

SOLID FUELS

The fuels are heat and light by oxidation and as a result of this, they are great energy-saving substances. Fuels are essentially carbon (C) and hydrogen (H) compounds.

Classifications;

A - Gas Fuels

1- Natural fuels

- a- Natural gas and its fractions (Ground gas)
- b- Liquefied petroleum gases (LPG)

2- Synthetic gas fuels

- a- Coke oven gas,
- b- Water gas,
- c- Acetylene,
- d- Generator gas (producer gas)
- e- blast furnace gas.

B- Liquid Fuels,

1- Natural liquid fuels

- a- Oil or crude oil

2- Synthetic liquid fuels

- a- Petroleum fractions and wastes
- b- Coal tar and fractions
- c- Alcohols

C- Solid fuels

1- Natural solid fuels

- a- Wood
- b- Peat
- c- Lignite
- d- Coal
- e- Anthracite

2- Synthetic solid fuels

- a- Coke

- b- Charcoal
- c- Briquette
- d- Oil odor,
- e-Colloidal fuel and pulverized coal

These fuels cover 90% of our total energy needs. The rest is 10% water power and others.

Coals from solid fuels that are currently required are generally used for two purposes.

1. Heater, as energizer
2. As the main ingredient in the chemical industry

Systems for heating and energizing:

1- Combustible combustion systems

- a- Rotary furnaces
- b- Shelf ovens
- c- Electro-furnaces
- d- Gas flame furnaces
- e-Pulverized Furnaces

2- Incinerator systems

- a- Rotary grating systems
- b- Grid moving step systems
- c- Fixed grill boilers
- d- Underfloor spiral thrust systems with fixed grid
- e- Fixed grid systems

3- Fluidized bed systems

- a- Classic fluidised bed combustion systems
- b- Rapid flow fluidized bed systems

The heating surface in the boilers is the sum of the surfaces in which the heat conduction is present.

Heating surface varies according to the boiler type. The boiler power is the weight of the steam produced in 1 hour of heating surface within 1 hour. The power of the boiler depends on the fuel, the calorie of the fuel, the capacity of the furnace, the rate at which the fresh air enters and the exit of

the burned vapors, the ratio of the surface of the grid to the heating surface, the type and structure of the boiler.

Evaporation Number:

It is the amount of coal that should be spent to obtain a certain amount of steam.

Efficiency of the boiler:

Energy is the amount of energy obtained for the coal that is expended to produce, that is, the ratio of the obtained to the spent. Theoretically 1 kg of coal is 7000 kcal. 1 KWS is 860 Kcal. In the above sample boiler 1,29 KWS energy was obtained. However, 7000/860 KWS energy should be obtained from 1 kg of coal. Accordingly, the yield is $1,29 \times 100 / 8,15 = 15,8$, ie 15,8%. Although it looks less, it is quite a yield. Boiler yields normally range from 12% to 1%. The highest yield to date has been achieved by burning pure oxygen in a trial in the UK at 30%.

After these considerations, it is necessary to determine the properties of coal and to obtain some values according to the places mentioned above. In general, the characteristics of some types of coals are shown in the table below.

Fuel type	Volatile matter	Constant C	Sulphur	H ₂	C	N ₂	O ₂	Heat value Btu/lb
Wood				6,02	50,16	0,09	43,4	8316
Wood coal				1,0	84,0			12850
Lignite	52,9	47,1	1,5	5,1	70,5	1,5	21,4	12160
Fat coal	30,2	69,8	1,1	5,9	87,1	1,4	4,5	15560
Anthracite	6,2	93,8	0,6	2,7	94,0	1,0	1,7	14070

(These coal samples were taken from the coals from Pennsylvania (US).)

For the same coals

	Wet %	Ash %	Required air to full combustion		Formed fume ¹ after full combustion		Formed water lb/lb coal Coal
			Cu ft	lb	Cu ft	lb	
Wood		0,37	78,6	6,0	88,1	7,0	0,53
Wood coal	12,0	3,0	131,2	10,02	132,5	10,87	0,12
Lignite	6,34	7,93					
Fat coal	1,44	6,18	139,0	10,6	145,1	11,53	0,49
Anthracite	2,26	12,69	127,5	9,57	130,4	10,63	0,23

Analysis of solid fuels

As already mentioned, it is necessary to know the properties of the coals according to the places where they are used. These are the temperature values, the compositions, the moisture content they contain, the coking values, the volatile substances they contain and the like.

The heat values of the coals vary according to their types and the composition of the compounds (Table). However, when this device is not available, it is possible to calculate it with Dulong and Vondrachak equations.

$$\text{Dulong equation : } I_u = 81 C + 334,6 \left(H - \frac{O + N}{8} \right) + 25 S \text{ cal/gr}$$

The $O + N / 8$ term can be taken as $O / 8$ when the amount of nitrogen is negligible. This equation goes away from accuracy when the percentage of oxygen is high. For this, Vondraček gave an empirical equation,

$$I_u = (89.1 - 0.062C') C + 270 \left(H - \frac{O + N}{8} \right) + 25 S$$

These are the upper heat values found with the help of equations. To find the lower temperature values

$$I_a = I_u - 60 W$$

W: the amount of water by weight in the sample.

The moisture content of the coals; There are two kinds of coarse moisture and hygroscopic humidity. However, drying in lignite coal, such as hard coal, is not suitable, as lignite coal is oxidized at 100-110 °C and its burning or decomposition is a matter of betting. This is because lignite coal is more yem than coal and therefore less determined. The volatiles contained in coal act on the state of the flame during combustion (long and short flame). This situation of the flame is very important in the furnaces, furnaces, boiler systems. It is important in the determination of ash that the ash amount affects the quality of the ash, where the coal is used.

NOTE: C, S, O, N, H: percent by weight of the elements

Carbon: Percentage of fixed carbon by weight

Ashes:

- a- Easy melting 1200 °C
- b- Medium melting 1200 °C - 1400 °C
- c- Hard melting 1400 °C - 1600 °C
- d- which are not melting. 1600 °C,

There are total four types.

The process of coking is important in determining the degree of coking, obtaining smoke-free fuel and benefiting from volatile substances.

The ultimate analysis of the analyzes for the determination of the coal composition is moisture, ash, volatile matter, heat value and coke analysis (proximate analysis).

Before proceeding with the analysis, it is important in terms of the health of the processes performed in the preparation of coal samples. There are many sampling methods. The main aim is to minimize or eliminate the local variations that may occur in the same kind of coals and to mix the sample to homogenize. The most common application of this mixing is the method of four. Accordingly, a coal heap (several kg) is divided into four and the diagonal two parts are mixed with each other and divided into four again and the diagonal is mixed with each other and these processes continue to be analyzed until the coal sample remains. Since the size of the parts is also important in the analyzes, it is necessary to bring the coal to the size of the material to be used in the analyzes. In laboratory studies, the size required for us is 196-256 mesh.

ANALYSIS

COAL ANALYSES

Lignite and fat coal distinction:

The line is drawn with a charcoal on a unglazed porcelain black, the line drawn with lignite charcoal is brown. This is because the carbon in the coal is high.

3 gr. the powdered lignite sample and the hard coal sample are boiled with 120 ml of water and 40 ml of 33% NaOH in a water bath for 15 minutes. Shake well, wait, filtered. The filtrate is colorless in stone coal and in lignite coal it is brown in color due to humic acid.

Determination of the amount of water:

Coarse moisture: The fuel is made by drying at ambient temperature until practically constant. The sample is placed in a tared container. It spreads uniformly. The relative humidity (60% + 10) is kept in the air at 20 oC until it reaches a constant scale. The sample should be protected against dust and heavy air flow.

$$\% \text{ coarse moisture} = \frac{(a - b)}{a} \cdot 100$$

a- Dried charcoal weighing gr. (initial weighing)

b- Amount of dried coal gr.

Hygroscopic humidity:

It is defined in two ways. Oven method, xylol method. (Distillation)

Oven Method: Air dried sample is taken. 25 g of a petri dish. (If the water content is low, weigh the sample with a sensitivity of 50 g. 0.01, weigh the glass of the petri dish again (one hour) with a precision of 0,01. The petri dish is again covered with a clock glass before it is taken to the desiccator and it is cooled in the desiccator.

$$\% \text{ Hygroscopic humidity} = \frac{(a - b)}{a} \cdot 100$$

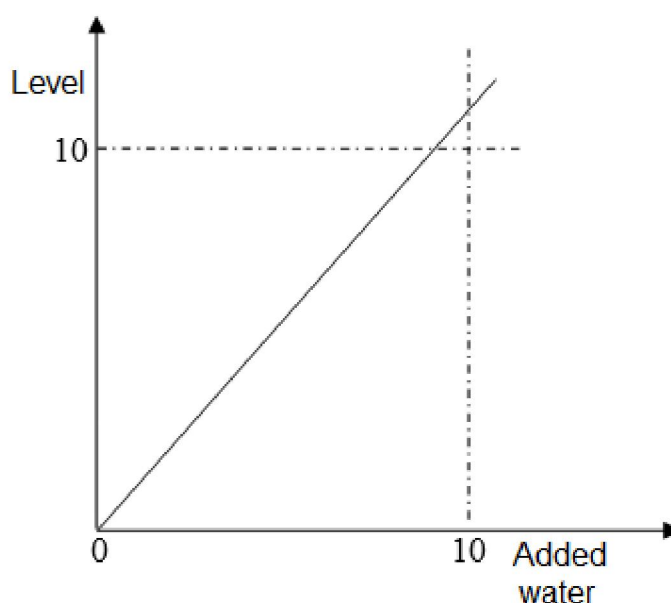
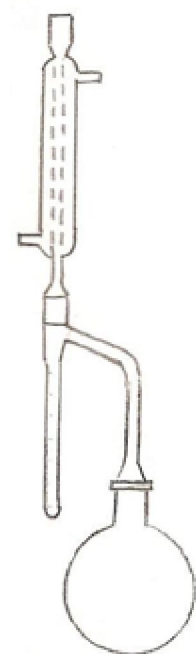
a- Dried coal weighing in air gr.

b- Dried coal weighing in the oven.

Xylol method: (Distillation method)

A quantity sufficient to deliver 3-6 ml of water from the sample (50 g of less than 30 g of samples with a lot of water) is quantitatively weighed, placed in a 500 ml volume flask of the device shown. 100 ml of xylol is saturated with water. 0.01 ml sensitive measuring cup is attached to the flask and heating is started under reflux. The heating is adjusted so that the distillation is faster then first, after a portion of the material has passed slowly. Very fast heating is blurred. The coolant flow through the cooler during the processing time is stopped. By allowing the water in the upper section to heat up near the boiling point, it is ensured that the hot xylol vapors drag water drops accumulated around the inner tube of the cooler. Distillation is continued until the water level in the water holder is fixed (approx. 3 hours). At the end of the process, the collected waste in the measuring cup is allowed to cool to room temperature. The volume of the water is absolutely read. As the water is under pressure of the xylol phase, the volume read is different from the actual volume. For this, it is necessary to prepare a correction chart. The measuring cup is filled with a little bit of xylol from the read mark and 1, 2, 3 ml of water is added respectively. The water level read after each addition is recorded. The curve drawn between the amount of water added and the level is used as the correction graph. Such a graph is shown in the figure to give an idea.

Before starting the determination, all parts of the device must be completely cleaned from the oils with bichromatesulphate acid. Otherwise, the water droplets stick to the oily surfaces, so that the results are inaccurate.



This cleaning process can be done by holding the containers in hot bichromate-sulphate acid for 15 minutes and then rinsing thoroughly with plenty of water and passing the steam for 10 minutes.

Water Determination in Fat Coal:

(a) The lapped sample is kept open to the fixed weighing of 105°C in the rinse bowl. % Water is calculated from the difference.

(b) -Lithium Water Determination: Here, rather than xylol is placed and boiled. Moisture is calculated from the volume of water collected in the water trap.

Determination of Ash:

After the determination of the coarse humidity, take 2-3 g of the powdered coal and weigh in the platinum crucible. In the light burnt flame before the heat is angled. Occasionally Pt is mixed with wire. After burning is finished, it is heated to 50 - 800 °C and put into constant weight. In the muffle oven (at 850 -900 °C) 300 mm width should be done in angular porcelain boat at a depth of 50 mm. The experiment is also carried out with porcelain crucibles. The determination of ash in lignite and coals is the same.

Preparation of coking sample

The sample is stored at 105 °C until constant weighing, cooled in desiccator. The dried sample is milled through a 0.2 mm sieve. During the milling, the whole sample must pass through the sieve. Even the very small portion of the sample cannot be discarded as it will eventually be divided.

Determination of crude coke

Take 1 g of powdered stone charcoal and put in weight 20 g, depth 4 cm, lower diameter 20, upper diameter 20 cm. It is placed on a triangle. The length of the Bunsen burner flame is adjusted to 20 cm. The distance between the blue flame and the crucible must be one inch. This is heated for 7 minutes. The mixture is cooled and weighed. The residue is crude.

Coking of lignite:

Coking is carried out according to the Finkler method. 1.00 + 0.005 g air dried sample is taken and weighed in a unglazed porcelain crucible. To remove the air from the pot to drag the sample in powder form 10 min. H₂SO₄ is also delivered with dried air gas or H₂. Then 2 min. a small Bunsen burner flame is heated. The flame is gradually enlarged. In this case, the crucible is heated on both sides so that the flames are wound. When the yellow flame of the gassed substance is lost, the crucible and the parts of the flammable material on the outside of the lid are heated strongly to the crucible. So that the coking 3 lu on the wait 10 min. it is over. The crucible is cooled and weighed in coal or H₂ stream.

Determination of Sulfur by Eschka Method in Coal:

1g of the sample is mixed thoroughly with two parts of superheated MgO and one part anhydrous Na₂CO₃ or 3g of the same amount of Na₂CO₃ and K₂CO₃ mixture (eschka mixture). The mixture is placed in a platinum or nickel crucible, heated strongly from the top. Occasionally platinum is mixed with wire. After heating up to red, no black particles are left in the mixture. The temperature in the heating oven can be gradually increased to 800 ± 25 °C. The crucible is placed in a beaker containing 100 ml of water and the mass is allowed to pass through the water by gentle heating. The crucible is washed with pure water and removed from the beaker. Add 25ml of concentrated HCl to the beaker. H₂O₂ is placed to boil and boil. The filtrate is filtered off and the filtrate is diluted with dilute NaOH to

give a methyl ratio. Add 1ml, 1N HCl and gently boil 10 ml of BaCl₂ with pipette and add the mixture. 15 min. Boil and stand under boiling temperature for two hours. The solution is filtered and washed with hot pure water and washing with AgNO₃ until precipitation is not carried out. The sediment is burned in the burner flame in the platinum and porcelain crucible and brought to the constant weight at 925 °C. A trial with the Eschka mix is done.

$$\% \text{ Sulphur} = (A-B)/T \times 13.4$$

A: BaSO₄ amount with sample

B: BaSO₄ amount of Blank experiment

C: Sample amount

Nitrogen Determination in Coal:

Nitrogen determination is done by kjeldahl method. In a sample sample of 1g, 7-10 g K₂SO₂ in the kjeldahl flask and 0.6-0.8 g of metallic mercury are decomposed with 30 ml of concentrated H₂SO₄. Upon warming, several KMnO₄ crystals are removed and the oxidation is complete. 200 ml of pure water is added to the cold flask. Add 4% 25ml 0.1N K₂S to precipitate mercury. Phenolphthalein is made basic with 40% NaOH beside the indicator. Prior to this, the tip of the cooler should be pressed to 25 ml of 0.1N H₂SO₄. Balloons are heated so that 100ml of waste is collected per hour and the balloons are heated so that 150-200ml of waste is collected and the process ends when 150-200 ml of waste is collected. The excess of the acid was titrated with 0.1N NaOH solution.

Analysis Results:

% Hygroscopic water = a

% Ash = b

% Raw coke = c

% Volatile = e

% Pure coke = c-b

% Flammable pure coal = 100- (a + b)

% pure coke in pure coal = (c-b)/(100-(a+b))*100

% ash in raw coke = b/c*100

% volatile matter = 100 – (a+c)

QUESTIONS:

1. How is sampling done by the method of quaternization?
2. Describe the lignite and hard coal differentiation test.
3. Why does the hydrophobic water determination in lignite coal not be carried out by the method of incineration?

4. What is the presence of turbidity in the determination of hygroscopic water by xylol method and how is it prevented?