IEA Bioenergy

One of the most widespread applications of producer gas is the production of power, heat or mechanical energy through gas engines. Gas engines have been widely used for many years, offer higher electrical efficiencies at small scales than Rankine steam cycles from biomass combustion, and allow fast start-up and part load operation. But the special features of producer gas impose specific requirements on the engine configuration.

PRODUCER GAS AS ENGINE FUEL

Producer gas is a mixture of CO, H_2, CH_4, CO_2, H_2O and N_2 (if air is used as gasifying agent). Therefore, it has a lower heating value than e.g. natural gas. Composition affects flame speed and temperature, crucial parameters in the performance of internal combustion engines (ICE).

DISTRIBUTION OF ENERGY IN AN ICE

Gas engine

The energy of the producer gas entering a gas engine (100%) is distributed as follows:

- ~42% electricity.
- ~23% heat in exhaust gases at 430 – 500ºC.
- ~35% in cooling water at 90ºC.

Some of the heat produced can be recovered for production of heat or cold. Gas engines can be used for combined heat and power (CHP) applications.

ICE CONFIGURATIONS

Producer gas can be used both in spark-ignited (Otto) engines and compression (Diesel) engines.

Spark ignition engines:

- ~ 25% capacity decrease compared to natural gas engines.
- High knock resistance of producer gas due to inert content (N_2, CO_2) and higher flame speed compared to natural gas.
- Few modifications for adaptation to producer gas.
- Ignition advance 20-24° (5-15° higher than gasoline engines).
- Two types: stoichiometric combustion, and lean-burn (reduction of T and NO_x emissions).

Dual-fuel engines:

- Small amount of oil (3 – 12 %) instead of spark plugs to start combustion.
- Relatively easy adaptation: modification of injection system.
- Fuel flexibility (interchangeability gas/diesel).
- Attractive for large units (5 – 40 MW), whenever fuel flexibility is important, or for gases with low content of CH_4 and/or low heating value.

PRODUCER GAS REQUIREMENTS FOR ENGINE APPLICATIONS:

$< 45°C$
Tar dew point

$< 50\ mg/Nm^3$
Particle content

NH_3, HCl, H_2S
Contaminant removal (meeting of emission limits).

IMPORTANT:

- **Previous tar and dust removal of gas**.
- T gas > T tar dew point: **avoid tar condensation**.
- Optimization of **engine control systems** (fluctuations of producer gas composition/flow rate).

EXAMPLES OF GAS ENGINES IN GASIFICATION PLANTS

	Harboore, Denmark	Gussing, Austria
Thermal input [MW]	3.5	8
Feedstock	Wood chips	Wood chips
Gasifier	Updraft fixed bed	FICFB indirect fluidized bed
Engine	2 x GE Jenbacher JMS 320 GS	1 x GE Jenbacher JMS 620 GS
Electric output [kW]	1000	2000
Thermal output [kW]	1900	4500
Engine air/fuel ratio, λ	2.2-2.4	2.2-2.4
Engine electric efficiency [%]	40	39
Overall electric efficiency [%]	28	25
Overall efficiency [%]	82.9	80.7