Influence of the Degree of Carbonization and Granulation of Fuel on Combustion Process

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This paper investigates the influence of the degree of carbonization and granulation of fuel on the combustion process. Experimental determinations were performed on samples of biomass (sawdust) and coal in various stages of carbonization. Grains were used in 0.09 mm, 0.1 to 0.25 mm and 0.25 mm over. Combustion research has been conducted under static conditions using thermogravimetric and termodifferential analysis equipment. The results showed increased self-ignition temperature with the degree of carbonization and granulation of fuel. They are particularly useful both to achieve an efficient combustion process and for processing and storing fuel safely.

Keywords: biomass, solid fuel burning, carbon dioxide pollution, granulation

There are many studies on the combustion process and determinants factors [1- 4]. This paper seeks to address these issues experimentally.

To this end, investigations were carried out with thermogravimetric and termodifferential analysis equipment, considering self-ignition temperature as the onset temperature of exothermic effect with weight loss.

The particle size has a significant influence on the conversion of solid fuel. In a solid fuel with large particles, there is a clear temperature difference between the gas and the surface of the solid fuel, whereas the gas and surface temperatures of smaller particles are almost the same. The conversion processes, drying, devolatilisation, and char combustion, are overlapped for large particles, whereas they are sequential for small particles. This allows considerable simplifications in the analysis of small particle fuel, since these beds can be described as a porous medium where there is a temperature difference between the gas and the solid phase. For the smallest particle size investigated here, this temperature difference is small, indicating that for these particle sizes, the description may be further simplified and the temperatures of gas and solid can be represented by the same temperature without any significant effect on the overall result.

It was supposed that the propagation of the reaction front through the bed should be slower for beds containing larger particles than for beds packed with smaller ones. In contrast, some measurements indicate that the larger particles attain a higher propagation rate. At present, it cannot be determined with certainty if this is the case because the model includes several simplifications, and the measurements are also imperfect. They are performed in rather small reactors compared to the particle sizes. In the experiments with the largest particle size, the highest measured propagation rates are most likely accompanied by problems in creating a stable propagation velocity due

Table 1
TECHNICAL AND ELEMENTAL ANALYSIS OF FUELS STUDIED

Currnet number	Fuel type	The technical analysis			The elemental analysis of fuel mass					
		W^a	A^{anh}	V^{waf}	C^{waf}	H^{waf}	S^{waf}	O^{waf}	N^{waf}	Q_s^{waf}
		%	%	%	%	%	%	%	%	kcal/ kg
1.	Dry fir wood	15.25	0.54	64.25	48.00	5.84	0.02	41.15	1.73	4114
2.	Dry beech wood	12.85	0.61	63.81	47.80	5.60	0.03	44.80	1.68	3962
3.	Rovinari coal	16.42	41.14	53.15	59.25	5.68	1.52	32.14	1.41	6054
4.	Lonea coal	2.25	32.15	48.40	76.11	5.54	1.45	15.93	0.97	7674
5.	Lupeni coal	2.07	34.65	40.80	78.64	5.19	4.00	11.02	1.15	8145
6.	Anina coal	1.82	35.24	32.40	84.18	5.18	0.64	9.31	0.69	8456
7.	Doman coal	1.74	30.40	20.20	90.74	4.82	0.68	4.51	0.25	8346

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Table 2
PARTICIPATION OF HYDROGEN IN CALORIFIC VALUE OF FUELS

Currnet number	Fuel type	Q_s^{waf}	H^{waf}	H_d^{waf} *)	The heat generated by burning hydrogen available Q_H^{waf}	Q_H^{waf}/ Q_s^{waf}
		kcal/kg	%	%	kcal/kg	%
1.	Dry fire wood	4114	5.84	0.19	65	1.58
2.	Dry beech wood	3962	5.69	0.09	31	2.71
3.	Rovinari coal	6054	5.68	1.66	564	9.32
4.	Lonea coal	7674	5.54	3.55	1207	15.73
5.	Lupeni coal	8145	5.19	3.81	1295	15.90
6.	Anina coal	8456	5.18	4.02	1366	16.15
7.	Doman coal	8346	4.82	4.26	1448	17.34
8.	Petroleum coke	8710	4.55	4.47	1520	17.45

*) H_d^{waf} = available hydrogen in the fuel mass (non-oxygen-hydrogen)

to the low pressure drop across the fuel bed and difficulties to obtain an even ignition over the cross-section [5 – 12].

It was noticed previously in experiments that an increase of fuel density does not have any significant effect on the conversion rate if the conversion rate is related to the mass loss per time unit and cross-sectional area of the bed. Of course, the velocity of the combustion front down through the bed of a low density fuel will be higher than that of a high density fuel. The model also shows that inside the reaction front there is no significant difference in combustion with a change of density, only a small shift in the location of the conversion of moisture, volatiles, and char can be observed. This means that experiences from one fuel density can be used directly for similar fuels with different densities.

Results and discussion

Experimental research aims to determine the beginning of burning, self-ignition temperature. A equipment for thermogravimetric and termodifferential analysis MOM type, in the medium of air was used. The amount was 100 mg samples and heating rate of 10^0 C / min [13]. Fuel analyses were made acoording to Romanian standards in force.

Fuel, in addition to basic features, has highlighted the contribution of pollutant carbon and clean hydrogen fuels in their calorific value.

Table 1 shows the technical and elemental analysis of fuels studied. Table 2 shows the ability of polluting fuels studied by hydrogen participation to their calorific value.

Table 3
SELF-IGNITION TEMPERATURE OF BIOMASS AND THE MAIN SOLID FUELS TYPES, ACCORDING TO THEIR GRANULATION

Currnet number	Fuel type	Self-ignition temperature		
		Granulation < 0,09 mm	Granulation 0,1 – 0,25 mm	Granulation > 0.25 mm
1.	Pine sawdust	208	215	224
2.	Beech sawdust	212	237	258
3.	Rovinari brown coal	218	225	241
4.	Lonea coal	292	315	350
5.	Lupeni coal	295	325	355
6.	Anina coal	386	406	428
7.	Doman coal	402	426	435
8.	Petroleum coke	415	431	446

Table 3 seeks self-ignition temperature variation, depending on the origin and fuel grain.

Tables 1 to 3 show differences in self-ignition temperature of about 200^0 C between biomass and solid fuels in various stages of carbonization.

Between very fine particles and the particles with a diameter of 2 to 3 times higher, appear differences of 20 to 40^0 C, depending on fuel composition.

Conclusions

Auto-ignition temperature of a fuel is determined by:

- degree of carbonization (volatile matter, composition, etc.);
- granulation of fuel.

An increase of granulation from 0.09 mm to > 0.25 mm has the effect of increasing the self-ignition temperature with over 20^0 C. Increases are higher to the coal in advanced stage of carbonization than to brown earth coal (Rovinari) or biomass .

Fresh coal dust can not be stored, but requires a quick use because of significantly reducing the self-ignition temperature.

Lower coal carbonization stages can not be stored for a long time because of high auto-ignition hazard.

A solid fuel is more polluting, the higher is the effect of heat generated by combustion of carbon, element formed by burning carbon dioxide, the more polluting is a solid fuel.

Biomass, wood, plants, etc. burning produces, in addition to thermal pollution, pollution with carbon dioxide as the hydrogen content available (non-oxygen) is very small;

The degree of carbonization of a fuel (rank) is more advanced, the heat resulting from burning effect is smaller because of the absence of oxygen and greater availability of hydrogen in the combustion process;

Available hydrogen burning provides 9 to 10% of the lignite combustion heat, 15 to 17% from coal and 17 to 20% in petroleum coke;

Petroleum coke has a lower level of pollution for combustion as 17 to 20% of heat generated is the result of combustion of hydrogen;

For combustion process is particularly recommended petroleum coke with 9 to 12% volatile matter what burn without smoke and the pollution is from 80 to 82% of capacity used polluting fuels - coal. But the diversity of fuel / combustible materials energy used as building materials or other destinations, implicitly require differentiated treatment in terms of pollution and risk of intoxication.

Burning biomass, the stubble fires, fires of forests, not only bring problems for fire intervention, but also problems of thermal pollution and whit carbon dioxide. Therefore, preventive measures must be directed primarily to these sectors.

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