

## THERMAL STABILITY OF HEXAMETHYLDISILOXANE (MM) FOR HIGH TEMPERATURE APPLICATIONS

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## **Future challenges concerning ORC**

High temperature applications without intermediate circuit



#### thermal stability





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## Methodology

## Test rig for hexamethyldisiloxane ( $p_{crit}$ = 19.39 bar, $T_{crit}$ = 245.6 °C)



test rig (modified from Angelino et al.)

- 1: stainless steel tube
- 2: electrical heating wire
- 3: needle valve
- 4: thermocouple
- 5: pressure sensor

#### boundary conditions

- Wacker® AK 0.65 (purity 97 %)
- ≈7g
- 0 ... 72 h
- 240 °C ... 420 °C (0.3 K/s)







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Method 1: vapour pressure curve





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Method 2: isothermal pressure gradient





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Method 3: comparison of pressure before and after experiment



- 1) temperature before and after the experiment is constant
- 2) pressure increases from 0.09 bar to 0.14 bar

#### high vapour pressure of degradation products





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Evaluation with GC/MS (T = 420 °C, t = 72 h)



 decrease of MM
 alkanes and alkenes with low molecular weight

cleavage of
 Si-C-bond leads
 to methyl radicals





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Evaluation with GC/MS: temperature dependence



Evaluation with GC/MS: time dependence



Degradation rate depending on temperature (t = 72 h)



- 1) Arrhenius-behaviour
- fluctuation increases
  with degradation rate
- 3) below 300 °C annual degradation rate is acceptable
  (lower than 3 %)
  - film temperature and hot-spots have to be less than 300 °C



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Degradation rate depending on time (T = 420 °C)



- clear dependence on time with plateau after 72 h
  - bleeding valve to release degradation products is useful
  - special care at first start-up of ORC:

"boil out" contaminants



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Methane as indicator for degradation



degradation can be 1) noticed instantly by monitoring methaneconcentration as soon as methane is monitored, special care concerning security aspects is necessary



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#### Summary... ... and Outlook

- Hexamethyldisiloxane is stable below a temperature of 300 °C under typical ORC-conditions (no drying of working fluid, pressure of 17 bar, ...).
- Special care has to be taken concerning film temperature and hot-spots.
- Methane is a clear indicator for degradation of MM.
- Monitoring the methane concentration in the vapour phase and implementing a bleeder valve to release degradation products can improve the security of systems without intermediate circuit.
- Strong time dependence makes dynamic test loop necessary.
- The influence of water has to be investigated in more detail.
- Possible impact on heat transfer coefficients has to be clarified.





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#### Summary... ... and Outlook







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