Setting up of modalities for normative coal requirement in respect of cement and sponge iron industries

Sponsored By

Coal India Limited

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1.0   Project Title   : Setting up of modalities for normative coal requirement in respect of cement and sponge iron industries

2.0   Sponsor   :   Coal India Limited, Apeejay House, B-Block, 6th Floor, 15, Park Street, Kolkata 700016

3.0   Objective   :   Fixation of normative quantity of coal requirement for different categories of cement and sponge iron sectors

4.0   Back ground :

As per the policy guideline, actual coal consumers get supply of coal through Fuel Supply Agreement (FSA). Previously CIMFR was entrusted with the responsibility to work out normative requirement of coal by the various industries based on scientific approaches and accordingly the detailed report on the above subject matter based on the UHV based grading system was submitted during 2008-09. To determine the normative quantity of coal requirements of different consumer segments CIMFR team had to evolve methodologies to formulate the basis for making a realistic assessment of the quality and quantity of coal requirement. Meanwhile, from 1st January' 2012, coal marketing is being done in India based on GCV based grading system instead of UHV based grading system. Moreover, coal demand supply scenario and fuel utilization strategies have also been changed in various sectors. In this context it is being felt necessary to reassess the coal requirement based on the GCV based grading system for different process technologies available within various energy and manufacturing industries. Under this scenario Coal India Limited has awarded a project to CIMFR, Dhanbad, in April' 2014, to work out normative coal requirements in Cement and Sponge iron industry based on the GCV based grading system on priority basis with the idea that similar kind of exercise will have to be done for other sectors also. All such exercises are essential to formulate well defined user friendly methodologies for allocation of coals to different sectors.

5.0   Approach:

The two industries which have been identified belong to the energy intensive sectors. The projected coal requirement of different sectors which have been identified by these two sectors is available in different plan documents. For making a rational estimate of the quality and

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required quantity of coal several factors are to be considered such as, the technology type, constraints in coal quality, consumption pattern vis-à-vis production trend analysis of the yester years, efficiency of conversion, etc. The energy status of the industries which utilize heat from fuel combustion have been carefully taken into account. It has been observed that industries adopt some unique fuel economization strategies resulting in the different type of fuel use for a particular sector. Moreover, depending on capacity, technology, vintage factor, product quality, product pattern, heat recovery techniques etc., specific energy consumption for a specific sector varies a lot. Indian context or Indian scenario has been considered for both sectors to find out rational process-/technology- specific thermal-energy consumption figures. Extensive literature survey and analysis of the gathered information were done and our earlier experience was utilized to arrive at the specific energy consumption values for various technologies available in India, based on which coal requirements have been evaluated. This evaluation is also based on present GCV based coal grading system.

Qualitative requirement of coal in both cement and sponge iron sectors are guided by Indian standards which have been summarized in Table 1 and Table 2 respectively.

Table 1: Requirements for Coal for Cement Industry (IS 12770:1989)

Sl. No.	Characteristics	Requirement
i)	Total Moisture content,	Max. 8
	(at 60 percent RH and 40ºC) percent by mass	
ii)	Volatile matter, (air dry basis) percent by mass	Min.24
iii)	Ash, percent by mass	
	a)dry Process	Max. 27
	b)Wet process	Max.24
iv)	Sulphur, percent by mass	Max.0.8
v)	Chloride, percent by mass	Max.0.01
vi)	Size, mm	Max.250

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Table 2: Requirements for Coal for Sponge iron industry in case direct reduction in rotary kiln and in other reactors   (IS 11860:1998)

Sl. No.	Characteristics	Requirement
i)	Inherent Moisture content, percent by mass, Max	4
ii)	Ash, percent by mass, max	24
iii)	Volatile matter percent by mass	25-35
iv)	Fixed Carbon , percent by mass	By diff in proximate analysis
v)	Sulphur, percent by mass, max	1.0

In general, major quality requirements of coal for Sponge iron production are:

1) Non-coking characteristics

2) Low ash content

3) Low sulphur content

4) Good reactivity

5) High ash fusion temperature

6) Medium volatile matter

Following specifications of coal quality are often considered by the sponge iron industries:

Fixed Carbon: 42.5 % (min.)

Ash: 27.5 % (max.)

VM: 30%

S: 1.0 % (max.)

Moisture: 7 % (Max.)

Reactivity: 1.75 cc of CO/gm C/sec

Caking index: 3 max.

Size Lumps: 3-20 mm

Contamination: < 3% (Shale & Stones etc)

An understanding of the desired coal quality required for the existing processes of the Indian Sponge Iron and Cement industries and an objective assessment of the variability of the quality

parameters of Indian non coking coals within the different grades suggest that coals belonging to the grades from G-4 to G-14 are good enough for both the industries. However, coal grades G-11 to G-14 may be accepted by the industries if user can either adopt proper blending / beneficiation strategies, or if some compromise in respect of product quality and efficiency be acceptable while using the above coals as such. In such cases coal requirement will have to be assessed depending on the blending ratio or yield of the beneficiation process. As per letter from CIL dated 10. 7. 2014 under ref. no. CIL/C-4B/14-15/NORMATIVE/385, this final report provides the normative requirement of coals of different coal grades from G1 to G-14 considering the specific energy requirement for Cement as well as Sponge Iron Industries and gross heat value available from the respective grade of coals.

The mean Gross Calorific Values of the coal grades from G-1 to G-14 utilized in this evaluation are summarized below:

Table 3: Coal grades (G-1 to G-14) and their Mean Gross Calorific Values

Coal grades	GCV range, kcal/kg	Mean GCV, kcal/kg
G-1	Above 7000	7150
G-2	6701-7000	6850
G-3	6401-6700	6550
G-4	6101-6400	6250
G-5	5801-6100	5950
G-6	5501-5800	5650
G-7	5201-5500	5350
G-8	4901-5200	5050
G-9	4601-4900	4750
G-10	4301-4600	4450
G-11	4001-4300	4150
G-12	3701-4000	3850
G-13	3401-3700	3550
G-14	3101-3400	3250

6.0 Normative coal requirement of cement industries:

There are basically three processes for manufacturing of Cement clinker, viz. wet process, semi dry process and dry process. All these processes are basically coal based processes. But due to shortage of required specified coals, many other fuels like Lignite, Petroleum coke, Coke, Natural Gas, Biomass products, etc. are being used in some cement manufacturing plants for supply of process heat.

The quality of coal required for cement Industries as per Indian Standard has been given in Table 1.

For assessing the coal requirement for different process types the specific heat consumption ranges were first considered. It has been noted from different sources and literatures [e.g., ref. No. 1-9] that specific heat consumption for different manufacturing processes are as follows:

Table 4: Specific energy consumption for different process technologies for manufacturing of cement clinker

Processes	Sp. Energy consumption, kcal/kg
Wet	1250-1400
Semi dry	850-1000
Dry	690-900

It is to be noted here that modern kiln (for dry process) generally consumes specific energy in the range of 690- 750 kcal/ kg of clinker production. Normally all such kilns are equipped with multistage Preheater and precalciner.

For each of the processes mean specific energy consumption figures were taken into account for evaluation of grade wise coal requirement per ton of clinker production in cement plant. Accordingly, the following simplified table may be implemented for fixing up normative requirement of coal for clinker production in cement industry.

Table 5: Normative requirement of coal for manufacturing of cement clinker

	Process		
	Wet	Semi- dry	Dry
Coal Grades	kg/ ton of clinker		
G-1	185	129	111
G-2	193	135	116
G-3	202	141	121
G-4	212	148	127
G-5	223	156	134
G-6	235	164	141
G-7	248	173	149
G-8	262	183	157
G-9	279	195	167
G-10	298	208	179
G-11	319	223	192
G-12	344	240	207
G-13	373	261	224
G-14	408	285	245

It is to be noted here that the coal requirement have been calculated only for the process heat supply for manufacturing of clinker. Coal requirement for generation of electrical energy required for grinding of clinker has not been evaluated in this attempt as this evaluation falls under the power sector. Cement is the final product of this sector which is generated from grinding of clinker and added materials. But assessment of coal requirement should not be based on the cement production because of the following reasons:

i.) Large varieties of cement in the market are blended cement and there may not be any generalized linear relationship between the cement production and clinker production. Proportion of clinker in the batch (fed to cement mill) varies case to case basis

ii.) Cement may be produced by a particular company from purchased clinker.

a.) Sample Calculation: <u>Coal requirement calculation with G-4 coals for Manufacture of cement clinker by dry process)</u>

Average specific energy requirement (A) = 795 k Cal/kg of clinker production

Mid value of GCV for grade G-4 (B) = 6250 k Cal/ kg of coal

Specific coal consumption = (A x 1000)/ B = (795 x 1000)/ 6250

$$= 127 \text{ kg coal /ton of clinker}$$

b.) Sample Calculation: <u>Coal requirement calculation with G-4 coals for Manufacture of cement clinker by wet process)</u>

Average specific energy requirement (A) = 1325 k Cal/ kg of clinker production

Mid value of GCV for grade G-4 (B) = 6250 kcal/ kg of coal

Specific coal consumption = (A x 1000)/ B -------------(i).

$$= (1325 \text{ x } 1000)/ 6250$$

$$= 212 \text{ kg coal /ton of clinker}$$

7. 0   Normative requirement of coal for sponge iron industries:

Direct reduction processes available for the production of sponge iron can be broadly grouped under two categories based on the type of reductant used. These are:

  i.) Solid based processes

  ii.) Gas based processes

From amongst various solid based processes, only a few have attained commercial significance. Most of the processes such as SL/RN, KRUPP-CODIR, DRC, TDR, SIIL, JINDAL, OSIL, Popurri utilise rotary kiln for reduction whereas Kinglor Metor process utilises an externally heated vertical retort.

Today gas based DR plants subscribe to more than 90% of installed DR capacity in the world, of which MIDREX and HYL together have about 85 % of the total capacity to their credit. In the gas based processes, the reduction of iron oxide is carried out by a mixture of CO & H_2 at a temperature of about 750-950°C. The reducing gas is produced by reformation of natural gas. The reformation is partial oxidation of hydro-carbons. To enhance the reformation process, normally a catalyst is used.

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The contribution of coal based sponge iron to the total production in India has remained above 60 per cent since 2004-05. The contribution of coal based sponge iron has been on the rise. From about 8 MT in 2004-05, contributing 63 per cent to the total production, it has grown to about 16 MT in 2008-09, contributing about 74 per cent. The contribution of gas based sponge iron to total production has gradually declined over the years and stands at about 26 percent as on 2008-09 (in India).

The gas based processes are beyond our consideration because the reducing gas is normally generated by reformation of natural gas. Where as coal based processes are very common in India and share of coal based processes is also very high.

For sponge iron industries the specific energy consumption (thermal energy) in the processes have been studied from different sources and literature. Some of those literatures have been mentioned under reference section [Ref. No. 1, 10-17]. As such, this sector is recognized as an energy intensive sector and for coal based direct reduction technologies in Indian DRI plants energy consumption lies in the range of 20- 25 GJ/ t-DRI. For large DRI plants with more than 100 tons/ day capacity waste heat utilization facility is economically feasible and that is why thermal energy requirement for such plants may be reasonably considered to be 10% less than the above values. Therefore, in case of large plants (capacity > 100TPD) the range of energy consumption has been considered to be 18 - 22.5 GJ/ t-DRI with mid value of 20.25 GJ/ t-DRI. The range of thermal energy consumption, i.e., 20- 25 GJ/ t-DRI has been considered for smaller units having production capacity up to 100TPD. In this case mid value are 22.5 GJ/ t-DRI.

It is to be noted here that the evaluation of normative requirement of coals for both the categories of plants (Category I: Capacity upto100TPD, Category II: Capacity > 100TPD) have been evaluated based on mid value of the respective range of thermal energy consumption. The normative coal requirements in coal based direct reduction units in India have been summarized in Table 6

Table 6: Normative requirement of coal for manufacturing of sponge iron by coal based direct reduction process

Category	I	II
Capacity	up to 100 TPD	> 100 TPD
Coal Grades	kg/ ton of sponge iron	
G-1	752	676
G-2	785	706
G-3	820	738
G-4	860	774
G-5	903	813
G-6	951	856
G-7	1004	904
G-8	1064	958
G-9	1131	1018
G-10	1208	1087
G-11	1295	1165
G-12	1396	1256
G-13	1514	1362
G-14	1654	1488

a.) **Sample Calculation: Coal requirement calculation with G-6 coals for Manufacture of sponge iron (up to 100 TPD)**

Average specific energy requirement (A) = 5373.78 k Cal/kg of sponge iron production

Mid value of GCV for grade G-6 (B) = 5650 k Cal/ kg of coal

Specific coal consumption = (A x 1000)/ B = (5373.78 x 1000)/ 5650

= 951 kg coal /ton of sponge iron

b.) **Sample Calculation: Coal requirement calculation with G-6 coals for Manufacture of sponge iron (capacity > 100 TPD)**

Average specific energy requirement (A) = 4836.4 k Cal/ kg of sp. iron production

Mid value of GCV for grade G-6 (B) = 5650 kcal/ kg of coal

Specific coal consumption = (A x 1000)/ B -------------(i).

= (4836.4 x 1000)/ 5650

= 856 kg coal /ton of sponge iron

8. Remarks:

i.) The specific coal requirements for different industrial uses have been worked out basically on the basis of the available information and based on earlier work experience of CIMFR, Dhanbad.

ii.) In the specific energy requirement/ consumption figures mentioned in the report all heat- inputs and heat- outputs are included.

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