Formulas

Statistical Process Control:

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}}$$

$$R = x_{\max} - x_{\min}$$

$$UCL_{\bar{x}} = \bar{x} + 3\sigma_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$

$$LCL_{\bar{x}} = \bar{x} - 3\sigma_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$$

$$C_p = \frac{USL - LSL}{6\sigma}$$

$$C_{pk} = \frac{\min\{|USL - \bar{x}|, |LSL - \bar{x}|\}}{3\sigma}$$

USL: upper specified limit
LSL: lower specified limit

Number of Observations in Subgroup n	Factors for $\bar{X}$ Chart A_2
2	1.88
3	1.02
4	0.73
5	0.58
6	0.48
7	0.42
8	0.37
9	0.34
10	0.31
11	0.29
12	0.27
13	0.25
14	0.24
15	0.22
16	0.21
17	0.20
18	0.19
19	0.19
20	0.18

Upper control limit for $\bar{X} = \text{UCL}_x = \bar{X}' + A_2\bar{R}$
Lower control limit for $\bar{X} = \text{LCL}_x = \bar{X}' - A_2\bar{R}$

Table 1: Constants for Control Charts

Surface roughness:

$$Ra = \frac{\sum |y_i - \bar{y}|}{n}$$

$$Rq = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n}}$$

Mechanics of materials

Elastic: $\sigma = E\varepsilon$

Plastic:
$\sigma = K\varepsilon^n$ *cold work*
$\sigma = C\dot{\varepsilon}^m$ *hot work*

$$e = \frac{\ell}{\ell_0} \qquad \varepsilon = \ln\frac{\ell}{\ell_0}$$

Hardness

UTS(MPa) = 3.5 (HB) UTS(psi)=500 (HB)

Taylor's tool life equation:

$$VT^n = C$$

Tool life for minimum cost

$$T_{\min} = \left(\frac{1}{n} - 1\right)\left(\frac{C_t + T_c C_o}{C_o}\right)$$

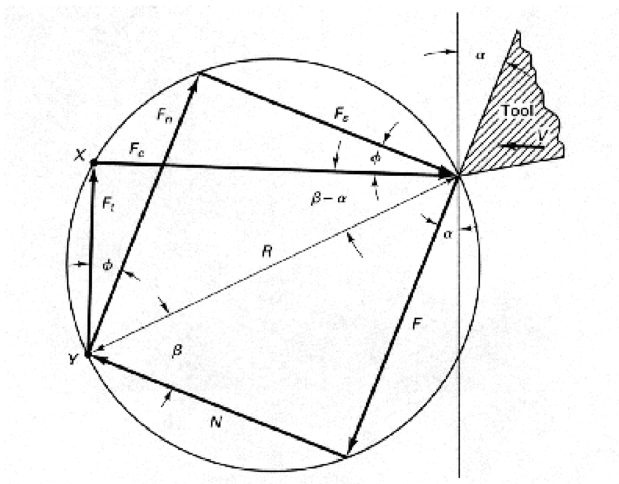
C_o: operating cost ($/min)
T_c: time to change the tool (min)
C_t: initial cost of the tool ($)
CT: cutting time (min)

$$Total\ Machining\ Cost = C_1 + C_2 + C_3 + C_4$$
$$C_1 = CT \times C_o$$
$$C_2 = \frac{C_t \times CT}{T}$$
$$C_3 = \frac{T_c \times C_o \times CT}{T}$$
$$C_4 = handling\ cost$$

Cutting mechanics:

$$\tan\phi = \frac{r_t \cos\alpha}{1 - r_t \sin\alpha}$$ where r_t is chip thickness ratio

$$F_s = F_c \cos\phi - F_T \sin\phi$$
$$F_N = F_c \sin\phi + F_T \cos\phi$$
$$F = F_c \sin\alpha + F_T \cos\alpha$$
$$N = F_c \cos\alpha - F_T \sin\alpha$$
$$V_s = \frac{\cos\alpha}{\cos(\phi - \alpha)} V_c$$: *shear velocity*
$$V_f = V_c \cdot r_t$$: *chip velocity*
$$r_t = \frac{t}{t_c}$$
$$A_s = \frac{A_0}{\sin\phi}$$: *shear plane area*



$$U_s = \frac{F_s \cdot V_s}{V_c \cdot f_r \cdot t}$$

$$U = \frac{F_c \cdot V_c}{V_c \cdot f_r \cdot t}$$

$$HP = \frac{F_c \cdot V_c (ft \cdot lb/\text{min})}{33{,}000} \qquad KW = \frac{F_c \cdot V_c (N \cdot m/\text{min})}{60{,}000} \qquad HP_m = \frac{HP}{E}$$

$$1KW = 1.43HP$$

<u>Surface finish</u>

$$R_a = \frac{R_t}{4} = \frac{f_r^{\,2}}{32CR}$$

<u>Longitudinal Turning</u>

CuttingSpeed $\quad \mathrm{V} = \frac{\pi \mathrm{DN}}{12} (\mathrm{fpm})$

Material Removal Rate: $12Vf_r t$

<u>Milling</u>

Cutting Time:

$$(\ell_c + \ell)/f_m = slab$$

$$(2\ell_c + \ell)/f_m = end\ and\ face$$

$$\ell_c = \sqrt{w(D-w)}\ \ for\ w < D/2$$

$$\ell_c = D/2\ \ for\ w > D/2$$

Material Removal Rate:

$$MRR = w \cdot t \cdot f_m \quad \text{in}^3/\text{min}.$$