process temp reach the setpoint eventually. Small I will lead the process temp always smaller than setpoint; on the other side, large I will cause unstable process temp around setpoint.

Examples



- **More data needed to show the influence of P and I.**
- **To be brief, P will increase the magnitude of the increase of process temp, and I will increase the frequency of temp oscillation.**

Disscussion

- PID are widely used in many operation process, choose best PID variations will make process more accuracy and faster. Bad PID will cause: setpoint never reached, overshoot, increasing too fast. In experiments, any step counts! Any wrong message will ruin the all!