Improving the Efficiency of Biomass-Fired CHP

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Relevance of the biomass use in the energy sector significant increase in the last decade, due to the cost of traditional fossil fuels. In many countries, one of the most important decisions made in recent years in order to improve energy security, is to increase the use of local and renewable energy resources. Increase ratio of wood, peat, straw, municipal waste, sewage and waste energy to produce electricity and thermal energy are foreseen. Also the introduction of biogas, wind energy and solar thermal systems, heat pumps, construction and rehabilitation of hydropower plants.

The main purpose of this work is the development and commercialization of technologies for the creation of biomass fired combined power plant and output technology for industrial production. The use of biomass will let to create small-scale CHP with high efficiency, to achieve a system fuel economy and reduce emissions of greenhouse gases. This work can be considered as part of a comprehensive program for the development of bio-energy in Belarus (and other CIS countries) based on the use of renewable energy sources.

For the combined production of electricity and thermal energy in this context, the most appropriate use peat, wood , pellets , straw and agricultural waste as a fuel. Currently, the most used cogeneration technologies are based on water or organic fluid steam usage in various types of heat engines (reciprocating and screw machines, turbines). These technologies are well tested and fairly well understood. In the CIS countries, recently special interest to the technology of organic Rankine cycle (ORC) was shown. A characteristic feature of ORC is use a working organic fluid, which thermal and physical properties allow to obtain a higher electrical efficiency compared to the water steam. If the boiler equipment on local fuels produced in the territory of the CIS countries, the ORC turbine generator manufacturers do not. In the world there is a relatively small number ORC-manufacturers Turboden (Italy), GMK (Germany), Adoratech (Germany). It is well known that the cost of power equipment not determined its production cost, but fuel cost. So today the cost of ORC - generating unit is about 2.0 thousand euro per kW of installed capacity, and taking into account the cost of the boiler and auxiliary equipment is 4.5-6 thousand Euro per kW of installed capacity.

One of potentially promising areas for biomass use for energy purposes is the use of externally-fired gas turbine (EFGT).The structure of gas turbines similar to the open-type gas turbine. The difference is that the heat supplied to the gas turbine produced not by direct air combustion, but using a high-temperature heat exchanger. It is possible to use two options:

- for a completely closed cycle air, helium or hydrogen are used as a working fluid.
- if air is used as a working fluid, after EFGT it can be used for biomass fire instead reuse cycle. In this case, the working fluid is constantly changing, and the compressor all the time gets fresh air.

The EFGT unites have two advantages. On the one hand, the utilization of waste heat from the turbine in a recuperative process increases the efficiency and, on the other, the possibility of burning "dirty" fuel.

In our opinion, units combining several technologies deserve consideration. For example, the combination of a EFGT and ORC turbine.

Our analysis of this biomass fired technology, showed the need for research on the development of technological schemes of combined technologies and equipment for Biomass fired combined power plant, which electrical efficiency can reach 25 - 40 %, and allow them to compete with traditional technologies on natural gas. These results were obtained according to the numeric experiment and show prospects of the considered energy application.

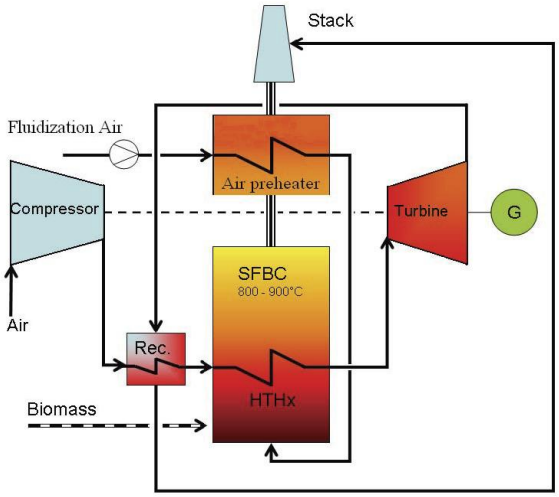

Fig. 1 – EFGT-Cycle.

In our opinion, the main problem in the creation of biomass fired EFGT-Cycle ORC unit is in the construction and manufacture of heat transfer equipment, such as high temperature heat exchangers (biomass fired exhaust gases /working fluid gas turbines).

Also subject of further investigations is working fluid selection of EFGT cycle and for this unit in particular. The working fluid must have good heat-transfer properties, low aerodynamic resistance, allow minimizing overall size of gas turbine and compressor, being capable of air substitute in case of emergency, being cheap and available.

Currently, based on nuclear reactor operating experience, there are several substances and mixtures, that could be used in EFGT technology. This working fluids and mixtures have one or several advantages as abovementioned. These are first of all helium He, air. Also argon Ar, neon Ne, crypton Kr, xenon Xe, carbon dioxide CO2, nitrogen N2, nitrogen oxide N2O4, sulfur hexafluoride SF6 [3]. And mixtures [4] as (He+CO2), (He+SF6), (He+C6F6), (He+N2), (He+Xe).

Conclusions

There are limited generating technologies that produce heat and power using biomass as fuel. Parts of these technologies are at research and development stage, others – commercialized.

Creation of effective biomass fired combined power plant, based on an externally-fired gas turbine help to achieve 25 - 40 % electrical efficiency that made such units attractive even in comparison with the gas fired CHP.

The potential customers for biomass fired combined power plant can be as small farms, settlements, located in energy-deficient areas and large enterprises, heading for the natural replacement of fossil fuels with renewable, environmentally friendly fuel.