**Classroom exercise 2**

**Task 1 Accumulation of sand and liquid**

A vertical well produces gas and small amounts of water.

- gas density at downhole conditions 150 kg/m3

- f.v.f. at downhole conditions 6.10-3 m3/Sm3

- gas viscosity at downhole conditions 0.015 cP

- density water, downhole conditions 1000 kg/m3

- interfacial tension, gas and water 60 dyn/cm

- inner diameter, production tubing 10 cm

1. Sand grains of diameter 0.1 mm and density 2400 kg/m3 may be produced. Estimate gas rate to secure sand removal
2. Estimate gas rate to avoid water accumulation
3. Estimate maximum water droplet size

**Task 2 Droplets in flowing gas**  
In Task 1 we found droplet velocity: 1.2 m / s According to the Turner criterion, the gas speed should exceed this. At gas velocity 1.2m / s, we may assume wall friction factor: f = 0.02  
  
a) Check if flow turbulence will affect droplet sizes.  
b) Estimate the maximum droplet size

**Task 3: Two-phase flow, including slippage**

In classroom exercise 1, we estimated the following at downhole conditions:

- superficial velocity, gas 0.875 m/s

- superficial velocity, oil 2.71 m/s

- gas density 189 kg/m3

- oil density 662 kg/m3

Additional data:

- viscosity, oil: 0.5 cP

- viscosity, gas: 0.0012 cP

- inner diameter production tubing: 10 cm

- inclination: 22 o

- production tubing length: 2010 m

- inflow pressure: 198 bar

- bubble distribution parameter: Co = 1.1

- rise velocity of bubbles: vo = 0.2 m/s

- friction factor correlation: fo = 0.16/Rem0.172

Estimate:

1. Liquid and gas fraction.
2. Liquid and gas velocity.
3. Pressure gradient.
4. Wellhead pressure