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COMBUSTION CURVES OF SOME TURKISH LIGNITES

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Abstract

In this study, combustion curves of twenty-five Turkish lignites were obtained through use of a differential thermal analyser. 20 mg lignite samples were heated at a constant rate of 10 deg·min^{-1} in a 40 cc/min flow of air up to 1073 K and held for 10 minutes at this constant temperature. The combustion curves of the samples are compared and discussed.

Keywords: coal, combustion, DTA, lignite

Introduction

In the design of industrial coal-fired boiler furnaces, it is necessary to have an assessment of the reactivity of the fuel.

Thermal analysis plays an important role in the determination of the combustion characteristics of coals. Coal DTA curves obtained in the presence of air are called 'combustion curves'. They provide information on combustion characteristics, such as ignition temperature, heat release rate, heat of combustion, etc.

In the present study, combustion curves of 25 Turkish lignites were obtained through use of a differential thermal analyser.

Experimental

DTA was carried out with a Shimadzu DTC 40 analyser. After grinding to pass through a 0.25 mm sieve, 20 mg lignite samples were spread uniformly on the bottom of a cylindrical crucible (Pt) and the furnace was heated up to 1073 K at a constant rate of 10 deg·min^{-1} while being swept by air at a rate of

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40 cc/min. They were then held at this constant temperature for 10 minutes. The chart speed was selected as 2.5 mm/min. The reference material was α-alumina.

The proximate analysis of the samples was performed according to ASTM standards [1].

The calorific values of the lignite samples were measured by using a bomb calorimeter [2].

The ultimate analyses of the samples were carried out with a Heraeus elementary analyser.

Table 1 Proximate analyses and calorific value of lignite samples (air-dried)

Sample Cod	Moisture / %	Ash / %	Volatile matter / %	Fixed carbon / %	Net cal. value / $MJ \cdot kg^{-1}$
L1	10.5	32.2	32.2	25.1	10.5
L2	4.4	40.6	22.2	32.8	14.5
L3	15.7	31.8	36.1	16.4	11.4
L4	9.6	11.0	39.2	40.2	21.7
L5	10.5	12.1	36.8	40.6	20.8
L6	19.9	14.0	30.3	35.8	17.0
L7	27.6	9.8	39.8	22.8	16.9
L8	24.2	6.2	38.4	31.2	17.2
L9	2.0	14.4	32.0	51.6	27.1
L10	14.0	26.6	36.1	23.3	14.2
L11	7.2	7.3	46.4	39.1	26.0
L12	25.3	29.3	28.7	16.7	11.6
L13	16.2	32.6	40.9	10.3	12.1
L14	15.9	6.7	41.0	36.4	20.0
L15	35.4	9.0	32.2	23.4	13.4
L16	12.5	22.9	32.3	32.3	19.2
L17	17.9	18.7	37.3	26.1	16.1
L18	27.0	20.6	34.4	18.0	14.6
L19	14.1	12.7	33.4	39.8	19.7
L20	13.9	39.2	24.6	22.3	12.1
L21	40.4	15.2	32.1	12.3	12.8
L22	6.4	27.6	28.6	37.4	19.0
L23	5.9	8.9	31.8	53.4	27.7
L24	27.5	14.1	34.4	24.0	12.3
L25	48.0	12.0	28.2	11.8	9.7

Results and discussion

The range of moisture content of the lignite samples was 2.0–48.0%; the ash content 6.2–40.6%; the volatile matter content 22.2–46.4%; the fixed carbon content 10.3–53.4% and the calorific value 9.7–27.7 $MJ\cdot kg^{-1}$ (Table 1). The proximate analysis results of the lignite samples used in this study vary widely.

The hydrogen contents of the lignite samples lie in the range 3.54–7.1%, and the carbon contents 26.1–65.51% (Table 2).

Table 2 Hydrogen and carbon contents of lignite samples (air-dried)

Sample Code	Hydrogen content / Weight %	Carbon content / Weight %
L1	3.88	36.42
L2	3.54	42.17
L3	4.91	30.24
L4	5.16	55.33
L5	4.90	53.08
L6	5.23	49.68
L7	5.62	45.53
L8	6.47	45.30
L9	5.02	64.74
L10	4.28	36.56
L11	5.53	56.69
L12	4.45	33.30
L13	4.77	27.69
L14	5.54	51.84
L15	5.53	39.95
L16	4.50	40.28
L17	4.73	43.93
L18	5.49	33.51
L19	4.90	49.75
L20	4.13	35.14
L21	4.44	38.29
L22	4.36	49.49
L23	4.91	65.51
L24	4.00	37.62
L25	7.10	26.10

The combustion curves of the lignite samples exhibit initially a small endothermic peak, due to water loss, and one or two exothermic maxima, due to combustion of the volatile matter released on heating, followed by burning of the residual solid. Their configurations, influenced by compositional variations, both organic, inorganic and rank, represent the amounts of heat generated by burning [3].

Coals contain mineral components contributing to their thermal behaviour. Endothermic reactions due to decomposition of the mineral matter during coal combustion reduce the exothermic peak area resulting from combustion of the organic part. The combustion curves are therefore representative of both endothermic and exothermic reactions of coal combustion [4].

Most of the combustion curves of the lignite samples contain two exotherms due to combustion of the volatile matter and the residual solid. Some of the lignite samples exhibit combustion curves with only one exotherm, while a few of the samples give three exotherms. The combustion curves of the lignite samples with high fixed carbon content generally exhibit two separate exotherms, but the combustion curves of the lignite samples with low fixed carbon content contain only one exotherm or several combined peaks.

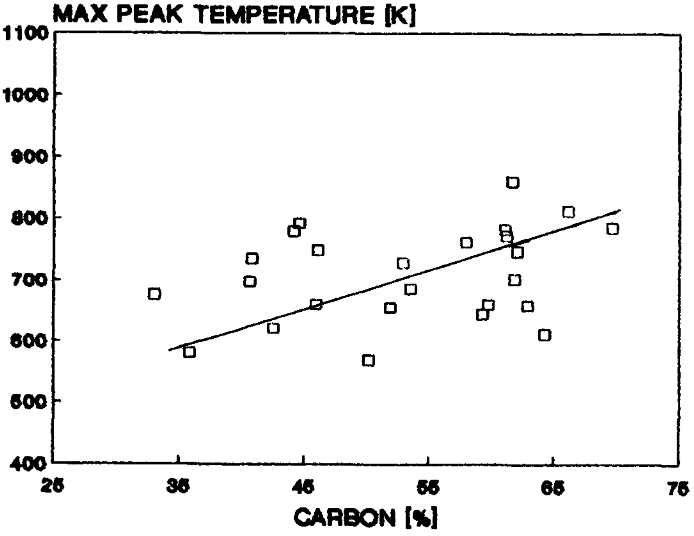

Fig. 1 Relation between maximum peak temperature and carbon content of lignite samples (on a dry basis)

The maximum peak temperatures determined from the combustion curves of the lignite samples exhibit significant differences. As shown in Fig. 1, increasing carbon content of the lignite sample appears to cause an increase in the maximum peak temperature.

An increase in the ratio of the volatile matter content to the total active matter content (the sum of the volatile matter and fixed carbon) causes a decrease in the maximum peak temperature (Fig. 2). Volatile matter and fixed carbon contents calculated on a dry basis were used to prepare Fig. 2.

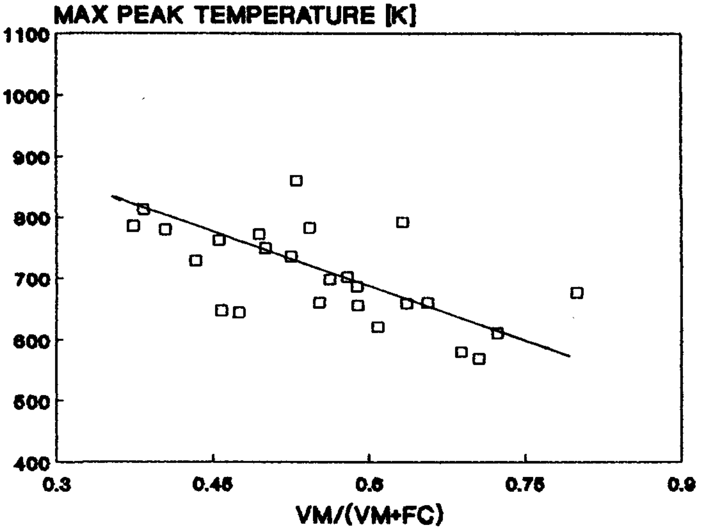

Fig. 2 Relation between maximum peak temperature and ratio of volatile matter content to active matter content of lignite samples (on a dry basis)

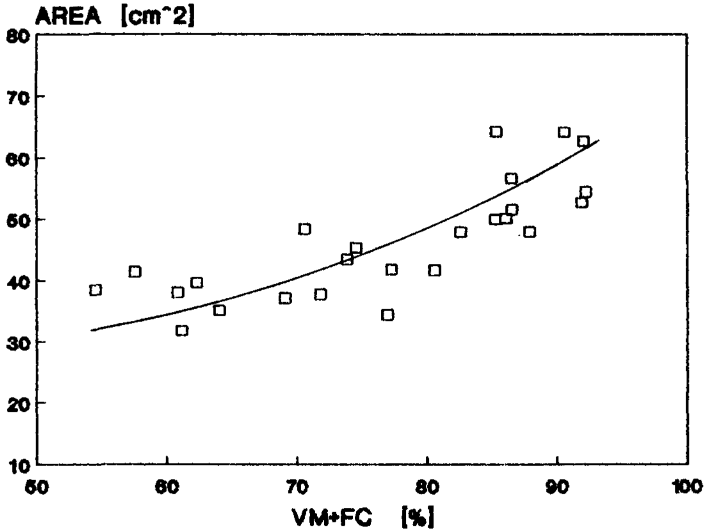

Fig. 3 Relation between area under exotherm of combustion curves and active matter content of lignite samples (on a dry basis)

The area under the exotherm of the combustion curve is dependent on the active matter content (on a dry basis) of the lignite sample (Fig. 3).

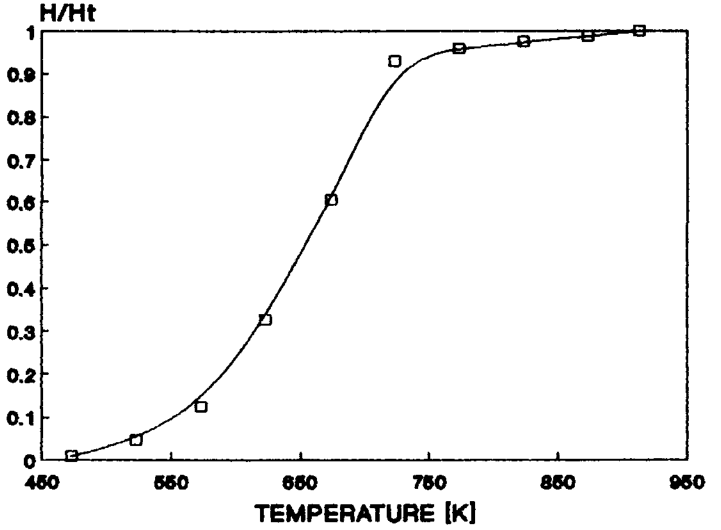

Fig. 4 Effect of temperature on rate of heat release from lignite sample L14 (Ht = net calorific value, H = heat released up to temperature T)

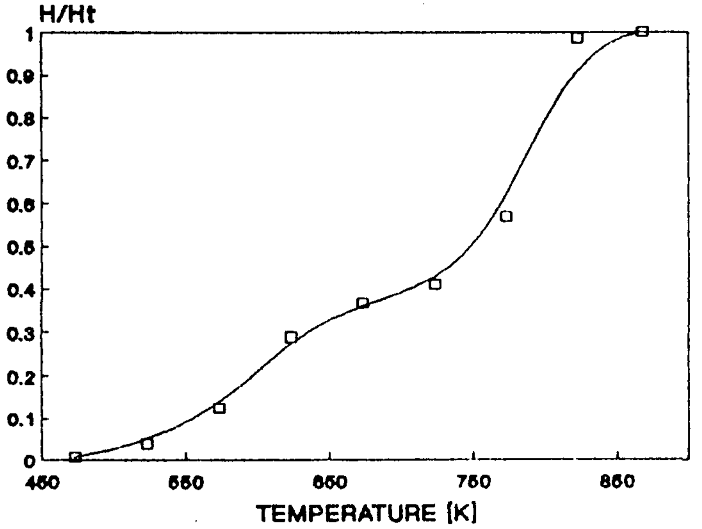

Fig. 5 Effect of temperature on rate heat release from lignite sample L12

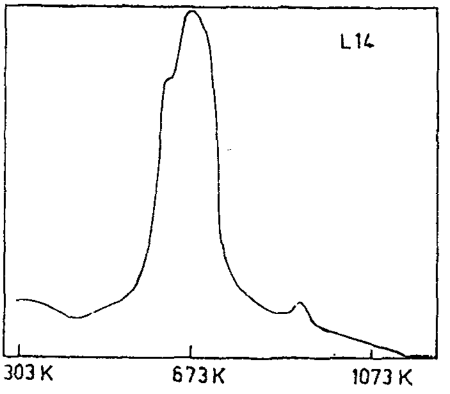

Fig. 6 Combustion curve of lignite sample L14

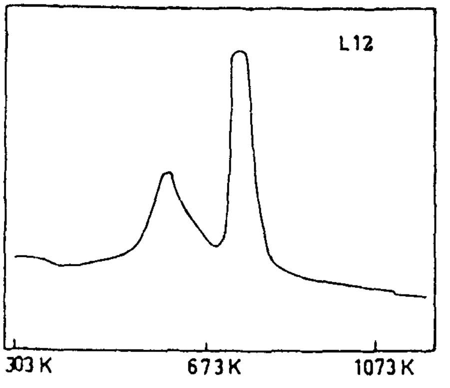

Fig. 7 Combustion curve of lignite sample L12

The rate of heat release from a coal is as important as its heat content for coal-fired boiler furnaces. The area under the exotherm of the combustion curve can be used to determine the rate of heat release from a coal [5]. Figures 4 and 5 illustrate the heat release rate curves for two lignite samples. Sample L14, which exhibits only one exotherm in the combustion curve, loses 60% of its calorific value up to about 673 K. However, sample L12 exhibits two separate exotherms in the combustion curve and releases only about 37% of its heat content up to the same temperature. The combustion curves of these lignite samples can be seen in Figs 6 and 7.

References

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Zusammenfassung — In vorliegender Untersuchung wurden mittels eines DTA-Gerätes die Verbrennungskurven von fünfundzwanzig Ligniten aus der Türkei aufgenommen. Proben aus 20 mg Lignit wurden bei einer konstanten Aufheizgeschwindigkeit von 10 deg/min, in einem Luftfluß von 40 cm^3/min bis hin zu 1073 K erhitzt und dort 10 Minuten lang belassen. Die Verbrennungskurven der Proben wurden miteinander verglichen und ausgewertet.