The biomass combustion and preparation technology development in anthracite coal fired boiler units

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The biomass and coal (anthracite) co-combustion (CCBC) research began back in 2007 under the NATO grant in collaboration with the National Energy Technology Laboratory - Department of Energy of the USA. As a result of experimental tests, at laboratory plants, at VGP-100 pulverized combustion plant of coal productivity up to 50 kg/h and by methods of mathematical modeling, the presence of the synergistic effect under CCBC of 8-10% biomass with anthracite was confirmed, that is the improvement of the anthracite dust ignition and combustion conditions due to heat generation during biomass volatile combustion. The reasonability of the separate preparation and supply of the anthracite dust and crushed biomass to boiler considering the different grinding properties and coal pulverization safety requirements, as well as the optimum size of biomass particles during grinding (particle size 2-2, 5 mm), was found. In the framework of this work, the technical solutions regarding the structural scheme of the unit for unloading, storage, drying and crushing of wood or agro-cultivated pellets under conditions of Trypiska TPP operation, the burner design of the TPP-210A boiler unit upgraded for anthracite co-combustion and 10% biomass part by heat rate, were developed, the boiler checking thermal calculation and furnace zonal thermal calculation were made.

The biomass pellets delivery is carried out by motor transport in big bags, hoppers or grain carriers. After their unloading, the pellets are pneumatically transported to storage bins. To remove excess moisture, a drum dryer is installed. The pellets' grinding to required size is made with help of a hammer mill from where the biomass enters the usage bin. The biomass usage bin is located in bin-deaerator compartment of the main building in power unit foot-print. The usage bin is equipped with screw feeders to dispense the required amount of biomass into appropriate pipelines with ejectors which it supplies to combined coal-biofuel burners.

For TPP 210A boiler, the burner draft for pellets and anthracite co-combustion is developed. The biomass supply is foreseen in central channel of existing boiler burners. This channel will maintain a constant air flow, the speed of which will ensure a stable supply of the fuel and the pellets consumption will be regulated by the feeder.

To assess the co-combustion impact on the performance of the furnace and boiler operation as a whole, the calculation was made by two methods using the Normative Boiler Calculation Method and the ANSYS FLUENT Program.

The zonal thermal checking calculation of the TPP-210A boiler furnace provides an opportunity to estimate the co-combustion effect on the boiler operation reliability, namely, the temperature in the LPF (low part of the furnace), on which depends the wet slag flow and temperature at furnace outlet. The calculation was made for 3 types of biomass and anthracite typical for Ukraine, which corresponds to design calculation (Table 1). The results of calculations (Table 2) confirm that under the CCBC with anthracite the conditions of the furnace reliable operation of the stable WSR (wet slag removal) and without heating surface slagging risk, are ensured; the furnace outlet temperature in these regimes provides a reliable boiler operation; the zone 1 outlet temperature provides a stable slag yield.

Table 1 – Composition and properties of the anthracite and solid biomass used in calculation

Component	Anthracite	Pine tree pellets	Agricultural pellets (of agricultural straw)	Pellets of sunflower husks
W^r	7,5	8,7	8,4	9,3
A^r	19,0	0,37	5,63	8,8
C^r	68,0	47,5	43,7	41,2
H^r	1,3	5,8	5,4	5,09
O^r	1,9	38,2	37,22	35,06
N^r	0,6	0,13	0,46	0,43
$S^r_{зar}$	1,7	0,027	0,13	0,12
Q_i^r, kcal/kg	5790	4211	3720	3538

The calculations of the temperature fields and coke residue burnout of the pellets and anthracite in the TPP 210A boiler furnace were obtained as a result of the ANSYS FLUENT Program package using with input data of the draft coal and the averaged indicators of the technical analysis of all three pellet types investigated. Figures 1 and 2 show the temperature fields and, for example, the coke residue burnout rates in the boiler furnace.

Table 2 – The results of zonal thermal calculation under CCBC

Index	Anthracite	Mixture of 90% anthracite and 10 % of pine tree pellets	Mixture of 90% anthracite and 10 % of agropellets (of agricultural straw)	Mixture of 90% anthracite та 10 % of sunflower husks pellets
Gas temperature at 1-st zone outlet,°C	1782	1772	1765	1766
Gas temperature at furnace outlet,°C	1145	1153	1151	1150

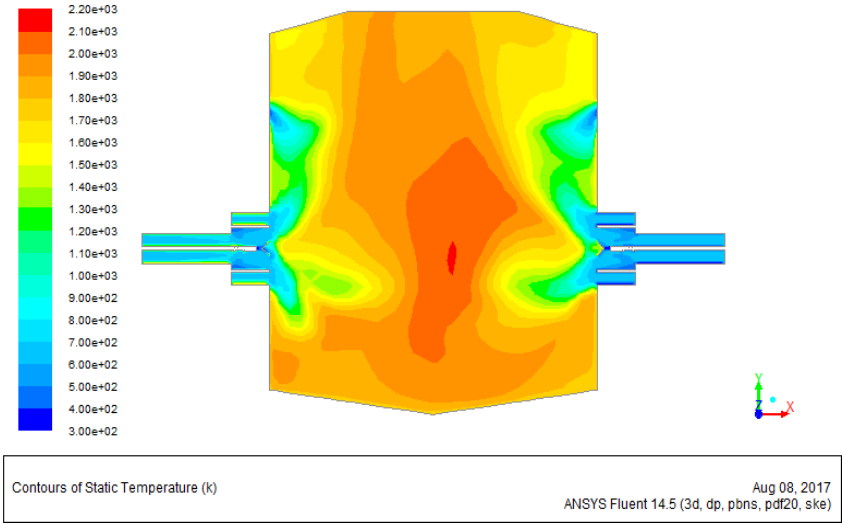
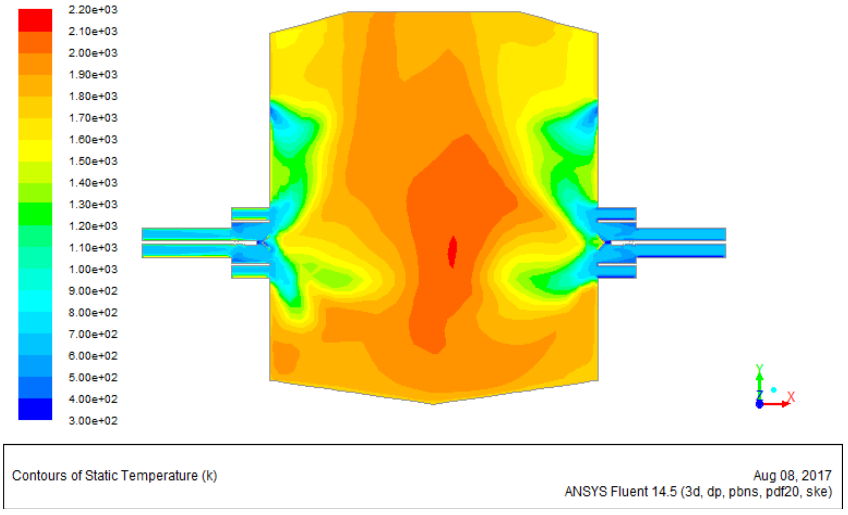
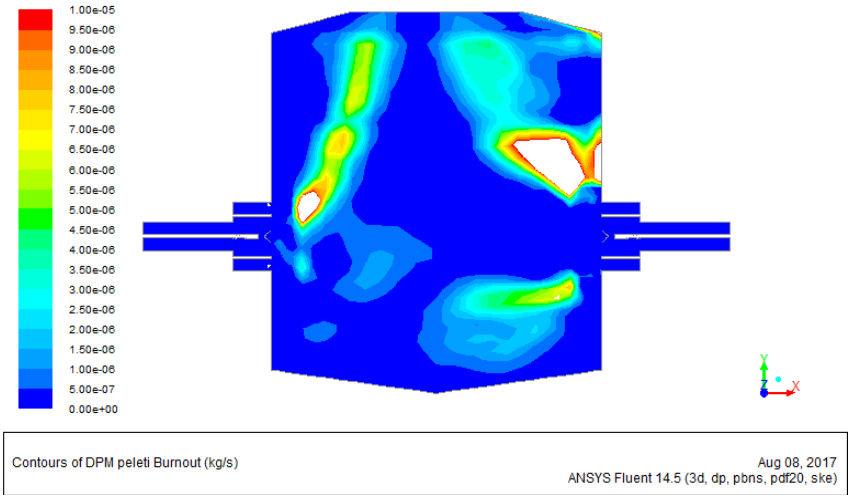


Figure 1 - The calculated field of the temperatures (K) in vertical section of the furnace along the axes of the 2-nd and 5-th burners (above), as well as in horizontal sections at level of the burners axes and in the cross section of the overpressure (below).





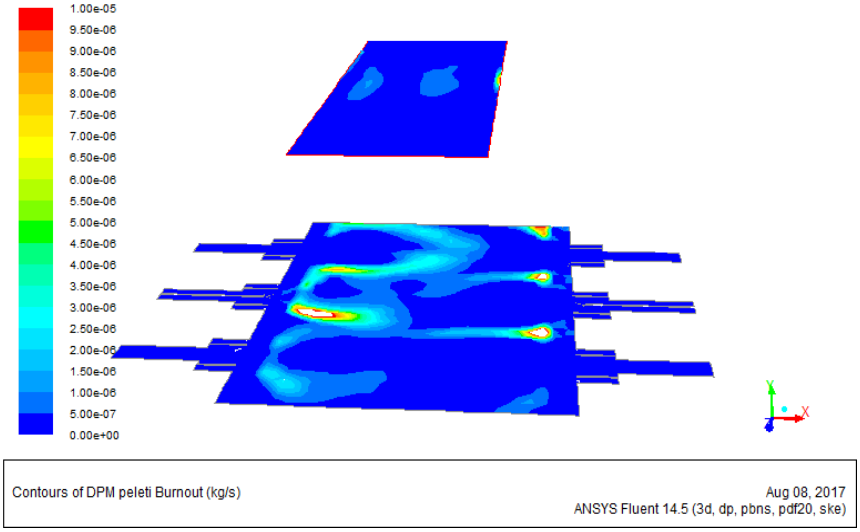


Figure 2 - The combustion rate field of the pellets coke residue (kg/s)

The performed calculations confirm that under the co-combustion of anthracite with a specified percentage of biomass of 8-10%, the conditions for reliable operation of the furnace of stable WSR regime and without heating surface slagging risk are provided, the furnace outlet temperature ensures a reliable regime of the boiler operation, the 1 zone outlet temperature provides a stable slag yield.

The technological solutions developed by authors of this work on biomass preparation and combustion in anthracite boiler units are handed over to Trypilska TPP and will be used for technical re-equipment of one of the TPP-210A boiler units 300 MW.