University of Tuzla,
Faculty for Mechanical Engineering, Postgraduate study
Modelling, Simulation, Optimisation

Design Integration for Screw Compressors

Part 4:
Application

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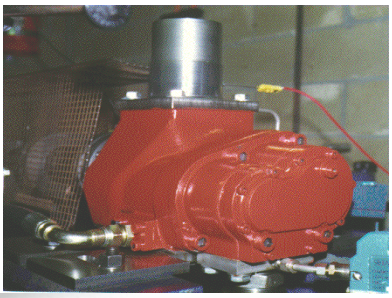
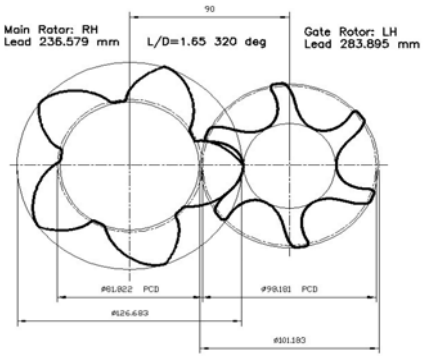
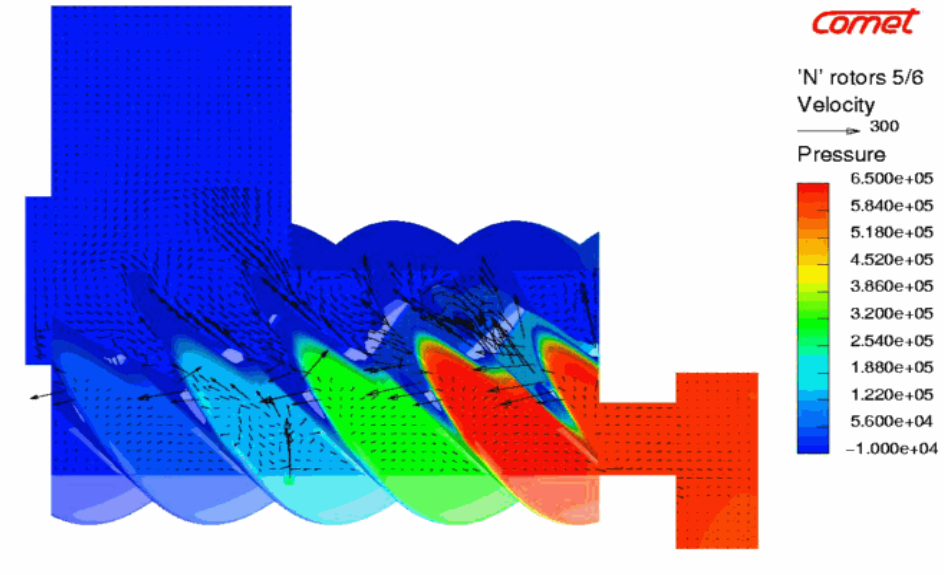
Oil injected compressor



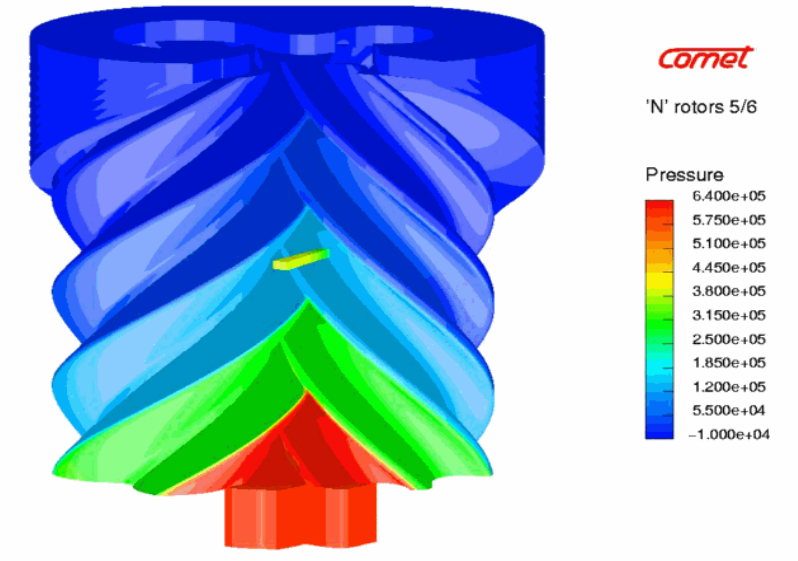


Configuration 5/6
d_1= 126.7 mm, d_2= 101.4 mm, a= 90 mm
l=212 mm, l/d=1.66, wrap angle=320 deg
Nominal clearance **65** μm
n=5000 rpm
442 130 cells, 25 time steps/cycle

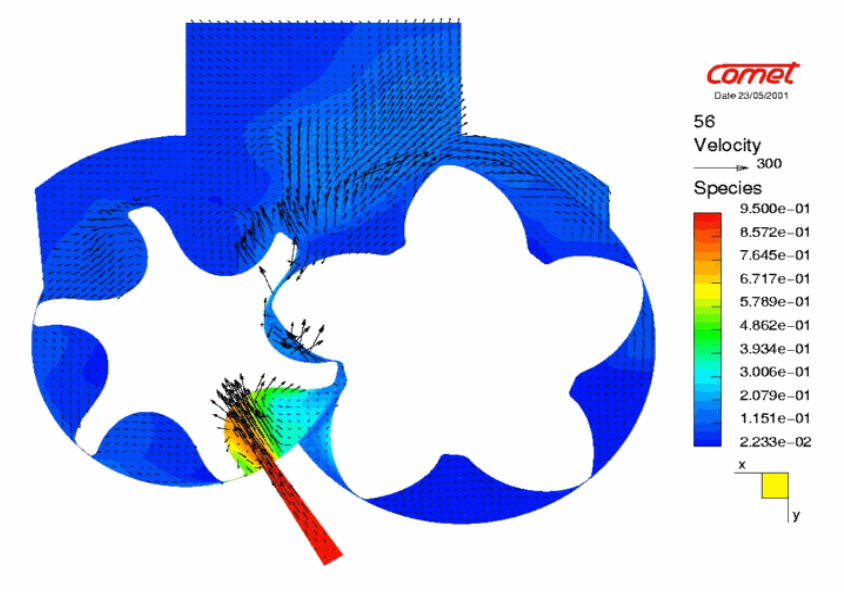
Oil injected – Pressure/Velocity



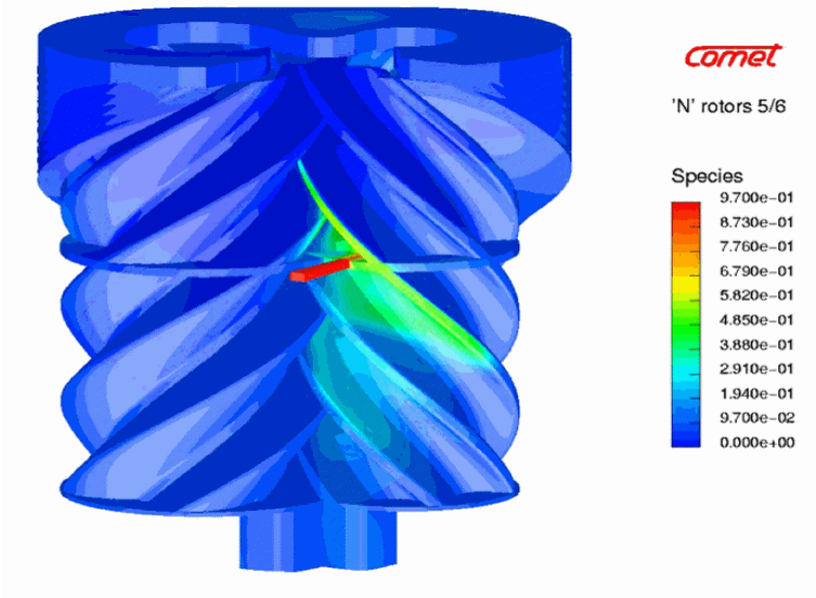
Oil injected - Pressure 3D view



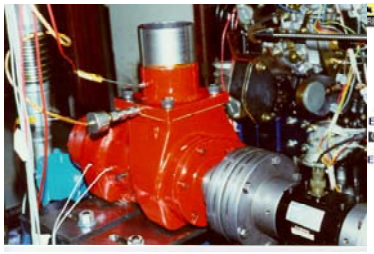
Oil injected - Oil concentration

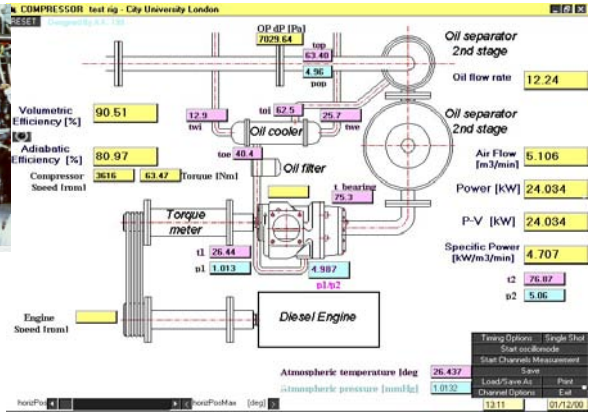


Oil injected - Oil distribution 3D view



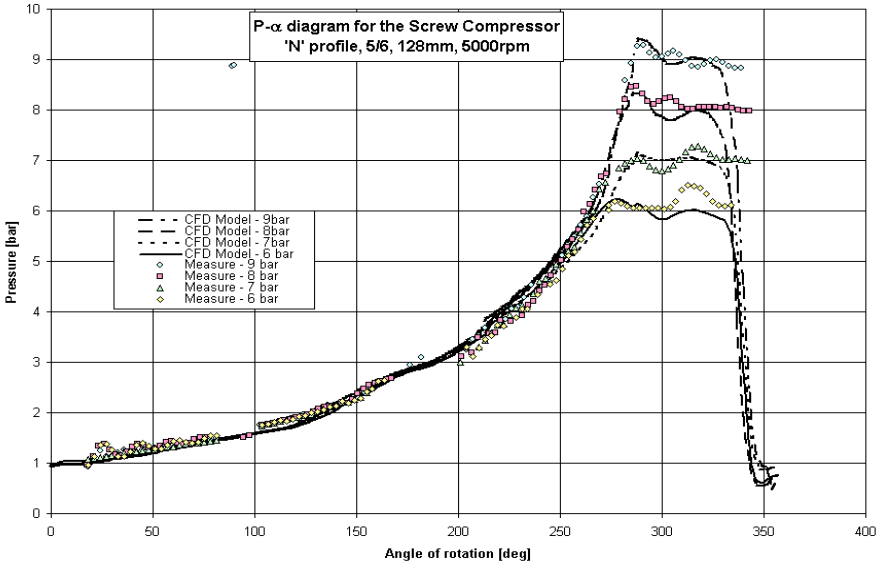
Experimental verification



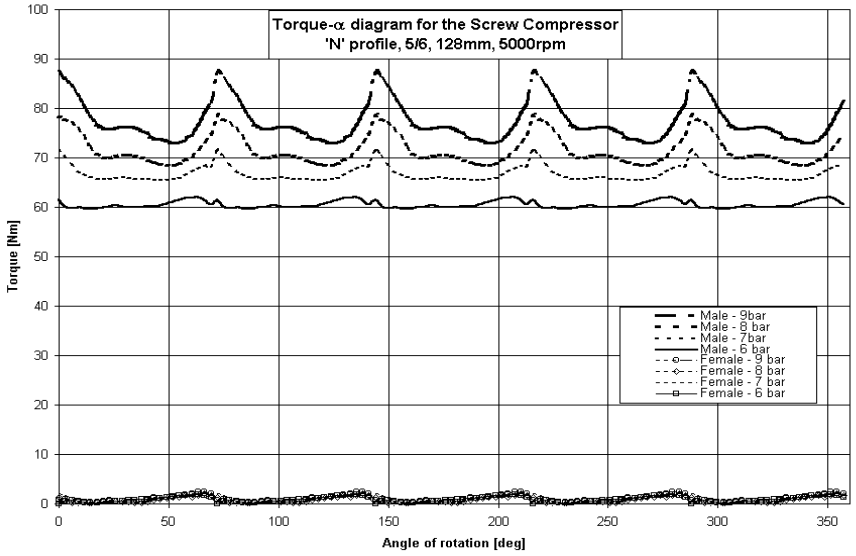


-Test rig enables oil flooded and dry air compressors to be measured. Limits:
  - Power <= 100 kW
  - Delivery <= 16 m^3/min
- High accuracy test equipment
- p-a diagram – piezoelectric transducers
- Computerized data logger
- Real time calculation and presentation
- Meets Pneurop/Cagi standards
- Compressor tested to ISO 1706
- Flow measurements BS 5600
- Certified by Lloyd's of London

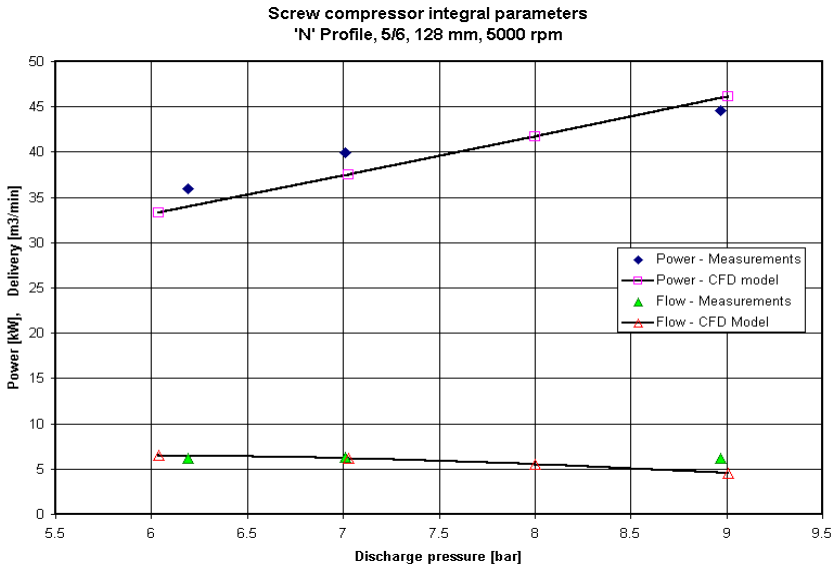
P-α diagram



Integral parameters – Torque



Integral parameters – Power, Delivery



FSI for screw compressor Examples:

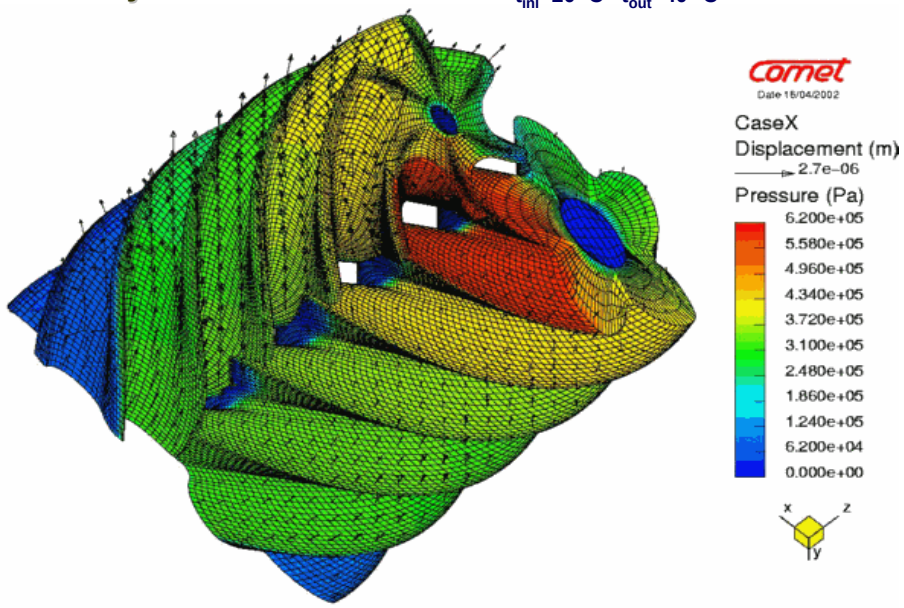
Case 1: Oil injected air screw compressor
P_{inl}= **1** bar, P_{out} = 6, **7**, 8, 9 bar
t_{inl} = 20 degC, t_{out} = 40 degC

Case 2: Dry air screw compressor
P_{inl}= **1** bar, P_{out} = **3** bar
t_{inl} = 20 degC, t_{out} = 150 degC

Case 3: High pressure CO_2 oil injected screw compressor
P_{inl}= **30** bar, P_{out} = **90** bar
t_{inl} = 0 degC, t_{out} = 40 degC

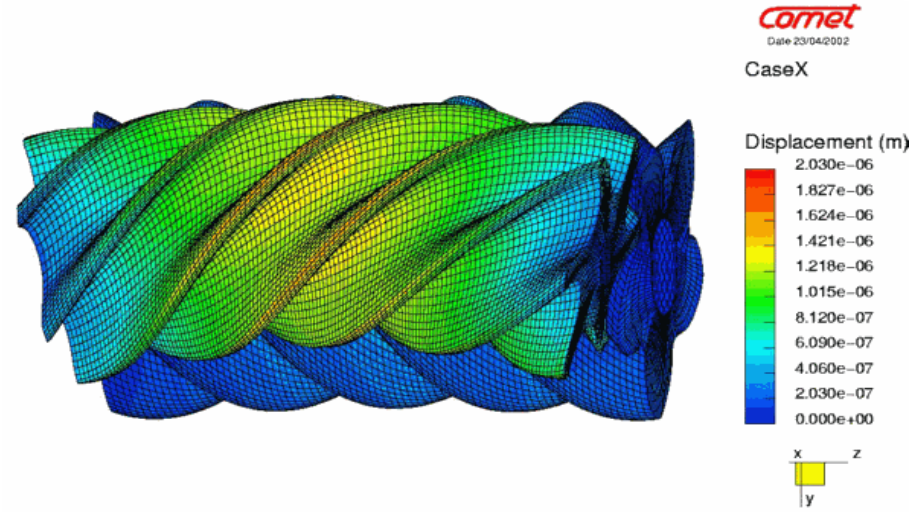
Oil injected

P_{inl}=1 b P_{out}=7 b n=5000 rpm
t_{inl}=20 °C t_{out}=40 °C



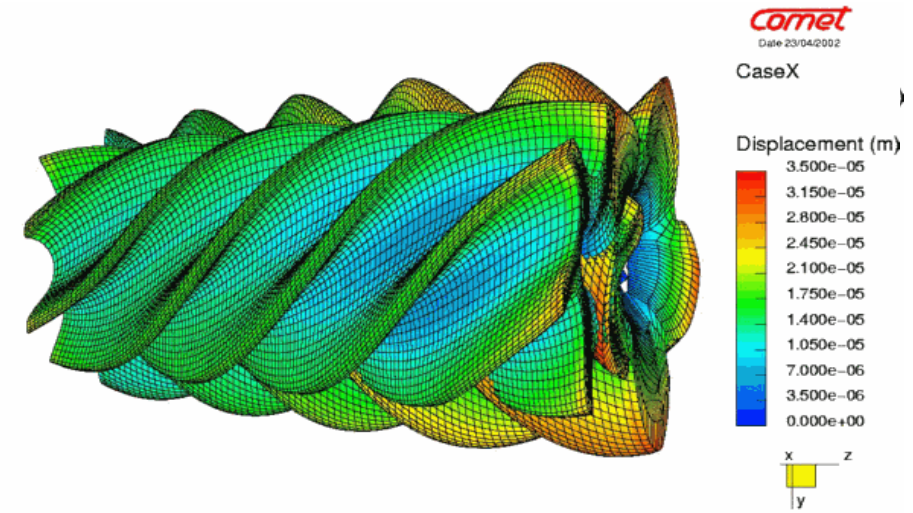
Oil injected

P_{inl}=1 b P_{out}=7 b n=5000 rpm
t_{inl}=20 °C t_{out}=40 °C mag=20,000x



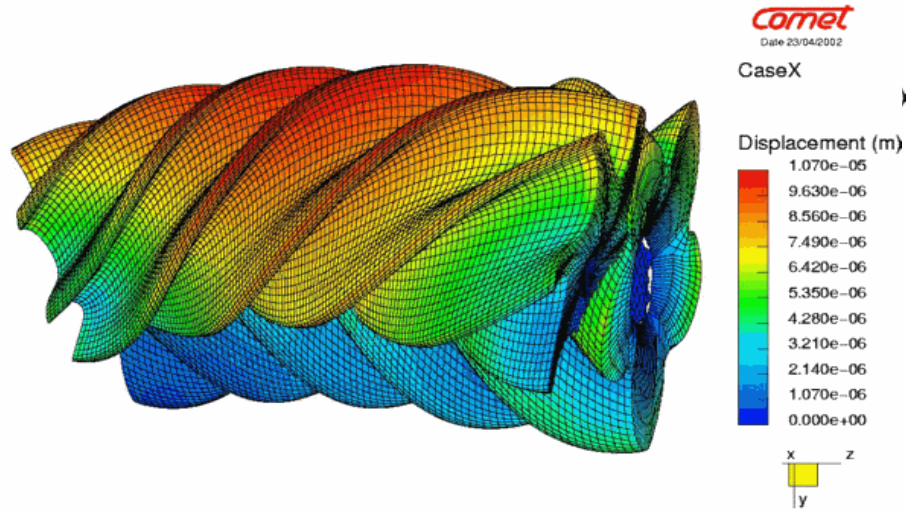
Oil free

P_{inl}=1 b P_{out}=3 b n=5000 rpm
t_{inl}=20 °C t_{out}=150°C mag=1,000x



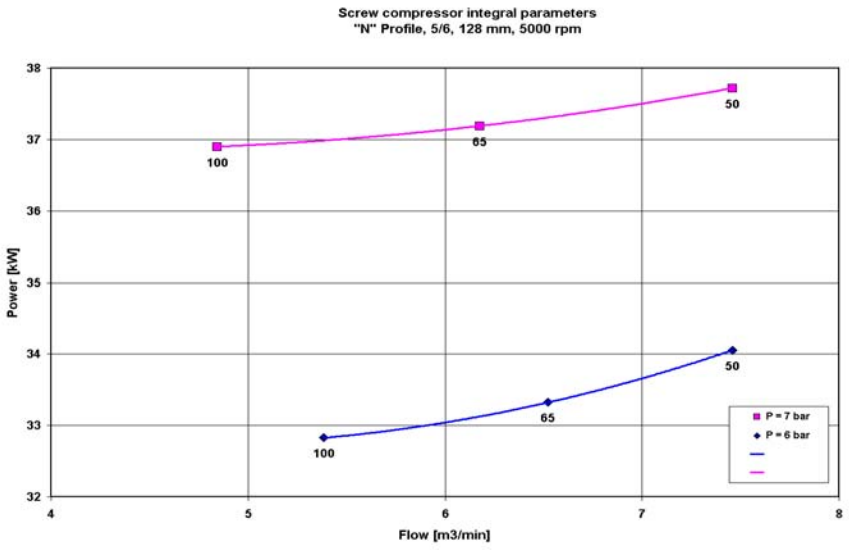
High pressure oil injected

P_{inl}=30 b P_{out}=90 b n=5000 rpm
t_{inl}=0 ºC t_{out}=40 ºC mag=2,000x



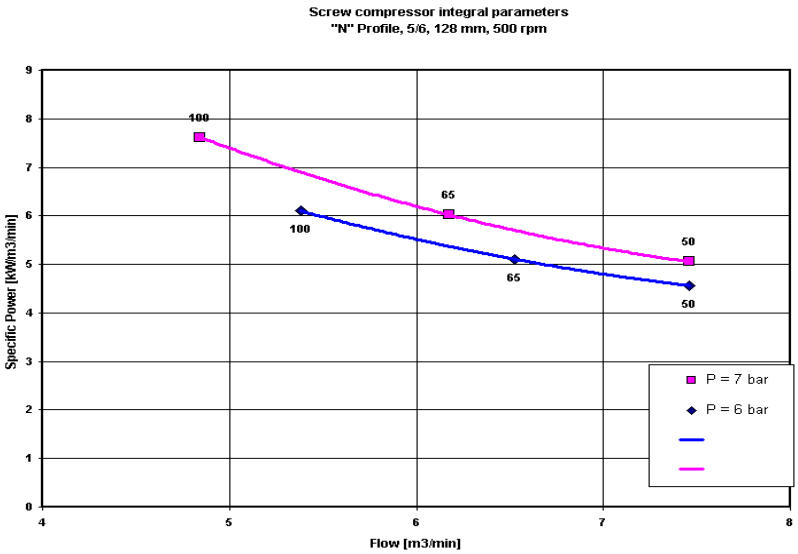
FSI integral parameters

Power-Flow diagram



FSI integral parameters

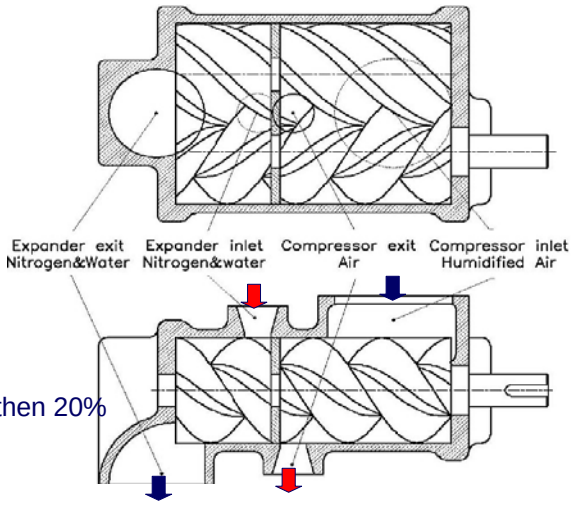
P_{sp}-Flow diagram



Fuel cell for automotive industry

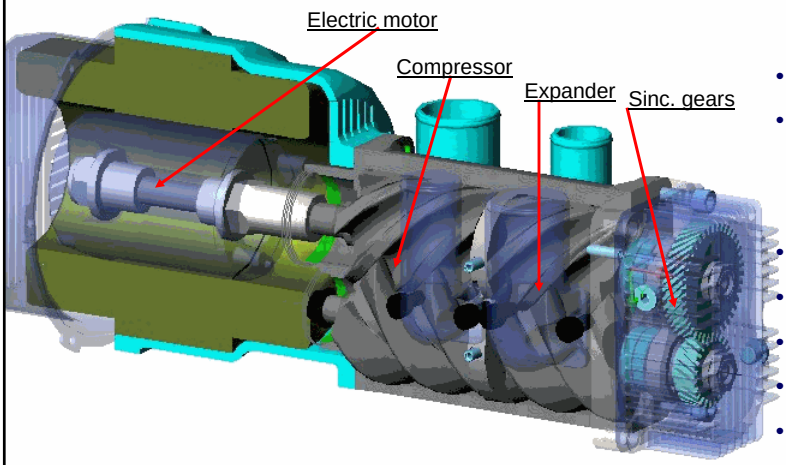
$$E \sim \sqrt{p_{Air}}$$

- Air
  - flow 20-150 kg/hr
  - pressure 3 bar
  - temperature <100 °C
- Nitrogen & water
  - pressure 2.8 bar
  - temperature 100-120 °C
- Compressor power is more then 20% of the fuel cell production



- Power recovered from the expansion of reaction products increases available driving time of a vehicle with fuel cell.

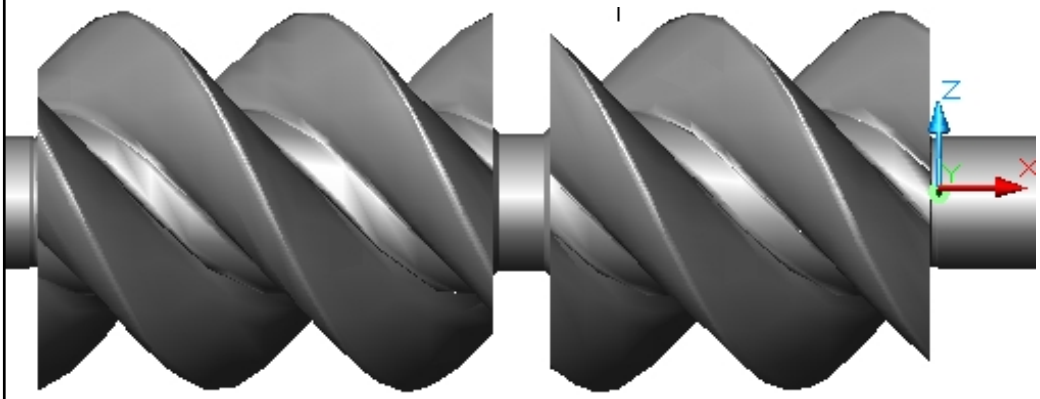
Compressor-expander for automotive FC



- Configuration 3/5
- Rotors dia:
  Male d_{e1}=69 mm
  Female d_{e2}=48 mm
- Compressor l/d=1.2
- Expander l/d=1
- Speed n=9500 rpm
- Size 450x180x180mm
- Weight 20 kg
- Motor power 3.5 kW

- Manufacturing costs as for the single machine
- Two pair of bearings – reduction in mechanical losses
- Balancing of forces – further reduction in losses

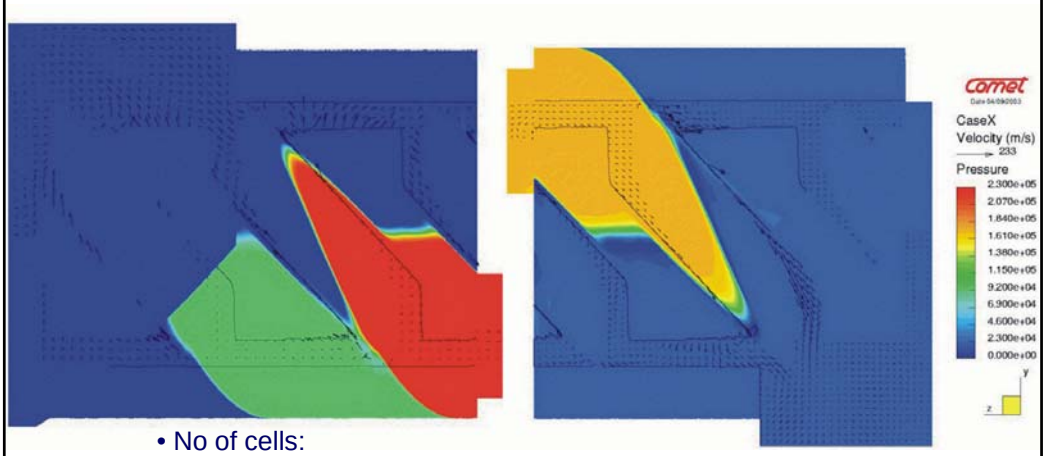
Rotors from CAD model



- No of cells:
  Solid – rotors 393,752
  Fluid – rotors 538,050
  Entire mesh 1.378,960

PC – Athlon 2000+
1.5 GB RAM

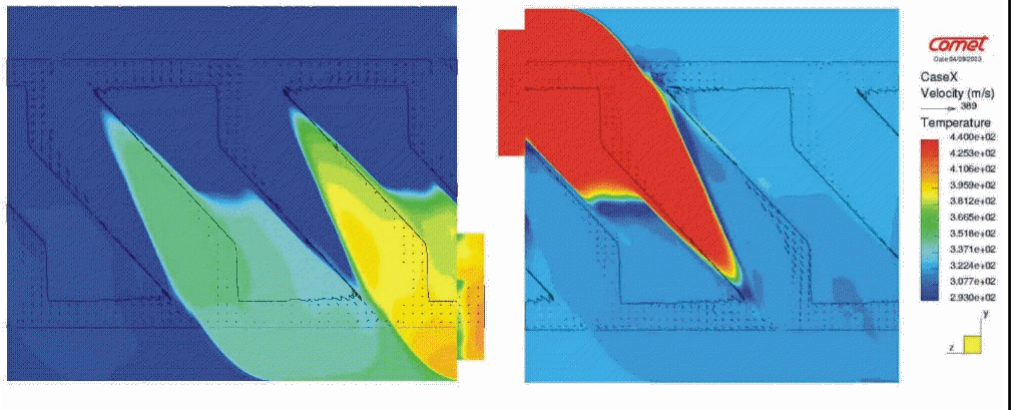
Pressure and velocity distribution



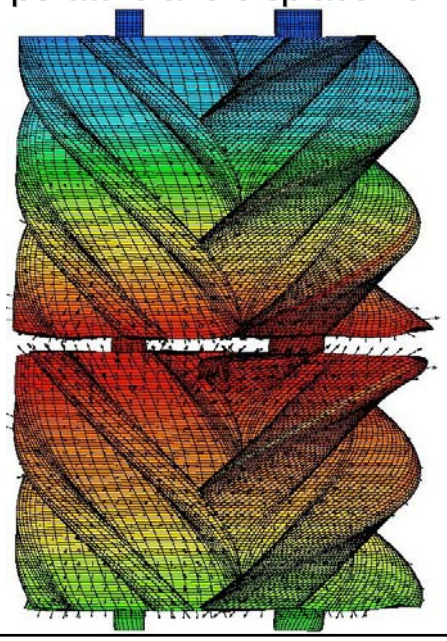
- No of cells:
  - Solid – rotors 393,752
  - Fluid – rotors 538,050
  - Entire mesh 1.378,960

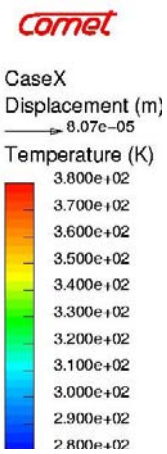
PC – Athlon 2000+
1.5 GB RAM

Temperature and velocity in the fluid domain



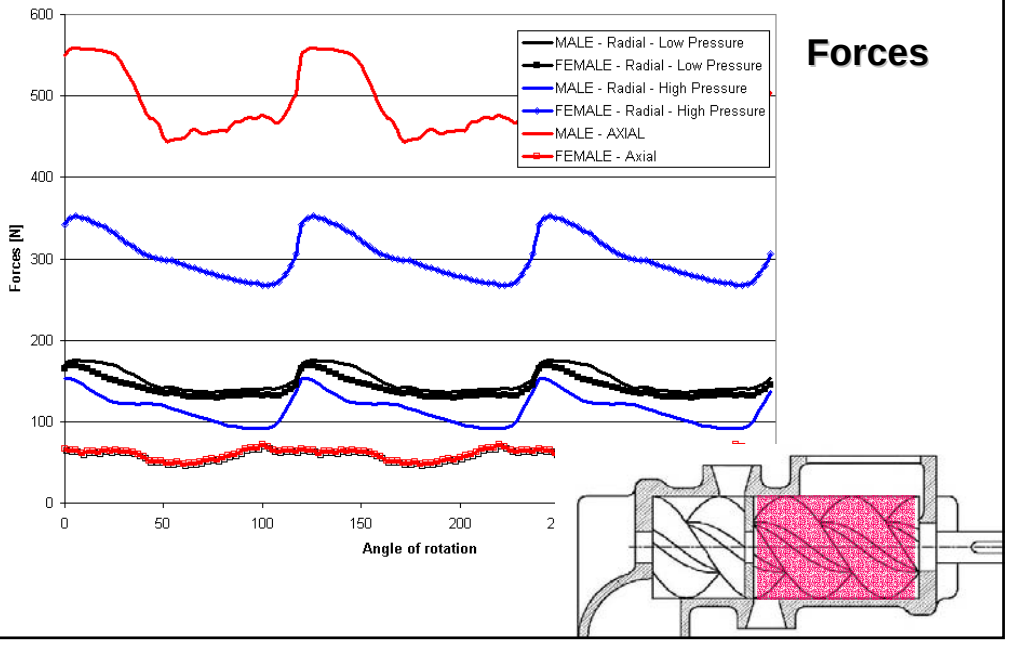
Temperature and displacement of solid parts

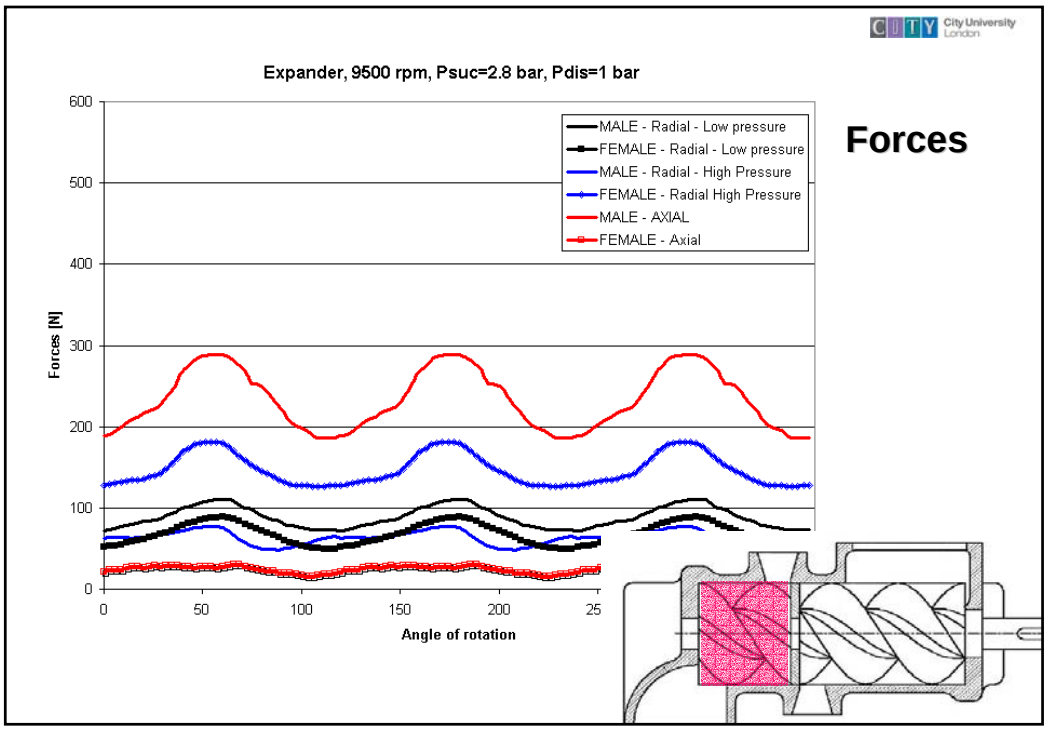


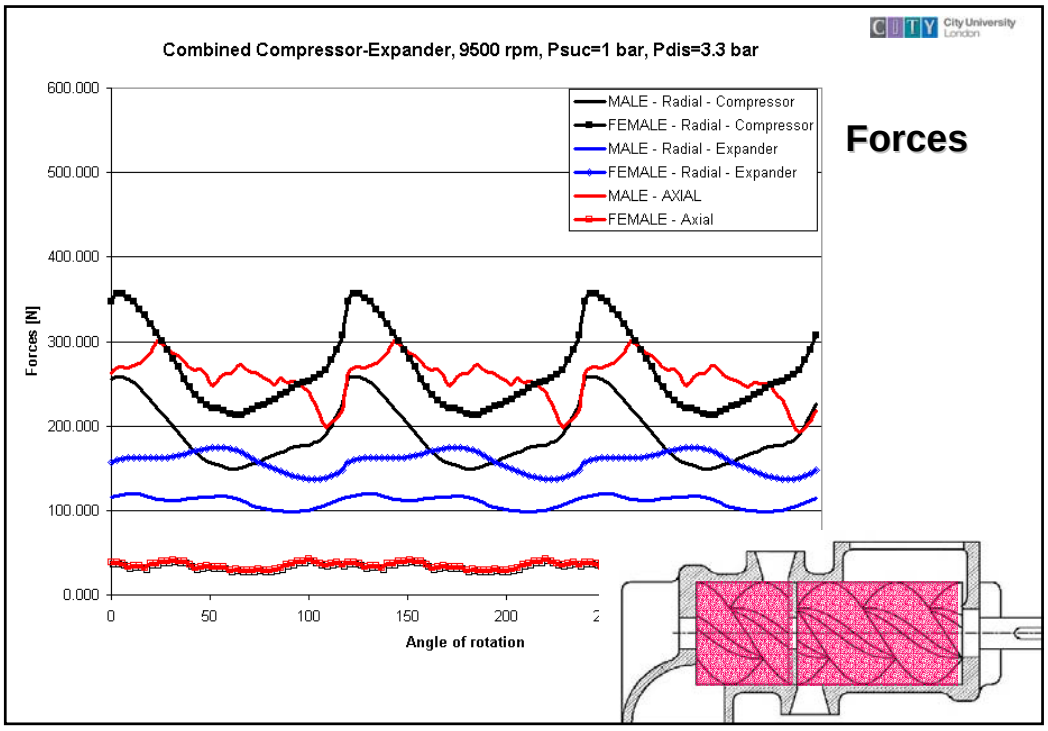


P_{inl}=1 b P_{out}=3 b n=9500 rpm
t_{inl}=20 ºC t_{out}=100ºC mag=750x

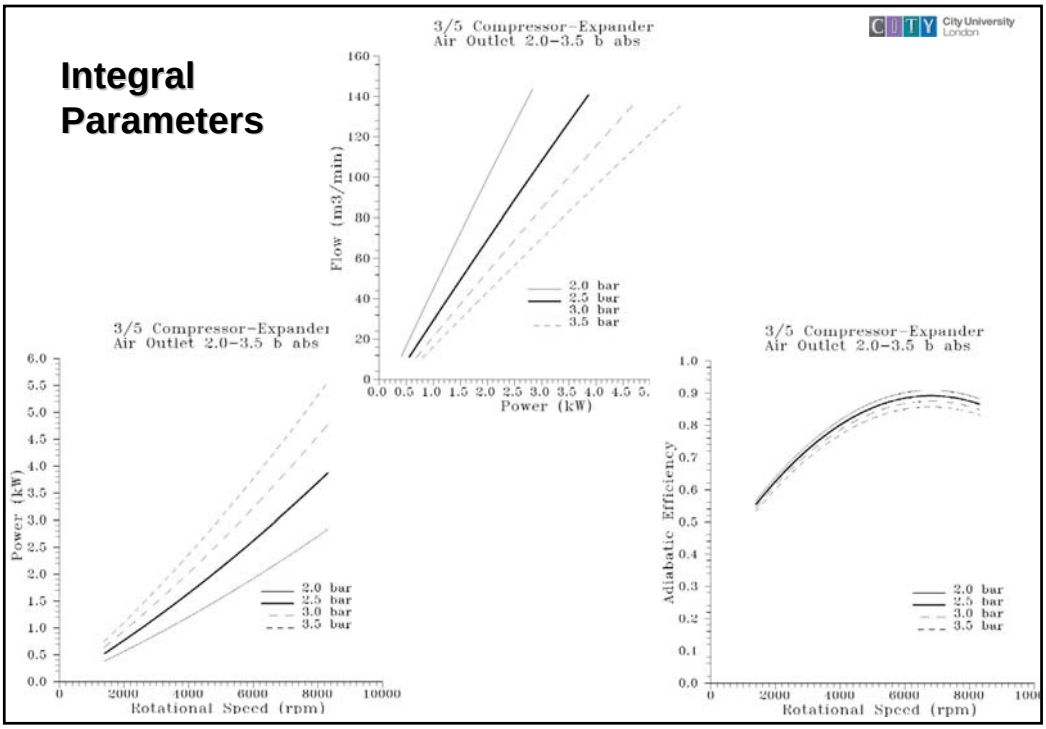
Forces

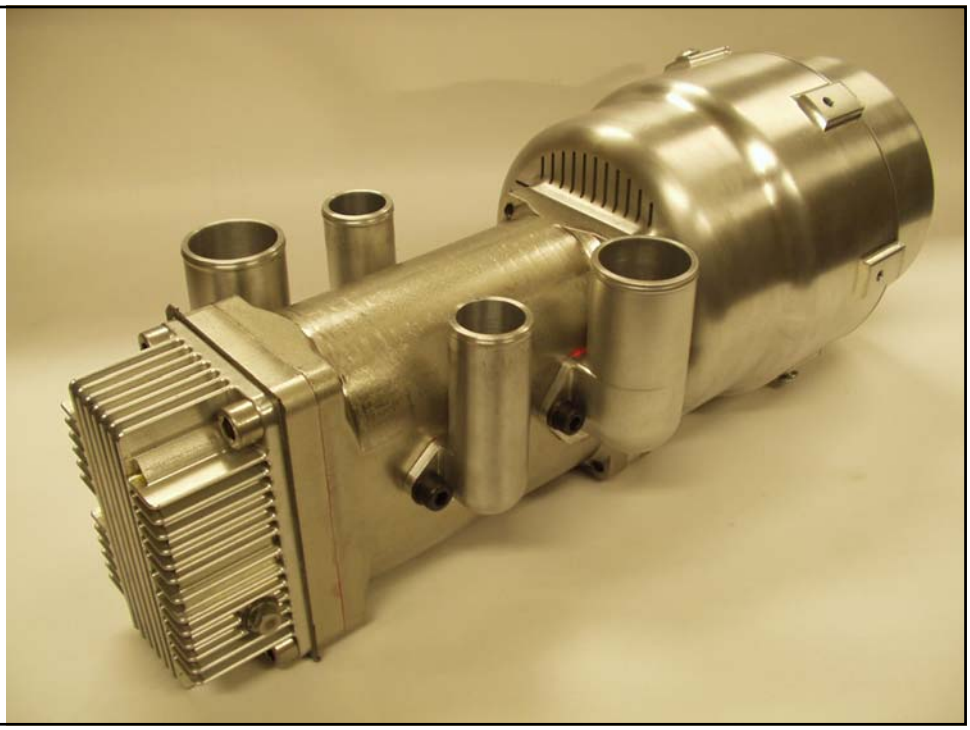



Expander, 9500 rpm, Psuc=2.8 bar, Pdis=1 bar
Forces
MALE - Radial - Low pressure
FEMALE - Radial - Low pressure
MALE - Radial - High Pressure
FEMALE - Radial High Pressure
MALE - AXIAL
FEMALE - Axial
Forces [N]
Angle of rotation


Combined Compressor-Expander, 9500 rpm, Psuc=1 bar, Pdis=3.3 bar
Forces
MALE - Radial - Compressor
FEMALE - Radial - Compressor
MALE - Radial - Expander
FEMALE - Radial - Expander
MALE - AXIAL
FEMALE - Axial
Forces [N]
Angle of rotation

Integral Parameters





Conclusion

- **DISCO Connects design software to allow and support concurrent and sustainable design process.**
- **Integrates software groups parametrically**
- **Enables entire design cycle, from a conceptual to detailed design, to be conducted in the unique environment**
- **Automatically manages data files through parameters**
- **Enables data sharing**
- **Enables for selection of different CAD & CFD to be used**
- **Makes CFD (CCM) more automatic**
- **Generates CAD models & drawings**
- **Prepares data for manufacturing**
- **Generates reports**
- **Enables and encourages further developments**