

**“Coal Beneficiation with Special reference to DRI
Making, Steel (Coking) & Gasification Processes”
National Seminar on Washing of Coal- Challenges & Opportunities**

Indian National Committee – World Mining Congress

New Delhi

28th July 2023

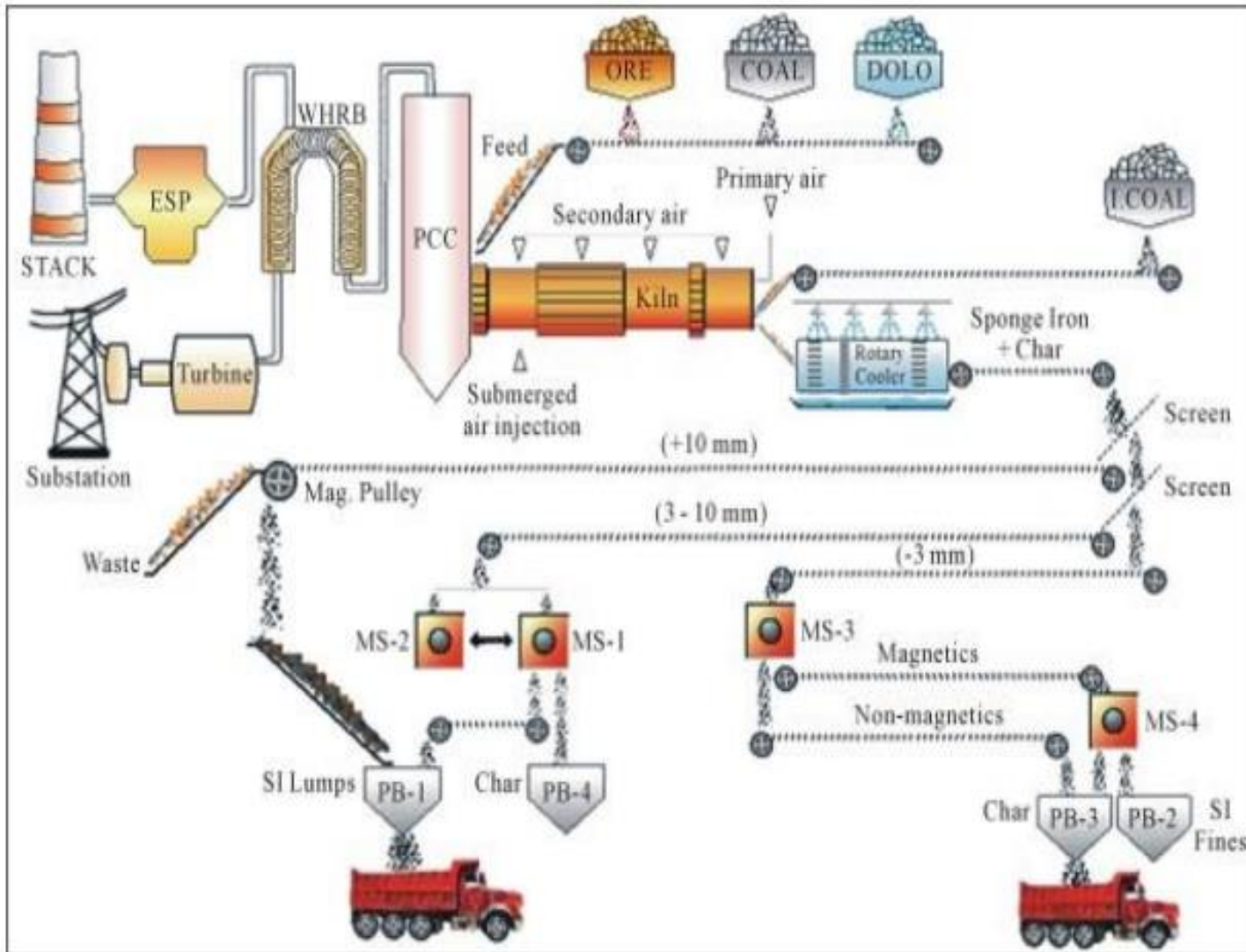
- Kapil Dhagat, EVP, JSPL & Team



- ❑ BF Route is a popular route to make Steel; It uses Coke with iron ore lumps for its reduction. Coke is derived in the coke ovens by feeding a blend of Coking Coals (Prime Hard, Semi Hard, Semi Soft)
- ❑ Direct reduction, is an alternative route of iron making. DRI is successfully manufactured in various parts of the world through either gas or coal-based technology. The specific investment and operating costs of Steel through direct reduction process are low compared to integrated steel plants, and are more suitable for many developing countries where supplies of coking coal are limited.



Process Flow Diagram of Sponge Iron/ Direct Reduction Iron Plant



Non-coking Coal :



		Imported Coal	Domestic Coal
Inherent Moisture		2 – 3 %	6% Max
% Moisture		8% Max	12% Max
% Volatile Matter		23 - 25 %	22 - 30 %
% Ash		20 - 23 %	30 %Max
% Fixed Carbon		52 % Min	40 %Min
% Gross Calorific Value		5500 Kcal/Kg Min	4800 Kcal/Kg Min
% Phosphorus		0.007 - 0.02%	0.007 - 0.02%
% Sulphur		< 0.8%	< 0.8%
Size (5-30 mm)	>30	10 % Max	5 % Max
	mm		
	< 5mm	15 % Max	5 % Max
IDT		1400°C	1300°C
CSN		0 preferable, If not than 1 max.	0 preferable, If not than 1 max.
Reactivity		2 Min CC of CO/gm of C per second	2 Min CC of CO/gm of C per second

Specific Consumption of Coal at the Plant

- Standard Sp.Cons. For DRI Plant :0.75-0.8 t/MT of DRI but with imported coal, the Sp. Cons rises to 1.35 t/MT of DRI with domestic coal whereby increasing the cost and coal consmpn
- Power Plant operations are designed for Sp. Cons. Of 0.67kg/kWh whereas with domestic coal, it rises to 0.8-0.9kg/kWh whereas with washing of coal, we can achieve the desired Sp.C;
- For Coal Gasification plant, the standard is 1kg of coal/1NM³ of Syn-Gas which is actually 1.8-1.9kg of coal/NM³ for domestic coal received from multiple sources hence needs washing

Other Parameters:

- For DRI, Fixed Carbon is also important hence blending with Imported Coal is considered to get at least 32-34% FC
- For Coal Gasification, higher FC coals are needed too with higher IDT and size ranging between +10mm to 50mm; Ash should not exceed beyond 32%

Coal	FC%	Consumption of coal in KG/NM ³ of gas
Imported coal	55	0.8
Washed coal	32	1.2

Coal plays a vital role in the plant economics:

% of Coal Cost in DRI is around 40%, In Power Plant 80%, In Blast Furnace, 26%

Benefit After Washing

Sl. No.	Particulars	Korba Coal	RB2 (Imported)	Own Commercial Mine
1	TM%	12	8	12
2	Ash%	37	21.5	35
3	VM%	23	22.5	20
4	FC%	30	53	35
5	GCV	3900	5700	4000
6	Landed Cost at Plant	3313	10777	3085
7	Rs/GCV	0.85	1.89	0.77
8	Sp. Cons	1.66	0.80	1.38
TCO	Contribution of Coal per tonne of DRI	6360	9716	4938
	Ranking	2	3	1

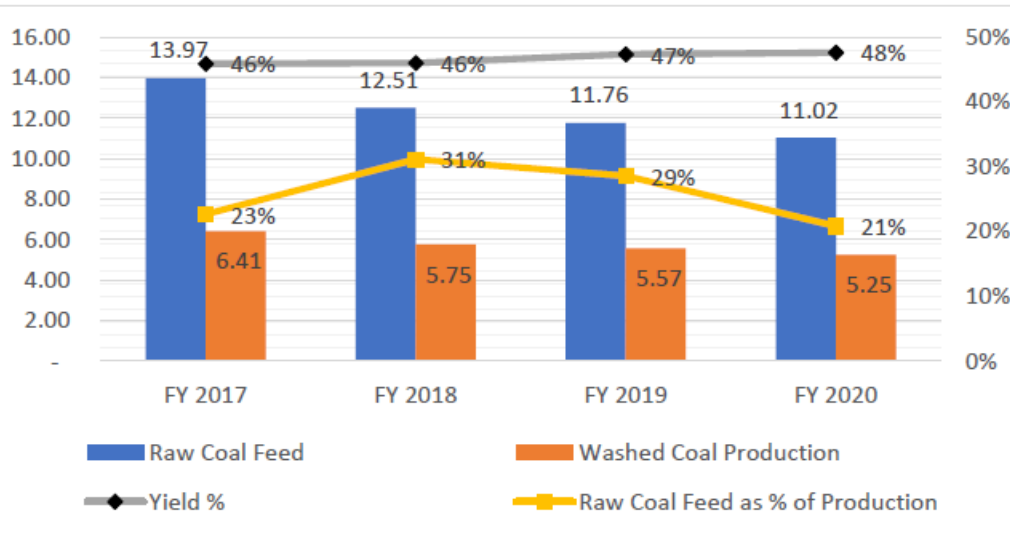
Quality Consciousness during Coal Mining

- From the experience, following quality control measures should be adopted in any opencast coal mine to improve the coal quality :
 - (i) cleaning of coal face, before drilling & blasting to extract coal;
 - (ii) Maintaining gap between coal & OB benches; benches should not be merged;
 - (iii) Ash mapping of coal face in advance of coal winning;
 - (iv) Effort should be made to mine thick bands separately & dump with OB; Accordingly the contract document should provide for such band removal;
 - (v) Proper identification of the roof and floor of the seam so as to avoid mixing of overlain or underlain dirt bands also helps in increasing coal quality;
 - (vi) In dragline benches, sub-grade drilling is cautiously decided to avoid toe & coal losses;
 - (vii) Use of ripper dozers to remove stone/shale bands;
 - (viii) Operation of Surface Miner should be planned in such a way that cutting of shale/stone bands are identified and the same is loaded separately for disposal into reject yard
 - (ix) During rainy season, mine should be regularly dewatered with adequate capacity of pumps to avoid accumulation of muck; Toes of OB dumps shall be protected with retaining walls & proper garland drains
- In Underground Mines, care should be taken to avoid working in heavily banded areas; Stones if obtained during winning of coal should be segregated & discarded belowground only.

It is a known fact that with increasing mechanization & deployment of high capacity Mining Equipment with large bucket sizes, it is difficult to mine selectively. Under such circumstances, best option is to install Pit-head Coal Beneficiation Plants.



Washed Coking Coal Production in India



- Of the 35 Bt coking coal reserves, ~20 Bt are Proved Reserves and remaining 15 Bt are Indicated and Inferred; Of the 35 Bt, about least 18Bt belonged to the LVMC variety;
- National Steel Policy'2017 envisages 300 Mt of crude steel by the year 2030, of which 181 MTPA would be through blast furnace (BF) route requiring about 161 Mt of washed coking coal at 10-11% Ash;
- There is an urgent need to use domestic coking coal as Global prices are highly fluctuating;
- Domestic coking production grew by 15.44% & 17.54% in FY22 & FY23 to 51.7Mt & 60.77Mt
- Most of the coal production is of lower grades i.e. Washery Grade III to V requiring washing of coal;
- Current coal washing capacity is about 23 MT per annum including 9.26 MT of the private sector;
- Over the last 4 years, only about 20-30% of coking coal produced was washed before utilisation with average yield of ~47% (5-7 Mt).
- CIL is planning to set up and operationalize 9 more new washeries with a capacity of 30 MTPA.
- With new washeries, CIL will be able to supply about 15 MT of washed coking coal at $\leq 18\%$ Ash;
- Washery Grade II & VI pose a big challenge for the coal washing fraternity due to high NGM, poor yields & generation of huge quantity of middling & rejects; New technologies to get higher yields.

Coking Coal Washing Capacity in India – Existing & Planned

S N	Particulars	Raw coal Throughput capacity (Mty)	Likely clean coal (Mty) 2029-30
I	CIL Washeries		
i	Existing	14.63	4.6
ii	Upcoming	30.50	13.8
	Sub-Total (CIL)	45.13	18.4
II	SAIL Washeries		
i	Existing	2.0	1.0
ii	Upcoming	4.0	2.0
	Sub-Total (SAIL)	6.0	3.0
III	TATA Steel Washeries		
i	Existing	10.0	5.0
	Total	61.13	26.4

Coking Coals in India

Sl.No.	Grade	Ash%	Sp.Gr.
1	Steel Grade - I	< 15%	1.42
2	Steel Grade -II	15% - 18%	1.44
3	Washery Washery Grade - I	18% - 21%	1.46
4	Washery Washery Grade - II	21% - 24%	1.50
5	Washery Washery Grade - III	24% - 28%	1.53
6	Washery Washery Grade - IV	28% - 35%	1.58
7	Washery Washery Grade - V	35%-42%	1.60
8	Washery Washery Grade - VI	42%-49%	1.64
9	Semi Coking - I	<19% (Ash+M)	1.44
10	Semi Coking - II	19%-24% (Ash+M)	1.46

Private players like JSPL & JSW are also gearing up to install Coking Coal Washeries & will participate in few CIL tenders. With the application of updated technologies like reflux classifiers, teetered bed separators, spirals, etc higher yields can be achieved with increased recovery of fines in these washeries. This is basically to promote more & more use of domestic coal.

Coal Quality Parameters for Fixed Bed Gasifiers

Coal Analysis (air Dry basis)	Basis	Coal Gasification Plant - Clean Coal Specification (Non-Coking Coal)	Coal Analysis	Basis	Coal Gasification Plant - Clean Coal Specification (Non-Coking Coal)
Proximate Analysis	%		Sizing mm		
			- 70 to 50	%	>3
Moisture	<i>ad</i>	7.50	- 50 to 33	%	16
Ash	<i>ad</i>	34.3	- 33 to 22	%	29
Volatiles	<i>ad</i>	26.3	- 22 to 15	%	21
Fixed Carbon	<i>ad</i>	31.9	- 15 to 10	%	18
Ultimate Analysis	%		- 10 to 7		7
Carbon	<i>daf</i>	76.4	- 7 to 5		3
Hydrogen	<i>daf</i>	5.3	- 5 to 2		>3
Nitrogen	<i>daf</i>	1.9	Coking Properties		
Sulphur	<i>daf</i>	0.7	CO2 Reactivity	<i>hr-1</i>	5.9
Oxygen	<i>daf</i>	15.7			
Intial Deformation	°C	1530			
Hemispherical	°C	1590			
Flowing	°C	1600+			

NB: Lower Fixed Carbon (24-28%) and higher Ash% (40-45%) of domestic coal makes it mandatory to wash domestic coal before blending with high FC imported coal 10

Operational Issues at CGP due to Coal Quality Issues

Coal Feedstock related Issues –

- Inconsistent quality; 45-50% Ash
- Weathered Coal
- High % of fines
- Multiple Sources
- Lower Reactivity than design
- High cost due to premiums

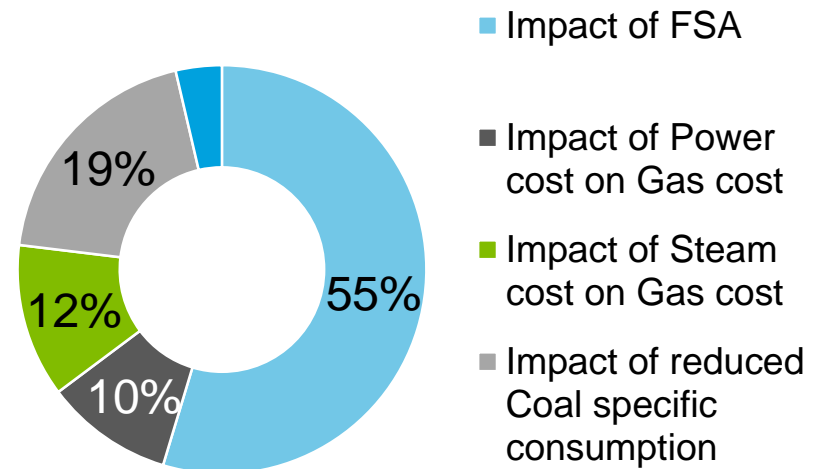
Impact on Operation –

- Unstable Operation and frequent tripping of Gasifiers due to high temperature at gasifier's outlet
- Lower capacity Utilization
- Higher cost.
- Damage of equipment

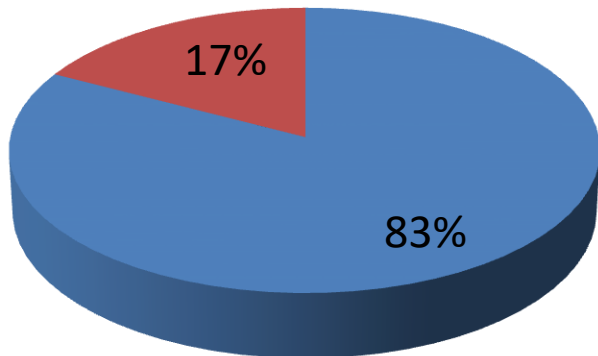
Measures Taken –

- Mixing of imported Coal as sweetener along-with Washed Talcher Coal
- Provision of blending facility (Additional cost)
- Installation of additional screens to separate fines

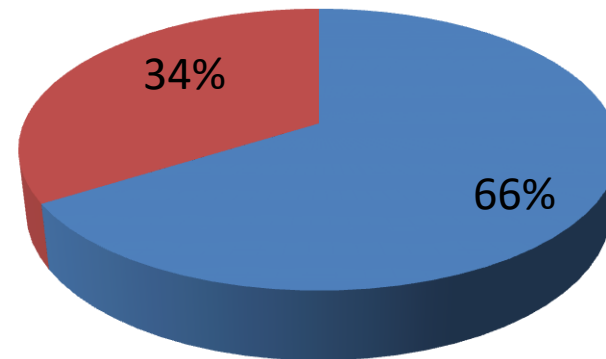
Cost Savings Breakup due to Clean Coal



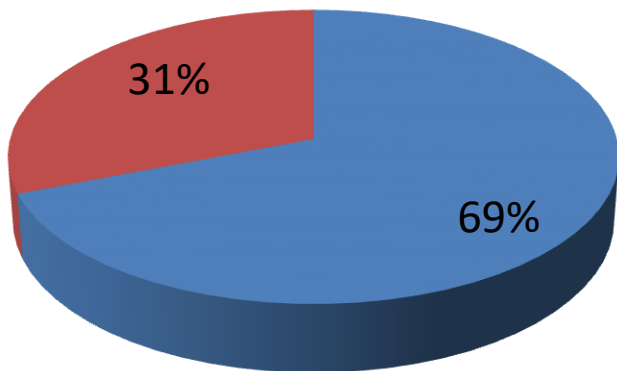
2014-15



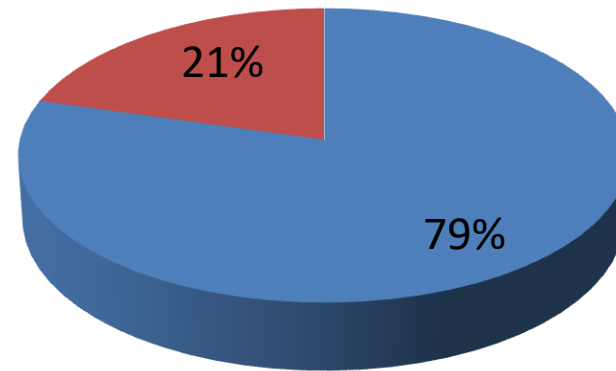
2015-16



2016-17



2017-18



■ Local Coal

■ Imported Coal

100% Domestic Coal is being used since FY 20-21

Design Data & Actual performance since commissioning

Sl No	Material	Unit	Design	FY 14-15	FY 15-16	FY 16-17	FY 17-18	FY 18-19	FY 19-20	FY 20-21	FY 21-22
1	Coal	kg/Nm3	1.34	1.89	1.33	1.51	1.64	No Operation	1.81	1.34	1.24
2	Oxygen	Nm3/Nm3	0.21	0.32	0.23	0.28	0.27		0.28	0.24	0.22
3	Nitrogen	Nm3/Nm3	0.14	0.4	0.22	0.35	0.36		0.33	0.22	0.19
4	HP Steam	kg/NM3	0.9	1.71	1.05	1.36	1.51		1.40	1.25	1.10
5	MP Steam	kg/NM3	0.12	0.64	0.29	0.56	0.77		0.65	0.46	0.57
6	Power	kWH/Nm3	0.15	0.46	0.3	0.39	0.43		0.44	0.34	0.31

Coal Consumption Kg/ Nm3 has improved significantly during last year due to coal beneficiation of Bhubaneswari Coal

Conclusion:

- ❖ It is quite evident that to meet the increasing demand of coal & to reduce imports, more & more coal needs to be washed by CIL, SCCL & Captive/Commercial Mines in future. In all cases, there is a need to have more quality consciousness.
- ❖ During mining, extreme care should be taken to avoid contamination;
- ❖ With washed coal, it is evident that plant efficiency increases, maintenance cost is lowered, by-products can be used in FBC boilers to generate Captive Power.
- ❖ Current Reject Disposal policy needs to be reviewed as it is quite cumbersome & time consuming.
- ❖ Expeditious installation of coal washeries at planned locations is the need of the hour;
- ❖ Existing washeries should be modernised with the application of suitable technology to enhance the yields, achieve cost reductions & enhance productivity.
- ❖ R&D initiatives to:
 - beneficiate coking coal with high ash% with upgraded technology; and
 - explore alternative technology for utilization of high grade non-coking coal for steel making
- ❖ Supply of washed coal to all Sectors like Power, Steel, DRI, Cement & Others, will generate confidence on procuring indigenous coal thereby saving precious foreign exchange
- ❖ Washery should be declared as an Approved End-Use like DRI, Steel, CPP, etc



Thank You

JINDAL 
STEEL & POWER

Cost Savings Breakup

