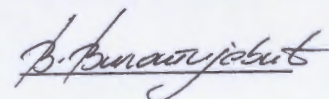


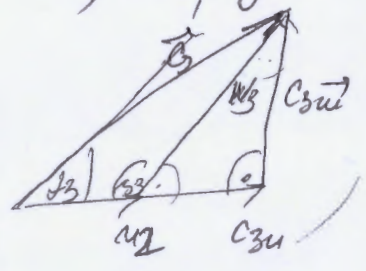
Prvi kolokvijum iz predmeta: Pumpe Ventilatori Turbokompresori
(26.03.2019)

1. **(11p)** Centrifugalni ventilator dimenzija $D_1 = 250$ mm, $D_2 = 400$ mm, radi sa vazduhom gustine $\rho = 1.2$ kg/m³ i naporom kola $\Delta p_k = 1100$ N/m². Ako je u tom režimu rada ulazni trougao brzina određen uglovima $\alpha_0 = 30^\circ$ i $\beta_0 = 25^\circ$, a izlazni trougao brzina uglom $\beta_3 = 135^\circ$ i odnosom relativnih brzina $w_3 = 0.85 \cdot w_0$, odrediti:
 - a) Kolika je brzina obrtanja ventilatora?
 - b) Trouglove brzina i nacrtati ih.
2. **(8p)** Pri protoku $Q = 0.118$ m³/s i naporu $H_p = 73$ m pumpa troši snagu od 120 kW. Mehanički i zapreminski stepen korisnosti su $\eta_m = 0.98$ i $\eta_q = 0.95$, a broj obrtaja radnog kola $n = 2900$ min⁻¹. Odrediti izlazni ugao lopatica kola ako je značica napora pumpe $\psi = 0.95$. $\alpha_0 = 90^\circ$. Širina kola na izlazu je 31 mm.
3. **(11p)** Dimenzije kola centrifugalnog ventilatora, koji se obrće sa brzinom obrtanja $n = 1650$ min⁻¹, su: prečnik i širina radnog kola na ulazu $d_1 = 1200$ mm, $b_1 = 260$ mm, prečnik i širina radnog kola na izlazu $d_2 = 2400$ mm, $b_2 = 130$ mm. Vazduh ulazi u kolo radialno a izlazi pod uglom $\alpha_3 = 45^\circ$. Stepen reakcije kola je $\Theta = 0.74$ dok su hidraulički i zapreminski stepeni korisnosti $\eta_h = 0.74$ i $\eta_Q = 0.96$. Odrediti:
 - a) protok kola, jedinični rad kola, značicu protoka i napora kola,
 - b) protok i jedinični rad struje ventilatora kao i značice protoka i napora ventilatora,
 - c) specifičnu brzinu obrtanja.

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$D_1 = 250 \text{ mm} = 0,25$; $\rho = 1,2 \text{ kg/m}^3$; $L_0 = 90^\circ$, $\beta_0 = 25^\circ$
 $D_2 = 400 \text{ mm} = 0,4$; $\Delta p_k = 1100 \text{ N/m}^2$; $\beta_3 = 135^\circ$, $v/3 = 0,85 \cdot v/0$
 а) $u = ?$ б) непроектна сфера .



$$\text{tg } \alpha_0 = \frac{c_{0u}}{c_u}$$

$$\text{tg } \beta_3 = \frac{c_{3u}}{u_2}$$

$$v_k = \frac{\Delta p_k}{\rho} = c_{3u} \cdot u_2 - u_1 \cdot c_{0u}$$

$$u_1 = d_1 \cdot \pi \cdot n \Rightarrow n = \frac{u_1}{d_1 \cdot \pi} \Rightarrow$$

$$u_2 = d_2 \cdot \pi \cdot n \Rightarrow n = \frac{u_2}{d_2 \cdot \pi} \Rightarrow \left. \begin{matrix} \Rightarrow \frac{u_1}{d_1 \cdot \pi} = \frac{u_2}{d_2 \cdot \pi} \\ \Rightarrow u_2 = u_1 \cdot \frac{d_2}{d_1} \end{matrix} \right\}$$

$$\frac{c_0}{\sin \beta_0} = \frac{v/0}{\sin \alpha_0} \Rightarrow v/0 = c_0 \cdot \frac{\sin \beta_0}{\sin \alpha_0} \Rightarrow c_0 = v/0 \cdot \frac{\sin \alpha_0}{\sin \beta_0}$$

$$c_{0u} = c_0 \cdot \cos \alpha_0 = \frac{v/0 \cdot \sin \beta_0 \cdot \cos \alpha_0}{\sin \alpha_0}$$

$$c_{3u} = u_2 + v/3 \cdot \cos 45^\circ = u_1 \cdot \frac{d_2}{d_1} + 0,85 \cdot v/0 \cdot \cos 45^\circ$$

$$c_{3u} = u_1 \cdot \frac{d_2}{d_1} + 0,85 \cdot v/0 \cdot \cos 45^\circ$$

$$u_1 = c_{0u} + v/0 \cdot \cos \beta_0 = v/0 \cdot \sin \beta_0 \cdot \text{ctg } \alpha_0 + v/0 \cdot \cos \beta_0$$

$$u_1 = v/0 (\sin \beta_0 \text{ctg } \alpha_0 + \cos \beta_0)$$

$$v/0 = \frac{u_1}{(\sin \beta_0 \text{ctg } \alpha_0 + \cos \beta_0)}$$

⊕

$$\frac{\Delta p_K}{\rho} = \left[\underbrace{\left(u_1 \cdot \frac{d_2}{d_1} + 0,85 \cdot u_1 \right)}_{C_{34}} \cdot \cos 45^\circ \right] \cdot u_1 \cdot \frac{d_2}{d_1} - u_1 \cdot \underbrace{\left(u_1 \sin \beta \operatorname{ctg} \beta \right)}_{C_{04}} \cdot \cos \beta$$

$$\frac{\Delta p_K}{\rho} = u_1^2 \cdot \frac{d_2^2}{d_1^2} + \frac{0,85 \cdot u_1^2 \cdot d_2 \cdot \cos 45^\circ}{d_1 (\operatorname{ctg} \beta \sin \beta + \cos \beta)} - \frac{u_1^2 \sin \beta \operatorname{ctg} \beta}{\operatorname{ctg} \beta \sin \beta + \cos \beta}$$

$$\frac{\Delta p_K}{\rho} = u_1^2 \left(\frac{d_2^2}{d_1^2} + \frac{0,85 \cdot d_2 \cdot \cos 45^\circ}{d_1 (\operatorname{ctg} \beta \sin \beta + \cos \beta)} - \frac{\sin \beta \operatorname{ctg} \beta}{\operatorname{ctg} \beta \sin \beta + \cos \beta} \right)$$

$$916,66 = u_1^2 \left(2,56 + \frac{0,2404}{0,4095} - \frac{0,7319}{1,6383} \right)$$

$$916,66 = u_1^2 (2,56 + 0,5871 - 0,4467)$$

$$u_1 = \sqrt{\frac{916,66}{2,7004}} = \sqrt{339,453} = 18,424 \text{ m/s}$$

$$u_1 = \frac{d_1 \cdot \pi \cdot n}{60} \Rightarrow n = \frac{60 \cdot u_1}{d_1 \cdot \pi} = \frac{60 \cdot 18,424}{0,25 \cdot 3,14} = 1408,20 \text{ min}^{-1}$$

$$u_2 = \frac{d_2 \cdot \pi \cdot n}{60} = \frac{0,4 \cdot 3,14 \cdot 1408,20}{60} = 29,478 \text{ m/s}$$

$$w_{10} = \frac{u_1}{(\operatorname{ctg} \beta \sin \beta + \cos \beta)} = \frac{18,42}{1,6383} = 11,24 \text{ m/s}$$

$$C_{04} = w_{10} \cdot \sin \beta \operatorname{ctg} \beta = 11,24 \cdot 0,7319 = 8,226 \text{ m/s}$$

$$C_0 = w_{10} \cdot \frac{\sin \beta}{\sin \alpha} = 11,24 \cdot 0,845 = 9,5004 \text{ m/s}$$

$$W_3 = 0,85 \cdot W_0 = 0,85 \cdot 11,24 = 9,554 \text{ m/s.}$$

$$C_{3u} = u_2 + W_3 \cdot \cos 45 = 29,478 + 9,554 \cdot \cos 45 = 36,234 \text{ m/s}$$

$$Q = 0,118 \text{ m}^3/\text{s}, H_p = 73 \text{ m}, P_{EM} = 120 \text{ kW}, \eta_m = 0,98; \eta_a = 0,95.$$

$$n = 2900 \text{ min}^{-1} \quad b_3 = ?$$

$$\psi = 0,55, \beta_0 = 90^\circ$$

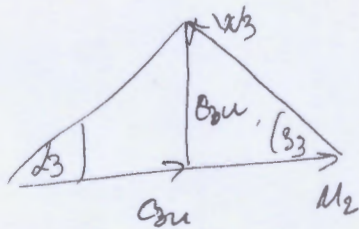
$$\psi = \frac{2\gamma}{u_2^2} \Rightarrow u_2 = \sqrt{\frac{2 \cdot g \cdot H_p}{\psi}} = \sqrt{\frac{2 \cdot 9,81 \cdot 73}{0,55}} = \underline{\underline{38,828 \text{ m/s}}}$$

$$u_2 = \frac{d_2 \pi \cdot n}{60} \Rightarrow d_2 = \frac{60 \cdot u_2}{n \cdot \pi} = \frac{60 \cdot 38,828}{2900 \cdot 3,14} = \underline{\underline{0,256 \text{ m}}}$$

$$P = \frac{\rho \cdot g \cdot Q \cdot H}{\eta} \Rightarrow \eta = 0,704.$$

$$\eta = \eta_m \cdot \eta_h \cdot \eta_a \Rightarrow \eta_h = \frac{\eta}{\eta_m \cdot \eta_a} = 0,756.$$

$$c_{3u} = \frac{Q}{d_2 \cdot \pi \cdot b_3 \cdot \eta_a} = 4,982 \text{ m/s}$$



$$Y_k = c_{3u} \cdot u_2 - u_1 \cdot c_{0u}$$

$$c_{3u} = \frac{Y_k}{u_2} = \frac{g \cdot H_p}{\eta_h \cdot u_2} = \frac{33 \text{ m/s}}{0,756} = 24,396 \text{ m/s}$$

$$\tan \beta_3 = \frac{c_{3u}}{u_2 - c_{3u}} \Rightarrow \beta_3 = \arctan \left(\frac{c_{3u}}{u_2 - c_{3u}} \right) = \arctan \left(\frac{4,982}{38,828 - 4,982} \right) = \underline{\underline{7,29^\circ}} \quad 19,037^\circ$$

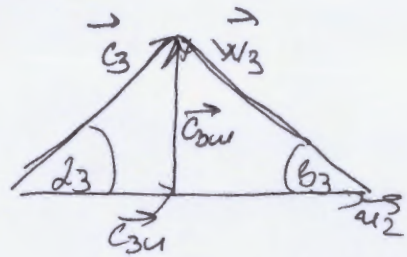
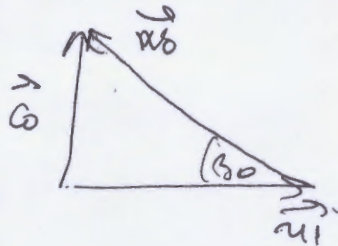
$n = 1650 \text{ min}^{-1}$, $d_1 = 1200 \text{ mm}$, $b_1 = 260 \text{ mm}$; $d_2 = 2400 \text{ mm}$; $b_2 = 130$

$\beta_3 = 45^\circ$, $\alpha_0 = 90^\circ$; $\theta = 0,74$, $\eta_h = 0,74$; $\eta_a = 0,96$

a) $Q_k = ?$ $\gamma_k = ?$; $\psi_k = ?$; $\rho_k = ?$

b) $Q, \gamma, \psi, \psi = ?$

c) $\eta_a = ?$



$$u_1 = \frac{d_1 \cdot \pi \cdot n}{60} = 103,62 \text{ m/s}$$

$$u_2 = \frac{d_2 \cdot \pi \cdot n}{60} = 207,24 \text{ m/s}$$

$$Q_k = c_{3u} \cdot d_1 \cdot \pi \cdot b_1 = c_{3u} \cdot \pi \cdot b_2 \cdot d_2 =$$

$$\Rightarrow \boxed{c_{3u} = c_{3u}}$$

$$\theta = 1 - \frac{c_{3u}^2 - c_0^2}{2 \gamma_k} = 1 - \frac{c_{3u}^2 - c_0^2}{2 \cdot c_{3u} \cdot u_2}$$

$$c_{3u} = \frac{2 u_2 (1 - \theta)}{2} = 107,765 \text{ m/s}$$

a) $\gamma_k = c_{3u} \cdot u_2 = 22,333,22 \text{ kJ/kg}$

$$\tan \beta_3 = \frac{c_{3u}}{c_{3u}} \Rightarrow c_{3u} = 107,765 \text{ m/s}$$

$$Q_k = \cancel{105,575} \cdot c_{3u} \cdot d_2 \cdot \pi \cdot b_2 = 105,575$$

$$\rho_k = \frac{Q_k}{d_2 \cdot \pi \cdot b_2 \cdot u_2} = 1,633$$

$$\rho = \frac{Q}{A_2 \cdot u_2}$$

$$\psi_k = \frac{2 \cdot \gamma_k}{u_2^2} = 1,04$$

$$\rho = 1,568$$

b) $\eta_h = \frac{\gamma}{\gamma_k} \Rightarrow \gamma = 16,526 \text{ kJ/kg}$

$$\psi = \frac{2 \cdot \gamma}{u_2^2} \Rightarrow \psi = 0,77$$

$$\eta_a = \frac{Q}{Q_k} \Rightarrow Q = 101,352 \text{ m}^3/\text{s}$$

c) $\eta_a = \frac{333 \cdot u \cdot Q^{1/2}}{\gamma^{3/4}} = 63,248$