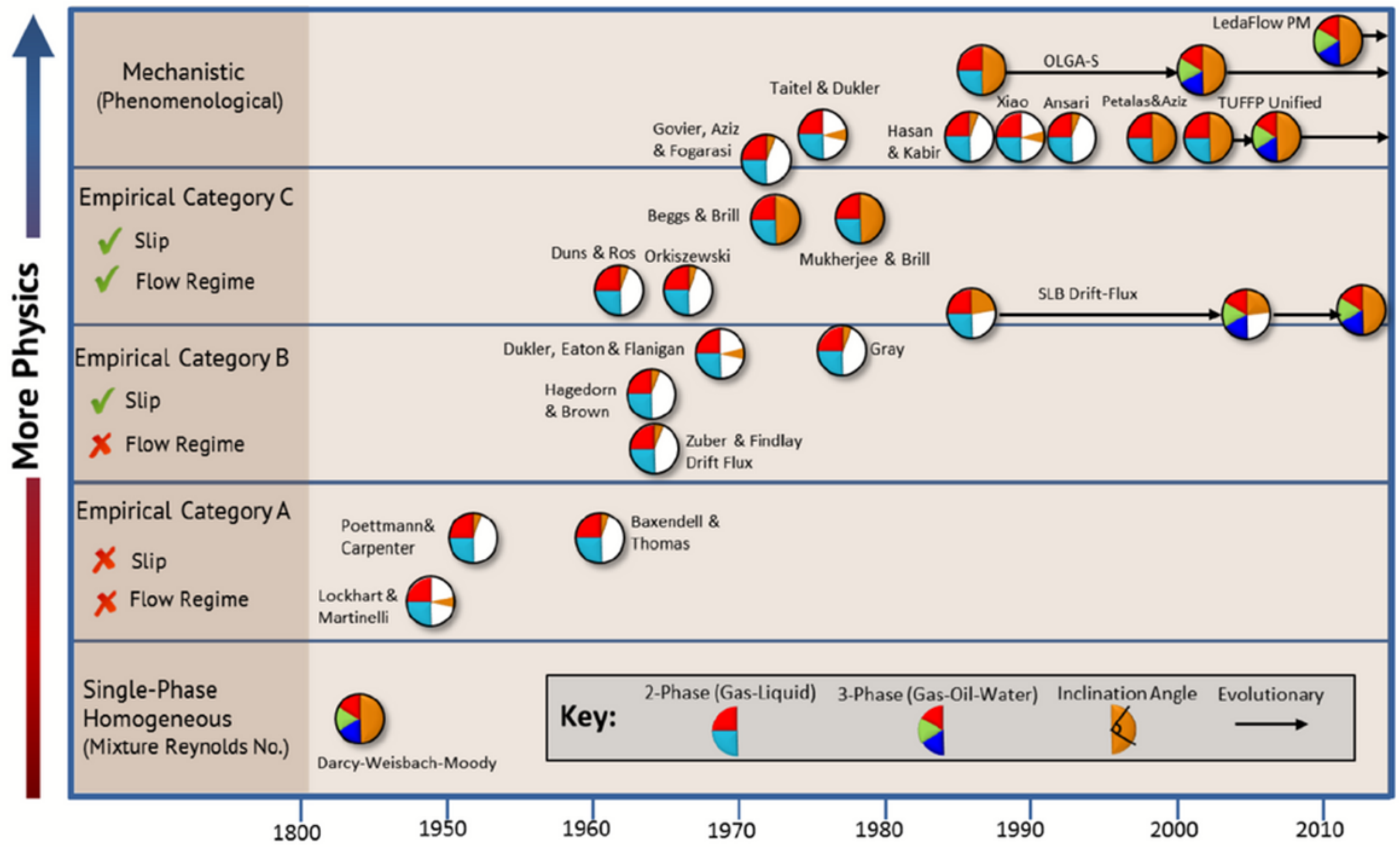
Video 29 - Some examples of pressure drop models for multiphase flow



A Study of Two-Phase Flow in Inclined Pipes

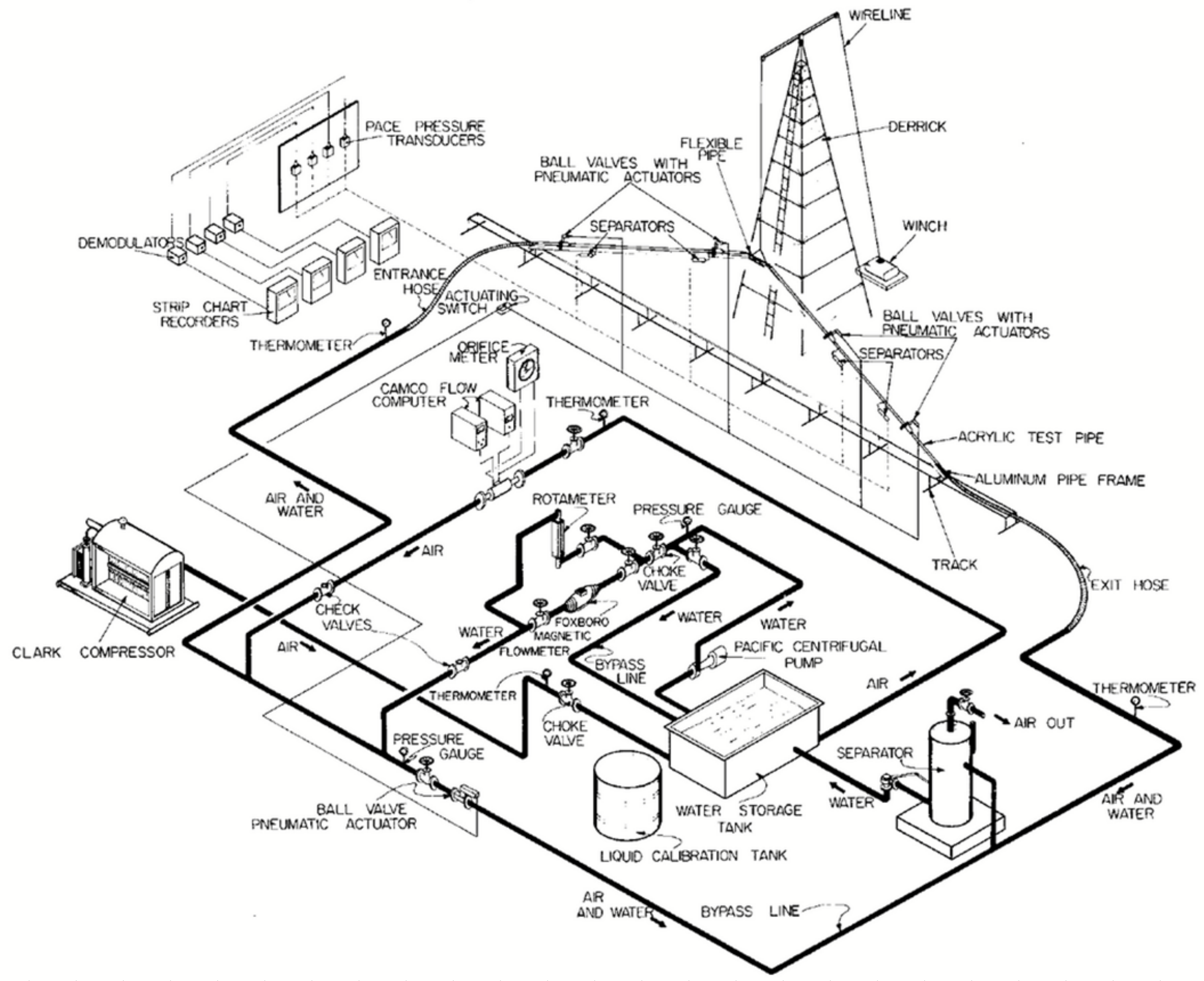
H. Dale Beggs,* SPE-AIME, U. of Tulsa
James P. Brill, SPE-AIME, U. of Tulsa

1973

$$-\frac{dp}{ds} = \frac{dp}{ds}\Big|_{grav.} + \frac{dp}{ds}\Big|_{fric.} + \frac{dp}{ds}\Big|_{accel.}$$

$$-\frac{dp}{dZ} = \frac{\frac{g}{g_c}\sin\theta\,[\rho_L H_L + \rho_g(1-H_L)] + \frac{f_{tp} G_m v_m}{2 g_c d}}{1-\{[\rho_L H_L + \rho_g(1-H_L)]\, v_m v_{sg}\}/g_c p}$$

https://wiki.whitson.com/pipeflow/correlations/beggs_brill/



A UNIFIED MODEL FOR PREDICTING FLOW-PATTERN TRANSITIONS FOR THE WHOLE RANGE OF PIPE INCLINATIONS

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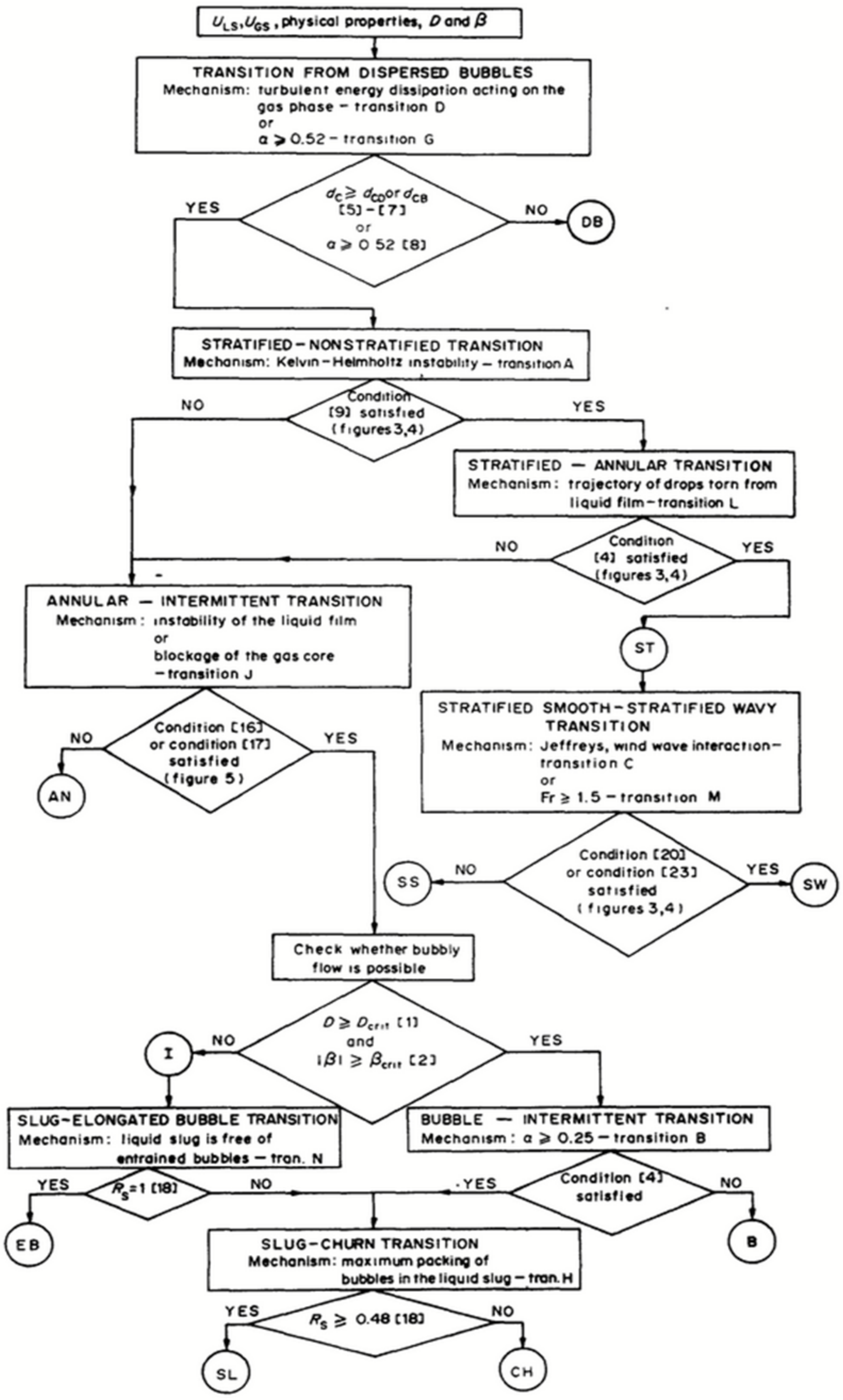
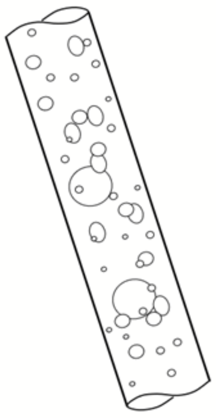


Figure 6. Logical pass for flow-pattern determination.

Bubble Flow-Pattern

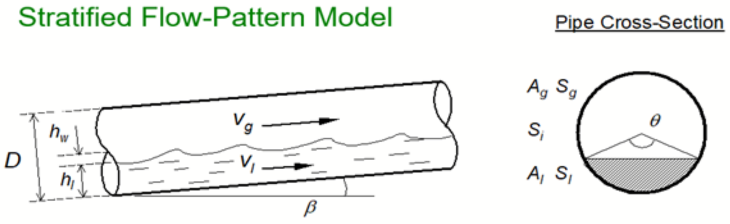


- Turbulent forces prevent bubble agglomeration and slip effect.
- Transition from bubble flow is given in the work of Barnea et al. (1987).
- The bubble flow-pattern is modeled as homogenous single fluid flow with averaged properties of liquid and gas.

Pressure gradient equation:

$$-\left(\frac{dP}{dx}\right) = f_m \frac{2\rho_m v_m^2}{D} + \rho_m g \sin\beta$$

Stratified Flow-Pattern Model



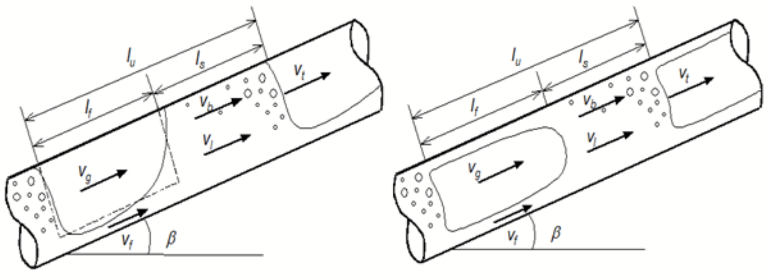
Combined momentum equation:

$$\frac{\tau_g S_g}{A_g} - \frac{\tau_l S_l}{A_l} + \tau_i S_i \left(\frac{1}{A_l} + \frac{1}{A_g}\right) - (\rho_l - \rho_g) g \sin\beta = 0$$

Pressure gradient equation:

$$-\left(\frac{dP}{dx}\right) = \frac{\tau_l S_l + \tau_g S_g}{A} + \left(\frac{A_l}{A}\rho_l + \frac{A_g}{A}\rho_g\right) g \sin\beta$$

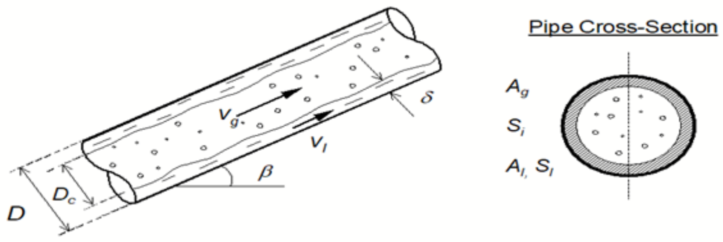
Intermittent Flow-Pattern Models



Pressure gradient equation:

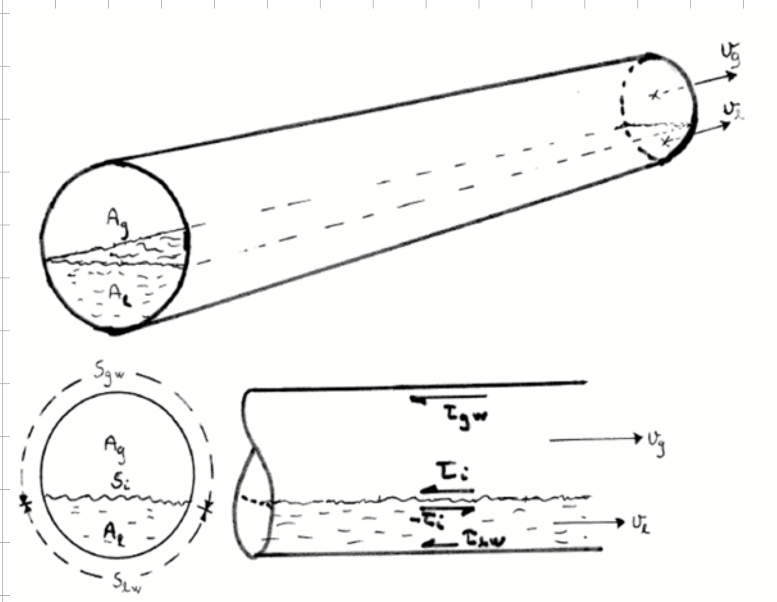
$$-\left(\frac{dP}{dx}\right) = \rho_u g \sin\beta + \frac{1}{l_u}\left[\left(\frac{\tau_s \pi D}{A} l_s\right) + \left(\frac{\tau_f S_f + \tau_g S_g}{A} l_f\right)\right]$$

Annular Flow-Pattern Model



Pressure gradient equation:

$$-\left(\frac{dP}{dx}\right) = \frac{\tau_l S_l}{A} + \left(\frac{A_l}{A}\rho_l + \frac{A_g}{A}\rho_{gc}\right) g \sin\beta$$



Harald Asheim's drift flux model

$$A_g\,dp + A_g\,\rho_g\,g_x\,dx + A_g\,\rho_g\,v_g\,dv_g + \tau_{gw}\,S_{gw}\,dx + \tau_i\,S_i dx = 0$$

+

$$A_l\,dp + A_l\,\rho_l\,g_x\,dx + A_l\,\rho_l\,v_l\,dv_l + \tau_{lw}\,S_{lw}\,dx - \tau_i\,S_i dx = 0$$

↓

$$dp + \left(\rho_g y_g + \rho_l y_l\right) g_x dx + \rho_g v_g y_g dv_g + \rho_l v_l y_l dv_l + \frac{\tau_g S_{gw} + \tau_{lw} S_{lw}}{A} dx = 0$$

$$\tau_g = \frac{1}{8} f_g \rho_g v_g |v_g|$$

$$\tau_l = \frac{1}{8} f_l \rho_l v_l |v_l|$$

$$S_{gw} = \pi d y_g$$

$$S_{gw} = \pi d y_l$$

$$\frac{dp}{dx} + \rho_{TP} g_x + \rho_g v_{sg} \frac{dv_g}{dx} + \rho_l v_{sl} \frac{dv_l}{dx} + \frac{1}{2 \cdot d}\left(f_g \rho_g v_g |v_g| y_g + f_l \rho_l v_l |v_l| y_l\right) = 0$$