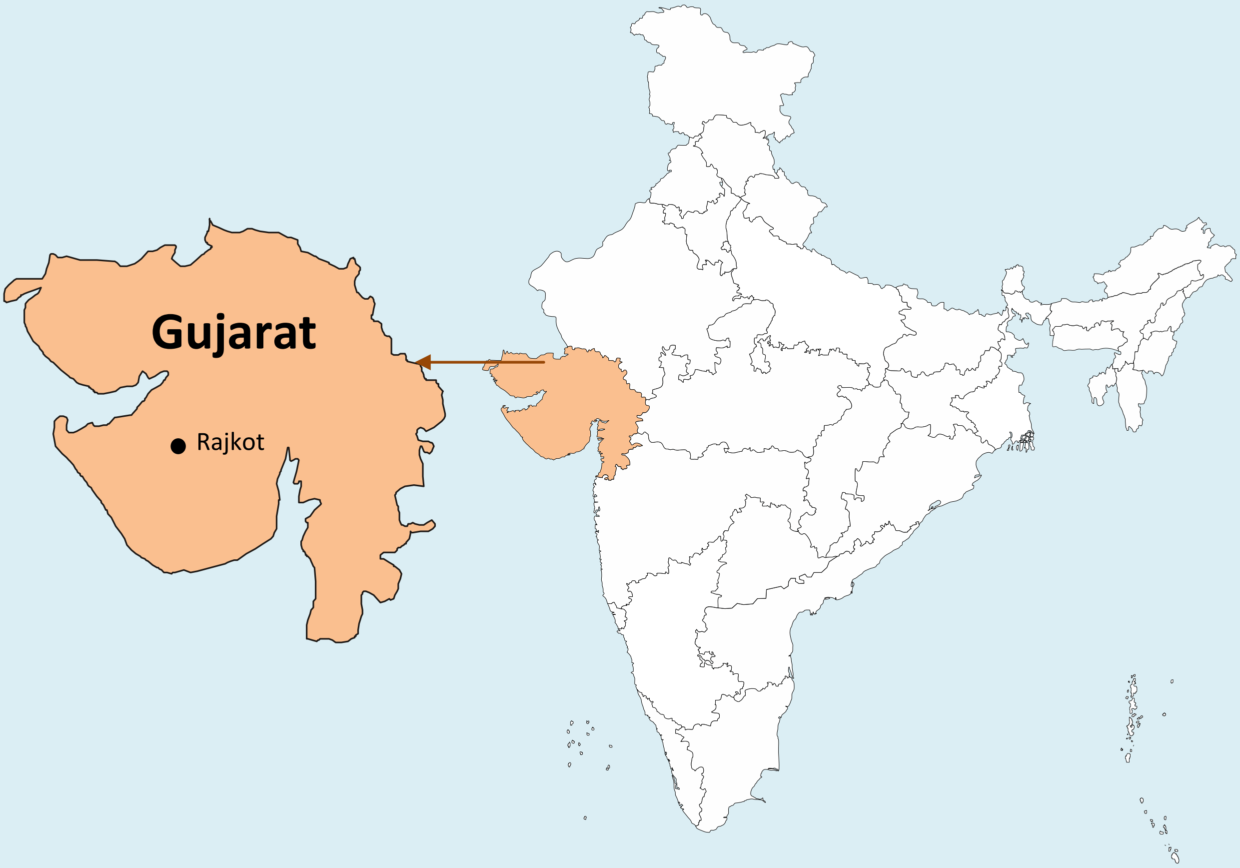
Cluster Profile
Rajkot forging industries



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Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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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 forging units in Rajkot. TERI also places on record the support provided by Mr N H Kantesaria (Chief Manager, GLIA), Mr Bhavesh Patel (President, REA) and Mr Pinakin Madeka (Director, Rolex Rolled Rings), Mr Subodh Prasad Ray (Manager, Rolex Rolled Rings), Mr Paresh Ghodasara (Director, Shradha Forge Pvt. Ltd), Mr Pramod Bhanvadia (Managing Director, Microtech Rollers Pvt. Ltd) and Mr Mehul Makwana (Director, Synergy Forge Pvt. Ltd) for their support and cooperation in organizing field visits and interactions with closed die forge and ring rolled forging manufacturing unit entrepreneurs during the study. TERI extends its sincere thanks to Mr Jignesh Patel (Secretary, IIF-Western region) and Mr Dilip Sarkar (Executive Secretary, REA) for facilitating field visits.

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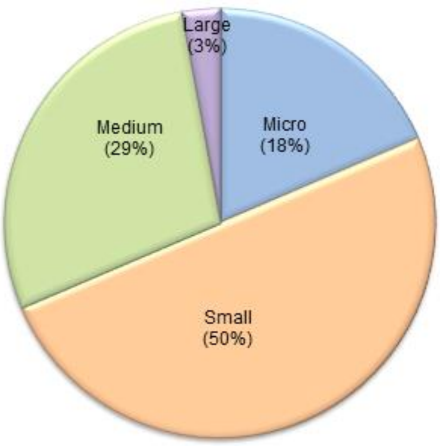
Rajkot forging industries

Overview of cluster

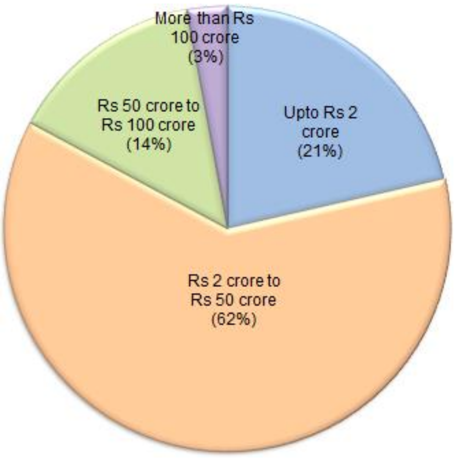
The Indian forging and heat treatment industry is a major contributor to the manufacturing sector of the Indian economy. Rajkot, located in Gujarat state houses a prominent cluster of about 140 forging units located in industrial estates around the city. The forging units in Rajkot cluster are principally known for their ability to make superior precision components and cater to wide range of secondary production industries including automobile, machinery and engineering, electrical equipment and others.

Heat treatment is an allied process for treatment of forging and machined components. Some forging units have in-house heat treatment facilities, while others undertake heat treatment from external heat treatment units. The total production from the Indian forging industry during 2015–16 was about 2.45 million tonne. The major raw materials used in the Rajkot forging units include carbon steel and alloy steel. The products after forging are heat treated and machined for use in various types of automobile and engineering products.

The Rajkot forging cluster mainly caters to the demands of large Original Equipment Manufacturers (OEM) like Tata Motors, Mahindra & Mahindra, L&T, Force Motors, Bajaj Auto, General Motors, Godrej and Ashok Leyland etc. Forging industries in Rajkot provides employment to about 15000 people directly or indirectly. The estimated total turnover of forging industries in Rajkot is more than Rs 4000 crores. The distribution of forging units based on category and annual turnover is shown in the figure.



Distribution of forging industries based on category



Distribution of forging industries based on annual turnover

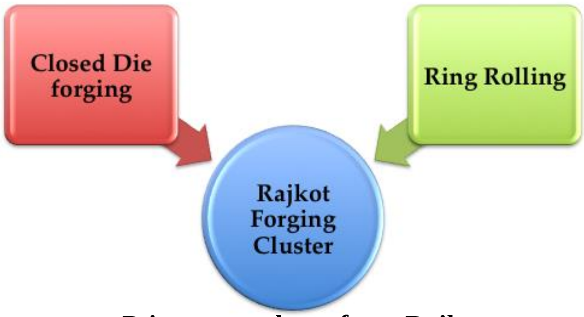
Product types and production capacities

The products from the Rajkot forging cluster are used mainly in different sectors automobiles, light and heavy machine tools, compressors, stationary diesel engines, earth moving equipments, material handling equipment, catering to both OEM and replacement market, general engineering. Followings are some of the primary products that are manufactured in Rajkot cluster:

- Closed die forging products

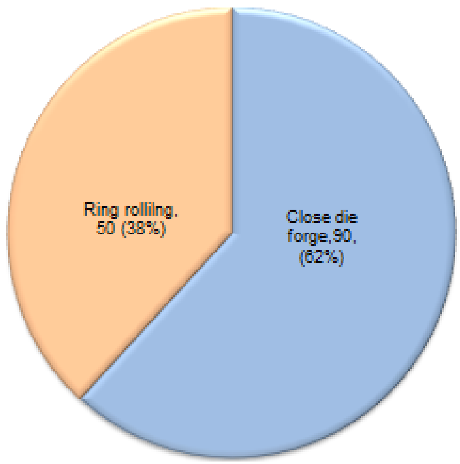
- Ring rolling forging products

These products can be grouped into two kinds of product manufacturers such as closed die forging and ring rolling units. The products forged in Rajkot are of various types. These include propeller shaft, front axle, upper pin, crown wheels, gears, shafts, connecting rods, forks, camshafts, bearing races and wheel hubs. These products are custom made and used mainly in the automotive sector.



Primary products from Rajkot

The production by the forging units under MSME category is in the range of 25 to 3000 tonnes per month. The product-wise distribution of forging industries in the cluster shows that close die forged products account for about 62% of forged products. The production and installed capacity of the similar industries in the cluster varies from unit to unit; the production of a unit also varies during the year. The production is recorded generally in terms of tonnes of forging manufactured of a particular type of product. Based on the interactions with stakeholders in the cluster, the total estimated production at cluster level is 434,211 tonne per year as shown in the table.



Distribution of forging industries based products

Annual production by forging industries

Product category	Number of units	Production (tonne/year)
Closed die forging	90	268,548
Ring rolling	50	165,663
Total	140	434,211

Source: *Collective 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 forging cluster produces a variety of materials. The major raw materials used in the forging units include mild steel, carbon steel, alloy steel, stainless steel, aluminium, super alloy and special steel. Different stainless steel grades used by the units are ASTM/ ASME SA 182 F, 304, 304L, 304H, 309H, 310H, 316, 316H, 316L, 316 LN, 317, 317L, 321, 321H, 347, 347H. Most of these raw materials are produced locally or obtained from other domestic markets. Long bars and billets are used as raw materials in forging industries. The main sources of raw materials of forging products are Jindal Steel Works Ltd and Bhushan Steel Ltd.

Raw materials used in forging industries

Energy scenario in the cluster

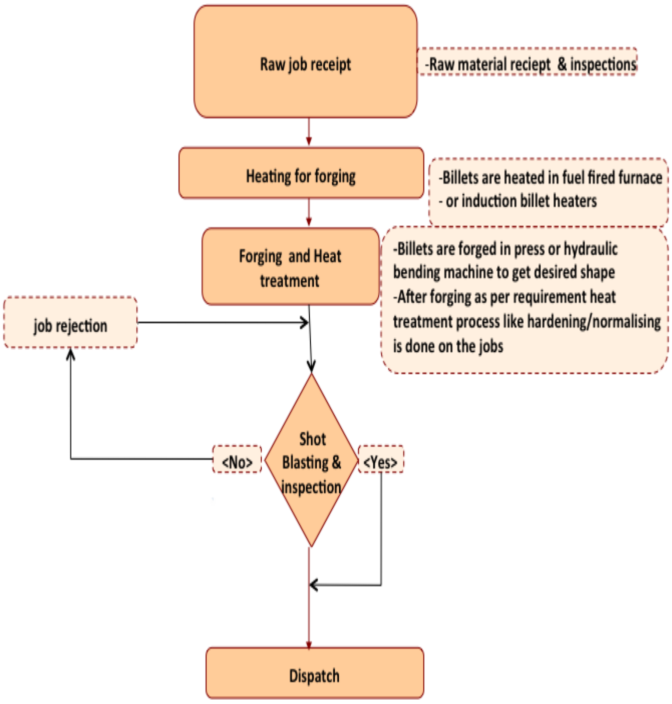
Electricity and diesel are the major sources of energy for the forging units. Electricity is supplied by Paschim Gujarat VIJ Company Ltd (PGVCL) and diesel is procured from local market. Electricity is used for running all machinery and diesel is used in DG-set in case of emergency during unscheduled 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)
FO	From local market	Rs 25 per litre (price subjected to market fluctuations)
NG	GSPC	Rs 34 per scm (price subjected to market fluctuations)
LDO	From local market	Rs 30 per litre (price subjected to market fluctuations)
Briquettes	From local market	Rs 5.5 per kg (price subjected to market fluctuations)

Production process

The forging industries in Rajkot cluster majorly produce closed die forging and ring rolling products. The major steps involved in forging include cutting of steel rods in the form of billets, heating of billets in the furnace and forging in presses. The forged components are trimmed and sent for heat treatment. The generic production steps of forging products are shown in figure. The generic process steps followed by the unit are briefed below:



Raw material procurement and quality inspection: The raw material (steel bar) is received from major steel suppliers or procured directly. The quality of raw material steel is inspected with spectrometric and microscope testing facilities either within the plant or from outside testing facilities for proper grade and quality of steel.

Raw material cutting: Raw material is cut in bandsaw machine and shearing machine in the form of billets as per weight required for forged job in desired length.

Raw material heating and forging: The billets are heated in furnace oil (FO) of natural gas (NG) fired furnaces or in induction billet heater upto about 1200–1270 °C as per forging temperature requirements of different grades of steel. The heated billets are removed from the furnace and placed in hammer for forging. The heated billet is forged into desired shape in one or number of strokes at the hammer.

Trimming and coining: Trimming/ coining presses are used for removing extra material on the forged job. Trimming is done in one stroke in the trimming press.

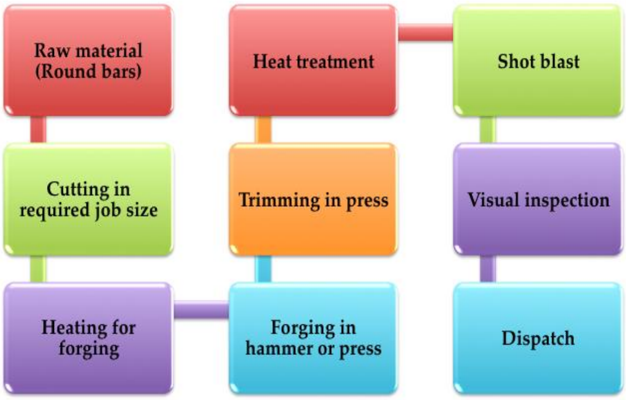
Heat treatment: After trimming/ coining operation, depending on the job requirement heat treatment is done on the forged job in hardening furnace or tempering furnace.

Inspection and despatch: Final inspection of jobs are done for quality and dimensional accuracy and sent to the machining shop or despatch.

The production process for each Forging component in the cluster is mentioned below:

(i) Closed die forging process

The metal is pressed between two dies (tooling) that contain a pre-cut profile based on specifications of the product. A temperature of about 1,250 °C is maintained for forging operation. In closed die forging, metals weighing between a few kilograms to about 25 tonnes are forged. The forgings are generally produced on hydraulic presses, mechanical presses, and hammers. Using impression die forging process, products with complex shapes and closer tolerances can be produced. Metals and alloys that can be forged through the impression-die process includes carbon and alloy steels, tool steels, and stainless, aluminium, and copper alloys, and certain titanium alloys.

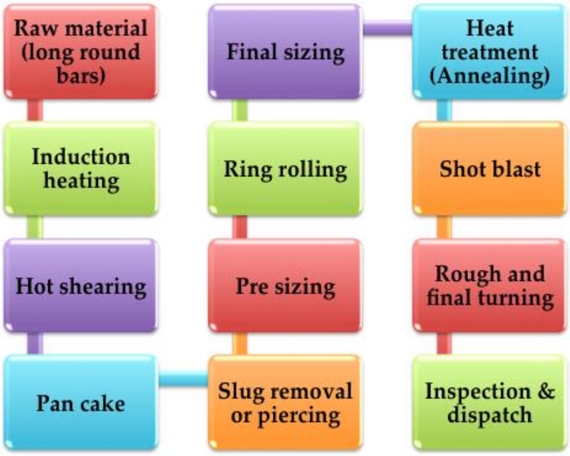


Production process in closed die forging

Production process in closed die forging

(ii) Ring rolling forging process

Long bars are used as a raw material for ring rolling forging. Induction heating furnaces using long bars are operated in line with ring rolling machine or high speed hot forming machine. Heated long bars are cut in required size and pressed into pancake shape. Piercing operation is done and pre-sizing is carried out before ring rolling operation. Ring rolling is done in either typical ring rolling machine or high speed hot former machine where multiple pieces can be processed simultaneously to enhance production. After final sizing in press, the components are shifted to annealing furnaces (electrical/ FO/ gas fired) for further heat treatment. Shot blasting is done to achieve desired surface finish followed by rough and final turning in lathe machines. Finally visual inspection is done and components are sent for final dispatch.



Production process in ring rolling forging

Ring rolled components

Technologies employed

The use of outdated technologies is a major challenge in the cluster. Presently, most of the units use belt drop hammers for forging and few units use forging presses for precision. Bandsaw used for cutting raw material may be replaced by shearing machines for productivity improvement. Heat treatment techniques include annealing, normalizing, case hardening, precipitation strengthening, carburizing, nitriding, tempering, quenching, and induction hardening. Mostly, heat treatment units use pit type furnaces and pusher type furnaces. Some of the primary process technologies are explained below.

(i) Oil fired and gas fired furnaces

Different designs of furnaces used include box and pusher types. Furnace oil, LDO, natural gas, and LPG are commonly used as fuel in the furnaces. The forging furnaces are used for heating of raw material (billets of various grades of steel) to 1150 –1200 °C. The capacities of these furnaces are in the range of 50-400 kg per hr. Billets are heated either in batches or continuously. Heat treatment furnaces are used for normalizing, annealing, hardening, tempering, and carburizing of forged and machined components as per requirements of the specific jobs. The temperatures in the furnaces vary widely depending on the treatment and ranges between 250-930 °C. The oil consumption in the forging furnaces typically ranges between 100–200 litre per tonne, and for heat treatment furnaces, the consumption is about 60–80 litre per tonne. NG consumption typically ranges between 100–150 scm per tonne and for heat treatment furnaces, it is about 50–80 scm per tonne. Blowers with electrical motors of 3 to 7.5 hp are used in furnaces for providing the combustion air for fuel.

Box type forging furnace

(ii) Electric furnaces

Electrical energy is also used for heating billets for forging and heat treatment. The production capacities of electrical induction furnaces typically range between 100–500 kg per hr with a connected load of 100–1000 kW. The 'specific energy consumption' (SEC) of electrical induction furnaces varies in the range of 450–500 kWh per tonne. The electrical resistive heating furnaces are used for heat treatment operations with capacities ranging from 200-600 kg per batch. The furnaces may be batch (pit type) or continuous (pusher type). The rating of these furnaces varies from 15-120 kW. The furnaces have recirculating air fans with electrical motors between 3 to 7.5 hp.

Induction billet heater

Bell type electrical heat treatment furnace

(iii) Closed die hammers of belt drop type

These hammers are used for forging of hot billets into various shapes for shafts, flanges, gear blanks, pipe fittings, rollers, hubs, and so on. The capacity of the forging hammers typically range between 0.5 to 3 tonnes. Electric motors of 30 to 100 hp are used for driving the hammers. Forging capacity, depending on the number of hammers and their capacities, varies from 300 to 3,500 tpa.

Closed die hammer forging

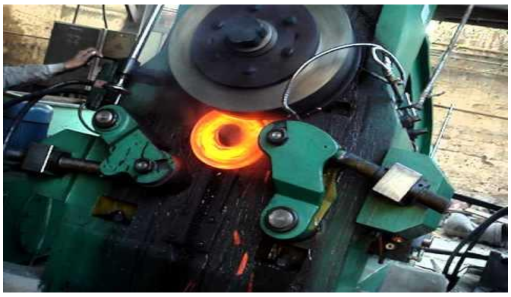
Screw press

(iv) Screw press

The capacity of screw presses is in the range of 100 to 1,500 tonnes. Electric motors used for driving these presses range between 30 to 150 hp. Screw presses with electrical motors of 5 to 30 hp are used for trimming and coining operations. These presses are operated with pneumatic clutch and brake and screw is used for adjusting the height of stroke length. It is used mostly with shaft end heating jobs.

(v) Ring rolling machines

Ring rolling machines are quipped to process one job at a time and are used by most of the ring rolling units. These machines can be effectively used for large diameter products. Although use of ring rolling machines would help in higher quality of products, the processing rates are quite low.




Ring rolling operation

Energy consumption

Electricity, furnace oil and natural gas provide the main source of energy for most of the forging units in the Rajkot cluster. Almost all the units are dependent on grid electricity to meet their energy needs. The average connected load per unit is dependent on type of products and installed capacity of the unit. A majority of the units have HT connection. The other forms of energy use in the cluster include furnace oil and natural gas. FO is used for heating for forging as well as heat treatment processes. NG is also used in some heat treatment furnaces. Most of the ring rolling units uses electrical resistance type furnaces for heat treatment process. The power situation is quite good in Rajkot and hence the dependence on DG set is very low.

(i) Unit level consumption

Energy intensity in large scale units is high as compared to micro, small and medium scaled units. The energy consumption of forging units varies from 61 toe per year to 10,178 toe per year. The annual energy consumption of ring rolling units varies from 161 toe to 2,641 toe. Also almost all of the forging units are using FO along with the electricity for heating purpose while ring rolling units are mostly using electrical induction furnaces for heating.

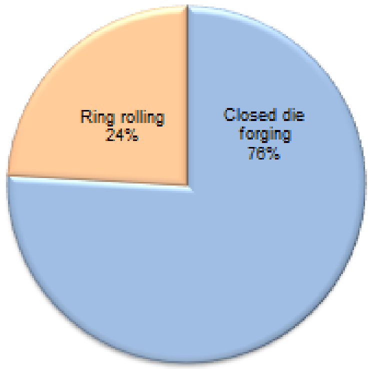
Energy consumption of typical forging and ring rolling units

Category	Thermal energy (toe/year/unit)	Electricity (kWh/year/unit)	Total energy (toe/year/unit)
Forging			
Micro	61	916	61
Small	262	16,489	264
Medium	542	24,108	544
Large	8782	16,240,200	10,178
Ring rolling			
Micro	160	10,800	161
Small	69	29,679	71
Medium	372	480,483	413
Large	212	39,873,150	3,641

Source: Energy data collected from representative units in the cluster

(ii) Cluster level consumption

The cluster level energy consumption of Rajkot forging cluster is estimated to be 62,365 toe per year. The share of different fuels shows that furnace oil, electricity and natural gas account for a share of 40%, 36% and 22% respectively.



Share of energy consumption

Annual energy consumption of forging industries in Rajkot cluster

Energy type	Annual consumption	Equivalent energy (toe)	Equivalent CO_2 emissions (tonne/yr)	Annual energy bill (million INR)
Electricity	262.8 million kWh	22,597	257,498	1874
NG	16.1 million SCM	13,660	28,131	547
FO	25,163 kilo litre	24,836	72,568	629
LDO	360 kilo litre	331	986	10.8
Briquette	2476 tonne	941	0	14
	Total	62,365	359,184	3074

Closed die forging units account for about 76% of energy consumption in the cluster.The break-up of estimated energy consumption of different types of forging units is shown in the table.

Energy consumption of forging units in Rajkot cluster

Type of unit	Energy consumption (toe/year)
Closed die forging	47,342
Ring rolling	15,024
Total	62,365

Energy saving opportunities and potential

Some of the major energy saving options in Rajkot forging units are summarised below.

(i) Induction billet heater

Induction billet heater in forging is a revolutionary new age technology having potential of 30-70% energy and monetary savings as compared to oil fired heating for forging. Induction technology is flexible in operation with reduction in scale losses, which leads to material savings. It also avoids other hassles of storage of oil, piping arrangements etc. Due to very low level of surface heat losses, it provides better working conditions as compared to fuel fired furnaces. The specific energy consumption (SEC) for FO fired furnace can be brought down from 0.15 toe/ tonne (150 litre/ tonne) to 0.04 toe/ tonne (450 kWh/ tonne) using induction billet heater. The investment for induction billet heater ranges from Rs 15-50 lakh depending on size with simple payback period of 1 to 3 years.

Induction billet heater

(ii) Reheating furnaces

Box type furnaces are mainly used in case of closed die forging. Cut billets are heated in reheating furnaces and manually transferred to hammer for forging operation. These furnaces are prone to high flue gas losses and surface heat losses. Normally furnace oil is fuel used in box type forging furnaces while NG is used in heat treatment furnaces. Some units are operating electrical heat treatment furnaces.

Recuperator for waste heat recovery from hot flue gasses of furnace

Many of the forging units use oil fired or gas fired forging and heat treatment furnaces. The exit flue gas temperatures of FO/ NG fired furnaces are in the range of 450-700 ^{o}C. These furnaces have not been equipped with any heat recovery system. The waste heat available with high temperature flue gases can be recovered using a metallic recuperator which can preheat incoming combustion air. The envisaged energy saving with WHR system is 8-15%. Natural gas savings of 15-30 SCM per tonne can be achieved depending on the flue gas temperature. The investment for recuperator varies from Rs 2-4 lakh with a simple payback period of 8 months to 2 years.

Insulation for furnace

Forging and heat treatment furnaces used are mostly built with a refractory brick lining which are prone heat losses after a continuous usage over the period and results in fuel loss. There is a huge potential in using ceramic insulations in the box type furnaces, which enables less fuel consumption in cold start in the furnace along with less heat up time. Energy savings of 4-6% can be achieved by improving insulation of the furnace. An NG saving of 5 to 15 SCM per hour can be saved depending on quantum of surface heat losses, type of refractory used and size of the furnace. Relining or repairing of heat treatment furnaces can be carried out with an investment of Rs 0.30-2 lakh depending on size of the furnace with simple payback period of 5 months to 1.5 years.

Thyristor control for electrical heat treatment furnaces

Electrical heat treatment furnaces used in the cluster are of resistance heating type. Normally on-off control is used for controlling the heating cycle. In 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 total electrical rating of heating coils with a simple payback period of 3 months to 1 year.

(iii) High speed hot former machine for ring rolling

This new age technology has been adopted by few ring rolling units in which multiple number of ring rolling components are forged at a time with high velocity and precision. The conventional ring rolling machines have an output of 10 pieces per minute are formed whereas high speed former machines have an output of 120-180 pieces per minute with near net job sizes. These are very sophisticated machines operated in line with induction long bar heaters for fast production. These machines increase productivity with assured component quality along with significant energy saving potential.

Hi-speed hot former machine for ring rolling

(iv) Application of variable speed drives in press motors

Motor driven systems often are oversized and inefficiently controlled. Variable Speed Drives (VSDs) can provide a more cost effective method for reducing flow or pressure by varying the speed of the connected load to match the process requirements. Energy savings in VSD applications usually range from 8-20%. The investment required for VSD is around Rs. 0.20-3 lakh depending on electrical rating of the motor with simple payback period of 8 months to 2 years. One of the potential applications of VSDs in forging industry is press motors. Mechanical and hydraulic presses are generally used in forging industries. Presses go under variable load depending on job size and operation to be performed. Jerk load operations are frequent in presses and this can be improved by using VSDs. The VSD can reduce overall power consumption along with soft starting of the motors which will improve life of motors.

(v) Compressed air

Energy savings of more than 40% 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 minimize the unload power consumption resulting in energy savings of 20-35%. The investment for VFD for air compressor ranges from Rs 0.50-3 lakh depending on size of the compressor with payback period of 6 months to 1.5 years.

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. The 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 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 6%.

(vi) Replacement of rewound motors with energy efficient motors

"Rewinding" of motors results in a drop in efficiency of about 3-5%. It is a 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 results into energy savings of 3 to 7% with simple payback period of 1.5 to 3 years on the investments done.

(vii) 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 1lakh burning hours life. T-12 tube lights (of 52W including choke) and halogen lamps (150W and 250W) are generally used by Forging 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. The simple payback period for lighting is about 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 forging industries.

Cluster development activities

There are no on-going activities in forging industries 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.

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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