1 Replicate Error

Replicates: $\{x_1, x_2, ..., x_n\}$

$s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2$

$e_{\text{s,rep}} = \frac{s}{\sqrt{n}}$

$\alpha \equiv (1 - \mathbb{P}) \quad \mathbb{P} \in [0, 1]$

$\nu = n - 1$

$t_{\alpha,\nu} = |\texttt{T.INV.2T}(\alpha, \nu)|$

$\text{CI}(\mathbb{P}) = \bar{x} \pm t_{\alpha,\nu} e_{\text{s,rep}}$

2 Process Control

$K_\text{p} = \frac{\Delta y^\ominus}{\Delta u^\ominus}$

$\tau \equiv \{t | y(t) = y_0 + 0.632\Delta y^\ominus\}$

$\tau_\text{p} \equiv \tau - t_\text{response}$

$\theta_\text{p} \equiv t_\text{step} - t_\text{response}$

$\text{PB} \equiv \frac{100}{K_\text{c}}$

3 Mass Transport

$\dot{V} = A_\sigma \langle \vec{v} \rangle \qquad \dot{V} = \frac{\dot{m}}{\rho}$

$\rho_1 A_{\sigma 1} \langle \vec{v}_1 \rangle = \rho_2 A_{\sigma 2} \langle \vec{v}_2 \rangle$

$\langle \vec{v}_z \rangle = \sqrt{2gz} \qquad \vec{v}_\text{t} = 2\pi R f$

$\frac{\Delta P}{\rho} + \frac{\Delta(\vec{v}^2)}{2\alpha} + g\Delta z + \sum \hat{F} = \frac{\dot{W}_\text{s,by}}{\dot{m}} \qquad \alpha \overset{\approx 1,\text{ turbulent}}{\underset{= 0.5,\text{ laminar}}{}}$

$\sum \hat{F} = \sum_i 4 f_i \frac{\ell_i}{\varnothing_i} \left(\frac{\langle \vec{v} \rangle_i^2}{2} \right) + \sum_j K_{\text{f},j} \left(\frac{\langle \vec{v} \rangle_j^2}{2} \right)$

$z_1 g + \frac{\vec{v}_1^2}{2} + \frac{P_1}{\rho} = z_2 g + \frac{\vec{v}_2^2}{2} + \frac{P_2}{\rho}$

$\eta_\text{pump} = \frac{\hat{W}_\text{s}}{\hat{W}_\text{pump}} \qquad -\hat{W}_\text{s} = \tilde{H} g \qquad \text{P}_\text{brake} = \frac{-\hat{W}_\text{s}}{\eta} \dot{m}$

$\tilde{H} = \frac{P}{\gamma} \qquad \gamma \equiv \rho g$

$\Delta P_\text{pipe} = 4 f \rho \frac{\ell}{\varnothing} \frac{\vec{v}^2}{2} \qquad \Delta P_\text{pipe,lam} = \frac{32 \mu \vec{v} \ell}{\varnothing^2}$

$\hat{F}_\text{pipe} = \frac{\Delta P_\text{pipe}}{\rho} = 4 f \frac{\ell}{\varnothing} \frac{\langle \vec{v} \rangle^2}{2} \qquad \hat{F}_\text{fitting} = K_\text{f} \frac{\langle \vec{v} \rangle^2}{2}$

$\text{Re} = \frac{\langle \vec{v} \rangle \rho \varnothing}{\mu} \qquad \text{Laminar: } f = 16/\text{Re}$

$K_\text{expansion} = \left(1 - \frac{A_{\sigma 1}}{A_{\sigma 2}}\right)^2 \qquad \hat{F}_\text{expansion} = K_\text{expansion} \frac{\langle \vec{v}_1 \rangle^2}{2\alpha}$

$K_\text{contraction} = 0.55 \left(1 - \frac{A_{\sigma 2}}{A_{\sigma 1}}\right) \qquad \hat{F}_\text{contraction} = K_\text{contraction} \frac{\langle \vec{v}_2 \rangle^2}{2\alpha}$

$\text{NPSH}_\text{A} = \frac{P - p^\star}{\rho g} + z - \tilde{H}_v - \frac{\sum \hat{F}}{g} \qquad \tilde{H}_v = \frac{\vec{v}^2}{2g}$

$\frac{\dot{V}_1}{\dot{V}_2} = \frac{\dot{N}_{\text{r},1}}{\dot{N}_{\text{r},2}} \qquad \frac{\tilde{H}_1}{\tilde{H}_2} = \frac{\dot{V}_1^2}{\dot{V}_2^2} = \frac{\dot{N}_{\text{r},1}^2}{\dot{N}_{\text{r},2}^2} \qquad \frac{\dot{W}_1}{\dot{W}_2} = \frac{\tilde{H}_1 \dot{V}_1}{\tilde{H}_2 \dot{V}_2} = \frac{\dot{N}_{\text{r},1}^3}{\dot{N}_{\text{r},2}^3}$

Gas: $p_1^2 - p_2^2 = \frac{4 f \ell \Phi_G^2 R T}{\varnothing \dot{m}}$

4 2^2 Factorial Design

$E_i = \bar{y}_{i+} - \bar{y}_{i-} = \frac{C_i}{2^{(N_\text{L}-1)} n} = \frac{C_i}{2n} \qquad E_{ij} = \frac{C_{AB}}{2^{(N_\text{L}-1)} n} = \frac{C_{AB}}{2n}$

$C_A = a + ab - b - (1) \quad C_B = b + ab - a - (1) \quad C_{AB} = ab + (1) - a - b$

$\text{SS}_i = \frac{C_i^2}{2^{(N_\text{L})} n} = \frac{C_i^2}{4n}$

$\text{SST} = \sum_{i=1}^{N_\text{L}} \sum_{j=1}^{N_\text{L}} \sum_{k=1}^{n} (y_{ijk})^2 - \frac{(\sum y_{ijk})^2}{4n}$

$\text{SSE} = \text{SST} - \sum \text{SS}_i$

$\nu_i = N_{\text{L},i} - 1 \qquad \nu_\text{SSE} = 4(n-1) \qquad \nu_\text{SST} = 4n - 1$

$\text{MS}_i = \frac{\text{SS}_i}{\nu_i} \qquad \text{MSE} = \frac{\text{SSE}}{\nu_\text{SSE}} \qquad F_{0,i} = \frac{\text{MS}_i}{\text{MSE}}$

$\alpha = 1 - \frac{\%\text{CI}}{100} \quad F_{\text{c},i} = \texttt{FINV}(\alpha, \nu_i, \nu_\text{SSE}) \quad p = \texttt{FDIST}(F_{0,i}, \nu_i, \nu_\text{SSE})$

$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \hat{\beta}_{12} x_1 x_2 + \varepsilon$

$\hat{\beta}_0 = \frac{\sum y_{ijk}}{n} \qquad \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_{12} = \frac{E_i}{|x_1 - x_2|}$

$e_i = y_i - \hat{y}_i \qquad e_{\text{s},\beta} = \sqrt{\frac{\text{MSE}}{2^{N_\text{L}} n}} \qquad t_i = \frac{\hat{\beta}_i}{e_{\text{s},\beta}}$

5 Statistical Process Control

$\bar{R} = \frac{\sum_i^n R_i}{n}$

$\text{UCL}_R = D_4 \bar{R} = \bar{R} + \frac{3 d_3 \bar{R}}{d_2}$

$\text{LCL}_R = D_3 \bar{R} = \bar{R} - \frac{3 d_3 \bar{R}}{d_2}$

$D_4 \equiv 1 + \frac{3 d_3}{d_2} \qquad D_3 \equiv 1 - \frac{3 d_3}{d_2} \qquad d_2 = \frac{\bar{R}}{\sigma_x} \qquad d_3 = \frac{\sigma_R}{\sigma_x}$

$\bar{\bar{x}} = \frac{\sum_i^n \bar{x}_i}{n}$

$\text{UCL}_{\bar{x}} = \bar{\bar{x}} + \frac{3\sigma}{\sqrt{n}}$

$\text{LCL}_{\bar{x}} = \bar{\bar{x}} - \frac{3\sigma}{\sqrt{n}}$

Unknown σ : $\hat{\sigma} = \frac{\bar{R}}{d_2} \qquad A_2 \equiv \frac{3}{d_2 \sqrt{n}}$

$\text{UCL}_{\bar{x}} = \bar{\bar{x}} + \frac{3}{d_2 \sqrt{n}} \bar{R} = \bar{\bar{x}} + A_2 \bar{R}$

$\text{LCL}_{\bar{x}} = \bar{\bar{x}} - \frac{3}{d_2 \sqrt{n}} \bar{R} = \bar{\bar{x}} - A_2 \bar{R}$

$\text{Cp} \equiv \frac{\text{USL} - \text{LSL}}{6\sigma}$

References

ISBN-13: 9781556173912, 9780471303534, 9780139304392, 9781119400363, 9781107003538