DEM41-1:
Critical Stack Parameters from System Point of View

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Critical Stack Parameters

- Critical stack parameters from (SOFC) system point of view
  - Mechanical tolerances
  - Manifolding
  - Leakages
  - Pressure losses and limits
  - Humidity/impurity tolerance
  - Start-up and thermocycling properties, incl. RedOx stability
  - Performance and size
  - Rigidity

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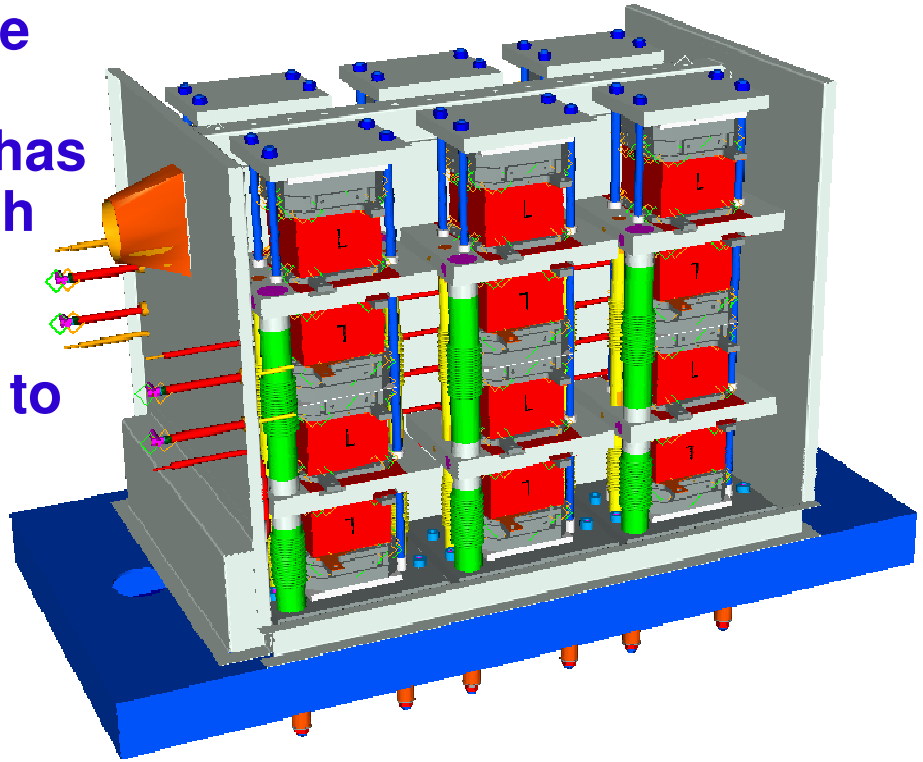
Mechanical tolerances

- Large system -> large number of stacks
  - Stacks cannot be manifolded separately -> stack ”towers”
- Mechanical tolerances become an issue
  - Differences in stacks sizes has to be taken into account with bellows, ball joints, etc.
  - Possible leakage and compression problems due to distorted towers

→ High tolerance required



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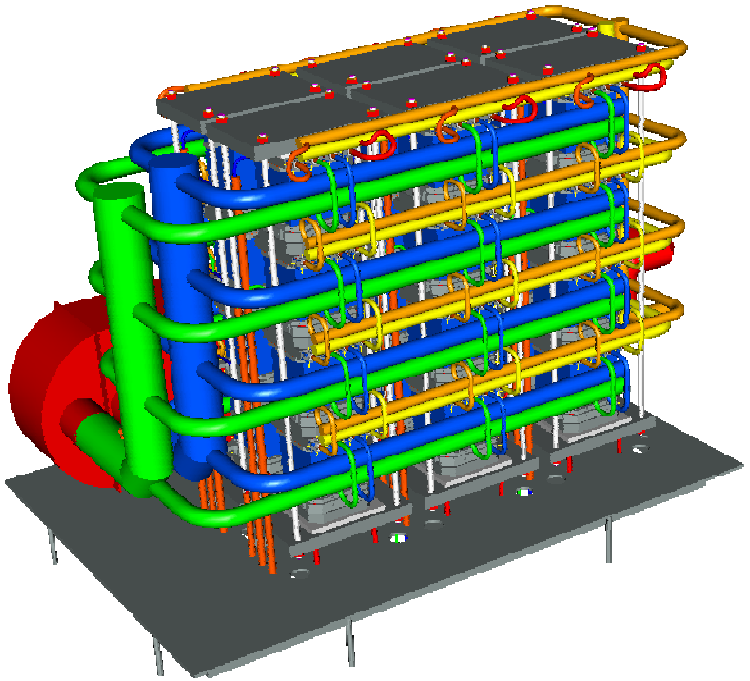
Manifolding

- Large number of inlet/outlet manifolds problematic
  - Possibility of leakages and break-downs increased (tolerances critical at gasketing area)
  - External manifolding laborous and expensive
  - Even flow distribution for stacks difficult to achieve

→ Simple stack/system interface manifolding required



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Leakages

- Internal leakages
  - Decreased efficiency
  - Increased degradation
  - Possible different stack performances cause problems on system control
- External leakages
  - Stack chamber flushing required due to safety regulations
  - Causes structural difficulties in case of pressurized chamber
- Leakages in general affect the heat management significantly, and has to be known when designing system
- In case of anode recycle makes the control scheme challenging

→ Low leakage level required

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Pressure losses and limits

- Pressure losses
  - System efficiency decreased with higher work required from blowers
  - Especially cathode side pressure loss should be small
- Pressure limit for atmospheric systems 500 mbarg
  - Stacks should be able to handle this in case of control problem
- Pressure difference limitations problematic
  - Possible restrictors needed if anode pressure has to be larger than cathode

→ Low pressure loss required, pressure tolerance up to 500 mbarg, no limitations for pressure differences

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Humidity/impurity tolerance

- Tolerance towards impurities should be high
  - Filtering requires continuous service
  - Chromium/Silicon present in all high-T materials → always a risk of poisoning
- Possible humidity intolerance an issue
  - Air drying techniques difficult to implement into system streams and/or expensive
  - A major issue in marine environment, incl. also dissolved salt
- Chlorium compounds and siloxanes present in biogas, rather complicated to remove

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Start-up, thermocycling, and RedOx properties

- Large system takes time to heat up -> typical allowable heating rates sufficient (20-200 K/h)
- Should not be affected by thermocycles caused by system shut-downs (cooling rates similar to heating rates)
- Should be able to handle cooling effect from high methane content (up to 60 vol% CH4 internal reforming)
- Should be RedOx stable enough to enable low protection gas flows during start-up and different shutdown modes (e.g. some Nl/h of H2)

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Performance and size

- High efficiency required (~0.8V/cell)
- Operational voltage preferably >60V for high efficiency conversion
- High power density enables less (similar sized) stacks -> less expensive external manifolding
- Size is typically not an issue, except high power stacks are required (>3 kW/stack)
- Single-pass FU should be high (min. FU~70%)
  - Low FU -> efficiency decreased
  - Low FU -> anode recirculation increased for adequate O/C-ratio
  - Differences in stack performances may deteriorate the overall efficiancy if FU has to be low

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Rigidity

- Rigidity typically not a problem in static systems
- In marine environment fluctuation and shocks may be severe
- Mærsk: ”Everything that goes into ship should manage a free fall of 20cm”

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