Indirect vs. Direct Gasification

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INDIRECT *vs.* DIRECT GASIFICATION

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GASIFICATION

matching energy consumption and production

energy production:

fuel + air (λ > 1) → flue gas + heat

25%

energy consumption:

fuel + heat → gas + char/coke

75%

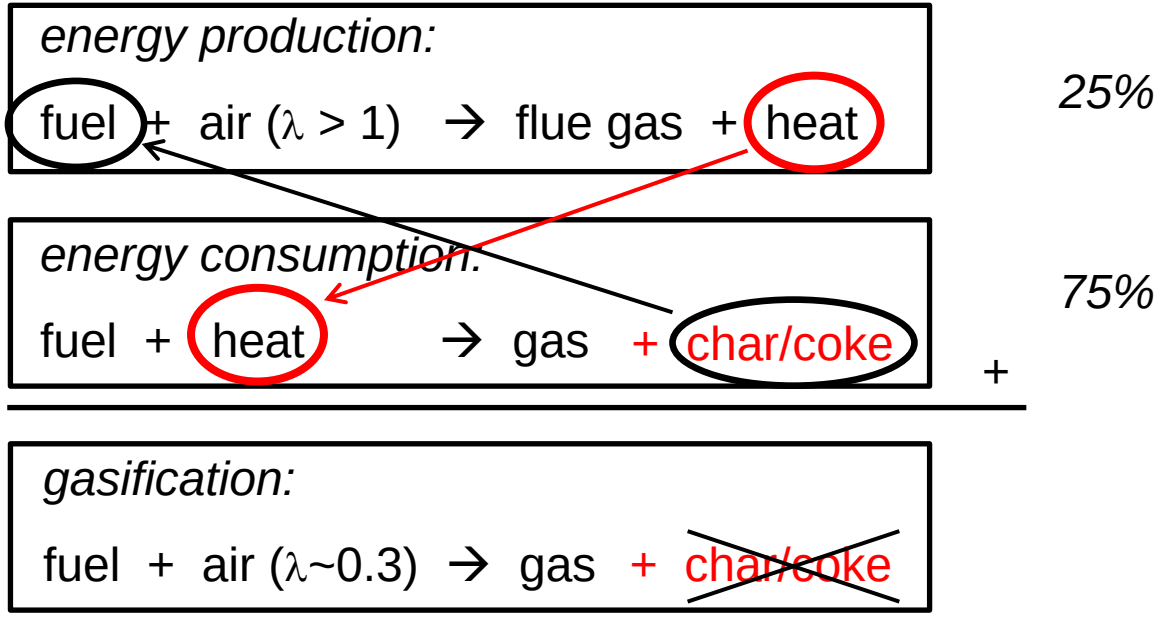
+

gasification:

fuel + air (λ~0.3) → gas + char/coke

SECOND GENERATION

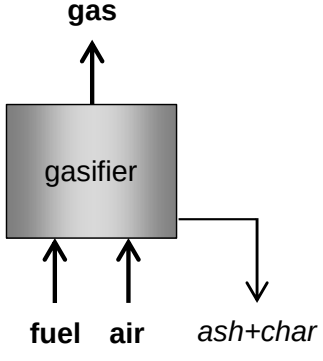
also called: indirect gasification



GASIFICATION
generations

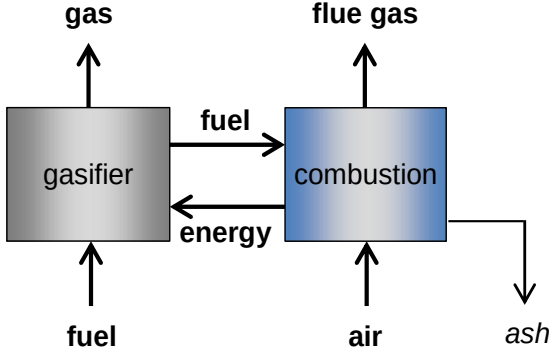
First generation (=direct)

- One reactor, one gas
- N_2-free gas requires ASU
- Incomplete carbon conversion
- High temperature, high steam, small fuel size, large residence time needed for acceptable conversion



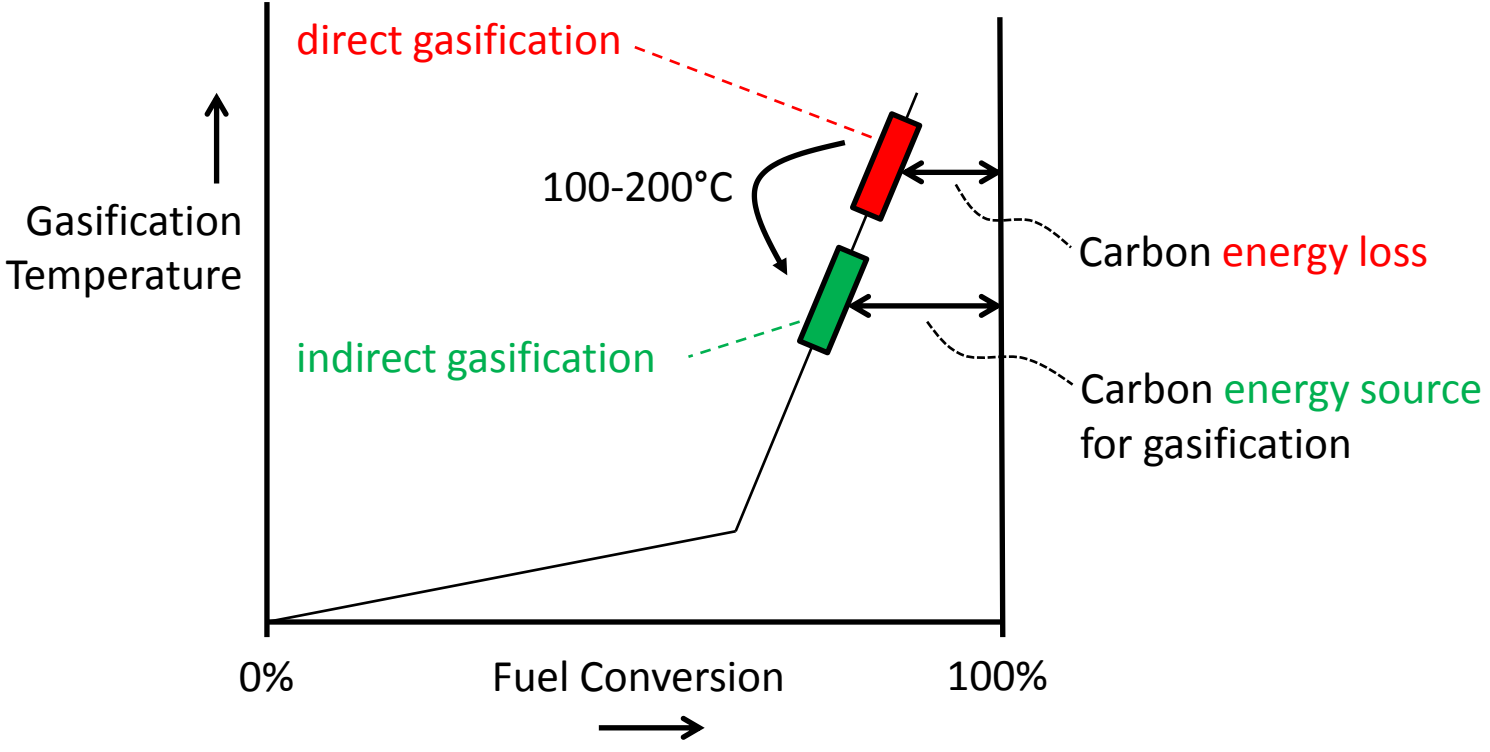
Second generation (=indirect)

- Two coupled reactors, two gases
- N_2-free gas without ASU
- Complete carbon conversion
- Additional degree of freedom: temperature, steam, fuel size, residence time



IN OTHER WORDS

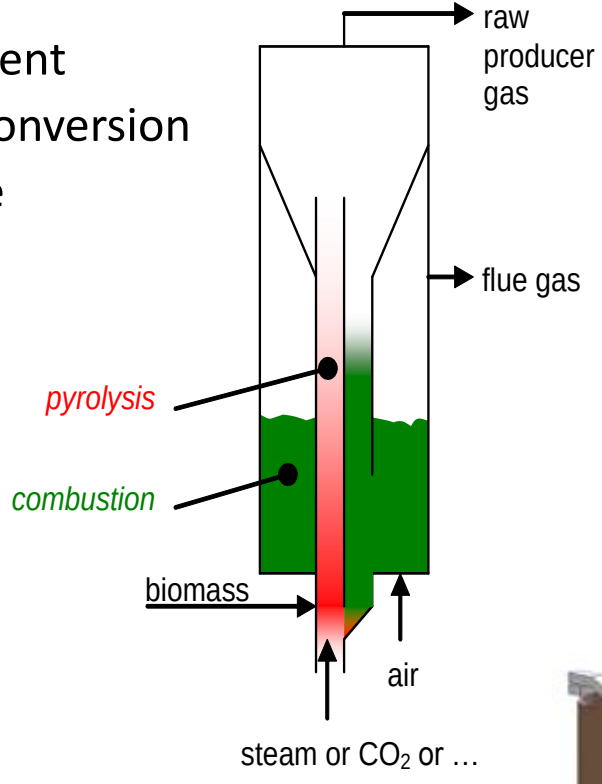
lower temperature, better efficiency, higher conversion

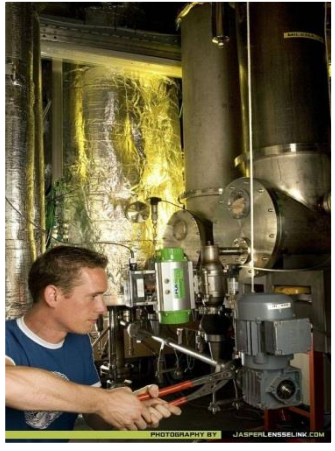


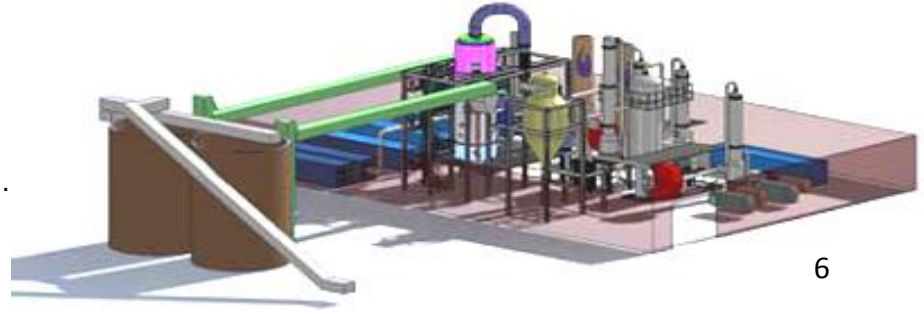
MILENA TECHNOLOGY

indirect gasification technology by ECN

- Highly efficient
- Complete conversion
- Fuel flexible
- Compact







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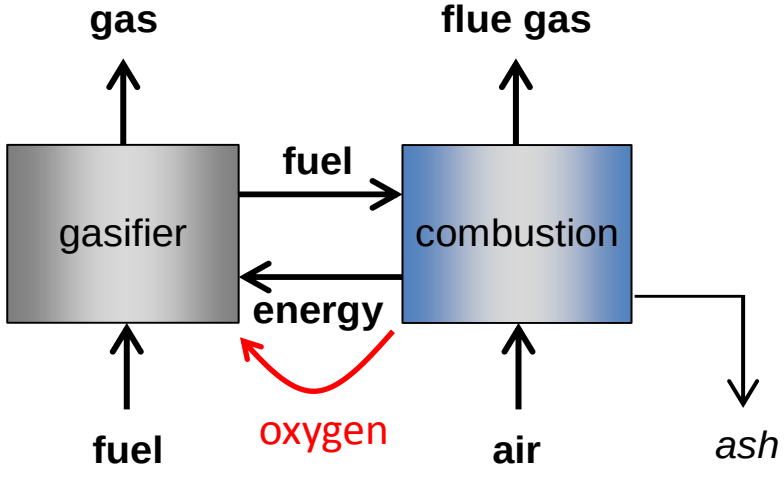
INDIRECT GASIFICATION

- Energy transport between the two reactors
- Bed material takes carbon from gasifier to combustor
  - Char flows with bed material
  - Tars adsorb on (porous) bed material
  - CO_2 transport through carbonates
- Bed material can take oxygen from combustor to gasifier



OXYGEN TRANSPORT

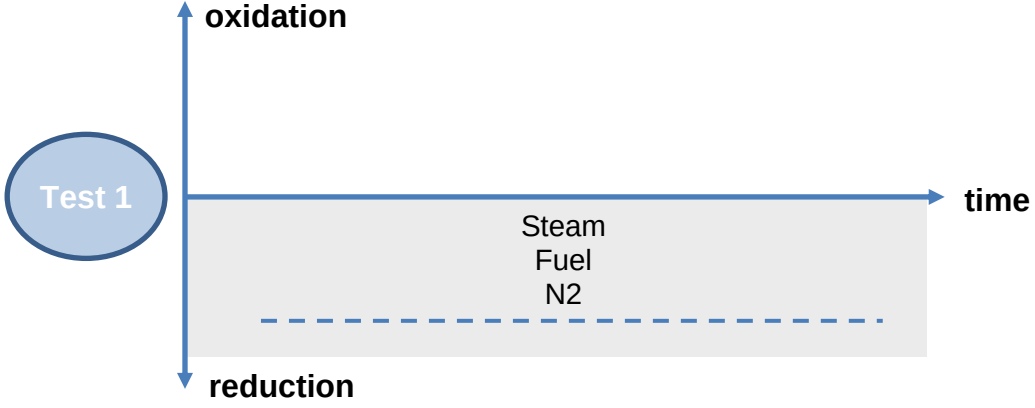
description of the tests

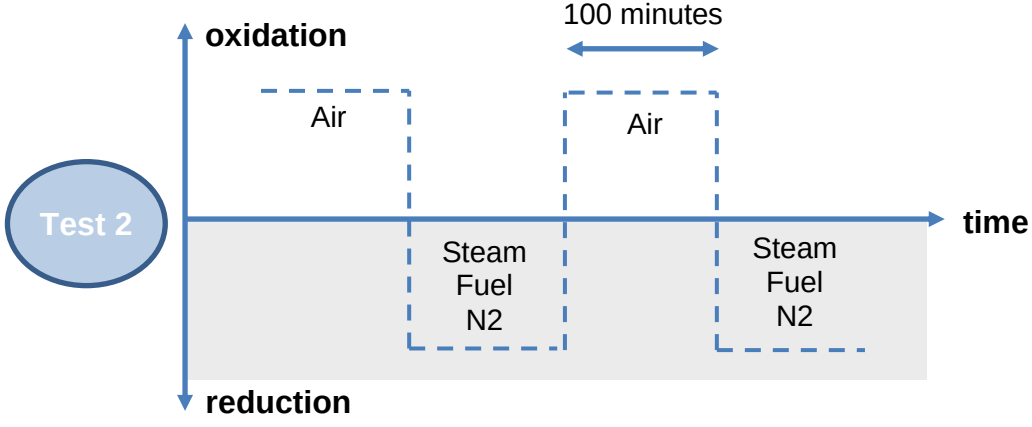
- Bubbling Fluidized Bed
- Olivine bed material (containing Fe)
- Clean wood fuel, 0.25 kg/h
- 880°C, 1 kg bed

- Two tests:
  - Test 1: only gasification
  - Test 2: intermittent gasification/combustion, 100 minutes cycle

OXYGEN TRANSPORT

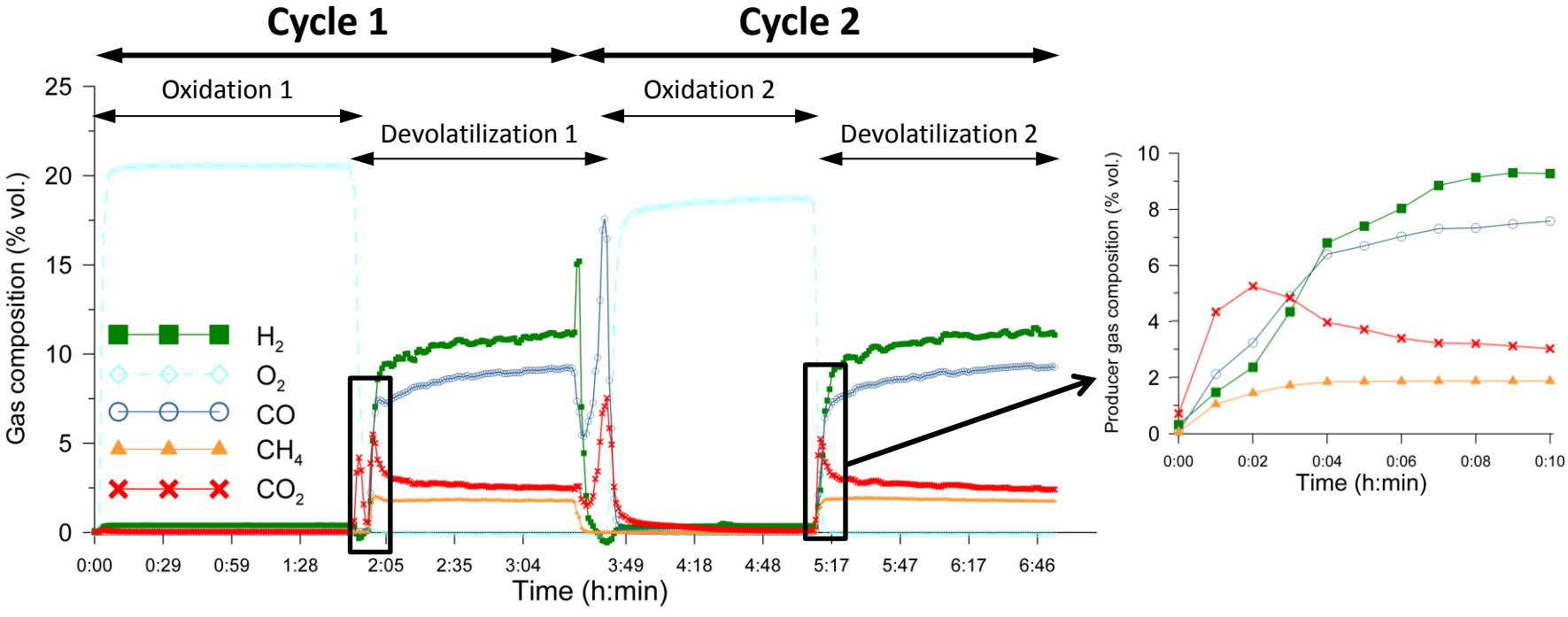
description of the tests





OXYGEN TRANSPORT

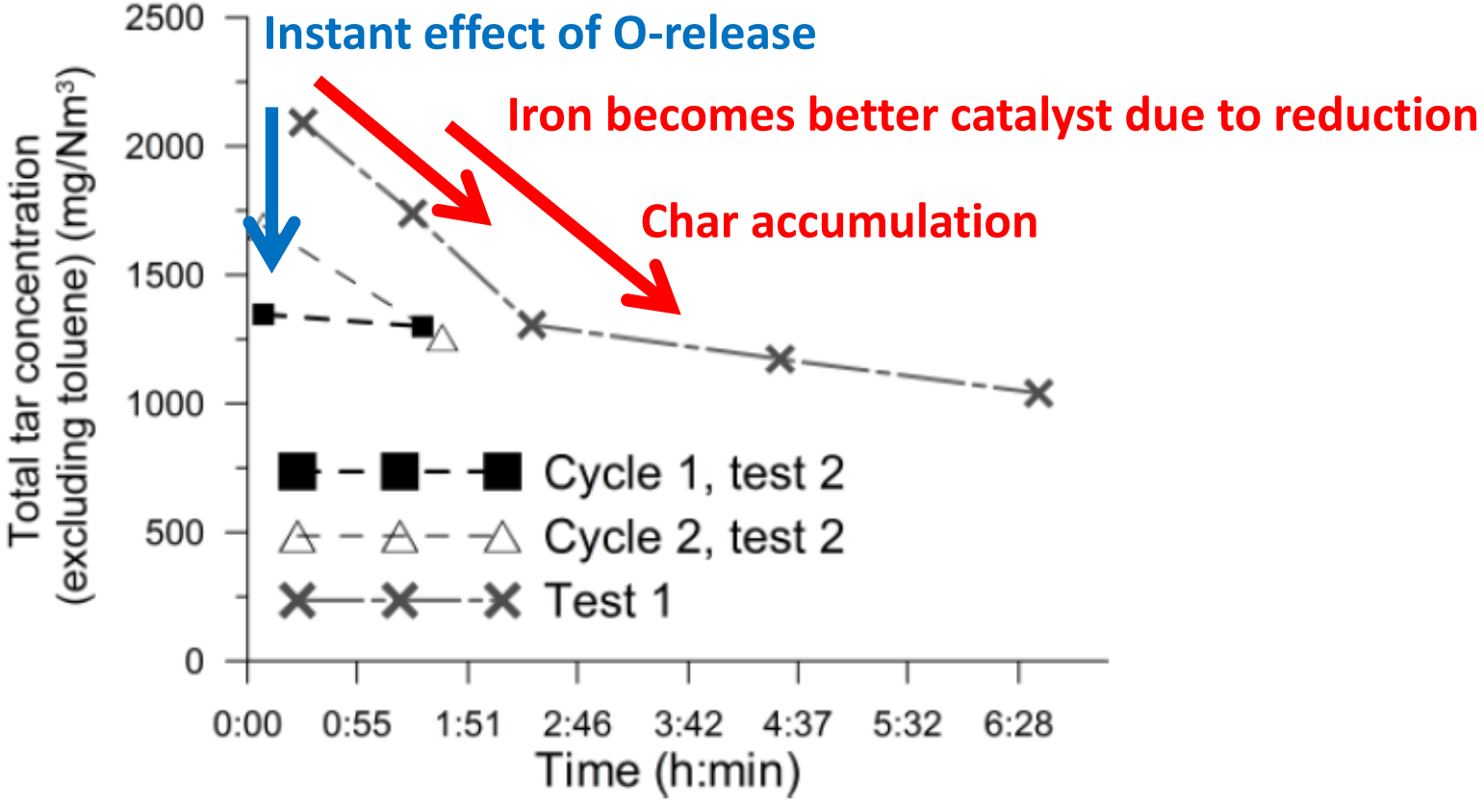
gas composition



Test 2

OXYGEN TRANSPORT

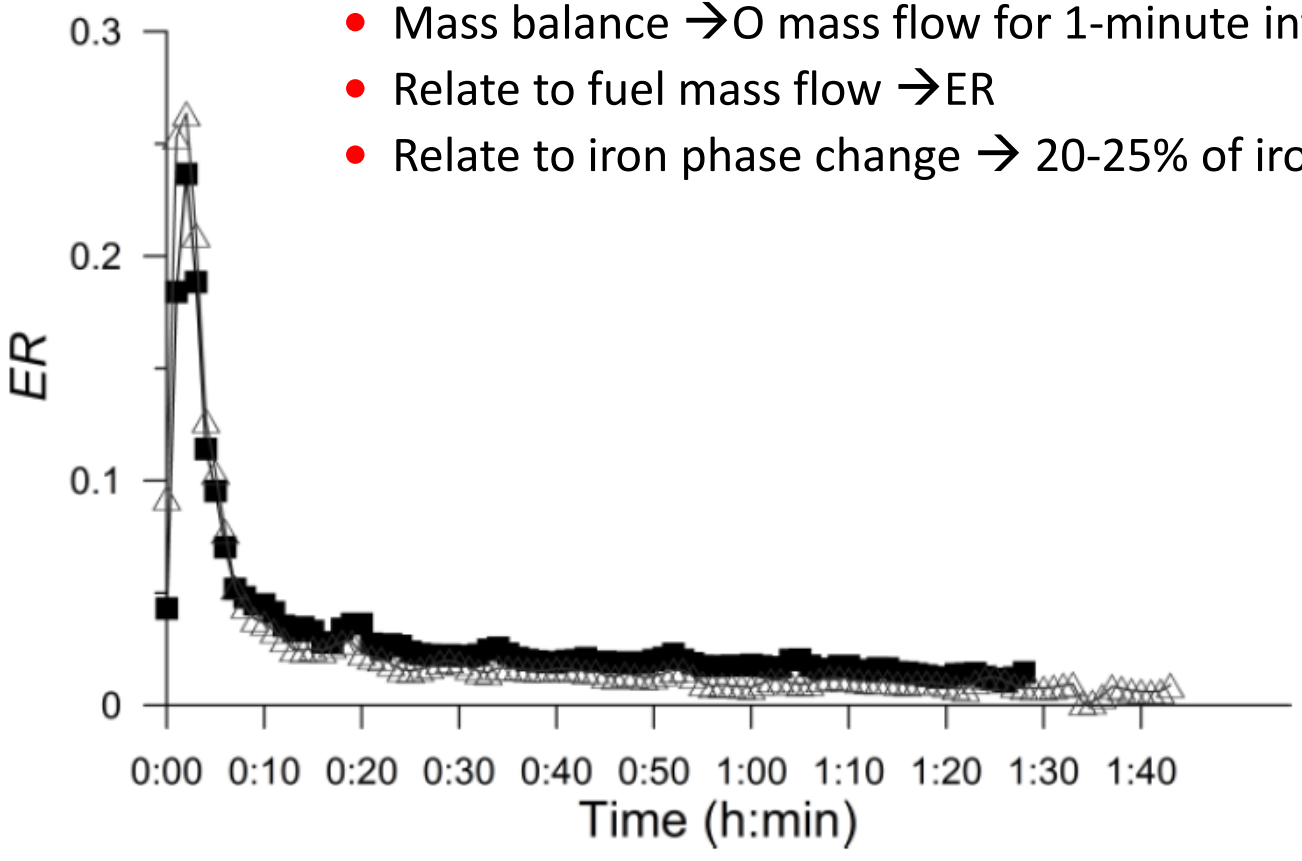
tars (by SPA method)



OXYGEN TRANSPORT

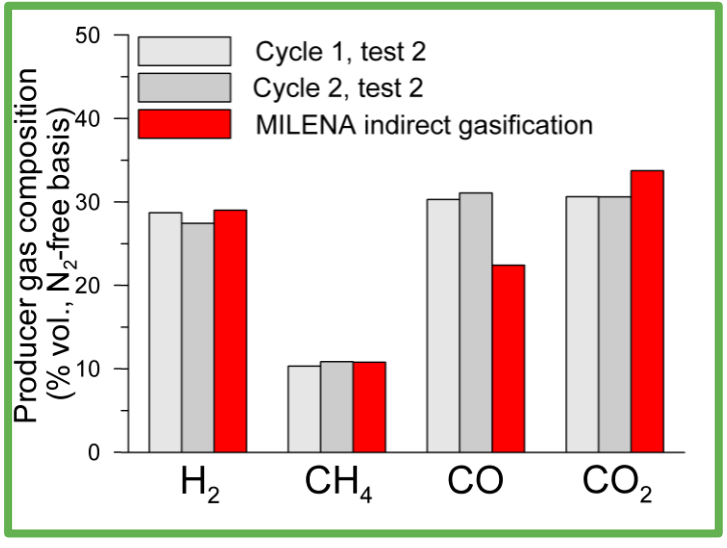
oxygen quantity

- Mass balance →O mass flow for 1-minute intervals
- Relate to fuel mass flow →ER
- Relate to iron phase change → 20-25% of iron acts as O-pump

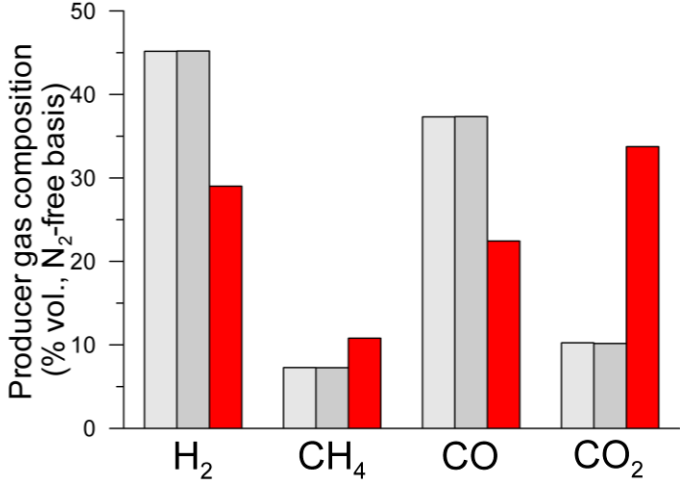


COMPARED TO MILENA

Test 2, first few minutes



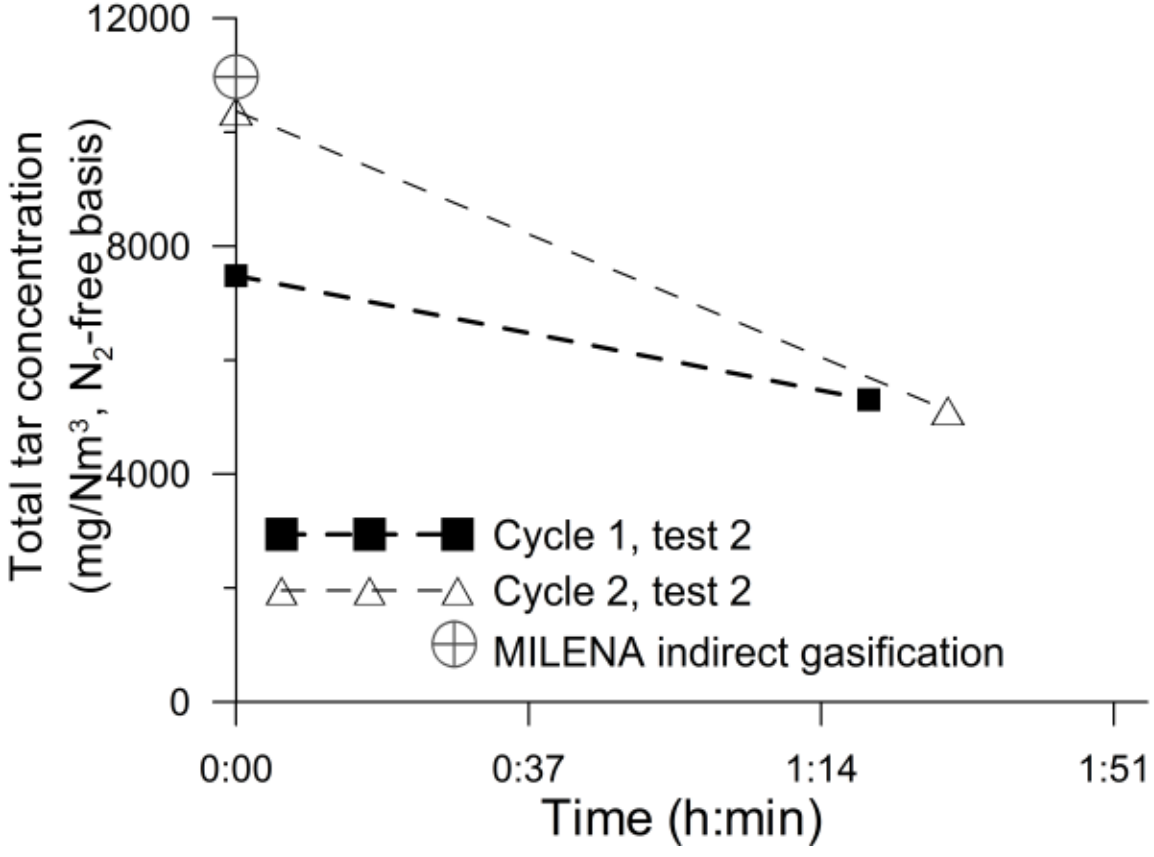
Test 2, after a while



MILENA operating conditions are equivalent to the initial point of maximum CO_2: olivine is kept at high oxygen transport capacity

OXYGEN TRANSPORT

compared to MILENA



CONCLUSIONS

- Indirect gasification offers degree of freedom compared to direct gasification, since unconverted carbon is not a loss: temperature
- Freedom to operate at low temperature means fuel flexibility

- Bed material in indirect gasification can transport oxygen through chemical looping
- This may add up to an ER of 0.2-0.3 during first few minutes of reduction
- This theoretically can supply all the required energy for gasification
- This also reduces tar:
  - By direct combustion of adsorbed tars on surface where iron reduces (O donor)
  - By increased gas phase reforming because of increased CO_2 and H_2O concentration
- MILENA is operated with fast reduction/short residence time: maximum oxygen transport

THANKS FOR THE ATTENTION

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