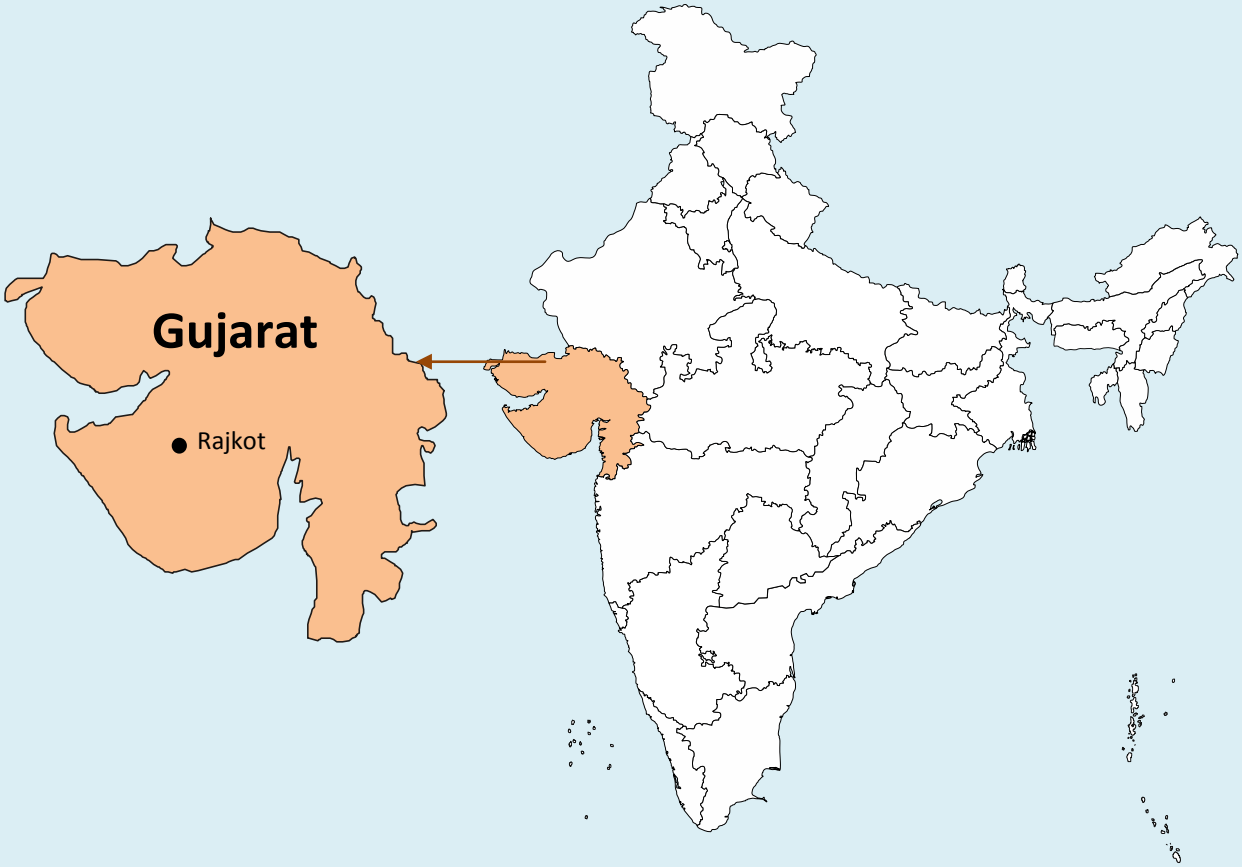
Cluster Profile
Rajkot aluminium foundries



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Certificate of originality

Original work of TERI done under the project "INDIA: TERI-SDC Partnership: Scaling up Energy Efficient Technologies in Small Enterprises (EESE)"

Suggested format for citation

TERI. 2016
Cluster Profile Report – Rajkot aluminium foundries
New Delhi: The Energy and Resources Institute 12 pp.
[Project Report No. 2014IE15]

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Published by

T E R I Press
The Energy and Resources Institute
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IHC Complex, Lodhi Road
New Delhi-110 003
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Acknowledgements

TERI places on record its sincere thanks to the Swiss Agency for Development and Cooperation (SDC) for supporting the long-term partnership project focusing on energy intensive MSME clusters in India.

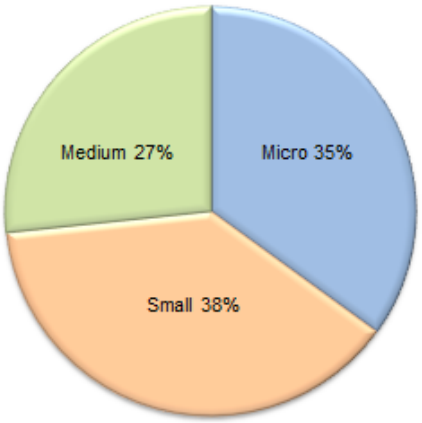
TERI team is indebted to Rajkot Engineering Association (REA), GIDC (Lodhika) Industrial Association (GLIA), AJI (GIDC) Industries Association and Shapar- Veraval Industrial Association for providing support and information related to Aluminium Foundry units in Rajkot. TERI also places on record the support provided by Mr Sri N H Kantesaria (Chief Manager, GLIA), Mr Bhavesh Patel, (President, REA), Mr Jyotishbhai Zalavadiya (Director, Venus Industries) and Mr Maulik Patel (Director, Shreeji Metals) for their support and cooperation in organizing field visits and interactions with entrepreneurs of aluminium sand castings, gravity die-castings and aluminium extrusions units. TERI extends its sincere thanks to Mr Jignesh Patel (Secretary, IIF-Secretary western region) and Mr Dilip Sarkar (Executive Secretary, REA) 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.

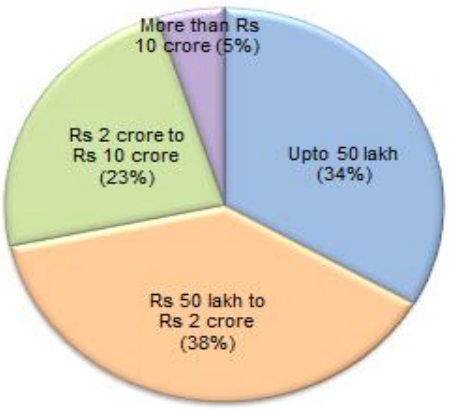
Rajkot aluminium foundries

Overview of cluster

Rajkot located in the state of Gujarat encompasses a prominent aluminium foundry cluster. There are about 60 aluminium foundry units located in industrial estates around the main city. These units are known for their ability to make superior precision components and cater to wide range of secondary production industries including investment casting dies, automobile, machinery and engineering, electrical equipment and others. The distribution of aluminium foundries based on size and annual turnover is shown in figure.



Size-wise distribution of aluminium foundries



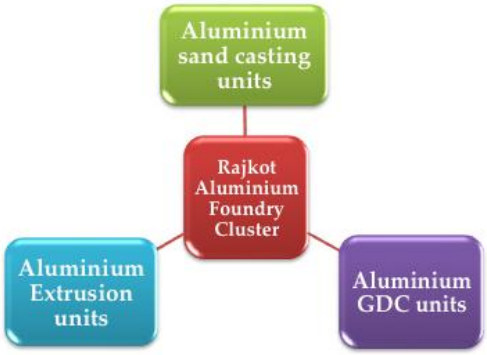
Distribution of aluminium foundries based on annual turnover

Aluminium casting and extrusion are allied processes for manufacturing aluminium components. The main advantages of aluminium components are higher weight reduction compared to steel and resistance to corrosion. The major raw materials used in the cluster include Aluminium scrap, LM2, LM6, LM9, LM13, LM25 graded ingots, commercial and non-graded aluminium.

The Rajkot aluminium foundry cluster mainly caters to the demands[1] of large 'Original Equipment Manufacturers' (OEM). For example, Atul Auto Ltd, Mahindra & Mahindra, Kirloskar Oil Engines Ltd, Godrej and aluminium extrusion products to various construction companies, etc. Aluminium foundry industries in the cluster provide employment to about 3,000 people directly and indirectly. The estimated total turnover of aluminium foundry industries is about than Rs 400 crore.

Product types and production capacities

The products manufactured in aluminium industries are used in different sectors like automobile, light and heavy machine tools, compressors, pistons of diesel engines, material handling equipment, dies and pattern for investment casting units, catering to both



Type of aluminium units in Rajkot cluster

[1] *http://www.aluminium-india.org/Newsstatistics.php*

OEM and replacement market, general engineering, civil constructions. Some of the primary products manufactured in the cluster are as follows:

- Sand castings units
- Gravity die casting (GDC)
- Extrusion products

These products can be grouped into three kinds of product manufacturers such as aluminium dies and pattern making, GDC and extrusion units. The products manufactured in these units are various types of dies and pattern used in investment castings, aluminium pistons used in diesel engines and extrusion products like window frame, tubing, aluminium tracks/ bus, and various sections used in construction hardware materials. The production of aluminium foundries is in the range of 1.5-32 tonne per month. The product-wise distribution of aluminium foundry industries in the cluster shows almost equal distribution of units in the cluster as shown in the figure.

Product-wise distribution of aluminium products

The production is recorded in terms of tonnes of aluminium castings and extrusion manufactured. The estimated production from the cluster is about 9670 tonne per year as shown in the table.

Production by Aluminium industries

Product category	Number of units	Production (tonne/year)
Aluminium sand casting units	21	790
Aluminium GDC units	19	2,628
Aluminium Extrusion units	20	6,252
Total	**60**	**9,670**

Source: Directory data of Rajkot Engineering Association, GIDC Lodhika Industrial Association, AJI (GIDC) Industries Association and Shapar-Veraval Industrial Association

Raw material usage in cluster

The Rajkot aluminium cluster[2] manufactures a variety of aluminium castings and extrusion components. The major raw materials used in the aluminium foundry units of Rajkot include commercial and non-graded aluminium scrap, half part, graded aluminium ingots of LM2, LM6, LM9, LM13, LM25. The cost of graded aluminium ingots are between Rs 1,28,000-1,31,700 per tonne and of commercial scrap between Rs 1,10,000-1,25,000 per tonne. Most of these raw materials are available either locally or obtained from other domestic markets. The sources of raw materials for the foundry units in the cluster include the following:

- National Aluminium company ltd. (Angul, Odisha)
- Bharat Aluminium company ltd. (Korba Chhattisgarh)

[2] http:/ / ibm.nic.in/ writereaddata/ files/ 05282015122910Aluminium%20&%20Alumina_2013.pdf
http:/ / www.balcoindia.com/ showfile.aspx?pageid=1

- Hindalco industries ltd. (Renukoot, U.P)
- Madras Aluminium company ltd (Mettur, Tamil nadu)
- Vedanta Aluminium Ltd (Jharsuguda, Odisha)

Raw material : Aluminium Scrap and Ingot

Energy scenario in the cluster

Electricity and diesel are the major sources of energy for the pump-set units. Electricity is supplied by Paschim Gujarat VIJ Company Ltd (PGVCL) and diesel is procured from local market. Electricity is used for running all machinery and diesel is used in DG-set in case of emergency during unscheduled power outage. The details of major energy sources and tariffs are shown in table.

Prices of major energy sources

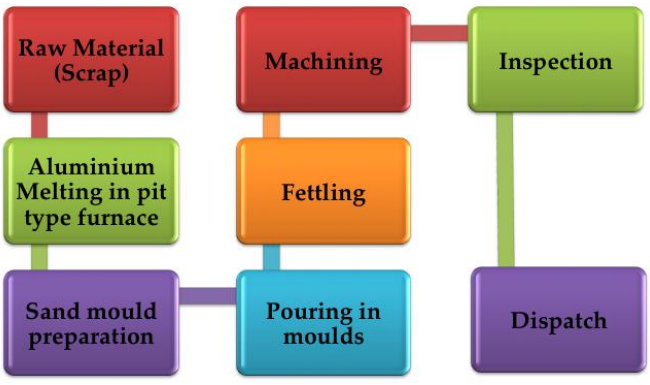
Source	Remarks	Price
Electricity	HT	Rs 8.00 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty)
	LT	Rs 9.00 per kWh (inclusive of energy, demand charges and electricity duty)
Diesel	From local market	Rs 55 per litre (price subjected to market fluctuations)
Coke	From local market	Rs 20 per kg (price subjected to market fluctuations)
LPG	BPCL/ HPCL	RSs 60 per kg (price subjected to market fluctuations)

Production process

The aluminium foundries mainly produce aluminium die and pattern making for the foundry industries, gravity die casting (GDC) products and aluminium extrusion products like window frames, etc. The processes followed are dependent on type of products - from melting or heating to moulding and extrusion. The production process for each aluminium foundry component in the cluster is mentioned below:

(i) Aluminium sand moulding units

Raw material in the form of scrap procured from local suppliers. Most of the micro scale units carry out melting in coke fired pit type furnaces of capacity ranging from 100-400 kg. Sand moulds are prepared simultaneously as per the design requirements. Aluminium melt at about 750 °C is poured into the moulds. Sand moulds are naturally cooled and



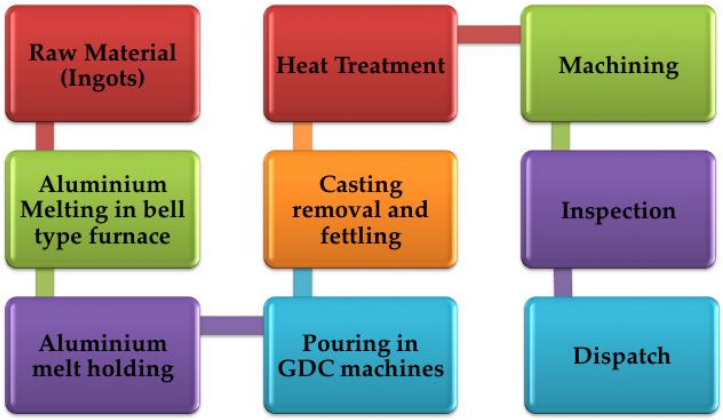
Sand moulding process flow

castings are sent for the fettling operation for removing extra parts and extensions by grinding. Machining is done as per specifications. After visual inspection, aluminium parts are dispatched.

Aluminium dies and patterns

(ii) Aluminium gravity die-casting units

Aluminium gravity die casting process is similar to the sand moulding process except that Gravity Die Casting (GDC) machines are used which are preloaded with pattern of the desired casting. Raw material in the form of ingots is melted in bell type electrical furnaces. The melt at about 700°C is transferred to holding furnaces. As GDC process takes relatively more time, holding furnaces are used to keep the melt at high temperatures.



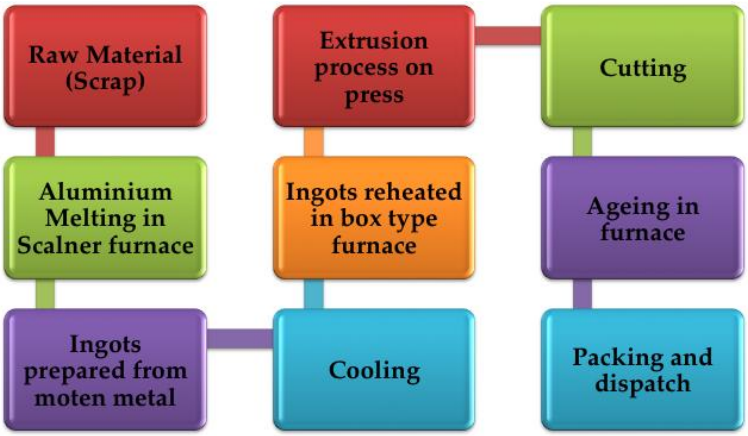
Gravity die-casting process flow

Castings are removed from GDC machines and then separated and basic finishing is done manually. Die release coating is applied on die for smooth release of dies from castings after removal of previous casting. Fettling operation is done to remove excess material and extensions and sent for heat treatment operation at 550 °C. Machining is carried out after heat treatment in the crucible type electrical furnace. After visual inspection, the products are sent for dispatch.

GDC products

(iii) Aluminium extrusion units

Aluminium extrusion units manufacture products like window frames, tracks, tubes and various construction parts. The raw material used is scrap, which is melted in scalener type furnace to make aluminium billets, which are cooled to atmospheric temperature. These billets are again reheated in box type billet reheating furnace at around 450-500 ºC to soften for extrusion process in extruder machines. Different types of dies are used for the extrusion operation as per the product specifications. In some case where thin aluminium tracks or frames are manufactured, ageing operation is carried out in LPG fired furnace. Finally products are packed and sent for dispatch.



Extrusion process flow

Extrusion products- Window frames

Technologies employed

The aluminium units still continue to use outdated technologies, which is a major challenge at cluster level. Presently, most of the units use coke fired / oil fired pit type furnace for melting whereas some units use electrical resistance bell type furnace for melting and holding the melt. Extrusion units use scalner furnace for melting and box type furnaces for reheating. These units use hydraulic presses for extrusions. A few units utilize heat treatment techniques which include hardening, tempering carried out in electrical resistance furnace. Some of the primary process technologies are explained below.

(i) Pit furnaces

Coke, Furnace oil, are commonly used as fuel in pit furnaces. The aluminium melting furnaces are used for heating raw materials such as aluminium ingots and scraps of various grades to 700 - 750 ºC. The capacities of these furnaces are in the range of 100-300 kg per batch. Aluminium ingots / scraps are heated either in batches or continuously. Pit type furnaces are inefficient and involvr high maintenance.

Pit furnaces (coke/ oil fired)

(ii) Electric furnaces

Electricity is used for melting billets or scrap in aluminium foundries and for heat treatment in electrical resistance type heating. The production capacities of electrical melting furnaces typically range between 100–500 kg per batch and connected load of furnace varies from 20–75 kW in GDC process holding furnace. The electrical resistance heating furnaces used for heat treatment typically have capacities from 200 to 600 kg per batch. The furnaces may be used in line with the melting furnaces, which operated at 700 ºC and maintain melt temperature. The rating of these furnaces varies from 15-60 kW with capacities of 100-500 kg per batch. Electrical bell type heat treatment furnaces are also used which are operated at 550 ºC for the cycle time of 9 hours with capacities of 300-700 kg. These furnaces have recirculating fans with electrical motors between 2 to 7.5 hp.

Electrical bell type melting and holding furnaces

(iii) Scalner and box type furnaces

Oil fired scalner furnaces are commonly used in scrap melting in aluminium extrusion industries. Scrap melting is done at around 750 ºC. Melted scrap is directly channelled into moulds in the shape of billets. The capacity of scalner furnaces ranges from 500- 2000 kg per batch. Box type billet reheating furnaces are operated in line with scalner furnaces where billets are reheated to 450 ºC to soften so that it can be extruded to required shape and size. These furnaces are prone to high surface heat losses and heat loss due to incomplete combustion and flue gasses.

Scalner melting furnace **Box type billet reheating furnace**

(iv) Extrusion machine

Extrusion machines are heart of the aluminium extrusion process. Extrusion for window frames, tracks, etc. of different shape and sizes can be done using different dies in extrusion machines. These machines are hydraulic operated. The load on the motor is variable depending on the weight and size of the product. Extrusion machines are continuously run for hours to produce long frames and tracks.

Extrusion machine

(v) Gravity die casting machines

Gravity die casting (GDC) is also referred as permanent mould which is a repeatable casting process used for aluminium castings. The heated die is coated with die release agent or dycote which is applied for smooth release of die from casting and cooling of mould face after removing previous die. Molten metal from holding furnace is manually poured into channels, which allows the melt to flow covering entire mould cavity. GDC machines are pneumatically operated and dies are changed according to the production requirement.

Gravity die casting machine

Energy consumption

Electricity, coke, furnace oil and LPG are the main sources of energy for most of the aluminium foundry units in Rajkot cluster. Almost all the units are dependent on electricity from grid to meet their energy needs. The average connected loads are dependent on type of products and installed capacity of the units. A majority of the units have LT connection. FO is used for heating for aluminium melting in pit type furnace as well as for scalner and box type furnaces. All GDC units use electrical resistance type furnaces for melting, holding and heat treatment processes. The power situation at cluster level is quite good and hence the dependency on DG sets is quite low.

(i) Unit level energy consumption

The specific energy consumption of aluminium extrusion industries is more than sand casting units. Most of the aluminium extrusion units use furnace oil (FO) as primary fuel for melting and heating in furnaces while some sand casting units use electricity for melting. Other major loads include extrusion machines which use hydraulic motors and are run continuously.

Energy consumption of typical aluminium industries

Type of industry	Thermal energy (toe/year/unit)	Electricity (kWh/year/unit)	Total energy (toe/year/unit)
Aluminium sand casting	9	5,393	10
Aluminium GDC	17	166,151	31
Aluminium extrusion	88	123,394	99

(ii) Cluster level energy consumption

The total energy consumption of the cluster is estimated to be 2775 toe per year. Furnace oil consumption accounts for about 64% of total energy consumption in the cluster. The details of energy consumption are provided in the table.

Details of energy consumption by aluminium foundries

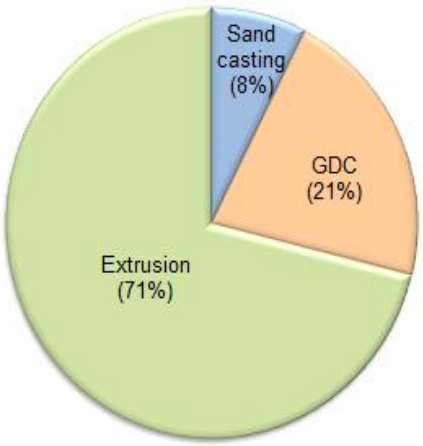
Type	Consumption	Equivalent energy (toe/yr)	Equivalent CO_2 emissions (tonne/yr)	Annual energy bill (million INR)
Electricity	5.7 million kWh	493	5,623	43
Coke	756 tonne	453	2,201	15
LPG	35.7 tonne	45	107	2
FO	1807.2kL	1784	5,212	36
	Total	2775	13,143	96

**Energy data collected from individual units in Rajkot*

The break-up of energy consumption of different types of industries is shown in the table. Close die aluminium extrusion units account for more than 70% of energy consumption in the cluster. It is followed by GDC units which account for about 21% of total energy consumption in the cluster.

Energy consumption of different types of aluminium foundries

Industry sector	Number of units	Energy consumption (toe/year)
Aluminium sand moulding	21	207
Aluminium GDC	19	594
Aluminium extrusion	20	1974
Total	**60**	**2775**



Energy consumption share by aluminium foundries

Energy saving opportunities and potential

Some of the major energy saving opportunities in aluminium foundry units in the cluster are discussed below.

(i) Electrical bell type furnaces for melting

Many of the aluminium sand casting units are presently operating pit type coke fired or oil fired furnaces, which are inefficient and require high maintenance. Electrical resistance heating bell type furnaces can be used in place of pit type furnaces, which will improve productivity along with ease of operation and efficient energy consumption. Bell type furnaces are flexible in operation and can be operated as per production load. Energy savings of 5-15% can be achieved with bell type electrical furnaces with cleaner production and no pollution.

(ii) Reheating furnaces

Scalner and box type furnaces are mainly used in case of aluminium extrusion units for melting and billet reheating purpose. These furnaces are prone to higher flue gas losses and surface heat losses. Normally furnace oil is used in reheating furnaces while some units use electrical heat treatment furnaces.

Recuperator for waste heat recovery from hot flue gasses of furnace

All aluminium extrusion units use oil fired scalner and box type furnaces. The exit flue gas temperatures of FO fired furnaces used in these units are in the range of 400-600 ºC. These furnaces do not have any heat recovery systems. The waste heat available in high temperature flue gases can be recovered in a metallic recuperator system to preheat combustion air which would result in an energy saving of 6-12%. FO savings of 5-15 litre per tonne can be achieved depending on flue gas temperatures. The investment for recuperator varies from Rs. 2-4 lakh with simple payback period of 8 months to 2 years depending on type of process and temperature.

Insulation for furnace

All reheating furnaces used are built with a refractory brick lining which are prone to heat losses upon continuous usage over the period which would result in fuel losses. There is a huge potential in using ceramic insulation in the box type furnaces, which would result in low fuel consumption during cold starts in the furnace along with less heat up time. Energy savings 4-6% can be achieved by improving furnace insulation. FO savings of 2 to 10 litre per hour can be saved depending on previous surface heat loss and type of refractory used and size of the furnace. Relining or repairing of the heat treatment furnace can be done with investment of Rs. 0.3-2.0 lakh depending on size of the furnace with a simple payback period of 5 months to 1.5 year.

Thyristor control for electrical melting, holding and heat treatment furnaces

Electrical furnaces are commonly used in GDC units for melting, holding and heat treatment processes. Electrical heat treatment furnaces used are of resistance heating type. Normally on-off control is used for controlling the heating cycle. In case of on-off control due to continuous switching, life of heating coil reduces due to thermal shocks and frequent failure occurs. Thyristor control can be used instead of on-off control, which can give around 7-15% energy savings and can increase coil life due to smooth switching with the precise temperature. Investment for thyristor control varies from Rs 0.20-1.5 lakh depending on requirements for electrical rating of heating coils with simple payback period of 3 months to one year.

(iii) Application of variable speed drives

Motor-driven systems often are oversized and inefficiently controlled. Variable speed drives (VSD) can provide a more cost effective method for reducing flow or pressure to match the process requirements. Energy savings in VSD applications usually range from 8-20%. Some of the potential applications of VSD in aluminium foundries are mentioned below. Investment required for VSD is around Rs 0.2-3.0 lakh depending on electrical rating of the motor with a simple payback period of 8 months to 2 years.

Extrusion machine

Each extrusion machine has one hydraulic motor. Load on this motor is variable depending on the size and weight of the extrusion product. As this machines runs continuously there is scope for significant energy and monetary savings using VSD drive which will run the motor at minimum load and hence minimum energy consumption. VSD will also provide soft starting to the motor avoiding jerks which increases life of the windings. Energy saving upto 15% can be achieved by implementing VSD in hydraulic motor of extrusion machines.

(iv) Compressed air

Energy savings of more than 10% can be realized through improving the supply and reducing demand in compressed air systems. Opportunities can be found in the supply side by installing new or optimizing existing equipment and reducing the system pressure. Demand can be reduced through improving end uses and repairing leaks. Blow-off nozzles can be upgraded to high-efficiency engineered nozzles or replaced with a low-pressure electric blower. Some of the potential areas of compressor system with specific option are mentioned below

Retrofitting air compressor with variable frequency drive

During normal operation, screw air compressor operated on unloading position for more than half the time. Installation of variable frequency drive (VFD) to such compressors will minimise the unload power consumption resulting in energy savings of 20-35%. Investments for VFD for air compressor range from Rs. 0.5-3.0 lakh depending on size of the compressor with a simple payback period of 6 months to 1.5 year.

Arresting the compressed air leakage

Compressed air is an expensive utility in a plant. However, in most cases, air leakages in piping system are quite high (more than 20%) and go unnoticed. The compressed air leakage can be reduced to about 5% with better operating practices. Plant can reduce significant energy consumption by controlling compressed air leakages with no or minimum investment.

Reduction in pressure setting of air compressor

The pressure setting of air compressors are often kept much higher than the actual air pressure requirement at the point of use in the plant. The typical unload and load pressure settings are 8.5 and 7.5 bar respectively. Reducing the compressed air pressure as per end-use requirements will result in high energy savings. Reduction of generation pressure by one bar can lead to energy saving of 4-6%.

(v) Replacement of rewound motors with energy efficient motors

Rewinding of motors would result in an efficiency drop of about 3-5%. It would be better to replace all old motors, which have undergone rewinding two times or more. The old rewound motors may be replaced with EE motors (IE3 efficiency class). This would result in an energy savings of 3-7% with simple payback period of 1.5 to 3 years on the investments done.

Extrusion machines with servomotors

Extrusion machines operate on a variable load condition and it varies with the type of product and its weight and dimensions. Servo motors based extrusion machines are the new technology which are being used in the industries for precise process control and achieve dimensional quality along with energy saving potential of 15-20%.

(vi) Lighting

Presently mercury vapor lamps (MVL) and halogen lamps of 150W, 250W and 400 W are generally used on shop floor. This lighting system has low lux levels with less life. Magnetic induction lamps of 100W, 150W and 200W can be installed in place of MVLs, which will give better illumination along with bright light with up to one lakh burning hours. T-12 tube lights (of 52W including choke) and halogen lamps (150W and 250W) are generally used by aluminium Foundries 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. The simple payback period for lighting is generally 2 to 3.5 years.

Major stakeholders

The primary stakeholders in the cluster are the manufacturing units based in Rajkot and the leading industry association of the region –Rajkot Engineering Association (REA), GIDC (Lodhika) Industrial Association (GLIA), AJI (GIDC) Industries Association and Shapar-Veraval Industrial Association. The other key stakeholders include Central Manufacturing Technology Institute (CMTI), National Small Industries Corporation (NSIC), District Industries Centre (DIC), MSME-DI (Rajkot), SIDBI, Indian Institute of Foundrymen, Rajkot chapter machinery supplier, etc.

Out of these stakeholders, REA is the most proactive in the region. It has about 1000 members drawing from all categories of industries in Rajkot. The association addresses the issues related to the welfare and grievance redressed of their member industries. Presently there are no individual industry associations for aluminium industries.

Cluster development activities

There are no specific cluster development activities related to aluminium foundries.

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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Swiss Agency for Development and Cooperation 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