GASIFICATION OF ORGANIC WASTE BY ULTRASUPERHEATED STEAM: THE EFFECT OF STEAM MASS FLOW RATE

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Abstract: Reported in the article is the progress in the development of the novel Pulsed Detonation Gun (PDG) technology for the conversion of organic wastes into syngas in a two-component medium containing ultrasuperheated steam (USS) and carbon dioxide obtained by pulsed detonations of a natural gas – oxygen mixture at a frequency of 1 Hz. Experimental studies were carried out on a waste converter with a 40-dm^3 flow reactor and two PDGs with a total volume of 2.4 or 3.2 dm^3 which is approximately a factor of 6 and 4.5 less than in previous studies, respectively. The objective of the research was to find the design and operation parameters of the waste converter which provide a minimum amount of CO_2 in the gasification products. Waste machine oil was used as a feedstock. It is shown that, compared with the earlier experiments with a higher average temperature of the gasifier wall and with a PDG of a much larger volume, the contents of H_2, CO, CH_4, and CO_2 in the syngas remained virtually unchanged whereas the efficiency of the gasification process increased significantly: the use of 1 g of natural gas made it possible to gasify up to 4 g of the feedstock. It is also shown that the determining role in the gasification process of liquid feedstock is played by the feedstock residence time in the PDG rather than in the gasifier itself. The minimum ratio between the flow rates of the USS and liquid feedstock, the minimum ratio between the flow rates of combustible gas and liquid feedstock, as well as the actual USS consumption in the gasification process are determined experimentally.

Keywords: pulsed detonation gun; organic waste; gasification; waste machine oil; syngas

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Figure Captions

Figure 1 Waste gasifier with two PDGs: (*a*) valveless scheme; and (*b*) valved scheme

Figure 2 Typical records of the wall temperature (*1*) and overpressure (*2*) in a gasifiers of valveless (*a*) and valved (*b*) schemes. Curves *3* correspond to the average overpressure in the gasifier

Figure 3 Typical records of the gas analyzer for experiments in gasifiers of valveless (*a*) and valved (*b*) schemes. Arrows indicate time instants of reaching a steady operation mode and PDG shutdown

Figure 4 The composition of dry gasification products of waste machine oil obtained in the gasifiers of valveless scheme 1 (*1* and *2*) and valved scheme 2 (*3* and *4*) when waste is supplied near (85 mm) (*1* and *3*) and at a distance (355 mm) (*2* and *4*) from the PDG outlet

Figure 5 The compositions of dry gasification products of waste machine oil obtained in the gasifiers of valveless schemes 1 and 3 (columns 1 and 2 in Table 4) and valved schemes 2 and 4 (columns 3 and 4) with PDGs of different lengths (*1* and *2* — short PDGs; *3* and *4* — long PDGs), when supplying waste at a distance of 295 mm from the closed end of the PDG

Figure 6 The compositions of dry gasification products of waste machine oil obtained in the gasifiers of valveless schemes with different residence times of feedstock in the PDG: *1* – minimum; *2* — intermediate; and *3* — maximum

Figure 7 The composition of dry gasification products of waste machine oil in valveless and valved gasifiers: *1* — scheme 1 with the supply of feedstock to the PDG near the inlet to the gasifier; *2* — scheme 2, supply away from the inlet; *3* — scheme 3, supply near the inlet; *4* — scheme 2, supply near the inlet; *5* — sheme 2, supply away from the inlet; and *6* — scheme 4, supply away from the inlet

Table Captions

Table 1 Properties and morphological composition of waste machine oil

Table 2 Elemental composition of waste machine oil (close to $C_{16}H_{24}$, proportions do not correspond to normal alkane)

Table 3 Experimental results for the gasification of waste machine oil in gasifiers of valveless (*1*) and valved (*2*) schemes, when waste is supplied near (85 mm) and at a distance (355 mm) from the PDG inlet to the gasifier

Table 4 Experimental results on the gasification of waste machine oil in gasifiers of valveless (*1* and *3*) and valved (*2* and *4*) schemes with PDGs of different lengths when waste is supplied at a distance of 295 mm from the PDG closed end

Table 5 Indicators of the efficiency of the gasification process in a gasifier of valveless scheme 1

Table 6 Indicators of the efficiency of the gasification process obtained in the gasifier of valveless scheme 3

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