MSME
सूक्ष्म, लघु एवं मध्यम उद्यम
MICRO, SMALL & MEDIUM ENTERPRISES

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

ENERGY IS LIFE
BEE
CONSERVE IT
Bureau of Energy Efficiency

सत्यमेव जयते
Ministry of New and Renewable Energy

Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India

A GEF-UNIDO-BEE Project

Best Operating Practices

Jalandhar Hand Tool Cluster

Published by

Bureau of Energy Efficiency
Ministry of Power
Government of India
4th Floor, Sewa Bhawan,
Sector-1, R K Puram,
New Delhi 110066

Developed specifically for units in the MSME cluster selected under GEF-UNIDO-BEE Project.

Disclaimer

This document has been developed after an extensive consultation with a number of experts and on the basis of BOP documents developed by expert energy auditing agencies engaged earlier under the project. The information contained in this document is indicative and is for information purposes only. BEE disclaim any liability for any kind of loss whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly, resulting from the publication, or reliance on this document.

Conceptualized by PMU, GEF-UNIDO-BEE Project

अभय बाकरे, आईआरएसईई
महानिदेशक
ABHAY BAKRE, IRSEE
Director General

सत्यमेव जयते

ENERGY IS LIFE
BEE
CONSERVE IT

ऊर्जा दक्षता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)

FOREWORD

With its objective to reduce energy intensity of the Indian economy, Bureau of Energy Efficiency has partnered with United Nations Industrial Development Organization (UNIDO) to implement the Global Environment Facility (GEF) funded national project on "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India".

I am pleased to share the handbook on "Best Operating Practices" for MSME units which has been published under the project. This handbook has been conceptualized as a single source of information and is an effort to provide summarized and lively presentation to enhance the knowledge on underlying issues in energy efficiency.

I trust that this book will be able to make wider reach in the clusters and will be greatly accepted by the engineers and managers as a ready reference for enhancing their knowledge and implementation of energy efficient operating practices.

I would like to record my appreciation for members of the Project Monitoring Unit – Shri Milind Deore (Energy Economist, BEE), Shri Niranjan Rao Deevela (National Technology Coordinator, UNIDO) and Shri Ashish Sharma (Project Engineer, BEE) for their hard efforts and tireless commitments to bring out this publication.

I also compliment the efforts of all participating MSME units towards their endeavor in contributing to energy efficiency and making this project a big success.

New Delhi (Abhay Bakre)

चौथा तल, सेवा भवन, आर०के०पुरम, नई दिल्ली-110 066 / 4th Floor, Sewa Bhawan, R.K. Puram, New Delhi-110 066
टेली/Tel.: 91(11) 26178316 (सीधा/Direct) 26179699 (5 Lines) फैक्स/Fax: 91(11) 26178328
ई-मेल/E-mail: dg-bee@nic.in, abhay.bakre@nic.in वेबसाईट/Web-site : www.beeindia.gov.in

ABOUT THE DOCUMENT

As the MSME units are limited in their capacities and lack access to latest technological advancements in the field of energy efficiency, the GEF-UNIDO-BEE project is spread across 12 MSME clusters under 5 different sectors (Brass, Ceramic, Dairy, Foundry and Handtools) with an inclusive approach to promote energy efficient technologies and use of renewable energy.

Under the project, sample energy audits were conducted in each cluster, which helped to understand the basic pattern of energy consumption and possible energy conservation measures in the units within a cluster. As an outcome of the activity, Best Operating Practices (BOP) were identified for each cluster, the implementation of which are very effective, easy to implement and, economically viable to avoid improper use of energy and reduce the energy cost.

Through this handbook energy professionals in the units will be able to identify to the underlying issues with the energy consumption and make quick reference for the best possible solutions.

Contents

CHAPTER 1: Introduction

1.1. Objective

Energy efficient operation of processes and equipment, and conducting periodic planned maintenance in industries are some of the most cost effective methods for improving energy efficiency. Coupled with this is the requirement of trained manpower that can run the plant in a seamless manner by forecasting process / equipment improvement and needs well ahead of any break-down.

This can be achieved by following some best operating practices which have low or no investments. This should be employed right from equipment to process level, and the plant staff needs to be well trained to effectively follow and carry out these best practices in day-to-day running of the plant. The major benefits of adopting and following good practices are:

- Manpower is well trained to identify equipment / process flaws and take remedial actions
- Low cost with negligible investment
- Easily installed / implemented by in-house personnel
- Faster return on investment
- Less complex engineering analysis

1.2. Approach

This best operating practice manual is focused to discuss the common operating, energy efficiency practices and technologies for major energy intensive equipment / processes commonly used by most of the units; and that can be followed and implemented at the component, process, system, and organizational levels in various units within the cluster. The information contained in this manual is intended to help the plant managers to reduce energy consumption in their units in a cost-effective manner, while meeting regulatory requirements and maintaining the quality of products manufactured.

Given the dynamic nature of the production process followed in the units, this guide addresses most common operating problems, issues and bottlenecks (with regard to energy efficiency) being faced by the units within the cluster. To overcome those challenges, it provides notes on best operation and maintenance practices that can be followed. Once implemented, these practices will help not only in improving the operating energy efficiency levels of these equipment / processes, but also in reducing operational downtime.

Although the recommendations in this manual are more of a generalized nature, individual plants can draw references from them to suit their respective production practices.

1.3. About Jalandhar Hand-tool Cluster

The MSME hand tool units of Jalandhar manufacture various products like hammers, hand-saws, screw-drivers, wrenches, chisels, scrapers, wire-strippers, hand drills, pliers, vises, spanners, files, etc.

Figure 1: Various hand tool products manufactured by MSME units of Jalandhar

Although, the size of the units may differ, the production process followed by most of them is similar in nature; and is shown in the figure below:

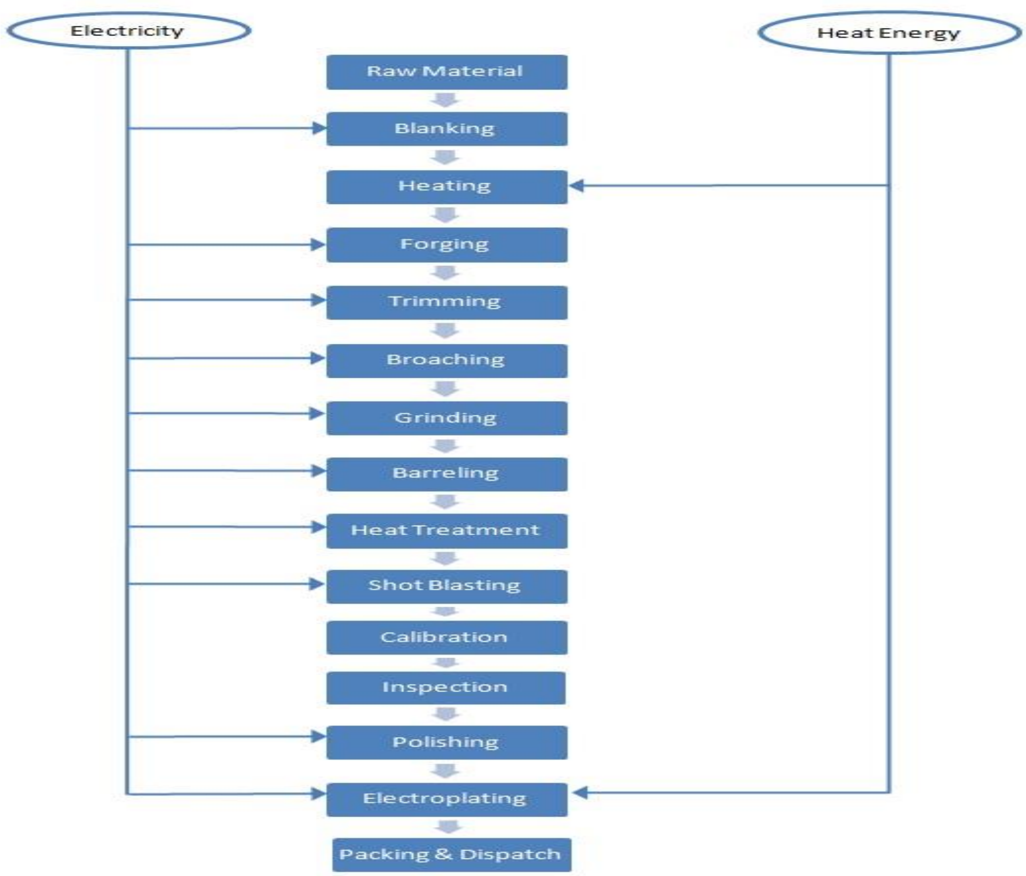

Figure 2: Process flow

Some of the common practices that can be followed by the units are:

- Monitoring of energy consumption by each equipment and maintaining a log book for the same
- Monitoring of electrical parameters for effective load management
- Good housekeeping practices along with periodic checks and maintenance of equipment
- Checking and arresting the compressed air leakages in various processes / equipment
- Providing proper insulation to equipment like forging and heat treatment furnaces, etc.

Normally most of the plants did not take proper housekeeping measures to upkeep these equipment, which results in their poor operating efficiencies. By adopting better maintenance and housekeeping practices, each unit can reduce their energy bills by at least 3 to 5%. This does not require high level of engineering competency or complex engineering designs, and can be implemented with very minimum or no investments. Simple measures like recording and maintaining log-books of fuel consumption, material input to furnace, identifying and plugging leakages in compressed air pipelines, periodic cleaning of electroplating baths and filters of air-compressors, proper lubrication of moving / rotating equipment, etc. can be implemented even by un-skilled workmen of the shop floor level.

CHAPTER 2: Best Operating Practices - Forging Furnace

In the hand tool industry, forging furnace is one of the main energy consuming equipment. Fuel consumed in forging furnaces contributes for around 50% of the total plant energy. The figure below shows a forging furnace and forging hammer in operation in a hand tool unit in Jalandhar.

Figure 3: Forging furnace in a hand tool unit at Jalandhar

Figure 4: Forging hammer in a hand tool unit at Jalandhar

Some of the suggested best operating practices that can be employed are discussed in future sections:

2.1. Measurement of fuel consumption

Accurate measurement of fuel consumption of the furnace and maintaining proper log of the same on a shift-basis is essential to improve furnace operating efficiency. Without records of fuel consumption, any effort towards efficiency improvement shall not bear fruits, as fuel consumption is the major energy input to the furnace.

Presently, in Jalandhar hand-tool cluster, no flow meter has been installed in any of the furnaces. In such a case, the fuel consumption is measured on a daily basis by measuring the level of the day tanks of individual furnaces (or the fuel tank common for all the furnaces) using dip scales.

Presently, fuel consumption records are not maintained for each of the furnace, and a common average value based on dip scale method of measurement conducted on one or two furnaces is assessed to record fuel consumption for all furnaces of the unit. Although dip-scale method is not a very accurate method of accounting fuel consumption, but it is the best alternative in the absence of online fuel flow-meters.

It is important that at the start of the shift, the furnace operator should make sure that the day-tank of the furnace is filled (with fuel) to adequate level and the same should be marked using dip stick. After intervals of one hour or two hours or on a shift basis, which-ever is convenient based on fuel consumption history of that particular furnace, the final fuel level reading must be recorded and fuel consumption calculated. The fuel consumption for each hour or for each shift needs to be recorded and fuel consumption reports with respect to production (for the particular duration) for each of the furnaces needs to be made. Taking these factors into consideration, the specific fuel consumption per kg of production should be calculated. Based on these reports, best performance of furnace needs to be drawn and the furnace parameters maintained in achieving the best performance needs to be recorded. These parameters can then be made the benchmark parameters to be set for achieving best operating specific fuel consumption.

Apart from the above, it is also recommended to install on-line flow meter at least on the common line delivering oil to the day tanks of the individual furnaces. This will help in measuring, monitoring and accounting oil flow and comparing the total fuel consumption with individual consumptions of furnaces measured with dip-scale method. This will result in reducing measurement errors of fuel consumption of individual furnaces using dip scale method. By continuous monitoring of SEC, deviations due to variations in production, fuel consumption, etc can be inferred and thereby day-to-day operations can be managed accordingly.

Figure 5: Fuel flow meter

2.2. Measurement of furnace production

Along with the fuel consumption, the material output from furnace in kg / hr or kg per shift also needs to be measured to calculate specific fuel consumption per unit of production. The production values have to be recorded both on the basis of weight and also on number of pieces coming out of the furnace. In hand-tool industry of Jalandhar, same furnace is used to heat materials of various sizes, shapes and weights based on various types of products manufactured. The fuel consumption for different types, sizes and weights of products heated in the same furnace shall vary and so shall the furnace efficiency values.

Generally, total weight of products heated in the furnace is not meticulously measured, but rather generalized based on the past experience of weights of products of similar shapes, sizes and specifications. This is not a good operating practice and it is recommended that the number of products (materials) coming out of the furnace be manually counted and the weight of a sample number of materials be measured. Taking the average weight of the sample, the total weight of materials heated could be calculated.

Proper recording of production from an individual furnace will also help in estimating the operating efficiencies of each of them. Based on the same, the reasons for good or not-so-good performance for all the furnaces can be investigated more precisely. Various factors like inefficiency or slackness on the part of the workman operating the furnaces, improper loading of material in the furnace, too much heat loss due to poor insulation, etc could be the reasons for one furnace operating less efficient than the other. Remedial actions for the reason for poor performance of that particular furnace can be taken to improve its efficiency.

It is recommended to install calibrated load cells to measure the weight of the materials at inlet and outlet of furnaces. Along with load cells, proper collection baskets / bins of known capacities need to be placed for collecting and transferring forged materials from the forging section to the next section.

2.3. Maintaining optimum excess air for combustion

It is necessary to maintain optimum excess air levels in combustion air supplied for proper combustion of fuel. The excess air level in combustion air is calculated based on the oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be known from the ultimate analysis of the fuel. All combustion processes require a certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much excess air results in excessive heat loss through the flue gases whereas too little excess air results in incomplete combustion of fuel and formation of black colored smoke in flue gases.

In most of the furnaces in Jalandhar hand-tool cluster, fuel is fired with too much of excess air. This results in the formation of excess flue gases, taking away the heat produced from the combustion and increasing the fuel consumption. This also results in the formation of excess GHG emissions. The excess air **effects the formation of ferrous oxide** resulting in increase in burning losses.

Presently, there are no proper automation and no excess air control systems installed at the forging furnaces to maintain optimum excess air levels. Fuel is fired from the existing burner and no air flow control mechanism is in place for maintaining proper combustion of the fuel. It was found that the oxygen levels in flue gases of forging furnaces both LPG fired and FO fired in various units were above 10% which indicates high amount of excess air supplied than required. This also indicates high amount of heat loss due to dry flue gases in the furnaces. Without proper control systems in place, adequate excess air levels cannot be maintained.

Based on various parameters like weight of material, temperature attained in furnace, insulation status of the furnace, etc.; the excess air levels to be supplied by the FD fan (blower) changes continuously. So, damper control for regulating combustion air supplied may not be a good solution to control excess air.

It is recommended to install online oxygen sensor in the flue gas path (in chimney) and use a PID controller and VFD on the FD fan. The online oxygen sensor will measure the oxygen level in the flue gas and send signal to the FD fan through PID controller. Based on the signal received, the FD fan will auto regulate its speed based on VFD control and consequently regulate flow of combustion air required by the furnace at a particular point of time.

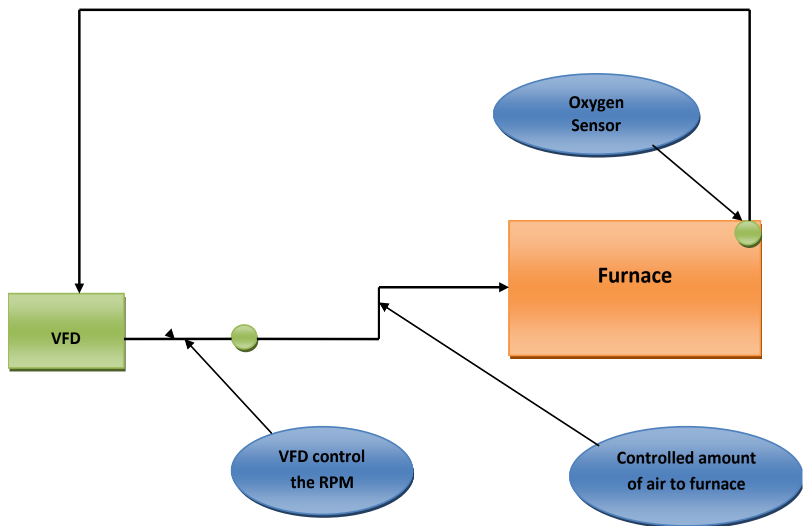

Figure 6: Excess air control system

2.4. Maintaining adequate furnace temperature

Forging furnaces commonly use furnace oil (FO) and LPG as fuel. The forging furnaces are used to heat the raw material (usually, blanks of various grades of steel) to about 1200°C. The production capacities of the furnaces range from 50 kg/hour to 400 kg/hour. In Jalandhar hand-tool cluster, the forging furnaces in use are of continuous pusher type.

It has been observed that though thermocouples are installed on the forging furnaces, but the furnace temperature is manually controlled as no automatic temperature control systems are in place in the furnaces. Fuel is fired continuously and combustion air is supplied by the FD fan. There is no system to continuously monitor and control fuel and air flow. The furnace operator observes and gauges the furnace temperature and, based upon his experience, use the burner's turn-down ratio to manually change the burner firing mode so as to control the fuel and combustion air supply. In absence of temperature control mechanism, the furnace temperature sometimes exceeds the desired temperature levels resulting in material losses due to over-heating, apart from fuel loss.

It is recommended to install proper temperature monitoring and control systems in the furnaces by installation of thermocouples and temperature indicator and control panel; whereby once the requisite furnace temperature is reached, the fuel and combustion air supply is automatically reduced adequately to desired levels as per the material load (production) on the furnace and later on increased when the temperature falls below a certain level. This will also help to determine if the material is under fired or over fired, thereby maintaining the desired quality of material. Better and automatic monitoring and control system to regulate the fuel and combustion air flow, based on the furnace temperature, will result in prevention of heat and material losses from the furnace as well as increase in operational efficiency of the furnace.

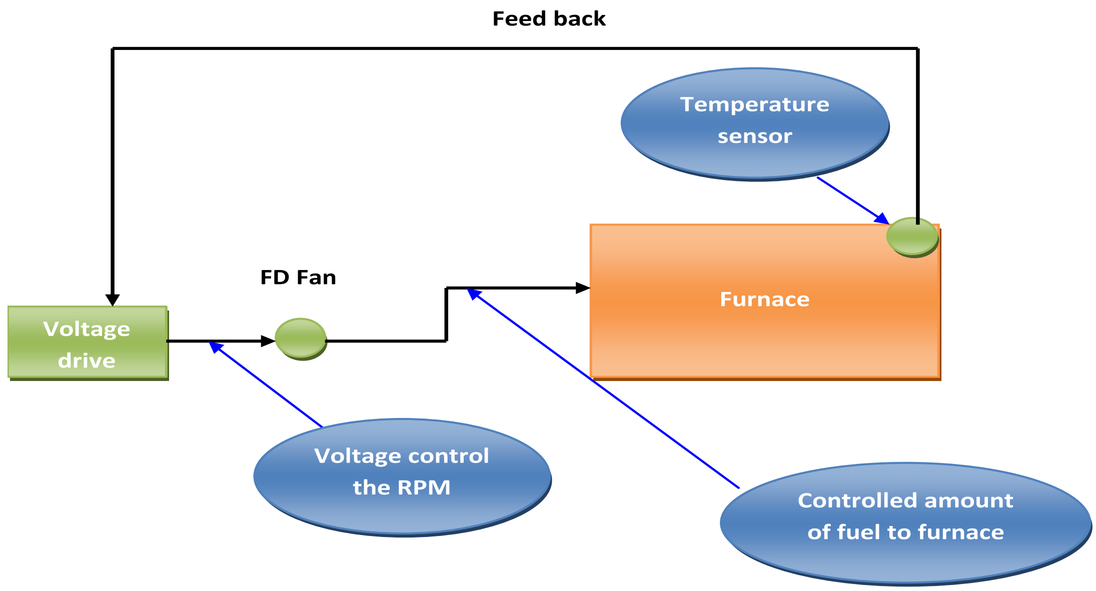

Figure 7: Furnace temperature control

2.5. Maintaining minimum surface temperature of furnace

In most of the forging furnaces, the surface temperature is in the range of 90°C which is high. It is recommended to keep the surface temperature at a maximum of 10°C above atmospheric temperature (approx. 45-50°C) so as to reduce heat losses due to radiation and convection from furnace surfaces, and thus increase furnace efficiency. Providing adequate refractory (**firebricks**) and insulation (**glass wool**) to the furnace and proper maintenance of the same will help to retain the useful heat within the furnace and avoiding heat loss from furnace surface (walls) due to radiation and convection.

Proper insulation is achieved by providing a layer of material with low heat conductivity between the internal hot surface of a furnace and the external surface, thus keeping the temperature of the external surface low. The choice of an insulating material must be based on its ability to resist heat conductivity and the highest temperature it can withstand. Firebrick is the most common form of refractory material. Glass wool is the most common insulation provided on furnaces, and they are wrapped with aluminum foils providing an additional layer of insulation.

2.6. Limiting losses due to openings in furnaces

Forging furnaces usually have two openings – for charging of blanks and for removal of heated materials. Both these openings are necessary for operation of the forging furnace. The openings in the furnace result in losses due to radiation. The losses are higher if the sizes of openings are large; and lesser if openings are smaller in size.

It is commonly observed that the sizes of the openings are usually larger than required, mostly due to safety considerations during design. The sizes of openings can be reduced to an extent that they do not hamper smooth operation of charging and removal of materials from the furnace. One of the retrofits that can be implemented is providing a cast door for the forging furnace.

Apart from the above, sometimes cracks and other damages in the furnaces occur due to excessive wear and tear resulting in useful heat loss. These losses can be minimized by periodic (once every month) checks and maintenance on door warping, cracks and other damages.

2.7. Utilization of residual heat during fresh start of furnace

In Jalandhar hand tool cluster, most of the units operate for 8-12 hours per day. When the unit is not operational, the furnace also remains shut and no heating takes place therein. During heating process, the furnace's operating temperature reaches about 1150 to 1200°C, and during new start the following day, the operator first heats the furnace to its desired temperature for duration of 1.5 to 2 hours by firing fuel in the empty furnace. This is an unwanted fuel loss occurring in those units that do not operate for 24 hours. To minimize this loss, it is recommended that as a good practice, the units need to improve the insulation of the furnace and close the furnace openings at the material feeding and material removal area with insulated metallic removable doors. This will help in storing most of the residual heat in the furnace from its previous day's operation; so that when the temporary doors of the furnace are opened the next day for starting the furnace, there is still heat inside.

2.8. Utilization of waste heat for pre-heating FO and combustion air

Flue gas temperature at furnace exits has been observed in the range of 600°C. In furnaces using FO, the flue gas was used to pre-heat the FO to make it viscous and flow through the pipeline for firing. The flue gas temperature at the exit of the recuperator (for heating the FO) is in the range of 250 to 300°C. This temperature is quite high and contains useful heat that could be used for pre-heating the combustion air of the furnace or used for pre-heating water used in electroplating baths for units having electroplating section.

It is also observed that the recuperators are chocked and proper heat-transfer not taking place through them. The flue gas ducts also have many pores and flue gas leakages from those pores is also observed. To better utilize the waste heat in the flue gases, it is recommended to repair the pores in the flue gas ducts, clean the recuperators at regular intervals, at least once a month, and remove any material deposits, etc. from the recuperator so that it performs to its design efficiencies.

2.9. Proper heat distribution in furnace

Proper placement of burners and equal distribution of heat throughout the furnace is essential for the proper operation of the furnace. The following point explains best practices in furnace operation for uniform heat distribution:

- The flame should not touch any solid object. Any obstruction will de-atomize the fuel particles, thus affecting combustion and create black smoke. If flame impinges on the stock, there would be increase in scale losses.
- If the flames impinge on refractories, the incomplete combustion products can settle and react with the refractory constituents at high flame temperatures.
- The burner flame has a tendency to travel freely in the combustion space just above the material. In small furnaces, the axis of the burner is never placed parallel to the hearth, but always at an upward angle. Flame should not hit the roof.
- For small furnaces, it is desirable to have a long flame with golden yellow color while firing furnace oil for uniform heating.
- The flame should not be too long that it enters the chimney or comes out through the furnace top or through doors. Then major portion of additional fuel is carried away from the furnace.

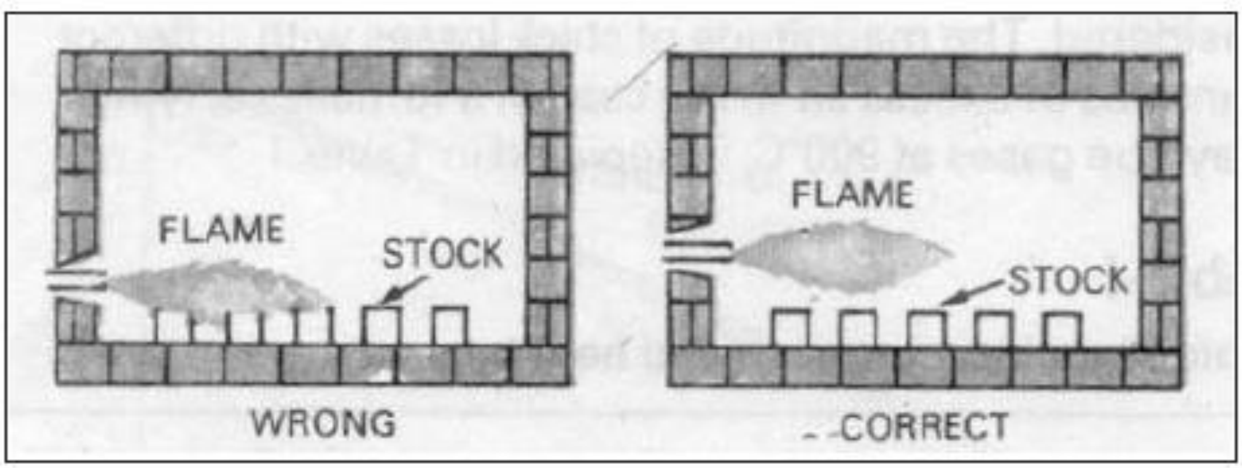

Figure 8: Burner replacement

2.10. Maintaining adequate furnace draft

During operation, the furnace should be maintained at slightly positive pressure. The following points explain the importance of the same:

- If negative pressures exist in the furnace, air infiltration occur through the cracks and openings, thereby affecting air-fuel ratio control.

- Neglecting furnace pressure results in problems of cold metal and non-uniform metal temperatures, which affect forging.
- Slight positive pressure should be maintained in the furnace.
- Negative draft could result in leaping out of flames, overheating of the furnace refractories leading to reduced brick life, increased furnace maintenance, burning out of ducts.
- Important to keep the openings as small as possible and to seal them in order to prevent the release of high temperature gas and intrusion of outside air through openings such as the charging inlet, extracting outlet.

CHAPTER 3: Best Operating Practices - Air Compressor

Make sure compressed air is best alternative for this application: Although compressed air can be a very versatile utility, not all applications are best served by it. The cost of compressed air often is overlooked because of the convenience and ergonomic advantages it provides. Many of the productivity improvements in automated manufacturing processes have been achieved through the appropriate use of compressed air.

3.1. Location of compressor

The fresh air intake should be cold (and not humid / moist). This is achieved by locating compressor in a well ventilated area and drawing cold air from ambient. Every 4°C rise in inlet air temperature (into the compressor) increases power consumption by 1%. It is also recommended that the compressor should be located near the point of usage so as to reduce the pressure drop across the pipeline. The figure below shows the internals of a screw type air compressor.

Figure 9: Screw type air compressor

3.2. Regular maintenance of air filters

Ambient air enters the compressors through air filters. It is observed that the air filters are choked most of the time due to deposition of dust, etc which flows along with the ambient air. The dusts deposited on the filters prevent air from flowing freely through the compressor intake valve and also causes pressure drops across the filter. It is recommended that the air filters be cleaned regularly (once a week) so as to remove the dust and particulate matter that is trapped in the filters.

3.3. Monitoring pressure of air receiver and at the point of usage

The maximum allowable working pressure of air receivers should never be exceeded except when being tested. Each air receiver should be equipped with at least one pressure gauge and an ASME safety valve of the proper design. A safety release valve shall be installed to prevent the receiver from exceeding the maximum allowable working pressure. The air pressure at the point of usage should be monitored by installing pressure gauges, which will help in identifying any pressure drop that can happen from generation to usage end.

3.4. Deliver air at lowest possible rate of pressure

By operating their systems at the highest rate of pressure, operators increase the air consumption of their end uses, number of system leaks and the overall energy consumption within the system. This means that to reduce energy consumption, leak rate and compressed air consumption, operators must use their equipment at the minimum practical pressure levels while reducing compressor discharge pressure.

3.5. Use storage carefully to manage demand

Operators should only have the necessary number of compressors required to meet demand in use at a given time during operations. However, significant levels of backup storage are required within the system to ensure that peak demands are met. To ensure that demand is met in an effective way, operators should optimize automatic sequencing of their compressors to keep the most efficient systems online and perform according to the needs of the plant through the plant's changing cycles.

3.6. Repair all leaks, beginning with the most significant

A comprehensive leak analysis can help units to understand the causes behind inefficiencies within their operations. Within busy compressed air operations, it is common to discover a 20-30% leakage rate, costing lakhs of rupees per year. This means that employing an aggressive leak detection programme can help units reduce energy expenditure significantly.

3.7. Shut off systems that are not required for applications

For those compressed air systems that are not required for a specific application, operators should shut off the system and have a process in place for managing the shut-off stage. The expense of compressed air means that units often lose system efficiency by sending compressed air into plant areas when it is not required. A simple shut-off process and an analysis of system requirements throughout the day can help reduce costs.

3.8. Quality check in air distribution lines

Compressed air lines should be made of materials that cause lesser friction between flowing compressed air and the pipe internal surface (for eg. PVC pipes), thereby reducing pressure drop in the pipelines. Further, the pipelines should be fitted with secure connections. Flexible hoses, if used, should be checked to make sure they are properly connected to pipe outlets before use. Air lines should be inspected frequently for identifying defects, if any; and any defects (leakage, loose joints, etc) once identified should be repaired and / or replaced immediately.

3.9. Looping of compressor

There should be a cycle formation in distribution pipeline of compressed air so as to maintain equal pressure at every point as per the process application. Due to this, unloading period of the compressor will increase and help in saving power.

3.10. Reduce moisture carry-over

- Drain fluid traps regularly or automatically
- Drain receiving tanks regularly or automatically
- Service air-drying systems according to manufacturer's recommendations

CHAPTER 4: Best Operating Practices - Electroplating Process

Electroplating is the application of a metal coating to a metallic or other conducting surface by an electrochemical process. The article to be plated is made the cathode (negative electrode) of an electrolysis cell through which a direct electric current is passed. The article is immersed in an aqueous solution (the bath) containing the required metal in an oxidized form, either as an aquatic cation or as a complex ion. The anode is usually a bar of the metal being plated.

Articles are electro-plated to (i) alter their appearance; (ii) provide a protective coating; (iii) give the article special surface properties; and (iv) give the article engineering or mechanical properties. The figure below shows an electroplating bath.

Figure 10: Electroplating bath in operation

The electroplating section consists of a boiler/electric heaters, electrolytic bath and rectifier for producing DC current. Some of the best practices that can be followed in the process are:

4.1. Temperature monitoring

In each of the electroplating baths, proper monitoring and control of temperature should be done by installing thermocouple so that required temperature for the process can be maintained in the baths. Based on the signals sent by the thermocouple sensors, once the desired bath temperature is reached, the heaters of the bath can be shutoff automatically and they can be automatically switched on when the bath temperature goes below certain set point.

4.2. Cleaning of electrodes

The electrodes of the electroplating baths should be cleaned periodically so as to remove the chemical deposition over them. This will reduce the percentage of voltage drop in the system right from source to end usage.

4.3. Maintaining proper material handling records

It is recommended to maintain proper records for a number of materials (spanners, etc) dipped into the electroplating bath and material coming out of the bath. This is necessary to compute the time and energy (heat) utilized in electroplating one set of materials. This will help in benchmarking best operations with respect to energy consumed. For different sizes, weights and quantity of materials will have different time required and heat / electricity required for electroplating process. Maintenance of records of time taken and materials handled for each batch will act as an MIS tool for plant management to check the performance of each batch and initiate remedial measures when any batch consumes more energy or takes longer time than expected for batch of materials of known size, shapes and weights.

4.4. Monitoring the hot water generator (boiler) - Fuel input and hot water (steam) output

A boiler or a hot water generator is used to generate hot water / steam required to heat the electroplating baths (nickel baths, chromium baths) and water cleaning bath to the desired temperatures of 65 to 70°C. The heat is transferred from the hot water to the bath by indirect method where the hot water is inside the pipes (coils) which are passed all around the bath.

In Jalandhar, in general it has been found that the fuels used in the boiler / hot water generators are usually HSD or wood and the amount of fuel consumed in the boiler is not measured on an hourly or a shift or a daily basis. Unit's keeps records for fuel purchased, but same fuel being consumed in both boiler and DG sets is not separately measured for either of the equipment system. Given such a situation, the efficiency of hot water generator / boiler cannot be computed. It is recommended to install fuel measurement, monitoring and recording system for both solid as well as liquid fuels used in hot water generators / boilers for electroplating process.

Apart from fuel measurement system, the steam generation parameters like temperature, pressure, flow along with the flow and temperature of return condensate from electroplating baths is also generally not measured. It is essential to measure all these parameters. Steam generation pressure for electroplating operations is usually 3 to 3.5 kg / cm^2 at saturated condition. But it is essential to know if the steam pressure being generated is actually required or if only hot water (at lesser pressure) could be generated which will help in reducing fuel consumption. Measurement and monitoring the flow of hot water / steam will help to calculate the actual energy being used for the electroplating baths. This can be further compared with design values to check if they are within ranges or not and corrective actions like maintenance / cleaning of baths & electrodes, checking pipelines for any chocking, etc can be taken if it is found to be consuming more hot water / steam than required.

4.5. Location of the boiler/ hot water generator

The boiler should be located closer to the electroplating section so that the length of pipelines carrying the steam is minimized. By doing so, the temperature and pressure drop across the steam pipeline can be reduced.

4.6. Checking of steam / hot water pipeline insulation

The steam / hot water generated in the boiler is transferred to the electro-plating baths through pipelines. These pipelines need to be insulated adequately, so as to minimize the heat loss due to radiation and convection from the pipe surface. It is recommended to conduct a periodic check of the steam pipelines and measure its surface temperature so as to maintain the same temperature upto a maximum of 10°C above ambient temperature. If any hot spots are observed, then proper remedial actions need to be undertaken.

4.7. Time scheduled cleaning of electroplating baths

The baths should be cleaned periodically, as it helps in removing the corrosive deposits that can accumulate along the walls. This will help in increasing the heat transfer rate between the material and the metal to be coated on the material (nickel, chromium etc).

CHAPTER 5: Best Operating Practices - Motor

Most of the processes like blanking, trimming, broaching, forging, etc. which are used in manufacturing of hand tools are equipped with motors. The total energy contributed by motors is 50 -60% of the total plant electrical energy. All the motors can perform efficiently when they are used and operated properly. As the load varies, the efficiency also varies.

5.1. Regular upkeep and operation

- **Preventing under-loading of motors.** If the motor is under loaded, i.e. it is operating at loads below 40%, change from star-delta to permanent star mode is an inexpensive and effective measure, as it requires only re-configuring of wiring at terminal box and resetting the over current relay. It helps in a voltage reduction of √3 times.
- **Properly lubricate moving parts.** Some motors have sealed bearings that require no servicing. For others, regular lubrication will avoid unnecessary wear. It needs to be ensured that appropriate types and quantities of lubricant are applied. Applying too little or too much can harm motor components.
- **Keep motor couplings properly aligned.** Correct shaft alignment ensures smooth & efficient transmission of power from the motor to the load. Incorrect alignment puts strain on bearings and shafts; shortening their lives and reducing system efficiency. Shaft alignment should be checked and adjusted regularly; should be parallel and directly in line with each other. Many couplings have hard rubber inserts that can degrade, so rubber dust on the equipment base may indicate problems.
- **Properly align tension belts and pulleys when they are installed, and inspect them regularly to ensure that alignment and tension stay within tolerances.** Abnormal wear patterns on belts may indicate problems. Loose belts may squeal and slip on the pulley, generating heat. Correctly tensioned pulleys run cool. Excessive tension strains bearings and shafts, and shortens their lives.
- **Maintain bearings by keeping them clean, lubricated, and loaded within tolerances.** Proper belt tension or shaft alignment minimizes strain on the bearings and helps them achieve their expected life.
- Pay particular attention to bearings on motors equipped with VFDs. These can be prone to shaft currents, which can cause serious damage to the bearings.
- **Check for proper supply voltages.** Unbalanced power, i.e. three-phase motors where the supply voltage to the phases varies by more than 1%c, can lead to overheating and reduced motor life.
- **Avoid painting motor housings.** Paint acts as insulation, increasing operating temperatures and shortening motor life. One coat of paint has little effect, but years of paint buildup can have a significant effect.
- **Periodically inspect commutators visually.** Potential problems with commutators (which are only required for DC motors with brushes) will be seen as discolorations, flat spots, or burn marks. Color patterns can be normal as long as they appear around the entire

commutator. If problems are noticed, commutator should be removed or repaired, or key components should be replaced.

5.2. Energy monitoring and record keeping

- **Maintain an up-to-date motor inventory.** The inventory should include all substantial motors, but can begin with the largest and those with the longest run times. This inventory lets facility managers make informed choices/decisions about replacement, either before or after a motor fails. Field-testing motors before they fail can help ensure that replacements are properly sized.

- **Keep maintenance logs.** These logs should contain vital information such as the make, model, serial number, type, and specifications of each motor; the locations and specifications for belts, pulleys, etc.; and a historical record of maintenance activities. This helps the maintenance staff remember when tests, inspections, or servicing are due. It also allows the staff to quickly identify spare parts or replacements when needed. In addition, comparing recent test results to past values can provide early indications of reduced motor performance.

5.3. Smart replacement strategies

- **When a motor fails, use an appropriately sized replacement.** Many motors are oversized for their applications, resulting in poor motor efficiency and excessive energy use. If a motor fails, it should be replaced with a similar sized, energy-efficient motor. Doing so will reduce the operating costs, since the new motor should operate closer to its point of maximum efficiency (generally around 75% of the motor's rated horsepower). In these situations, it should be verified that the new motor can still provide sufficient output under all operating conditions. For replacing a failed motor with a new energy-efficient model, the planning should be made in advance. Stocking premium-efficiency replacements for critical motors can help avoid the hasty replacement of a failed motor with a standard efficiency model that happens to be the only one available on short notice. Maintenance staff can decide which motors warrant such advanced planning.

- **Replace, rather than rewind, motors when appropriate.** Many motors have been rewind more than once, with a typical loss of nearly 1% in efficiency at each rewind. These motors may be much less efficient than their nominal ratings, making them good candidates for replacement when they next fail. It is more common to rewind larger motors due to their high capital cost. But these motors usually operate at very high duty, and even a modest efficiency improvement may make it worthwhile to replace them with new, premium-efficiency motors rather than repairing them.

Table 1: Maintenance schedule for motors

Description	***Comments***	***Maintenance Frequency***
Motor use/ sequencing	Turn off or sequence unnecessary motors.	Weekly
Overall visual inspection	Verify equipment is operating and safety systems are in place.	Weekly
Check bearings and drive belts	Inspect for wear, and adjustment, repair, or replace as necessary.	Weekly
Motor alignment	Look for rubber or steel savings under couplings, or listen for odd noises as these may indicate a problem.	Weekly
Motor condition	Check condition by analyzing temperature or vibration, and compare to baseline values.	Quarterly (or as needed on weekly inspections)
Cleaning	Remove dust and dirt to facilitate cooling.	Quarterly
Check lubrication	Ensure bearings are lubricated as recommended by manufacturer.	Annually (or based on run hours)
Check mountings	Secure any loose mountings.	Annually
Check terminal tightness	Tighten any loose connections.	Annually
Check for balanced three-phase power	Troubleshoot unbalanced motor circuit and fix problems if the voltage imbalance exceeds 1%.	Annually
Check for over – or – under voltage conditions	Troubleshoot motor circuit and fix problems if the supply voltage differs significantly from rated voltages.	Annually

5.4. De-merits of motor re-winding

Generally two types of winding are used in the motor.

1. ***Lap winding*** - It is the winding in which successive coils overlap each other. It is named "Lap" winding because it doubles or laps back with its succeeding coils.
2. ***Wave Winding*** - In wave winding, a conductor under one pole is connected at the back to a conductor which occupies an almost corresponding position under the next pole which is of opposite polarity.

When a motor is designed for a specific mechanical output, the electrical specifications are also designed accordingly.

1. The type of winding in the stator is also designed as per application. If the requirement of voltage is high then wave winding is preferred and when requirement of current is high then lap winding is preferred.
2. The number of turns of copper or aluminum coil in one span or pole pitch is fixed. When a motor is designed, then the total number of turns is fixed for generating a specific amount of magnetic field inside the stator.
3. When motor is designed, then the air gap between rotor and stator is also fixed and it is uniform in interior peripheral of stator with rotor.

When the motor is re-wounded after some period of time, following technical problems will occur:

1. It may so happen that, the air gap in a rewound motor may not be uniform. This is due to the fact that the person repairing the motor might have tried to maintain the requisite numbers of turns in one span or pole pitch.
2. The number of turns in all three phase is not uniform; due to this, flux generating current is also not uniform or same for the three phases of the motor.
3. The leakage of flux is generated because of mismatching or fitting of the conductor on the rotor.
4. Sometimes the rotor axis is not fixed, due to which the overall flux is less than or greater than the design flux.

Due to one or combination of the above, the electrical power consumption of a re-wounded motor increases and its efficiency decreases.

CHAPTER 6: Best Operating Practices – Pumping System

6.1. Introduction

Pumps used in units/industries are generally centrifugal type. The main function of the pump is to convert energy of a prime mover into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. Improvements in efficiency of pumping systems can also:

- Reduce energy costs
- Reduce maintenance requirements
- More closely match pumping system capacity to production requirements.

Figure 11: Centrifugal pump

6.2. Efficient pumping system operation

To understand a pumping system, one must realize that all of its components are interdependent. When examining or designing a pump system, the process demands must first be established and most energy efficient solution introduced. For example, does the flow rate have to be regulated continuously or in steps? Can on-off batch pumping be used? What are the flow rates needed and how are they distributed in time?

The first step to achieve energy efficiency in pumping system is to target the end-use. A plant water balance would establish usage pattern and highlight areas where water consumption can be reduced or optimized. Good water conservation measures, alone, may eliminate the need for some pumps.

Once flow requirements are optimized, then the pumping system can be analysed for energy conservation opportunities. Basically this means matching the pump to requirements by adopting proper flow control strategies.

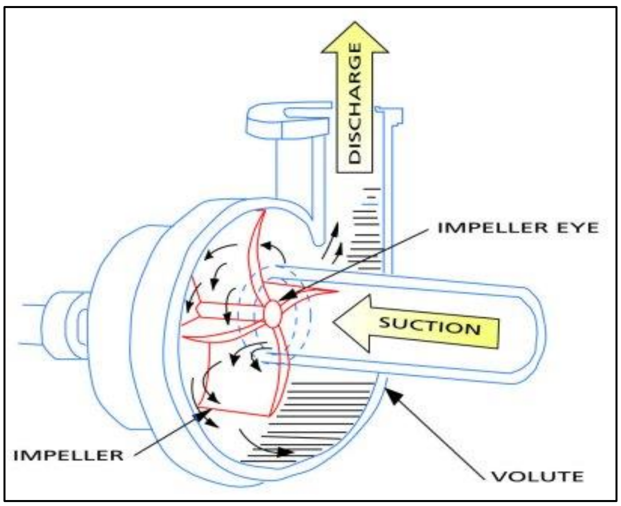

Figure 12: Sectional view of a pump

Common symptoms that indicate opportunities for energy efficiency in pumps are given in the table below:

Table 2: Symptoms that indicate potential opportunity for energy savings

Symptoms	Likely reason	Best solutions
Throttle valve-controlled systems	Oversized pump	Trim impeller, smaller impeller, variable speed drive, two speed drive, lower rpm
Bypass line (partially or completely) open	Oversized pump	Trim impeller, smaller impeller, variable speed drive, two speed drive, lower rpm
Multiple parallel pump system with the same number of pumps always operating	Pump use not monitored or controlled	Install controls
Constant pump operation in a batch environment	Wrong system design	On-off controls
High maintenance cost (seats, bearings)	Pump operated far away from BEP	Match pump capacity with system requirement

6.3. Best operating practices for pumps

BOP 1: Location of pump

The location of pump plays a significant role in energy consumption pattern for pumping unit. Guidelines for efficient pumping system are:

- Ensure adequate Net Positive Suction Head (NPSH) at site of installation
- Operate pumps near best efficiency point.
- Avoid pumping head with a free-fall return (gravity);
- Reduce system resistance by pressure drop assessment and pipe size optimization

BOP 2: Measurement and control

The pump efficiency can be determined by regular monitoring of key performance parameters like pressure, discharge flow etc.

- Ensure availability of basic instruments at pumps like pressure gauges, flow meters.
- Modify pumping system and pumps losses to minimize throttling.
- Repair seals and packing to minimize water loss by dripping.
- Balance the system to minimize flows and reduce pump power requirements.

BOP 3: Use of variable speed drives

- Adapt to wide load variation with variable speed drives or sequenced control of multiple units.
- Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.

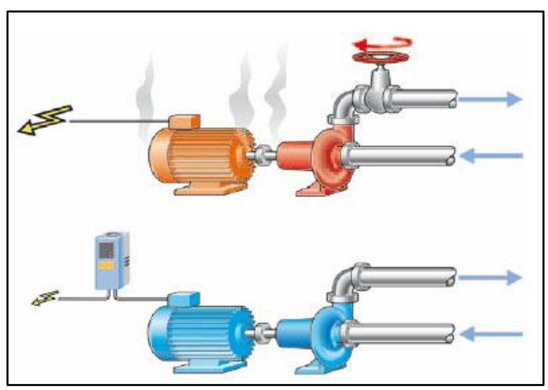

Figure 13: Pictorial depiction of use of VFDs in pumps

➲ BOP 4: Pumping system design consideration

The efficiency of the pumps depends predominately by the design of the pumping system and selection of pumps of right capacity.

- Increase fluid temperature differentials to reduce pumping rates in case of heat exchangers.
- Conduct water balance to minimise water consumption
- Avoid cooling water re-circulation in DG sets, air compressors, refrigeration systems, cooling towers feed water pumps, condenser pumps and process pumps.
- In multiple pump operations, carefully combine the operation of pumps to avoid throttling
- Provide booster pump for few areas of higher head
- Replace old pumps by energy efficient pumps
- In the case of over designed pump, provide variable speed drive, or downsize / replace impeller or replace with correct sized pump for efficient operation.
- Optimise number of stages in multi-stage pump in case of head margins
- Reduce demand on Pumping System: Demand on pumping system can be reduced by:
    - Reducing consumption
    - Reducing leaks
    - Lowering pumping system flow rate
    - Lowering the operating pressure
    - Operating the system for a shorter period of time each day
    - Having the system off when not needed.

6.4. Do's and Don'ts in pump operation

The common dos and don'ts for efficient pumping operations are:

Table 3: Summary of best operating practices for efficient operation of pumps in hand-tool units

Do's	Don'ts
• Replace throttling valves with speed controls	• Do not use inefficient pumps
• Reduce speed for fixed load	• Avoid pumping head with a free return (gravity)
• Replace motor with a more efficient motors	• Avoid water loss by dripping
• Ensure adequate NPSH at site of installation	• Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area.
• Provide metering of components (such as flows, kWh)	• Avoid inadequate NPSH
• Operate pumps near best efficiency point	• Do not run the system when not needed
• Use booster pumps for small loads requiring higher pressures	• Avoid over loading the pump system

CHAPTER 7: Best Operating Practices - Electrical Distribution, Lighting & DG System

Best operating practices for electrical distribution system, lighting system and DG sets are given below:

7.1. Electrical distribution system

- Phase/line voltage and line current monitoring of the transformer by analog/digital voltmeter and ammeter helps to check proper balancing of voltage and current in the electrical distribution line. This helps to avoid unbalancing situation in the system which affects the performance of the equipment and break down in the manufacturing process.
- Proper arrangements should be made for cooling of transformers, electrical panels and drive panels to avoid unwanted shutdown and accidents. It also improves safety of the equipment as well as safety of the workers.
- Secondary side cable size of the transformer to the equipment should be proper as per the load demand to avoid over heating of the cable which can cause accidents.
- Periodic check-up of the capacitor banks are required to maintain the power factor (PF). De-rated capacitor banks should be immediately replaced to maintain the PF close to 0.99 or unity. Improved PF will reduce the demand (kVA) from grid and also reduce the line losses leading to energy savings.
- Continuously monitoring electrical parameters like V, I, PF, kW and kWh by installing energy monitoring system at each process, incomer side thereby loading of the system can be found out, which helps in proper load and energy management.
- Load sharing of transformers: If more than one transformer is there in the unit, shifting of load from one transformer to the other, thereby making the transformers to operate nearby 50% load. This will reduce the losses and increase the efficiency.

7.2. Lighting system

- Schedule to clean the lighting fixtures periodically, i.e. removing dirt from the luminaries, occasionally cleaning and re-painting the walls and ceiling of the room; and occasionally cleaning air supply vents to prevent unnecessary dirt distribution.
- Proper record of the lighting inventory helps to identify the failure frequency and new installation to choose better lighting fixtures in terms of life and energy consumption.
- Separate feeder for lighting to monitor the energy consumption and to operate at required voltage (single phase at 220 V). This can induce energy savings and decrease the failure rate of the lighting fixtures.

7.3. DG system

- In DG, log sheets should be maintained properly which includes fuel consumption, number of hours of operation and number of units generated, etc. Using these parameters, the specific fuel consumption (SFC) or specific energy generation ratio (SEGR) of the DG can be calculated. This will help in performance study of the DG regularly.

- Digital energy meter with parameters of V, I, PF, kVA, kW, Hz and kWh will help continuous monitoring on DG for the proper load and energy management. DG on loading of less than 30% load is operated very inefficiently and increases the specific energy generation ratio (SEGR). There is also requirement of frequency (Hz) monitoring of DG (less than 50 Hz) to maintain the SEGR. Sometimes DGs are operated at more than 50Hz which results in poor SEGR.
- If 2 DGs are there, during light load condition, instead of operating two simultaneously, operating a single DG at a slightly higher load by keeping other shut down is a better practice.
- The air filters should be checked and cleaned periodically; otherwise it will lower the combustion efficiency of DG.

ABOUT PROJECT

With an aim to develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in the selected energy-intensive MSME clusters, Bureau of Energy Efficiency (BEE) in collaboration with United Nations Industrial Development Organization (UNIDO)) is implementing a project titled "Promoting Energy Efficiency and Renewable Energy in Selected MSME cluster in India" funded by Global Environment Facility (GEF) and co-financed by Ministry of Micro, Small and Medium Enterprises (MOMSME) and Ministry of New and Renewable Energy (MNRE).

The project is being executed in 12 selected MSME clusters in 5 varied sectors (brass, ceramics, dairy, foundry and hand tools) identified as the most energy consuming sectors.

Project Component

- Increased capacity of suppliers of EE/RE product suppliers/ service providers/ finance providers.
- Increasing the level of end-use demand and implementation of EE and RE technologies and practices by MSMEs.
- Scaling up of the project to a national level.
- Strengthening policy, Institutional and decision making frameworks

Project Activities

- Conducting techno-economic studies at the unit and cluster level
- Assisting in information sharing
- Conducting training and awareness workshops to share experiences and knowledge on energy efficiency and renewable energy measures
- Assisting in detailed planning of the implementation of energy efficiency and renewable energy measures
- Providing initial financial assistance will be provided to "first movers" for a demonstration project
- Assisting in identifying financial resources for energy efficiency and renewable energy measures
- Training on best operating practices
- Capacity building of local service providers to provide energy efficiency and renewable energy services and products to the MSMEs
- Facilitation of "Energy Management Cells" at the cluster level

Project Beneficiaries

MSMEs shall be the key beneficiaries of this project as they shall receive technical, as well as, financial benefits from the implementation of energy efficient technologies.

With the increased use of energy efficiency and renewable energy, the capacity of energy efficiency and renewable energy product suppliers, service providers and finance providers will also increase.

For any further information and clarification related to project activities, please contact:

GEF-UNIDO-BEE Project Management Unit
BUREAU OF ENERGY EFFICIENCY
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, Sector – 1, R. K. Puram, New Delhi - 110 066
Telephone: +91 11 26179699, Fax: +91 11 26178352
E-mail: gubpmu@beenet.in

Details of GEF projects on energy efficiency being implemented by BEE can be found on www.indiasavesenergy.in