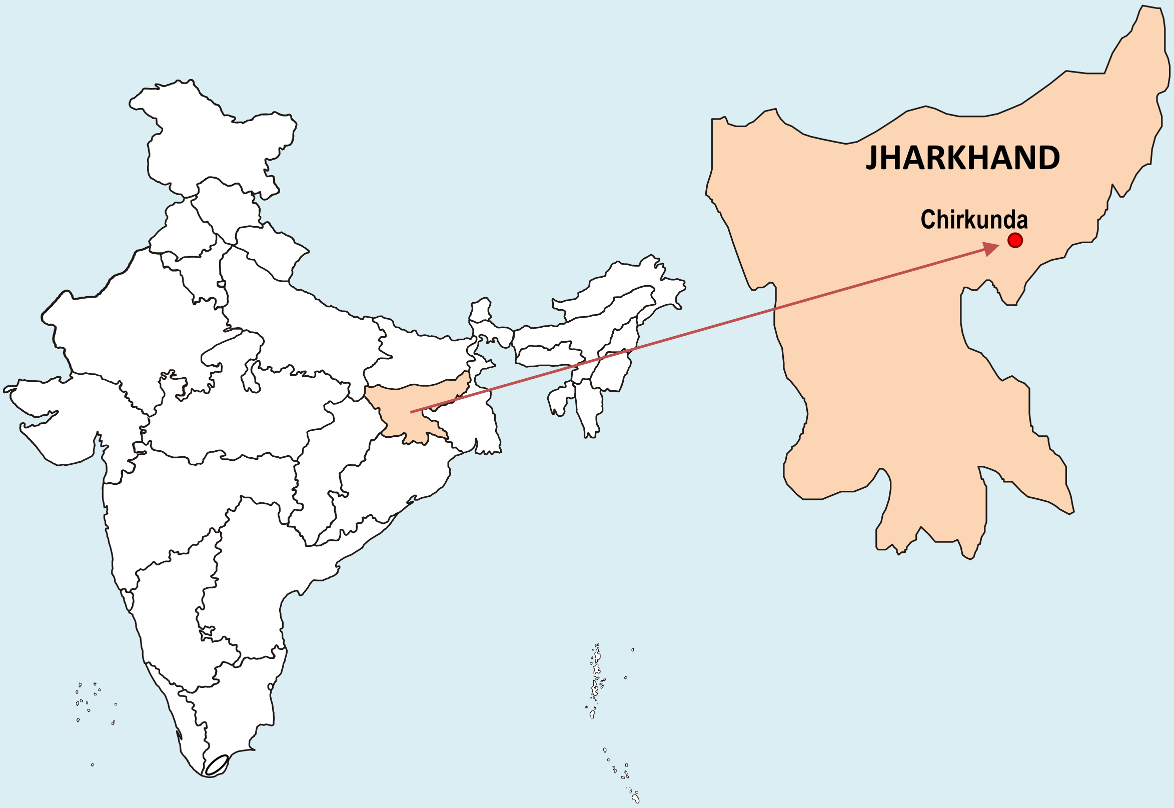
Cluster Profile
Chirkunda refractory industries



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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.

Chirkunda refractory industries

Overview of cluster

Chirkunda refractory industries in Jharkhand
Source: Google maps

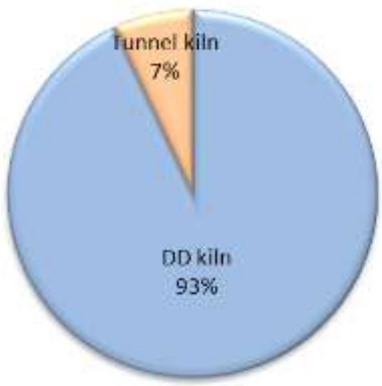
Chirkunda refractory cluster is the one of the important industrial cluster in Jharkhand. The cluster is more than 100 years old. It is a notified area in Dhanbad district. The area is rich in mineral resources such as coal, lime stone, fire clay, china clay, granite, stone and sand. Some of the large industries in and around the cluster include Kumardhubi Fire Silica Works (KFSW), Kumardhubi Metal Casting Limited (KMCL), Om Bosco (Railway Component manufacturer), Maithan Power Limited (JV of Tata Power and Damodar Valley Corporation) and McNally Bird Engineering (coal handling equipment). Apart from these, there are also a few large ceramics (Maithan ceramic limited, Associated ceramic limited, foundries - cupola based and induction furnace 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 material produced are used within the country, with more than 95% of products are sold outside the state. 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 129 refractory industries in the cluster of which about 120 units use down draft (DD) kilns and 9 units have tunnel kilns. The industries are located in about 10 kilometre radius. Some of the primary areas are Mera, Kumardhubi, Maithan, Mugma, Taldanga and Chirkunda etc.

The type of refractory products produced in the cluster include refractory blocks & 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) whereas of tunnel kiln is 600 tpm (equivalent to 20 tonne per day). The estimated average production of refractory products in the cluster is about 102,960 tonne per year (tpy). 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 Chirkunda cluster use coal as the major fuel in downdraft kilns. The tunnel kilns use mainly petcoke. Electricity from grid – Jharkhand State Electricity Board and Jharkhand Urja Vikas Nigam Limited is used in the refractory units. DG sets are used only 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 9,000 per tonne
Petcoke	Rs 15,000 per tonne
Diesel	Rs 60 per litre
Electricity	Rs 5.80 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. 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.

Mixing in Muller machine

(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.

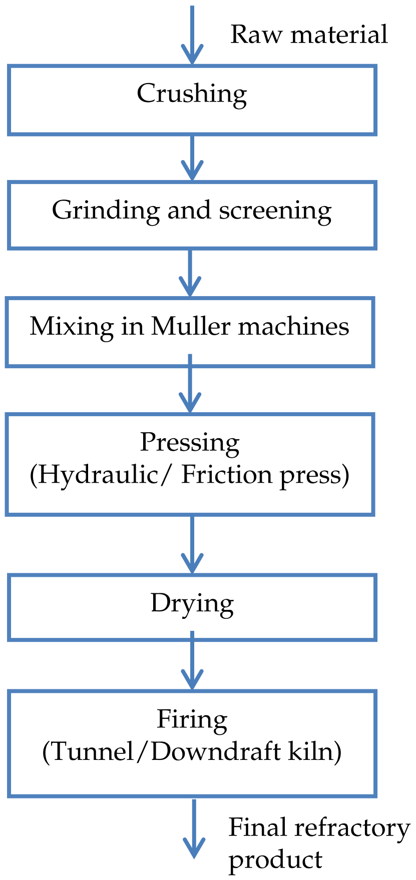
(vii) Firing

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.

Natural drying in downdraft kilns

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, Chirkunda 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 followings feature in common.

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

Downdraft kiln

- 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 18–30 feet (5.48-9.14 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 9 number of tunnel kilns operating in the cluster. Of these, 3 tunnel kilns are smaller in capacities and operated continuously for short duration depending on market demands. The balance 6 tunnel kilns are owned by large players and 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 °C 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 1300°C 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 50-60°C before they exit the kiln.

Kilns used in Chirkunda refractory cluster

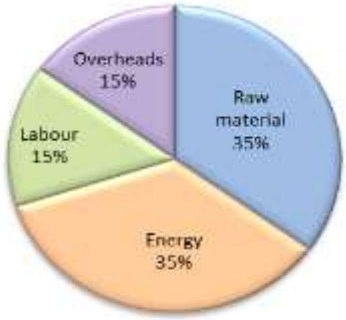
Type of kiln	Number of kilns
Downdraft kiln	120
Tunnel kiln	9
Total	129

Energy consumption

Coal is the main fuel used in downdraft 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 in DD kiln; tunnel kiln 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
Tunnel kiln	Pet coke



Share of production cost

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.

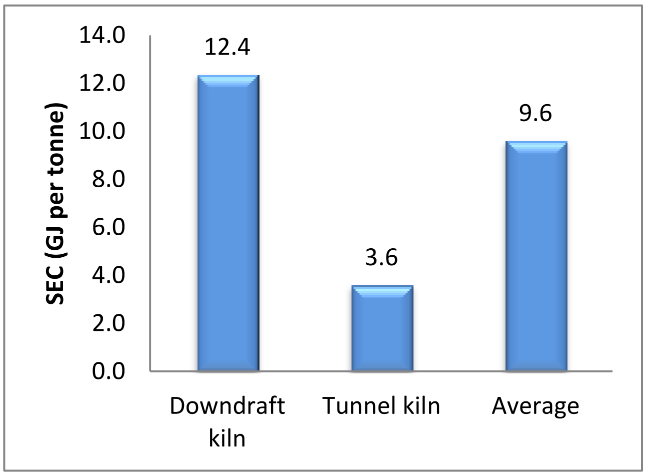
(i) Unit level consumption

Thermal energy (coal/ petcoke) accounts for about 99% 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. The total energy consumption of a ceramic/refractory unit varies between 249 toe per year (downdraft kiln) to 312 toe per year (tunnel kiln). The typical energy consumption by refractory industries in Chirkunda is shown in table.

Typical energy consumption of kilns

Type of unit	Thermal energy (tpy)	Diesel (kL)	Electricity (kWh/yr)	Total energy (toe/yr/unit)
Down draft kiln	378 tonne coal	0.28	29,400	249
Tunnel kiln	360 tonne petcoke	1.20	127,400	312

With the batch type process, the 'specific energy consumption' (SEC) of downdraft kiln units is about 12.4 GJ per tonne of refractory product whereas, the SEC of tunnel kilns of continuous type is about 3.6 GJ per tonne. The weighted average SEC of refractory manufacturing at cluster level is about 9.6 GJ per tonne as shown in the figure. Higher SEC levels of DD kiln units may be attributed to a large mass of dead weight used in the kilns (support structure) along with the products. The typical energy



SEC variations at cluster level

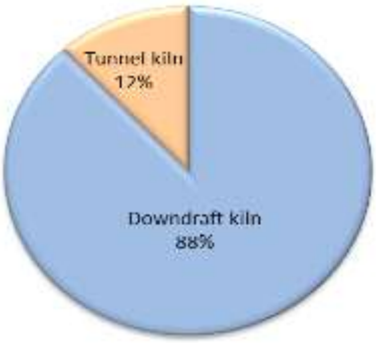
consumption of downdraft kiln and tunnel kiln units and the SEC level of production are provided in table below.

Specific energy consumption of kilns

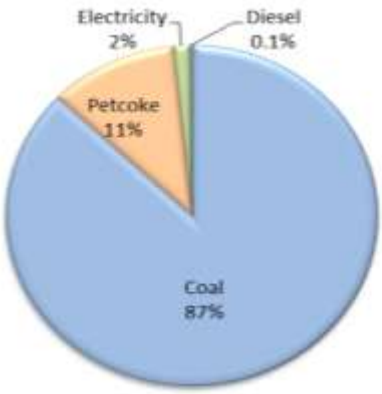
Kiln type	Specific energy consumption	
	kcal/kg	GJ/t
Downdraft kiln	2958	12.4
Tunnel kiln	865	3.6
Overall	**2299**	**9.6**

(ii) Cluster level consumption

The total annual energy consumption at cluster level is estimated to be 23,674 toe. The share of energy consumption by coal is about 87% and of petcoke is 11% (figure). It may be noted that coal is consumed only by downdraft kilns and petcoke by tunnel kilns. The electricity consumption and diesel to meet power failure are negligible. The estimated GHG emissions from the cluster are about 100,430 tonne of CO_2. The break-up energy consumption and GHG emissions based on different energy sources is shown in table.



Energy consumption share at cluster level



Share of energy forms at cluster level

Energy consumption of Chirkunda refractory industry cluster (2016)

Energy type	Annual consumption	Equivalent energy (toe/yr)	GHG emissions (t CO_2/yr)	Annual energy bill (million INR)
Coal	31,752 tonne	20,639	83,349	286
Petcoke	3,240 tonne	2,657	13,014	49
Diesel	34.32 kilo litre	29	91	2
Electricity	4.06 Million kWh	349	3976	23
	Total	**23,674**	**100,430**	**360**

Energy saving opportunities and potential

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

(i) Downdraft kilns

Use of insulating refractory in furnace 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 3 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 gases

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.

Technology switch over for firing

Adoption of tunnel kilns

The SEC in tunnel kilns is 865 kcal/kg as against of 2958 kcal/kg in DD kilns. It would be possible to reduce energy consumption by about 70% 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 14,766 toe per year with tunnel kiln adoption.

Adoption of chamber kilns

Another potential option for DD kiln units 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 1100°C are possible to achieve in chamber kilns and the temperature of exiting flue gases at chimney can be lowered to about 100°C. 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 0.13 toe/tonne 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.

(ii) 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 64 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 Chirkunda refractory industry cluster include Jharkhand Small Industries Association and MSME Development Institute (Dhanbad).

Cluster development activities

The cluster has established a Special Purpose Vehicle (SPV) with financial support from the Ministry of MSME in the name of Jharkhand Refractories and Research Development Centre (JRRDC). There are 35 registered members from refractory industries in Chirkunda. The SPV is equipped with a number of testing equipment to undertake chemical composition of different minerals used as raw material for refractory products and physical analysis of final products.

Instruments at Jharkhand Refractories and Research Development Centre

The Centre has established a business model for its self-sustainability. Some of the equipment available at the SPV include (1) furnaces (1600 ºC and 1450 ºC), (2) pyrometric, (3) refractory under load, (4) reverse thermal expansion, (5) thermal conductivity meter, (6) refractory cutting machine and (7) minerals testing machine.

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