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# Innovative Price Adjustments Technique for Thermal Coal: A Study of Operation Function under Changing Techno Environment

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*Abstract -* Coal is a vital source of energy in India. Major portion of energy requirement in India fulfill by coal based thermal power plant. Price of electricity indirectly depends on raw material (coal). In India coal trading generally done on over the counter basis, in which price of coal is depend on settlement price of coal as per the quality of coal. Coal price is generally calculated on certain parameter moisture content, calorific value, ash content, sulfur content. India supplier settles coal prices on some formula to adjust coal price.

The object of this paper is to highlight the price adjustment formula which buyer and seller used to calculate price settlement for their contract agreement. Price of coal is generally decided by their calorific value, moisture content, ash content and sulphur content in coal. So for the adjustment in price Coal supplier and buyer use some formula as per quality to adjust quantity.

The aim of this paper is to amend existed formula, and to give innovative approach to implement a price adjustment formula of coal as per the quality bases.

*Keywords :* *moisture content, sulphur content, Ash content, calorific value, price adjustment.*

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# Innovative Price Adjustments Technique for Thermal Coal: A Study of Operation Function under Changing Techno Environment

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The aim of this paper is to amend existed formula, and to give innovative approach to implement a price adjustment formula of coal as per the quality bases.

*Keywords : moisture content, sulphur content, Ash content, calorific value, price adjustment.*

## I. Introduction

Coal is a vital source of energy in India. Major portion of energy requirement in India fulfill by coal based thermal power plant. Cost of electricity indirectly depends on raw material (coal). In India coal trading generally done on over the counter bases, in which price of coal is depend on settlement price of coal as per the quality of coal. Coal price is generally calculated on certain parameter moisture content, calorific value, ash content, sulfur content. India supplier settles coal prices on some formula to adjust coal price.

Coal being a commodity does not have uniform quality of coal. The quality of coal changes with every shipment and is different for every rake supplied to power utilities. Commercially, in India and various countries some adjustment is done in case of variation in quality of coal. There are some quality parameters guaranteed by supplier within the quality range, as finalized with their Suppliers.

*a) Price Adjustment Formula*

The imported coal to be supplied under any agreement between two parties follow price adjustment formula based on calorific value of coal specification. There is specified range of guaranteed parameters which depends on agreement specified earlier:

**Typical price basis for supply of coal to major thermal power plants in India**

**Total Moisture: 16%**

**Ash content: 10%**

**Sulphur content: 80%**

**Gross calorific value: 6400kcal/kg**

Generally a range of coal parameters are specified along with base parameter for price. The indices of these base parameters are published daily e.g. API4, NEX, global Coal Index.

Based on the published indices and actual quality of coal supplied, price of coal is determined.

## II. Adjustments Due to Quality Variation

In the variation of the quality parameter, suitable adjustment will carried out as per the formula given here:

*a) Total Moisture ( ARB)*

If there are moisture present in the coal then adjustment in quantity of coal in weight for x% increase over the guarantee total moisture, total weight is reduced by x%.

But the in case of decrease in total Moisture below the guaranteed value is ignored.

**ARB: as received bases**.

*b) Ash Content (ADB)*

For every increase of x% of the ash content, the weight of coal reduced by x%.

But the decrease in the ash content below the guaranteed value will be ignored.

*c) Sulphur (As Dried Bases)*

If the sulphur content in delivered coal quantity is increased by some percentage then penalty should be levied as per the agreement in the contract.

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*d) Objectives of the Study*

1. To compute Adjustment in quantity of Coal as per moisture content.
2. To compute penalty should be levied on quantity of coal as per sulphur content.

*e) Research Design*

Research Methods which have been used for this project are as follow:

i. *Exploratory Research Method*

This research is considered as an exploratory due to the following reasons:

- The research aims is to provide a comprehensive insight study into a newly developed situation.
- The research primarily relies on secondary sources of data.

*f) Source of Data*

In this study of project secondary data used:

i. *Secondary Source of Data*

For this research several source of secondary data have been used.

- Tender report for Coal trading contract.
- Modern ***ABC*** of ***Textbook Chemistry*** Vol. I & II For by Dr. S.P.Jauhar Modern.
- Internet search
- Research paper publish on world /India energy market
- Report published on Coal trading.

## III. Adjustment Due to Moisture Content in Imported Coal

If coal contains moisture then extra energy in form of heat require to burn coal. The amount of heat can be calculated as:

*a) Amount of Heat Required to Evaporate Moisture Contain in Thermal Coal*

The amount of heat required to heat a subject from one temperature level to another can be expressed as:

$$Q = c_p\, m\, DT$$

**Where**

Cp = Specific Heat (kJ/kg.K),
Q = Amount of heat (kiloJoule) and
M = mass (kg)
dT = temperature difference between hot and cold side (K)

*b) If Coal Contains Moisture in form of Water then Amount of Energy Required to Evaporate Water is*

Let the energy (in form of heat) needed to heat 1.0 kg of water from 0 °C to 100 °C when if the specific heat of water is 4.19 kJ per kg K:

$$Q = (4.19\ kJ/kg.K)^* (1.0\ kg)^* ((100\ °C) - (0\ °C))$$
$$= 419\ (kJ)$$

*c) Boiling Water at 100°C, 0 Bar Atmospheric Pressure*

At atmospheric pressure water boils at 100 °C, and 417.51 kilo joule of energy will be required to heat 1 kg of water from 0 °C to its evaporating temperature of 100 °C.

Another 2257.92 kJ of energy in form of heat are also required to evaporate 1 kg of water at 100 °C into 1 kg of steam at 100 °C

Total heat requires to evaporating water is:

$$Hs = (417.51\ kJ/kg) + (2257.92\ kJ/kg)$$
$$= 2675.43\ kilojoules/kg$$
$$= 639.443Kcal/KG$$

So from the above result we justified that 640 kilo cal heat is required if coal contain 1 kg of water as form of moisture. So there should be a requirement of amendment of price adjustment formula of coal as specified above.

*d) Adjustment*

In moisture contain adjustment generally we reduced weight of coal by x% if moisture is excess by x%.

- One kg of coal equivalent to 6300kcal of energy.
- One kg of water requires 640kcal of heat to evaporate.

So in a adjustment formula 1 kg of water = 0.1 kg of coal

*e) Finding*

Actual amendment in price adjustment should be 1.1x% of reduction in quantity of coal if there is x% moisture contain in imported coal. Because this excess of amendment should be done due to equivalent the amount of heat require to evaporate water inform of moisture present in coal.

*f) Mechanical Work done on Excess of Moisture Contain in Coal*

There are also some mechanical work should be done to uplift the weight of coal due to the excess of moisture which can be calculated as:

$$Work = Force \times Distance$$

**Example - Work done by Force**

**Let if 100 kg of coal have 1% moisture that means it have 1kg of water, so to lift this excess amount of coal work has to be done, which can be calculated as follow:**

The work done by force 1 kg water moving a body 50 m can be calculated as

$W = F^*L = mg^*l$ where m is weight and g is gravitational force.

$$= 1^*10^*50 = 500Nm$$

Work is described as the product of the applied pressure and the displaced volume:

Work = Displaced volume x Applied pressure



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The unit of work is joule, which is defined as the amount of work done when a force of 1 Newton acts for a distance of 1 m in the direction of the force.

$$1 J = 1 Nm$$

So total energy required is 500 joule.

**Example - Work due to Gravitational Force**

The work done when lifting a mass of 1kg an elevation of 10 m can be calculated as

$$W = m^* g^* h$$
$$= (1 kg)^* (10 m/s^2)^* (10 m)$$
$$= 100Nm (J)$$

## IV. Result

Energy required lifting and transport of moisture contain in coal can be calculate by excess of work done on weight of moisture. Amount of this energy is variable in nature depends upon distance travelled by coal.

*Finding:* First finding of our report due to moisture content require following amendments:

- If imported coal content x% moisture above the agreed limit then we should decrease coal quantity by 1.1x% because of extra energy requirement of burning of coal.
- There should be amendment because of uplifting the excess moisture, which cause excess of freight charges to transport coal.

## V. Adjustment Due to Sulphur Content in Coal

Sulphur is a most harmful and environmentally damaging pollutant in our air. Each year, uncontrolled power plants release much more sulphur into the air then cars, truck and factories. Power plants sulphur comes from burning coal. $SO_2$ emissions are a major problem in the burning of coal and depend on the level of their sulphur concentration. Thermal coal is used in power plant is,a major source of sulphur emission in India.

*a) Price Adjustment for Sulphur: (Air Dried Bases)*

i. *Present Penalty Adjustment in Indian Industry*

The sulphur content in coal should be limited to 0.8 % and there shall not be any penalty for sulphur content in the coal received upto 0.8 %. The penalty for sulphur content upto 0.9% shall be @ Rs.10/- per MT for every 0.1% rise and the same above 0.9% shall be @ Rs.15/- per MT for every 0.1% rise .

**It is to be noted that if the sulphur content exceed 0.9% for which buyer has to pay penalty for SOx emission above permissible limit that has to be borne by the party.**

Calculation of penalty for Sulphur Content (ADB) above 0.8 %

Let the coal sample is having sulphur content of 1 %.

Thus the penalty for high sulphur will be levied in two slabs as below: 5

- @ Rs. 10/- per MT for every 0.1% rise in Sulphur upto 0.9%. As per this, penalty will be for 0.9 (-) 0.8 = 0.1 % = Rs.10/-
- @ Rs. 15/- per MT for every 0.1% rise in Sulphur above 0.9%. As per this, penalty will be for 1.0 (-) 0.9 = 0.1% = Rs.15/-

Hence, penalty deduction per MT for coal received having Sulphur 1.0% the penalty will be:

= Rs. [(i) + (ii)]
= Rs. (10 + 15) = Rs. 25 per MT

Here above rate of penalty change depends upon prior agreements.

*b) Penalty Associated with Sulphur Content in Imported Coal Depends Upon Following*

Sulphur content in coal is removing by scrubbers, so total cost incurred in purification of flue gas desulphurization is associated as penalty of imported coal .Capital costs for So2 scrubbers applied to electric utilities are reported to be approximately $150/Kw.

| Type of scrubber | Size of unit in (MW) | Capital Cost in ($/KW) | O&M Cost ($/KW) | Cost per annum ($/KW) | Cost per tonne of Pollutant Removed ($/ton) |
|---|---|---|---|---|---|
| Wet | >400 | 1000-2500 | 2-8 | 20-50 | 200-500 |
| | <400 | 2500-1500 | 8-20 | 50-200 | 500-5000 |
| Spray Dry | >200 | 40-150 | 4-10 | 20-50 | 150-300 |
| | <200 | 150-1500 | 10-300 | 50-500 | 500-4000 |

*Source : EIA, EPA 2001*



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*c) Calculation*

Since the desulphurization cost data is of 2001 and in absence of current data, we may make price adjustment for the inflation.

Assuming a minimum of 5% inflation, compounded inflation factor for 10 years becomes (1.05) ^10 = 1.63

So from the above calculation average cost per ton of pollutant removed is 500$/ton.

=500*54 * 1.63 Rs per ton
=44000 per ton
=44 Rs per kg of pollutant removed

Such that if our coal sample content 0.1% of excess of sulphur per metric ton of coal

= 1 kg of sulphur per metric ton of coal

So penalty should be levied should be more than the cost of desulphurization i.e. Rs 44.00 per Mt of coal.

More aware, consumers of steam coal are aware of the fact and have updated the penalty of sulphur. M/s West Bengal Power Development corporation Limited charges Rs 50 PMT for 0.1% increase in sulphur from the guaranteed parameter of 0.8% and charges rs 150 for every 0.1%

## VI. Recommendation

Sulphur content in coal is also a major problem for environment. Coal based Thermal power plant are reluctant to cut sulphur contain and their policies are not stringent to contain sulphur pollution in future. Sulphur has ill effect for environment as well as health. Penalty levied on imported coal should be more than cost of desulphurization there should be proper regulation on sulphur emission act.

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