Is Energy Recovery Cokemaking a Challenge to Conventional Byproduct Recovery Met Coke Production ?

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Introduction

It is interesting to note that though many processes are gaining grounds for production of iron, blast furnace process of ironmaking in the form of hot metal is most predominant and would remain so in the foreseeable future not because it has a long history, but that it has remained up-to-date and competitive owing to several innovations it has witnessed during its life time. Today around 65% steel production accounts from BF-BOF route for which met coke is an essential input raw material.

What it means is that cost-effective and environmentally compatible supplies of high quality of metallurgical coke needs to be available while addressing depleting resources of high quality hard coals. The history of cokemaking is a convincing proof that the process of met cokemaking can adapt to the modern technological and social requirements to a high standard. When the US EPA had put a stop to setting up new cokemaking facilities based on conventional slot ovens-byproduct recovery method due to environmental reasons unless they are designed to operate under negative pressure, beehive coke ovens have staged a come back with a host of innovative design features that could meet today's requirements of environment-friendly and energy efficient method of coke production, and that too cost competitively. The Sesa Energy Recovery Cokemaking is one such technology that fulfills all the modern day requirements and much more!

History of Cokemaking

The manufacture of coke by heating coal in absence of air has its origin at the start of industrial revolution when Abraham Darby used it in the smelting of iron ores in 1709 in England. The introduction of coke had the effect of slowing down the destruction of forests that were the source of charcoal at that time.

The main development of cokemaking took place in England and Germany, most importantly its use in the blast furnace facilitated iron melting at higher temperatures. Cokemaking began with the charcoal pile. The method of coke production was initially the same as for the production of charcoal, stockpiling of coal in round heaps, igniting the piles, and then covering with sides with clay. This laid the foundation for beehive cokemaking. Gradually innovative advances led to the development of the beehive, reverberatory and byproduct ovens, culminating into regenerative coke oven with byproducts a century ago.

Slot ovens were evolved in Pittsburgh in the USA primarily due to the need to recover coal chemicals and coke oven gas for lighting. In fact the coal chemicals were the main products then with coke as a byproduct of coal carbonization. By product recovery coke ovens remained dominant cokemaking route reaching state-of-the-art cokemaking technology in the late '70.

Conventional By-Product Recovery Cokemaking

In byproduct cokemaking, gases evolved during the carbonization are cooled, and various primary chemicals like ammonia, tar and benzol are recovered. Purified coke oven gas is used at various locations in the steel plant, such as firing of coke ovens, reheating furnaces etc. The coking is carried out in slot ovens, which are also designated as conventional coke ovens. This has been the traditional method of cokemaking in the integrated iron and steel works. Byproduct ovens are 12 to 18 meter long, 3 to 8 meter tall and 400 to 600 mm wide. Several chambers are grouped to form one battery and a single battery may consist up to 85 ovens.

Until recently, the value of these byproducts exceeded that of the coke. However, the advent of petroleum refining has driven the price of these chemicals to such a low level that today the byproduct plant of coke ovens is no more than a major polluting source in the integrated steel plant.

Nonrecovery Cokemaking

In the nonrecovery cokemaking process, volatiles evolved during coal carbonization, are not recovered as by-products but are combusted completely in presence of controlled quantity of air and the heat of the volatiles of evolving gases is utilized for coking the coal mass into coke and thus no external heating is required. The higher level of heat importantly is used to break up the potentially polluting hydrocarbons into the constituent combustible compounds and to burn them thus avoiding the potentially hazardous pollution. The heat consequent to combustion is only partially utilized during the process and the balance heat in waste flue gas gainfully utilized for energy generation.

Sesa Energy Recovery Coke Ovens

Sesa Goa Ltd., in India has a 280,000 TPA coke plant in Goa, India. The coke plant comprising 84 ovens are of nonrecovery type (2745 width, 10760 Length), 21 ovens connected to a stack. The ovens with top charging and are operating satisfactorily to produce high quality met coke since 1999. Over the years several in-house modifications/innovations have been introduced to maintain its competitive edge.

The Sesa coke plant is presently being retrofitted with compacted charging developed by VeCon of Germany. This state-of-the-art coal compaction facility capable of obtaining a stable coal cake with bulk density > 1.1 t/m^3 will be commissioned soon. With this significant amount of cheaper semi soft coal will find way into Sesa coal blend and would bring down the met coke production cost significantly.

Continual development at Sesa has resulted in the latest development of Sesa In-situ Desulphurization (SID) technology customized with compacted charging. The SID technology is not only capable of reducing SOx emissions by 65-75% but in the process restrict burning loss to less than 1%. The added advantage is the reduction in the capacity of external desulphurization unit.

Efforts are on to further minimize the SOx emission level to a level where external desulphurization is dispensed with. The SID has further sharpened the cutting edge of SER cokemaking technology. The salient features of SER-SID Cokemaking are given in **Table 1**.

A 30 MW power plant is also being installed on a BOO basis and is expected to go on stream in the last quarter of 2006.

The block flow diagram of Sesa Energy Recovery Coke production with cogeneration of electric power is depicted in **Figure 1**

Comparison between Conventional Slot Ovens & Sesa Energy Recovery Ovens

Comparison of conventional byproduct recovery slot oven battery and Sesa energy recovery coke oven battery underlying the design considerations, coal quality usage & resultant coke quality, emission levels with cost considerations is presented in the following paragraphs clearly shows that the Sesa

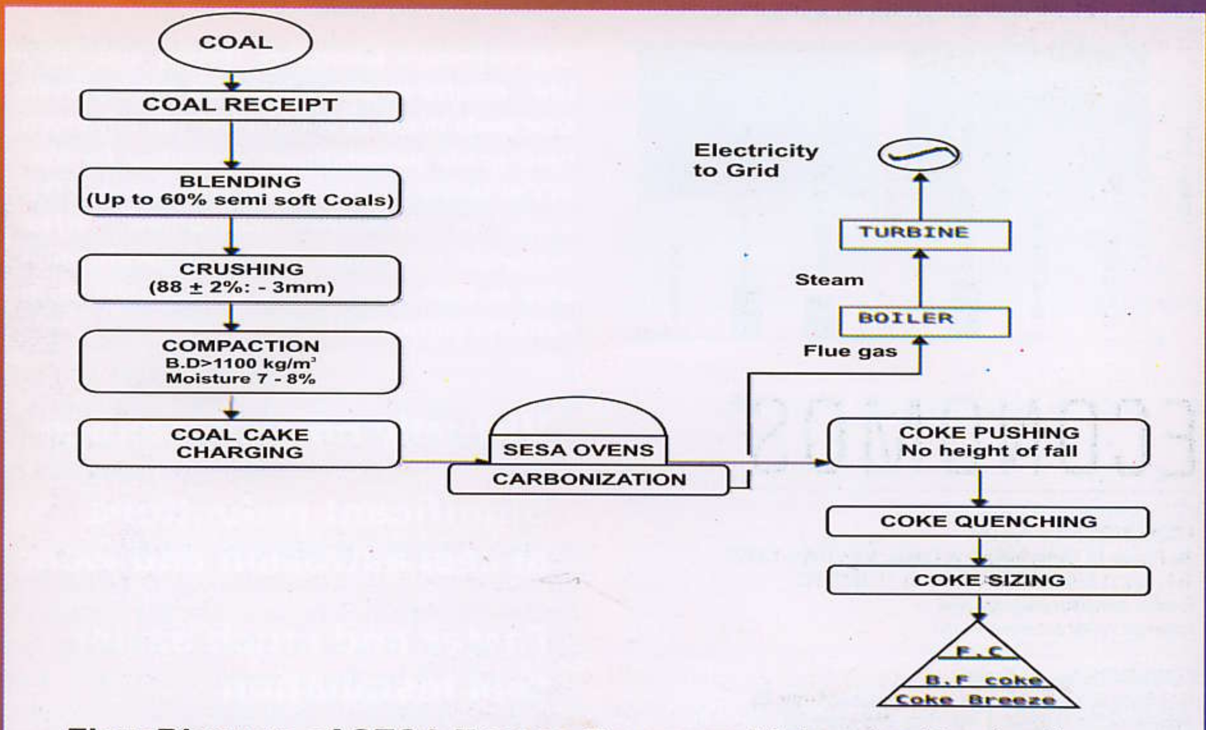
Table1

Salient features of Sesa Cokemaking

Oven Design	Simple, studier
Refractory	High Alumina
Coal Charging	Compacted, VeCon design
Heat Recovery	Highest; hot foundation air re-circulation
Emissions	
SPM	< 50 mg/Nm³
SOx	< 450 mg/Nm³
	< 115/50 mg/Nm³ (In-situ desulf Gen1/Gen2)
NOx	< 75 mg/Nm³
CO	Nil
H/C	Absent
Operation & Maintenance cost	Low due to simple design & alumina bricks
Coal quality usage	Wide flexibility, up to 60% semi soft coals
Standard Module	300,000 TPA
ECO Friendliness	Very high level

Figure 1

Block Flow Diagram Sesa Energy Recovery Coke Ovens with Heat Recovery Power Plant



Flow Diagram of SESA Energy Recovery Metacoke Production technology has a distinct edge over conventional slot ovens.

Design Considerations

Sesa Ovens due to its semicircular dome are sturdier than nonrecovery ovens offered by competing technologies. The selection of fireclay alumina refractory brickwork that has evolved after extensive site trials has a potential to improve significantly longevity of ovens compared to coke oven batteries in nonrecovery category as well as conventional coke oven batteries. The other parameters of comparison are presented in **Table 2.**

Table 2

Design Considerations Conventional vis–a–vis SESA Cokemaking

Parameter	Conventional Slot Ovens	Sesa Ovens
Design Shape Brickwork	Complicated Ovens taller than wider Large number of brick shapes	Simple Ovens wider than taller Few brick shapes
Operating Pressure	Slightly Positive	Slightly Negative
Heat Supply	Externally by combustion of CO/BF/mixed gas	Internally by partial combustion of evolving gases
Heat Transfer Direction & Mode	Horizontal & Indirect: conduction	Vertical & Direct: Radiation & convection from top. Indirect: Conduction from the bottom/sole
Wall Pressure	Susceptible	Not susceptible

The basic changes in the Sesa design consists of improvement in oven refractory materials, closer control of combustion conditions through controlled primary air input to, sub-stoichiometric level and at underflues /sole flues as secondary air and tertiary air in the common header/flue to ensure complete combustion without excessively diluting the heat in the flue.

Coal Quality Usage & Coke Characteristics

Both the processes produce high quality coke as long as appropriate coal blends are used, though Sesa coke ovens produce superior quality of coke for the same blend in terms of cold and hot strength properties because of higher coking temperature, longer soaking time ability to use low volatile-high rank coals in the blend and greater presence of pyrolytic carbon.

Sesa Ovens being much wider than slot ovens, the swelling pressure is released from the top which in case of narrow slot ovens is exerted dangerously on the heating walls and thus free from any wall pressure effects. It is worthwhile to elaborate this point in greater details as to why Sesa ovens offer greater flexibility to raw material base (wider coal quality spectrum).

Sesa ovens operate with very low bed height, less than a meter, as compared to slot ovens and thus problems encountered swelling pressure on side walls is negligible. The side wall pressure is lower by about 6.5 times than for Sesa ovens as compared to conventional slot ovens which are designed to tolerate 1.0/1.5 psi wall pressure. In case of Sesa Ovens this parameter amounts to less than 0.2 psi.There are certain categories of met coal that they give excellent coke but they exert wall pressure more than the permissible designed limit which means conventional ovens are deprived of the possibility of using these coals characterized for producing excellent met coke. Moreoverno wall pressure, no stickers!

The byproduct coke ovens are characterized to give higher coke yield as there is no burning loss. However, burning loss of ~ 3% is partially compensated by increase corresponding electric power generation.

Table 3 illustrates merits and demerits related to coal blend usage and resultant coke quality of the two technologies.

Environmental Considerations

Like any other nonrecovery/heat recovery ovens, Sesa operates under slight negative pressure which means no leakages from the oven doors. There is no generation of effluents unlike conventional coke ovens wherein coke oven gas purification in the byproduct recovery plants generates huge quantities effluents

Table 3
Coal & Coke Quality Conventional vis–a–vis SESA Cokemaking

Parameter	Conventional Slot Ovens	Sesa Ovens
Coal Quality Usage	Restricted	Wide flexibility
Coke Quality	Lower compared to that from Sesa coke ovens	Higher compared to that from conventional ovens
Coke Yield	Higher than Sesa coke ovens by 3-5%	Lower due to burning loss. Can be limited to 3% by proper process control
Carbonization Temperature	Max achievable temperature lower than Sesa ovens	Max achievable temperature higher than in Byproduct slot ovens

that need effluent treatment/ BOD plant. Solid wastes are totally absent as there is no processing or crude tar or benzol involved which generates toxic sludge.

Sesa ovens are operated at sufficiently high temperatures to prevent emissions of PAH which are fully broken down into its components and combusted.

In compacted charging version, gap between surface of coal cake and the bottom of oven door is few millimeters thus avoids gushing of air and upsetting the hydraulic regime and blowing up of the ovens. The charging of coal cake does not involve leveling and fugitive emissions thereof.

Flat bed hot coke car/quenching car inbuilt in the Sesa technology minimizes pushing emissions as incandescent coke glides in to the hot coke car on the same level and there is no fall of coke from a height of up to 7 meters as in case of tall ovens. High level of superiority of Sesa coke ovens as compared to slot oven batteries which operate under positive pressure is highlighted in **Table 4**.

Byproduct oven battery requires large investment in providing pollution control equipments to make it environmentally compatible.

Operation of Ovens

Simplicity of operation and absence of complicated heating regime characteristic of the coke plan based on the Sesa Cokemaking technology not only makes less dependent on skilled operator but requires significantly less manpower.

Cost Considerations

Capital cost of Sesa coke oven battery is significantly lower compared to that of conventional byproduct recovery coke oven battery for the given coke capacity. This is mainly due to simple design, fewer shapes of refractory bricks, no complex gas network and absence of byproduct recovery facilities. Needless to mention installation time is almost 60% of that required for conventional coke oven & byproduct complex.

While initial investment for Sesa Energy Recovery

Table 4
Environmental Considerations Conventional vis–a–vis SESA Cokemaking

Parameter	Conventional Slot Ovens	Sesa Ovens
Land Requirement	Higher for low capacities	Lower for low capacities
Environmental Investment for pollution control devices	Environment unfriendly Large investment to make environmentally compliant	Environment friendly No additional investment
Solid waste	Sludge Generation in by products	No solid waste
Effluents	Excessive generation	No effluents
Emissions	Present	Absent
Fugitive Charging /Pushing	Present	Absent
Carcinogens	Present	Absent
US EPA regulation	Non compliant except PrOven	Compliant