Gleitlagen

TECHNISCHE UNIVERSITÄT DARMSTADT

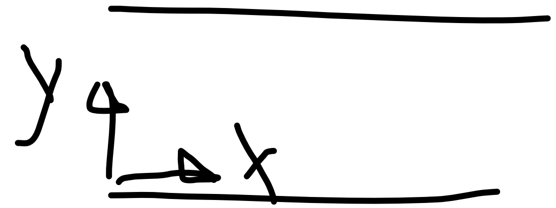
FLUID SYSTEM TECHNIK

Prof. Dr. Ing. Peter Pelz
Wintersemester 2011/12
Technische Fluidsysteme
Vorlesung 3

Couette - Poiseulle - Strömung

Navier - Stokes - Gleichungen

$$\rho \frac{D\vec{u}}{Dt} = \rho \vec{k} - \nabla p + \nabla \cdot (\eta \nabla \vec{u})$$



Kontinuitätsgleichung (inkompressibel)

$$\nabla \cdot \vec{u} = 0$$

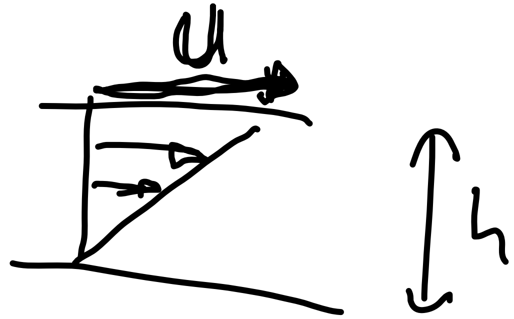
$$\rho \left(\cancel{\frac{\partial u}{\partial t}} + \cancel{\frac{\partial u}{\partial x}} u + \cancel{\frac{\partial u}{\partial y} v} + \cancel{\frac{\partial u}{\partial z}} w \right) = -\frac{\partial p}{\partial x} + \eta \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \cancel{\frac{\partial^2}{\partial z^2}} \right) u$$

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

eben
stationär
Schichtenströmung

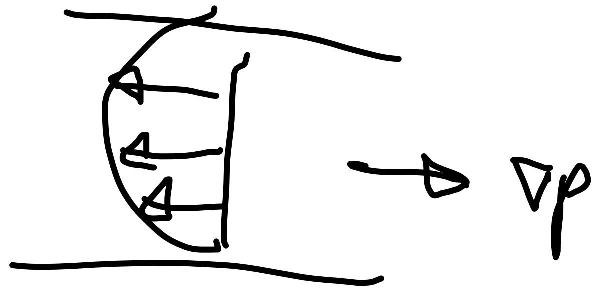
$$0 = \frac{\partial p}{\partial x} + \eta \frac{\partial^2 u}{\partial y^2}$$

Couette - Strömung



$$u = U \, \frac{y}{h}$$

Poiseulle-Strömung



$$-\frac{\partial p}{\partial x} + \eta \frac{\partial^2 u}{\partial y^2} = 0$$

$$-\frac{\partial p}{\partial x} = K$$

$$K + \eta \frac{\partial^2 u}{\partial y^2} = 0$$

$$\frac{\partial^2 u}{\partial y^2} = -\frac{K}{\eta} \quad \| \int (\ldots)\, dy$$

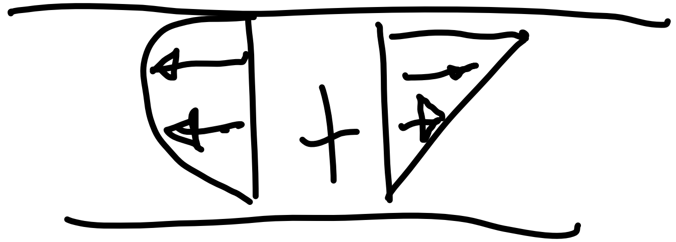
$$\frac{\partial u}{\partial y} = -\frac{K}{\eta}\left(y + C_1\right) \quad \| \int (\ldots)\, dy$$

$$u = -\frac{K}{\eta}\left(\frac{y^2}{2} + C_1 y + C_2\right)$$

$$u = -\frac{K}{\eta}\left(\frac{y^2}{2} + C_1 y + \cancel{C_2}\right) \quad 0$$

RB $\quad u(y=0) = 0 \quad (1)$

$\quad u(y=h) = 0$



$$C_1 = -\frac{h}{2}$$

$$u = -\frac{K}{\eta}\left(\frac{y^2}{2} - \frac{h}{2}y\right) = -\frac{K}{2\eta}\, y(y-h) + \frac{U}{h}\, y$$

$$\dot{V}_x = \int u \, dy = \frac{K}{12\eta} h^3 + \frac{U}{2} h$$

$$\int \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \right) dy$$

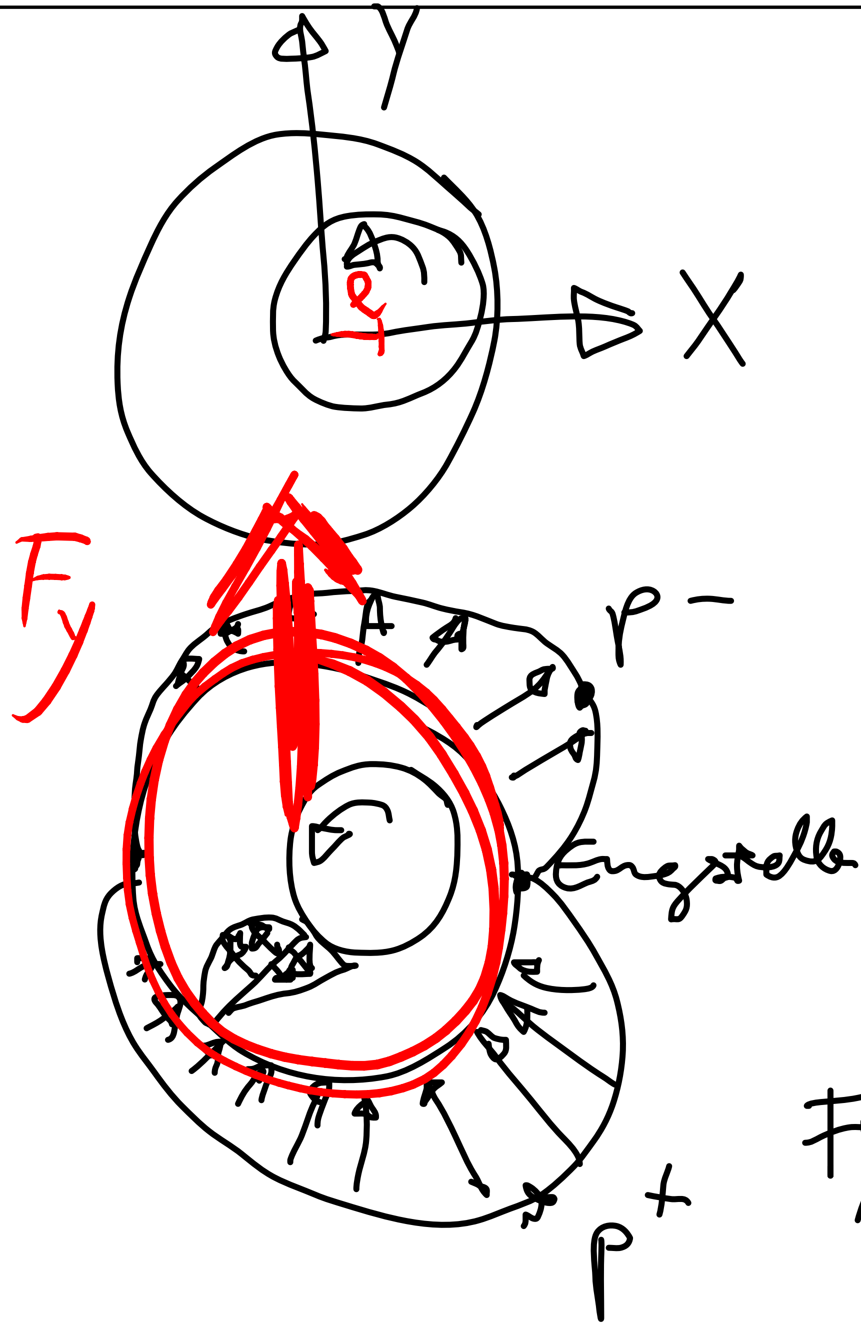
$$\frac{\partial \dot{V}_x}{\partial x} + \underbrace{v(h) - v(0)}_{\partial h/\partial t} + \frac{\partial \dot{V}_z}{\partial z} = 0$$

$$\frac{\partial}{\partial x}\left(\frac{1}{2} U h - \frac{\partial p}{\partial x} \frac{h^3}{12\eta} \right) + \frac{\partial h}{\partial t} + \frac{\partial}{\partial z}\left(\frac{1}{2} W h - \frac{\partial p}{\partial z} \frac{h^3}{12\eta} \right) = 0$$

$$\frac{\partial}{\partial x}\left(\frac{1}{2} U h \right) + \frac{\partial}{\partial z}\left(\frac{1}{2} W h \right) + \frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left(\frac{h^3}{12\eta} \frac{\partial p}{\partial x} \right) + \frac{\partial}{\partial z}\left(\frac{h^3}{12\eta} \frac{\partial p}{\partial z} \right)$$

Reynolds'sche Schmierfilmgleichung

TECHNISCHE UNIVERSITÄT DARMSTADT
FLUID SYSTEM TECHNIK
Technische Fluidsysteme



$$So = \frac{F_y}{\eta \Omega R L}\psi^2 \qquad \psi = \frac{\bar{h}}{R}$$

$$\varepsilon = e/\bar{h}$$

$$So = \frac{12\pi\varepsilon}{\sqrt{1-\varepsilon^2}\,(2+\varepsilon^2)}$$

$$F_y = So \cdot \frac{\eta \Omega R^3 L}{h^2} = \frac{\eta \Omega R^3 L}{h^2} \cdot \frac{12\,\varepsilon\pi}{\sqrt{1-\varepsilon^2}\,(2+\varepsilon^2)}$$

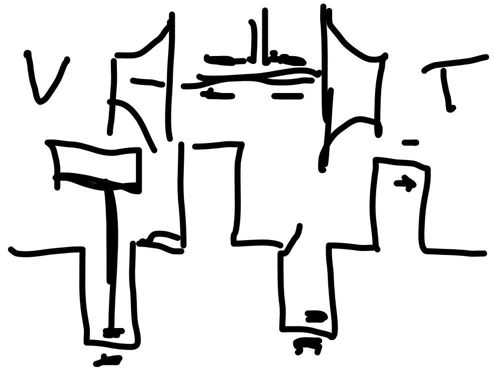
$$M = \eta \frac{\Omega R^3}{h} \cdot \frac{4\pi(1+2\varepsilon^2)}{\sqrt{1-\varepsilon^2}\,(2+\varepsilon^2)}$$

Technische Anwendungen

Abgasturbolader

Kurbelwelle KFZ

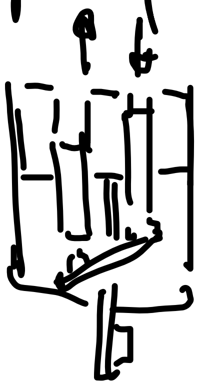
Schraubenspindelpumpe



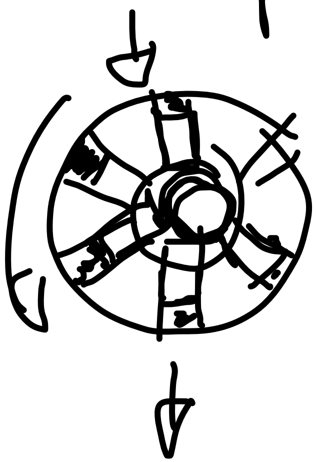
Verdrängerpumpen

Kolbenpumpen

- Axialkolbenpumpe

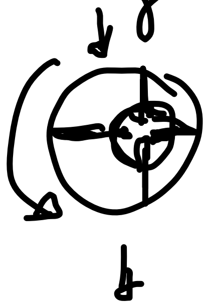


- Radialkolbenpumpe

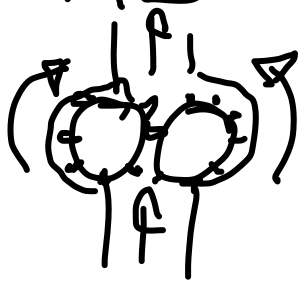


Rotierende Verdrängerpumpen

- Flügelzellenpumpe

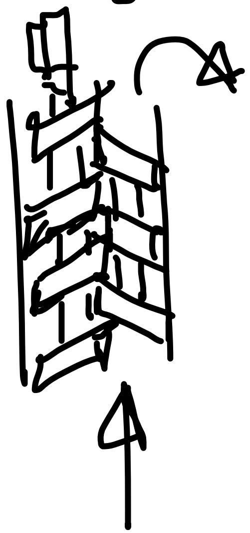


- Zahnradpumpen
  - AZP



  - IZP

- Schraubenpumpe



- Exzenterschneckenpumpe