FORMULÁRIO

Forma integral das equações de conservação

Massa: $\frac{\mathrm{d}}{\mathrm{d}t}\int_{V_c} \rho \, \mathrm{d}V + \int_{S_c} \rho(\vec{v}_r \cdot \vec{n}) \, \mathrm{d}S = 0$

Quantidade de movimento: $\frac{\mathrm{d}}{\mathrm{d}t}\int_{V_c} \rho\vec{v} \, \mathrm{d}V + \int_{S_c} \rho\vec{v}(\vec{v}_r \cdot \vec{n}) \, \mathrm{d}S = \sum \vec{F}$

Energia: $\frac{\mathrm{d}}{\mathrm{d}t}\int_{V_c} \rho \left(e + \frac{1}{2}V^2 + gz\right) \mathrm{d}V + \int_{S_c} \rho(e + \frac{1}{2}V^2 + gz)(\vec{v}_r \cdot \vec{n}) \, \mathrm{d}S = \dot{Q} - \dot{W}_{\mathrm{m}} - \dot{W}_{\mathrm{p}} - \dot{W}_{\mathrm{v}}$

Momento angular: $\frac{\mathrm{d}}{\mathrm{d}t}\int_{V_c} \rho(\overrightarrow{r_0} \times \vec{v}) \, \mathrm{d}V + \int_{S_c} \rho(\overrightarrow{r_o} \times \vec{v})(\vec{v}_r \cdot \vec{n}) \, \mathrm{d}S = \sum \overrightarrow{M}_0$

Equações de Navier-Stokes

Equações do movimento para um escoamento incompressível de um fluido newtoniano com propriedades constantes em coordenadas cartesianas:

Continuidade:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

Transporte de quantidade de movimento:

$$\rho\left[\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right] = \rho g_x - \frac{\partial p}{\partial x} + \mu\left[\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right]$$

$$\rho\left[\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z}\right] = \rho g_y - \frac{\partial p}{\partial y} + \mu\left[\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right]$$

$$\rho\left[\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}\right] = \rho g_z - \frac{\partial p}{\partial z} + \mu\left[\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right]$$

Componentes do tensor das tensões viscosas:

$$\tau_{xx} = 2\mu\frac{\partial u}{\partial x}$$

$$\tau_{yy} = 2\mu\frac{\partial v}{\partial y}$$

$$\tau_{zz} = 2\mu\frac{\partial w}{\partial z}$$

$$\tau_{xy} = \tau_{yx} = \mu\left[\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right]$$

$$\tau_{xz} = \tau_{zx} = \mu\left[\frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}\right]$$

$$\tau_{yz} = \tau_{zy} = \mu\left[\frac{\partial w}{\partial y} + \frac{\partial v}{\partial z}\right]$$

Curva da Instalação

$$H = \frac{p_B - p_A}{\rho g} + z_B - z_A + \left[\frac{f\left(\frac{l}{d}\right)}{2gA^2} + \frac{\sum k}{2gA^2}\right]Q^2 \qquad H_s = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} - \frac{p_{vap}}{\rho g}$$

Turbomáquinas

Potência ao veio em máquinas hidráulicas: $P = \rho g Q H \eta$ *ou* $P = \rho g Q H / \eta$

Coeficientes adimensionais em turbomáquinas:

$$C_P = \frac{P}{\rho N^3 D^5} \quad C_Q = \frac{Q}{ND^3} \quad C_H = \frac{gH}{N^2 D^2} \quad \Omega = \frac{N\sqrt{Q}}{(gH)^{\frac{3}{4}}} \quad \Delta = \frac{D(gH)^{\frac{1}{4}}}{\sqrt{Q}} \quad S_i = \frac{N\sqrt{Q}}{(gH_{si})^{\frac{3}{4}}}$$

Pontos dinamicamente semelhantes (mesma máquina) : $\frac{Q_1}{Q_2} = \frac{N_1}{N_2} = \left(\frac{H_1}{H_2}\right)^{1/2}$

Para bombas e turbinas temos, respetivamente: $S_{i\eta} = 3{,}0$ *e* $S_{i\eta} = 4{,}0$

Diagrama de Cordier:

Bomba / Ventilador

$H_s = \frac{P_{atm} - P_{vap}}{\rho g} - e_s - z_{asp}$

Turbina

$H_s = \frac{P_{atm} - P_v}{\rho g} - e_s$