Energy conservation measures in the foundry sector

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BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)
CONSERVE IT

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Director General

MESSAGE

The contribution of Micro, Small and Medium Enterprises (MSMEs) has been significant in India's economic development. Due to its contribution towards employment and balanced regional development, it is imperative to take measures to strengthen this vital sector.

With increased competition and the ongoing economic slowdown, adopting innovative practices which can manage the bottom line are a necessity for enhanced competitiveness and profitability. Energy efficiency enhancement is a powerful bottom line management intervention for the MSME sector, as it reduces energy consumption while maintaining current levels of productivity and quality – in other words, producing the same goods or services while using less energy.

The Bureau of Energy Efficiency (BEE) has a number of programs to facilitate delivery mechanisms for energy efficiency in all sectors in the country. In the MSME units, local service providers, technology vendors and banks collaborate in the implementation of energy efficiency interventions on a sustainable for-profit basis. To enable this business model, BEE and SIDBI have signed a Memorandum of Understanding to partner and create a shelf of energy efficiency projects for 25 MSME clusters across India.

This booklet contains wide-ranging tips on housekeeping for energy saving practices, at the shop-floor level in the foundry sector. I am delighted by this practical knowledge product and congratulate SIDBI on their continued and innovative efforts in disseminating knowledge in this important area.

I am confident that these simple housekeeping measures, identified best practices, and cost saving tools will help in raising awareness, reducing energy bills, and minimizing waste and will go a long way in contributing to increased competitiveness of the entire MSME sector.

(Ajay Mathur)

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FOREWORD

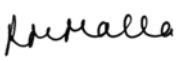
The Micro, Small and Medium Enterprises (MSMEs) sector has, over the years, emerged as an important vehicle for the economic growth of India. The sector's contribution to the Indian economy has been immense, providing the second largest source of employment, 45% of the industrial manufacturing output and 35% of the country's exports. Through its sheer size and potential, MSMEs play a vital role towards coordinated balanced regional development and inclusive growth of the country. It is noteworthy that this sector has also proved to be innovative, adaptable and resilient throughout different phases of economic cycles.

Small Industries Development Bank of India (SIDBI), being the principal financial institution for MSMEs, is committed towards holistic growth of the MSME sector by making it strong, vibrant and globally competitive. We recognize energy efficiency as an effective tool to promote competitiveness of the MSME sector. SIDBI and the Bureau of Energy Efficiency (BEE) are cooperating to promote energy efficiency in MSME clusters. SIDBI has also tied up a line of credit with the Japan International Cooperation Agency (JICA) to finance energy saving projects at concessional terms.

In our endeavor towards creating widespread awareness on the necessity and urgency of energy saving measures in the MSME sector, we are bringing out this booklet which is an attempt to disseminate information on simple, cost-effective solutions in foundry enterprises. The booklet presents measures that guide adoption of energy efficiency and greener practices to help MSMEs cut costs and attain higher competitiveness. This publication is the second in the series; the first being energy saving measures in the fruit and vegetable processing sector published in association with The Energy and Resources Institute (TERI).

I am confident that this booklet will be a valuable resource for MSMEs in the foundry sector in reshaping their manufacturing process by adopting energy efficiency measures and technologies.

I wish the entire MSME fraternity the very best for success in all their endeavors.



RM Malla,
Chairman and Managing Director,
SIDBI

Introduction

The Indian foundry industry is the fifth largest in the world. There are more than 6,000 foundries in India, and they have a combined installed capacity of approximately 7.5 metric tonnes per annum (MTPA). Most foundries (nearly 95%) in India fall under the small and medium scale category and are located in clusters. These units produce a wide range of castings that include automobile parts, agricultural implements, machine tools, diesel engine components, manhole covers, sewing machine stands, pump-sets, decorative gates and valves.

Many of the foundry clusters cater to some specific markets. For example, the Coimbatore cluster is famous for pump-set castings, the Kolhapur and the Belgaum clusters for automotive castings, and the Rajkot cluster for diesel engine castings. The major foundry clusters and their products are listed in Table 1.

Manufacturing Process

The manufacturing process in a typical foundry unit comprises many operations like sand preparation for moulds and cores, mould and core preparation, charge preparation for the melting furnace, melting and pouring and a range of cleaning and machining operations. The process flow diagram for a typical foundry is shown in Figure 1.

Table 1: Details of major foundry clusters with major products in India

Foundry Cluster	Approx No. of Units	State	Major Products
Batala	200	Punjab	Agricultural implements, machine tools
Belgaum	100	Karnataka	Automotive/oil engines, Electric motors
Coimbatore	500	Tamil Nadu	Pumps/valves, Textile machine parts
Howrah	300	West Bengal	Machine covers, Sanitary pipes
Jalandhar	80	Punjab	Agricultural implements, machine tools
Kohlapur	250	Maharashtra	Automotive/oil engines, Sugar mill parts
Ludhiana	350	Punjab	Sewing machine parts, Auto parts
Rajkot	500	Gujarat	Oil engine, Textile machine parts, Pump/valves

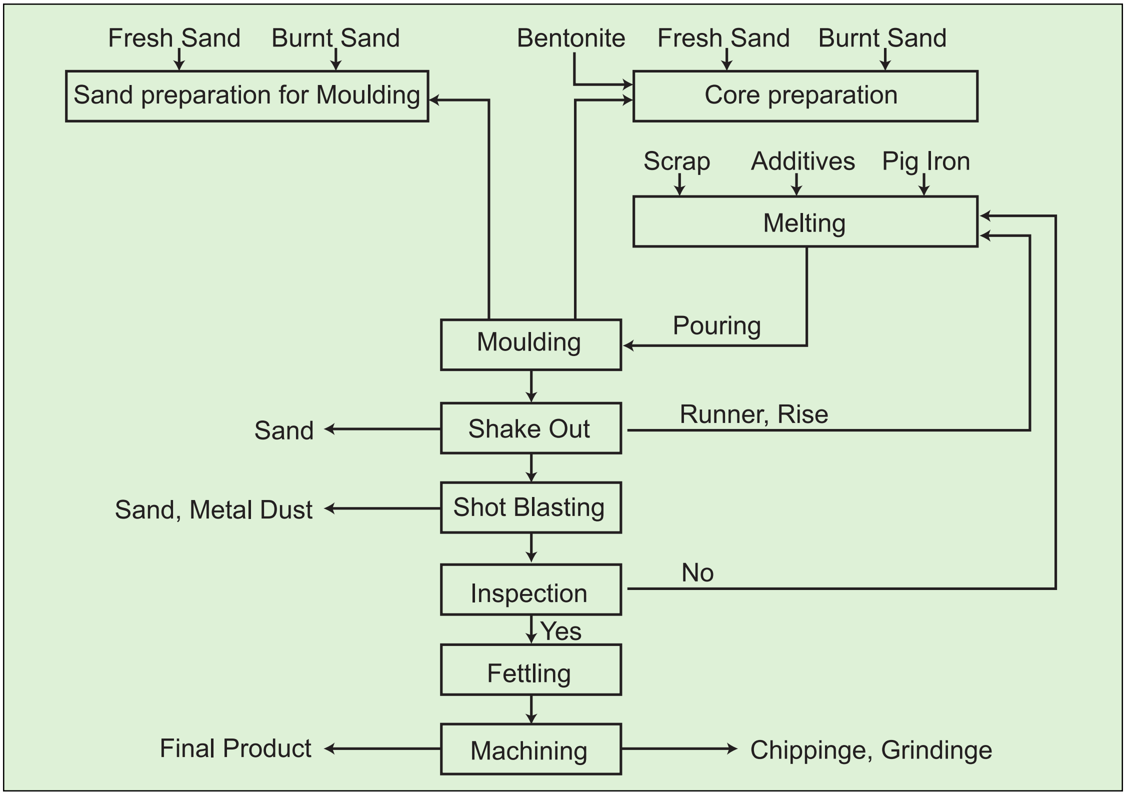


Figure 1: Flowchart for a typical foundry

Energy Savings in Cupolas

Cupola, which is the most commonly used melting furnace in the Indian foundries is also the most energy intensive operation. It accounts for up to 50% of a foundry's total energy consumption and is a prime candidate to focus attention on, for improving energy use efficiency in a foundry.

For efficient cupola operation, the following operating practices are recommended. For easy comprehension, the recommendations are categorized under various operations, starting from preparation of the cupola to tapping of molten metal.

Bottom Sand

The base of the cupola plays an important role in proper cupola functioning and in the flow of hot metal from the cupola. Note the following points while making up the base of the cupola

- Ensure that the bottom sand is free from iron, etc., and that it has the proper moisture and clay content.
- It should be dense, with a correctly rammed bottom, heeled up around the wall and sloping towards the tap hole.

Preparation of coke bed

The most important part in the successful operation of a cupola is the preparation of the coke bed. The initial height of the bed above the tuyeres and the degree to which it is burned before the charging commences are vital factors governing, to a large extent, the metal temperature and melting rates obtained during the early

Be sure that the vents in the cupola bottom doors are open

The weight of a single piece of metal should be limited to 1% of the hourly melting rate

4% oxygen enrichment in a conventional cupola improves the production rate by 25%

A 2% oxygen level in a divided blast cupola with inclined tuyeres, reduces coke consumption by 12.5%

part of the melt.

- Clean the vent holes on the damper plates
- Select and weigh the bed coke carefully every day
- Place kindling wood or torches properly to ensure even lighting
- Measure the bed height with a calibrated rod/gauge. If needed, add green coke to bring the height to the required level
- Record all coke bed data

Charging

The operating efficiency of a cupola depends, to a large extent, on the charging of raw material. The following practices should be adopted in order to ensure proper operation of the melting furnace.

- The acid insoluble content in flux stone should not exceed 5% of its total weight.
- The diagonal dimension of a single piece of metal should be less than 1/3rd the hearth diameter to ensure that the cupola operates efficiently.
- The weight of a single piece of metal should be limited to 1% of the hourly melting rate.
- The quality of purchased scrap should meet the specifications of the product to be manufactured.
- The charging sequence of the metal must be maintained.
- Once charging starts, it has to be continued till, (i) the cupola shaft is filled up with the charging material, (ii) the cupola is lit up, and (iii) the blower and tuyeres are switched on.
- Use light scrap for filling up to achieve initial tap temperatures.
- Ensure that the cupola is full before turning on the blast.

Melting

- Establish the proper initial blast rate and maintain it right through to tap-out.
- Dry and thoroughly pre-heat all runners and ladles daily.
- Use only dry inoculants. If the alloy is wet, proper inoculation will not take place; pinholes or other defects may occur.
- Black top gas suggests that the blower motor is blocked or greasy scraps have been used in the charge.
- If the stack discharge appears reddish, the reasons could be:
  - o Oxidizing conditions on account of low bed or high blast
  - o Excessive amount of rust in charge material
  - o Scaffolding or hanging of charge
- Strong flame and high temperature at the charge door indicate a high bed and excessive coke splits between charges, or low stack height in the cupola.
- A blue-pink flame moving up and down the walls and clinging to projections indicates good melting conditions.
- During melting, burn-back occurs above the tuyeres in the melting zone. The following factors contribute to burn-back:
  - o Low temperature of the melting zone
  - o High blast rate
  - o Incorrect tuyere dimensions
  - o Uneven charge distribution.

Tapping and Slagging

Slag is removed from the hot metal with the help of a slag overflow notch. Normal slag is colored grey to grey-green. The color and other properties of slag appearance can point to problems in the cupola's performance. Check for the following:

- Thick, viscous slag indicates insufficient flux or low temperatures.
- Dark to black slag indicates a low bed (slag sometimes foamy) and oxidizing conditions.
- Light green to cream color slag indicates excess flux.

Energy Saving Measures in a Cupola Furnace

- Maintain a continuous melting operation. Long standby time increases energy losses and causes metallurgical variations. Consider changing the cupola lining's inside diameter and tuyere's diameter if extended levels of low or high melt rates are expected.
- Keep the upper stack full. Maximum charge levels increase preheating of metals and reduce coke consumption. Varying stack levels also cause metallurgical variations. Thus, maintaining constant stack levels decreases metallurgical variations.

Table 2: Advantage of DBC over conventional Cupola

Saving in Coke	7 - 10%
Saving in Refractories	20%
Si and Mn loss	5% as compared to 15% in a conventional cupola
Carbon gain	20% better than conventional cupola.
Rise in metal temperature	30^0C
Reduction in pollution	30%
Cupola operation	Operator friendly with no pocking of tuyeres
Inclined tuyeres	Inclined at 7.5 deg downwards to yield better performance in the combustion of coke.

- With advances in melting practices, the conventional cupola has given way to the improved and more efficient Divided Blast Cupola (DBC). Table 2 presents the advantages of a DBC over conventional cupolas.
- Another advanced technology used in cupola operation is oxygen enrichment of the cupola. The enrichment quantity usually required is around 2-4% of the air blast. The following advantages are achieved over the conventional cupola operation.
  - o Carbon pick-up is higher
  - o Molten metal temperatures are higher by about 30^0C

The measures for operating the cupola in the most efficient manner are given in Table 3.

Table 3: Summary of operating tips in a Cupola

Dos	Don'ts
• Ensure that the bottom sand is free from iron, etc., and that it has the proper moisture and clay content.	• Don't hold the molten charge inside the cupola. It consumes energy as well as changes the metallurgical properties of different batches.
• Measure the bed coke height with a calibrated gauge. If needed, add green coke to bring the height to the required level.	• Once charging starts, do not stop till, (i) the cupola shaft is filled with the charging material, (ii) the cupola is lit up, and (iii) the blower and tuyeres are switched on.
• While charging, ensure that the diagonal dimension of a single piece of metal is less than 1/3rd the hearth diameter.	• Don't use wet inoculants.
• Use light section scrap for filling up, to increase the initial tap temperatures.	• Don't allow very heavy raw material pieces weighing more than 1% of the hourly melting rate, in the cupola.
• Dry and thoroughly pre-heat all runners and ladles daily.	

Energy Savings in Induction Furnaces

Induction melting furnaces are inherently more efficient than cupolas. They are also easier to use because there are fewer steps in their operation and maintenance compared to cupolas. Further, most of the operating parameters in an induction furnace are electrically controlled and specifications are pre set as per the manufacturer's guidelines. Hence, the only factor that needs to be controlled in order to save energy during induction melting is cycle time. Adopting the following practices will optimize the cycle time and allow efficient operation of the induction furnace.

- Plan the charge mix and material beforehand.
- Weigh and keep the charge and alloying elements ready before charging.
- Keep the size of the charge materials about 1/3rd of the crucible's diameter.
- First charge the steel and carburizers.
- Always keep the crucible full of charge and keep poking in order to achieve maximum compaction.
- Always operate the furnace at full power.
- Use proper frequency in the induction furnace for various alloys, to ensure a faster mixing of additives and to reduce the cycle time.
- Cover the crucible with an asbestos blanket after charging.
- Do not superheat the metal beyond the required temperature.
- Avoid holding of molten metal.
- Avoid delay in the de-slagging operation.
- Keep the charge free from dirt and rust.
- Foundry return should be, preferably, shot blasted.

Weigh and keep the charge and alloying elements ready before charging.

Keep the size of the charge materials about 1/3rd of the crucible's diameter.

Cover the crucible with an asbestos blanket after charging.

Table 4: Summary of operating tips in Induction melting furnace

Dos	Don'ts
• Keep the size of charging material to about one third of the furnace crucible size.	• Don't superheat the metal.
• Operate the furnace at full power and full capacity. Go for maximum compaction of material while charging.	• Don't hold the material in the furnace. It consumes power without increase in production.
• Keep the cycle time as short as possible by proper housekeeping.	• Don't uncover the furnace unnecessarily.

Table 4 summarizes the methods to be adopted for the efficient operation of the induction furnace.

Energy Savings in the Mould and Core-Making Process and Heat Treatment

Making moulds and cores is another important operation in any foundry. Mould and core making and heat treatment together account for 25–27% of the total energy consumed in a foundry. Given below is a list of operating practices that must be followed to improve the efficiency of these processes.

- Remove any metal pieces from the sand using sand processing equipment so that no undesirable object appears in the mould. Malfunction of even a single mould can lead to the loss of material and energy.
- Ensure that components of the mould/core such as sand additives meet rated specifications. Any deviation from the rated composition may lead to frequent failure of moulds/ cores. This could mean rejection of the entire lot of castings.
- The water content in the mould plays an important role in binding of material. Too much water gives way to casting defects, while too little water may result in insufficient binding and the collapse of the mould at critical points.
- For heat treatment furnaces with larger capacities and voluminous heating chambers, always install more burners with smaller firing capacities in place of a few burners with larger firing capacity.
- Clean burner nozzles once in a month.
- Do proper planning to avoid furnace cold starts.
- Don't leave air supply open while fuel supply is closed.
- Use temperature indicators and automatic controllers in place of human judgement. This will reduce the chances of overheating of the material and the resulting energy/material loss.
- Do not obstruct the flow of hot gases, the flame path and the exhaust port. Ensure this by placing/arranging the material correctly and through optimal loading of the furnace.

Don't cut air supply while fuel supply is running.

Every 20°C rise in combustion air temperature will raise the thermal efficiency of the furnace by 1%

Install more burners with smaller firing capacities in place of a few burners with larger firing capacity.

Table 5: Summary of operating tips in core-making and heat treatment furnaces

Dos	Don'ts
• Clean burner nozzles once in a month. • Use optimum quantity of water while mould making. • Ensure proper planning to avoid furnace cold start • Seal unnecessary furnace openings and leakages.	• Don't obstruct the flow of hot gases, the flame path and the exhaust port. Ensure this by placing/arranging the material correctly and through optimal loading of the furnace. • Don't rely on human judgement for critical furnace parameters like temperature. Use digital temperature indicators.

Given in Table 5 are operating tips for improving the efficiency of core-making heat treatment furnaces.

Energy Savings in the Machine Shop

For efficient operation, carry out routine and simple maintenance of machine tools. This will help avoid expensive breakdown maintenance, which also leads to loss of production and other associated losses. Such routine maintenance takes only a few minutes to complete and should be conducted before the shift begins. The following checks should be carried out in the routine maintenance of machine tools:

- Clean chips from the chip pan.
- Check hydraulic oil level in the main hydraulic tank and top up if required.
- Check the coolant levels in the coolant sump and top up, if required.

Check the lubricating oil level in the guide ways, lubricating oil tank and top up if required.

Perform alignment check between spindle, carriage assembly and other components to ensure accuracy of cut.

Undertake periodic calibration of gauges and instruments

- Perform alignment check between spindle, carriage assembly and other components to ensure accuracy of cut.
- Undertake periodic calibration of gauges and instruments.

Energy Savings in the Compressed Air System

Air compressors are used in the machine shop for pneumatic equipment and machine tools. Air compression consumes a lot of energy. From Figure 2 it is clear that only 10 – 30% of input energy to the compressor reaches the point of end-use and the balance 90 – 70% of the input energy is wasted in the form of friction and heat loss.

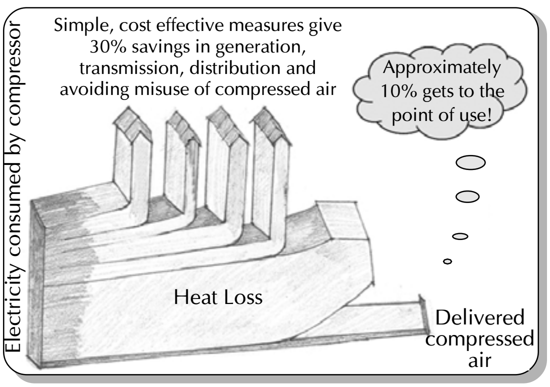


Figure 2: Sanky diagram of a compressed air system

Energy savings of up to 30% can be realized in a compressed air system by regular simple maintenance measures. Some practices that will optimize air compression are listed below.

- The location of air compressors and the quality of air drawn by the compressors will have a significant influence on the amount of energy consumed. The following points should be taken into consideration while deciding the location of compressors or combined compressed air systems.
  - o Locate the compressor away from heat sources such as kilns, dryers and other items of equipment that radiate heat.

The following Table 6 shows the relative power savings that result from a decrease in intake air temperature.

Table 6: Effect of inlet air temperature on energy consumption

Inlet temperature (°C)	Relative air delivery (%)	Power Saved (%)
10.0	102.0	+1.4
15.5	100	Nil
21.1	98.1	-1.3
26.6	96.3	-2.5
32.2	94.1	-4.0
37.7	92.8	-5.0
43.3	91.2	-5.8

  - o The compressor should be located such that it draws cool ambient air from outside because the temperature of the air inside the compressor room is high. While extending the air intake from the outside of the building, minimize excess pressure drop in the suction line by selecting a duct of large diameter with the smallest number of bends.
  - o The compressor should be placed where there is no particulate matter. Do not place the compressor near spray coating booths, sawing machines, the buffing section, etc.
- Any moisture in the inlet air to the compressor will affect its performance adversely. The compressor should be placed away from equipment which may add moisture to the atmosphere, for example, rinsing lines, cooling towers, dryer exhaust, etc. If the compressed air is moist the components of the compressed air system will corrode. Also, the specific power consumption will increase.
- Choose the pressure setting in the compressed air system very carefully. Judge/assess the requirement of different compressed air users before connecting them to common compressed air grid. This is the most important criterion for optimizing the efficiency of the compressed air system.
- Segregate users of compressed air on the basis of the pressure they require for proper operation. Set up two or more compressed air grids if needed, with each having the air pressure set according to the requirement of equipment in that particular grid. A single compressed air network will always have delivery pressure set equal to the requirement of the equipment which demands the highest pressure. This is not desirable.
- Some items of equipment in the grid require air at low pressures. Do not use valves to reduce the pressure in the compressed air grid, because it wastes the energy that is consumed in building up the excess pressure. Compressed air pressure must be set at the point of generation.
- Optimization of compressor loading and unloading pressure, and segregation of high and low pressure loads in the compressed air grid can lead to significant energy savings with-

Every 4°C rise in the inlet air temperature results in an increase in energy consumption by 1%, to achieve an equivalent output.

Increase in air discharge pressure by 1 kg/cm^2 above the desired value will result in an increase in the requirement of input power by about 4–5%.

Higher the compressed air pressure, the more expensive it is to provide the air.

In industrial practice the typical acceptable pressure drop is 0.3 bar in the mains header at the farthest point, and 0.5 bar in the distribution system.

out any major investment requirement.

- Minimize the pressure drop in the line between the point of generation and the point of use. Excess pressure drop can result from the following:
    - o Inadequate pipe size
    - o Choked filter elements
    - o Improperly sized couplings and hoses

All these lead to significant energy losses. Table 7 shows typical energy wastage on account of pressure drop created by smaller pipe diameter.

Table 7: Typical energy wastage due to smaller pipe diameter for 170 m^3/h (100 cfm flow)

Pipe Nominal Bore (mm)	Pressure drop (kg/ cm^2) per 100 meters of pipe length	Equivalent power losses (kW)
40	1.84	9.5
50	0.66	3.4
65	0.22	1.2
80	0.04	0.2
100	0.02	0.1

- Clean the air intake filters regularly so that clean air can enter the compressor and permit a low pressure drop across the filters.
- It has been observed that Free Air Discharge (FAD) by compressors increases by as much as 12.5% in some cases by simply cleaning the air intake filters.
- Maintain the proper level of tension in the belt in compressors connected by belt drives. Improper belt tension, loose or vibrating belts can cause an increase in power consumption of the prime mover by as much as 6%.
- Put the right kind of compressor to use. This is specially important in a compressed air network consisting of several compressors of the same or different size, capacity, operational efficiency, etc. The following points should be noted while deciding the operating pattern of compressors
    - o If all compressors are similar, adjust the pressure setting of the compressors so that only one compressor handles the load variation; the others should operate with full load, to the extent possible.
    - o If compressors are of different sizes, the pressure switch should be set such that only the smallest compressor is allowed to modulate (vary in flow rate) according to the demand of compressed air.

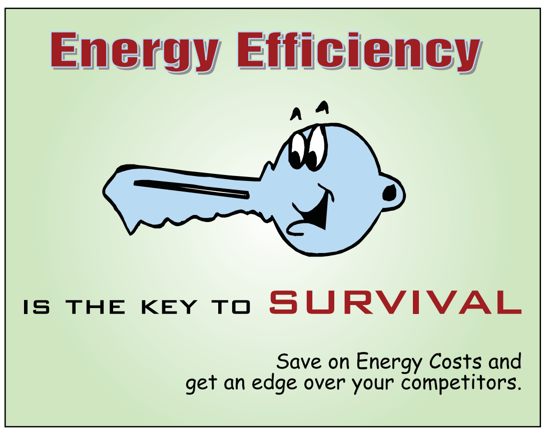


Table 8: Discharge of air (m^3/minute) through orifice (orifice constant C_d = 1.0)

Air Pressure (Bar)	Orifice size in mm						
	0.5	1	2	3	5	10	12.5
0.5	0.06	0.22	0.92	2.1	5.7	22.8	35.5
1.0	0.08	0.33	1.33	3.0	8.4	33.6	52.5
2.5	0.14	0.58	2.33	5.5	14.6	58.6	91.4
5.0	0.25	0.97	3.92	8.8	24.4	97.5	152.0
7.0	0.33	1.31	5.19	11.6	32.5	129.0	202.0

Avoid air leaks and associated energy losses. Conduct leakage tests regularly (once a month) to remove air leaks in the compressed air system. Table 8 shows the loss in FAD through orifices of different sizes in a compressed air grid.

Table 9 shows summary of best operating practices for efficient operation of compressors in foundry units.

Energy Savings in the Electrical Distribution System

The electrical system is an integral part of all foundry units. An efficient electrical distribution system together with demand management can reduce the electricity bill significantly. Adopt the following practices in order to maintain an efficient electrical distribution system.

- Stagger the non-critical load according to the electricity tariff to reduce the energy bill. The benefits of load staggering are shown in Table 10.
- Maintain a high power factor, which will lead to reduced demand, better voltage, high system efficiency as well as rebates from the electricity supplying company. The power factor can be improved by installing capacitors in the electrical system. Table 11 illustrates the benefits of power factor improvements from the point of view of costs.
- Any shortfall in power factor from the desired value can be made up by the use of capaci-

Table 9: Summary of best operating practices for efficient operation of compressors in foundry units

Dos	Don'ts
• Try to locate the compressor suction pipe away from heat sources and moisture sources.	• Don't use valves to reduce the pressure in the compressed air grid because it wastes the energy that is consumed in building up the excess pressure. Compressed air pressure must be set at the point of generation.
• Clean the air filters regularly for minimizing pressure drop.	• Don't leave compressed air leaks unattended. Conduct leakage test once in a month.
• Use proper size of pipe for distribution of compressed air.	• Don't allow the compressors to run with loose or vibrating belts.
• Segregate users of compressed air on the basis of the pressure they require for proper operation.	

Table 10: Benefits of load staggering

Load to be shifted to night shift (10 PM - 6 AM)	10 kW
Assumed working hours per shift	8 hours
Monthly power consumption (30 days/month)	2400 kWh
Electrical cost for night shift operations (@ Rs 3/kWh during 10 PM - 6 AM)	Rs 7200
Electrical cost for general shift operations (@Rs 4.5/kWh)	Rs 10,800
Savings per month	Rs 3,600
Annual savings	43,200 Rs

Table 11: Cost benefit analysis of power factor improvement

Existing load of the unit (KW)	100
Existing power factor	0.9
Desired power factor	0.99
Existing demand (kVA)	111
Capacitor required (kVAr)	~35
New demand (kVA)	101
Reduction in maximum demand (kVA)	10
Monthly savings in demand charges @ Rs 300/kVA	3000
Cost of capacitors @ Rs 250/kVAr	8,750
Simple payback period	3 months

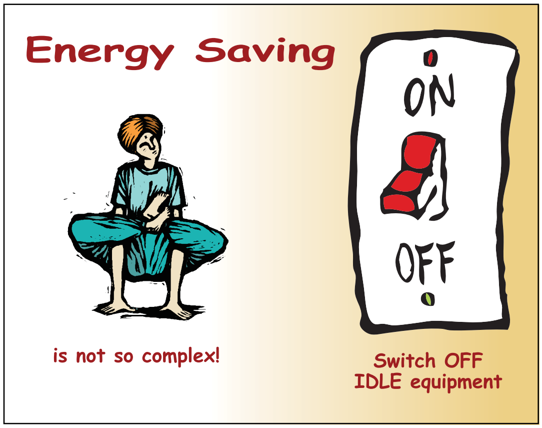
tor banks. Table 12 shows the value of capacitance required per kilowatt to improve the power factor.

- Transformers are normally designed to operate at maximum efficiency between loadings of 32% and 35% of their full capacity. If the load on the transformer increases beyond 80% of the designed capacity, it is better to buy a new or bigger transformer to prevent a sharp rise in transformer losses.
- Control the maximum demand by tripping non-critical loads through a demand control-

Table 12: Multipliers to determine capacitor KVAR required for power factor correction

Original Power Factor	*Desired Power Factor*															
	0.85	**0.86**	**0.87**	**0.88**	**0.89**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.00**
0.85	**0.86**	**0.87**	**0.88**	**0.89**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.00**	
0.85	0.00	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.23	0.26	0.29	0.33	0.37	0.42	0.48	0.62
0.86		0.00	0.26	0.53	0.08	0.11	0.34	0.17	0.20	0.23	0.26	0.30	0.34	0.39	0.45	0.59
0.87			0.00	0.03	0.06	0.08	0.11	0.34	0.17	0.20	0.24	0.28	0.32	0.36	0.42	0.57
0.88				0.00	0.03	0.06	0.08	0.11	0.15	0.18	0.21	0.25	0.29	0.34	0.40	0.54
0.89					0.00	0.03	0.06	0.09	0.12	0.15	0.18	0.22	0.26	0.31	0.37	0.51
0.90						0.00	0.03	0.06	0.09	0.12	0.16	0.17	0.23	0.28	0.34	0.48
0.91							0.00	0.03	0.06	0.09	0.13	0.16	0.21	0.25	0.31	0.46
0.92								0.00	0.03	0.06	0.10	0.13	0.18	0.22	0.28	0.43
0.93									0.00	0.03	0.07	0.10	0.14	0.17	0.25	0.40
0.94										0.00	0.04	0.07	0.11	0.16	0.22	0.36
0.95											0.00	0.03	0.08	0.13	0.19	0.33
0.96												0.00	0.04	0.09	0.15	0.29
0.97													0.00	0.05	0.11	0.25
0.98														0.00	0.06	0.20
0.99															0.00	0.14
1.00																0.00

Required capacity rating (KVAR) = load (kW) x multiplication factor



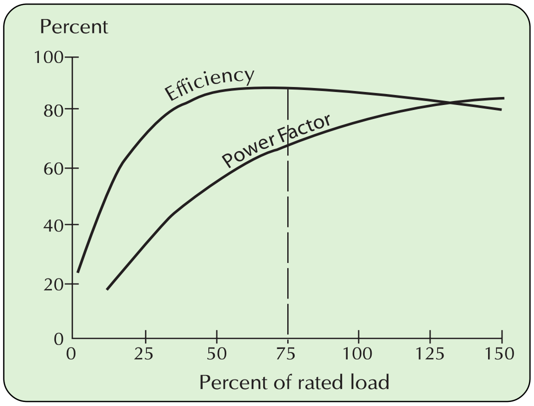


Figure 3: Variation of motor efficiency and power factor with percentage load on motor

ler. This will avoid the penalty levied when usage is greater than the sanctioned load.

- Balance the system voltage to reduce the distribution losses in the system. For every 1% increase in voltage imbalance, the efficiency of the motors decreases by 1%.

> Make sure that the power factor at the main feeder is greater than 0.9 to avoid penalty and further improve it to above 0.95 to avail the rebate from the state electricity board, wherever applicable.

Energy Savings in Electrical Utilities – Motors and DG Sets

Electrical motors are the principal source of motive power in any foundry unit. Machine tools, auxiliary equipment and other utilities come equipped with one or more electric motors. A machine tool can have several electric motors other than the main spindle motor. These are used for allied operations. Motors are generally efficient, but their efficiency and performance depends on the motor load. Figure 3 shows the variation in efficiency and power factor vis-à-vis the total load, for a typical motor.

Since there are many motors in a foundry unit, it is very important to maintain them and adopt proper operating practices. These practices will save a significant amount of energy. A list of such practices and measures is presented below.

- Always use motors sized according to the requirement of the load. It is good practice to operate motors between 75 -100 % of their full load rating because motors run most efficiently near their designed power rating.
- Oversized motors result in energy losses owing to a decrease in efficiency and power factor. Oversized motors can be identified by measuring the actual power drawn and comparing it with the rated power of the motor. Oversized motors should, therefore, be replaced with motors of appropriate rating. The energy and cost benefits resulting from replacing oversized motors are presented in Table 13.
- When replacing motors, always buy energy-efficient motors instead of conventional motors. The cost of energy consumed by a conventional motor during its life is far greater than the incremental cost of the energy efficient motor.
- A properly balanced voltage supply is essen-

Table 13: Benefits of using properly sized motors

Parameter	Existing case	Proposed case
Rating (kW)	15	11
Shaft load (kW)	8.3	8.3
Percentage loading of the motor	55.3	75.5
Power factor	0.75	0.88
Motor efficiency (%)	84	86
Motor input power (kW)	9.88	9.65
Reduction in input power (kW)	–	0.23
Working hours per year	6000	6000
Annual electricity savings (kWh)	–	1380
Monetary savings (@ Rs4.5/kWh)	–	6210
Cost of new motors	–	20,000
Simple payback period (years)	–	3.2

tial for a motor to reach its rated performance. An unbalanced three-phase voltage affects a motor's current, speed, torque, and temperature rise. Equal loads on all three phases of electric service help in assuring a voltage balance while minimizing voltage losses.

- Regular maintenance helps to minimize friction losses, heat losses and extends a motor's life. The motor should be lubricated and cleaned periodically.
- Motors should be rewound only by a qualified person. This will minimize losses in the rewound motor.
- Every time a motor is rewound, its efficiency drops by 2%.
- Motors frequently drive variable loads such as pumps, hydraulic systems and fans. In these applications, the motors' efficiency is often poor because they are operated at low loads. It is appropriate to use a variable speed drive (VSD) with the motor.
- Check motor for over-heating and abnormal noises/sounds, sparking and ensure proper bedding of brushes.
- Tighten belts and pulleys to eliminate transmission losses.
- Install capacitors across motors with a high rating to reduce the distribution losses.

Apart from electric motors, diesel generator (DG) sets are also installed in a majority of foundries, as a source of back up power. Tips to monitor/improve the performance of DG sets are highlighted below:

- The performance of the generator set is monitored in terms of the SEGR (Specific Energy Generation Ratio), which is the ratio of units of electricity generated (in kWh) per unit of diesel consumption (in liters).
- Conduct regular SEGR trials to monitor the performance of the generator. Contact the manufacturer for overhauling if the operating value of SEGR is less than 80% of the designed value at optimum load.
- The SEGR value drops significantly at a loading of below 60%. Try to optimally load the DG sets.
- Ensure that the air intake to the generator is cool and free from dust. Warm air can seriously decrease the generator's performance on account of a reduction in volumetric efficiency.
- Clean the air filters regularly.
- Unbalanced loads on A.C. generators lead to an unbalanced set of voltages and additional heating in the generator. When motors, for example, are fed with an unbalanced

.........................State Electricity Distribution Co. Ltd.
ELECTRICITY BILL FOR THE MONTH OF May-2008 Page 1 of 1

RASTAPETH CIRCLE .... B'GARDEN DIVN ....

No. 170019031210 Alias: .... DTC	**BILL DATE: 04-06-2008** DUE DATE: 18-06-2008
Customer Name: ABC	Last receipt No./Date: PU00804103/13-05-2008
Address: XYZ AREA	Last Month Payment : 95,170.00
Village: .... Pin Code:	DG Set (KVA) : .00
Connected Load (KW) 183.00 Sanctioned Load (KW) 183.00 Supply at: **HT**	Scale/ Sector : Small Scale/Private Sector
Contract Demand (KVA) 156.00 Sanctioned Demand (KVA) 156.00 Prev. Highest (Mth) **NOV**	Activity :
Recorded MD (KVA) 78.00 Meter No. .... Bill Demand (KVA) 117	Seasonal :
Date of Connection 09-10-2006 Tariff 56 HT-IN Elec. Duty **60 PART F ASC %**	Load Shed Ind INDUST
	Express Feeder Flag: No
	Feeder Voltage (KV): 11.0

Reading Date	KWH	KVAH	RKVAH (LAG)	KW (MD)	KVA (MD)
Current 26-05-2008	184039.000	199889.000	63519.000	0.000	40.045
Previous 26-0-2008	177818.000	192770.000	60748.000		
Difference	6221.000	7119.000	2771.000		
Multiplying factor	2.0000	2.0000	2.0000	2.0000	2.0000
Consumption	12442.000	14238.000	5542.000	0.000	80.090
LT. metering	0.000	0.000	0.000	0.000	0.000
Adjustment	0.000	0.000	0.000		
Assessed consumption	0.000	0.000	0.000		0.000
Total Consumption	12442.000	14238.000	5542.000	0.000	80.000
Billed Demand (KVA) 30 @Rs. 300 Assessed P.F. 0.87 Billed P.F. 0.87 L.F. 13					

Observe difference between recorded MD and billing MD, if difference is high for overall year change the contract demand as per requirement.

Maintain PF Above 0.9 to avoid PF Penalty

Consumption Type	Units	Rate	Charges Rs.	E.D. On (Rs.)		Amount Rs.
Industrial	12,442	3.4	42302	59,732.98	6	3583.98
Residential	0	2.6	0.00		12	
Commercial	0	4.6	0.00		13	

Zone	Units	Demand	Charges
A Zone	9,740	80.00	-8,279.00
B Zone	1,780	79.00	0.00
C Zone	416	12.00	332.80
D Zone	506	61.00	556.60

Cr. Adj. Rs. 835 of type PROMPT PAYMENT DISCOUNT Cr. Adj. Rs. 20406 of type interest on Security Deposit ASC Units: 0 Benchmark Consump: 1822 Period from 200711 to 200804

Arrears = Rs. -20.404.70
Interest = Rs. 0.00

FAC2 @ 9 p/u Units: 12442, Amount: 1119.78, ASC@ 536 p/u, Units: 0, Amount: 0; IASC @p/u, Units: 0, Amount: 0

Current time one wise tariffs
Zone A - Rs. 3/KWh (10 PM - 6 AM) Zone B - Rs. 3.85/KWh (6 AM - 9 AM) & (12 PM - 6 PM)
Zone C - Rs. 4.65/KWh (9 AM - 12 PM) Zone B - Rs. 4.95/KWh (6 PM - 10 PM)

	Amount in Rs.	Amount in Rs.
Demand Charges	23,700.00	
Addl. Supply Charges + IASC	.00	
Energy charges	42,302.00	
TOD Tariff EC	-7,389.60	
FAC @p/u + FAC2	1,119.78	
Electricity Duty	3,583.98	
Other Charges	0.00	
Tax On Sale @ Ps./U 4	497.68	
P.F. Penal Charges/P.F. Incentives	2,389.32	
Charges for Excess Demand	0.00	
Reliab Charge@42 p/u	5,225.64	
Debit Bill Adjustments	0.00	
TOTAL/CURRENT BILL		71,429.60
Interest on Arrears Upto 31/05/2008	0.00	
Arrears Payable + S.D. Arr.	-20,404.70	
Total Bill Amount (rounded) Rs.		51,020.00
Delayed payment charges Rs.		1,428.59
Amount payable after 18-06-2008 (Rounded) Rs.		52,450.00

Amount Rounded to Nearest Rs. (10/-)

For maximum benefit, Energy Consumption should be maximum in off peak hours 10 pm - 6 am

Avoid penalty for low Power Factor by installing capacitors

Security Deposit Head Rs. 4,39,750.00 Addl. S.D. Demanded Rs. 0.00 S.D. Arrears Rs. 0.00

E&O.E. And Subject To Conditions overleaf

FIFTY ONE THOUSAND TWENTY ONLY

**** BILL AMOUNT ACCPTABLE Rs. IF PAID ON OR BEFORE 10-06-2008

**** PROMP DISCOUNT Rs. IF PAID ON OR BEFORE 10-06-2008

APR-08	MAR-08	FEB-08	JAN-08	DEC-08	NOV-07
18,214	19,608	15,916	17,298	15,514	22,772

Chief Engineer (Commercial)

Life cost of a motor is often over 100 times the purchase cost

Reduce energy consumption by 10% by changing from delta to star connection

Every 10°C drop in inlet air temperature will lead to a 2% saving in fuel costs

set of voltages, additional losses occur in the motors. Hence, the load on A.C. generators should be balanced as far as possible.

- DG sets require regular and periodic maintenance for efficient running. Carry out maintenance once in a month covering the following points.
  - o Check the level and appearance of lubricant oil. Top up or change the lubricant oil periodically as per the manufacturer's guidelines.
  - o Clean the radiator fans and heat exchanger.
  - o Check the belt condition. Loose or damaged belts will lead to high coolant temperatures.
  - o Optimize the operating frequency of the generator.

Conclusion

It can be seen from Table 14 above that significant energy savings are realizable in the foundry sector by adopting Best Operating Practices and implementing simple housekeeping measures. Various energy intensive sections and processes in any typical foundry unit, which require focused attention for regular upkeep and maintenance for efficient operation, are Cupola, Induction furnace, Core baking kiln, Machine shop and other plant utilities. In general, adoption of the following measures in a variety of foundry units would result in higher energy efficiency, lower operating costs and increased profit and equipment life.

- Be sure that the vents in the cupola bottom doors are open
- The weight of a single piece of metal should be limited to 1% of the hourly melting rate
- 4% oxygen enrichment in a conventional cupola improves the production rate by 25%
- A 2% oxygen level in a divided blast cupola with inclined tuyeres reduces coke consumption by 12.5%
- Keep the size of the charge materials about 1/3rd of the crucible's diameter in induction furnace
- Every 20°C rise in combustion air temperature will raise the thermal efficiency of the furnace by 1%
- Every 4°C rise in the inlet air temperature to air compressor results in an increase in energy consumption by 1%, to achieve an equivalent output
- Install more burners with smaller firing capacities in place of a few burners with larger firing capacity
- Use BEE star rated equipment (minimum 3 star) for considerable energy saving.

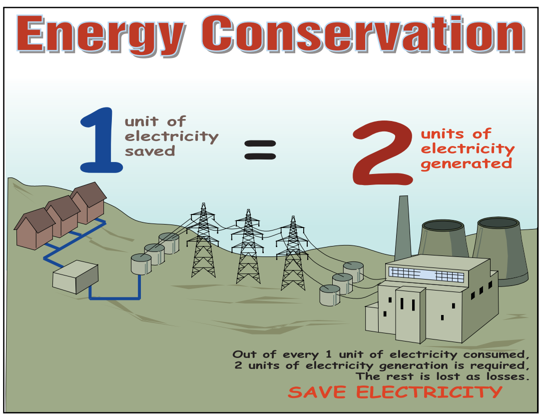
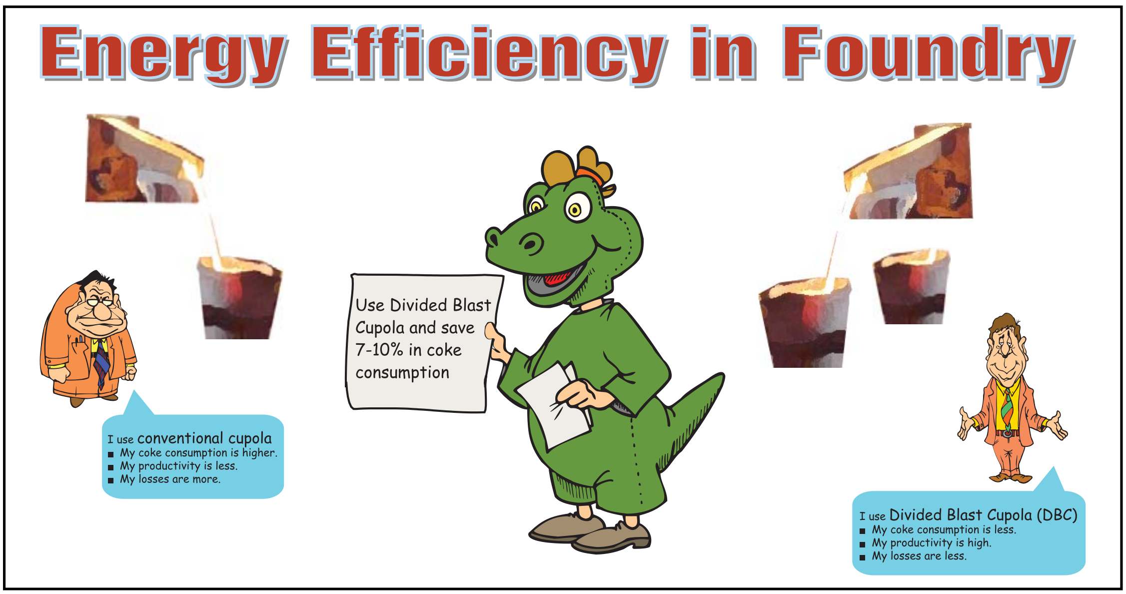


Table 14: Energy conservation potential in different sections of a foundry

Section where Best Operating Practices can be adopted	Energy conservation potential in the section (%)	Remarks
Cupola preparation	1 – 1.5	Maintain proper bed height; maintain adequate charge in the cupola stack before lighting; measure each component of charge before mixing, clear the bottom vent holes.
Cupola operation	10 – 12	Maintain same charging sequence for all components and all buckets; observe colour of slag – it should be green-grey; avoid super heat, use Divided Blast instead of single blast cupola.
Induction furnace	1 – 2	Reduce cycle time; avoid prolonged holding; avoid superheating; maintain suitable stirring index depending on the metal and alloy.
Compressed air system	6 – 10	Regular upkeep of compressors; proper location; suitable pipe size; regular leakage tests.
Electrical distribution system	0.5 – 1.0	Use transformer of correct size; proper loading; capacitors at load ends; segregation of loads; optimizing contract and maximum demand.
Electrical utilities – DG sets and motors	2 - 3	Maintain health of process motors; avoid rewinding of motors; use adequate capacitors; locate DG set correctly; clean filters regularly.



Energy Audit

What is energy audit?

Energy audits indicate the ways in which different forms of energy are being used and quantify energy use according to discrete functions. An energy audit does not provide the final answer to the problem; it identifies where the potential for improvement lies, and therefore, where energy management efforts must be directed. Energy audit is broadly classified as preliminary energy audit and detailed energy audit, as explained below.

Preliminary energy audit

In a preliminary energy audit, the entire audit exercise can be divided into three steps. Step one identifies the quantity and cost of the various energy forms used in the plant. Step two identifies energy consumption at the department/process level. Step three relates energy input to production (output), thereby highlighting energy wastage in major equipment/processes. In a preliminary energy audit study, one basically relies on the data supplied by the unit or panel readings from meters installed in the industry.

Detailed energy audit

A detailed energy audit goes much beyond the quantitative estimates of energy savings and cost savings. It is generally preceded by a plant visit, which is also called a scoping study or preliminary energy audit, wherein the scope of the audit assignment is discussed in detail with the plant personnel. The study involves detailed mass and energy balance of major energy consuming equipments. The system efficiencies are evaluated and measures are identified for improving the end-use energy efficiency. The study proposes specific projects/feasibility studies for major retrofitting/replacement proposals, providing a cost-benefit analysis of the recommended measures. The duration of the audit is a function of the size and complexity of the plant, the areas to be covered under the study, and so on.

Winrock International India sincerely acknowledges the industries for their cooperation and their support extended during the conduct of Energy Conservation Studies at their premises.

- Sandfits Foundaries Pvt Ltd.
- CPC Pvt Ltd.
- Sri Sita Lakshmi Steel Castings Pvt Ltd
- Kovai Auto Products
- KSG Castings and products
- Bright Castings
- Indo Shell Casting
- PSG Foundry
- Coimbatore District Small Scale Industries Association (CODISSIA), Coimbatore
- Indian Institute of Foundrymen (IIF) - Coimbatore Chapter
- Anugraha Valve Castings Pvt Ltd.
- Sarva Lakshmi Foundaries Pvt Ltd.

Government Fiscal Incentives for MSME Sectors

The Ministry of Micro, Small and Medium Enterprises (MoMSME) provides support to activities in MSME units. The schemes that are eligible for the foundry industry are given below.

1. Credit Linked Capital Subsidy Scheme (CLCSS)

Under this scheme, the Ministry of MSME is providing subsidy to upgrade technology (Machinery/ Plant equipments). Subsidy limit per unit is Rs. 15 Lakh or 15% of investment in eligible Machinery / Plant equipments whichever is lower. For more details of the scheme visit www.laghu-udyog.com/schemes/sccredit.htm

2. Credit Guarantee Fund Trust for MSE

This scheme will cover both term loan and working capital facility upto Rs. 100 Lakh. Under this scheme, loan will be sanctioned without any collateral security or third party guarantee. For more details of the scheme visit www.cgtmse.in/

3. Market Development Assistance Scheme

To encourage MSME entrepreneurs to tap overseas market potential and represent India in the overseas market, Government of India is reimbursing 75% of air fare by economy class and 50% space rental charges of stalls for exhibition of their products in the overseas trade fairs / exhibitions. For more details of the scheme visit www.fisme.org.in/MDA%20Faq.doc

4. Quality Upgradation/Environment Management Scheme

Under this scheme charges would be reimbursed for acquiring ISO-9000/ISO-14001/HACCP certifications to the extent of 75% of the expenditure (maximum to Rs. 75,000/- in each case). For more details of the various schemes visit http://msme.gov.in/

5. SIDBI Financing Scheme for Energy Saving Project in MSME Sector

To improve the energy efficiency levels in various MSME sectors, SIDBI is providing loans to eligible projects under JICA line of credit at a nominal rate of interest of 9.5-10% p.a. For more details of the list of eligible projects under this line of credit visit: www.sidbi.in

MSMEs and Green House Gases (GHG) Reduction Benefits

- Implementation of energy efficiency projects leads to reduction in emission of Green House Gases, leading to earning of revenue through carbon credits. The mode of operation for this benefit scheme is under Clean Development Mechanism (CDM). Therefore, also called CDM benefits.
- Generally, for MSMEs, it does not make economic sense to apply for carbon credits individually. This is because the number of credits generated would not be sufficient to even meet the transaction cost associated with the various steps of the CDM cycle.
- To tackle this there are 2 options that MSMEs can make use of, i.e, bundling and Program of Activities (PoA)
- Bundling of CDM projects is an option that has been available for a few years now. Under this option, a number of similar projects can be put together as a single CDM project and submitted for registration to the United Nations Framework Convention on Climate Change (UNFCCC). The transaction costs are reduced in this case.
- PoA is a very new concept wherein a single organization/agency is the organizing entity and it claims the carbon credits and further distributes it amongst the individual units based on the agreement. This is also useful if the technology intervention, i.e, energy efficient measures, fuel switch, etc. are carried out in a phased manner with some units doing it first and the others following suit later. A single umbrella PoA is created that has a life of 28 years. Within this PoA, several CDM project activities can be added without any additional cost. The life of these project activities within the PoA is as much as 21 years.
- MSMEs can make use of forward trading mechanisms where organizations can help them bear the transaction cost upfront and then buy the carbon credits later at a slightly discounted price.

SIDBI Financing Scheme for Energy Saving Projects in MSME Sector Under JICA Line of Credit

The Japan International Cooperation Agency (JICA) has extended a line of credit to SIDBI for financing Energy Saving projects in Micro, Small and Medium Enterprises (MSMEs). This project is expected to encourage MSME units to undertake energy saving investments in plant and machinery to reduce energy consumption, enhance energy efficiency, reduce CO_2 emissions, and improve the profitability of units in the long run.

Eligible Sub Projects / Energy Saving Equipment List Under JICA Line of Credit:

- Acquisition (including lease and rental) of energy saving equipments, including installing, remodeling and upgrading of those existing.
- Replacement of obsolete equipments and/or introduction of additional equipments which would improve performance.
- Equipments / Machinery that meet energy performance standards /Acts.
- Introduction of equipments that utilize alternative energy sources such as natural gas, renewable energy etc., instead of fossil fuels such as oil and coal etc.
- Clean Development Mechanism (CDM) projects at cluster level that involve change in process and technologies as a whole, duly supported by technical consultancy, will be eligible for coverage.

Eligibility criteria for units (Direct assistance)

- Existing units should have satisfactory track record of past performance and sound financial position.
- Projects will be screened as per Energy Saving List, which is available on the SIDBI website.
- Units should have minimum investment grade rating of SIDBI.
- Projects which may result in negative environmental and social impacts are also not eligible under this scheme.

Financial parameters

The financial parameters for appraising the project are:

Parameter	Norms
Minimum assistance	Rs. 10 lakh
Minimum promoters contribution	25% for existing units; 33% for new units
Interest rate	The project expenditure eligible for coverage under the Line will carry the following rate of interest: • Fixed rate: 9.5 to 10% per annum based on rating • Floating rate: 9.75 to 10.5% per annum based on rating
Upfront fee	Non-refundable upfront fee of 1% of sanctioned loan plus applicable service tax
Repayment period	Need based. Normally the repayment period does not extend beyond seven years. However, a longer repayment period of more than seven years can be considered under the line, if necessary

For further details, please contact the nearest SIDBI branch office or refer to the SIDBI website **www.sidbi.in**

Small Industries Development Bank of India (SIDBI)

Small Industries Development Bank of India (SIDBI) was set up under an Act of Parliament viz. Small Industries Development Bank of India Act, 1989 and commenced its operations from April 02, 1990 for financing, promotion and development of Industries in the Micro, Small and Medium Enterprises (MSME) sector and to coordinate the functions of other institutions engaged in similar activities.

Mission

"To empower the Micro, Small and Medium Enterprises (MSME) sector with a view to contribute to the process of economic growth, employment generation and balanced regional development."

SIDBI has been supporting the MSME sector with various innovative schemes and has brought special products for addressing the requirements in the areas of cleaner production measures and energy efficiency, with the support of various multilateral agencies.

Direct Finance Schemes of SIDBI

- **Term Loan Assistance** – For setting up of new projects and for technology upgradation, diversification, expansion, etc., of existing MSMEs, for service sector entities & infrastructure development & upgradation.
- Various other schemes e.g. Working Capital, Inland Letter of Credit, Guarantee Scheme, Equity Support, Vendor Development Scheme & Bill Discounting Facility, Credit Linked Capital Subsidy Scheme etc.

SIDBI has a country wide network of 100 branches to service the MSME sector efficiently.

Eastern Zone
Bhubaneswar
Bhubaneswar MFB
Dhanbad
Durgapur
Jamshedpur
Kolkata
Kolkata MFB
Patna
Ranchi
Rourkela

Northern Zone
Alwar
Baddi
Chandigarh
Faridabad
Ghaziabad
Greater Noida
Gurgaon
Jaipur
Jammu
Jalandhar
Janakpuri
Jodhpur
Ludhiana
Kishnagarh
Kundli
New Delhi
Noida
Okhla
Shimla
Udaipur

Southern Zone
Ambattur
Balanagar
Bengaluru
Bengaluru MFB
Belgaum
Bellari
Chennai
Chennai MFB
Coimbatore
Erode
Hosur
Hubli
Hyderabad
Hyderabad MFB
Kochi
Kozhikode
Mangalore
Nellore
Peenya
Puducherry
Rajahmundry
Tirupur
Trichy
Vishakhapatnam
Vijayawada

Western Zone
Ahmedabad
Ahmednagar
Andheri
Ankleshwar
Aurangabad
Baroda
Chinchwad
Gandhidham
Jamnagar
Kolhapur
Mumbai Bandra Kurla Complex
Mumbai Metropolitan RBBO
Nagpur
Nashik
Panaji
Pune
Rajkot
Surat
Thane
Vapi
Vatva
Waluj

Central Zone
Agra
Aligarh
Bareilly
Bhopal
Bilaspur
Dehradun
Indore
Kanpur
Lucknow MFB
Lucknow RBBO
Raipur
Roorkee
Rudrapur
Varanasi

Guwahati Region
Agartala
Aizawal
Dimapur
Gangtok
Imphal
Itanagar
Shillong
Guwahati
Guwahati MFB

MFB – Micro Finance Branch
RBBO – Retail Business Branch Office

For further details please contact the nearest SIDBI branch
Toll free number: 1800226753. Website: www.smefdp.net, www.sidbi.in

SIDBI has also set up the following subsidiary / associate organizations for the development of MSME sector.

SIDBI Venture Capital Ltd (SVCL)	www.sidbiventure.co.in
Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE)	www.cgtmse.in
SME Rating Agency of India Ltd (SMERA)	www.smera.in
Indian SME Technology Services Ltd (ISTSL)	www.techsmall.com
Indian SME Asset Reconstruction Company Ltd (ISARC)	www.isarc.in