This issue continues with the exploration of diverse MSME clusters belonging to a specific energy-intensive sub-sector. The theme for this issue is the Indian forging industry, which is a major contributor to the manufacturing output of the Indian economy, and a key element in the growth of the Indian automobile industry as well as other industrial sub-sectors such as general engineering, construction equipment, oil, gas and power.

The theme article provides an overview of the Indian forging industry, with a broad outline of the basic forging process, the kinds of forged products and their end-uses, and the potential for energy savings in the forging and heat treatment processes. The article underlines the fact that most MSME forging units in India continue to use outdated, inefficient technologies and that significant energy and cost savings can be achieved through the adoption of improved technologies and operating practices, with attractive payback periods on the investments required.

These points are explored in greater depth in the two articles that follow. One presents a profile of the Rajkot forging cluster, based on studies conducted under the TERI–SDC EESE project, with brief descriptions of the possible energy conservation measures (ECMs) that could be adopted by units. The other article is on the Pune forging cluster, which was one of the focus clusters under the GEF-World Bank-SIDBI project titled ‘Financing energy efficiency at SMEs’. The article summarizes the ECMs that have since then been implemented by a number of forging units in Pune with technical support from TERI.

SAMEEEKSHA Secretariat
INDIAN FORGING INDUSTRY

Overview

The forging industry is a major contributor to the manufacturing output of the Indian economy, and a key element in the growth of the Indian automobile industry as well as other industrial sub-sectors such as general engineering, construction equipment, oil, gas and power. According to the Association of Indian Forging Industry (AIFI), the umbrella organization of the forging industry in India, the total turnover in 2015–16 was over 278 billion rupees, including 61 billion rupees contributed from exports. The total production during 2015–16 was 2.45 million tonnes, against an installed capacity of around 3.77 million tonnes.¹ The automobile sector alone accounts for about 70% of total production.

The production capacity of forging units ranges from below 5000 tonnes to above 75000 tonnes per annum (tpa). Almost 95% of all forging units are MSMEs. The micro and small units mainly depend on manual labour; medium and large units are more mechanized. The forging industry provides employment to about 100,000 people. Forging units are generally concentrated in the vicinity of their respective customers. This issue carries stories on two prominent forging clusters, located in Rajkot (Gujarat) and Pune (Maharashtra) respectively.

Forging process

Forging is one of the oldest known metal working processes, going back to the Mesopotamian civilization over 4500 years ago. In essence, the forging process involves pressing, hammering or squeezing a metal work piece under high pressures. This process greatly increases the strength of the forged products (known as ‘forgings’), and also helps in improving other mechanical properties of the metal. The forging process is usually carried out on hot metal (hot forging), but may also be carried out on cold metal, depending on the characteristics of the metal and the specific material properties required in the forged products (see process chart).


Products

Forgings are characterized by strength, toughness and reliability. Hence, forged components are commonly used in the automobile industry at points of shock and stress such as wheel spindles, kingpins, axle beams and shafts, torsion bars, and steering arms. Another common application is in the powertrain, where connecting rods, transmission shafts and gears, differential gears, drive shafts, clutch hubs and universal joints are often forged.

Potential for energy saving

Most of the MSME forging units in India use obsolete, low efficiency technologies, particularly in their forging and heat treatment processes. Typically, about 70% to 80% of total energy consumed by a forging unit goes towards heating prior to forging, and heat treatment post-forging. As illustrated by the cluster profiles that follow, significant energy and cost savings can be achieved in forging units through the adoption of improved/energy efficient technologies and better operating practices. The investments required on these energy saving measures typically offer attractive payback periods, ranging from 3 months to 3 years.
Background

The industrial city of Rajkot, located in the state of Gujarat, hosts a prominent cluster of about 140 MSME forging units located in industrial estates around the city. The Rajkot forging units are principally known for their ability to make superior precision components that cater to a range of secondary production industries including automobiles, compressors, earth moving machinery, electrical equipment, light and heavy machine tools, material handling equipment, stationary diesel engines and others. The products include propeller shafts, front axles, upper pins, crown wheels, gears, shafts, connecting rods, forks, camshafts, bearing races and wheel hubs. The main clientele are large Original Equipment Manufacturers (OEM) such as Tata Motors, Mahindra & Mahindra, L&T, Force Motors, Bajaj Auto, General Motors, Godrej and Ashok Leyland.

The forging units fall under two broad categories, based on the type of forgings they produce: (1) closed die forgings, which account for 62% of total production and (2) ring rolling forgings, which account for the remaining 38% (Table 1). The unit-level production varies widely, from 300 tonnes to 36,000 tonnes per year. The total annual production of forgings is estimated to be 434,200 tonnes. The total turnover is estimated at over 40 billion rupees. The cluster provides employment to about 15000 people.

<table>
<thead>
<tr>
<th>Type of forging</th>
<th>No. of units</th>
<th>Production (tonnes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed die</td>
<td>90</td>
<td>268540</td>
</tr>
<tr>
<td>Ring rolling</td>
<td>50</td>
<td>165660</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>434200</td>
</tr>
</tbody>
</table>

The main industry associations are Rajkot Engineering Association (REA), GIDC (Lodhika) Industrial Association (GLIA), AJI (GIDC) Industries Association, and Shapar-Veraval Industrial Association. Other key cluster-level stakeholders include Central Manufacturing Technology Institute (CMTI), Rajkot; National Small Industries Corporation (NSIC), District Industries Centre (DIC), MSME-DI (Rajkot), SIDBI, and Institute of Indian Foundrymen (IIF), Rajkot chapter.

Technology status and energy use

The primary raw materials used in the Rajkot forging units are long metal rods and bars of alloy steel, carbon steel, mild steel, stainless steel, super alloy, special steels and aluminium. The main sources of raw materials are Jindal Steel Works Ltd and Bhushan Steel Ltd. The forging process broadly involves cutting the metal rods or bars into billets of appropriate size; heating the billets to 1200–1270° C for hot forging; hammering and/or pressing the billets to obtain the forged products; heat treatment of the forgings at temperatures between 250–930°C (annealing, hardening, tempering, carburizing etc.); and finishing operations such as trimming and coining. The important technologies used during the process are outlined in Table 2.

Energy consumption

The main sources of energy for the forging units in Rajkot cluster are furnace oil (FO), electricity and natural gas (NG), which together account for 98% of total energy consumption (Table 3). The majority of the units have high tension (HT) connections. The power situation is quite satisfactory in Rajkot, and hence the dependence on DG sets for backup power is very low. The cluster-level energy consumption is estimated to be 62,365 tonnes of oil equivalent (toe) per year, of which about 76% is accounted for by closed die forging units, and the remaining 24% by ring rolling units.

Potential options for energy saving

The following measures can bring significant energy savings and other benefits to forging units in the Rajkot cluster.
Induction billet heater to replace FO-fired forging furnace

Replacement of the existing FO-fired forging furnaces with induction billet heaters can yield significant energy savings (30–70%), reducing the specific energy consumption for forging from 0.15 toe/tonne to 0.11–0.04 toe/tonne. Scale losses are reduced with induction billet heaters, thus improving productivity. Also, due to reduced surface heat loss, the temperature near an induction billet heater
is much lower compared to FO-fired furnaces, resulting in a better working environment. The investment required ranges from 1.5–5.0 million rupees, depending on size of the induction billet heater, with simple payback period of 1–3 years.

**Recuperator for waste heat recovery**

The exit flue gas temperatures in the FO-fired and NG-fired furnaces range between 450–700°C. A metallic recuperator can be installed to recover waste heat from the flue gases and use it to preheat the combustion air. Energy savings of 8–15% are possible through this measure. The investment for recuperator varies from 0.2–0.4 million rupees, with a simple payback period of 8 months to 2 years.

**Improved furnace insulation in FO and NG-fired furnaces**

The forging and heat treatment furnaces are usually lined with refractory bricks. Prolonged usage damages the lining, resulting in heat losses. The application of ceramic lining in box-type furnaces can yield energy savings of 4–6%, besides reducing fuel consumption during cold start.

In NG-fired furnaces, improved insulation can save about 5–15 SCM of gas/hour, depending on the level of surface heat losses, type of refractory used and size of furnace. Relining or repairing of heat treatment furnaces can be carried out with an investment of 350–400 rupees per square foot, with simple payback period of 5 months to 1.5 years.

**Thyristor control for electrical heat treatment furnaces**

The electrical heat treatment furnaces in use have on–off switches to control the heating cycle. Continuous switching results in thermal shocks which reduce the life of the heating coil and may lead to frequent failures.

About 7–15% energy savings can be obtained through replacement of the on–off switch with thyristor control. The investment for thyristor control varies from 0.02–0.15 million rupees, depending on the total electrical rating of heating coils, with a simple payback period of 3 months to 1 year.

**High speed hot former machine for ring rolling**

With this new age technology, multiple ring rolling components can be forged at a time with high speed and precision. A few ring rolling units have already adopted this technology. The conventional ring rolling machines have an output of 10 pieces per minute, whereas high speed former machines have an output of 120–180 pieces per minute with near net job sizes. These highly advanced machines can be operated in line with induction long bar heaters for fast production. These machines increase productivity with assured component quality and significant energy saving.

**Variable frequency drives for press motors**

Energy savings of 8–20% can be obtained by connecting the motor-driven presses with variable frequency drives (VFD), which vary the speed of the connected load to match the process requirements and also extend motor life. The investment required on VFD is around 0.05–0.30 million rupees, depending on the electrical rating of the motor, with a simple payback period of 8 months to 2 years.

**Replacement of screw air compressor with VFD-based air compressor**

Currently, the existing screw air compressors operate on unload position for more than half the time, resulting in wastage of power. Installation of new VFD air compressors to replace the existing air compressors can yield energy savings of 20–35%. The investment required for VFD air compressor ranges between 0.05–0.30 million rupees, depending on the size of the compressor, with a simple payback period of 6 months to 1.5 years.

**Other options**

In addition to the above, energy savings of 3–7% can be achieved at little or no cost through measures such as plugging air leakages in compressed air systems; reducing the pressure setting of air compressors; replacement of low-efficiency rewound motors with energy efficient (IE3) motors; and switchover to energy efficient lighting.
IMPLEMENTATION OF ENERGY EFFICIENT TECHNOLOGIES IN PUNE FORGING CLUSTER

Background

The Pune forging cluster contributes about 20–25% of India’s total production of forgings (0.4–0.5 million tonnes out of a total of about 2.4 million tonnes in 2015–16), and has about 120 MSME forging, heat treatment and pressure die casting units in operation. In general, the processes used by units are low in energy efficiency. Energy is drawn from various sources such as electricity, natural gas (NG), liquefied petroleum gas (LPG), light diesel oil (LDO), furnace oil (FO) and high speed diesel (HSD). The annual cluster-level energy consumption is about 24,250 tonnes of oil equivalent (toe). Heating accounts for a major share of energy consumption (80%–90%); the balance energy is accounted for by other equipment such as hammers, presses, pumps, and air compressors.

The Pune forging cluster is one of the three energy intensive MSME clusters in which TERI, as consultant, provided development support for enhancing energy efficiency under the World Bank–GEF–SIDBI project titled ‘Financing energy efficiency at MSMEs’ (the other two clusters are Ankleshwar chemicals cluster and Kolhapur foundry cluster).

Intervention

As a first step, TERI conducted a comprehensive study of the Pune forging cluster and prepared a cluster profile report, both in English and Marathi (for a summary of the cluster profile report, see Sameeksha December 2013, Vol.4, Issue 4). TERI conducted walk-through audits (110 units) and detailed energy audits (76 units), and identified potential energy conservation measures (ECMs) for each unit. For each ECM, the investments required were identified through interaction with vendors while matching the technical specifications of the units. Based on performance evaluation and discussions with vendors, energy savings and monetary savings were estimated along with estimation of CO₂ emission reductions. Taking into account the technical and economic feasibilities of the ECMs, investment grade detailed project reports (IGDPRs) were prepared for 75 units. In all, close to 500 possible ECMs were identified, of which 330 ECMs (66% of the total) were accepted by the concerned units for implementation following discussions with TERI. Some of these ECMs are shown in Table 1.

<table>
<thead>
<tr>
<th>New/improved technology</th>
<th>Best operating practice (BOP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement of FO-fired furnace with induction billet heater</td>
<td>Application of ceramic fibre insulation (veneering modules) to furnaces to reduce heat loss</td>
</tr>
<tr>
<td>Replacement of inefficient burners with EE burners</td>
<td>Optimization of compressed air pressure</td>
</tr>
<tr>
<td>Installation of recuperator (waste heat recovery) system</td>
<td>Use of energy efficient motors</td>
</tr>
<tr>
<td>Fuel switch from FO to NG</td>
<td>Use of energy efficient blowers</td>
</tr>
<tr>
<td>Replacement of FO-fired normalizing furnace with electrical rotary hearth furnace</td>
<td>Improvement of power factor</td>
</tr>
<tr>
<td>Replacement of holding furnaces</td>
<td>Excess air control</td>
</tr>
<tr>
<td>Replacement of inefficient compressors by EE compressors with VFD</td>
<td>Sliding door for furnace opening</td>
</tr>
</tbody>
</table>
Results
The units have implemented the ECMs progressively, with TERI providing the requisite technical support during implementation and also for post-implementation monitoring & verification (M&V). Around 180 ECMs were implemented in 66 units (till May 2016), resulting in energy saving of 2059 toe/year. Against a total investment of 106 million rupees, the ECMs are saving 101 million rupees each year in energy costs. Table 2 summarizes some of the ECMs that have been implemented and their benefits.

Lessons and insights
To start with, the project team found a general lack of awareness in most units on the importance of energy conservation and best operating practices (BOPs). The project demonstrated how BOPs can yield significant savings in energy costs at little or no investment. Such BOP demonstrations instilled confidence and enthusiasm among the entrepreneurs and operators in adopting energy efficiency measures.

At cluster level, the TERI team was closely involved with entrepreneurs and vendors (suppliers/ manufacturers/ fabricators) in proper selection of equipment with suitable specifications. Case studies were prepared on successful ECM implementations and shared with cluster-level stakeholders at various events, motivating other units to invest in energy efficiency and reduce their production costs.

Table 2. Select ECMs implemented by units in Pune forging cluster

<table>
<thead>
<tr>
<th>ECM</th>
<th>Implementations</th>
<th>Energy costs savings (Rs million/year)</th>
<th>Energy saved (toe/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimizing pressure setting in air compressor</td>
<td>44</td>
<td>3.6</td>
<td>40</td>
</tr>
<tr>
<td>Furnace veneering/relining</td>
<td>31</td>
<td>9.4</td>
<td>169</td>
</tr>
<tr>
<td>Power factor improvement</td>
<td>19</td>
<td>3.9</td>
<td>–</td>
</tr>
<tr>
<td>Replacing FO-fired forging furnace with induction billet heater</td>
<td>17</td>
<td>47.1</td>
<td>1187</td>
</tr>
<tr>
<td>Replacing low efficiency air compressor with EE air compressor</td>
<td>12</td>
<td>9.1</td>
<td>158</td>
</tr>
<tr>
<td>Insulation improvement</td>
<td>7</td>
<td>1.7</td>
<td>29</td>
</tr>
<tr>
<td>Furnace replacement</td>
<td>7</td>
<td>3.7</td>
<td>71</td>
</tr>
<tr>
<td>Electrical melting/holding furnace</td>
<td>7</td>
<td>10.2</td>
<td>223</td>
</tr>
<tr>
<td>Lighting improvement</td>
<td>7</td>
<td>5.0</td>
<td>5</td>
</tr>
</tbody>
</table>
12th Meeting of SAMEEEKSHA

The 12th meeting of SAMEEEKSHA was held on 12th April 2017. The key participants included representatives from SDC, BEE, TERI, EESL, SIDBI, SBI, GIZ, UNIDO, Indian Banks Association, Shakti Sustainable Energy Foundation, financial institutions, implementing agencies, and technical consultancy organizations. The meeting was chaired by Mr Abhay Bakre, Director General, BEE. The meeting focused on a specific theme: financing energy efficiency (EE) in the SME sector.

Presentations and discussions

The following presentations were made:

- SAMEEEKSHA Platform and TERI-SDC EESE project: an update—Mr Sachin Kumar, Secretary, SAMEEEKSHA and Fellow, TERI
- Energy Efficiency programs for SMEs by BEE—Mr Milind Deore, Energy Economist, BEE
- GIZ-SIDBI Responsible Enterprise Finance Programme—Ms Poonam Sandhu, GIZ
- Promoting EE financing among SMEs [three presentations]
  » Mr Rajiv Kumar, SIDBI
  » Mr Chandan Bhavnani, YES Bank
  » Mr Ashutosh Tandon, IFC

The salient points from the presentations and discussions are summarized below.

- Implementations of various EE initiatives are yielding significant results in terms of annual energy savings:
  » BEE SME Program—305 toe
  » GEF-UNIDO-BEE program—1500 toe
  » WB-GEF-SIDBI project—22,500 toe
- A Knowledge Management (KM) portal has been launched under GEF-WB-BEE program (www.indiasavesenergy.in); a KM centre for motor efficiency is being established in Faridabad.
- GIZ has developed an excel-based analytical tool under its ‘Responsible Finance Enterprise Program’, intended to assist banks/FIs in assessing the ‘Environmental, Social and Governance’ (ESG) risks associated with financing MSMEs.
- Under the project ‘Promote Competitive SMEs’ (a component of IFC-EU Partnership for Eco Cities in India program), TERI conducted a feasibility study to identify industry sub-sectors/clusters with the highest potential for resource-saving in five targeted cities, and to get a better understanding of the key banks/FIs engaged in EE financing.
- There is need and scope to drive EE through supply chain: for instance, as in initiatives taken by the automotive sector for greening of supply chain.
- The ESCO model should be promoted for EE among MSMEs, as the ESCO takes on the ‘risk’ perceived by banks/FIs in directly financing MSMEs for EE, as well as assumes responsibility for monitoring and verification (M&V) of actual energy savings.
- With the lack of collateral remaining a major impediment for MSMEs to access finance, RBI has taken measures by which ‘movable collaterals’ can be offered by MSMEs as security for loans.