SDR (free surface)/Twin Screw Dryer

(first approaches)

JUNE, 21st 2017.

NEWCASTLE PIN MEETING

ANALISIS-DSC

We are a SME engineering service company specialized in **Mechanical** and **Industrial Processes** using **CAE** (Computer Aided Engineering) software tools in Fluids, Heat Transfer, Structural Mechanics and Granular Flows.

Engineering services such as:

- Basic Engineering.
- Failure Engineering.
- Analysis and Optimization of Industrial Processes.
- Scale-up/Scale-down Industrial Processes.

Our history:

- **2002** company was founded, as distributors of CAE software.
- **2006** we start offering mechanical and industrial processes engineering services using **CFD** (Computational Fluid Dynamics) software tools.
- **2009** we broaden our engineering services using **FEA** (Finite Elements Analysis), **DEM** (Discrete Elements Modelization).

Engineering Services

APPLICATION SECTORS

- Food & Beberages
- Automotive & Rail
- Oil & Gas
- Turbomachinery
- Aeronautics & Aerodynamics
- Pharmacy & Medicine
- Civil Engineering
- Naval
- Steel & Cement & Mining
- Machinery
- Hydraulics & Water treatment
- Chemistry
- Agriculture

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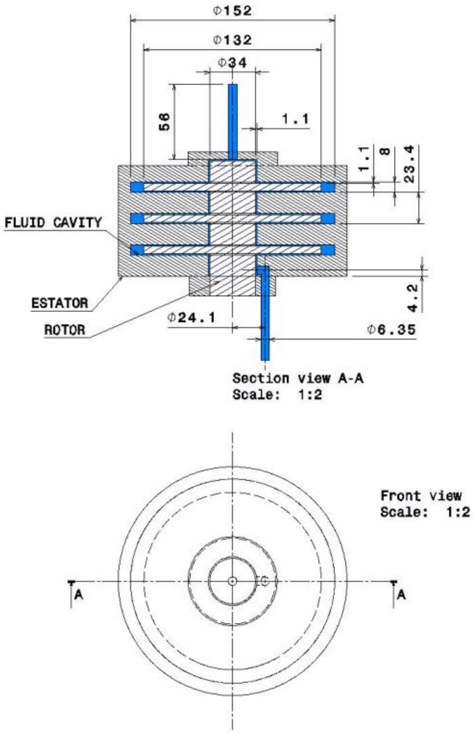
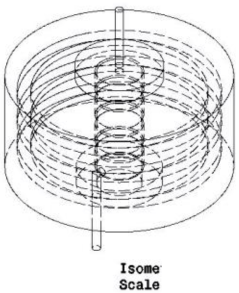
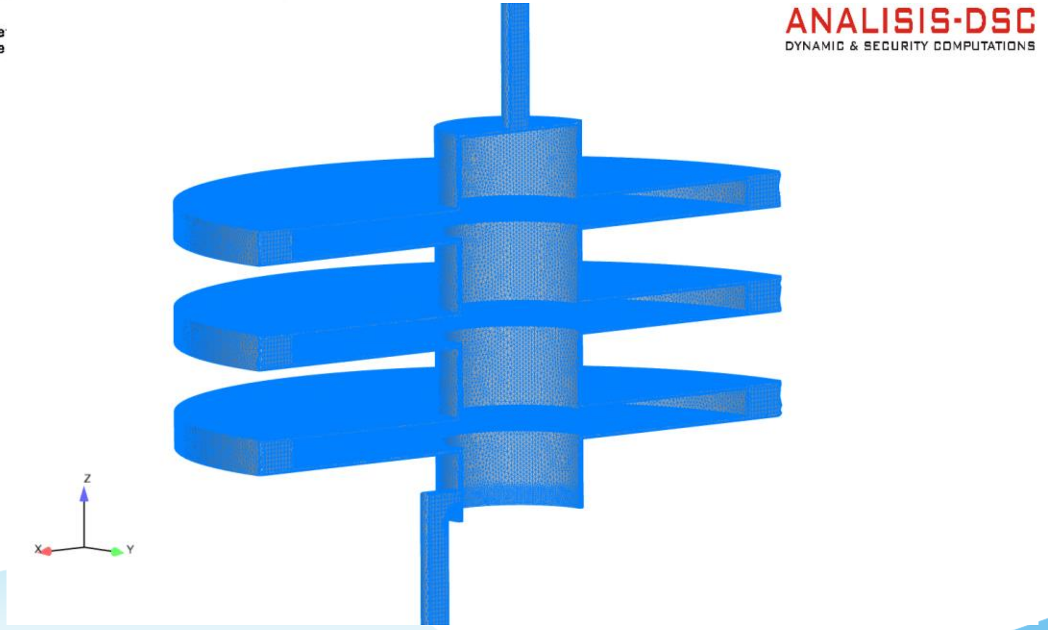
RS Spinning Disk Reactor







RS Spinning Disk Reactor

- A spinning disc reactor is a technology that imposes high centrifugal acceleration to fluids flowing in the surface of a rotating disc.
- This produces the form of a slightly wavy film on the disk (50 - 500µm)

-- SDR working parameters:

• Disc rotating speed.

• Feed flow(s) rate(s).

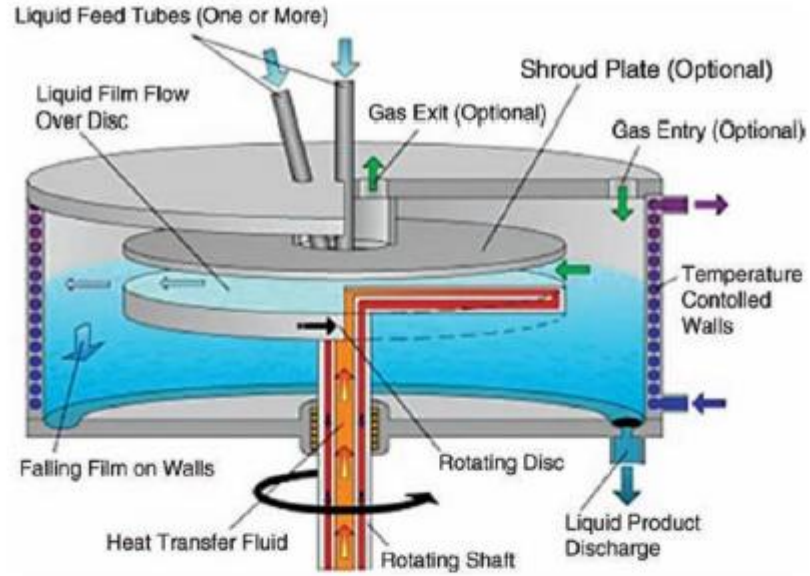
• Disk temperature.

• Reactor pressure.

-- SDR geometrical parameters:

• Disc diameter

• Gap between disks (for multi-disk SDR or rotor-stator SDR).



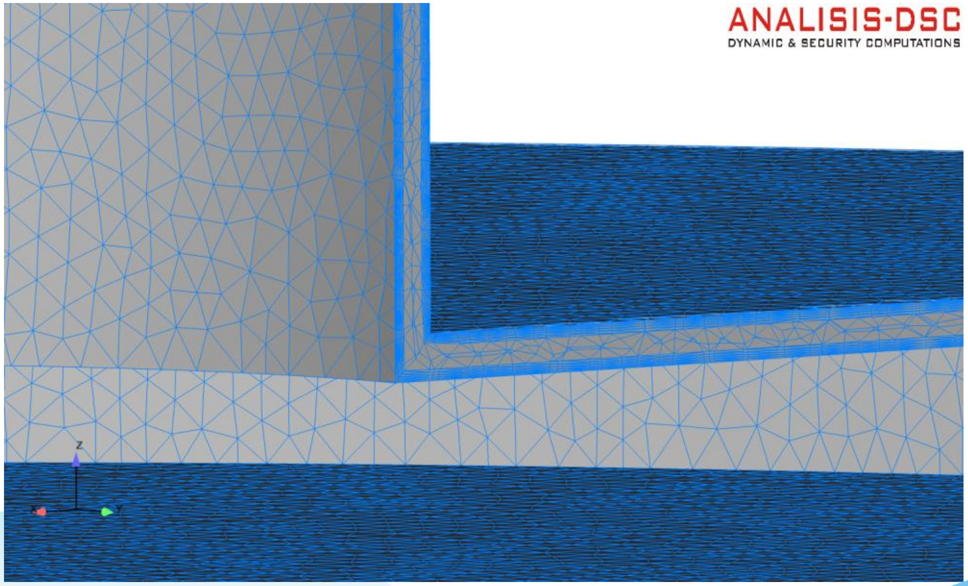
Typical SDR with temperature control system.

RS Spinning Disk Reactor

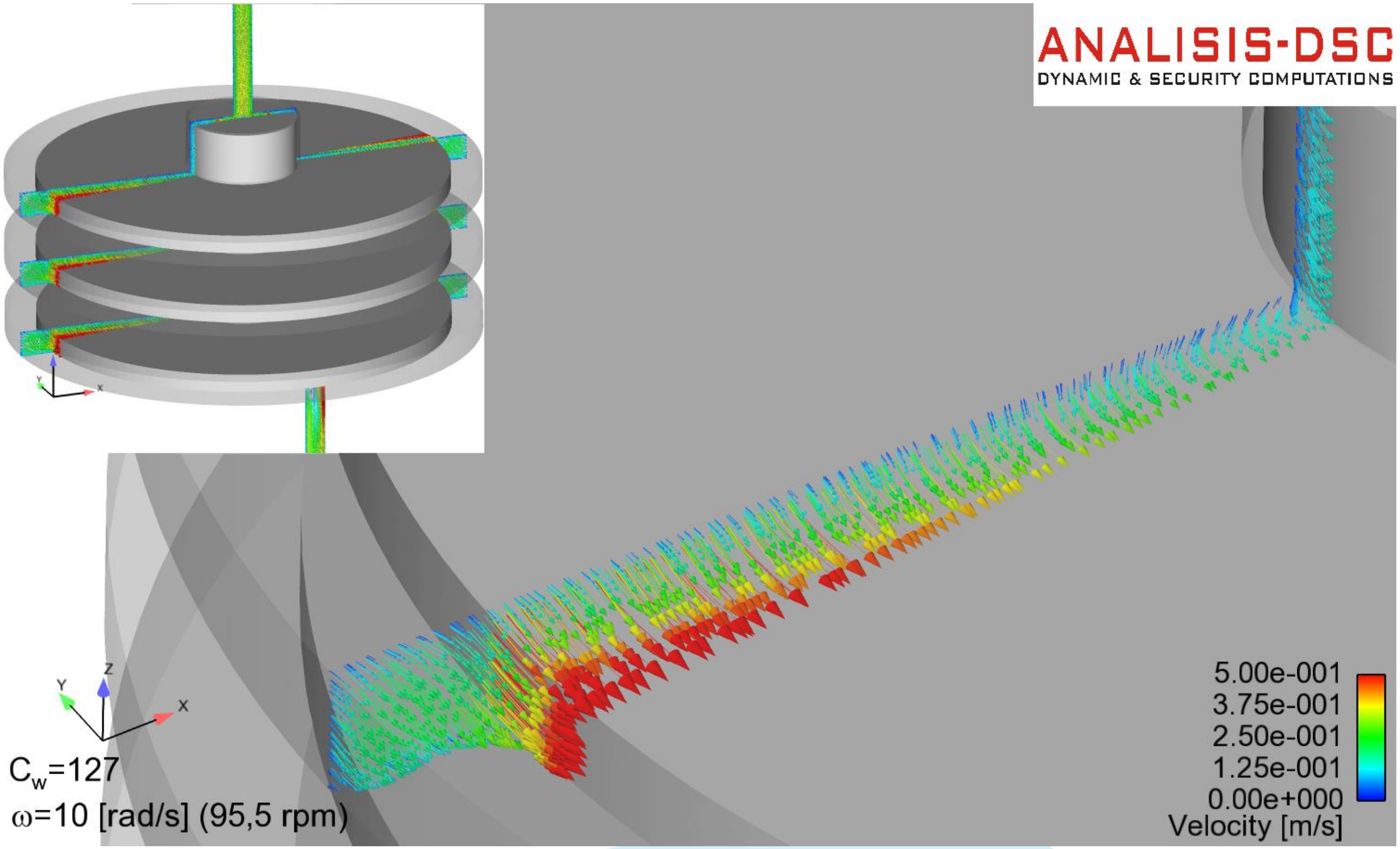
Simulations based on tech. Article:

Engineering model for single-phase flow in a multi-stage rotor spinning disc reactor M.M. de Beer at al. Laboratory of Chemical Reactor Engineering . Eindhoven Univ. of Tech. Chemical Engineering Journal 242 (2014) 53-61.

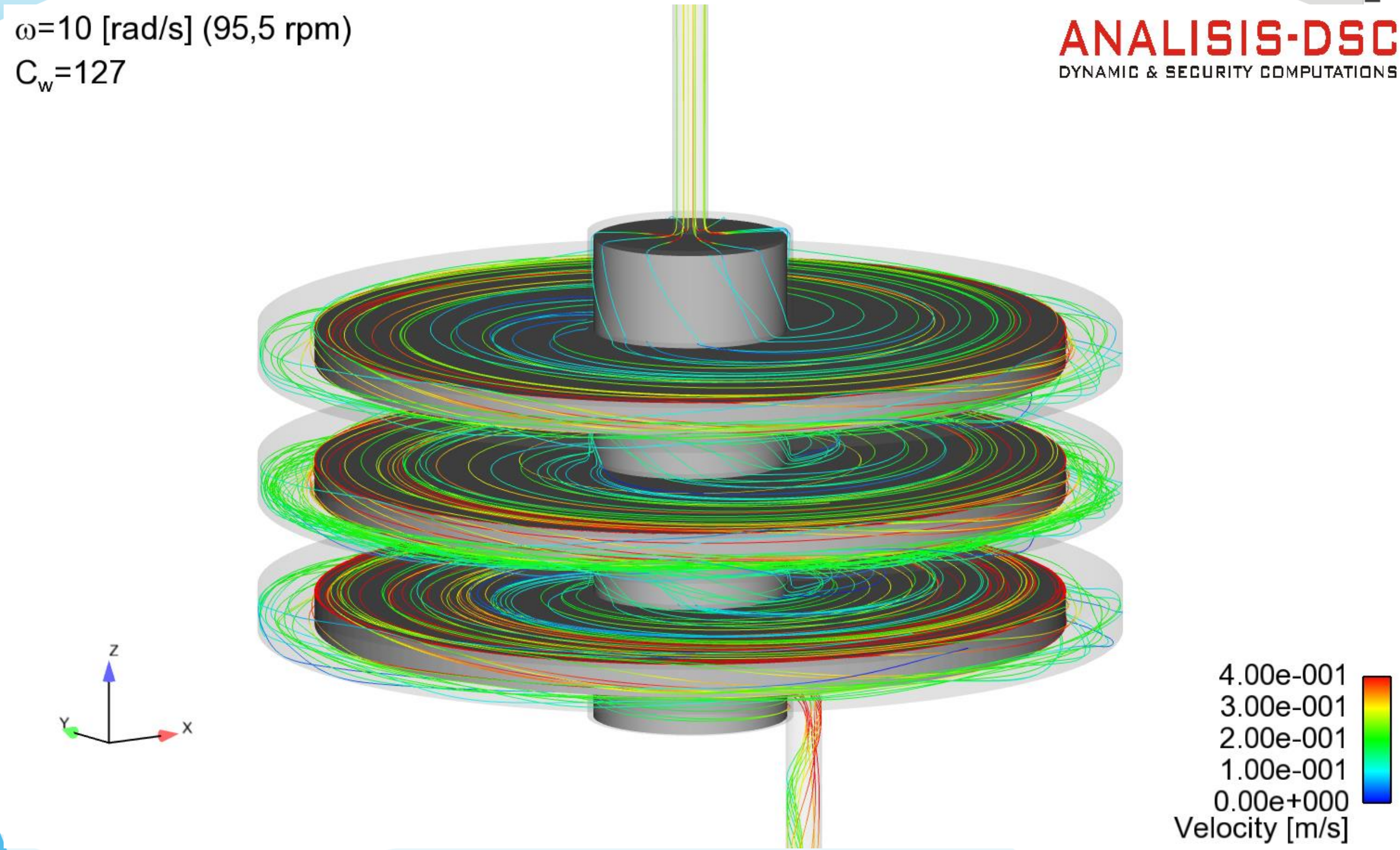
- Shown case:
  - SDR radius: 66 mm
  - SDR gap: 1,1 mm
  - Fluid Mass Flow: 8,39 g/s
  - SDR rpm: 10 rad/s
- Fluid is isothermal water



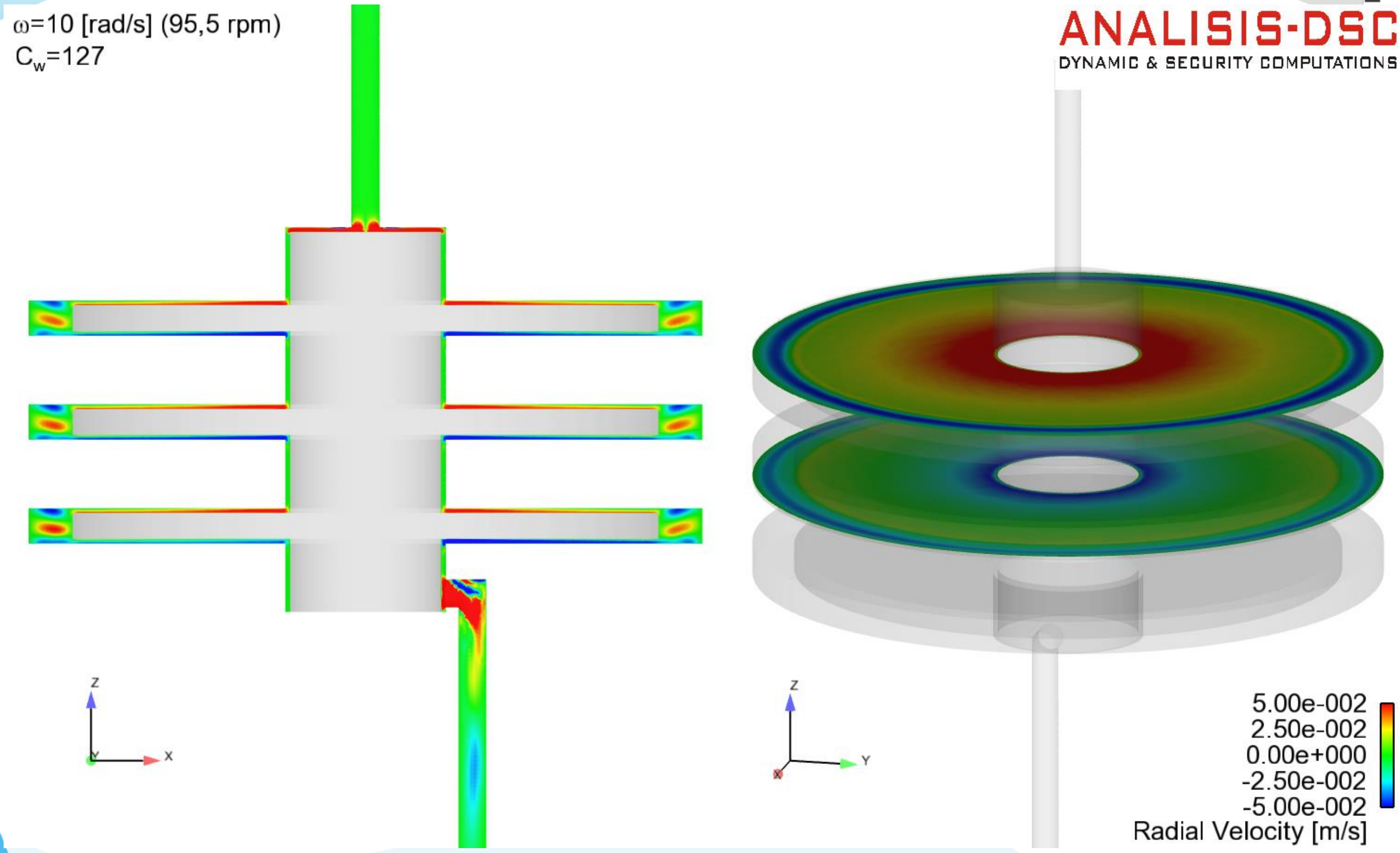
RS Spinning Disk Reactor



RS Spinning Disk Reactor

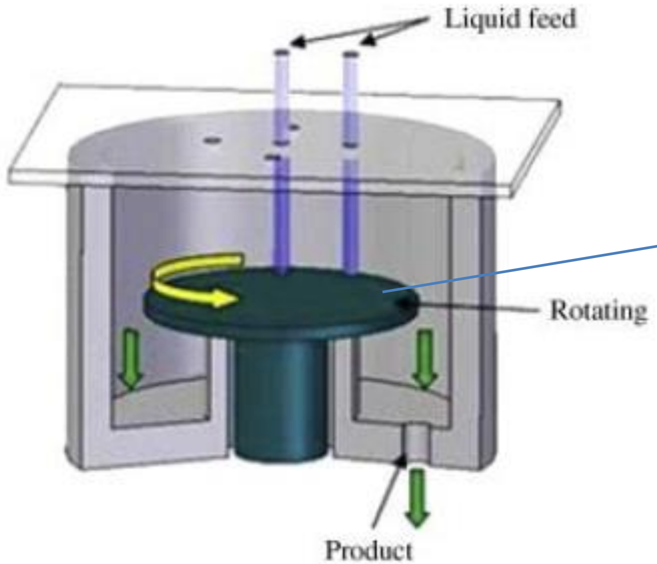


RS Spinning Disk Reactor



Open-Spinning Disk Reactor

- Two or more inlets feed reactants (liquid phase) over a spinning disk (~1000 rpm) , then, a fluid film with intense interfering waves are formed under the influence of the centrifugal force.
- Fast mixing
- Intensified mass transfer.



Wavy free surface. Film Thickness in the order of 150 microms

O-SDR, modelling

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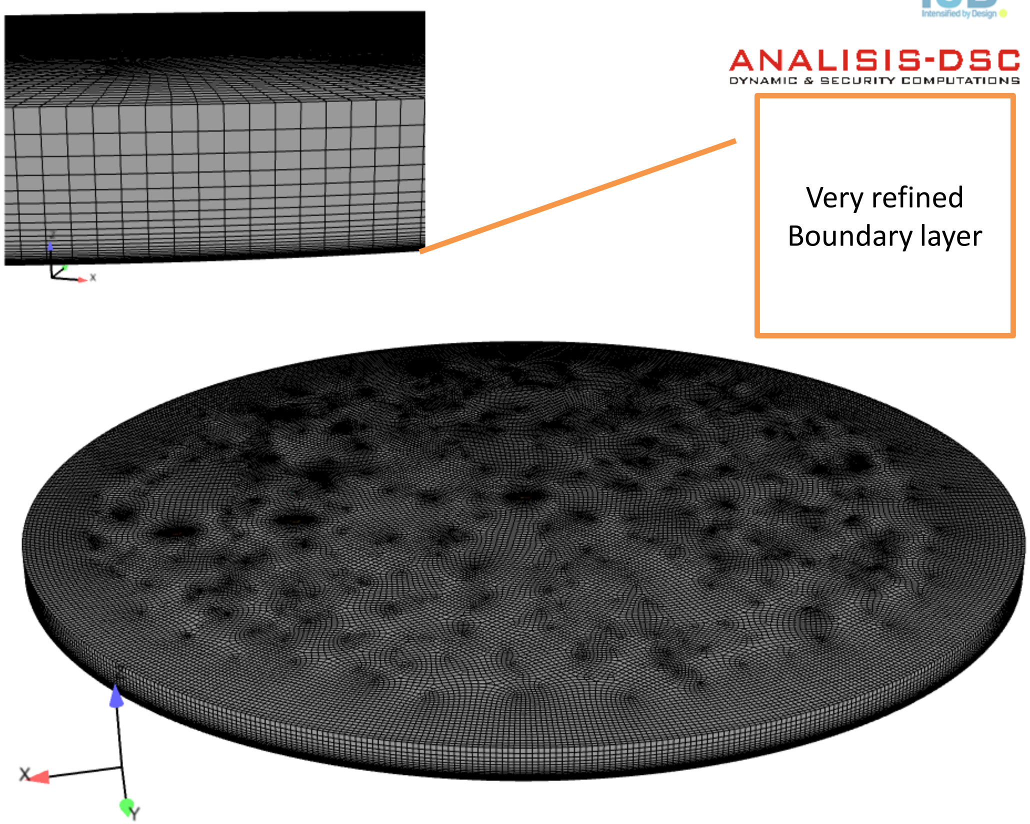
DYNAMIC & SECURITY COMPUTATIONS

IbD Intensified by Design ®

- CFD: can model the O-SRD and its heat and mass transfer, but:
  - To track the free surface, a VOF (volume of fluid) method is required.
  - Special turbulence models are required too: LES (Large Eddy Simulation)→ A very refined computational mesh is needed to run this kind of turbulence models.
  - It is “a state of the art” technology → Not many references are available.
  - The development of the liquid film is a transient process → a time step of **<u>0.0005 seconds</u>** is required to carry out the simulation

Very expensive in terms of computational resources and calculation time

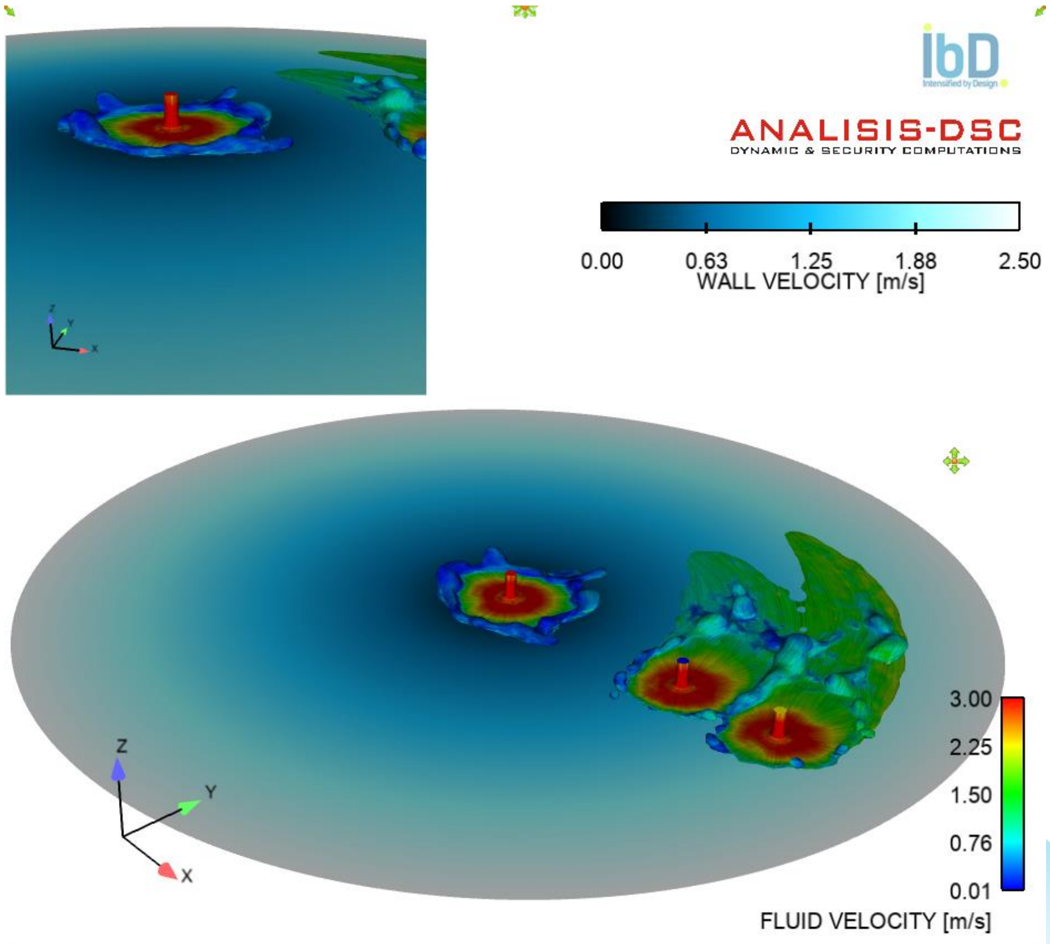
O-SDR, Geometry and mesh



OSDR 185 mm diameter.

- 553 RPM
- 9 kg/hour Liquid mass Flow per inlet (3 water inlet)
- Liquid + Gas phases
- Transient
- VOF/LES
- No Chemical reactions are modeled in this stage.
- Mesh statistics:
    - tria3 :44
    - Quad4: 103308
    - Penta6:572
    - Hexa8:1117220

O-SDR, fluid flow



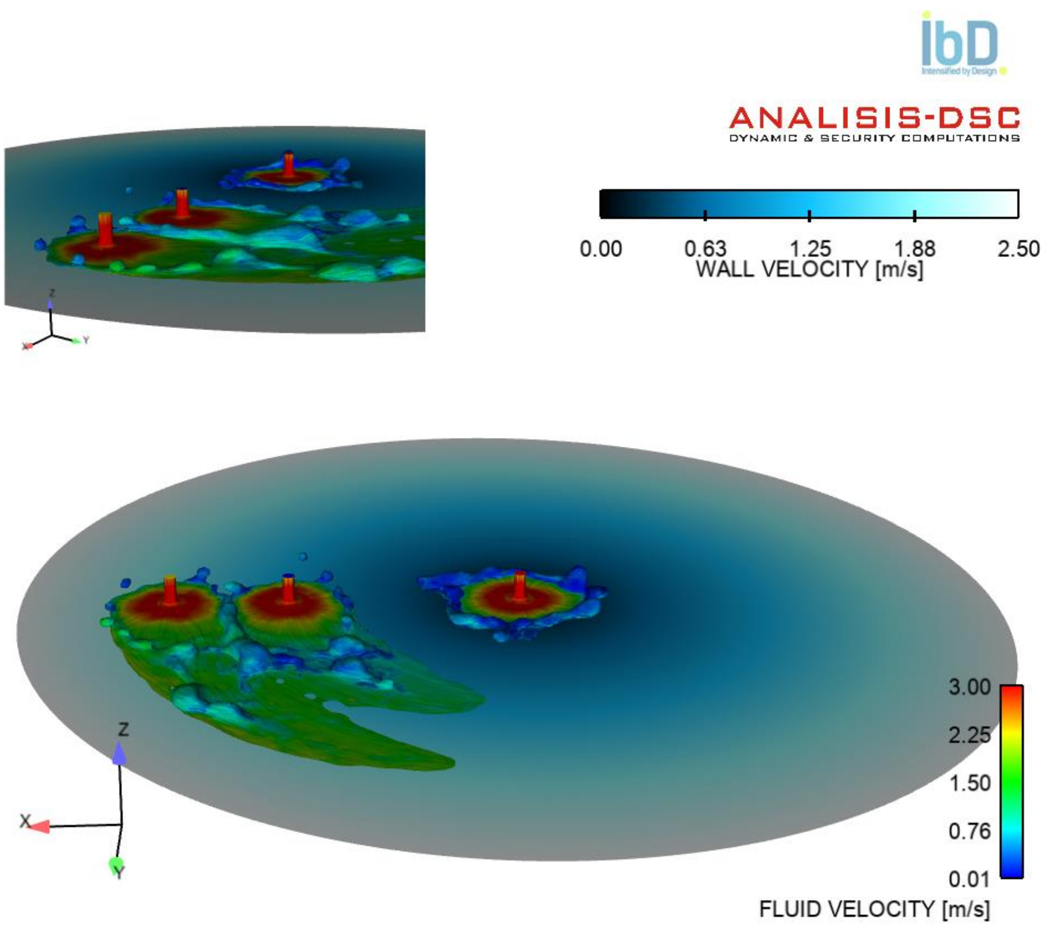
Physical time= 0.0235 sec.

CPU time= one week aprox.

Note the 3 inlet regions and the splashing/sloshing of liquids.

The film is not full developed. Further time steps are required.

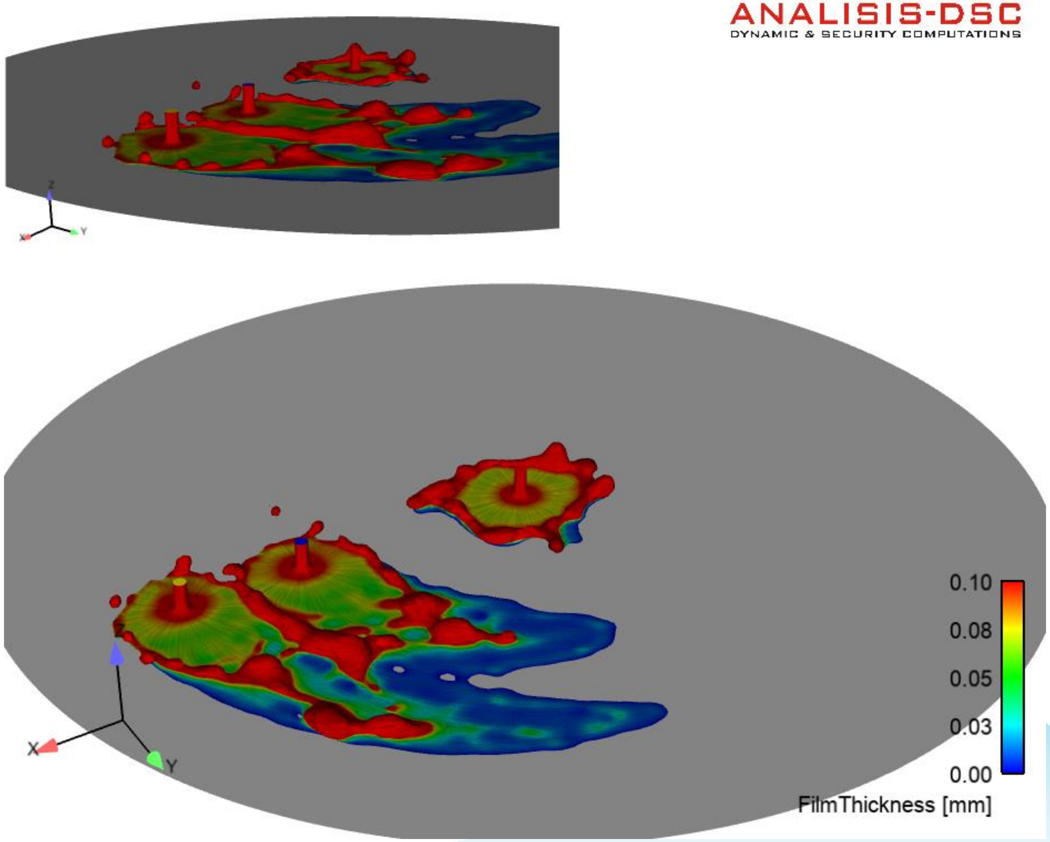
O-SDR, fluid flow



Physical time= 0.0235 sec.

Other view of liquid regions and film development.

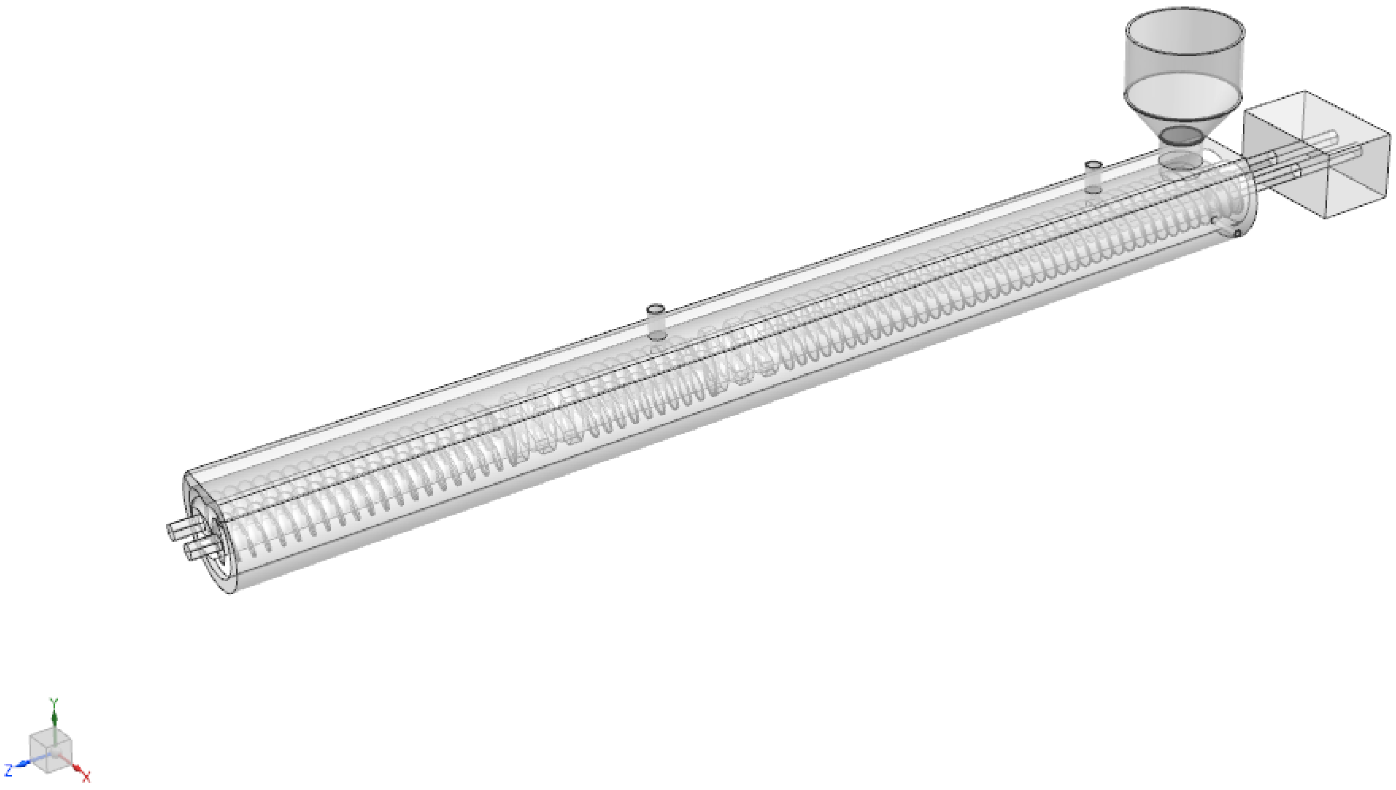
O-SDR, fluid flow



Physical time= 0.0235 sec.

The Radial Film thickness distribution is a very important parameter to evaluate the accuracy of the simulations.

Twin Screw Dryer. TC4.01



Twin Screw Dryer

- Drying and Granulation based in the in movement of two screws with a tight gap between them.
- From powders to agglomerate (similar to the TC2)
- The different stages of the granulation process occurs in different length of the screws.
- The evolution of particles diameter has to be modeled. In CFD the Population Balance Model is required to do this.

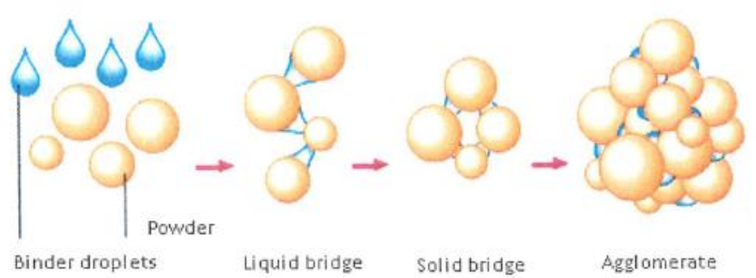


Figure 2.1.1 Typically mechanisms in the process of agglomeration (Glatt, 2011).

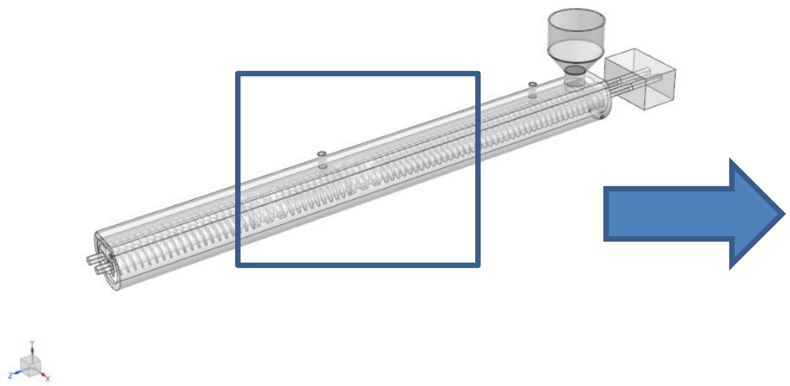
Twin Screw. Modelling.

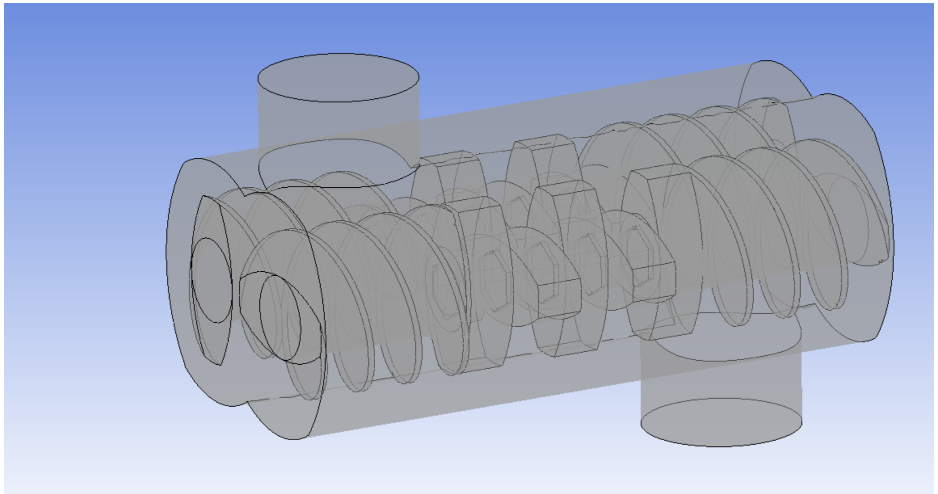
- CFD
  - Euler/Euler approach (Gas Phase+(Particles+water))
  - Kinetic Theory (Gidaspow Model) for particle-particle interaction (commonly used in fluidized beds)→Probability of particle Vs. particle “successful collisions”
  - Population balance to model the particle growth along the screws
  - Due to the geometry of the screws, the common meshing methods are not suitable→ the immersed solid technique is being evaluated.

Goals:
- Model granulation
- Model Fouling
- Model risk of obstruction.

- Other approachs DEM + Population Balance→ State of art.

Twin Screw Dryer



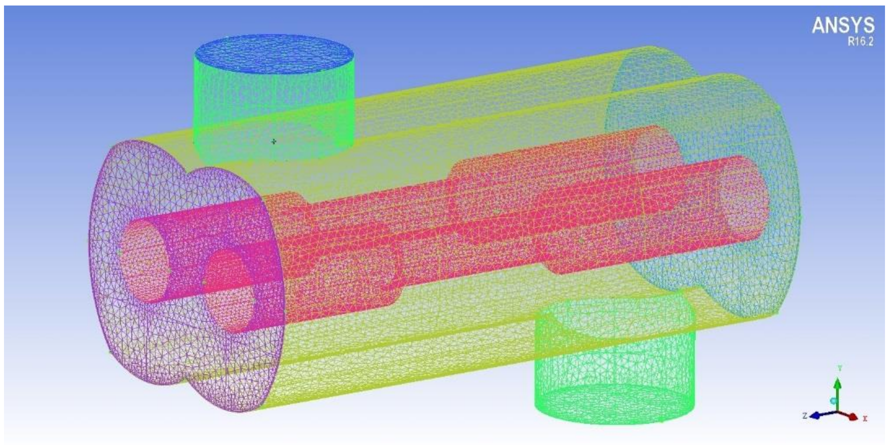


The original CAD model is given by Newcastle University (Ahmad Moustaffar).

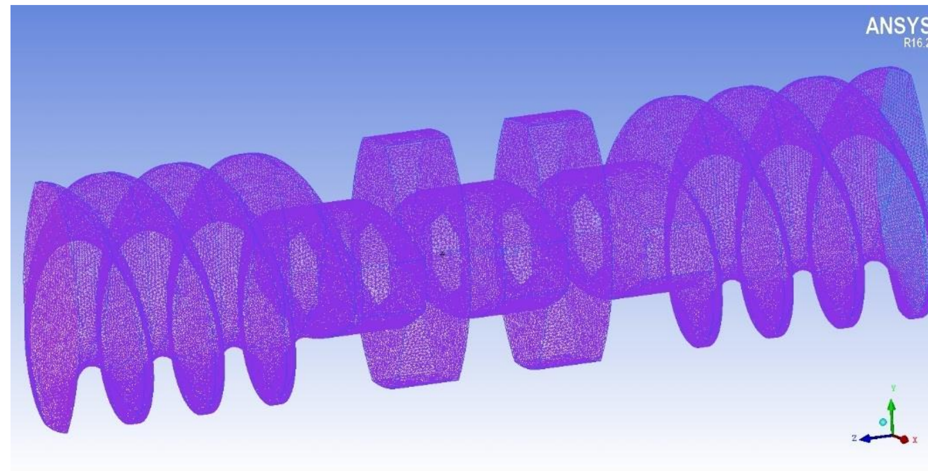
In the present case, only a section of the TSD is modeled, using the Immersed Solid Technique with a continuous fluid . This technique allow the modeling of the interaction of immersed bodies with fluids overlapping solid an fluid meshes In Example: Gear Pumps.

The case is transient, time dependent.

Twin Screw Dryer

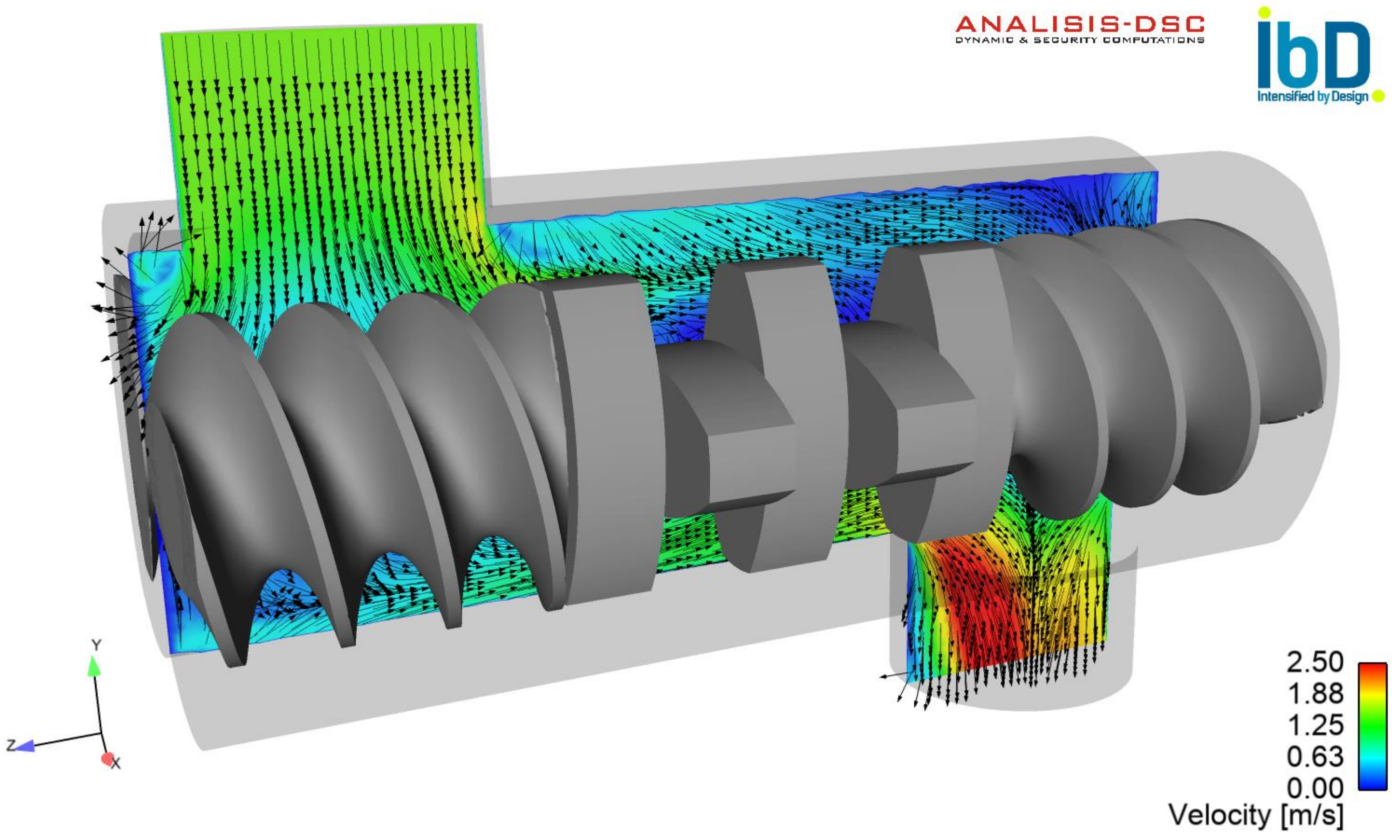


Fluid volume “empty”



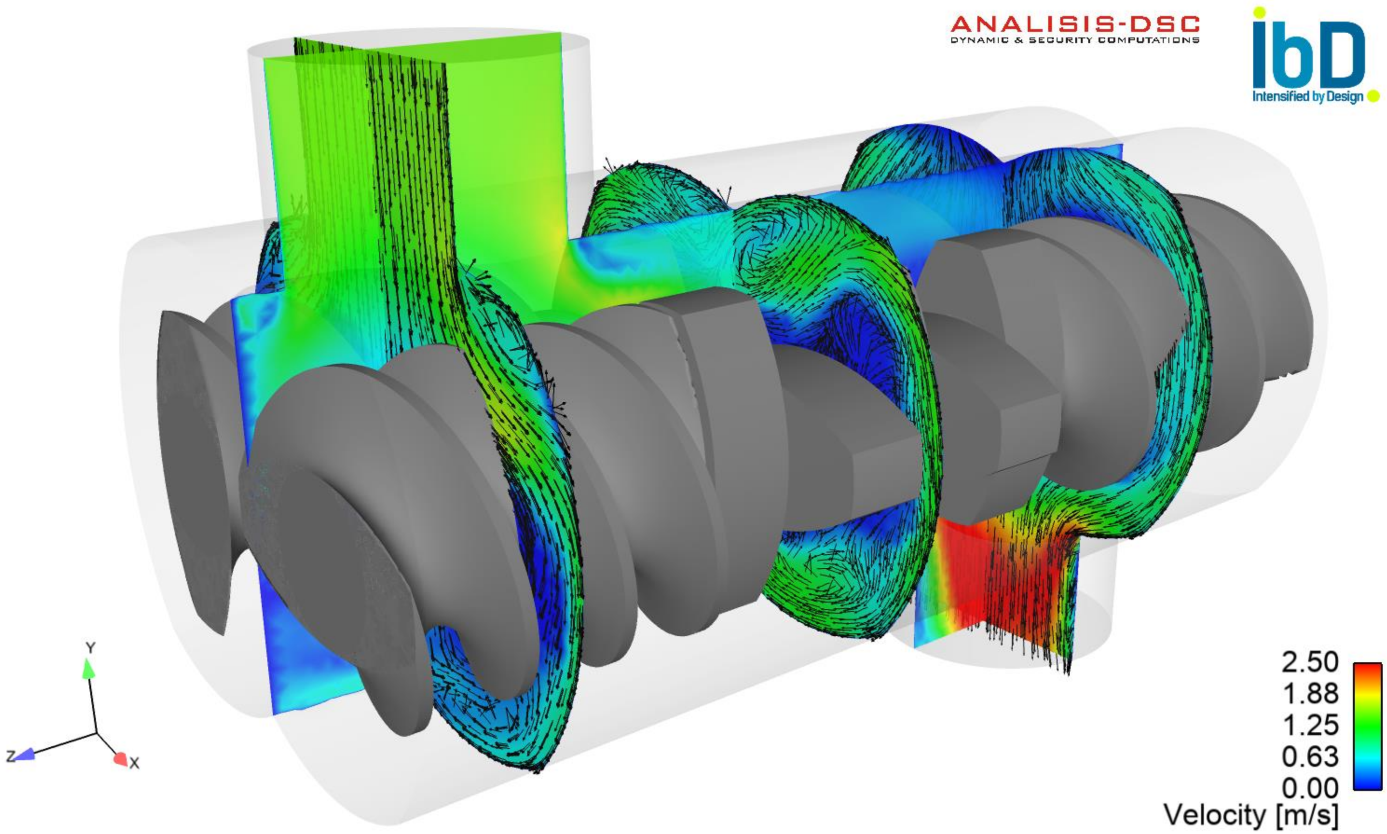
Solid screw.

Twin Screw Dryer. Results



The flow field is reasonably good modeled.
This technique give us a qualitative idea of the flow, but not quantitative yet.
The actual development is trying to reach a better accuracy level and the inclusion of particulate phase models.

Twin Screw Dryer. Results



Other view of the flow field.

View the animation.

Conclusions

- RS-SDR:
  - Simpler to model in CFD as there is no open atmosphere.
- O-SDR:
  - The CFD method can model this type of PI technology, being able to take into account all the physical phenomena involved in reacting flow.
  - The necessary computational effort discards the use of CFD in this project and analytical/empirical methods are recommended
- Twin Screw dryer
  - A CFD model is being developed based in the immersed solid technique.
  - The actual development is based in use of kinetic theory and Euler-Euler approach.
  - The high shear granulator is based on the same Euler-Euler approach and could share the development for the IBD platform.

Contact

- If your company is interested on additional information about our services, do not hesitate to contact us at:

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