Schemes and New Developments in Combinations of Gasification with Fuel Gas Cleaning for Power Generation in Piston Gas Engines and Gas Turbines

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Schemes and new developments in combinations of gasification with fuel gas cleaning for power generation in piston gas engines and gas turbines

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In the contribution, possibilities are presented and discussed in details, how to employ the internal combustion engines and gas (combustion) turbines or their suitable combination for producing the electric power and heat from the gas produced by the partial oxidation (gasification) of biomass and alternative solid fuels. Requirements are also presented for the quality of burned gas, the limit contents of the main undesirable components (tar and dust) and methods for reducing their amounts with the aid of primary and secondary measures. A certain problem of the combustion engine utilized for the combustion of low-calorific gas with a high content of CO, is to ensure low emissions of CO. Therefore, methods and possibilities of reducing the emissions of CO and NOx are also discussed in this contribution. Application examples of the combustion engines, operational experience are presented from small gasification units located in Czech Republic.

By application of the modern combustion engines, the increase of efficiency in the production of electric power and heat can be attained. The overall efficiency of electric power production (η_{tot}) is the product of production efficiency of the fuel gas by gasification (η_{ce}) and the efficiency of the co-generation unit (η_k) realized by an engine-generator. The use of modern combustion engines with integrated turbo-chargers enables to attain the efficiency parameters comparable to those with conventional combustion technologies using the steam cycle. In the engine combustion of fuel gas with a LHV (lower heating value) 5.5–6.5 $MJ.m^{-3}$, the electric efficiency (η_k) as high as 37 % can be attained with the top modern engines. When standard gasification generators (moving bed con-current, counter-current, fluidized bed) with the recuperation of heat of the produced gas are applied, the cold gas efficiency of fuel gas production (η_{ce}) can reach values about 70 %. Under these conditions, the overall efficiency (η_{tot}) of the power generation system reaches a value exceeding 25 % at the units considerably smaller than the comparably efficient units with the steam cycle (with the steam turbine).

Needed installation of an additional cleaning system for tar and dust particles removal increases the overall installation and operational costs. In combination with low reliability and removal efficiency of tar, it belongs to the main obstacles to commercial use of the combustion (gas) engines and is the main cause of commercial failure of similar projects in small scale gasification based co-generation.

The starting point of future applications of the gasification units in combination with the engines is the use of more efficient gasification systems employing the principle of in-space separated pyrolysis and partial oxidation of the released volatile combustibles with subsequent gasification of the residual solid carbon. These systems enable to increase the efficiency of fuel gas production (η_{ce}) to values 80 - 90 % (according to the construction). Considerable advantage of the use of the multistage generator is also the production of gas with a lower content of dust and tar (< 50 mg/m^3). At combustion of the fuel gas in modern turbo-charged engine, it is thus possible to attain the overall electric efficiency (η_{tot}) about 32 %. Although the prototype of the two-stage generator (concept Viking) was developed already before the year 2000 , its commercial realization with higher throughput (power) was not successful.

In our contribution, it is also mentioned a new and very efficient conception of more-stage gasification system developed and realized by TARPO Ltd. (CR) in the form of a prototype with an output of 300 kW_t. The unit is located on the company grounds, in the small town Kněževes not far from Prague. In the mentioned unit, basic process technological parameters of the system, reliability of the elements of the pyrolysis unit and partical oxidation chamber were tested in long-term operation. In the course of tests the composition and quality of the produced gas and the contents of tar and dust were examined. Different methods of the after-cleaning of gas and the operation of modernized combustion engines and the influence of the gas composition on the operation of modernized combustion gas engines (e.g. type 6S160, producer ČKD Hořovice, CZ).

We will present also characteristics of another stage of the practical realization of the multi-stage technology of gasification (an installed more efficient version of the multistage generator). Combustion of the producer gas after removal of dust in hot (ceramic) filters (390-450°C) is carried out in two modern co-generation units J316GC (Jenbacher AG) with an overall electric output 2 x 550 kW_{el}. The overall efficiency of electric power production attains at least 32 % related to the energy contained in the feedstock (raw wood chips).

Power generation based on fuel gas from coal gasification and biomass is dependent on operational pressure of the gasification process. Atmospheric pressure processes of gasification are not suitable for the combination with gas (combustion) turbines, because the produced gas has to be cooled and compressed. Pressurized gasification (fluidized bed or moving bed) is technically much more demanding than atmospheric processes. The produced gases must be prior to utilization in gas turbine properly cleaned, e.g. the vapours of alkali and heavy metal compounds must be removed and concentrations of HCl and sulfur compounds must be substantially decreased etc. For the sake of pressurized gasification and combination with gas turbine, the entrained flow gasification of fuels with LHV above 20 MJ/kg (mainly coal, partly liquid waste fuels and co-gasification with PET-coke, biomass and waste) is applied. As rather an exception, the pressurized gasification of coal by oxygen-steam mixtures in moving beds is operated (IGCC facility at Vřesová, Sokolovská uhelná a.s., CZ). The produced fuel gas must be, however, properly cleaned (dust, tar and sulfur compounds removal) prior to utilization of fuel gas in gas turbines

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