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Abstract. Latent heat thermal energy storage (LHTES) systems using phase change material (PCM) have received significant research attention in numerous engineering fields. The transient heat transfer phenomenon inside a vertical LHTES unit is numerically investigated, with the paraffin as the PCM and water as the heat transfer fluid (HTF). As a performance enhancement technique, the metal foam insert is applied in both the HTF and PCM sides. The conjugate thermal model for the HTF/foam−wall−PCM/foam system is built, considering the non-equilibrium effects between the solid and fluid phases with two-temperature energy equation and the natural convection inside the PCM with Boussinesq approximation. The enthalpy-based method is employed to account for the solid-liquid phase change problem. The overall performance is compared with other three cases: no foam insert, foam insert in HTF side and foam insert in PCM side. Besides, parametric study is also conducted on the melting features, including the foam structural parameters and inlet conditions of HTF. The results show that foam insert in both sides accelerates the PCM melting effectively. The foam porosity and HTF inlet temperature play important roles in the overall heat transfer, whereas the pore density and HTF inlet velocity have limited effects on the melting rate. The findings can provide referential information for the design of a LHTES system.

[FES2103] Plasma-Fuel Systems for Clean Coal Technologies

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Abstract. This paper presents a new effective and ecologically friendly plasma technology for pulverised coal ignition and energy efficiency improving of thermal power plant. Plasma-fuel systems (PFS) were developed to realize this technology. PFS are combination of pulverized fuel burners with arc plasmatron. The main idea of PFS is to replace fuel oil or natural gas by products of plasma chemically treated pulverized coal for boiler start up and flame stabilization. Part of the coal-air mixture is fed into the PFS where the plasma-flame induces heating, devolatilization and gasification of the coal particles and partial oxidation of the char carbon. The coal-air mixture is deficient in oxygen therefore the carbon being mainly oxidized to carbon monoxide. As a result, a highly reactive two component fuel (mixture of combustible gases and partially oxidized char particles) is formed at the exit of the PFS. On the furnace entry, this highly reactive two component fuel is easily ignited. This allows prompt ignition and much enhanced flame stability of the main portion of the coal which was not directly treated by plasma. PFS increases efficiency of coal ignition and combustion, eliminated fuel oil expenditure for boilers start up and flame stabilization, decreased unburned carbon, NO_X, SO_X, and V_2O_5 emissions. Experiments showed that the NO_X concentration is halved, and the amount of unburned carbon is reduced by a factor 4. The NO_X decrease is caused by the fact that the fuel nitrogen, released from the coal inside the PFS in conditions of oxygen deficiency, forms molecular nitrogen in the gas phase. Since the fuel nitrogen is evolved inside the PFS and converted to molecular nitrogen there, mainly thermal nitrogen oxides are formed within the furnace volume. However, fuel nitrogen is the main source of nitrogen oxide emission from coal-fired thermal power plants. As to unburned carbon, its decrease indicates a fuel reactivity increase which is explained by enlargement of the coal

particles reactive surface due to devolatilization and gasification of the coal particles and partial oxidation of the char carbon. PFS have been tested at power boilers of 75 to 950 t/h steam-productivity of 30 coal fired thermal power plants. Steam coals of all ranks were used. Volatile content of them was from 4 to 50%, ash varied from 15 to 56% and heat of combustion was from 1600 to 6000 kcal/kg.

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[FES2104] Plasma Gasification of Biomass to Produce Power Gas

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Abstract. This paper presents the results of thermodynamic analysis and experiments on plasma gasification of biomass by the example of wood waste. Wood waste is represented by mixture of sawdust and wood chips. The results of thermodynamic analysis of high-calorific fuel gas production by gasification of biomass in air is discussing. Also, experimental installation is presented and the results of experiments on gasification of biomass in air plasma compare with the computation. Thermodynamic computation of plasma gasification of biomass revealed that synthesis gas utilizable in heat-and-power engineering, metallurgy and chemical industry can be produces from biomass. Air gasification of biomass allows producing synthesis gas with yield of 71.6% (CO - 41.9%, H_2 - 29.7%). Specific calorific value of synthesis gas is 9,450 kJ/kg. Computed parameters of the processes of biomass plasma gasification in air were used to develop experimental plasma installation. Experiments on biomass plasma gasification were conducted in a setup composed of plasma gasifier of 50 kg/h productivity by biomass and long live DC plasma torch of 70 kW nominal power. As a result of biomass plasma gasification synthesis gas of 67.1% (CO – 42.0%, H_2 – 25.1%) concentration was produced. Measured temperature in the bottom of the plasma gasifier was 1,560 K. Under the influence of air plasma flame, the weight average temperature in the gasifier reached 1,600 K, an organic part of biomass was gasified and inorganic part (ash) was accumulated in the slag formation zone of the gasifier and in the bag filter. The obtained synthesis gas was incinerated in cyclone combustion chamber. Combustion products were continuously withdrawn through the cooling and purification systems. The ash was removed from the gasifier after the plasma torch shutdown and cooling the gasifier. Biomass in form of briquettes of 9.9 kg total mass were gasified during 25 minutes. Biomass consumption was 23.8 kg/h. Air flow rate through plasma torch was 23.6 kg/h. The specific power consumption for plasma air gasification of biomass amounts to 1.53 kW h/kg. The total concentration of the synthesis gas (67.1%) agrees well with the thermodynamic calculations. Discrepancy between experimental and calculated data by the yield of synthesis gas was not more than 7%. Harmful impurities were revealed in neither gas nor condensed products of biomass plasma gasification.

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