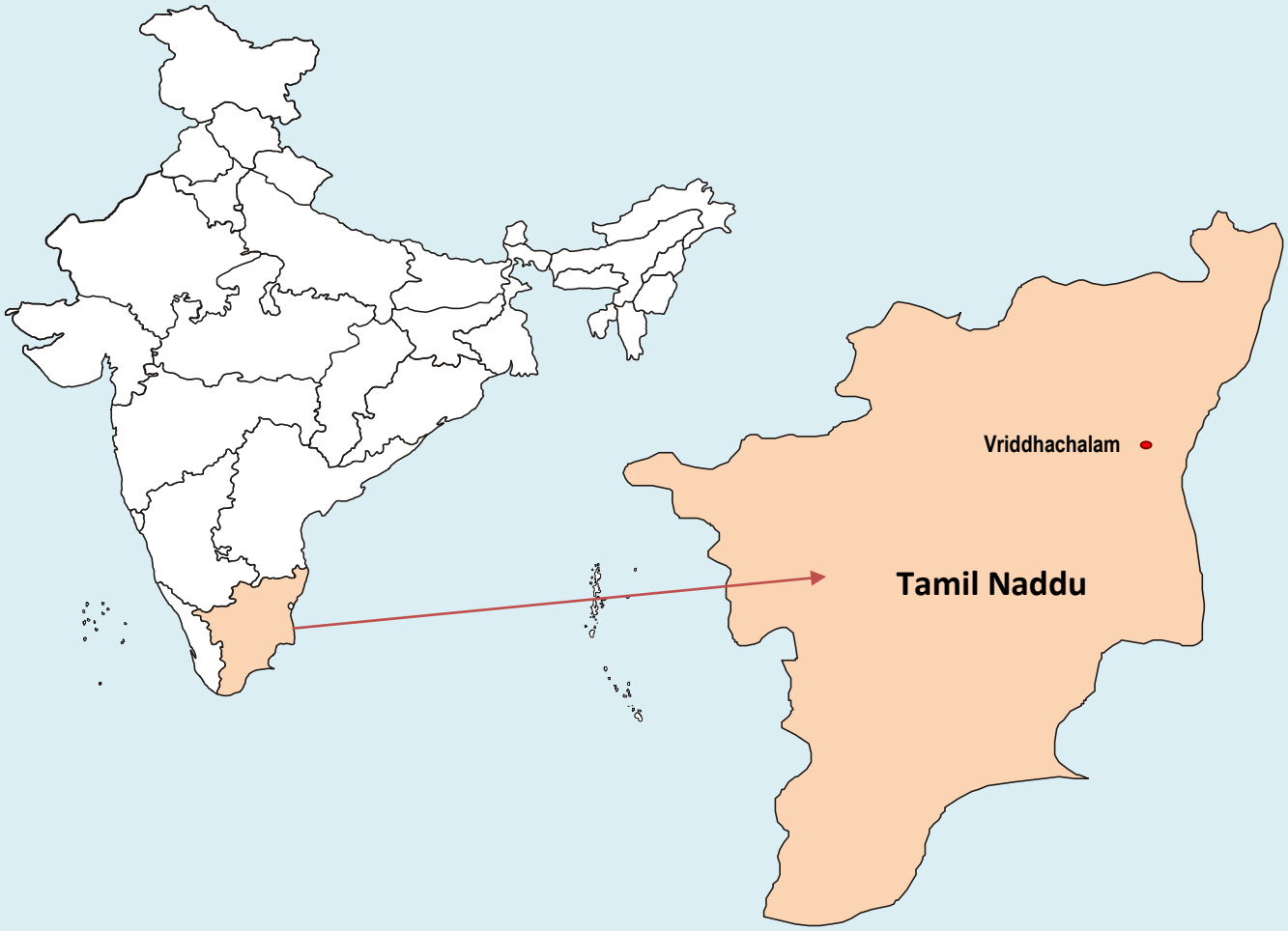
Cluster Profile
Vriddhachalam ceramics and refractory industries



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Vriddhachalam ceramic and refractory industries

Overview of cluster

This cluster is 50 years old and started by Tamil Nadu State government by establishing a ceramic manufacturing industry with an aim to create a local ceramic industrial hub for the state. Considering the availability of relevant raw material, a skill development institute, institute of ceramic technology was also established to create pool of trained person in the area. Vriddhachalam cluster had more than 100 down draft kilns at one time engaged in manufacturing different ceramic and refractory products. Slowly, cluster also developed capacity to make large category of artisan and handicraft products.

Product types and production capacities

At present there are about 300 small and micro units in the cluster engaged in production of various types of ceramic and refractory products. The units are engaged in the manufacture of a variety of ceramic products like insulators, electrical items and decorative items. The total annual production is estimated to be 60,000 tonne. Some of the primary products in the cluster are shown in table.

- Ceramic insulator
- Terracotta
- High Alumina refractory bricks
- Ceramic art-ware products
- Chemical porcelain
- Abrasive products (grinding media)
- Refractory filters for steel industries
- Assorted tiles
- Bottom boring set for steel industries
- Bed material for boilers
- Artisan products (Toys, terracotta, small lamps)

Energy scenario in the cluster

The ceramic and refractory units in Vriddhachalam cluster were initially using either fire wood for firing in downdraft kilns. With the technology up gradation, cluster has started using tunnel, shuttle, rotary as well as downdraft kilns. Apart from fire wood, the cluster extensively uses Light Diesel Oil (LDO) and Rubber Process Oil (RPO) for firing kilns. A Few units use imported coal from Australia and limited use of pet coke is also started as well. Electricity requirements at cluster level are mainly met through grid – Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO). The unit has LT connection. The power failure is generally quite low. Estimation of energy consumption indicates thermal energy accounts for 99% and electrical energy about 1% of total energy consumption. The details of major energy sources and present tariffs are shown in table.

Prices of major energy sources

Raw material	Price
Rubber Process Oil	Rs 3940,000 per kilo litre
Coal (imported)	Rs 10,000 per tonne
Petcoke	Rs 16,000 per tonne
Firewood	Rs 3,000 per tonne
Electricity	Rs 6.75 per kWh

Production process

Ceramic manufacturing process broadly consists of mould preparation, body material preparation, shaping, drying and firing. The general manufacturing process of ceramic products is described below.

(i) Mould preparation and curing

Most of the refractory and ceramic products are shaped using dies. Mould is used in manual casting during forming process for artisan and decorative ceramic products. Generally, moulds are made of Plaster of Paris (POP). Pre-shaped pattern is used to prepare green moulds which are strengthened through sun dry and in some cases controlled heating in kiln. The curing and strengthening cycle for a batch of green mould is dependent on availability of sun.

(ii) Body material preparation

Batch preparation is the first step towards shaping of any ceramic product. Batches of coarser size raw materials are reduced to desired mixture of target size through series of operation like crushing, grinding, sieving and magnetic separation following either wet or dry body preparation methods to produce final body mix or slip. The final body mass is transferred to pressing and/pouring areas for castings. It may be 6-8% for dry process and 30-40 % for plastic/wet process.

(iii) Shaping

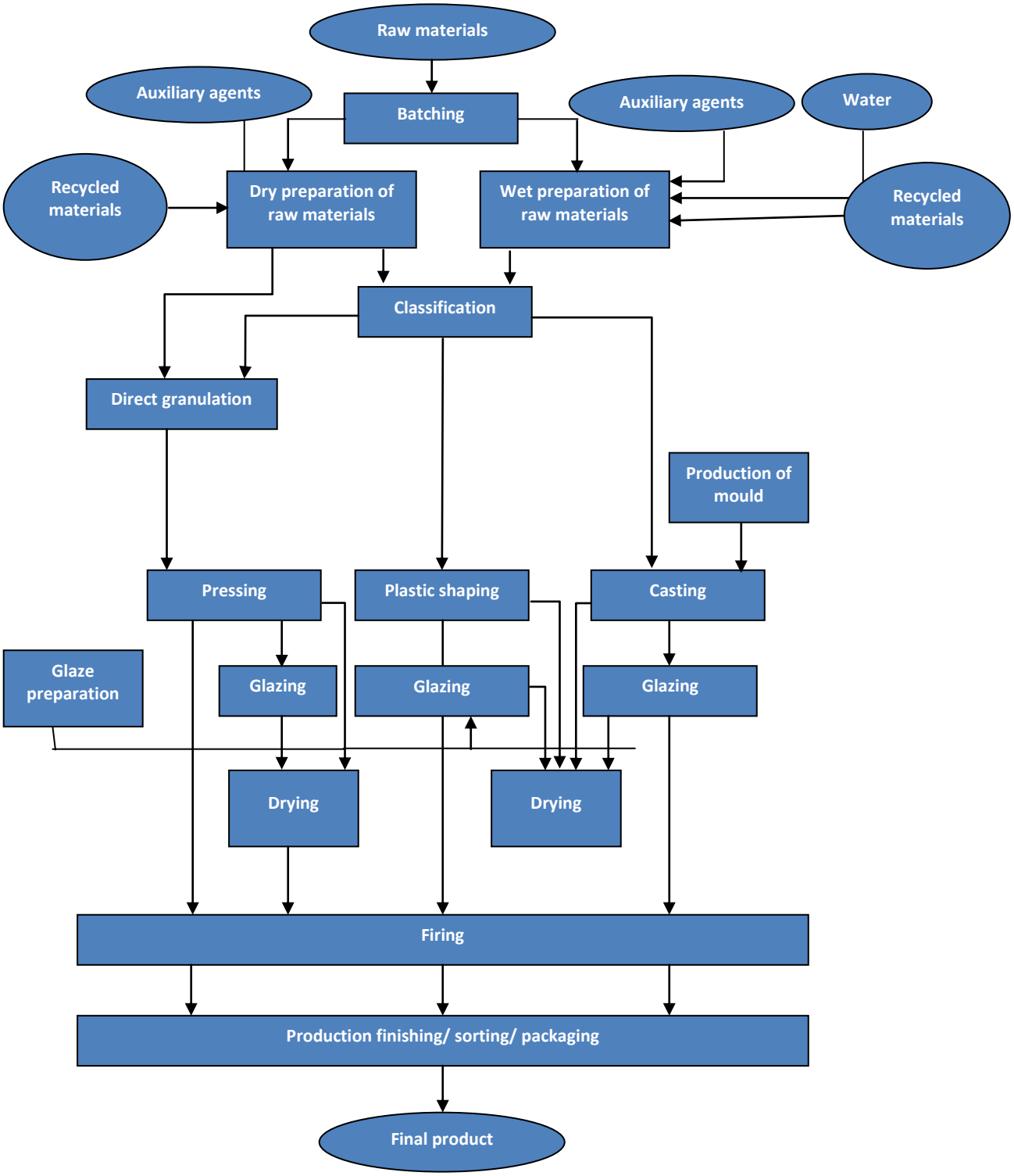
Depending upon the target product, either shaping processes of pressing or moulding is undertaken. Mostly manual presses are used in the ceramic industry. Refractory industries use hydraulic press for their products. In wet shaping, slurry is manually poured into the mould for generally small toys and artisan products. The cycle time in wet shaping for typical artisan products is about 6 hour covering pouring to de-moulding activities. Normally, 5-6% rejection in wet shaping is observed, which is mostly recycled in the process after suitably modified. The shaped products are dipped in glazing solution manually if required before sun drying.

(iv) Drying

The green products are stacked on trays and dried either in open sun or at room temperature before taken to next process step of sintering. The duration of sun drying depend on product batch to be dried. However, products are exposed to maximum sunlight to reduce firing load while heated in firing kiln.

(v) Firing

Firing is the process by which ceramics are thermally consolidated into a dense, cohesive body composed of fine, uniform grains. This process also is referred to as sintering or densification. Ceramics are generally fired at 50-75% of the absolute melting temperature of the body material. Kilns used in firing may be intermittent or continuous types.



Process flow chart

Technologies employed

Traditionally, Vriddhachalam ceramics and refractory cluster was using downdraft kilns which were mainly using fire wood as fuel. However, there were number of issues related to operation of downdraft kilns which included (1) higher Specific Energy Consumption (SEC), (2) Lower yield and (3) Poor Environmental Performance. Over the years, new units in the

cluster have adopted energy efficient kilns such as tunnel, rotary shuttle etc. At present 3about 135 kilns provides firing services in the cluster. These kilns use LDO/RPO as the main fuel for firing of ceramic products. Around 20 operational downdraft kilns use wood for firing process in the kilns. Different types of kilns used in the cluster are shown in table.

Types of kilns used in Vriddhachalam cluster

Type of kiln	Number of kilns
Tunnel kiln	5
Shuttle kiln	20
Rotary kiln	10
Downdraft kiln	100
Total	135

(i) Tunnel kiln

Tunnel kilns are continuous type kilns which are used for firing of various ceramic products. There are 5 number of tunnel kilns. Three tunnel kilns are used for production of ceramic products and use Rubber Processed Oil (RPO) and Light Diesel Oil (LDO). Other two tunnel kilns use pet coke and are used for manufacturing of products such as high alumina refractory bricks. The capacity of tunnel kilns is about 7.5 tonne per day for ceramic products and for refractory products; the production is about 20 tpd.

Tunnel Kiln

A typical tunnel kiln has three different zones, namely, preheating, firing and cooling zones. The kiln has two ends viz. loading end and unloading end. The green wares are stacked on trolleys, and moved on rails inside the kiln. The speed of the trolleys inside the kiln is controlled with the help of an electrically operated pusher. The pushing time is adjusted to provide the required residence time for the type of products being fired in the kiln. For loading the greens and unloading the fired products, a side rail is provided parallel to the kiln. The proximity of the side rails to the kiln walls also helps in drying of the greens before they are fed in the furnace. A temperature of 1130-1260 ^{o}C is maintained in the firing zone based on the type of products such as red clay products, small lamps, heavy refractory products, etc. Upon completion of soaking, the trolleys are further pushed towards cooling zone, wherein the products are cooled before taken out from unloading end.

(ii) Shuttle kilns

Shuttle kilns are batch operated kilns. These kilns are mainly used for production of ceramic toys. RPO/LDO is used as the fuel in shuttle kilns. There are two burners with one each located on opposite sides of the furnace. The dried products are loaded inside the furnace and closed down. These materials are heated slowly and gradually to reach required

temperature. The products are soaked at the maximum temperature for about one hour to enable effective firing of glazed products.

After completion of soaking, the fuel supply is cut off and only cooling air is supplied to the kiln. The accelerated cooling through air blowers is done to maintain a cooling temperature gradient for the wares. Forced cooling till the kiln temperature has dropped to about 200-250ºC, after which the blower is stopped and the doors are opened for natural cooling of the products. The kiln does not have any waste heat recovery system to recover high temperature heat available in flue gases.

Shuttle kiln

(iii) Rotary kilns

Rotary kilns are continuous type furnace used to process minerals for calcination to convert base mineral material to a target product. Generally, these kilns are used in manufacturing processes like cement, refractory, lime etc. The kiln comprises a cylindrical vessel inclined to its horizontal axis on which the vessel rotates slowly. The speed or Rotations per Minute (RPM) may vary between 0.5 to 5 maximum depending upon its application. Variable Speed Motors (VSDs) are commonly used in rotary kilns.

In most of the cases, raw material to be processed and heat source move in opposite direction (counter-current), but sometimes in the same direction as the process material (co-current). It has an outer metallic shell made of mild steel plate, usually between 15 and 30 mm thick, welded to form a cylinder which may be up to 230 metre in length and up to 6 metre in diameter. Inner face of shell is provided with refractory lining to avoid hot spot development on shell side. The thickness of the lining is generally in the range 80-300 mm. It may consist of refractory bricks or cast refractory concrete, or may be absent in zones of the kiln that are below around 250 C.

Rotary kiln

Rotary kilns use a variety of fuels such as gas, oil, pulverized petroleum coke or pulverized coal. Rotary kilns in Vriddhachalam cluster use pulverised coal.

(iv) Down draft kilns

Down draft (DD) kilns are batch type kilns. There are about 100 DD kilns in the cluster. DD kilns are mainly involved in production of 'Bottom Boring Sets' which are used in steel

Downdraft kiln

industries. Due to recession in recent years, it is estimated only 20 DD kilns are operating in the cluster.

The downdraft kilns use manual process for forming of green products. These kilns generally use wood as fuel for firing of products. In a down draft kiln, the products of combustion from fuel rise up. These gases are allowed to pass downwards thereby transferring maximum heat available in combusted gases. The hot flue gases then pass through the bottom duct and exit through chimney. Since DD kilns are batch operated type, their specific energy consumptions are generally observed to be higher than continuous type kilns.

Energy consumption

The ceramic & pottery units in Vriddhachalam use different fuels for kiln firing. These include Processed Rubber Oil (RPO), coke (imported), petcoke and firewood (table). DG sets are used to meet electricity requirements only during power cuts and their consumption is negligible.

Fuels used in kilns

Type of kiln	Fuel used
Tunnel kiln – Ceramic products	Processed Rubber Oil/ LDO
Tunnel kiln – Refractory products	Pet coke, coal dust powder*
Shuttle kiln	Processed Rubber Oil
Rotary kiln	Coal dust
Downdraft kiln	Firewood

* *Imported coal from Australia*

The energy consumption in different kilns is also dependant on type of products and the firing temperature requirements. Different ceramic products require different temperature profiles as shown in the table.

Firing temperature requirements for different products

Product	Firing temperature (°C)
Red clay products	1130-1140
Lamps	1180
Heavy products (refractory bricks)	1260
Toys	1190

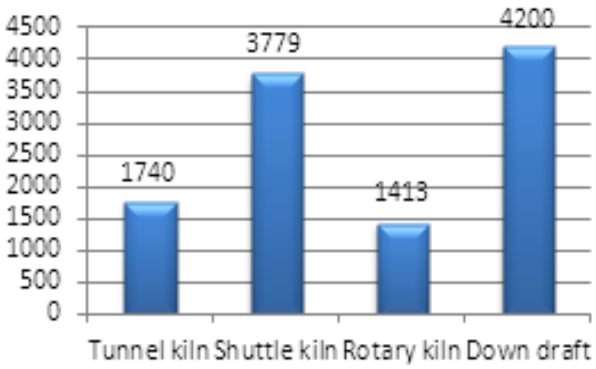
Thermal energy accounts for about 99% of share in total energy consumption. With majority of forming/ moulding processes used in the cluster employ manual processes, electricity consumption accounts for less than 1% of total energy consumption. In terms of energy costs, thermal energy cost is about 96% of total energy costs. The energy costs are estimated to be 50% in overall production costs (table). The tunnel kilns and shuttle kilns in the cluster presently use mainly RPO gradually replacing Light Diesel Oil (LDO) attributed to its lower prices.

Share of different costs

Cost head	Share (%)
Energy	50
Labour	20
Raw material	20
Others	10

(i) Unit level consumption

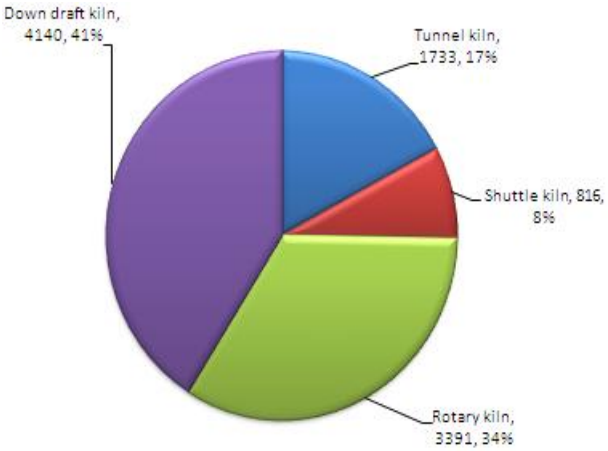
The specific energy consumption (SEC) of ceramic and refractory units varies with type of kiln used in the cluster – batch type or continuous type. It may be noted that in manufacturing of ceramic and refractory products, a significant quantity of dead-weight is also heated and cooled along with the products leading to higher energy consumption levels. The average SEC of kilns used in the cluster varies from 5.9 MJ per tonne to 17.6 MJ per tonne (table). The SEC levels are very high as compared to kilns operating in other clusters in the country.



Comparison of SECs of kilns (kcal/kg)

Specific energy consumption of kilns

Kiln type	Specific energy consumption	
	kcal/kg	MJ/kg
Tunnel kiln	1740	7.3
Shuttle kiln	3779	15.8
Rotary kiln	1413	5.9
Down draft kiln	4200	17.6



Energy consumption – Kiln-wiseTunnel kiln

The total energy consumption of a ceramic/refractory unit varies between 41 toe per year to 644 toe per year. Tunnel kilns producing heavier refractory products account for higher energy consumption levels whereas shuttle kilns producing toys account for lower energy consumption levels. The typical energy consumption by industrial units in Vriddhachalam employing different types of kilns and producing different types of products are shown in table.

Typical energy consumption of kilns

Kiln	Thermal energy (toe/yr/unit)	Electricity (kWh/yr)	Total energy (toe/yr/unit)
Tunnel kiln (Ceramic products)	138	115,556	149
Tunnel kiln (Refractory products)	633	115,556	644
Shuttle kiln	40	12,400	41
Rotary kiln	336	35,556	339
Down draft kiln	207	-	207

(ii) Cluster level consumption

The total annual energy consumption at cluster level is estimated to be 10,079 toe. The break-up energy consumption based on different energy sources is shown in table. The major share energy consumption is in downdraft kiln (41%), followed by rotary kilns (34%) as shown in the figure.

Energy consumption of the Vriddhachalam cluster (2015)

Energy type	Annual consumption	Equivalent energy (toe/yr)	Annual energy bill (million INR)
RPO	1316 kilo Litre	1,211	51.3
Coal (imported)*	4800 tonne	3,360	48.0
Petcoke	1440 tonne	1,267	23.0
Firewood	18000 tonne	4,140	54.0
Electricity	1.18 Million kWh	102	8.0
	Total	**10,079**	**184.3**

*** Imported coal from Australia**

Energy saving opportunities and potential

Some of the major energy-saving opportunities in the cluster are discussed below.

(i) Use of low thermal mass cart

The weight reduction of the kiln carts in tunnel kilns provides significant amount of energy savings in tunnel kiln. Low thermal mass materials are now being used for kiln car construction, which reduces the weight of the kiln car considerably. 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 the 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/ nano material 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 52 toe per year.

(ii) Kiln automation and improved burner system

The existing tunnel kilns and shuttle kilns are operated and controlled manually. This results in deviations in various operating parameters as compared to design/ desired specifications and hence higher energy losses. Temperatures in different zones of the furnaces, fuel flow and blower operation can be integrated to result in optimum performance of the furnace. Moreover, the burner operations are controlled manually resulting in uneven ratio of air to fuel as compared to optimum ratio. Proper selection of burners along with automatic control of air-to-fuel ratio using ratio controllers would result in reduced energy consumption of the furnace. The envisaged energy saving with these measures is about 3% equivalent to an annual saving of 178 toe.

(iii) Waste heat recovery in shuttle kilns

Shuttle kiln is a batch type kiln wherein the products are kept inside the kilns wherein they are slowly preheated, fired, soaked and cooled at the same location. The temperature of flue gases also increases gradually over the firing cycle, with the highest temperature reaching about 900-1000 ºC. By incorporating a Waste Heat Recovery (WHR) system, the combustion air at ambient temperature can be preheated from 100-350ºC depending on flue gas temperatures. An average energy saving potential of 7% exists with air preheating system, equivalent to an annual energy saving of 57 toe.

(iv) Other energy saving measures

Other energy saving measures having potential for adoption in the cluster include the following:

- Extension of length of tunnel kiln
- Use of decker plate in place of saggers
- Use of baffle wall inside firing zone
- Cladding of outer surfaces to ensure better effectiveness and long life
- Provision of inlet filter for the blower
- Adjusting pressure setting in compressors
- Energy efficient motors
- Energy efficient blowers
- Energy efficient lighting

Apart from above options, following options can also help in growth and improve sustainability of the cluster.

- Product diversification and manufacturing of high-end products
- Upgradation of existing Self Help Groups (SHGs) with high end tool room
- Use of high-end technologies such as furnace with high temperature range, automatic/ iso-static press machines, injection moulding

Major stakeholders

The major stakeholders in Vriddhachalam ceramic & refractory cluster include the following.

- Government Institute of Ceramic Technology provides diploma course on ceramic technology
- Tamil Nadu Refractory Manufacturers Association
- Refractory Manufacturers Association
- Vriddhachalam Industrial Estate Ceramic Manufacturers Association
- Vriddhachalam Integrated Ceramic SHG Association. Predominantly this is artisan based cluster having 200 micro industries engaged in the production of toys, terracotta and decorative items.
- District Industries Centre, Cuddalore

Cluster development activities

MSME-Development Institute has set up a Common Facility Centre (CFC) involving SHGs known as Vriddhachalam Integrated Ceramic SHG Association. The CFC has about 100 members. Under this initiative, a tunnel kiln unit has been established to provide services related to firing of ceramic products on chargeable basis. Members are provided with lower charges as compared to non-members. MSME-DI (Chennai) conducts awareness programs in the cluster.

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

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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