Cluster Profile
Asansol refractory industries

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Promoting Energy Efficiency in SMEs
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Last but not least, our sincere thanks to MSME entrepreneurs and other key stakeholders in the cluster for providing valuable data and inputs that helped in cluster analysis.

Asansol refractory industries

Overview of cluster

Asansol refractory industries
Source: Google maps

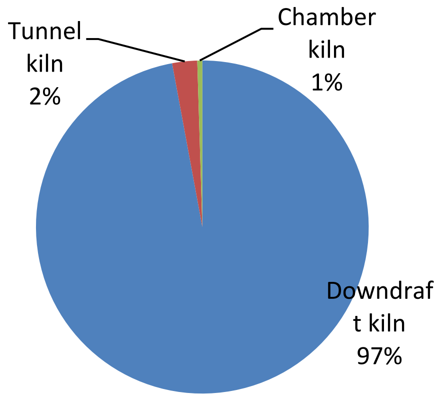
Asansol refractory cluster is the one of the important industrial clusters in West Bengal. The Asansol-Burnpur area is located in the land area between the river Ajoy on northern side and river Damodar on the southern side. The area is located within the Raniganj-Asansol coal mine belt. It is rich in mineral resources such as coal, lime stone, fireclay, china clay, granite, stone and sand. The refractory cluster under this region is developed within 50 kilometer around Asansol town. Some of the large industries located in and around the cluster are Durgapur Steel Plant, Alloy Steel Plant, Hindustan Cables Ltd., Burn Standard Co., Eastern Coalfields, Chittaranjan Locomotives, Maithan Steel & Power Limited, Damodar Valley Corporation etc.

Apart from these, there are also a few large ceramics (Maithan ceramic limited, Associated ceramic limited, foundries (cupola based and induction furnace based units), sponge iron units and coke oven industries. The industries in the cluster under micro, small and artisan categories include engineering & fabrication, refractories, mineral, leather, paper products, rubber goods, etc. The refractory cluster is more than 100 years old. The refractory materials produced are used within the country. The primary domestic market includes large steel manufacturing industries within 200 kilometre area like TISCO (Digwadih), TELCO (Jamshedpur), IISCO (Jamadoba), Bokaro Steel, SAIL (Durgapur), Alloy steel plant – Durgapur, etc. A small quantity is also exported to neighbouring countries.

Product types and production capacities

There are about 206 refractory industries in the cluster of which about 200 units use downdraft (DD) kilns. Five (5) units are tunnel kiln based and one unit is equipped with chamber kiln. The industries are located in about 50 kilometre radius. Some of the primary areas are Gorandi, Salanpur, Burnpur, Chittaranjan, Kulti, Raniganj, Jamuria, Hirapur, Kalyanpur and Asansol etc.

The type of refractory products manufactured in the cluster include different categories of refractory blocks and bricks, graphite stopper head, insulation bricks, ladle, refractory mortar, ramming mass, roof bricks, silminite bricks, suspended roof bricks, monolithic, burner quarl, bottom pouring, silica brick, etc.



Distribution of Kilns

The average production capacity of DD kilns is about 100 tonne per month (tpm) with 20 feet size whereas of tunnel kiln is 600 tpm (20 tonne per day). The chamber kiln produces around 750 tpm (25 tonne per day). The total production of different refractories in the cluster is estimated to be 1,20,600 tonne per year (tpy), which is around 42% of the installed capacity. The average level of rejections from DD kilns is reported to be about 10%.

Energy scenario in the cluster

The refractory units located in different industrial areas of Asansol cluster use coal as the major fuel in both downdraft and chamber kilns. The tunnel kilns use petcoke for firing. Electricity is used for all motive power requirements. The sources of grid power include Dishergarh Power Supply and Damodar Valley Corporation. DG sets are used during power failure. The details of major energy sources and existing tariffs are shown in the table.

Prices of major energy sources

Energy source	Price
Coal	Rs 8,500 per tonne
Petcoke	Rs 15,000 per tonne
Diesel	Rs 60 per litre
Electricity	Rs 5.50 per kWh

Production process

Manufacturing of refractory item uses wide range of raw material combination to produce different customized shape, size and unshaped refractory mass. It requires both electrical as well thermal energy at different stage of the process through connected process equipment and plant utilities like motors, pumps, different presses, kilns etc. Refractory manufacturing process primarily consists of die/mould preparation, crushing, grinding, mixing, shaping (pressing/casting), drying and firing. The different steps of manufacturing steps are described below.

(i) Mould preparation

Most of the products are shaped using dies, which are normally outsourced and kept ready in stock for use the production. The castable refractory products are made using customized pre-fabricated in-house moulds as per requirements of product dimensions. Dies and moulds are designed as per the product dimensions required by potential customers.

(ii) Raw material preparation

The refractory units procure basic raw materials such as plastic clay and other ingredients as lumps or powder which are generally tested in laboratories to match customer requirements. Jaw crushers are used to reduce the size of lumps before they are sent for grinding.

(iii) Grinding and screening

Grinding is a batch process for reducing the size of batch materials. It ensures homogeneity of the material being processed. Ball mills are used for grinding process. In ball mills, the raw materials are grinded to reduce size as per requirements for pressing. Screening is done to separate large particles present if any, from batch material to avoid any potential imperfection in products.

(iv) Mixing

Mixing of raw materials is done in Muller machines. It is done in batches of fixed quantity. These machines are used for uniform and quick mixing of a heterogeneous mass of two or more materials of varying aggregate size mechanically into uniformly blended batch of raw materials. Mullers are fitted with large mulling rollers for mixing of raw materials. Water is added to raw materials in required proportions and loaded in muller machines to obtain homogeneous mass of raw material.

(v) Pressing

Pressing machines are used to provide shape to the product. Each refractory unit has 4 to 6 press machines which are operated manually. Two types of press machines are commonly used in the cluster namely (1) Hydraulic press of 30-150 tonne capacity and (2) Friction press of 80-200 tonne capacity. The type of press used is dependent on type of products being manufactured. For large size products, friction press is commonly used; hydraulic press is used for other products. The homogenously mixed raw material in Muller machine is loaded manually in hydraulic/ friction press to provide shape and strength to the products. The pressed product is manually removed for drying.

Friction press

Hydraulic press

(vi) Drying

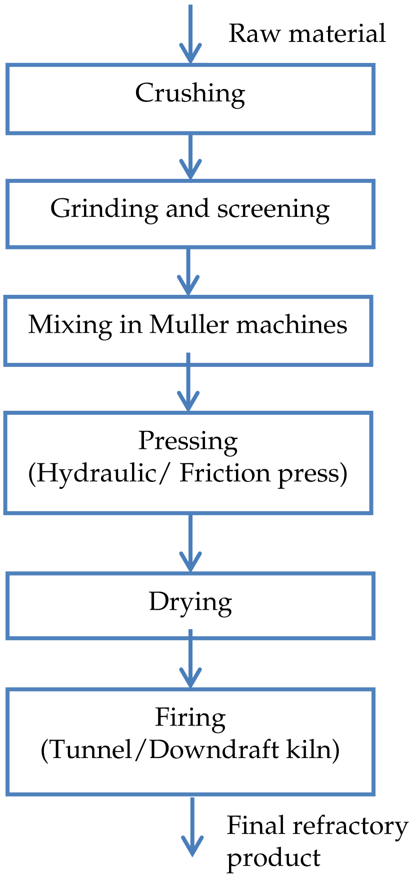
The green products are stacked inside sheds to allow slow and uniform drying in DD kiln based units. The dried products are manually loaded in downdraft kilns for further firing. Tunnel kilns are equipped with dryers which utilize waste heat available in flue gases for removal of moisture from moulded products.

Natural drying of green refractories

(vii) Firing

Firing is the process by which refractories are thermally consolidated into a dense, cohesive body composed of fine and uniform grains. This process also is referred to as sintering or densification. Refractories are generally fired at 50-75% of the absolute melting temperature of the body material. Downdraft kilns are commonly used by the refractory units in the cluster and a few units are using tunnel kilns for firing process. The final temperature depends on the material composition used in products (hollow/solid), size and stacking (only solid/ only hollow/ mix of hollow and solid products). Generally, fire temperature is 1150–1200°C and some special product may need to be fired at more than 1400°C.

A typical manufacturing process followed in the cluster for production of refractory products is shown in the figure.



Process flow chart for refractory manufacturing

Technologies employed

(i) Downdraft kiln

Traditionally, Asansol refractory industries are using downdraft kilns for firing of refractory products. DD kilns are batch type systems, wherein loading and unloading of refractory products and firing is carried out manually. Coal is the fuel used in downdraft kilns. The traditionally designed DD kilns in the cluster have the followings feature in common.

- Design specifications of DD kiln, lining material and flue path layout are old and do not have proper design.

- Coal is not properly sized before feeding into coal grate. It is also loaded at irregular intervals and varying quantities.
- Layout of existing coal grate and its capacity are unscientific thereby permitting flame/ flue to travel fast without proper heat transfer to refractory blocks
- Dampers are very provisional arrangement without proper maneuvering lever in place resulting in high negative drafts
- Measurements of furnace temperature are not being done barring a few units which use pyrometer for measuring furnace temperatures
- There is no control of combustion air through coal grate which is always open. This provides no option for throttling to reduce airflow if felt necessary during firing cycle.
- Long flame carry over to chimney base was observed indicating high flue velocity and low residence time resulting in higher level of coal consumption
- High surface temperature at loading/unloading area, which needs to be appropriately insulated with movable fixture for repeated use

Most of the DD kiln units have two kilns with different size to cater variable production volume in a given season. The internal diameter of the kiln may vary within 16–26 feet (4.88-6.70 metre) with the average size being 20 feet (6.1 metre). However, flue path size and length depends on the individual site layout and chimney location, which is unscientific. Cycle time per batch production depends upon kiln size, quantity of refractory stacked, product mix in the stack and type of material under firing. The total cycle that includes stacking of green refractory, firing, cooling and unloading is about 20 days.

(ii) Tunnel kiln

Tunnel kilns are continuous type and can be operated using pet coke, oil and gas. There are about 5 number of tunnel kilns operating in the cluster. Of these, smaller tunnel kilns use 3 cars with 2 tonne capacity per hour and large tunnel kilns uses more numbers of cars per hour with similar capacity and operated continuously for short duration depending on market demands. Mostly large plants with 5 cars are operated regularly at full production capacity.

Tunnel kiln

The tunnel kilns in the cluster use pet coke as the fuel. The refractory products loaded in trolleys, after removal of moisture in the dryer, are pushed inside the tunnel kilns using an adjustable mechanical pusher mechanism. As the trolleys move inside the tunnel kiln, the products are gradually preheated close to about 700-800 ºC before reaching firing zone. Pulverized pet coke is used as fuel in the cluster and is fed through an automatic fuel feeding system. The temperature of the firing zone is close to 1300ºC wherein the products are soaked to about 1½-2 hours. The quantity of fuel is controlled through a feedback loop system with the temperature of firing zone. The products are gradually cooled down after the firing zone to about 50-60ºC before they exit the kiln.

(iii) Chamber kiln

Chamber kiln

A chamber kiln consists of number of rooms or chambers with permanent side wall and roof that are arranged in series with provision of coal grate for firing stacked refractory products for vitrification. Each chamber is connected to the next chamber and with the central chimney in a manner that would help in directing flue gas from source to chimney after it travels through next chamber by appropriately positioning damper in flue path and passageway in partition wall. During firing cycle, hot exhaust gases from room under fire will be directed through passageway provided in partition wall to following adjacent two rooms in series that are scheduled to be fired next. While hot gases pass through the kiln circuit, they transfer heat to the stacked refractories thereby preheating stack materials. Finally, flue gases at reduced temperatures will be dispersed through the chimney. This arrangement recovers sensible heat of hot exhaust gases thereby making chamber kilns more efficient than downdraft kilns.

Chamber kilns are also batch type kilns, wherein loading and unloading of refractory products and firing is carried out manually. Coal is the primary fuel used in chamber kilns. The key features of chamber kilns used in the cluster are as follows.

- Design specifications of the kiln, lining material and flue path construction require improvements. The kilns do not use compatible refractory material.
- Coal is not properly sized before feeding into coal grate. It is also loaded at irregular intervals and varying quantities leading to significant unburnt losses.
- Manual control is practiced across the cluster for monitoring and control of furnace temperatures
- Limited use of ceramic blanket and insulating refractory in furnace construction.

Kilns used in Asansol refractory cluster

Type of kiln	Number of kilns
Downdraft kiln	200
Tunnel kiln	5
Chamber kiln	1
Total	206

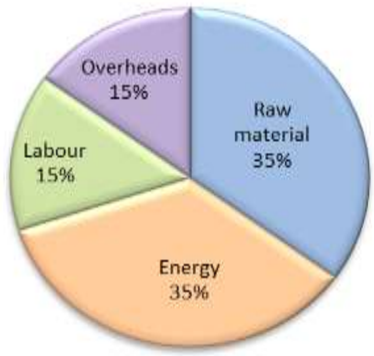
Energy consumption

Coal is the main fuel used in downdraft and chamber kilns and petcoke is commonly used in tunnel kilns for firing of refractory products. Electrically operated plant utilities such as press, crusher, muller, vibrating screen and belt conveyor are operated using power supply from local grid. Normally power cut from grid does not interrupt firing cycle except tunnel kiln, which requires standby power source (generally DG set) to continue operation. The energy consumption in different kilns is also dependant on type of products and the firing temperature needed. The temperature requirements of different refractory products are in the range of 1280–1310°C.

Fuels used in kilns

Type of kiln	Fuel used
Downdraft kiln	Coal
Chamber kiln	Coal
Tunnel kiln	Pet coke

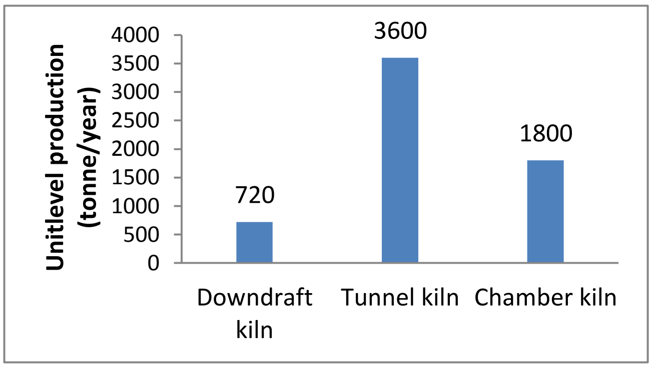
The share of production cost for regular refractory products is same for energy as well as raw materials, which is about 35%. The raw material cost for better quality high end products may go up to 50% of total production cost.



Share of production cost

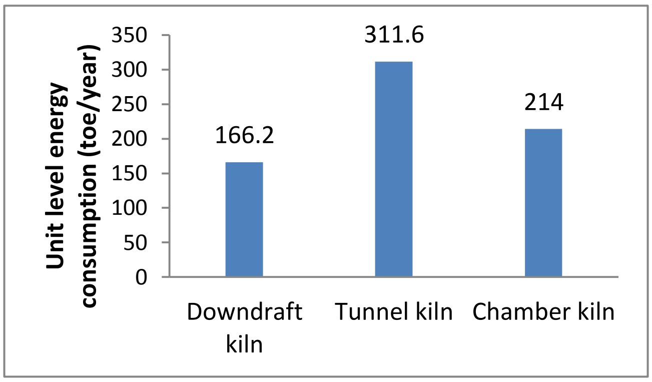
(i) Unit level consumption

Thermal energy (coal/petcoke) accounts for about 98% of share in total energy consumption in a refractory manufacturing industry. Product forming/ moulding is done through electrical presses but operated manually. However, the share of electrical energy consumption is negligible as compared to the energy consumption required for firing process.



Unit level production

The total energy consumption of the refractory unit in the cluster varies from 166 toe per year (downdraft kiln) to 312 toe per year (tunnel kiln) as shown in the figure. The unit level energy consumption depends on "specific energy consumption" (SEC) of the kiln and the annual production. The production in DD kiln is quite low whereas it has very high SEC level.



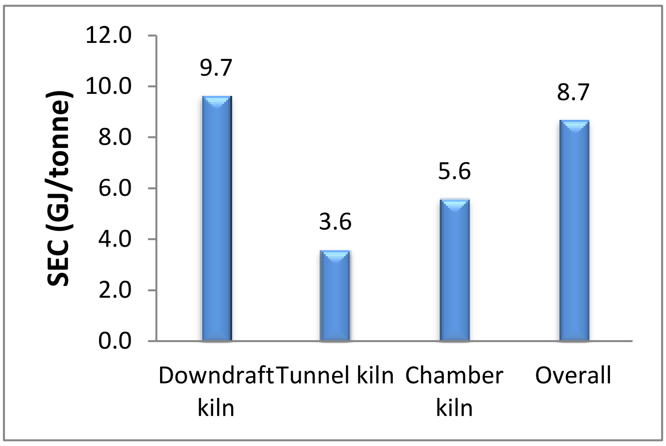
Unit level energy consumption

The typical energy consumption by refractory industries using different technologies in Asansol cluster is shown in table.

Typical energy consumption of kilns

Type of unit	Thermal energy (tpy)	Diesel (L/yr)	Electricity (MWh/yr)	Total energy (toe/yr/unit)
Down draft kiln	252 tonne coal	240	25.2	166
Chamber kiln	360 tonne coal	600	60.0	214
Tunnel kiln	360 tonne petcoke	1200	180.0	312

With the batch type process, the SEC of downdraft kiln units is about 9.7 GJ per tonne of refractory product whereas, the SEC of tunnel kilns of continuous type is about 3.6 GJ per tonne and of chamber kiln is 5.6 GJ. The weighted average SEC of refractory units at cluster level is about 8.7 GJ per tonne as shown in the figure. Higher SEC levels of DD kiln units may be attributed to a larger dead weight used (support structure) as well as high heat losses in flue gases. The typical SEC of different kilns in the cluster are provided in the able.



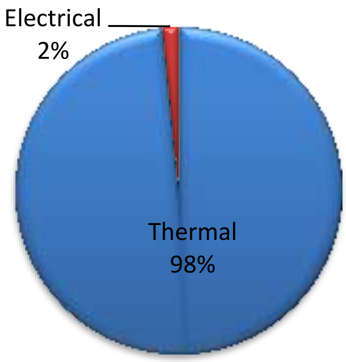
SEC variations at cluster level

Specific energy consumption of kilns

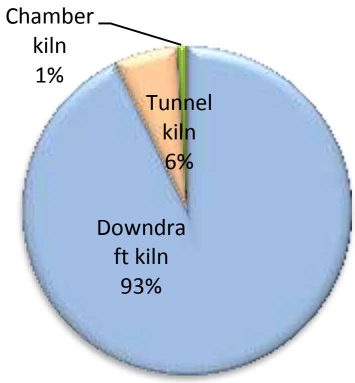
Kiln type	Specific energy consumption	
	kcal/kg	GJ/t
Downdraft kiln	2308	9.7
Chamber kiln	1339	5.6
Tunnel kiln	866	3.6
Overall	**2078**	**8.7**

(ii) Cluster level consumption

The total energy consumption at cluster level is estimated to be 25,063 toe per year. The share of energy consumption by thermal energy (coal, petcoke and diesel) is about 98% and of electrical energy is 2% (figure). It may be noted that coal is consumed only by chamber and DD kilns, whereas petcoke by tunnel kilns. The consumption of diesel towards meeting electricity consumption during power failure is negligible. The GHG emissions at cluster are estimated to be 105,295 tonne of CO_2.



Consumption share of energy form at cluster



Share of energy consumption by kilns

The break-up energy consumption and the corresponding energy bills and GHG emissions of different energy sources are provided in the table.

Annual energy consumption of Asansol refractory industry cluster

Energy type	Annual consumption	Equivalent energy (toe/yr)	GHG emissions (t CO_2/yr)	Annual energy bill (million INR)
Coal	35640 tonne	23,166	93,555	303
Petcoke	1800 tonne	1,476	7,230	27
Electricity	4.49 million kWh	386	4,403	24
Diesel	40.2 kilo litre	35	107	2
Total		**25,063**	**105295**	**356**

Energy saving opportunities and potential

Asansol refractory cluster offers significant scope for energy savings from adopting best practices to energy efficient technologies. Some of the major energy saving opportunities in Asansol refractory cluster are discussed below.

(i) Downdraft kilns

Use of insulating refractory in lining

Traditionally, the linings of downdraft kilns are made mainly with low grade refractory bricks. Higher thickness of refractory inside walls and crown has led to considerable reduction in surface temperatures but have led to increased dead-mass resulting in higher heat losses during each firing cycle. It is suggested to modify existing lining with insulating refractories which would reduce heat losses through kiln surfaces. Further, ceramic fibre blankets can be added between layers of bricks in bottom layer, side wall and the crown that would help in reducing heat losses.

Sizing of coal and feeding practices

Coal is the primary energy source in downdraft kilns. It was observed that (1) large quantity of coal is fed every time without considering inside furnace temperatures and (2) coal lumps are fed and no proper sizing of coal is maintained. This leads to insufficient opening for combustion air supply resulting in thick black smoke from chimney exhaust. Thus improper fuel size and feeding practices have affected the thermal performance of DD kilns in the cluster. It is suggested to (1) use coal of about to 1 inch size before feeding and (2) maintain suitable fuel feeding frequency based on requirements of the kiln which would ensure improved and complete combustion of fuel and avoid formation of black smoke from chimney.

Installing temperature indicators for monitoring furnace temperature

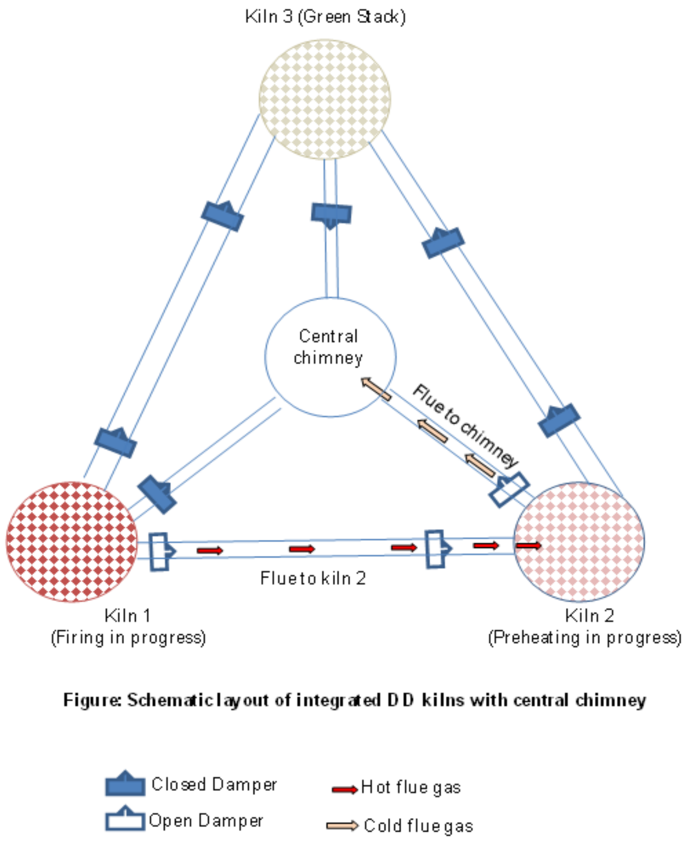
The refractory industries in the cluster do not use temperature indicators for monitoring and controlling furnace temperatures. At present, furnace temperature and fuel firing is done through human judgement and skill level of firemen. This can lead to substantial variations in furnace temperatures vis-à-vis actual requirements for different products. Thus it can lead to (1) over-firing which can result in higher fuel consumption and damage to products, and (2) under-firing which can result in sub-standard product quality. It is suggested that all DD kilns must install on-line temperature probes at least in three locations at crown level of the kiln to monitor furnace temperature and control fuel feeding as per requirements.

Improved damper system for downdraft kilns

The downdraft kilns use locally precast circular ceramic material as damper system which is a crude design. These dampers do not have appropriate fixtures for adjusting their levels to control draft kiln draft. Existing practice of damper control is crude and non-scientific resulting in negative draft and loss of heat through high temperature flue gases. It is suggested to use ceramic board based damper system along with mechanical arrangement for movement of damper plate to increase or decrease the draft as per requirements. This would further improve ease of work for firemen.

Preheating of green refractory by flue gas

Traditionally built existing downdraft kilns in the cluster are unscientific and lacks proper layout as well as dimensions are inadequate. The chimney height is also more resulting very high negative draft in the furnace after initial firing cycle as dampers are not suitable to control the draft. Owing these facts, high temperature flue gases from downdraft kilns are vented out to chimney without any heat recovery system in place. Combustion air for firing coal in downdraft kilns are obtained with the help of natural draft, which is generated by connected chimney to the furnace. It would be easily possible to recover sensible heat from exhaust flue gases by integrating existing downdraft kilns in a manner to ensure flue gases are directed from source kiln to another kiln, which is loaded with green refractory and next in line for firing. Hence, the waste heat available in flue gases can be effectively utilised to preheat green refractory without installing any waste heat recovery system which can lead to substantial fuel saving.



Preheating arrangement in DD kilns

Technology switch over for efficient firing

Adoption of tunnel kilns

The SEC in tunnel kilns is 866 kcal/kg as against of 2308 kcal/kg in DD kilns. It would be possible to reduce energy consumption by about 62% by switching over to tunnel kilns with existing product volume. Other advantages with tunnel kilns include kiln automation, better monitoring and control of operating parameters, higher yield and enhanced production volumes. The estimated energy saving at cluster level is about 14,539 toe per year with tunnel kiln adoption.

Adoption of chamber kilns

Another potential technology option available for DD kilns is switch over to chamber kilns. In a chamber kiln, exiting flue gases are directed to flow to immediate following chamber after which the gases join central flue path connected with chimney. The sensible heat in flue gases is recovered through preheating of refractories. Preheat temperatures of up to 1100ºC are possible to achieve in chamber kilns and the temperature of exiting flue gases at chimney can be lowered to about 100ºC. Thus the preheating of refractory product reduces the heat load requirements substantially leading to significant energy savings. The specific energy consumption in chamber kiln is 1339 kcal/kg and estimated to save around 56% of energy if refractory products are fired using chamber kilns. At cluster level, about 11,698 toe per year can be by switching from downdraft kilns to chamber kilns.

(2) Tunnel kilns

Use of low thermal mass cart

Green refractory products are loaded on to kiln cars to transfer inside tunnel kilns. Presently, kiln cars are made of metallic frame and refractory material resulting in higher dead weight and hence heat losses. Kiln cars can be fabricated using low thermal mass material which would help in reducing both dead weight of cars and heat losses. The weight reduction of the kiln carts in tunnel kilns provides significant scope to improve energy performance of tunnel kiln system. The following modifications can be incorporated to reduce the weight of the kiln cars:

- Replacement of refractory bricks with the hollow ceramic coated pipes at the supporting pillars for holding racks
- Use of ceramic fibre blankets at the base of the car instead of refractory brick base
- Use of cordierite (hollow) blocks to hold the raw-wares instead of solid refractory mass

Reducing the dead weight by about 30%, heat losses from kilns can be reduced substantially. The envisaged fuel saving with dead weight reduction of trolleys in tunnel kilns is about 3% of total heat input equivalent to 44 toe per year.

Enhanced insulation of tunnel kilns

The surface temperatures of firing zone of tunnel kiln are observed to be high leading higher heat losses and hence higher fuel consumption. It is suggested to introduce ceramic fibre blankets in tunnel kiln that would help in reducing heat losses from kiln surfaces.

Optimum furnace loading

The present level of loading of tunnel kilns was observed to be lower which may be attributed mainly to existing market conditions. It may be noted that various associated heat losses in tunnel kilns such as heat losses due to deadweight of trolley structure, surface heat losses, etc. would remain the same irrespective of loading of the kiln. Hence reduced loading would lead to higher specific energy consumption and hence higher production costs. It is suggested to plan optimum loading of tunnel kilns in order to minimise SEC levels.

Fuel switch over

The tunnel kilns in the cluster use petcoke as fuel. There is a significant potential to use other fuels such as processed rubber oil which may be explored by the refractory industries. The fuel switch over would help in reducing energy costs as well as close control of fuel firing.

Other energy saving measures

Other energy saving measures relevant for refractory industries in the cluster include the following:

- Power factor improvement with automatic power factor controller
- Installing energy efficient motors in different drives
- Use of clogged V-belts in place of flat belts
- Energy efficient lighting

Major stakeholders

The major stakeholders in Asansol refractory industry cluster include Refractory Manufacturers Association, West Bengal and MSME Development Institute (Durgapur).

Cluster development activities

The cluster has established a Special Purpose Vehicle (SPV) in the name of Bangabhumi Cluster of Refractories Association during September 2012. There are 34 registered members from refractory industries in Asansol. The SPV is yet to be fully equipped and is exploring financial support to establish as material testing hub for local refractory industries.

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local and national level strategies to suggesting global solutions to critical energy and environmental issues. The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy intensive Micro Small and Medium Enterprises (MSMEs) to improve their energy and environmental performance.

About SDC

SDC (Swiss Agency for Development and Cooperation) has been working in India since 1961. In 1991, SDC established a Global Environment Programme to support developing countries in implementing measures aimed at protecting the global environment. In pursuance of this goal, SDC India, in collaboration with Indian institutions such as TERI, conducted a study of the small-scale industry sector in India to identify areas in which to introduce technologies that would yield greater energy savings and reduce greenhouse gas emissions. SDC strives to find ways by which the MSME sector can meet the challenges of the new era by means of improved technology, increased productivity and competitiveness, and measures aimed at improving the socio-economic conditions of the workforce.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions - Indian and international, public and private - that are working towards the development of the MSME sector in India through the promotion and adoption of clean, energy-efficient technologies and practices. The key partners are of SAMEEEKSHA platform are (1) SDC (2) Bureau of Energy Efficiency (BEE) (3) Ministry of MSME, Government of India and (4) TERI.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit http://www.sameeeksha.org