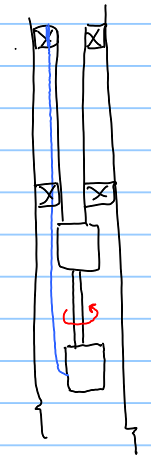
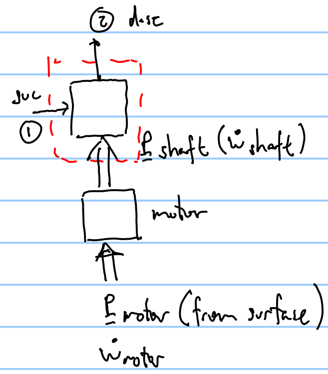
Note Title

Lecture 39 - Flow performance of ESP - part 2

Hydraulic efficiency





$$\eta_H = \frac{P_{pump}}{P_{shaft}}$$

$$\eta_m = \frac{P_{shaft}}{P_{motor}} \approx 0.95 - 0.98$$

$$\dot{Q} + \dot{W} + \dot{E}_1 - \dot{E}_2 = 0$$ ($\dot{Q} \to 0$)

$$\dot{W}_{shaft} = \dot{E}_2 - \dot{E}_1 = \dot{m}\,(e_2 - e_1)$$

$$e = \left(g \cdot z + \frac{v^2}{2} + h\right)$$ ($g \cdot z \to 0$, $\frac{v^2}{2} \to 0$, $h \to u + p\,v$)

ideal pumping process $\Delta s = 0$ isentropic

$\Delta u = 0$ $\quad u = f(T)$

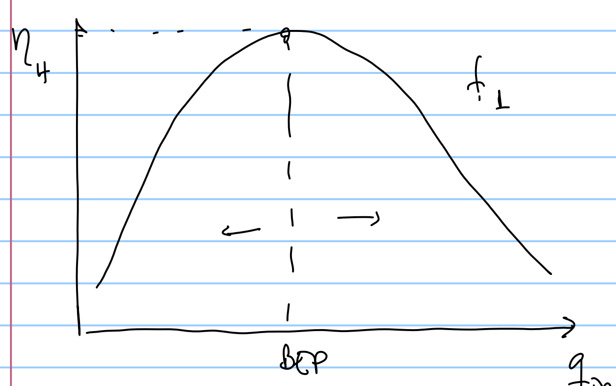
$$\dot{W}_{ideal} = \dot{m}\,(P_2 v_2 - P_1 v_1)$$

$v =$ constant $= \frac{1}{\rho}$

$$\dot{W}_{ideal} = q\,(P_2 - P_1)$$

$$\eta_H = \frac{q\,(P_2 - P_1)}{P_{shaft}} = 0.4 - 0.8$$

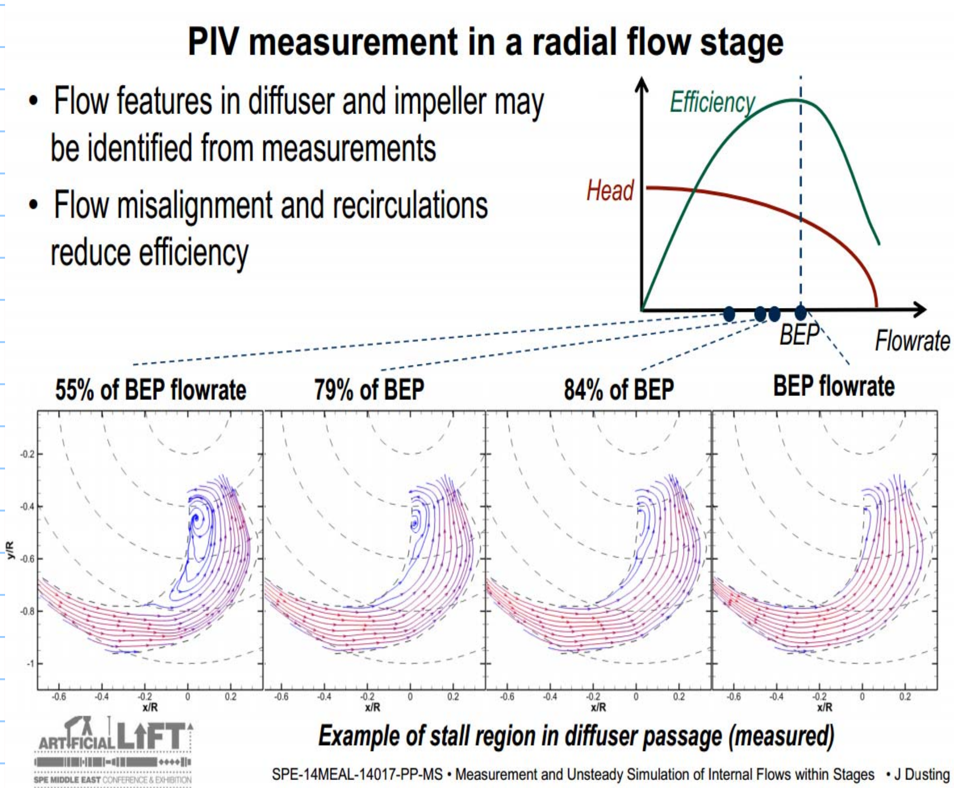
- friction : vanes, bearing, impeller
- volumetric: backflow in pump
- turbulence, eddies



$$\eta_H = b_1 q^2 + b_2 q + b_3$$

$$\dot{W}_{shaft} = \frac{\Delta p \cdot q}{\eta_H}$$

$$\dot{W}_{motor} = \frac{\dot{W}_{shaft}}{\eta_m}$$


PIV measurement in a radial flow stage
• Flow features in diffuser and impeller may be identified from measurements
• Flow misalignment and recirculations reduce efficiency
Efficiency
Head
BEP
Flowrate
55% of BEP flowrate
79% of BEP
84% of BEP
BEP flowrate
y/R
x/R
Example of stall region in diffuser passage (measured)
ARTIFICIAL LIFT
SPE MIDDLE EAST CONFERENCE & EXHIBITION
SPE-14MEAL-14017-PP-MS • Measurement and Unsteady Simulation of Internal Flows within Stages • J Dusting

analytical

$$Q_B = Q_A \cdot \frac{n_B}{n_A}$$

$$H_B = H_A \cdot \left(\frac{n_B}{n_A}\right)^2$$

$$P_B = P_A \cdot \left(\frac{n_B}{n_A}\right)^3$$

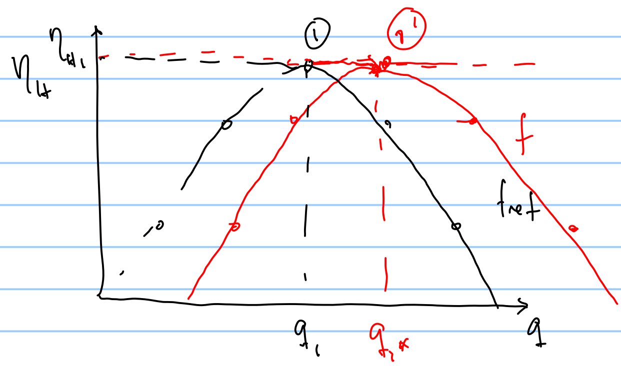
Similarity law

$$\eta_{H\,ref} = \frac{q_{ref}\cdot \Delta h_{ref}}{P_{shaft\,ref}} \longrightarrow \eta_{H@f} = \frac{q\ \Delta h}{P_{shaft}}$$

$$\eta_{H@f} = \frac{q_{ref}\frac{f}{f_{ref}}\ \Delta h_{ref}\left(\frac{f}{f_{ref}}\right)^2}{P_{shaft\,ref}\left(\frac{f}{f_{ref}}\right)^3}$$

w_{shaft}

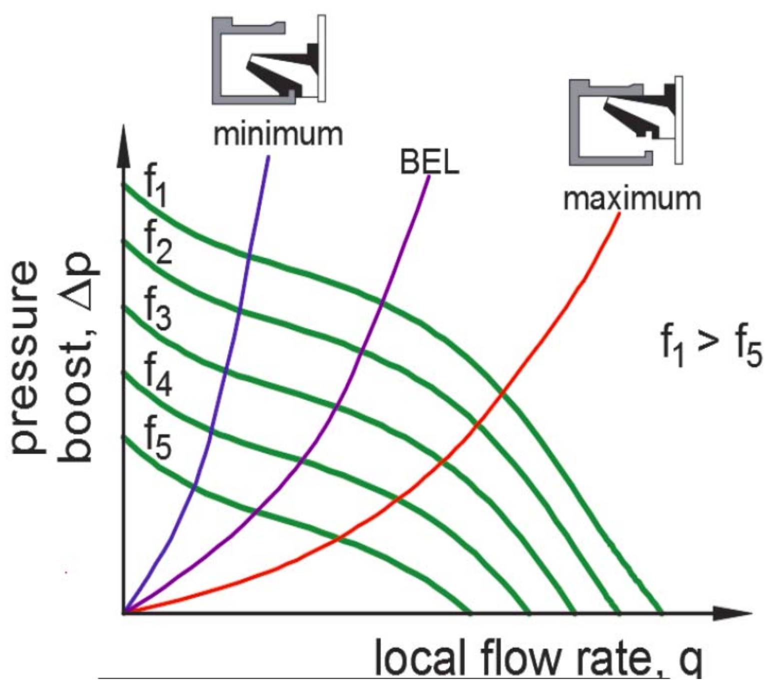
$$\eta_{H@f} = \eta_{H@f_{ref}}$$

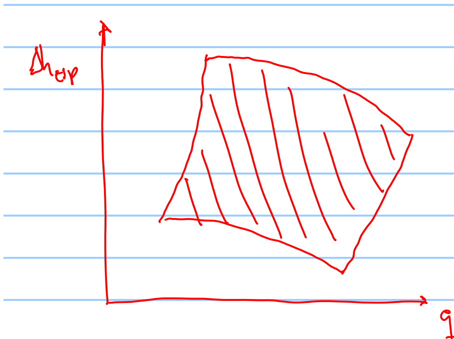


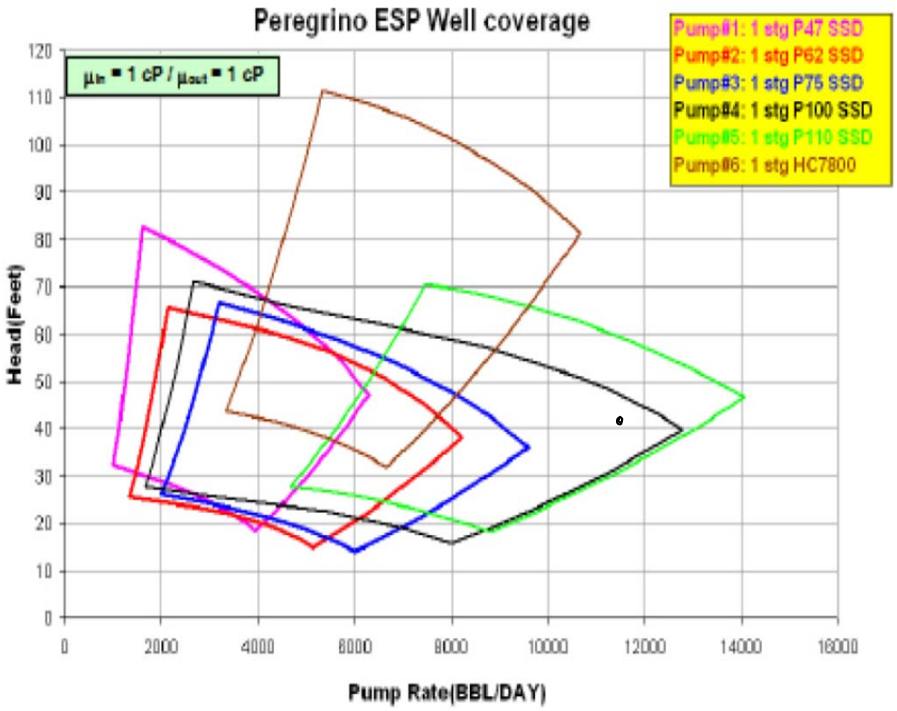
$$\eta_{H,q^*@f} = \eta_{H,1@f_{ref}}$$

$q_{1@f_{ref}}$

$$q_{2*@f} = q_{1@f_{ref}}\cdot\frac{f}{f_{ref}}$$







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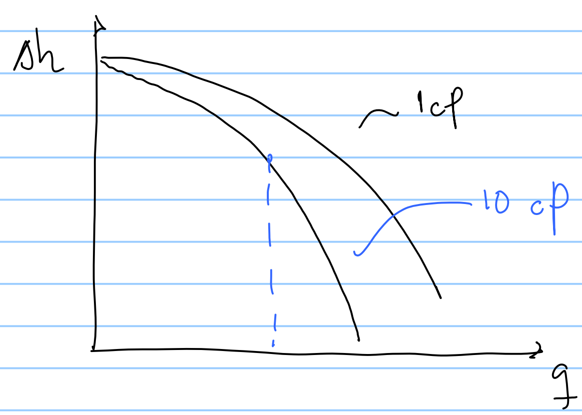
ESP Application on Heavy Oil in Peregrino Field

Vinicius Castro, and Daniela Leite, Statoil; Daniel Lemos, Jean Marins, Rui Pessoa, and João Magalhães, Baker Hughes

the viscosity of fluid also affects the performance of pump



 ANSI/HI 9.6.7-2010

American National Standard (Guideline) for

Effects of Liquid Viscosity on Rotodynamic (Centrifugal and Vertical) Pump Performance