

индекси:

o - објектат  
m - модел

010

# МОДЕЛИ

## РАЗМЕРА :

- за дужине  $L_* = \frac{L_o}{L_m}$
- за површине  $A_* = L_*^2$
- за запремине  $V_* = L_*^3$
- за брзине  $U_* = \frac{U_o}{U_m}$
- за притисак  $[p = \rho \frac{1}{2} U^2]$

геометријска сличност

кинематиска сличност

$$P_* = (\rho)_* \left(\frac{1}{2}\right) S_* (U^2)_* = S_* (U_*)^2$$

- за силе  $F_* = \frac{F_o}{F_m}$

динамичка сличност

- за густини (ако је флуид на моделу и објекту исти, онда :

$$- [S_* = 1]$$

$$\text{ако није: } - S_* = \frac{\rho_o}{\rho_m} \neq 1$$

$$U_o = \frac{L_o}{T_o} ; U_m = \frac{L_m}{T_m}$$

$$T_* = \frac{T_o}{T_m} \text{ - параметар за време (??)}$$

## 1) Рејнолдсова сличност :

инерс. и виск.

$$Re_* = 1 = \frac{S_* U_* \cdot L_*}{\eta_*} = \frac{U_* \cdot L_*}{\nu_*}$$

$$\text{ако је исти флуид: } U_* L_* = 1 \Rightarrow U_* = \frac{1}{L_*}$$

НАПОМЕНА: време на моделу знатно брже иде него на објекту :

$$U_* = \frac{1}{L_*} \quad \frac{L_*}{T_*} = \frac{1}{L_*} \Rightarrow T_* = L_*^2$$

а на гравитација није исти :

$$g_* = \frac{L_*}{T_*^2} = \frac{U_*^2}{L_*} = \frac{1}{L_*^3}$$

## 2) Фрудова сличност :

(сличност за инерцијалне и гравитацијске)

$$Fr_* = 1 = \frac{U_*^2}{g_* L_*}$$

$$\frac{U_*^2}{L_*} = 1 \Rightarrow U_* = \sqrt{L_*}$$

$$T_* = \frac{L_*}{U_*} = \frac{L_*}{\sqrt{L_*}} = \sqrt{L_*} \quad (\text{време})$$

$$Q_* = U_* A_* = \sqrt{L_*} \cdot L_*^2 = L_*^{5/2} \quad (\text{проток})$$



МОД ЕЛУ

ЈАНУАР 2009

(A)

6) Фругова сличности

размера: - дужине  $L_*$  = 15

Флуид вода (истаи на  $\mu$  и  $\rho$ )

$$T_H = 2 \text{ s}$$

$$T_0 = ?$$

$$T_* = \sqrt{L_*} = 3,873$$

$$T_* = \frac{T_0}{T_H}$$

$$T_0 = T_* \cdot T_H = 2 \cdot 3,873 = \boxed{7,75 \text{ s}}$$

С) 6)  $L_* = 22$

$$T_H = 2,2 \text{ s}$$

$$T_0 = ?$$

$$T_* = \sqrt{22} = 4,69$$

$$T_0 = T_* \cdot T_H = \boxed{10,32 \text{ s}}$$

$$10L = 10 \cdot 10^{-3} \text{ m}^3$$

Б) 6)  $L_* = 18$

$$T_H = 2,1 \text{ s}$$

$$T_* = \sqrt{18} = 4,24$$

$$T_0 = T_* \cdot T_H = \boxed{8,91 \text{ s}}$$

Април 2007

истаи флуид на  $\mu$  и  $\rho$

$$20L_H = L_0$$

$$I_H = 40$$

$$I_0 = ?$$

Фругова сличности

$$L_* = \frac{L_0}{L_H} = \frac{20L_H}{L_H} = 20$$

$$I_* = SQV = 1 \cdot L_*^{\frac{5}{2}} \cdot L_*^{\frac{1}{2}} = 8000$$

истаи флуид  
за  $S=1$

$$I_* = \frac{I_0}{I_H} ; I_0 = I_* \cdot I_H = 8000 \cdot 40 = 320\,000 \text{ H} = \boxed{320 \text{ kH}}$$

27. 11. 2007. (2)

Фругова сличности

$$Q_p = 8 \text{ m}^3/\text{s}$$

$$Q_H = 10 \text{ L/s}$$

$$L_* = ?$$

$$T_* = ?$$

$$Q_* = \frac{8 \text{ m}^3/\text{s}}{10 \cdot 10^{-3} \text{ m}^3/\text{s}} = 800$$

$$L_*^{\frac{5}{2}} = Q_* \Rightarrow L_* = 800^{\frac{2}{5}} = \boxed{14,435}$$

$$T_* = \sqrt{L_*} = \boxed{3,81 \text{ s}}$$

04.12.2007

② Фрутова сличности

$$L_0 = 4L_H$$

$$F_{H0} = 100 \text{ H}$$

$$F_{0B} = ?$$

$$L_* = \frac{L_0}{L_H} = \frac{4L_H}{L_H} = 4$$

$$F_* = S_* \sigma_*^2 L_*^2 = 1 \cdot L_* \cdot L_*^2 = L_*^3$$

$$F_* = \frac{F_0}{F_H} = 4^3 \Rightarrow F_0 = 4^3 \cdot 100 \text{ H} = 6400 \text{ H} = \underline{\underline{64 \text{ kH}}}$$

18.12.2007

② - Фрутова

- истии Фругов

$$16L_H = L_0$$

$$I_H = 48 \text{ H}$$

$$I_0 = ?$$

$$I_* = S_* Q_* \sigma_* = 1 \cdot L_*^{5/2} \cdot \sqrt{L_*} = L_*^3 = 4096$$

$$L_* = \frac{L_0}{L_H} = \frac{16L_H}{L_H} = 16$$

$$I_* = \frac{I_H}{I_0} \Rightarrow I_0 = 48 \text{ H} \cdot 4096 = 196608 \text{ H} = \underline{\underline{196,608 \text{ kH}}}$$

АВГУСТ 2007

④  $15L_H = L_0$   
Фругов.

$$\frac{\sigma_H^2}{2g_H} = 6 \text{ cm}$$

$$\frac{\sigma_0^2}{2g_0} = X$$

$$L_* = \frac{15L_H}{L_H} = 15$$

$$\sigma_* = \sqrt{L_*} = \sqrt{15}$$

$$\sigma_*^2 = 15$$

$$\sigma_* = \frac{\sigma_0}{\sigma_H} ; \sigma_*^2 = \frac{\sigma_0^2}{\sigma_H^2}$$

$$g_* = 1 = \frac{g_0}{g_H}$$

$$\sigma_*^2 = \frac{X \cdot 2g_0}{6 \text{ cm} \cdot 2g_H} \Rightarrow g_* = 1$$

$$\Rightarrow 15 \cdot 6_{\text{cm}} = X$$

$$\underline{\underline{X = 90 \text{ cm}}}$$

АВГУСТ 2007

④ Фругов

$$20L_H = L_0$$

$$\frac{\sigma_H^2}{2g_H} = 4 \text{ cm}$$

$$\frac{\sigma_0^2}{2g_0} = X$$

$$L_* = \frac{L_0}{L_H} = \frac{20L_H}{L_H} = 20$$

$$\sigma_* = \sqrt{L_*} ; \sigma_*^2 = 20$$

$$\sigma_*^2 = \frac{\sigma_0^2}{\sigma_H^2} = \frac{X \cdot 2g_0}{4 \text{ cm} \cdot 2g_H} \Rightarrow 1$$

$$20 \cdot 4 \text{ cm} = X \Rightarrow \underline{\underline{X = 80 \text{ cm}}}$$



2006

③ Другой козел

$$12L_n = L_0$$

$$F_H = 50 \text{ Н}$$

$$F_0 = ?$$

$$F_x = S_x \cdot \overset{1}{\sigma_x^2} L_x^2 = L_x^3 = 12^3 = 1728$$

$$L_x = \frac{12L_n}{L_H} = 12$$

$$\sigma_x^2 = L_x$$

$$F_x = \frac{F_0}{F_H} \Rightarrow F_0 = 50 \text{ Н} \cdot 1728$$

$$F_0 = 86,4 \text{ кН}$$

СЕПТЕМ БАР 2007

④ Рейнольдса (инерц. и вискоз)

$$10L_n = L_0$$

$$g_x = \frac{1}{L_x^5} = \frac{1}{10^5} = \underline{\underline{10^{-5}}}$$

$$L_x = \frac{10L_n}{L_H} = 10$$

СЕПТ. 2007 С1

④  $6L_n = L_0$

$$L_x = \frac{6L_n}{L_H} = 6$$

$$g_x = \frac{1}{L_x^5} = \frac{1}{6^5} = \underline{\underline{4,63 \cdot 10^{-3}}}$$

ггн 2007

(A)

3)  $SLH = L_0$

$S = 1,2 \text{ кг/м}^3$ ,  $\mu = 1,35 \cdot 10^{-5} \text{ Па} \cdot \text{с}$  - модель

$S = 1 \text{ кг/м}^3 = 1000 \text{ кг/м}^3$ ;  $\mu = 1,1 \cdot 10^{-3} \text{ Па} \cdot \text{с}$  - объект

$T_H = 0,08$

$S_* = \frac{1000}{1,2} = 833,33$

$\mu_* = \frac{1,1 \cdot 10^{-3}}{1,35 \cdot 10^{-5}} = 56,41$

$L_* = \frac{SLH}{L_0} = 5$

$Re = 1 = \frac{S_* \cdot V_* \cdot L_*}{\mu_*} \Rightarrow V_* = \frac{\mu_*}{S_* \cdot L_*} = \frac{56,41}{833,33 \cdot 5} = 0,0135..$

$V_* = \frac{L_*}{T_*} \Rightarrow T_* = \frac{L_*}{V_*} = \frac{5}{0,0135} = 369,32$

$T_* = \frac{T_0}{T_H}$ ;  $T_0 = T_* \cdot T_H = 369,32 \cdot 0,08 = \boxed{29,5 \text{ с}}$

ггн 2007 (D)

$SLH = L_0$   $T = 0,08$

$L_* = 8$

$S_* = 833,33$

$\mu_* = 56,41$

Итого по 3 вопросам задания!

$V_* = \frac{56,41}{833,33 \cdot 8} = 8,46 \cdot 10^{-3}$

$T_* = \frac{8}{8,46 \cdot 10^{-3}} = 945,46$

$T_0 = 945,46 \cdot 0,08 = \boxed{75,64 \text{ с}}$

2007

(C)

$$L_M = L_0$$

$$\mu_{\text{огел}}: S_M = 1,2 \text{ kg/m}^3$$

$$\mu_M = 1,95 \cdot 10^{-5} \text{ Pa} \cdot \text{s}$$

$$\text{объект } S_0 = 1 \text{ kg/dm}^2 = 1000 \text{ kg/m}^3$$

$$\mu_0 = 1,1 \cdot 10^{-3} \text{ Pa} \cdot \text{s}$$

$$Re = 1$$

$$T_M = 0,08 \text{ s}$$

$$T_0 = ?$$

$$T_* = \frac{T_0}{T_M} ; T_0 = T_* \cdot T_M$$

$$Re = 1 = \frac{S_* \cdot U_* \cdot L_*}{\mu_*}$$

$$\mu_* = S_* \cdot U_* \cdot L_*$$

$$U_* = \frac{\mu_*}{S_* \cdot L_*} = \frac{56,41}{833,33 \cdot 7} = 9,67 \cdot 10^{-3}$$

$$U_* = \frac{L_*}{T_*} \Rightarrow T_* = \frac{7}{9,67 \cdot 10^{-3}} = 723,89$$

$$T_* = \frac{T_0}{T_M}$$

$$T_0 = T_M \cdot T_* = 0,08 \cdot 723,88 = \boxed{57,91 \text{ s}}$$

$$S_* = \frac{1000}{1,2} = 833,33$$

$$\mu_* = \frac{1,1 \cdot 10^{-3}}{1,95 \cdot 10^{-5}} = 56,41$$

$$L_* = \frac{7 \text{ km}}{2\pi} = 7$$

$$U_* = \frac{L_*}{T_*}$$

$$T_* = \frac{7}{9,67 \cdot 10^{-3}} = 723,89$$



Апрел 2007

Формулы

$$6) A = \frac{D^2 \pi}{4} \quad Q = A \cdot V \quad Re = \frac{SDV}{\mu} \quad \lambda = \frac{64}{Re} \quad \Delta E = \Delta \Pi = \lambda \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

$$\Delta p = Sg \Delta \Pi$$

$$\mu = 10^{-3} \text{ Pa} \cdot \text{s}$$

$$S = 1000 \text{ kg/m}^3$$

$$D = 1 \text{ cm} = 0,01 \text{ m}$$

$$Q = 15 \text{ cm}^3/\text{s} = 1,5 \cdot 10^{-5} \frac{\text{m}^3}{\text{s}}$$

$$L = 1 \text{ m}$$

$$\Delta p = ?$$

$$A = 7,85 \cdot 10^{-5} \text{ m}^2$$

$$Q = A \cdot V$$

$$V = \frac{Q}{A} = 0,191 \text{ m/s}$$

$$Re = \frac{1000 \cdot 0,01 \cdot 0,191}{10^{-3}} = 1910,83$$

$$\lambda = \frac{64}{1910,83} = 0,033$$

$$\Delta E = \Delta \Pi = 0,033 \cdot \frac{1}{0,01} \cdot \frac{0,191^2}{2 \cdot 9,81} = 6,23 \cdot 10^{-3}$$

$$\Delta p = 1000 \cdot 9,81 \cdot 6,23 \cdot 10^{-3} = \underline{\underline{61,09 \text{ Pa}}}$$

Ано же турс.

$$\lambda = 0,115 \left( \frac{\mu}{D} + \frac{60}{Re} \right)^{1/4}$$

Ано же турс

$\mu = 0$

$$7) S = 1 \text{ kg/dm}^3 = 1000 \text{ kg/m}^3$$

$$\mu = 0,001 \text{ Pa} \cdot \text{s}$$

$$L = 8 \text{ m}$$

$$1 \text{ m} \text{ диаметр}$$

$$\kappa = 1,5 - \text{храбровости}$$

$$U = 15 \text{ m/s}$$

$$\text{На средити ? } S = ?$$

$$Re = \frac{SUL}{\mu} = \frac{1000 \cdot 15 \cdot 8}{0,001} = 12 \cdot 10^6$$

$$Re(L) > Re_{crit}$$

$$Re(0,1 \text{ m}) = 12 \cdot 10^6 > Re_{crit}$$

$$\text{ТУРБУЛЕНТАН ЖЕ!}$$

$$\text{Но! шововити } L \rightarrow \frac{L}{2} = \underline{\underline{4}}$$

$$S(4) = 0,38 \cdot \frac{4}{Re(4)^{1/5}} = \underline{\underline{42,29 \text{ mm}}}$$

$$Re(4) = 60 \cdot 10^6$$

$$8) B = 0,12$$

$$I_0 = 2\% = 0,02$$

$$Q = 3 \text{ L/s}$$

$$\text{по формуле } n = 0,013 \text{ m}^{-1/3} \text{ s}$$

$$h_n, h_u = ? \text{ решить ?}$$

$$Q = \frac{1}{n} A R^{2/3} \sqrt{I_0}$$

$$3 \cdot 10^{-3} = \frac{1}{0,013} \cdot 0,12 \cdot h_n \cdot R^{2/3} \sqrt{0,02}$$

$$h_n \cdot \left( \frac{0,12 h_n}{0,12 + 2 \cdot h_n} \right)^{2/3} = 2,29 \cdot 10^{-3}$$

$$[A = B \cdot h] \text{ — шовити}$$

$$\boxed{R = \frac{A}{B + 2h}}$$

$$\rightarrow h_n^{5/3} \cdot \frac{1}{(0,12 + 2h_n)^{2/3}} = 9,41 \cdot 10^{-3} / ^3$$

$$\frac{h_n^5}{(0,12 + 2h_n)^2} = 8,34 \cdot 10^{-7}$$

$$\frac{F_R = \frac{Q^2 B}{A^3 g} = 1}{\frac{3 \cdot 10^{-3} \cdot 0,12}{(h_n + 2h_n)^3 \cdot 9,81} = 1}$$

$$\Rightarrow h_n = \underline{\underline{3,99 \text{ cm}}}$$