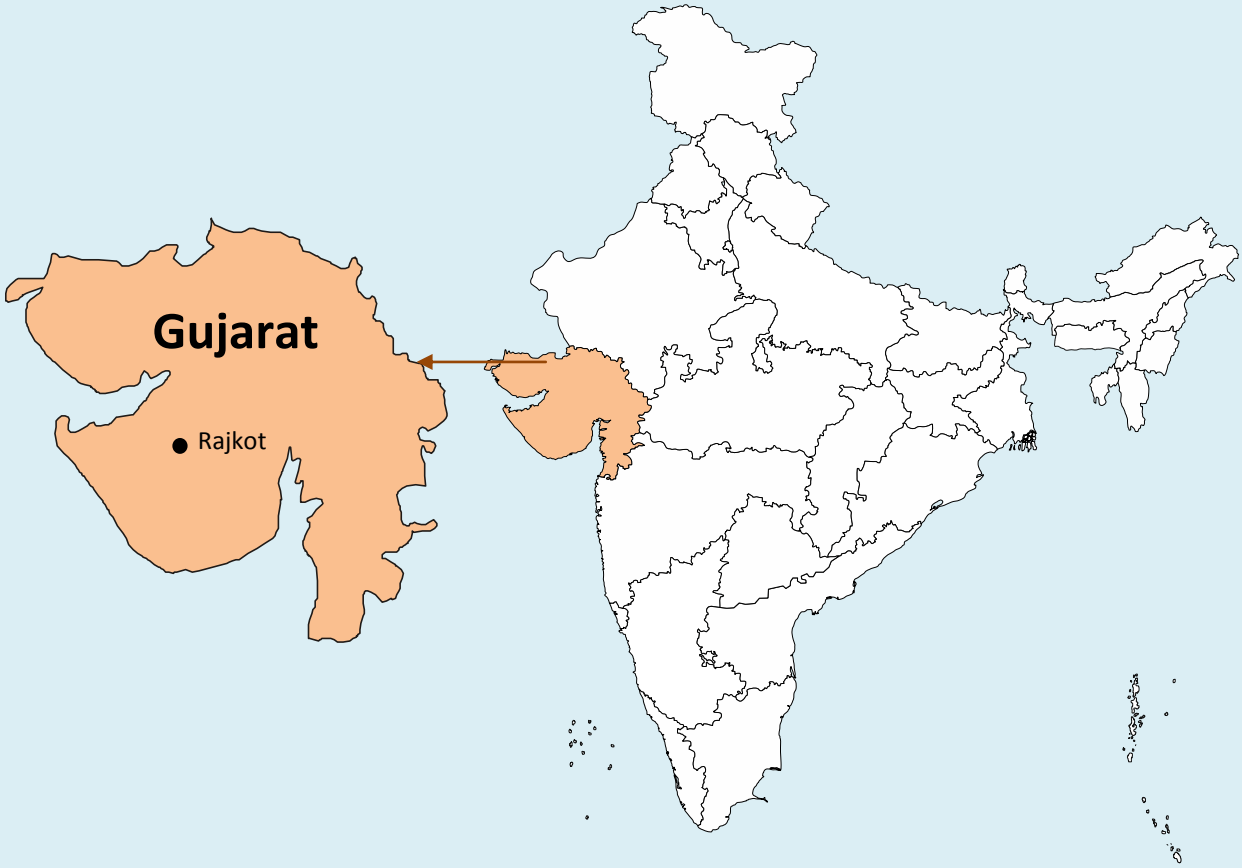
Cluster profile
Rajkot bearing industries



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Rajkot bearing industries

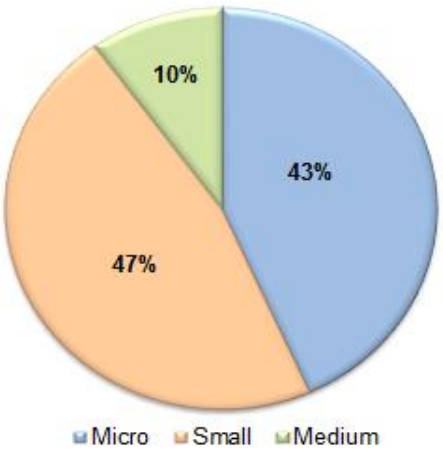
Overview of cluster

Rajkot is one of the prominent bearing clusters in the country. Rajkot is largely known as an industrial hub situated in Saurashtra region of Gujarat state. The Rajkot district located in south-west region of Gujarat state has more than 23,000 industries spreading over an area of around 25 square kilometres in 15 different industrial estates.

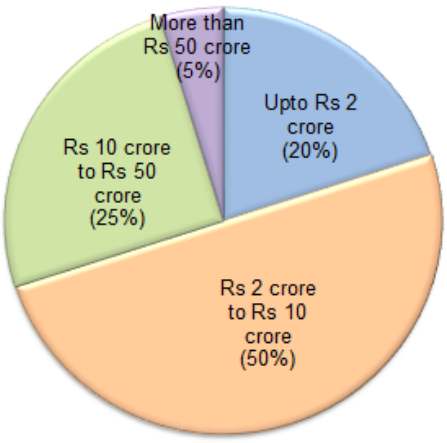
The manufacturing activities are concentrated in three main industrial estates – Aji, Metoda and Shapar. The current trend of industrial growth is towards engineering and auto ancillaries. The district has various manufacturing units for machine tools, industrial equipments, lathe machines, metallurgical industries, electronics, engineering and auto ancillary sector. The small and medium industries are dominated by foundries, bearings, engineering & automobile works, textile related units, gold & silver jewellery, handicrafts, spices, medicines, and wall clocks.

The Indian bearing industry is estimated at Rs 100 billion. The domestic industry caters to the 74% of total demand for common varieties and sizes. The organized sector units contribute[1] around 53% of the industry sales. The imports are about 26% of the total demand of the industry. The bearing industries in Rajkot generate around 15,000 direct or indirect employment. A majority of them is associated with bearing assembly units, roller and cage manufacturing industries.

There are about 150 bearing industries operating in the cluster. Most of these industries are registered under micro, small and medium categories. Majority of the units are either small or micro type. The total turnover of bearing industries in Rajkot is estimated to be around Rs 1500 crores with the annual turnover of majority of industries in the cluster (50%) are around Rs 2-10 crores. The distribution of the bearing industries based on type and annual turnover are shown in the figures.



Distribution of bearing units as per category



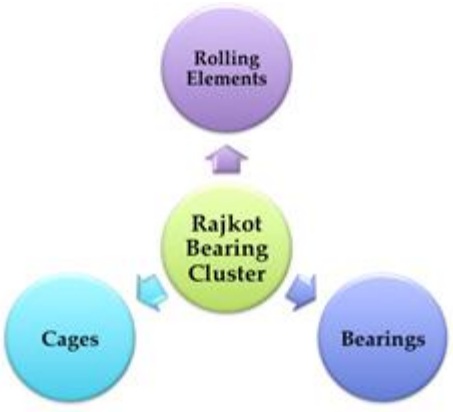
Distribution of bearing units based on annual turnover

[1] *Source: Technology study report on bearing industries, MSME DI, Government of India*

Product types and production capacities

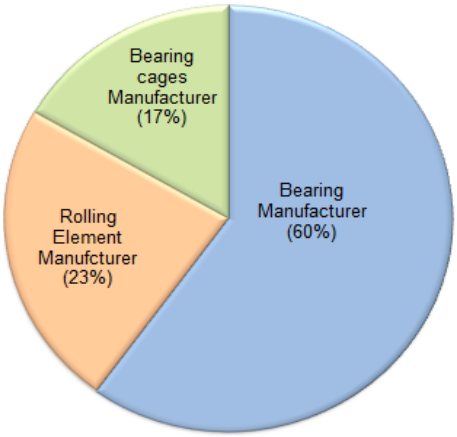
The products from bearing industries in Rajkot cluster are used mainly in different sectors starting from automobiles, light & heavy machine tools, compressors, stationary diesel engines, earth moving equipment, material handling equipment. The bearing industries cater to Original Equipment Manufacturers (OEM), replacement market and general engineering. The primary products manufactured in Rajkot bearing cluster are as follows.

- Ball bearings
- Taper roller bearings
- Cylindrical roller bearings
- Needle roller bearings
- Thrust bearings



Product types from Rajkot bearing cluster

Above products of Rajkot bearing cluster could be grouped primarily into three kinds of product manufacturers namely (1) cage manufacturers, (2) rolling element manufacturers and (3) bearing assembly units. Around 60% plants in Rajkot are bearing assembly units, which take cages, rolling elements from outside vendors and assemble bearings. A product-wise distribution of bearing industries in the cluster is provided in this figure.



Product-wise distribution of bearing industries

The production and installed capacity of the similar industries in the cluster varies unit to unit and even production of a unit is also not constant during the year. The nature of the cluster and the type of products manufactured is such that the production is recorded in format of the number of pieces manufactured of a particular type of product. Based on interactions with entrepreneurs, industrial bodies and government body in the cluster, the estimated production of bearings, rolling elements and cages are shown in the table.

Annual production by bearing industries

Product category	Number of units	Production (lakh pieces/year)
Bearings	90	1.8 to 40
Rolling elements	35	20 to 840
Cages	25	10 to 36

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 raw material used in the manufacturing of bearing races is SAE 52100 high carbon

chrome bearing steel, which has composition similar to EN-31 (100 CR 6 as per BIS specifications). The raw materials for bearing races are in the form of rods and seamless hollow tubes which are spherodised annealed steel. Alloy steel wire rods are used for the manufacture of rollers and balls. The cages and retainers are made out of plain carbon steel of 1008 & 1015 grade. Other materials like stainless steels are also used as per the customers

Cages: The material used for manufacturing cages is CRC strips of C2015 bearing grade steel having carbon percentage at 0.08% (maximum) and magnesium ranging from 0.25% to 0.45%.

Rolling elements: Steel balls/ rollers of grade 20, 16 & 10 with close tolerance smooth surface made using SAE 52100 high carbon chrome bearing steel wire rods made up of ferroalloy containing carbon.
The sources of major raw materials are provided below.

- Indian Seamless Metal Tube, Pune
- Indian Seamless Steel & Alloy, Pune
- Mahindra Ugine Steel Company Khopoli
- Jindal Steel Works Ltd
- Diado Stell Company Ltd, Japan
- Ascometal Industries, France

CRC sheets for cages

Wire rod for rolling element

Forged rings for bearing races

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

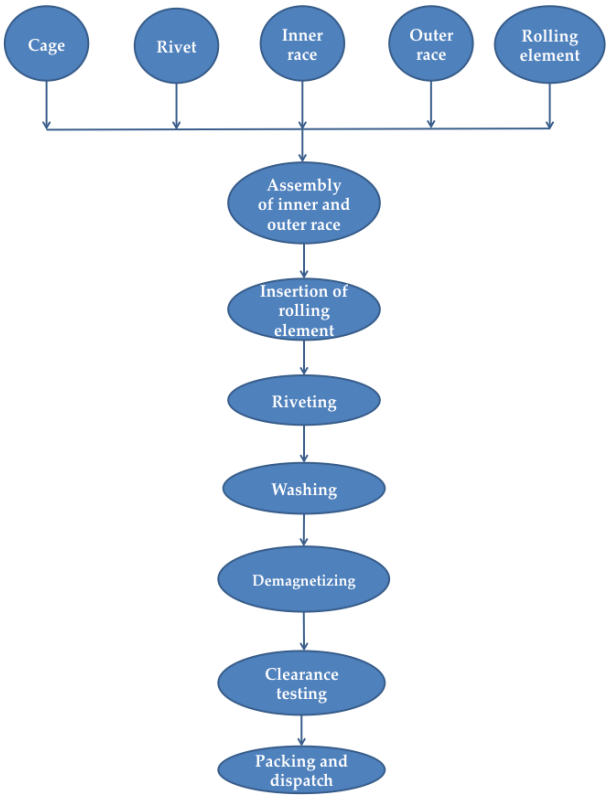
Source	Remarks	Price
Electricity	HT	Rs 8.00 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty)
	LT	Rs 9.00 per kWh (inclusive of energy, demand charges and electricity duty)
Diesel	From local market	Rs 55 per litre (price subjected to market fluctuations)
NG	GSPC	RS 34 per scm (price subjected to market fluctuations)

Production process

The bearing manufacturing industries in Rajkot imports the assembly components of bearing from local vendors. The components include inner and outer races, cages, rolling elements and rivets. The heat treatment and super finishing of rolling elements are done before final assembly of bearing. The generic process steps of manufacturing bearing products are explained below.

- **Raw material:** Raw materials for bearing manufacturing industries are different components of bearing that is inner and outer races, cages, rolling elements and rivets. These components are procured from local vendor as per specifications.
- **Assembly of races and rolling elements**: At first inner and outer races are assembled and then rolling elements are inserted manually or using press for taper roller bearings.
- **Riveting and washing**: Riveting is done on order to ensure complete assembly of bearing components. Washing in oil is done remove any burs and foreign particles from bearing surface.
- **Filtering and demagnetizing**: Contamination, if any from the batch composition is removed using both filtering element and demagnetiser.
- **Clearance testing**: Clearance testing is done in the lab using feeler gauge to check the alignment of the assembled components.
- **Packaging and dispatch:** The final marketable products are packed as per marketing and despatch requirement.

The generic production steps for bearing products are shown in figure.

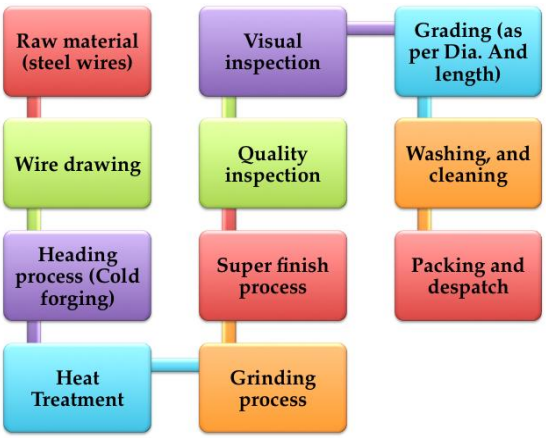


Generic process flow chart

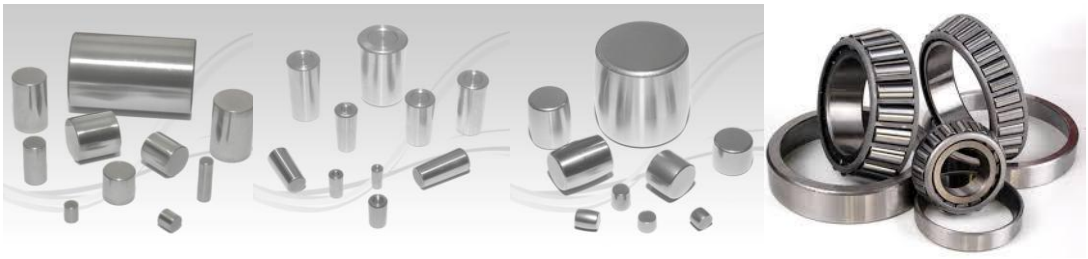
The production process for each bearing component in the cluster is mentioned below:

(i) Rolling elements manufacturing process

Rolling elements are made from steel wire rods of different sizes. Steel wire rods are cut to required size by cold forging operation in header machines. Heat treatment of rolling elements is carried out in heat treatment furnaces. It is followed by super finishing in super finishing machines. After quality and visual inspection, oil washing is done in batches before final dispatch.



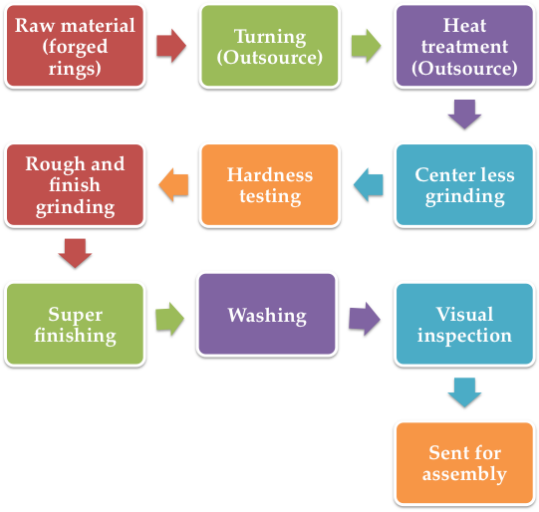
Process flow chart for rolling elements



Cylindrical roller **Tapper roller** **Spherical roller** **Taper roller**

(ii) Races manufacturing process

All bearing assembly units procure races from ring rolling forging units and carry out only finishing operations like in house grinding of face, OD (outer diameter)/ ID (inner diameter) and inner race ways. Forged rings are used as raw material for manufacturing of races. Turning of forged rings is done after which they are sent for centre-less grinding. Heat treatment of the rings is done to achieve required hardness. Both turning and heat treatment operations are generally outsourced. After testing the hardness levels achieved in heat treatment process, rough and finish grinding is done on the rings. After super finishing and washing operations, visual inspection is done before final assembly of bearings.



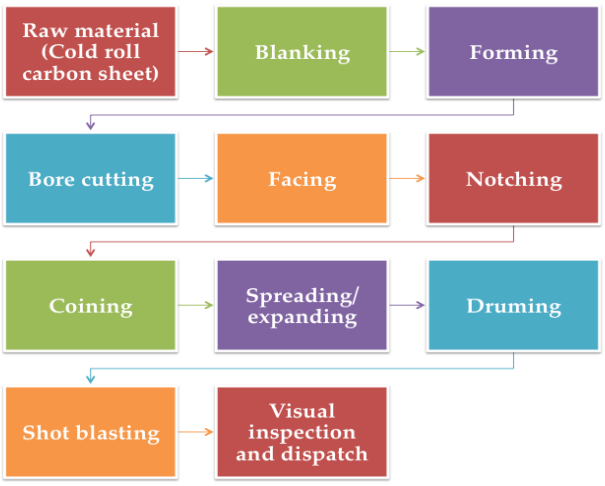
Process flow chart for races

Ball bearing

Needle roller

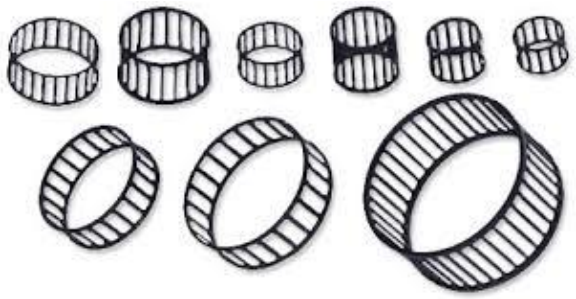
(iii) Cages manufacturing process

The manufacturing process of cages is shown in the figure. Cold roll carbon (CRC) sheets are used as a raw material in the manufacturing of the cages. Blanking and forming operations are done on the cut pieces of CRC sheets. Bore cutting is done to make a hole in the centre after which finishing operations like facing, notching, spreading and expanding and drumming are carried out to achieve required finishing specifications. In the



Process flow chart for cages

end shot blasting is done to achieve surface finish. Visual inspection is done before final dispatch of cages.



Bearing cages

Technologies employed

Bearing industries in the Rajkot cluster use conventional machines like lathe machines for rough turning and CNCs machines for finished turning operations of races. Grinding machines like centre-less grinding, face grinder, duplex grinding and super finishing machines are used along with air compressor, heat treatment furnaces, header machines and presses in the manufacturing of components of the bearings. Some of the primary process technologies are explained below.

(i) Machineries for rolling elements

Header machines are used for the cold forging i.e. wire-cutting and shaping operations of rolling elements. Header machines continuously draw wire rods and cut into predefined length to cold forge into balls or any other required shape of rolling elements. Natural gas (NG) fired or electrical heat treatment furnaces are used for hardening and tempering operations. Tumb blast machines are used for washing of the rolling elements in batches. Super finishing machines are used to meet required quality standards of the rolling elements.

Header machine

Ball Grinding machine

(ii) Machineries used for races

For races manufacturing, conventional machineries like lathes, surface finish machines are used as well as CNC machines. Other auxiliary systems used in the unit include electrical heat treatment furnaces and air compressors. Grinding is an important operation and inner diameter (ID), outer diameter (OD) and face grinding is done using duplex grinding and centre-less grinding machines.

Race finish turning on CNC machine

Rollers super finishing machine

Rolling element heat

Centre-less grinding machine for race O.D grinding

(iii) Machineries used for cages

Most of the operations in cage manufacturing are done in mechanical or pneumatic presses. Conveyor belts are used on the manufacturing line to transfer the jobs. Shot blast machines are used in the last operation of surface finishing of cages.

Mechanical press

(iv) Assembly of bearings

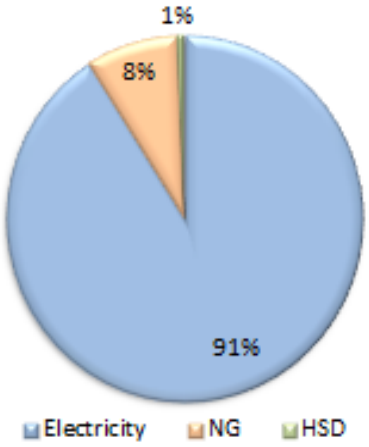
Most of the units do manual assembly of the bearing components like inner and out race, insertion of rolling elements and riveting. Press is used in case of insertion of taper rolling elements.

Bearings manual assembly line

Energy consumption

Electricity is the main source of energy for most of the bearing units in the cluster. These units are dependent on grid to meet their electricity needs. The average connected load of a bearing industry is dependent on kind of products and installed capacity. A majority of the units have LT connection, about 20hp to 40hp. The bearing assembly units of medium size have HT connection about 150 kVA to 700 kVA.

The other forms of energy use in the cluster include natural gas (NG) and high speed diesel (HSD). NG is mainly used by a few rolling elements manufacturing plant if they have NG fired heat treatment furnaces. HSD is used in gen-sets to meet electricity demands during power failure, which is however not very common in the cluster. Hence the consumption of HSD is insignificant at cluster level.



Share of energy sources

Unit level energy consumption

The unit level energy consumption of bearing units vary between 4.6 toe per year for a micro unit to 137.8 toe per year for a medium size bearing unit as shown in the table.

Unit level energy consumption of bearing manufacturing units

Bearing manufacturing units	Thermal energy (toe/year)	Electricity (kWh/year)	Total energy (toe/year)
Micro	0	54,024	4.6
Small	0.29	237,726	20.7
Medium	33.4	1,228,411	137.8

Cluster level energy consumption

The total energy consumption of the cluster is estimated to be 3903 toe per year. Electricity accounts for about 91% of total energy consumption in the cluster.

Annual energy consumption of bearing industries in Rajkot cluster

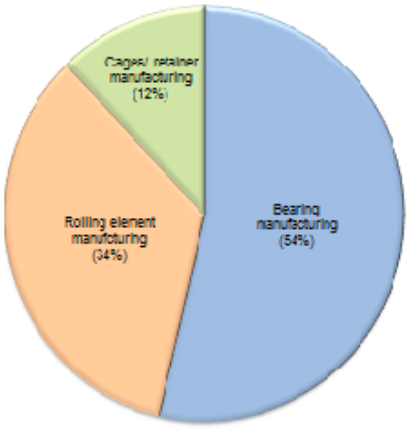
Type	Annual consumption	Energy equivalent (toe/year)	Equivalent CO_2 emissions (tonne/yr)	Annual energy bill (million INR)
Electricity	41.3 million kWh	3,555	40,511	296
Natural gas	0.4 million SCM	326	671	13
HSD	23.6 kilo litre	22	68	1.3
	Total	3,903	41,250	311

source: Energy data collected from individual units in Rajkot

The breakup of estimated energy consumption of different categories of bearing industries in the cluster is shown in the table. Bearing assembly industries account for about 53% of energy consumption in the cluster. It is followed by rolling elements manufacturing units, which is about 34%.

Category-wise energy consumption of bearing units

Industry sector	Energy consumption (toe/year)
Bearing manufacturing	2,095
Rolling elements manufacturing	1,333
Cages manufacturing	475
Total	3,903



Category-wise distribution of energy consumption

Energy saving opportunities and potential

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

(i) Application of variable speed drives

Motor-driven systems are often oversized and inefficiently controlled. The 'variable speed drives' (VSD) can provide a more cost effective method for varying loads and to match with the requirements. Energy savings in VSD applications usually range from 8-20%. Some of the potential applications of VSDs in bearing industry are mentioned below.

Header machine motor

The header machines are used in the manufacturing of rolling elements. They operate continuously drawing wire and cold forging the cut parts to required specifications. Load on header machines varies as pert the weight and diameter of the steel wires. Hence use of variable frequency drive in place of constant speed will reduce of power consumption upto 15%.

Super finishing machine motor

Super finishing machines are used for final finishing processes, which are carried out as per customer's requirements of profile, roughness, cylindricity and roundness. Motors of super finishing machines can run with VSDs, which can result into significant energy savings upto 8 %.

(ii) Compressed air

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%.

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% by adopting best operating practices (BOP). The industry 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%.

(iii) Replacement of rewound motors with energy efficient motors

'Rewinding' of motors results in a drop in efficiency by 3-5%. It is 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.

(iv) Heat treatment furnaces

Heat treatment furnaces are used to carry out processes like hardening and tempering. Box type furnaces are used which use either natural gas or electricity.

Recuperator for waste heat recovery from hot flue gasses of natural gas fired furnace

The roller elements manufacturers use NG fired or electrical heat treatment furnaces. The exit flue gas temperatures of natural gas fired furnaces used in these units are in the range of 450-600 ^{o}C and there are no waste heat recovery systems available with furnaces. The waste heat available with high temperature flue gases can be recovered in a metallic recuperator system to preheat combustion air that can result in significant improvement in furnace efficiency (over 10%) substantial reduction in fuel consumption. Energy savings of 8-15% can be achieved depending on the type of process, process cycle time and flue gas temperature.

Insulation for furnace

Heat treatment furnaces used are mostly built with simple refractory brick lining which are prone to heat losses with continuous usage over a period resulting in fuel losses. There is a huge potential in using ceramic insulations in box type furnaces, which enables lower fuel consumption during cold starts as well as less heat up time. Energy savings 4-6% can be achieved by improving insulation of the furnace.

Thyristor control for electrical heat treatment furnaces

Electrical heat treatment furnaces used 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 system can be used instead of on-off control, which can provide around 7-15% energy savings and can enhance life of coils due to smooth switching with the precise temperature controls.

(v) Lighting

T-12 tube lights (of 52W including choke) and halogen lamps (150W and 250W) are generally used by bearing 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 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 bearing industries.

Cluster development activities

There are not much of development activities in the bearing cluster because of the absence of association. Some of the bearing industries have collaborated together to form a cluster to take advantage of “Lean manufacturing” cluster program offered by the Central government.

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