Process activated ilmenite as catalyst for cleaning of biomass producer gas

Huong N.T. Nguyen, Nicolas Berguerand, Henrik Thunman - Chalmers University of Technology, Division of Energy Technology

Background

Biomass gasification into a gaseous fuel is a promising technology for reducing the CO2 emissions and the dependency on fossil fuels. The raw gas produced mainly consists of permanent gases such as H2, CO, CO2, CH4, and light hydrocarbons but also an unacceptable amount tars that need to be mitigated to further upgrade the gas. Hot gas cleaning using catalysts is particularly attractive. With this technique, not only the tar concentration in the producer gas is reduced, but the gas composition can also be adjusted.

In contact with the raw gas, the metal oxide catalyst MeOx is reduced, but the gas composition can also be adjusted. Particularly, with this technique, not only the tar concentration in the producer gas is reduced, but the gas composition can also be adjusted. In particular, tar removal at the temperature of 800°C and fed with a raw gas from the Chalmers 2–4 MW indirect biomass gasifier. The reactor was operated in batch mode with alternating redox conditions to decouple the effect of oxygen transport and actual catalysis. Three levels of gas–solid contact time were investigated. Overall, the potential of using process activated ilmenite as a reforming catalyst for upgrading raw gas has been demonstrated. Moreover:

- Tar removal efficiency & tar decomposition pattern depend on the gas – solid contact time. 52% on tar-to-reformed gas basis achieved at the contact time of 1.1 s. The longer the gas – solid contact time, the higher tar removal efficiency.
- The gas composition was adjusted with an H2/CO ratio brought from 1 in the raw gas to almost 3, an interesting value if methanation is considered downstream.
- Nearly all C6H6 are converted at the higher RT.

Experimental

The ilmenite (FeTiO3) used here was collected in the fly-ash from the Chalmers 12 MW circulating fluidized bed boiler. The fraction used was in the range 45–90 µm. The idea was to test the catalytic ability of ilmenite towards raw gas upgrading; in particularly tar removal at the temperature of 800°C and

In contact with the raw gas, the metal oxide catalyst MeOx is reduced, but the gas composition can also be adjusted.

Conclusions

Ilmenite fines from the Chalmers 12 MW circulating fluidized bed boiler were used as a tar reforming catalyst in a bubbling fluidized bed reactor operated at 800°C and fed with a raw gas from the Chalmers 2–4 MW indirect biomass gasifier. The reactor was operated in batch mode with alternating redox conditions to decouple the effect of oxygen transport and actual catalysis. Three levels of gas – solid contact time were investigated. Overall, the potential of using process activated ilmenite as a reforming catalyst for upgrading raw gas has been demonstrated. Moreover:

- Tar removal efficiency & tar decomposition pattern depend on the gas – solid contact time. 52% on tar-to-reformed gas basis achieved at the contact time of 1.1 s. The longer the gas – solid contact time, the higher tar removal efficiency.
- The gas composition was adjusted with an H2/CO ratio increased from approximately 1 in raw gas to slightly higher than 3 in the reforming gas.
- No deactivation of the ilmenite bed was observed during the reducing raw gas operation (>80 min). Thus, high rate of particle circulation for regeneration in an up-scaled system probably is not required.
- Using ilmenite fines for secondary tar reforming of raw gas and/or in the gasifier for primary tar reforming seems possible.

Results

- Tar reduction up to 52% at the higher RT (gas upgrading basis).
- From a RT of 5 s, one could expect full conversion of all tars but benzene.

Conclusions

Ilmenite fines from the Chalmers 12 MW circulating fluidized bed boiler were used as a tar reforming catalyst in a bubbling fluidized bed reactor operated at 800°C and fed with a raw gas from the Chalmers 2–4 MW indirect biomass gasifier. The reactor was operated in batch mode with alternating redox conditions to decouple the effect of oxygen transport and actual catalysis. Three levels of gas – solid contact time were investigated. Overall, the potential of using process activated ilmenite as a reforming catalyst for upgrading raw gas has been demonstrated. Moreover:

- Tar removal efficiency & tar decomposition pattern depend on the gas – solid contact time. 52% on tar-to-reformed gas basis achieved at the contact time of 1.1 s. The longer the gas – solid contact time, the higher tar removal efficiency.
- The gas composition was adjusted with an H2/CO ratio increased from approximately 1 in raw gas to slightly higher than 3 in the reforming gas.
- No deactivation of the ilmenite bed was observed during the reducing raw gas operation (>80 min). Thus, high rate of particle circulation for regeneration in an up-scaled system probably is not required.
- Using ilmenite fines for secondary tar reforming of raw gas and/or in the gasifier for primary tar reforming seems possible.

Background

Biomass gasification into a gaseous fuel is a promising technology for reducing the CO2 emissions and the dependency on fossil fuels. The raw gas produced mainly consists of permanent gases such as H2, CO, CO2, CH4, and light hydrocarbons but also an unacceptable amount tars that need to be mitigated to further upgrade the gas. Hot gas cleaning using catalysts is particularly attractive. With this technique, not only the tar concentration in the producer gas is reduced, but the gas composition can also be adjusted.

In contact with the raw gas, the metal oxide catalyst MeOx is reduced, but the gas composition can also be adjusted.

Conclusions

Ilmenite fines from the Chalmers 12 MW circulating fluidized bed boiler were used as a tar reforming catalyst in a bubbling fluidized bed reactor operated at 800°C and fed with a raw gas from the Chalmers 2–4 MW indirect biomass gasifier. The reactor was operated in batch mode with alternating redox conditions to decouple the effect of oxygen transport and actual catalysis. Three levels of gas – solid contact time were investigated. Overall, the potential of using process activated ilmenite as a reforming catalyst for upgrading raw gas has been demonstrated. Moreover:

- Tar removal efficiency & tar decomposition pattern depend on the gas – solid contact time. 52% on tar-to-reformed gas basis achieved at the contact time of 1.1 s. The longer the gas – solid contact time, the higher tar removal efficiency.
- The gas composition was adjusted with an H2/CO ratio increased from approximately 1 in raw gas to slightly higher than 3 in the reforming gas.
- No deactivation of the ilmenite bed was observed during the reducing raw gas operation (>80 min). Thus, high rate of particle circulation for regeneration in an up-scaled system probably is not required.
- Using ilmenite fines for secondary tar reforming of raw gas and/or in the gasifier for primary tar reforming seems possible.