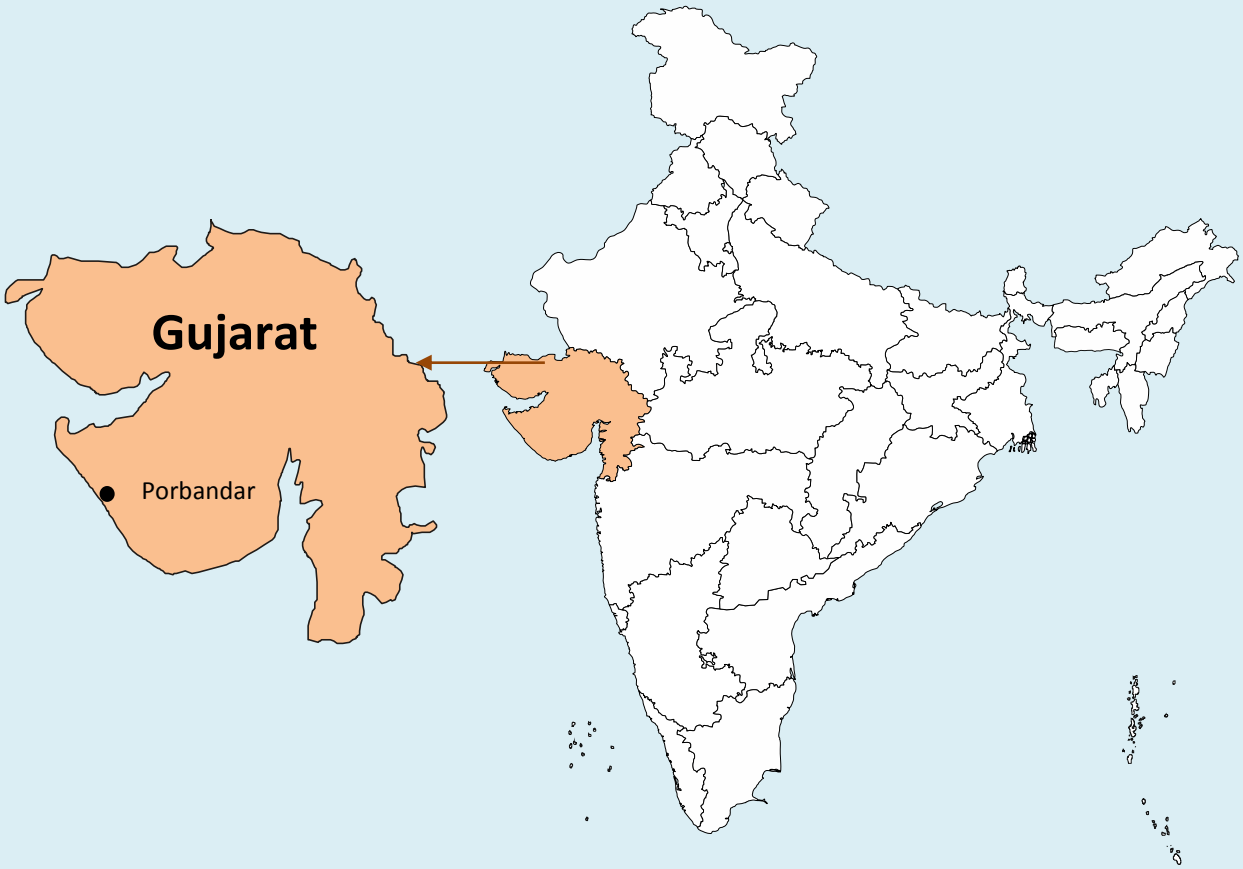
Cluster Profile
Porbandar mixed minerals processing industries



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TERI team is indebted to Porbandar Industrial Association, GIDC (Dharampur, Porbandar), for providing support and information related to mixed mineral processing industries in Porbandar. TERI also places on record the support provided by Mr Kishore Shilu (Owner, Nikhil Industries), Mr Dilip Patel (Owner, Ashirvad Minerals) for their support and cooperation in organizing field visits and interactions with entrepreneurs of different mixed mineral processing manufacturing units during the study. TERI extends its sincere thanks Mr Bharath (Partner, Nikhil Industries) for facilitating field visits.

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.

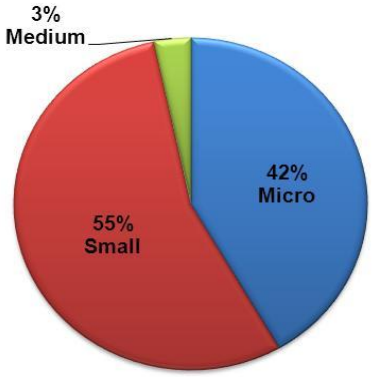
Porbandar mixed minerals processing industries

Overview of cluster

Porbandar is one of the prominent Mixed minerals processing clusters in the country. There are an estimated 280 number of MSME units in Porbandar, of which majority are ice manufacturing and mixed minerals processing units. The cluster is spread within Porbandar and neighbouring GIDC industrial estates. The engineering industry is diverse in nature. Some of the major engineering segments include mixed minerals processing, ice manufacturing and also hosts some large-scale industries like Saukem (Division of Nirma), Saurashtra cement, etc.

Porbandar mixed minerals cluster in Gujarat
Source: Gooble map

The industry cluster comprises medium, small and micro industries. The products manufactured include chalk powder, emery abrasives, calacine bauxite. There are about 60 number of mixed mineral processing units located in the cluster. Mixed mineral processing industries are majorly micro and small category units with few medium sized units. Some of the large sized mixed minerals processing industries in Porbandar include Saurashtra Calcined Bauxite Allied industries Ltd (SCABAL Ltd), and Orient abrasives Ltd Industries which provide employment to more than 2000 people. The annual turnover of the cluster is estimated to be around Rs 300 crores.

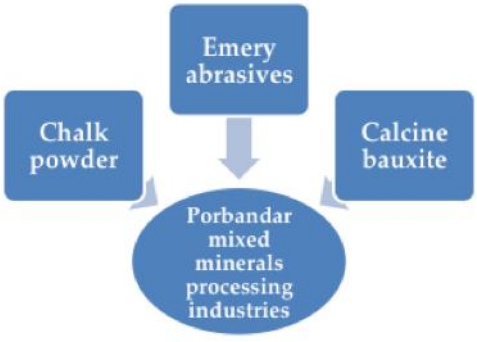


Distribution of mixed mineral industries

Product types and production capacities

Mixed minerals processing industries are producing variety of products which are used in different end-use sectors such as paints and distemper, rubber, putty, abrasives, refractory industries, flour mill stones. Followings are some of the primary products manufactured in the cluster:

- Chalk (loose, lump and powder)
- Micro-fine whiting powder
- Monolithic castables
- Refractory mortar
- High alumina refractory cement
- Brown and white fused alumina
- Calcined bauxite
- Synthetic emery abrasives
- Blasting abrasives

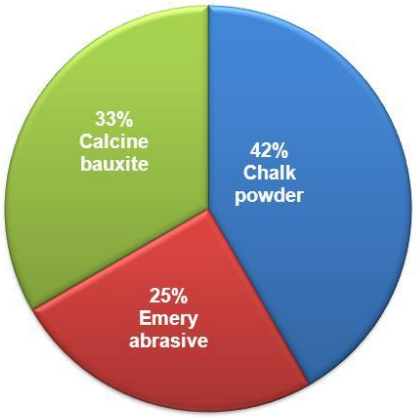


Product categories

These products can be grouped into following primary products:

(1) Chalk powder
(2) Emery abrasives
(3) Calcined bauxite

More than 40% of the units are involved in chalk powder production in the cluster followed by calcined bauxite and emery abrasive industries. The installed capacity and production of similar type of industries vary with each unit and the production is accounted in terms of tonne of products. The total estimated production of different mineral processing units is estimated to be 239,600 tonne per year (table).



Product-wise distribution of industries

Annual production by mixed minerals processing industries

Product category	Number of units	Production (tonne/year)
Chalk powder	25	90,000
Emery abrasive	15	21,600
Calcined bauxite	20	128,000
Total	**60**	**239,600**

Raw material usage at cluster level

(i) Chalk powder products

The primary sources of raw material for chalk powder products are chalk lumps (calcium carbonate) of size 15 to 20 inches from mining at Aadinayana town 10 km from Porbandar. The cost of raw materials varies between Rs 2000 and 2500 per tonne depending on type, quality and source of material. The quality of white chalk in Aadinayana is considered as the best quality for the rubber industry due to its elasticity and whiteness.

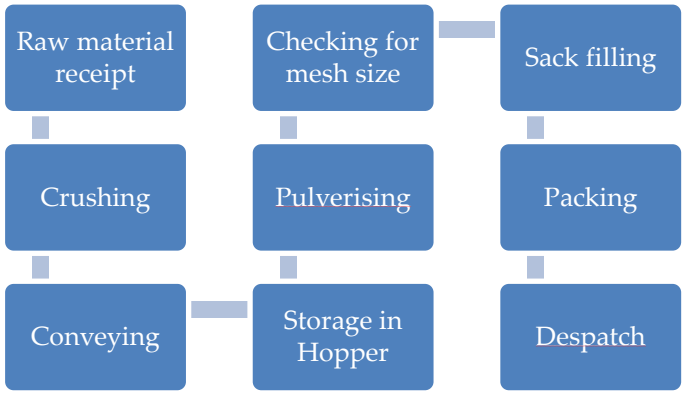
Chalk lumps raw material for chalk powder

(ii) Emery abrasives and calcined bauxite

The primary sources of raw material for emery abrasives and calcined bauxite is low grade and high grade bauxite respectively which are obtained from mining at Jamnagar, Bhatia, Kutch, Bhuj and Dwarka regions. In low grade bauxite, alumina content is less than 50% whereas in high grade bauxite alumina content is close to 58%. The average cost of raw materials for low grade bauxite 1500 Rs per tonne and for high grade bauxite is 2500Rs per tonne.

Low grade bauxite raw material for emery abrasives

High grade bauxite raw material for calcine bauxite



Process flow chart for Chalk powder manufacturing

Energy scenario in the cluster

Electricity and coke are the major sources of energy in the cluster. Electricity is supplied by Paschim Gujarat VIJ Company Ltd (PGVCL) and coke is procured from Reliance. Electricity is used for running motors and other equipment and coke is used in kilns. The details of major energy sources and tariffs are shown in table.

Prices of major energy sources

Source	Remarks	Price
Electricity	HT	Rs 8.00 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty)
	LT	Rs 9.00 per kWh (inclusive of energy, demand charges and electricity duty)
Coke	From local market Reliance	Rs 8000 per tonne

Production process

The production process for each product in the cluster is explained below:

(i) Chalk powder manufacturing

After receipt of raw material as chalk lumps of 15 -20 inches sizes, they are crushed in jaw crusher and conveyed through belt conveyor into storage hopper. After pulverising in

pulveriser of capacity 2-2.5 tonne/ hr, the raw materials are checked for required mesh size, fine micronized sizes are white chalk powder of mesh sizes 250, 300, 500 and 700 mesh. Sizes are checked using sieve analysis. After achieving required size, chalk powder is packed in sacks and despatched to various industries like rubber tyre, paints/ distemper, paper, cosmetics, putty.

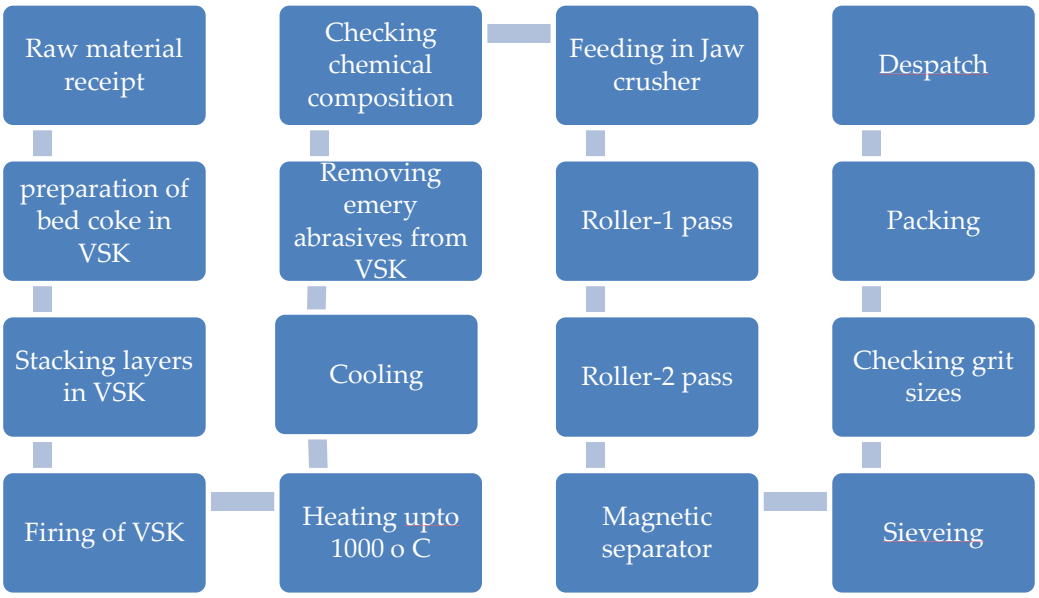
Chalk Power

(ii) Emery abrasives manufacturing

Emery abrasives lumps taken out from VSK

Low grade bauxite in the form of lumps of sizes 10 to 15 inches is the raw material for production of emery abrasives. Lumps of bauxite are broken manually using hammer. Vertical Shaft Kiln (VSK) is used for production of emery abrasives. The typical dimensions of VSK include 2.5 metre height and 1.25 metre internal diameter (ID). Bed coke is prepared inside the kiln. Alternate layers of low grade bauxite and coke are stacked in the kiln. A temperature of about 1000 ºC is maintained inside the kiln which leads to melting of raw material. Cooling cycle of the VSK is more than 24 hours. The final product i.e. emery abrasive lumps are removed from the kiln using crowbar and hammered to a size of 4-6 inches. The final products are sent to laboratory for testing of chemical composition.

Emery abrasives are fed to jaw crusher reducing its size to 1- 2 inch. To reduce the size further, it is passed through two rollers. Any iron particles present are removed by passing the material through magnetic separator. Emery has property of hardness which makes it a suitable material for abrasive use. Near about 50 different grit sizes of emery abrasives are manufactured in the cluster. Coarse size is considered to be of good quality and it is a basic raw material for abrasive manufacturing industries like grinding wheel, flour mill wheel, buffing wheel and used for abrasive blasting in investment casting units. The generic production process of emery abrasives manufacturing is shown in the figure.



Process flow chart for emery abrasives manufacturing

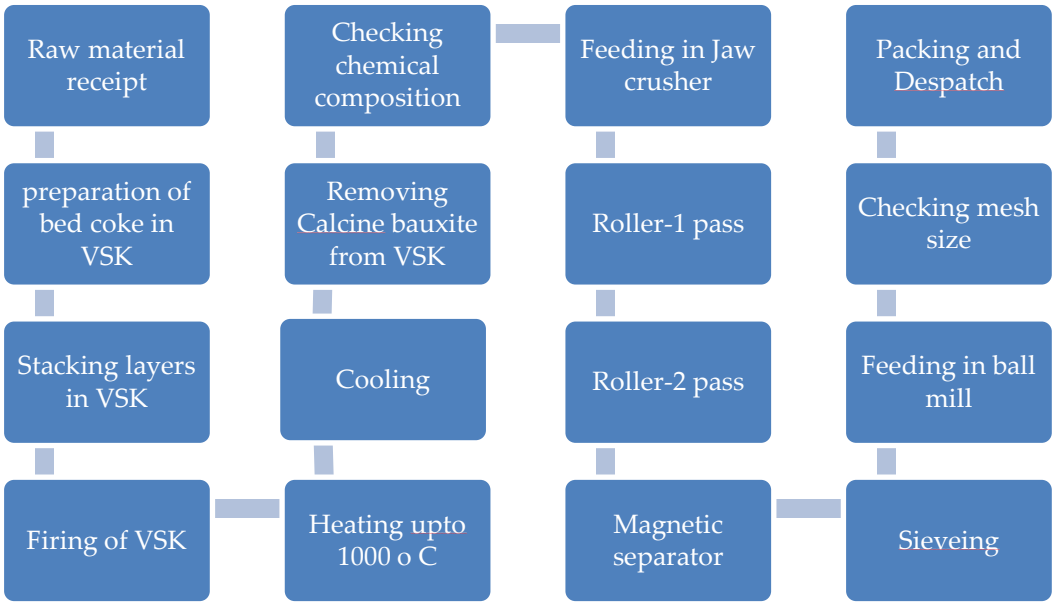
(iii) Calcined bauxite manufacturing

Calcined bauxite is obtained by calcination (heating) of high grade Bauxite at 1000 °C temperature to remove moisture thereby increasing alumina content. Alumina content of calcined bauxite is 84-88% as compared to raw bauxite of 57-58%.

Calcine bauxite lumps taken out from VSK

The process for production of calcined bauxite is similar to emery abrasives manufacturing. Vertical Shaft Kiln (VSK) is used in the production process. The typical dimensions of VSK include 3.6 metre height and 1.8 metre internal diameter (ID). High grade bauxite and coke are arranged in layers (typically 28 layers) and heated upto 1000 ºC for 24 hours. During the process, about 25% of the weight of raw material loss takes place. For example, out of 8.5 tonne of raw material, near about 6.5 tonne of calcined bauxite formation takes place, which is the base material for refractory industries. Lumps of calcined bauxite -are removed from the kiln using crowbar. After testing for chemical composition in laboratory, the lumps are fed to jaw crusher to reduce the size o 1-2 inches which is followed by two rollers to further reduce the grain size to about 0-1 mm, 1-3 mm, 3-5 mm, 5-8 mm.

Calcine bauxite in grain and powder form



Process flow chart for calcine bauxite manufacturing

Ball mills are used for powder formation of calcined bauxite of mesh size 100 to 200. Fine powdered calcined bauxite is the best base material for refractory industries used for preparation of refractory bricks, mortar and monolithic constables as calcined bauxite exhibits high strengths and high PCE[1] (Pyrometric Cone Equivalent). Calcined bauxite is a popular raw material for manufacturing fused alumina and high alumina refractories.

Some of the units in Porbandar are using rotary shaft kiln for calcined bauxite, which has a high bulk density compared to calcine bauxite formed in vertical shaft kiln. The generic process is as shown in the figure.

Technologies employed

Mixed minerals processing industries in Porbandar cluster use product based forming technologies like jaw crusher, pulverising mill, vertical shaft kiln, rotary kiln, ball mill along with connected auxiliary equipment as required for smooth operation of these machines. Apart from belt conveyor, rollers are mostly used in mixed minerals processing plants. Some of the primary process technologies are explained below.

(i) Jaw crusher with belt conveyor

Chalk lump raw material are crushed in jaw crusher and conveyed to pulveriser hopper through conveyor belt. Jaw crusher and belt conveyor are driven by motor through gear box. Chalk lump of 20 inches size are crushed in jaw crusher and conveyed through flat belt conveyor.

Jaw crusher with belt conveyor

[1] PCE test is a must for the quality control purpose for refractories and refractory raw materials

(ii) Pulveriser

Pulveriser

Pulveriser consists of an encased rotor carrying swing hammers, whizzer classifier for fineness regulation. Raw material to be pulverised enters the crushing chamber through the hopper and automatic rotary feeder. The impact of the hammer on the feed material against the liner plates reduces it into fine powder. The ground material is carried towards the whizzer classifier for classification and the over-sized particles are rejected by the classifier and returns to the crushing chamber for further grinding. This operation is continuous and in the process, moisture is also removed from raw materials by heat generated due to rotational movement in the mixer barrel. Pulveriser is driven by motor and gear box. The typical capacity of pulveriser is 2.5 tonner per hour .with a motor of 60 hp rating.

(iii) Vertical shaft kiln

Vertical shaft kiln

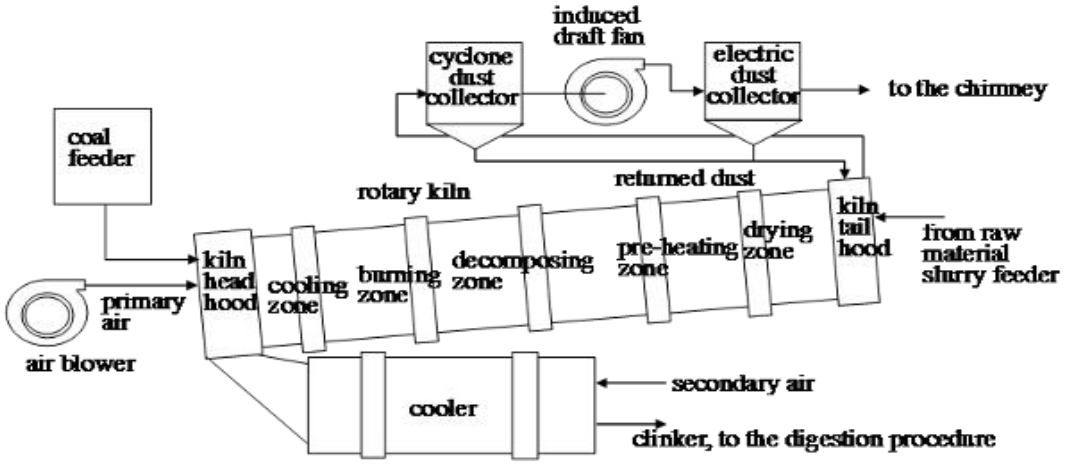
Vertical shaft kiln is used for manufacturing of both emery abrasive as well as calcined bauxite. In VSK, raw material bauxite and coke are stacked in layers. Batch process is adopted in VSK. The kiln has a single brick lining and a blower of 5-7.5 hp is used to supply air for heating as well as cooling. A temperature of about 1000 ºC is achieved during production process. Single blower supplies air through V-connection pipe to two VSK at a time. Generally after every heat, VSK relining is done. Calcined bauxite produced in VSKhas a bulk density of around 2.6 gm/ cc, which is less than bulk density of calcined bauxite produced in rotary kiln.

(iv) Rotary kiln

Rotary Kiln

Rotary kiln[2] are generally 100m long with inside diameter of about 2 metres. Rotary kiln manufacturing process is a continuous process in which bauxite is feed from one end and firing of coke is done at the other end. The conveyor belt fixed below the kiln outlet ensures continuous production of calcined bauxite. The product is taken out and cooled. The rotary kiln requires a motor of 100 hp capacity. The blower uses 15 hp motor. The bulk density of calcined bauxite formed in rotary kiln is 3.0 gm/ cc which is better than calcined bauxite manufactured in VSK.

[2] http:/ / www.intechopen.com/ books/ reinforcement_learning/ reinforcement_learning-based_supervisory_control_strategy_for_a_rotary_kiln_process



Schematic of rotary kiln

(v) Ball mill

Ball mills are commonly used where grain form of raw material is used. Ball mills operate in batch mode. Many of the balls mills are belt driven and operate on partial loading. Calcined bauxite powder industries use ball mills for crushing coarse grains to a size of 100 to 200 mesh fine calcined bauxite powder.

Ball mill

Energy consumption

Electricity and coke are the main source of energy for the mixed mineral processing units in the Porbandar cluster. Almost all the units depend on electricity from grid to meet their energy needs. A majority of the mixed mineral units have LT connection and the average connected load is about 100 kVA. Calcined bauxite manufacturing units have HT connection of about 200 kVA or more depending on installed capacities. The power situation has significantly improved in Porbandar over the past few years. Consequently, the dependence on DG set is reduced and its use is insignificant in term fuel consumption compared to electrical energy from connected grid supply. Coke is used as fuel in vertical shaft kilns and rotary kilns.

(i) Unit level energy consumption

Unit level energy consumption indicates that calcined bauxite type of mixed mineral processing industry consumes more energy than other mixed mineral processing industries.

Energy consumption by typical mineral industries

Industry type	Thermal energy (toe/year/unit)	Electrical energy (kWh/year/unit)	Total energy (toe/year/unit)
Chalk powder	-	54,648	4.7
Emery abrasives	265	70,416	271.3
Calcine bauxite	832	141,944	884.2

(ii) Cluster level energy consumption

Calcined bauxite industries in Porbandar contribute around 80% of total energy consumption in the cluster. The contribution of all the industry segments to total energy consumption is also presented in the figure. The total energy consumption of mixed mineral processing industries in the cluster is estimated to be 21,070 toe. Coke accounts for about 98% of total energy consumption in the cluster.

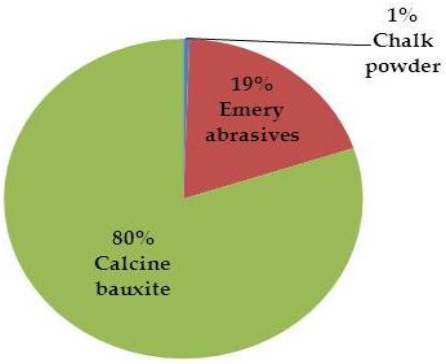
Total Energy consumption by mixed mineral processing industries

Type	Unit	Equivalent energy(toe/yr)	GHG emissions (tonne CO_2/yr)	Annual energy bill (million INR)
Electricity	5.3 million kWh/ yr	452	5,156	42
Coke	31720 tonne/ yr	20,618	92,366	254
	Total	**21,070**	**97,522**	**296**

**Energy data collected from individual units in Porbandar*

Energy consumption profile in the cluster

Type of industry	Energy consumption (toe/Year)
Chalk powder	117
Emery abrasives	4,069
Calcine bauxite	16,884
Total	21,070



Distribution of energy share by mixed mineral processing industries

Energy saving opportunities and potential

Some of the major energy-saving opportunities in the mixed mineral processing units in the cluster are discussed below.

(i) Double layer refractory lining in vertical shaft kilns

Presently single layer refractory lining is used for the vertical shaft kilns. Due to single layer refractory, significant heat loss takes place through walls of the kilns. Further, it also reduces the kiln life and increases maintenance costs. It is recommended to use double layer refractory lining for VSK, which will reduce the coke consumption. Refractory damage will also reduce, saving the investment for relining after every heat. Depending on the base case potential energy saving could be in the range of 5-8 %.

(ii) Divided blast of air for kilns

Single blast design with V-pipe connection is presently being used for two kilns simultaneously, which does not cater to proper air supply for fuel combustion resulting in increased formation of unburnts and hence higher coke consumption. Divided blast of air can be adopted for VSK to ensure optimum combustion of coke along with better product composition with energy savings in the range of 4-6% annually.

(iii) Application of variable frequency drives

Motor-driven systems often are oversized and inefficiently controlled. Variable frequency drives (VFDs) can provide a more cost-effective method for reducing flow or pressure at the source by varying the speed of the connected load to match the process requirements. Energy savings in VFD applications usually range from 20-50%. Some of the potential applications of VFDs in mixed mineral processing industry are mentioned below.

Pulveriser and conveyor motor

Motor for pulveriser run on variable loads due to inconsistent size of the chalk lumps. Weight and size of the chalk lumps vary and hence load on conveyor motor is also varying considerably. Hence use of variable frequency drive in place of constant RPM will reduce of power consumption up to 10 %.

Kiln rotor motor

In rotary kilns, 100hp motor is used for rotation of kiln. The load on motors varies with weight of raw materials inside the kiln. Also, there is significant reduction in weight of the material inside kiln towards its output due to removal of moisture eventually reducing load on the motor. To cater to this variable load, VFD drive can be used which, will rotate the motor at minimum current consumption. Energy saving upto 15% can be achieved using VFD for kiln rotor motor.

(iv) Waste heat recovery for drying raw material for emery and calcined bauxite

Low/ high grade bauxite can be dried using heat available in flue gases. At present, the sensible heat in flue gases is not utilized and vented to atmosphere. By utilizing the waste heat, the raw materials can be preheated and dried using simple waste heat recovery (WHR) systems. Optimizing process heating with WHR can reduce heating costs for drying raw material by 5-7 % annually.

(v) Replacement of rewound motors with energy efficient motors

Rewinding of motors results in drop in efficiency by about 3-5%. It is better to replace all old motors, which have undergone rewinding three times or more. The old rewound motors may be replaced with EE motors (IE3 efficiency class). This would results into significant energy savings with simple payback period of 2 to 3 years.

Motor rating (kW)	IE2 Efficiency (2 Pole), %	IE3 efficiency (2 Pole), %	Energy saving (%)
2.2	83.2	85.9	2.7
3.7	85.5	87.8	2.3
5.5	87	89.2	2.2
7.5	88.1	90.1	2
11	89.4	91.2	1.8

**Source: Siemens IE3 motors brochure*

(vi) Use of cogged v-belts

The driving motors are generally coupled with flat V-belts. The transmission efficiency of flat V-belt is around 90–92%. It is recommended to use cogged V-belt instead of flat V-belt. The transmission efficiency of cogged V-belt is 3–5% higher than flat belt.

Cogged V-belts use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and the power transfer capability of belts. V-belt drives can have a peak efficiency of 95-98%. They play a dynamic role in allowing for heat dissipation and better contact with the pulley. There are several other potential benefits of using cog belts which include (i) less slippage at high torque, (ii) low maintenance and re-tensioning and (iii) suitable for wet or oily environments.

Cogged V Belt

(vii) Lighting

T-12 type tube lights (of 52W including choke) and halogen lamps (150W and 250W) are generally used by units in the cluster. These inefficient lightings can be replaced with energy efficient LED lighting (LED tube lights of 10W and 20W) and flood lamps and high bay lamps (20W, 40W and 80 W) which would provide better illumination and energy savings. Since a large number of lamps are used in the units, the existing lighting may be replaced with EE lighting in a phased manner.

Major stakeholders

The important stakeholders in the cluster include leading industry association of the region – Porbandar Industrial Association, GIDC (Dharampur, Porbandar) Industrial Association and Chamber of Commerce (Porbandar). Of these, GIDC industrial association is the most proactive in the cluster. It has about 200 members from different parts of Porbandar district.

Cluster development activities

There are no specific cluster development activities in Porbandar cluster specific to mixed mineral processing 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