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Implementing a Subsea Oil-Water Separation System in Modelica

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Scope

- Create a Modelica model from scatch based in the Matlab model made by P. FürstTyvold for:
  - Subsea Gravity Separator
  - Cyclone Deoiler (Oil in water phase)
  - Cyclone Dewaterer (Water in oil phase)

- Create a connection system that allows the simulation of the system and connection with Modelica models.

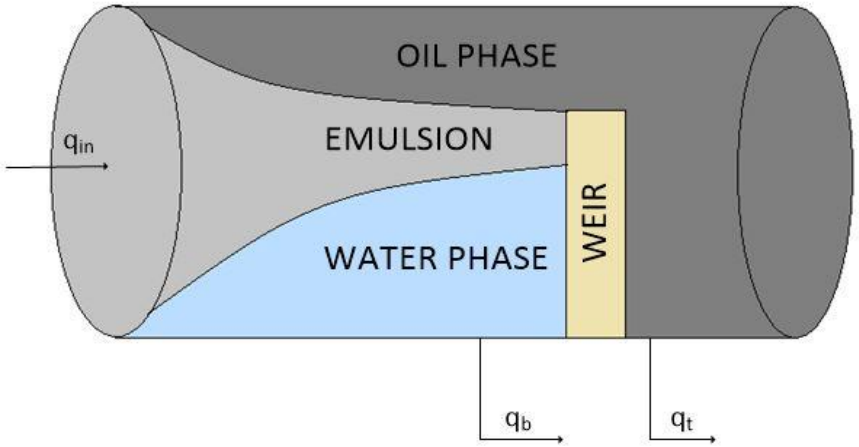
- Simulating and optimizing the system.

Horizontal gravity separator.

- DRIVING FORCE: Gravity

  Based in Stokes law

$$v_v = \frac{2r_d^2(\rho_d - \rho)g}{9\mu(\alpha)}$$



Inputs:

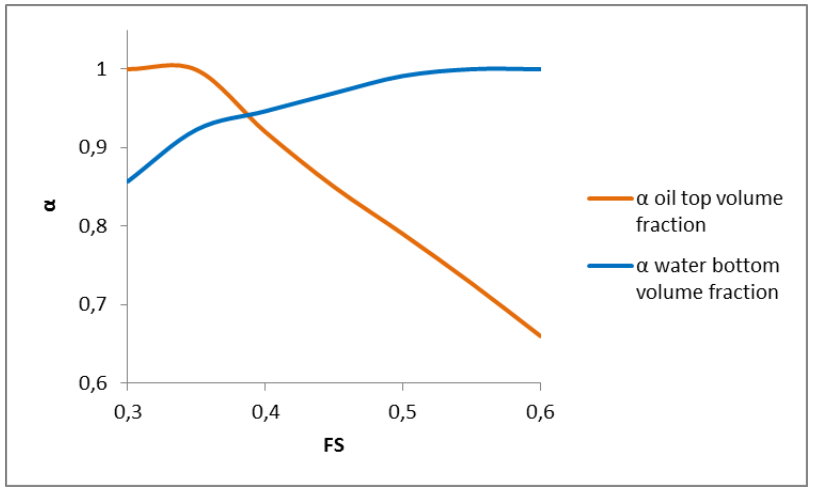
- Inlet flow rate
- Inlet oil volume fraction
- Flow split

Outputs:

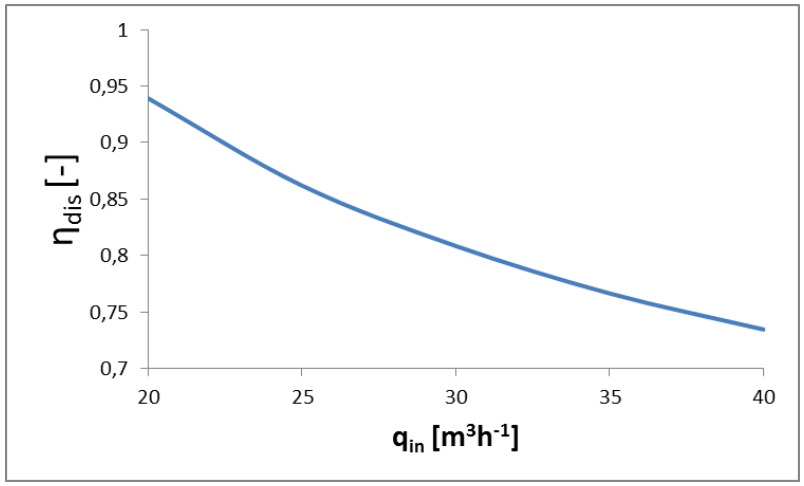
- Flow rate — Bottom
- Oil volume fraction — Top

Effect of the flow split and inlet flow rate in gravity separator

- Varying *FS*, q_{in}=20m^3/h α_{in}=0,4



- Varying q_{in} , α_{in}=0,4 0.4 FS 0.4.



Dispersed efficiency

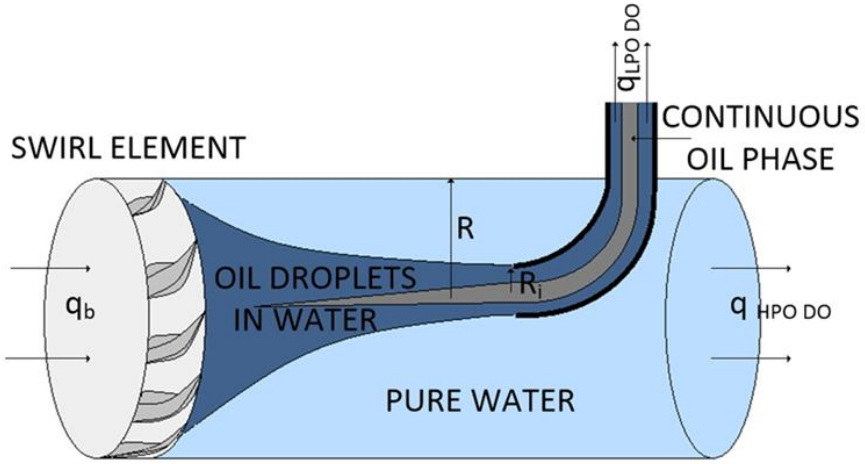
- $\eta_{dis} = \frac{Oil\ flow\ rate\ in\ light\ output + Water\ flow\ rate\ in\ heavy\ output}{Inlet\ flow\ rate}$

DEOILER

- DRIVING FORCE: Tangential acceleration generated by static swirl element

  Based in Stokes law

  Oil in water phase



Inputs:

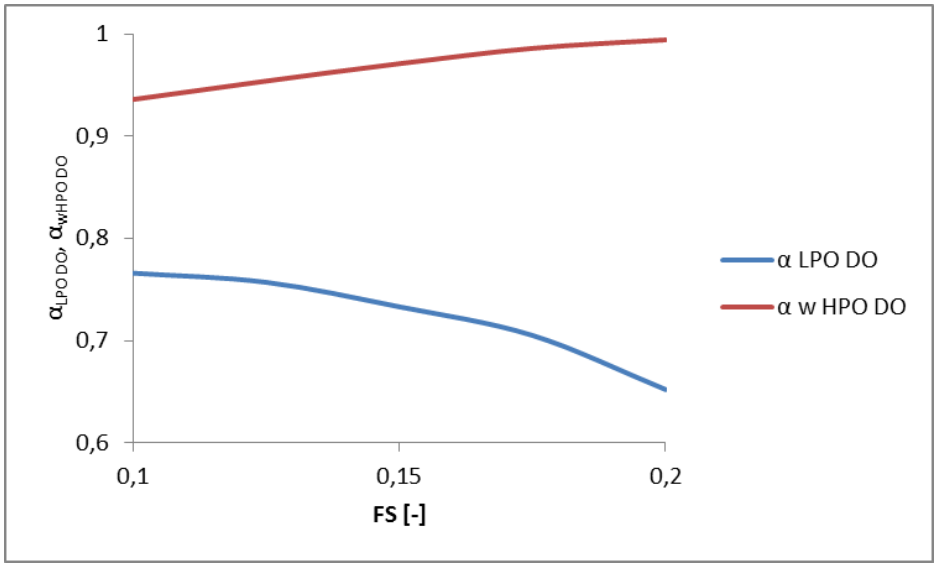
- Inlet flow rate
- Inlet oil volume fraction
- Flow split
- Swirl element

Outputs:

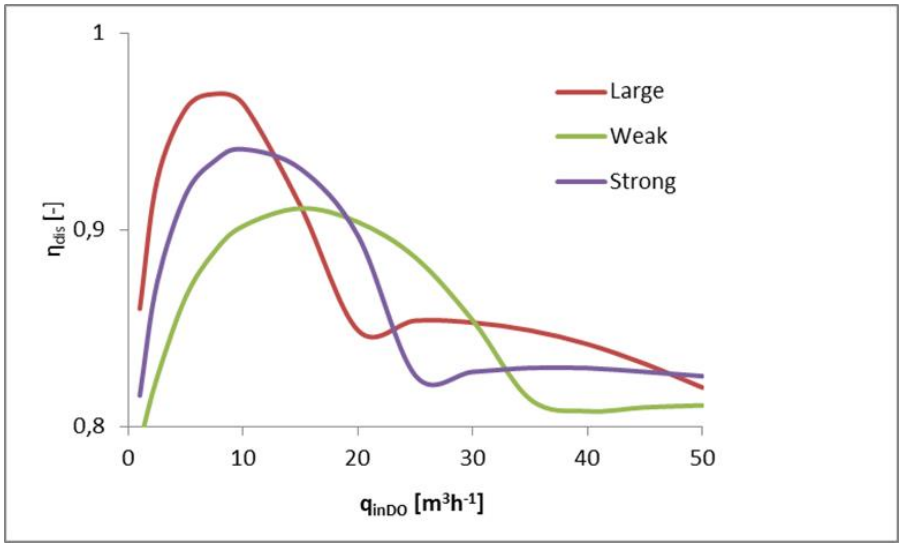
- Flow rate — Heavy phase
- Oil volume fraction — Light phase

Effect of the flow split and inlet flow rate in deoiler/dewaterer

- Varying *FS*, q_{in}=13,65m³/h α_{in}=0,135



- Varying q_{in} , α_{in}=FS= 0.135



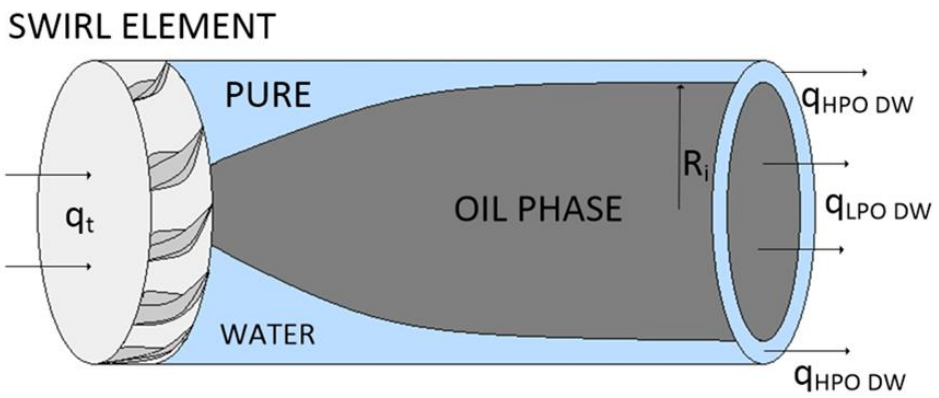
Swirl element acts as a scaling factor of the tangential velocity

DEWATERER

- DRIVING FORCE: Tangential acceleration generated by static swirl element.

  Based in Stokes law

- Water in oil phase
- Now the droplets have higher density than continuous phase.



Inputs:

- Inlet flow rate
- Inlet oil volume fraction
- Flow split
- Swirl element

Outputs:

- Flow rate — Heavy phase
- Oil volume fraction — Light phase

CONNECTING THE BLOCKS

- **Connector** – Setting up equations relating properties in connnected units
  – Fluid connector variables: pressure, mass flow, mass fractions, enthalpy

```
1  connector Flow_port
2
3    import Oil_Water_Separation_System;
4    import SI = Oil_Water_Separation_System.Units;
5  SI.OilVolumeFraction volfracc "Volume fraction in the connection point";
6  SI.VolumeFlowRate volflow "Volume flow rate in the connection point";
7
8  end Flow_port;
```

And the blocks are connected together as follows:

```
9   equation
10    connect(GS.flowporttop,DEW.flowportindew);
11    connect(DEW.flowportoutdewH,NODE1.flowportinleta);
```

Separation system (I)

- Inlet conditions: q_{in}=20m³/h α_{in}=0,4

  Objective ,$\alpha_{oil,\ water\ phase}$ = 0.03

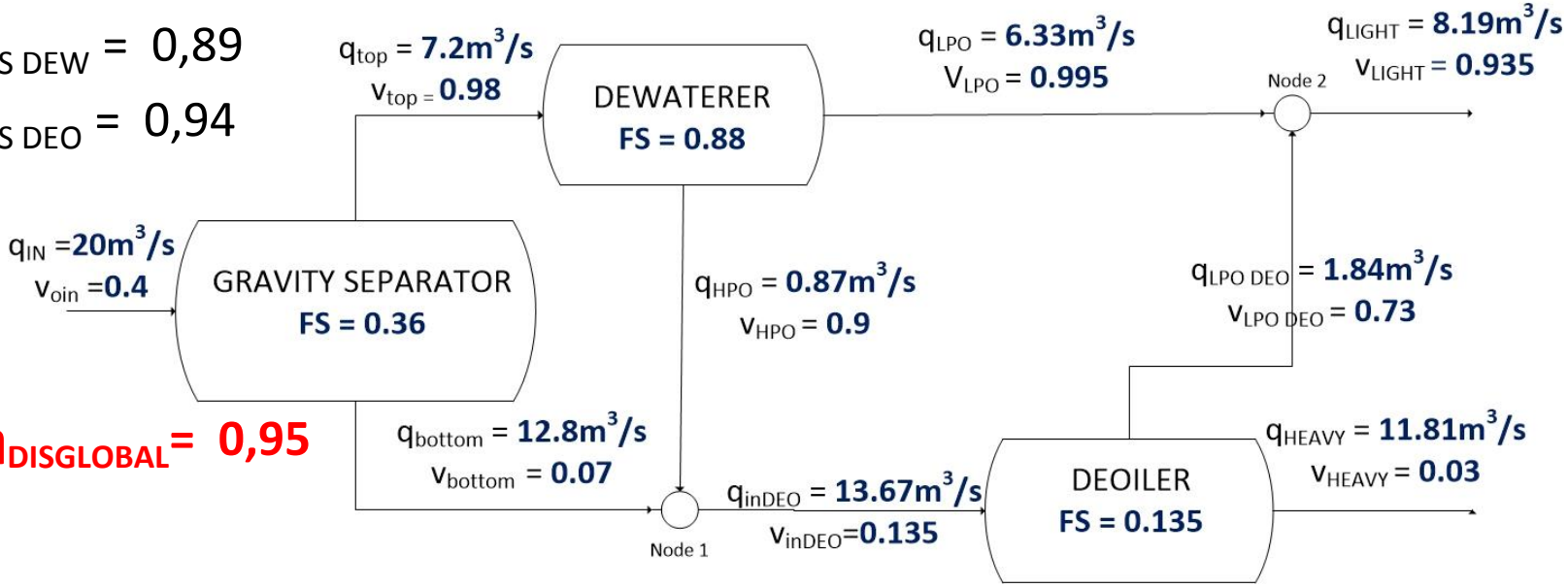
  Maximize ,$\alpha_{oil\ oil\ phase}$ manipulating FS

$\eta_{DIS\ GS}$ = 0,95

$\eta_{DIS\ DEW}$ = 0,89

$\eta_{DIS\ DEO}$ = 0,94

- **$\eta_{DISGLOBAL}$= 0,95**



SEPARATION SYSTEM (II)

- Inlet conditions: q_{in}=20m^3/h α_{in}=0,4

  Objective ,$\alpha_{oil,\ water\ phase}$ = 0.03

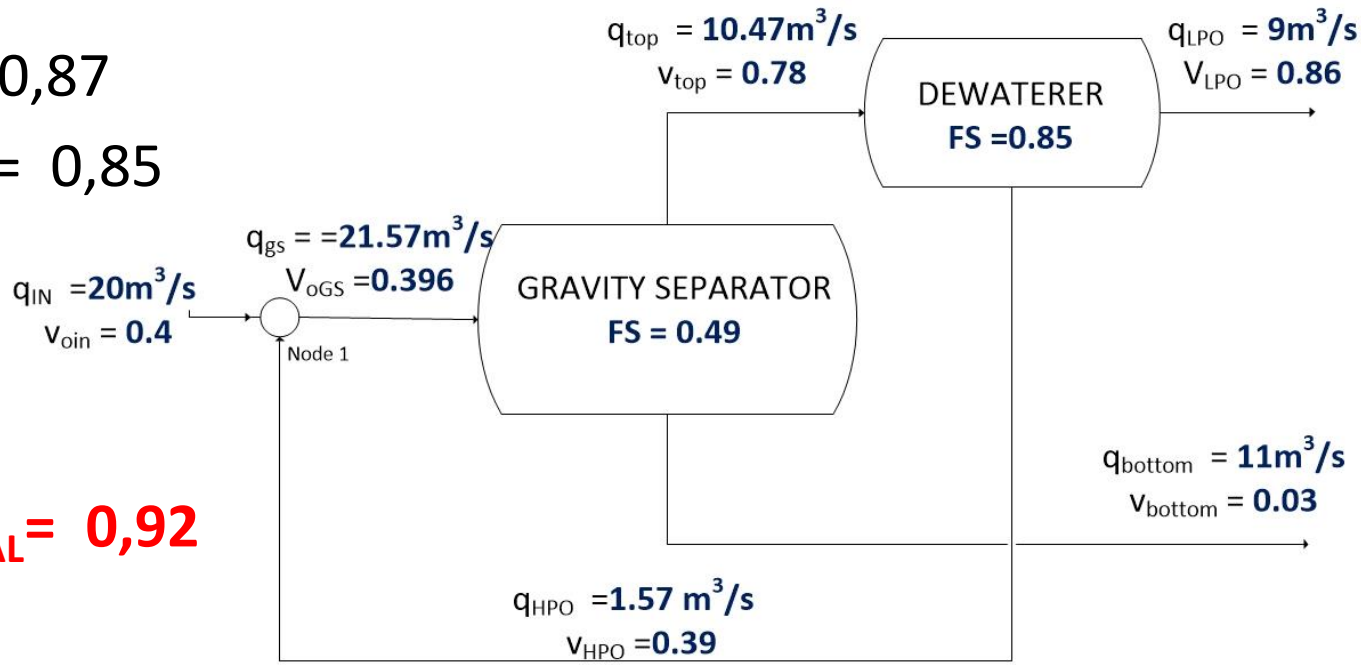
  Maximize ,$\alpha_{oil\ oil\ phase}$ manipulating FS

Purity loss: 7,5%

$\eta_{DIS\ GS}$ = 0,87

$\eta_{DIS\ DEW}$ = 0,85

$\eta_{DISGLOBAL}$= 0,92



Benefits of using Dymola

- Modeling and simulation platform .
- Graphical and text based coding .
- Flexibility :
  - Transparent code
  - Model structure
  - Equation based
  - Simple re-use of code .
- Object-oriented modeling language .
- Equation based, but allows using algorithms .