Cluster Profile
Rajkot investment castings foundries

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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Rajkot investment castings foundries

Overview of cluster

Rajkot, in the state of Gujarat, is one of the largest clusters of MSMEs (micro, small and medium enterprises) in the country. Earlier Rajkot was known for diesel engines all over the world. It was exporting diesel engines to African and Gulf countries. Diesel engine manufacturing was at its peak during the 1980s and early 1990s. However, the industry was severely hit after the farmers switched to electric pumps after expansion of the grid. Therefore, the foundries that were catering to diesel engine manufacturers were diversified to other products like pumps, automobiles, electric motors and so on. The bearing industry also developed locally due to the demand for bearings in the diesel engine and pump-set industry.There are an estimated 14,000 MSME units in Rajkot cluster, of which around 5,500 are engineering units. The cluster is spread within Rajkot and neighboring Metoda and Shapar The engineering industry in the cluster is diverse in nature. Some of the major engineering segments include foundry, investment casting, pump-sets, forging, machine tools, auto components, building hardware, kitchenware, plastics and diesel engines generating sets, bearings, sheet metal, cables and wires, printing and packaging and food machinery.

Product types and production capacities

There are about 110 investment castings units in Rajkot cluster. These units are scattered both within and outside the city. Some of larger geographical concentration of investment casting units are; GIDC Lodhika (Metoda), Bhunava, Kuwadva, Aji, Hadamtala areas.

Based on their production levels, investment casting units can be categorised under A, B and C categories as follows:

Major concentrations of foundries in Rajkot

Category A: Average production level: 70 tonne per month
Category B: Average production level: 40 tonne per month
Category C: Average production level: 10 tonne per month

Majority of investment casting units in n Rajkot fall in Category B. Only about 10 units fall in Category A and about 25 units fall in Category C. The total production of investment castings in the cluster is about 160 tonnes per day (about 48,000 tonnes per annum). The industry employs nearly 10,000 direct employees. The estimated turnover of the investment casting units in the cluster is approximately Rs 1,000 crore per annum.

Most of the investment casting units in Rajkot manufactures parts for pumps, valves, automobile components, textile and other industries.

Energy scenario in the cluster

Electricity, natural gas, and diesel oil are the major sources of energy. The investment casting units produce ferrous (stainless steel and carbon steel) as well as non-ferrous (brass) components. The typical raw materials melted in the induction furnaces used by investment casting units include base metals (pig iron, returns, turnings etc.) and alloys (molybdenum, nickel and ferrochromium etc.). The details of major energy sources and their costs are shown below.

Details of major energy sources

Energy source	Remarks	Price
Natural gas	Supplied by GSPC	Rs 45 per SCM
LPG	Supplied by BPCL, IOCL	Rs 1,500 – 1,700 per 19.2 kg cylinder
Electricity	HT	Approx. Rs 8.00 per kWh (inclusive of demand charges)
	LT	Approx. Rs 9.00 per kWh (inclusive of demand charges)

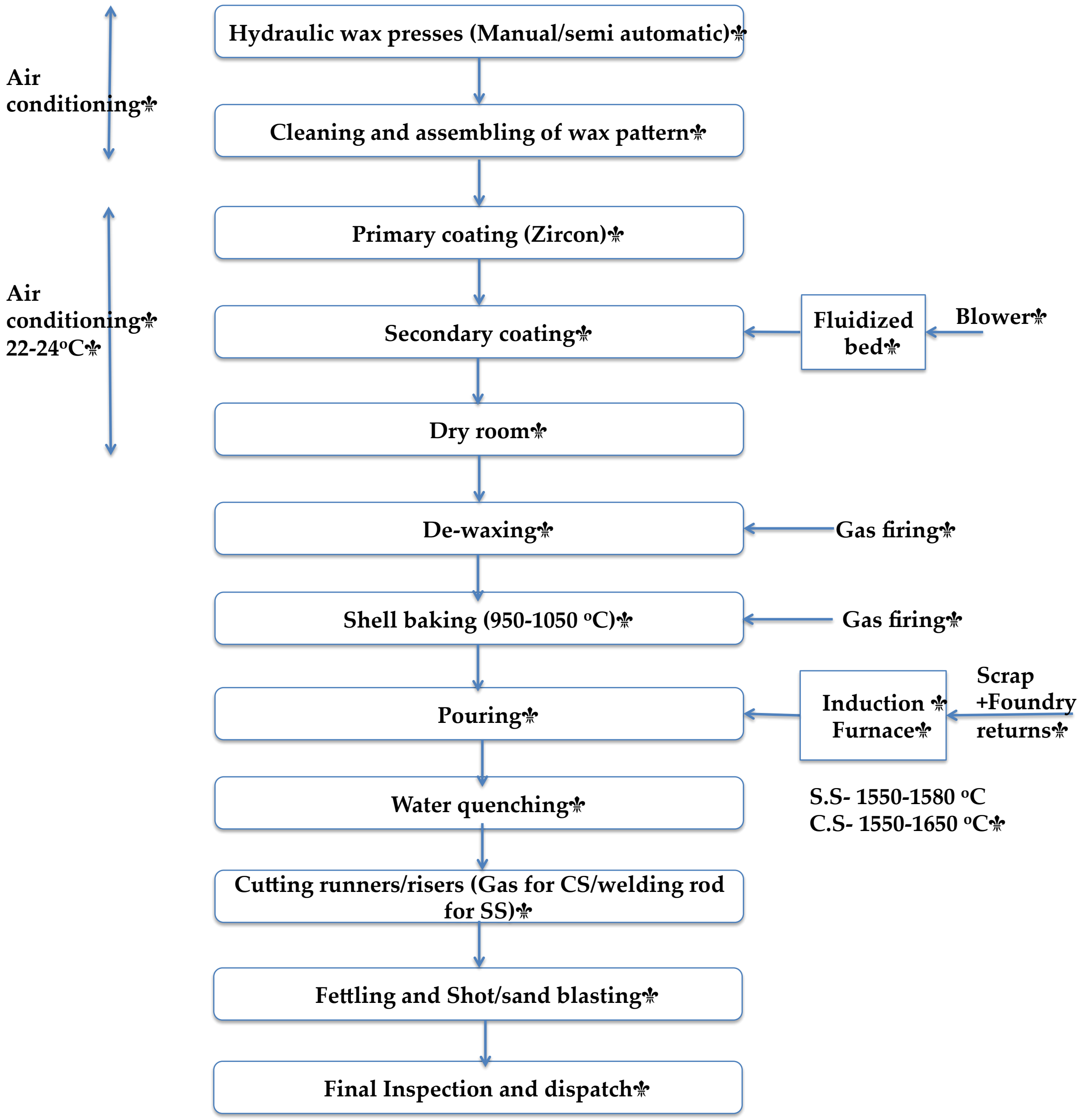
Production process

The investment casting units produce precision castings by lost wax method. The units use induction furnaces for melting. The other energy intensive processes/equipment in the plant are chillers (space cooling of cold rooms used to manufacture and store wax patterns), shell baking furnace (using oil/gas) and air compressors.

The major processes in production of investment casting are as follows.

- Press room
- Coating and drying rooms
- Dewaxing
- Shell baking
- Melting of metal and pouring in shells
- Knockout
- Fettling
- Shot blasting
- Heat treatment (if required)
- Testing

A process flow diagram of a typical foundry is given below.



Manufacturing process of investment casting

Technologies employed

Some of the energy-intensive processes/equipment used in investment casting are described below.

(i) Melting furnace

Melting of raw material is either done using electricity in an induction furnace. The size (crucible capacity) of induction furnaces in the cluster varies from 50 kg to 300 kg. However, the most common size of the furnace is 200 kg. On an average, induction furnaces melting consumes about 2,000 kWh per tonne of product although the just energy consumption of molten metal is 600–850 kWh per tonne. The specific energy consumption of the furnaces varies considerably depending on the type of metal melted (carbon steel, stainless steel or non-ferrous) and size of castings. The time taken to charge the raw materials into the furnace is considerably long in investment casting units (45 to 100 minutes). This is due to the fact that tapping is not done all at once into the ladle, rather divided into a number of times according to the state of preparation of the shell. This method of divisional tapping increases the energy consumption in melting as power is continually applied in order to maintain the temperature of molten metal in the furnace while the body of the furnace is inclined. From the perspective of energy consumption, operation involves much waste.

(ii) Preparation of wax pattern

Preparation of the wax patterns is an important process in investment casting industry. The molten wax is injected into moulds to get the desired shape using hydraulically operated presses. Subsequently cleaning and assembling of the wax pattern is done. The pressing, cleaning and assembling operations is conducted in air-conditioned spaces to ensure dimensional accuracy of the patterns. The wax patterns are then dipped in refractory slurry of zircon base. After drying, the patterns are re-coated. Usually about 8-12 coatings of the refractory material is applied to each pattern over a period of 72 hours. The coating and drying rooms for the wax patterns are also air-conditioned.

(iii) Air-conditioning

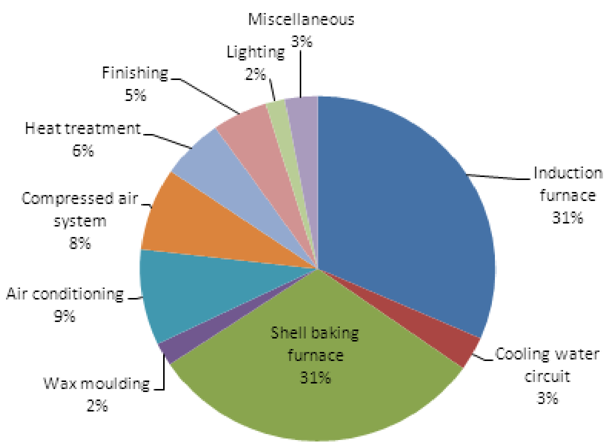
The wax patterns are stored in cold rooms which are maintained at a temperature of 22-24 C and relative humidity of 55±5 %. This, along with the the air-conditioning required in the wax press rooms, account for a significant share of the energy consumed in the manufacture of investment castings. A typical investment casting unit has 3-4 package chillers with a cooling capacity of about 50 TR.

(iv) Shell baking furnace

The wax is removed from the refractory shells by heating in oil-fired furnaces. Steam heated autoclaves are used by some units for de-waxing. The refractory shells are then heated to a high temperature (950-1000 C). After manually removing from the shells in red hot condition from the shell baking furnace, molten metal is poured into them to get the final shape of castings.

Energy consumption

Investment casting unit uses two main forms of energy: electricity and natural gas or light diesel oil. Shell baking and heat treatment are done using either PNG or LPG as energy source. Melting and shell baking account for major share of energy consumption (about 30% each). The other important energy consuming areas include air conditioning, air compressor and heat treatment. The share of energy usage in a typical small and medium foundry is given in figure.



Energy use in investment casting unit

(i) Unit level consumption

The specific energy consumption (SEC) varies considerable in an investment casting units depending on the type of shell baking furnace, fuel used and degree of mechanisation. On an average, units with PNG and LPG as fuel for shell baking consume about 0.55 and 0.72 toe per tonne of good castings respectively. Out of this, about 700–850 kWh is consumed per tonne of molten metal. The total energy consumption per ton of product is higher on account of relatively lower product yields (40-50%) achieved in investment casting. Energy consumption of some typical sizes of investment casting units is given in table below.

Typical energy consumption in investment casting units

Production – saleable castings (tonnes/year)	Electricity (kWh/yr)	PNG or LPG (toe/yr)	Total energy (toe/yr)	Annual energy bill (million INR)
100	4,00,000	25	60	4.6
500	19,00,000	100	264	19.0
900	31,50,000	180	451	32.0

(ii) Cluster level consumption

Typically 70% of investment casting units uses PNG for shell baking and heat treatment, remaining 30% units use LPG. The energy consumption pattern in the cluster is given below.

Energy consumption of the Rajkot investment casting cluster (2014-15)

Energy type	Annual consumption	Equivalent energy (toe)	Annual energy bill (million INR)
Electricity	184 million kWh	15,800	1,290
Thermal (Oil/gas)	2,610 tonnes LPG 8.9 million SCM	9,175	575
	Total	**24,975**	**1,865**

Energy-saving opportunities and potential

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

(i) Improvements in baking furnace energy efficiency

The refractory lining of shell baking furnace is typically damaged and the average surface temperature is in range of 90-110 oC. The higher surface temperature of the furnace leads to higher heat loss and thereby poor efficiency of the furnace. It is recommended to do relining of the furnace to avoid the surface heat loss due to high surface temperature. Implementation of this recommendation will cause reduction in specific energy consumption and will also improve the working atmosphere near the furnace due to reduce heat losses.

(ii) Waste Heat Recovery in shell baking furnace by installation of recuperator and energy efficient burner

The shell baking furnace is typically equipped with mono-block burners. The temperature of air at the inlet of burner is around 40oC which is very low and flue gas temperature is above 900 oC which is high. Efficiency can be improved drastically by installing a waste heat recovery (WHR), recuperator to utilize flue gas to pre-heat combustion air up to 250 oC.

(iii) Excess air optimization

The shell baking furnace is typically equipped with mono-block burners. The CO ppm and O_2 level in flue gas is often found unsatisfactory. By optimization of excess air by proper setting of damper at the suction of blowers of burners proper amount of excess air can be maintained for complete combustion of fuel (natural gas or LPG).

(iv) Replacement of inefficient induction furnace with efficient induction furnace

Older induction furnaces having higher SECs e.g. 750 kWh per tonne of molten metal or higher can be replaced with new EE induction furnaces. With new furnaces, an SEC level of about 600 kWh per tonne of molten metal can be achieved. The capital investment in the new furnace will have an attractive payback period of less than one year.

(v) Lid mechanism for induction furnace

Most of the induction furnaces do not have a lid which results in higher heat losses due to radiation and convection (about 4-6% of energy input). A lid mechanism helps in reducing these losses in an induction furnaces and the payback period for installation of lids is less than one year.

(vi) Retrofitting air compressor with variable frequency drive

During normal operation, an air compressor operated on unloading position for more than half the time. Installation of variable frequency drive (VFD) to the air compressor will minimise the unload power consumption. The investment for VFD is about Rs 2-3 lakh and has a simple payback period of about 2 years.

(vii) 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 (above 20%) and go unnoticed. The compressed air leakage can be brought down to about 5% with good housekeeping practices. The foundry can save a considerable amount of energy by controlling compressed air leakages with no investment.

(viii) Reduction in pressure setting of air compressor

The pressure setting of air compressors are often much higher than the actual air pressure requirement in the plant. The typical unload and load pressure settings are 7.5 and 6.5 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 6%.

(ix) Replacement of rewound motors with energy efficient motors

Rewinding of motors result in a drop in efficiency by 3-5%. It is better to replace all old motors which has 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.

(x) Replacement of inefficient pumps with energy efficient pumps

Very often the pumps used in cooling water circuit of an induction furnace are inefficient and selection is not done on technical basis. This results in higher power consumption. The inefficient pumps may be replaced with energy efficient pumps. The investments are paide back in a year or two.

(xi) Improvement in inspection system

The inspection for product is only carried out by visual and dimensional check, followed by shipping. Non-destructive inspection (color check, fluorescent penetrant inspection, x-ray penetrant inspection) is not carried out. Component testing of steel is load management, and destructive inspection of mechanical properties is dealt with as necessary on a case by case basis. It is speculated that in the future, along with intensification of competition and increased quality requirements, the company will be required to improve its inspection system.

Major stakeholders

There is a District Industries Centre (DIC) in Rajkot which comes under the Industries Commissionerate, Government of Gujarat. The office provides several incentives to MSMEs like the capital investment subsidy, interest subsidy, venture capital. quality certification, energy and water audits and so on. There is a branch office of the MSME Development Institute, Ahmedabad in Rajkot.

There are several industry associations related to the foundry industry in Rajkot. The major industry associations, related to foundry industry, are the following:

Rajkot Engineering Association (REA) is the apex industry association for engineering industry in Rajkot and has a membership of over 1600 industrial units. The association was incorporated in 1963 with an objective of extending help to its members for the promotion and development of its manufacturing activities. The association also supplies raw materials like pig iron to its members on 'no-profit-no-loss' basis. The association is centrally located in Bhaktinagar Industrial Area of Rajkot and has its own building and conference facilities. It regularly arranges meetings, seminars and workshops for its members. It publishes a monthly 'Information Bulletin' in Gujarati to communicate with its members on a regular basis.

The Institute of Indian Foundrymen (IIF), Rajkot chapter is active in promoting information exchange and networking among the foundry industries in the cluster. The chapter is under the Western Region. The chapter works closely with REA and is also located within the association premises.

GIDC (Lodhika) Industrial Association (GLIA) was established in 1996 by the industries located in GIDC (Lodhika) Estate. The estate was setup by Gujarat Industrial Development Corporation in 1990 and spread over 424 hectares. It has about 1000 industries, consisting of engineering, plastics, packaging, food-processing, building material, pharmaceutical, cold storage and so on. There are about 50 foundry units located in this estate.

Aji GIDC. Industries Association. Aji GIDC is one of the oldest industrial estate established around 40 years ago. The industrial estate covers an area of about 270 acres and has about 80 foundry units.

Shapar Veraval Industrial Association (SVIA). Shapar Veraval are has various types of industries ranging from investment castings, plastics and packaging, auto parts, engineering, bearings, brass parts, kitchenware and so on. There are almost 300 foundries located Shapar Veraval and surrounding areas.

Cluster development activities

The industry associations in the cluster have been primarily active in networking and outreach activities.

National Small Industries Corporation Ltd (NSIC) has a centre in Rajkot. The Centre was established several decades back and used to offer many courses However most of these courses have been discontinued and the facilities in the centre are being used sub-optimally. The centre mainly focuses on testing of materials and pump-sets and vendor registration services for SMEs. Vendor certification is mandatory for submitting quotation for DGS&D (Directorate General of Suppliers & Disposal) government rate contracts. A testing laboratory of CMTI (Central Manufacturing Technology Institute), Bangalore, has been established within the campus with assistance under the UNIDO a few years back.

A common facility centre (CFC) for testing of pump-sets and foundry materials is coming-up in Rajkot. The CFC was conceived by TERI and REA in 2010, in order to cater to the needs of local pump manufacturers who were facing difficulties obtaining BIS certification due to long delays in testing of their products. A Special Purpose Vehicle (SPV) named 'Rajkot Engineering, Testing and Research Centre' was formed with the partnership of local industry, state and central government; and land for the CFC was provided by REA. The CFC project, with a total cost of about Rs 7.2 crores, was approved in March 2014. Over Rs 74 lakhs was contributed by 62 local industries; Rs 3.82 crores by the central government towards testing equipment; and Rs 2.45 crores by the state government towards the building.

Common facility centre at Rajkot

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