A Status Report on the Babcock Volund Biomass Gasification Project
By Bjorn Teislev, Babcock Volund, Denmark
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Introduction

Since 1988 Babcock & Wilcox Volund (BWV) has devoted considerable efforts at developing a biomass updraft gasification Combined Heat and Power (CHP) technology for industrial application. Today, the Company commercially offers plants for a fuel input up to about 16 MW_{TH} with power efficiencies in excess of 30% and simultaneous delivery of hot water for district heating.

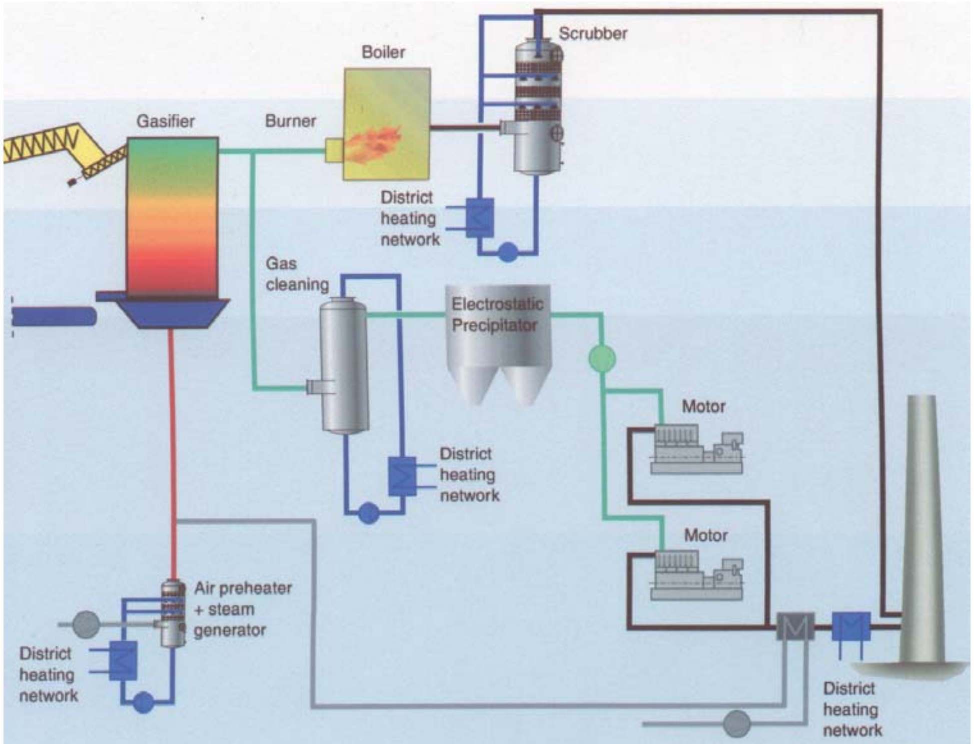
A significant part of the work has been related to the cleaning of the gasifier product gas for use in gas engines and a reliable solution based on gas cooling, wet electrostatic precipitation and a novel technology for cleaning the resulting tar contaminated water has been demonstrated.

Further, the technology has been automated to a level comparable with more old fashioned technologies for biomass based power generation and the overall environmental performance is significantly improved compared to these steam generation based approaches.

The initial work was carried out at a – nominally – 1 MW_{TH} updraft gasifier located at the Kyndby Power Plant (Denmark) and partly sponsored by ELKRAFT A.m.b.A. power utilities and the Danish Energy Agency. The reactor was based on a design from the Company Keramische Industrie Bedarfs and the aim was to develop gasification of straw, which is the most abundant biomass in most European countries. However, this was proven quite difficult because of the low ash melting points for this fuel and BWV R&D Centre soon concentrated their efforts on the gasification of wood-chips.

BWV now – since January 1994 – has a (maximum 6 MW_{TH}) wood-chips updraft gasifier in commercial operation at Harboore (Denmark) for the provision of district heating for the municipality. Since then, the aim has been to convert this plant for Combined Heat and Power (CHP) generation using gas-engines powered by the gasifier.

The main task has been to clean the product gas to a level acceptable to an internal combustion engine and initially BWV R&D Centre used large efforts to clean the product gas for tars and dust in catalytic tar crackers and candle filters. The work was carried out in co-operation with the Danish Technological Institutes and partly sponsored by the Danish Energy Agency. The approach was not successful, and – because in the meantime we optimised the gasifier to produce a gas with a stable tar content and a low dust content – we concentrated on the development of gas scrubbers/coolers and associated waste-water cleaning.



Today, the cleaned gas quality and also the problems connected with effluent waste-water have been verified and 2 gas-engines – each 768 kW_E power (down-rated 1000 kW_E natural gas engines from Austrian manufacturer Jenbacher) – are now in more or less continuous operation.

Babcock & Wilcox Volund gas cleaning : The raw gas derived from the BWV updraft gasifier is available (water-saturated) at a temperature of about 75°C and has a (dry) composition: 18 – 19% H_2, 23 – 25% CO, 10 – 12% CO_2 and 5 – 6% CH_4. In addition the raw gas has a tar-content of 0.060 – 0.080 kg/Nm^3 .

In the gas conditioning system the product gas is cooled – using the district heating grid – to about 45°C, during which a considerable amount of water/tar condensate and also aerosols (microscopic water/tar droplets) are released. The aerosols are subsequently removed from the gas stream by means of a wet electrostatic precipitator. After this treatment the gas is clean and applicable for the gas-engines (both tar and dust contents are below 25 mg/Nm^3) and is boosted to a slightly higher pressure to accomplish engine inlet pressure regulation

At full engine output, the amount of tar contaminated waste water from the Harboore gasifier amounts to about 1200 litres/hour containing about 18% of various organic acids and tars. The waste water clean-up system comprises:

- In a separator (a so-called coalescer) about 80 litres/h of heavy (high molecular) tars are separated. This tar has a gross calorific value of 26 – 28 MJ/kg and is used for District heating peak load and also re-injection into the gasifier reaction zones
- In a process developed by BWV (TARWATC – patents pending) the remaining waste water is cleaned before discharge into the sewerage system. The tar contaminated water is evaporated and the light (low molecular) tars are separated. The traces of tar remaining in the steam phase is cracked at a high temperature using heat derived from the separated light tar (about 100 litres/h having a gross calorific value of 13 – 15 MJ/kg)

The contaminated waste water inlet for TARWATC may contain 15 – 20 g/litre of organic acids (causing an acidity about pH = 2), 5 – 10 g/litre of phenols (and similar compounds) and a total organic carbon content (TOC) of 40 – 50 g/litre. The clean condensate from TARWATC has a TOC below 15 mg/litre, a total phenol content below 0.15 mg/litre and an acidity of pH = 6.90 – 7.10 (thereby eliminating need of neutralisation before discharge)

BWV R&D Centre has carried out pilot-scale experiments with the process at a capacity of 50 kg/h which was operated for prolonged periods. All experiments have proven successful (regarding environmental performance, corrosion and fouling) and BWV is presently in the process of commissioning a full scale implementation at the Harboore gasifier, capable of handling all tar contaminated water from the product gas clean-up system.

At nominal conditions the wood-chips fuel input at Harboore is 4800 kW_{TH}, which is transformed into 1500 kW_E power and 3200 kW_{TH} district heating (at a forward temperature 90^{o}C and return temperature 40^{o}C). The power efficiency (from wood-chips to electricity) is about 31%. The wood-chips have a typical size of 10 to 80 mm (however, the fuel feeding system may be modified to accept much larger "particles"). For the operation with engines it is further required, that the fuel humidity must be in the range 30 – 55% to avoid fouling problems in the gas clean-up system (however, the gasifier itself can handle fuel moisture down to practically zero).

The annual operation of the Harboore plant amounts to more than 8000 hours and is handled by two persons (which are also responsible for managing the district heating grid – about 750 subscribers)

The exhaust from the gas-engines has been analysed and the following results were achieved under full operational load (two measurement sessions – each one day) – referred to a flue gas O_2 of 5%: CO (mg/Nm^3,dry)1500 – 1800, NO (mg NO_2/Nm^3,dry) 400 – 500, UHC (CH_4) (mg C/Nm^3,dry) 50 – 60, Naphthalene (μg/Nm^3,dry)3 – 5 and other PAH's (μg/Nm^3,dry) 1 - 2

Recently, Jenbacher has – during prolonged tests using a pilot-scale catalyst system – achieved a reduction in the CO to 500 – 700 (mg/Nm^3,dry) and therefore the plant is now capable of meeting the Danish environmental regulations.

Concerning the ash from the Harboore plant, the wood-chips (which is harvested from near-coastal plantations) has an inherent ash content of about 0.6%. The ash leaving the gasifier has been analysed having a carbon content of about 3%. and has been tested negative for dioxine and PAH's.