PLASMA TECHNOLOGY FOR ENERGY PRODUCTION: CONVERSION OF COAL TO SYNTHESIS GAS, CO_2 REFORM AND TAR TREATMENT

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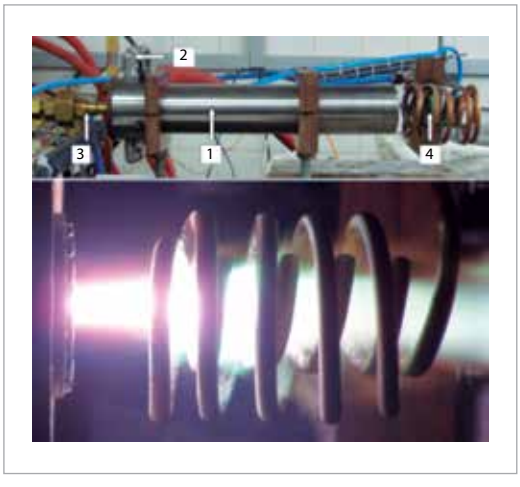

Figure 1. DC transferred arc steam plasma torch of ITA, Brazil for power P = 30-300 kW, thermal efficiency h = 95-97%. 1. Plasma torch, 2. Gas inlet, 3. Cathode, 4. Anode

The aims of this project are the development of plasma technologies for coal and biomass gasification and the reform of compounds generated by this process, especially tars (condensable hydrocarbons : furans, phenols, etc.), non-condensable hydrocarbons (as methane, ethane and dioxins) and carbon dioxide (CO_2), in order to enhance the generation of synthesis gas (CO and H_2). The planned activities have been focused on the coal and sugarcane bagasse gasification processes by using air and steam plasma torches. To fulfill of gasification process a number of efficient thermal plasma torches were last years developed, including of DC transferred electric arc torch (EAT) with water steam or air as plasma gas and power of 50-300 kW, which is currently adopted at ITA for experiments with coal feedstock (*Figure 1*). For engineering design of plasma gasifiers with EAT (*Figure 2*) is necessary to determine the chemical composition and transport properties of high temperature medium in these under gasification, with a taking into account the specific characteristics and composition of feedstocks. This work presents the thermochemical assessment for the comparison of plasma gasification process with low grade coal and biomass feedstock at use of different oxidants.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The thermochemical assessment of plasma gasification efficiency for the case of Brazilian industrial scale coal and coal-based water slurries with using of steam and air as gasifying agents was carried out. The data calculated show that for reforming this coal feedstock (with quite high ash content of 28 %) to syngas with yield of near 100% the energy consumption level of 10-12 MJ/(kg of syngas) is sufficient on the thermodynamic results at the using of regimes with ratio of mass flow rates of feedstock to gasifying agent $G_C / G_{ST} = 4.0$ for coal. The calculated level of calorific value of syngas, that is possible to produce from this kind of low–grade feedstock at the optimal thermochemical conditions of plasma gasification is quite high for special fuel using of syngas in the industrial combustion and power generation systems and is as 9.6-10.0 MJ/ nm^3. Thermochemical assessment for the case of biomass waste composed of sugarcane bagasse was carried out for different variants of use of individual gasifying agents, which can be used for practical realization in operating regimes of thermal plasma reactors for syngas production with heating value up to 25-30 MJ/kg. The data obtained for the case of simplified analysis for the equilibrium thermodynamic conditions shows that the most efficient case among the analyzed individual and mixed gasifying oxidative agents is use of steam oxidant. For this case the optimal regime predicted from realized series of calculations corresponds to value of the steam to biomass ratio SBR = 0.4 at such temperature level as 1000 K (at 0.1 MPa) and for these conditions maximal value of energy efficiency (cold gas efficiency) is 0.91 and value of exergy efficiency is 0.84. This level is even 4-5 % higher than the one, which was found for the case of use of air gasifying agent with optimal ratio of ER operating parameter. The results show that the case of gasification of these two kinds of feedstock using air as gasifying agent is more efficient on such output parameter as energy efficiency, which is higher (up to 0.65 for the bagasse and up to 0.79 for the coal) at the optimal level of temperature (1250 K) and the ratio of mass flow rates of the feedstock to air.

Figure 2. Plasma gasifier of ITA

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