

Proximate analysis of some Turkish lignites by thermogravimetry

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Abstract

In this study, the moisture, ash, volatile matter and fixed carbon contents of 24 lignite samples from different coal reserves in Turkey were determined by using TGA and results were compared with those obtained by the ASTM standards.

The mean differences in moisture, ash, volatile matter and fixed carbon contents between the TGA and ASTM methods are 0.38%, 0.68%, 1.53% and 1.47%, respectively.

INTRODUCTION

Proximate analysis of coal includes the determination of its moisture, volatile matter, fixed carbon and ash contents. These coal parameters have long been determined by different standard methods. However, the standard procedures for proximate analysis are tedious, time consuming and their success depends on the skill of the operator.

Because all the measurements of the proximate analysis involve weight changes under certain conditions of temperature, time and atmosphere, thermogravimetry is ideally suited to this type of analysis. In using the TGA method for proximate analysis of coal, a great saving of time can be achieved by performing all of the measurements sequentially on one sample.

The purpose of this study is to investigate the application of TGA to the proximate analysis of 24 Turkish lignites.

EXPERIMENTAL

Thermogravimetric analysis was carried out using a Shimadzu TG 41 thermal analyser. During the studies, the flow rates of nitrogen and dry air

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were fixed at 40 cc min^{-1} . The chart speed was selected as 2.5 mm min^{-1} . All lignite samples studied were prepared as for the ASTM standard proximate analysis, i.e. samples of less than 0.25 mm and 100 mg were used.

Before heating, the system was flushed with dry nitrogen for 30 minutes to remove all traces of oxygen. The furnace was then turned on and the temperature was raised at a rate of 20 K min^{-1} to 383 K and held there to drive off the moisture for 30 minutes. After the weight became constant, the temperature was then raised at 40 K min^{-1} to 1223 K and held for 7 min. After 7 min, the constant weight was used to calculate the volatile matter content of the sample. The temperature was then reduced to 1023 K at 20 K min^{-1} and air was then allowed to flow through the system at a rate of 40 cc min^{-1} , which oxidized the remaining organic matter of the lignite sample, causing a weight loss until only ash was left and the weight became constant. The weight loss represents the fixed carbon of the lignite sample. After only ash remained, the system was closed.

The proximate analyses of the lignite samples were also performed according to ASTM standards [1] to compare with those obtained by the TGA method.

RESULTS AND DISCUSSION

The proximate analysis results which have been determined by ASTM methods are given in Table 1. According to the ASTM standards the moisture content of the lignite samples varies between 4.4% and 48.0% ; the ash content between 6.2% and 40.6% ; the volatile matter content between 22.2% and 46.4% and the fixed carbon content between 10.3% and 53.4% .

A typical thermogram obtained for the proximate analysis of the lignite samples is shown in Fig. 1. The results of the proximate analysis determined by using thermogravimetry are given in Table 2.

The results of the ASTM and TGA proximate analyses are in good agreement. In particular, the differences in moisture and ash contents between the TGA and ASTM methods are relatively low.

According to the results given in Tables 1 and 2, the mean difference in the moisture content between the TGA and ASTM methods for twenty-four lignite samples is 0.38% ; the minimum and maximum differences are 0.1% and 1.3% , respectively.

The mean difference in the ash content of the lignite samples between the two methods is 0.68% ; the minimum and maximum differences are 0.0% and 1.8% , respectively.

The volatile matter content of the lignite samples determined by TG is slightly higher than the ASTM value. This may be caused by the nitrogen flow through the system in the TGA method, which improves the mass transfer between the gas and solid phases.

TABLE 1

Proximate analyses of the lignite samples determined by ASTM methods

Sample no.	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)
L1	10.5	32.2	32.2	25.1
L2	4.4	40.6	22.2	32.8
L3	15.7	31.8	36.1	16.4
L4	9.6	11.0	39.2	40.2
L5	10.5	12.1	36.8	40.6
L6	19.9	14.0	30.3	35.8
L7	27.6	9.8	39.8	22.8
L8	24.2	6.2	38.4	31.2
L9	14.0	26.6	36.1	23.3
L10	7.2	7.3	46.4	39.1
L11	25.3	29.3	28.7	16.7
L12	16.2	32.6	40.9	10.3
L13	15.9	6.7	41.0	36.4
L14	35.4	9.0	32.2	23.4
L15	12.5	22.9	32.3	32.3
L16	17.9	18.7	37.3	26.1
L17	27.0	20.6	34.4	18.0
L18	14.1	12.7	33.4	39.8
L19	13.9	39.2	24.6	22.3
L20	40.4	15.2	32.1	12.3
L21	6.4	27.6	28.6	37.4
L22	5.9	8.9	31.8	53.4
L23	27.5	14.1	34.4	24.0
L24	48.0	12.0	28.2	11.8

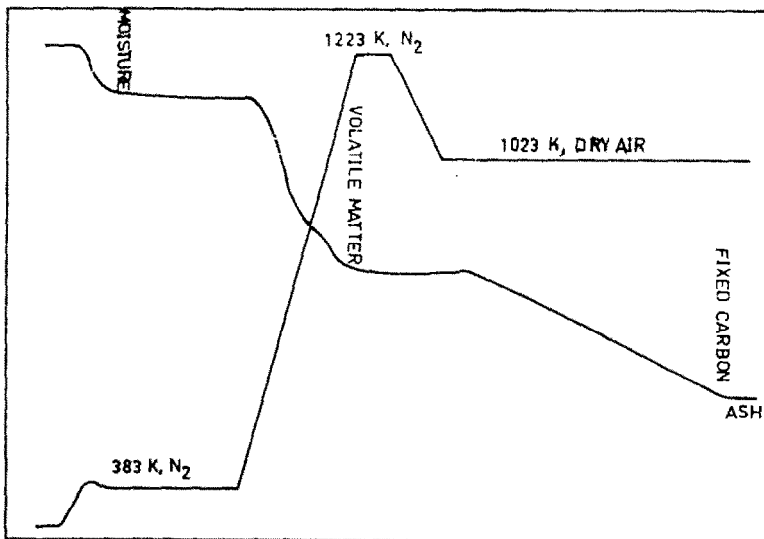


Fig. 1. A thermogram obtained for the proximate analysis.

TABLE 2

Proximate analyses of the lignite samples determined by using TGA

Sample no.	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)
L1	10.0	32.7	33.1	24.2
L2	4.2	41.6	23.8	30.4
L3	16.0	30.2	38.8	15.0
L4	9.8	11.4	42.3	36.5
L5	10.6	12.0	37.8	39.6
L6	19.8	14.2	32.4	33.6
L7	26.7	9.6	39.5	24.2
L8	23.0	6.4	39.7	30.9
L9	14.1	26.7	36.2	23.0
L10	7.0	7.8	48.6	36.6
L11	25.0	28.9	28.0	18.1
L12	16.0	30.8	41.4	11.8
L13	16.0	5.7	42.0	36.3
L14	34.7	7.3	33.8	24.2
L15	12.6	22.2	34.4	30.8
L16	17.8	20.0	37.2	25.0
L17	27.4	19.0	35.6	18.0
L18	14.8	12.0	36.2	37.0
L19	13.8	39.2	24.9	22.1
L20	39.7	14.5	33.1	12.7
L21	6.8	26.6	30.8	35.8
L22	6.0	9.0	36.4	48.6
L23	27.2	14.0	36.8	22.0
L24	46.7	11.5	29.1	12.7

The mean difference in the volatile matter content between the TGA and ASTM methods is 1.53%; the minimum and maximum differences are 0.1% and 4.6%, respectively.

In the TGA method, the fixed carbon is measured directly by observing the weight loss on going from the volatile free weight to the ash weight. In the standards procedure in common use the fixed carbon content of coal is proposed to be calculated by the difference. In both cases, proximate analysis must total 100%. Thus, in the ASTM method, all factors which cause errors in moisture, volatile matter and ash content analysis contribute as an added error in the calculated fixed carbon content of coal.

The mean difference in the fixed carbon content of the lignite samples between the TGA and ASTM methods is 1.47%; the minimum and maximum differences are 0.0% and 4.8%, respectively.

REFERENCE

- 1 Annual Book of ASTM Standards, Part 26, Am. Soc. Test. Mater., Easton, 1977, D 3173-73, D 3175-77, D 3174-73.