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Topic 1

Calorific Value of fuel is the measure of heat or energy produced. It is usually expressed in GCV(HHV) or NCV(LHV). The difference being the latent heat of condensation of the water vapour produced during the combustion process. Gross calorific value assumes all vapour produced during the combustion process is fully condensed. Net calorific value assumes the water leaves with the combustion products without fully being condensed. Fuels should be compared based on the net calorific value. The calorific value of coal varies considerably depending on the ash, moisture content and the type of coal while calorific value of fuel oils are much more consistent.

Energy content of the Indian Coal is expressed in “Useful Heat Basis (UHV)”. Indian coal (non-coking) is classified by grades (A-G) defined on the basis of Useful Heat Value (UHV). UHV is an expression derived from ash and moisture contents for non-coking coals as per the Government of India notification. UHV is defined by the formula:

$$\text{UHV kcal/kg} = (8900 - 138 \times [\text{percentage of ash content} + \text{percentage of moisture content}])$$

In the case of coal having moisture less than 2% and volatile content less than 19%, the UHV shall be the value arrived as above, reduced by 150 kcal/kg for each 1% reduction in volatile content below 19% fraction pro-rata. Both moisture and ash shall be determined after equilibrating at 60% relative humidity and 40°C temperature as per relevant clauses of the Indian Standard Specification No. IS:1350-1959.

The quality of coal depends upon its rank and grade. The coal rank arranged in an ascending order of carbon contents is **Lignite --> sub-bituminous coal --> bituminous coal --> anthracite**

Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal ranges from 35% to 50%.

Chemical composition of the coal is defined in terms of its proximate and ultimate (elemental) analysis. The parameters of proximate analysis are moisture, volatile matter, ash, and fixed carbon. Elemental or Ultimate analysis encompasses the quantitative determination of carbon, hydrogen, nitrogen, sulfur, and oxygen. The calorific value **Q**, of coal is the heat liberated by its complete combustion with oxygen. **Q** is a complex function of the elemental composition of the coal. **Gross Calorific value Q** is mostly determined by experimental measurements. A close estimate can be made with the Dulong formula

$$Q = (144.4 \% [C]) + (610.2 \% [H]) - (65.9 \% [O]) + (0.39 \% [O]^2)$$

Q is given in Kcal/kg or Btu/lb. Values of the elements C, H, and O, are calculated on a dry ash-free coal basis.

Empirical Relationship of GCV, UHV, and NCV

UHV: Useful heat value = $8900 - 138(A+M)$

GCV: Gross Calorific Value = $(UHV + 3645 - 75.4 M)/1.466$

NCV: Net Calorific Value = $GCV - 10.02M$

UHV, GCV, NCV in Kcal/Kg, "A" is %age Ash; "M" is %age Moisture.

Non-coking Coals produced in all states other than Assam, Arunachal Pradesh, Meghalaya, Nagaland are graded on the basis of Useful heat value (UHV) in Kcal/Kg from Grade A (>6200), 'B' (5600-6200), 'C' (4940-5600), 'D' (4200-4940), 'E' (3360-4200), 'F' (2400-3360), 'G' (1300-2400). Coal from Assam, Arunachal Pradesh, Meghalaya, Nagaland are not graded. Coking coal used for steel industry grade-I (ash < 15%) and grade-II (ash 15-18%). Further classification for semi-coking, weakly coking coal is done on ash %age and UHV.

Rational for adopting UHV system:

The origin of Indian coal is through drift theory, as a result of which the coal matter is intimately mixed with mineral matter causing deterioration in its quality. Coal of most of the other coal producing countries originates through insitu theory in which the possibility of deterioration of the quality is far less during its formation stage. Indian coal due to its origin has some inherent ash content and some extraneous ash content. The inherent ash cannot be taken away because it is embedded in the coal in such a fine manner that you just cannot take it off. Extraneous ash can be taken care of by washing. The wash-ability curve shows that to reduce ash below a certain limit, there is too much of rejects in it and each percentage of ash reduction in the coal will cost lot of money. It is totally dependent on the economics. Due to this particular fact, the wash-ability characteristics of Indian coal the washing becomes, at times, prohibitive, vis-à-vis cost. Coal is mostly beneficiated before dispatches in most of the countries abroad, which results in consistent quality of the product.

In the GCV system of grading of non-coking coal, it is possible to determine the exact value of non-coking coal grades supplied to consumers whereas in the existing UHV system, the heat value cannot be determined directly but computed by using an empirical formula based on ash and moisture content. The band variation in GCV grades of non-coking coal is narrower than the existing variation of heat value in the UHV system.

The average GCV of total coal supplied to different sectors including power sectors during the past few years has been of the order of 4900 K.Cal./Kg. This is far below the GCV of imported coal which often exceeds 6000 K.Cal./Kg. Existing system of grading of non-coking coal on the basis of Useful Heat Value (UHV) to Gross Calorific Value (GCV) is under review by government.