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(x) (y)

$$\alpha \quad K = K_s e^{\alpha h}$$

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$$\frac{\partial \theta}{\partial z} = -\frac{\partial q}{\partial t} \quad \square$$

$$\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial z} \quad \square$$

$$\frac{\partial q}{\partial \theta} = \frac{\partial t}{\partial z} \quad \square$$

$$\frac{\partial \theta}{\partial q} = \frac{\partial z}{\partial t} \quad \square$$

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$$\phi = \int_{\theta}^0 d(\theta) d\theta = \int_h^h -K(h) dh \quad \square$$

$$\phi = \int_{\theta}^0 -K(\theta) d\theta = \int_h^h D(h) dh \quad \square$$

$$\phi = \int_h^h \frac{2h}{q} dh \quad \square$$

$$\phi = \int_{\theta}^0 (D(\theta)/q) d\theta \quad \square$$

$$x = 0.5, z = 0 \quad \square$$

$$z = 0.5, x = 0 \quad \square$$

$$x = z = 0.5 \quad \square$$

$$x = z = 0.1 \quad \square$$

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$$C = \frac{dK}{dt} \quad \square$$

$$C = \frac{d\theta}{dt} \quad \square$$

$$C = \frac{dh}{dt} \quad \square$$

$$C = \frac{dK}{d\theta} \quad \square$$

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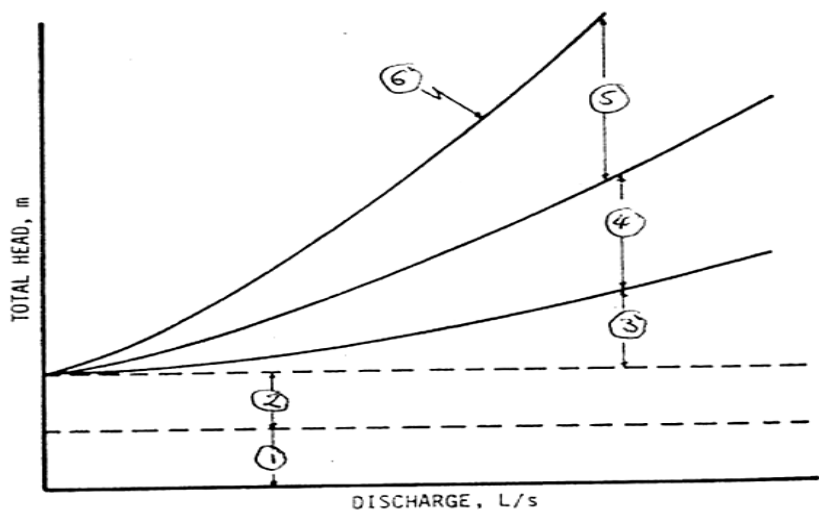
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$$X = 2.74 T_a^{0.5}$$

$$Y = 0.5 T_a^{0.8}$$

$$= Y, X = T_a :$$

(X, Y)

(T_a)

(I)

(q_e)

(Δθ)

$$V_t = S_e \times S_L \times Z = 15 \times 20 \times 0.75 = 2.25 \text{ m}^3$$

$$V_D = P_w \cdot V_t = 0.35 \times 2.25 = 0.7875 \text{ m}^3$$

$$\therefore 0.7875 \times 10^6 = \pi (2.74 T_a^{0.5})^2 (0.5 T_a^{0.8})$$

$$\therefore T_a = 476 \text{ min} = 7.93 \text{ hr}$$

$$X = 2.74 (476)^{0.5} = 60 \text{ cm}$$

$$Y = 0.5 (476)^{0.8} = 69.4 \text{ cm}$$

$$q_e = \frac{48}{7.93} = 6.05 \text{ L/hr}$$

$$q_e = \frac{2\pi R^3 (\theta_f - \theta_i)}{3 \times 10^3 \cdot T_a}$$

$$R = X = 60 \text{ cm} = 0.60 \text{ m}$$

$$\Delta \theta = \frac{6.05 \times 3 \times 10^3 \times 7.93}{2\pi (60)^3} = 0.106$$

$$q = \pi R I$$

$$6.05 = \pi (0.60)^2 \times I$$

$$\therefore I = 5.35 \text{ mm/hr}$$

$$D_1 = 100 \text{ mm} \quad D_2 = 400 \text{ mm} \quad A_1 = 7.54 \times 10^{-3} \text{ m}^2$$

$$A_2 = 1.885 \times 10^{-2} \text{ m}^2 \quad \beta_1 = 44^\circ \quad \beta_2 = 60^\circ \quad N = 600 \text{ RPM}$$

اتجاه السرعات في الاتجاهين عند المدخل مكررا .

$$V_1 = ? \quad V_2 = ? \quad P_i = ?$$

$$\therefore u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 0.100 \times 600}{60} = 3.14 \text{ m/s}$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.400 \times 600}{60} = 12.566 \text{ m/s}$$

$$\therefore \text{water enters radially} \quad \therefore v_{w1} = 0$$

$$\therefore \tan \beta_1 = \frac{v_{f1}}{u_1 - v_{w1}} = \frac{v_{f1}}{u_1} \quad \therefore v_{f1} = 3.14 \cdot \tan 44^\circ = 3.03 \text{ m/s}$$

$$v_{f1} = v_1 = 3.03 \text{ m/s} \quad v_1 = \sqrt{u_1^2 + v_1^2}$$

$$\therefore v_1 = \sqrt{3.14^2 + 3.03^2} = 4.37 \text{ m/s}$$

$$\therefore Q = A_1 v_{f1} = A_2 v_{f2}$$

$$\therefore Q = v_{f1} \cdot A_1 = 3.03 \times 7.54 \times 10^{-3} = 0.02285$$

$$\therefore v_{f2} = \frac{7.54 \times 10^{-3} \times 3.03}{1.885 \times 10^{-2}} = 1.212 \text{ m/s}$$

$$\therefore \tan \beta_2 = \frac{v_{f2}}{u_2 - v_{w2}}$$

$$\therefore v_{w2} = 12.566 - \frac{1.212}{\tan 60} = 11.866 \text{ m/s}$$

$$\therefore v_2 = \sqrt{(1.212)^2 + (12.566 - 11.866)^2}$$

$$\therefore v_2 = 1.4 \text{ m/s}$$

$$\therefore H_i = \frac{v_{w2} \times u_2}{g}$$

$$\therefore H_i = \frac{1.212 \times 12.566}{9.81} = 15.23 \text{ m}$$

$$\therefore Q = A_2 v_{f2} = 1.885 \times 10^{-2} \times 1.212 = 0.02285 \text{ m}^3/\text{s}$$

$$P_i = \gamma Q H_i$$

$$\therefore P_i = 9.81 \times 0.02285 \times 15.23 = 3.41 \text{ kW}$$

$$Q_1 = 30 \text{ lit/sec} , H_1 = 20 \text{ m} , D_1 = 40 \text{ cm} , N_1 = 1500 \text{ rpm} , E_1 = 80\%$$

$$D_2 = 25 \text{ cm} , N_2 = 3000 \text{ rpm}$$

$$Q_2 = ?? , H_2 = ?? , BP_2 = ?? , N_{s2} = ?? , E_2 = ??$$

تصرف المضخة الثانية ونتيجة التشابه

$$\frac{Q_1}{Q_2} = \left(\frac{N_1}{N_2} \right) \times \left(\frac{D_1}{D_2} \right)^3$$

$$\frac{30}{Q_2} = \left(\frac{1500}{3000} \right) \times \left(\frac{40}{25} \right)^3$$

$$Q_2 = 14.65 \text{ Lit/sec}$$

ضغوط المضخة الثانية ونتيجة التشابه

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2} \right)^2 \times \left(\frac{D_1}{D_2} \right)^2$$

$$\frac{20}{H_2} = \left(\frac{1500}{3000} \right)^2 \times \left(\frac{40}{25} \right)^2$$

$$H_2 = 31.25 \text{ m}$$

القدرة اللازمة لتشغيل المضخة الأولى

$$BP_1 = \frac{Q_1 \times H_1}{102 \times E_1} = \frac{30 \times 20}{102 \times 0.8} = 7.35 \text{ kw}$$

السرعة النوعية للمضخة الأولى

$$N_{s1} = 0.2108 N_1 \left(\frac{Q_1^{0.5}}{H_1^{0.75}} \right) = 0.2108 \times 1500 \times \frac{(30 \times 60)^{0.5}}{20^{0.75}} = 1418.5 \text{ unit}$$

القدرة اللازمة لتشغيل المضخة الثانية ونتيجة التشابه

$$\frac{BP_1}{BP_2} = \left(\frac{N_1}{N_2} \right)^3 \times \left(\frac{D_1}{D_2} \right)^5$$

$$\frac{7.35}{BP_2} = \left(\frac{1500}{3000} \right)^3 \times \left(\frac{40}{25} \right)^5$$

$$BP_2 = 5.61 \text{ kw}$$

السرعة النوعية للمضخة الثانية

$$N_{s2} = 0.2108 N_2 \left(\frac{Q_2^{0.5}}{H_2^{0.75}} \right) = 0.2108 \times 3000 \times \frac{(14.65 \times 60)^{0.5}}{31.25^{0.75}} = 1418.5 \text{ unit}$$

أي أن السرعة النوعية للمضخة ثابتة لا تتغير نتيجة التشابه أو تغير قطر الدافع أو سرعة دورانه
كفاءة المضخة الثانية:

$$BP_2 = \frac{Q_2 \times H_2}{102 \times E_2}$$

$$5.61 = \frac{14.65 \times 31.25}{102 \times E_2}$$

$$BP_2 = 0.80 = 80\%$$

أي أن كفاءة المضخة ثابتة لا تتغير نتيجة التشابه أو تغير قطر الدافع أو سرعة دورانه

- (P_i)
- (σ)
- (N_s)
- (β_i)
- (η_n)
- (ε)

① $D_2 = 2D_1$ $N = 1400 \text{ RPM}$ $H = H_t = 30 \text{ m}$
 $v_{f1} = v_{f2} = 2.95 \text{ m/s}$ $\beta_2 = 36.5^\circ$
 $D_2 = 30 \text{ cm}$ $B_2 = 4 \text{ cm}$
 $v_{w1} = 0$ ($v_{f1} = v_1$ نظرية)
 الماء عند سرعة نظرية

$$u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 0.15 \times 1400}{60} = 11 \text{ m/s}$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.30 \times 1400}{60} = 22 \text{ m/s}$$

$$\therefore \tan \beta_1 = \frac{v_{f1}}{u_1 - v_{w1}} = \frac{2.95}{11 - 0} = 0.268$$

$$\therefore \beta_1 = 15^\circ$$

$$\therefore \tan \beta_2 = \frac{v_{f2}}{u_2 - v_{w2}} \quad \therefore \tan 36.5 = \frac{2.95}{22 - v_{w2}}$$

$$\therefore 0.74 = \frac{2.95}{22 - v_{w2}} \quad \therefore v_{w2} = 18 \text{ m/s}$$

السرعة السينية $v_2 = \sqrt{2gH_t} = \sqrt{2 \times 9.81 \times 30} = 24.26 \text{ m/s}$

السرعة الكلية $V_2 = \sqrt{v_2^2 + u^2} = \sqrt{(24.26)^2 + (22)^2} = 32.75 \text{ m/s}$

$$H_i = \frac{v_{w2} \cdot u_2}{g} = \frac{18 \times 22}{9.81} = 40.36 \text{ m}$$

$$\eta_h = \frac{H}{H_i} \times 100 = \frac{30}{40.36} \times 100 = 74.3\%$$

$$\phi = (\pi D_2 B_2) v_{f2} = (\pi \times 0.30 \times 0.04) \times 2.95 = 0.111 \text{ m}^3/\text{s}$$

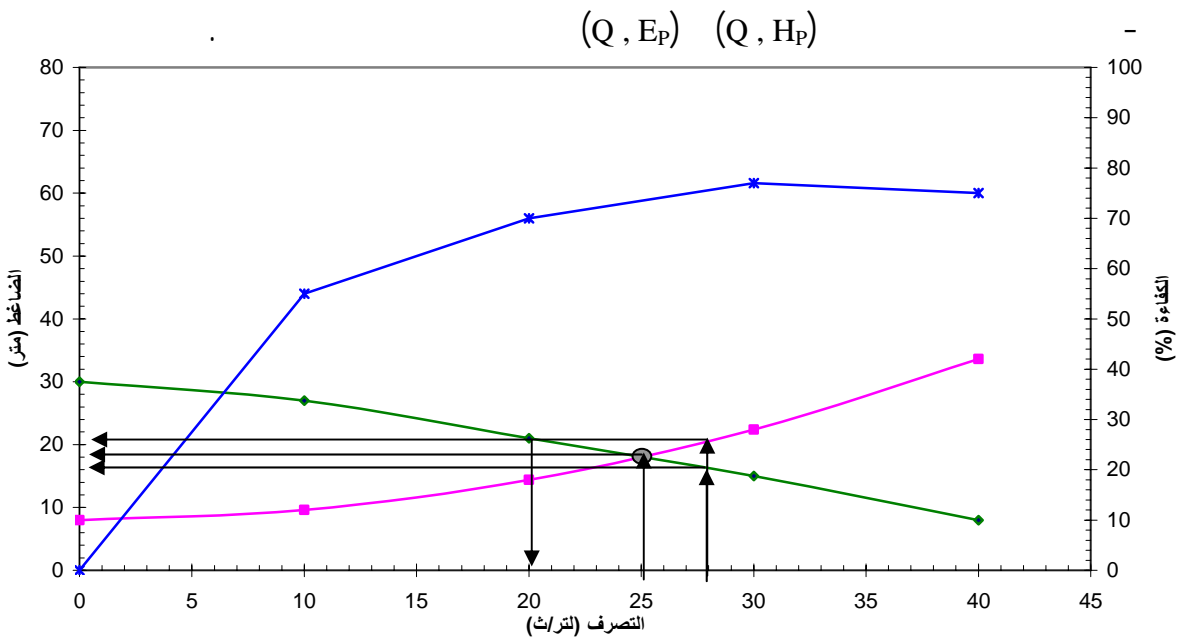
$$\text{Power} = \rho \phi H_i = 9.81 \times 0.111 \times 40.36 = 43.9 \text{ KW}$$

نسبة السرعة $\sigma = \frac{u_2}{v_2} = \frac{22}{24.26} = 0.91$

نسبة الضغط $\epsilon = \frac{v_{f2}}{v_2} = \frac{2.95}{24.26} = 0.12$

السرعة النوعية $N_s = \frac{N \sqrt{\phi}}{H^{3/4}} = \frac{1400 \sqrt{0.111}}{(30)^{3/4}} = 36.39 \text{ unit}$

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$$H_m = H_{St} + h_f + h_p$$

$$H_{St} = 8m \quad h_p = 0 \quad h_{Ls} = 0$$

$$H_m = 8 + h_f$$

$$H_m = 8 + K Q^2$$

$$(H_m = 18 m) \quad (Q = 25 \text{ lit/sec})$$

$$K$$

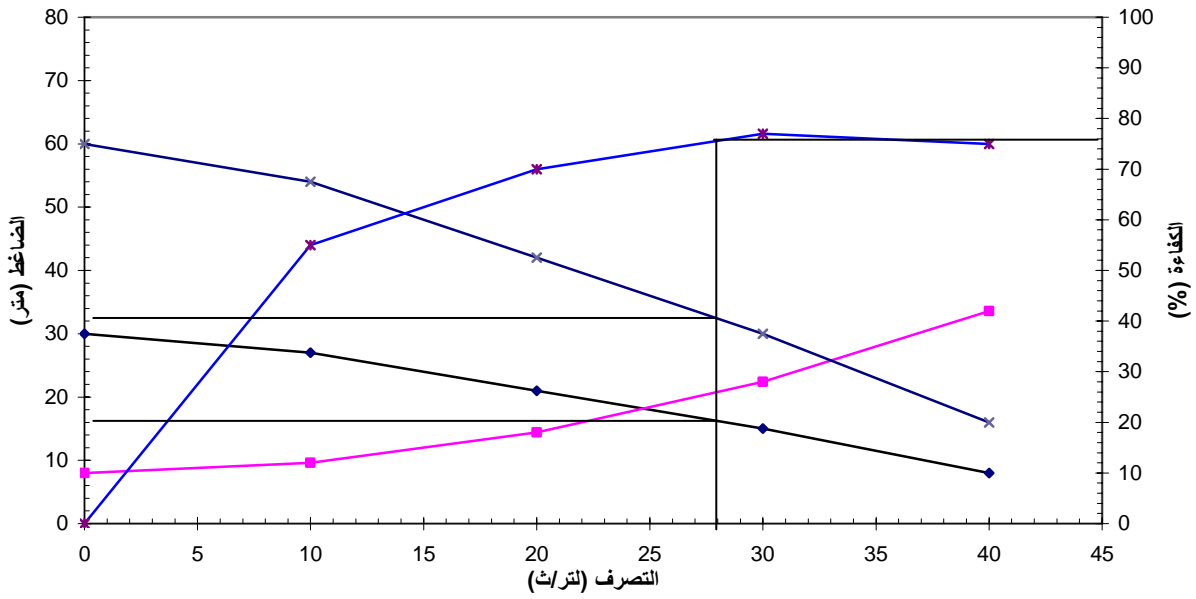
$$K = \frac{(18 - 8)}{(0.025)^2} = 16000$$

$$H_m = 8 + 16000 Q^2$$

Q (lit/sec)	0	10	20	30	40
Hm (m)	8	9.6	14.4	22.4	33.6

(Q , Hm)

$$N_{\text{pump}} = \frac{H_{\text{total}}}{H_{\text{one}}} = \frac{21}{16} = 1.3 = 2$$



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$$Q_{\text{one}} = 28 \text{ L/sec}$$

$$Q_s = 28 \text{ L/sec}$$

$$H_{\text{one}} = 16 \text{ m}$$

$$H_s = 32 \text{ m}$$

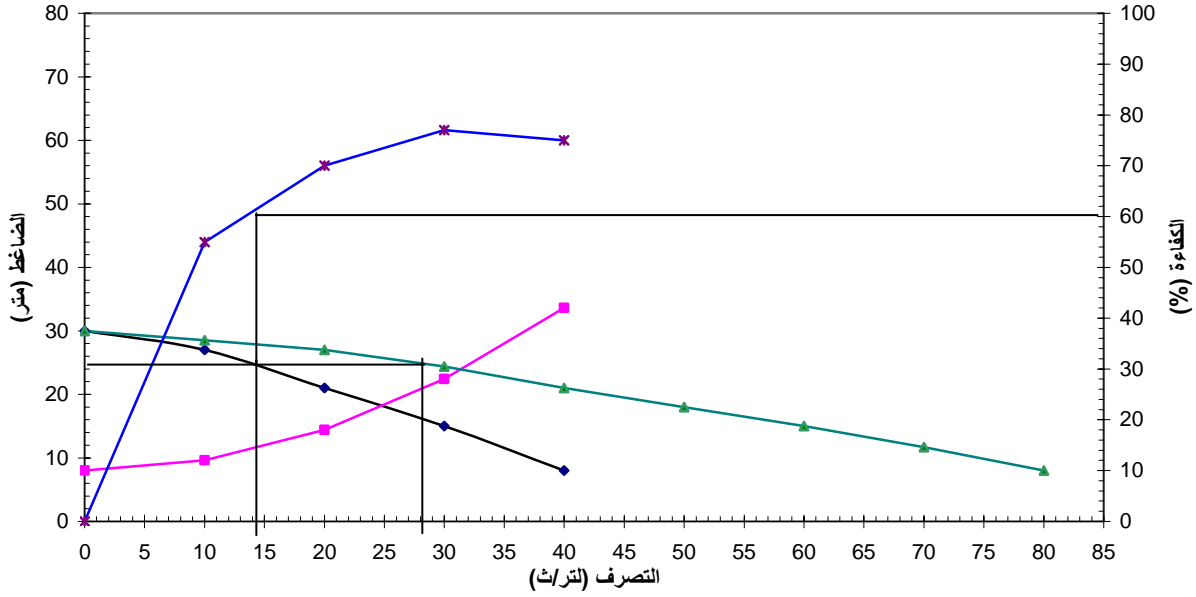
$$E_{\text{one}} = 76 \%$$

$$E_s = 76 \%$$

$$BP = \frac{Q \cdot H}{102E} = \frac{28 \times 16}{102 \times 0.76} = 5.78 \text{ kw}$$

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$$N_{\text{Pump}} = \frac{Q_{\text{total}}}{Q_{\text{one}}} = \frac{28}{20} = 1.4 = 2$$



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$$Q_{\text{one}} = 14 \text{ L/sec}$$

$$Q_P = 28 \text{ L/sec}$$

$$H_{\text{one}} = 25 \text{ m}$$

$$H_P = 25 \text{ m}$$

$$E_{\text{one}} = 60 \%$$

$$E_P = 60 \%$$

$$BP = \frac{Q \cdot H}{102E} = \frac{14 \times 25}{102 \times 0.60} = 5.72 \text{ kw}$$

(β)

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(Cp)

1580	1690	1680	1660	1500	1690	1590	1580	1600	1630
1520	1660	1520	1680	1610	1550	1610	1590	1540	1520

$$B = 0.5$$

$$Np = 4$$

$$Cp = 0.07$$

رقم المنطق	الحجم المتجمع X_i	الزهد عن المتوسط $ X_i - \bar{X} $	مربع الزهد $ X_i - \bar{X} ^2$	تكررت العنصر نقاعياً
1	1580	30	400	1500
2	1690	90	8100	1520
3	1680	-	"	"

$$q_a = \bar{x} = \frac{\sum x_i}{n} = \frac{32000}{20} = 1600$$

$$s_d = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{73600}{20-1}} = 62.239$$

$$C_v = \frac{s_d}{q_a} = \frac{62.239}{1600} = 0.039$$

$$U_s = (1 - C_v) \times 100 = (1 - 0.039) \times 100 = \underline{96.1\%}$$

$$q_n = \frac{1500 + 1520 + 1520 + 1520 + 1540}{5} = 1520$$

$$q_m = \frac{1690 + 1690}{2} = 1690$$

$$q_{var} = \frac{q_m - q_n}{q_m} \times 100 = \frac{1690 - 1520}{1690} \times 100 = \underline{10.1\%}$$

$$(EU)_f = \frac{q_n}{q_a} \times 100 = \frac{1520}{1600} \times 100 = \underline{95\%}$$

$$\begin{aligned} (EU)_a &= \frac{1}{2} \left(\frac{q_n}{q_a} + \frac{q_a}{q_m} \right) \times 100 \\ &= \frac{1}{2} \left(\frac{1520}{1600} + \frac{1600}{1690} \right) \times 100 \\ &= \underline{94.84\%} \end{aligned}$$

$$C_{hh} = \frac{C_v}{\beta} = \frac{0.039}{0.5} = 0.078$$

$$\begin{aligned} (U_s)_h &= (1 - C_{hh}) \times 100 \\ &= (1 - 0.078) \times 100 = \underline{92.2\%} \end{aligned}$$

$$\begin{aligned} (EU)_d &= \left(1 - \frac{1.27 C_v}{\sqrt{HP}} \right) \times \frac{q_n}{q_a} \times 100 \\ &= \left(1 - \frac{1.27 \times 0.039}{\sqrt{4}} \right) \times \frac{1520}{1600} \times 100 \\ &= \underline{92.65\%} \end{aligned}$$

$$\begin{aligned} C_{hp} &= \sqrt{C_v^2 + C_p^2} = \sqrt{(0.039)^2 + (0.07)^2} \\ &= 0.08 \end{aligned}$$

$$\begin{aligned} (U_s)_p &= (1 - C_{hp}) \times 100 \\ &= (1 - 0.08) \times 100 = \underline{92\%} \end{aligned}$$

$$q_{var} = (1 - (1 - Hvar)^B) \times 100$$

$$0.101 = 1 - (1 - Hvar)^{0.5}$$

$$\therefore Hvar = \underline{0.192 = 19.2\%}$$

$$\begin{aligned} C_{ht} &= \sqrt{C_{hp}^2 + C_{hh}^2} = \sqrt{(0.08)^2 + (0.078)^2} \\ &= 0.112 \end{aligned}$$

$$\begin{aligned} (U_s)_t &= (1 - C_{ht}) \times 100 \\ &= (1 - 0.112) \times 100 = \underline{88.8\%} \end{aligned}$$