Control valve trim

The trim is the plug , stem and seat of the valve. The valve stem position or travel (X_v)

$$x = \frac{x_v}{x_{v\,max.}}$$

Stem position or valve travel is the displacement of the valve plug from fully seated . By changing the shape of the plug and seat ,we get different relation between the fraction of total flow f(x) and the stem position.

There are three relation:

1. Linear trim :f(x)=x $\quad \frac{C_v}{C_{v\,max.}} = \frac{x_v}{x_{v\,max.}}$
2. Quick opening : f(x)=$\sqrt{x}$ $\quad \frac{C_v}{C_{v\,max.}} = \left(\frac{x_v}{x_{v\,max.}}\right)^{\frac{1}{2}}$

Some time called decreasing sensitivity

$$\frac{area}{(area)_{max.}} = \frac{Q_v}{Q_{v\,max.}} = \frac{C_v}{C_{v\,max.}}$$

3. Equal percentage

$$f(x) = Ke^{ax}$$

$$\frac{C_v}{C_{v\,max.}} = Ke^{a\frac{x_v}{x_{v\,max.}}}$$

Or $f(x) = \propto^{x-1}$ $\quad ,\alpha = \frac{C_{vmax}}{C_{v\,min}}$

For the gasses

$$mg = 760\, C_v \sqrt{\frac{P_1(\Delta P)M}{RT_1}}$$

mg :flow rate of air, (Ib_m /hr)

C_v : valve size coefficient

P_1 :pressure before valve

ΔP : pressure different

R :universal gas constant , 10.73

M :mol. wt

T_1 :temperature before valve

Stability of Dynamic system

Stable system gives a bounded response when subjected to a bounded input.

Analysis of stability

$$G(s) = \frac{y(s)}{f(s)} = \frac{b_m s^m + b_{m-1} s^{m-1} + \cdots + b_1 s + b_0}{a_n s^n + a_{n-1} s^{n-1} + \cdots + a_1 s + a_0}$$

$$= \frac{(s+z_1)(s+z_2)\cdots(s+z_m)}{(s+p_1)(s+p_2)\cdots(s+p_m)} = \frac{z}{p}$$

Z's zeros of G(s)

P's poles of G(s)

If s=-z then G(s)=0 ,S=-p then G(s)=∞

If z=0

$$G(s) = \frac{c_1}{s+p_1} + \frac{c_2}{s+p_2} + \cdots + \frac{c_n}{s+p_n}$$

$$G(s) = c_1 e^{-p_1 t} + c_2 e^{-p_2 t} + \cdots + c_n e^{-p_n t}$$

$$G(s) = \frac{c_1}{s-p_1} + \frac{c_2}{s-p_2} + \cdots + \frac{c_n}{s-p_n}$$

$$G(s) = c_1 e^{p_1 t} + c_2 e^{p_2 t} + \cdots + c_n e^{p_n t}$$

The characteristics equation is:

$$p(s) = a_n s^n + a_{n-1} s^{n-1} + \cdots + a_1 s + a_0$$

To find the roots of this equation will be equal to zero

$$p(s) = 0$$

This eq. gives "n" roots or n poles

S=$\pm\propto \pm\beta j$

$Roots$	$G(t)$
s_1	$c_1 e^{\propto_1 t}$
s_5	$c_1 e^{-\propto_5 t}$
s_3, s_3^*	$c_1 \cos\beta_3 t + c_2 \sin\beta_3 t$
s_4, s_4^*	$e^{-\propto_4 t}(c_1 \cos\beta_4 t + c_2 \sin\beta_4 t)$
s_2, s_2^*	$e^{\propto_2 t}(c_1 \cos\beta_2 t + c_2 \sin\beta_2 t)$
s_6	c

Roots of p(s)

1. Real
   a) If the one root is positive then the system is unstable
   b) If the all roots is negative then the system is stable
2. If the one root is imaginary then the system is critical stable
3. If the one root is complex then the system is oscillation as the following:
4. If the real part of one root is positive then the system is unstable
5. If the real part of all root is negative then the system is stable

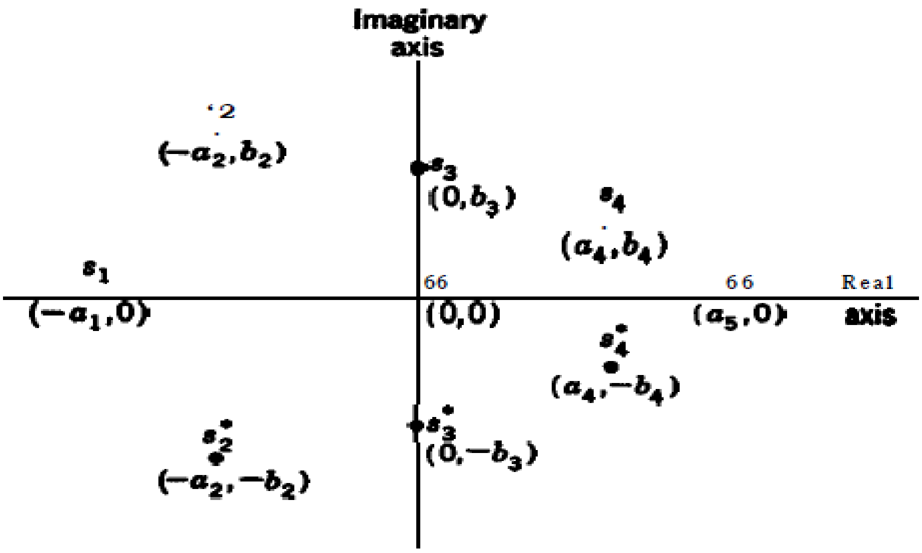

Fig.49 Location of typical roots of characteristics equation