MSME
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MICRO, SMALL & MEDIUM ENTERPRISES

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ENERGY IS LIFE
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Bureau of Energy Efficiency

Ministry of
New and
Renewable
Energy
सत्यमेव जयते

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

A GEF-UNIDO-BEE Project

Best Operating Practices

Nagaur Handtools Cluster

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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

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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)

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation

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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.

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CHAPTER 1: Introduction

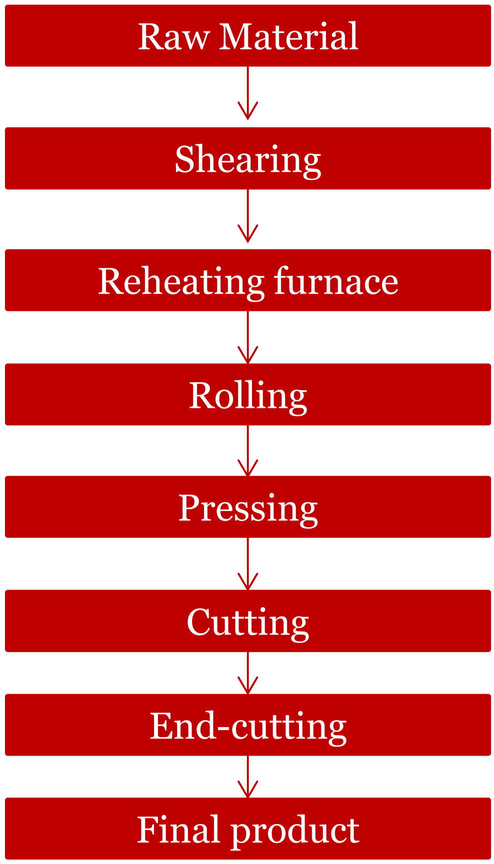
1.1. Brief about the project

GEF-UNIDO-BEE project titled "Promoting energy efficiency and renewable energy in selected Micro Small and Medium Enterprises (MSME) clusters in India" is developing and promoting market environment for introducing energy efficiency and renewable energy in process applications in 12 selected energy-intensive MSME clusters in India which includes Nagaur Handtools cluster also. The overall motive of this project is to improve the productivity and competitiveness of units as well as to reduce carbon emissions and improve the local environment.

The 'Nagaur Handtools Cluster' located in Nagaur, Rajasthan is one of the selected cluster under the project, wherein the units are being supported to adopt energy efficient and renewable energy technologies and practices. Hand Tools Industries Association, Nagaur is the cluster level project partner association which has collaborated to carry out the activities in the cluster.

1.2. About the cluster and production process

Nagaur Hand-tools cluster is dominated by manufacturing units of pliers, hammers, etc. established mostly in Basni road industrial area and finishing units established in Loharpura area in Nagaur. A typical process flow for hand-tools industry in Nagaur is depicted below for reference:



From process point of view, reheating furnace is the major energy consuming equipment followed by motors which are used for providing motive power to common shaft, shearing machine, press machines, etc.

However, in case of finishing units in Loharpura, major processes include broaching for cutting teeth in pliers, drilling for making hole for rivet, riveting of pliers, preliminary hardening of pliers teeth and packaging. Herein, major energy consuming equipment is motors which are used for driving common shaft for machines. There is also little usage of LPG which is used for hardening of plier teeth.

CHAPTER 2: Best Operating Practices - Installation of Automatic Power Factor Controller (APFC)

Existing scenario of power factor in plants of Nagaur cluster is very poor. Even capacitors have been installed some capacitors for the improvement of power factor but maintenance and monitoring of the capacitors is not good. In the units, various process are carried out under different load condition, therefore it is not easier to maintain power factor with the help of those installed capacitors. In different type of loading condition, improvement in power factor to unity can be achieved with the installation of some additional capacitors if required and the installation of APFC panel helps in reducing the electricity bill amount by availing the benefit of incentive on improving the power factor.

In the handtools industry, presently some capacitors are already installed during the plant setup. But with the rise in load to increase the production capacity, the plant owner has not installed the additional required capacitors. It is difficult for the technicians to maintain the power factor at unity in absence of APFC panel. If the reactive power is provided in excess than the requirement, then the plant has to pay penalty for that to state electricity board. Therefore, it is very important to provide the reactive power to the unit according to the load conditions of the plant. For that the implementation of capacitors with APFC panel is very important. APFC panel switches ON and OFF the capacitors according to the requirement and maintain the power factor to unity. So that by installing APFC panel, plant can maintain the power factor for respective lagging load. It will not require manual operation as it automatically select capacitor bank as per requirement.

Power factor is improved by the installation of capacitors and replacement of the existing de-rated capacitors. This technology is

- simple in monitoring
- requires less maintenance
- requires no additional manpower
- easy to install

By providing incentive on improving the power factor to the consumers the State Electricity Distribution Board is promoting the awareness on importance of power factor improvement.

CHAPTER 3: Best Operating Practices - Installation of Electric Billet Heater

In Nagaur handtools cluster, there are handful industries that are using electric billet heater in their units. Induction billet heating system comprises of following major elements:

- Solid state power supply unit
- Capacitors
- De-ionized water circulation unit
- Interconnecting flexible cables
- Heating coil assembly
- Mechanical handling system

Solid state power supply unit conditions the incoming power suitable to operate induction furnace. The incoming three-phase supply at 50 Hz is converted into a DC using a three phase diode rectifier. The DC supply is converted to a single phase AC at required frequency using single-phase IGBT based Voltage source (series) inverter. The Power Supply Unit consists of fast acting semiconductor grade back up semi-conductor fuses, diode six pulses, DC smoothing choke & capacitors, single phase IGBT bridge inverter, controlled electronics with necessary feed-back elements and power supply, protection circuits, a set of fault indicating lamps, meters, push buttons, interconnecting bus bars, flow monitoring switch and conductivity meter. All these components are fitted into a dust proof MS cubicle.

Medium Frequency capacitors are used to form a tank circuit with the inductor coil. This presents resonant load to the inverter. Water-cooled tubes to ensure proper cooling at the joint provide the electrical connections to the main bus bars. Carbon-free rubber hose pipes are used for inlet and outlet water connection.

De-mineralized water is used for cooling various components in a closed loop. The de-mineralized water circulation system consists of:

- Water storage tank
- Non-ferrous pump with stand by pump
- Plate type heat exchanger (made of SS grade 316)
- Mixed bed resin cartridge and inter-connecting pipelines

Inter connecting bus bars between capacitors and coil carry large reactive currents. Adequately rated EC copper bus bars with high contact past at contact points are used to keep the losses minimum.

The induction heating coils are specially designed as per job dimensions, fitted in an insulated box enclosure and lined with special graded high alumina refractory. A robust base frame is provided for mounting the heating coil. These heating coils are cooled by DM water.

The induction billet heating system is specially designed for heating billets of diameter 32 mm to 36 mm at a temperature of 1050 °C for forging application. Heating coils are connected with quick release water coupling for easy interchanging between the set of heating coils.

The feeding system comprises of a variable time that drives the feeding for transporting the billet through the heating coil at a constant speed. Main parts of mechanical handling system are in feed chain conveyor mechanism, job detecting device, tractor drive system & multiple chain type quick extraction system with necessary connections etc.

The billets are loaded manually on the in-feed chain conveyor mechanism. A detecting device will sense the movement of job and it will protect the system against possible jamming while feeding the job. Inside the heating coil the billet slides on SS Water cooled guide rails.

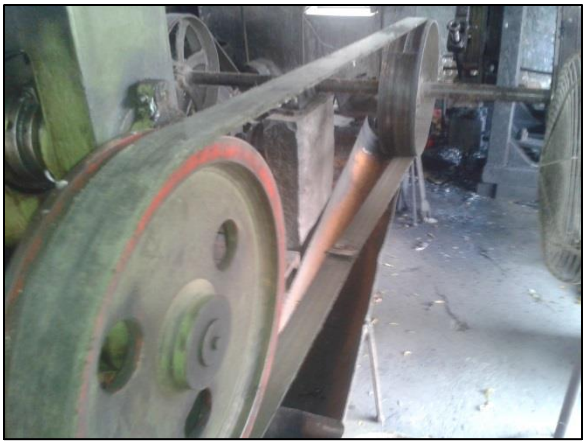
At the exit end the hot billets are automatically ejected piece by piece and conveyed to press / hammer via extraction system. This is still an unexplored option in the cluster primarily due to following reasons:

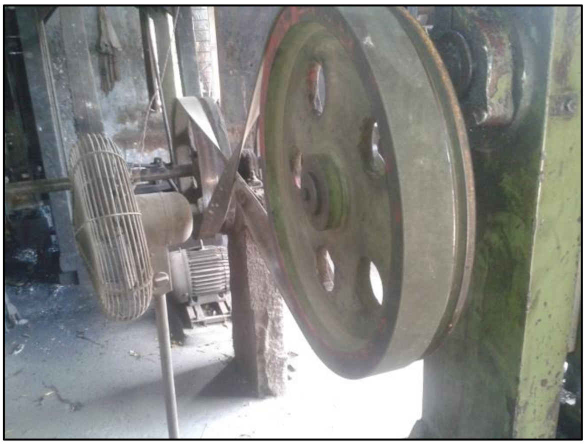
- High initial capital requirement for equipment
- Need to increase contract demand from State Electricity Board (AVVNL)
- Need of installation of dedicated transformer due to higher contract demand

CHAPTER 4: Best Operating Practices - Installation of Cogged Belt on Load Side and Poly-V Belt on Common Shaft Drive Side

In Nagaur, almost all the handtools industries are utilizing common shaft drive with belts for running different loads of the plant barring a few units which are using induction billet heaters or dedicated drives for different loads. The belts being used on drive side are usually V-belts but these belts are old and are wearing out fast; whereas flat belts are used on load side which are highly inefficient and are almost on the verge of breaking. Poor quality of belts does affect the electricity consumption of common shaft motors.

A snapshot of existing belts and pulleys is provided below:





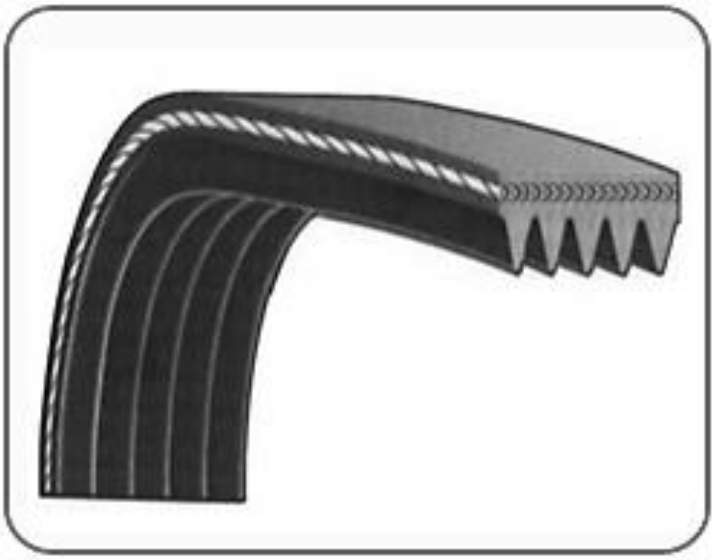
A good practice for such systems, which are mostly driven by belts, is to install cogged belts on load side and poly-V belts on drive side. These installations will also require modification in pulleys as well since existing pulleys are flat and without any crowning.

The majority of belt drives on drive side use classical V-belts which have a trapezoidal cross section to create a wedging action on the pulleys to increase friction and improve the belt's power transfer capability. V-belt drives can have a peak efficiency of 95 to 96 % at the time of installation.

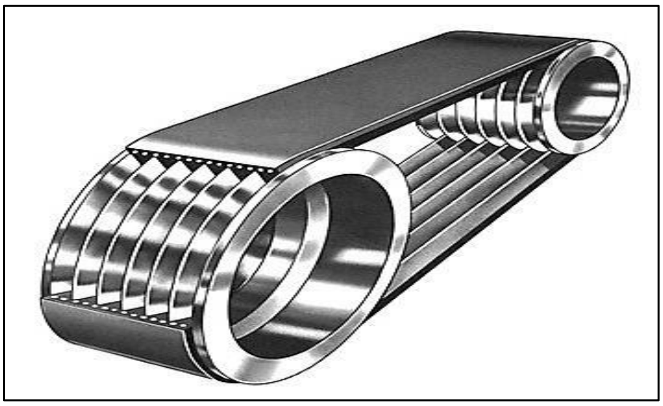
However, efficiency is also dependent on following major factors:

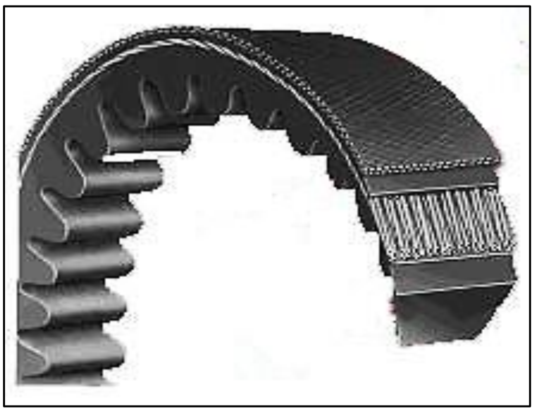
- Pulley size
- Driven torque
- Under or over-belting
- V-belt design and construction

Over the time, the efficiency deteriorates by as much as 5 % (to a nominal efficiency of below 90 %), if slippage occurs because the belt is not periodically re-tensioned. The suggested option is a poly-V belt for drive side which has number of V-belt type trapezoidal sections along the length of the belt. A snapshot of **poly-V belt** is shown below for reference:



Installation of these belts would require special type of pulley rather than traditional crowned pulleys for easy running of these belts. A snapshot of **pulley for poly-V belt** is shown here for reference:



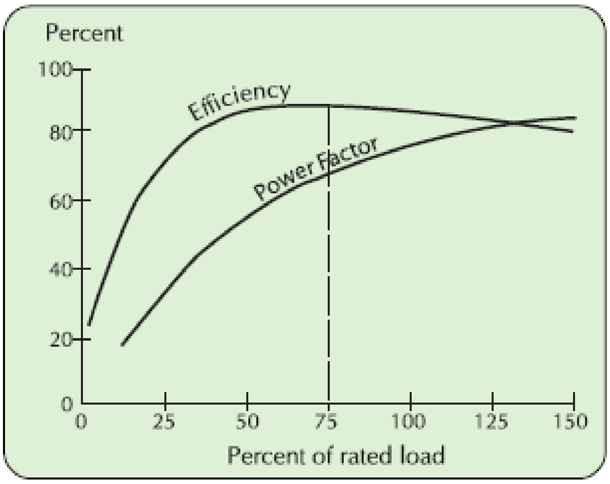


On the load side, low efficiency flat belts are used which should be replaced by energy efficient cogged belts which have slots that run perpendicular to the belt's length. The slots reduce the bending resistance of the belt. Cogged belts can be used with the same pulleys as equivalently rated V-belts. They run cooler, last longer, and have an efficiency that is about 2 percent higher than that of standard V-belts. A snapshot of **cogged belts** is shown here for reference:

CHAPTER 5: Best Operating Practices - Motors

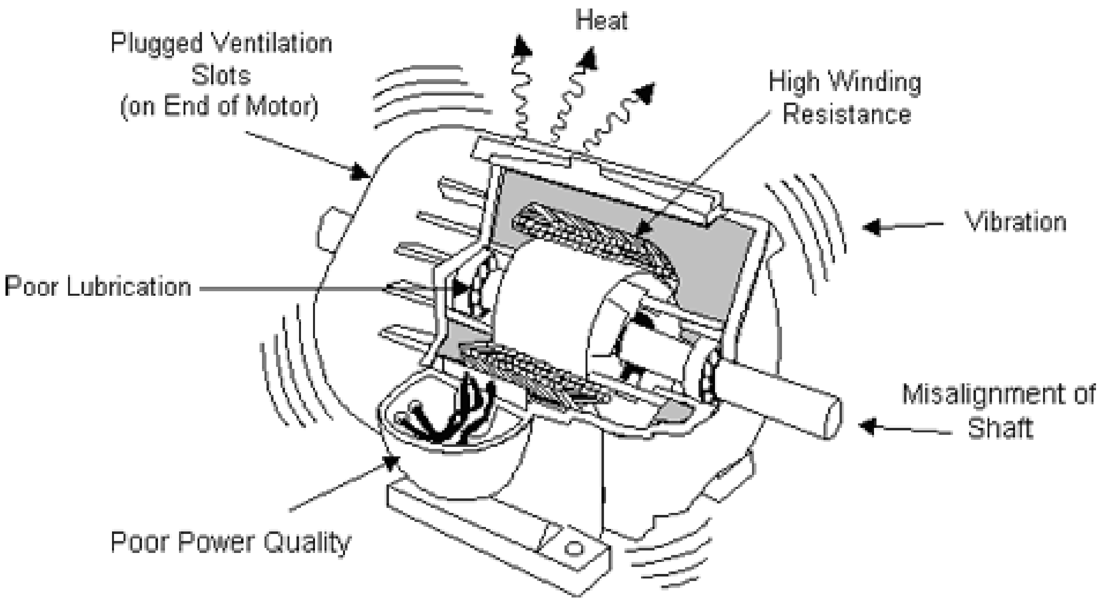
5.1. Motors description

Electrical motors are the principal source of motive power in hand tools units. 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. Below figure shows the variation in efficiency and power factor vis-à-vis the total load, for a typical motor.



Motor efficiency / power factor vs load curve

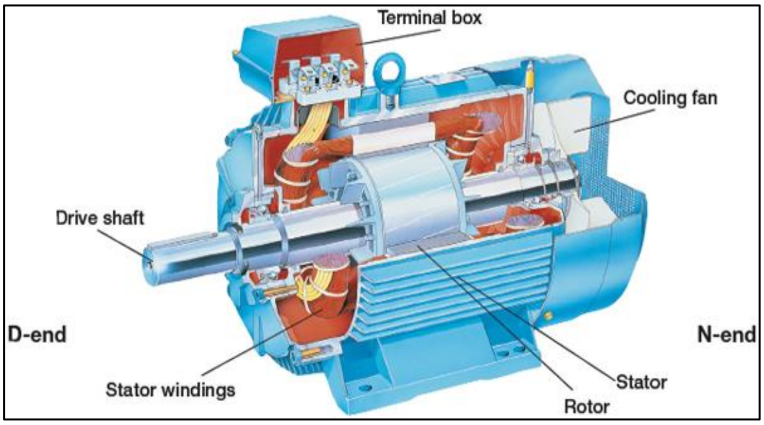
Since there are different types of motors in a hand tool unit, it is very important to maintain them and adopt proper operating practices. As they run for years, motors can become less efficient because of wear, breakdown of lubricants, and mis-alignment. Good motor-maintenance practice helps avoid or postpone these problems. A lack of maintenance can reduce a motor's energy efficiency and increase unplanned downtime. Scheduled maintenance is the best way to keep the motors operating efficiently and reliably.



Operational problems of a motor

5.2. Types of motors

➲ Induction motors

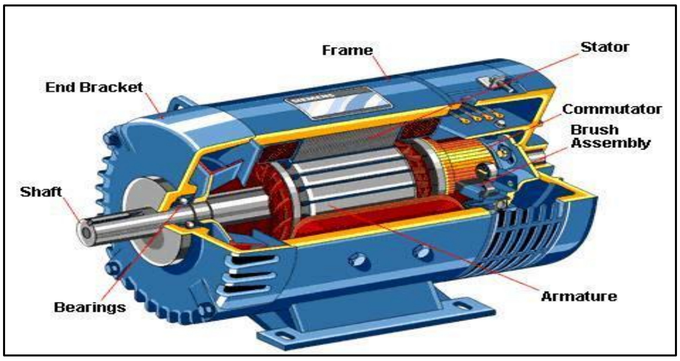


Sectional view: induction motor

Induction motors are the most commonly used prime mover for various equipment in industrial applications. In induction motors, the induced magnetic field of the stator winding induces a current in the rotor. This induced rotor current produces a second magnetic field, which tries to oppose the stator magnetic field, and this causes the rotor to rotate. The 3-phase squirrel cage motor is the workhorse of industry; it is rugged and reliable, and is by far the most common motor type used in industry. These motors drive pumps, blowers and fans, compressors, conveyers and production lines. The 3-phase induction motor has three windings each connected to a separate phase of the power supply.

➲ Direct-Current motors

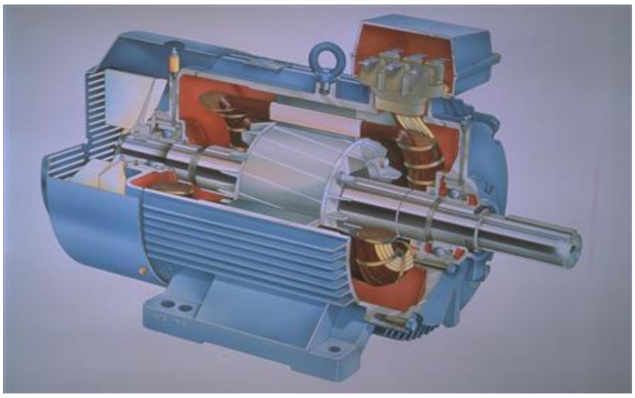
Direct-Current (DC) motors, as the name implies, use direct-unidirectional current. Direct current motors are used in special applications- where high starting torque or smooth acceleration over a broad speed range is required.



Sectional view: DC motor

➲ Synchronous motors

Synchronous Motor is called so because the speed of the rotor of this motor is same as the rotating magnetic field. It is basically a fixed speed motor because it has only one speed, which is synchronous speed and therefore no intermediate speed is there or in other words it is in synchronism with the supply frequency. Alternating Current (AC) power is fed to the stator of the synchronous motor. The rotor is fed by DC from a separate source. AC power is fed to the stator of the synchronous motor. The rotor is fed by Direct Current (DC) from a separate source. The rotor magnetic field locks onto the stator rotating magnetic field and rotates at the same speed. The speed of the rotor is a function of the supply frequency and the number of magnetic poles in the stator. While induction motors rotate with a slip, i.e., Revolutions Per Minute (rpm) is less than the synchronous speed, the synchronous motor rotate with no slip, i.e., the rpm is same as the synchronous speed governed by supply frequency and number of poles. The slip energy is provided by the D.C. excitation power.


Synchronous motor

5.3. Best operating practices for motors

➲ BOP 1: Replace motors, rather than rewind, motors when appropriate

Motors are generally repaired more than once, with a typical loss of nearly 2 % in efficiency at each rewind. These motors are generally less efficient than their nominal ratings, and must be replaced appropriately. 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 repair them.

➲ BOP 2: Use appropriately sized motors for replacement

- Many motors are oversized for their applications, resulting in poor motor efficiency and excessive energy use. 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.
- 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.

➲ BOP 3: Ensure voltage balance across motor terminals

A properly balanced voltage supply is essential 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. The options that can be exercised to minimize voltage unbalance include:

- Balancing any single phase loads equally among all the three phases
- Segregating any single phase loads which disturb the load balance and feed them from a separate line / transformer

➲ BOP 4: Reducing under-loading

Probably the most common practice contributing to sub-optimal motor efficiency is that of under-loading. Under-loading results in lower efficiency and power factor, and higher-than-necessary first cost for the motor and related control equipment.

- Carefully evaluate the load that would determine the capacity of the motor to be selected.
- For motors, which consistently operate at loads below 40% of rated capacity, an inexpensive and effective measure might be to operate in star mode. A change from the standard delta operation to star operation involves re-configuring the wiring of the three phases of power input at the terminal box
- Motor operation in the star mode is possible only for applications where the torque-to-speed requirement is lower at reduced load.
- For applications with high initial torque and low running torque needs, Del-Star starters are also available in market, which help in load following derating of electric motors after initial start-up.

➲ BOP 5: Regular up-keep

Properly selected and installed motors can operate for many years with minimal maintenance. Nonetheless, regular care will extend their life and maximize their energy efficiency. A list of such practices and measures is presented below:

- Clean motor surfaces and ventilation openings periodically. Heavy accumulations of dust and lint will result in overheating and premature motor failure.
- Properly lubricate moving parts to avoid unnecessary wear. Be sure to apply appropriate types and quantities of lubricant. Applying too little or too much can harm motor components.
- Check motor for over-heating and abnormal noises/sounds, sparking and ensure proper bedding of brushes.
- Tighten belts and pulleys to eliminate transmission losses.

➲ BOP 6: Install variable frequency drives

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 Frequency Drive (VFD) with the motor.

Use of VFDs

➲ BOP 7: Install capacitor banks

Induction motors are characterized by power factors less than unity, leading to lower overall efficiency (and higher overall operating cost) associated with a plant's electrical system.

- Install capacitors banks across motors with a high rating to reduce the distribution losses.
- Capacitors connected in parallel (shunted) with the motor are typically used to improve the power factor.
- The size of capacitor required for a particular motor depends upon the no-load reactive kVA (kVAR) drawn by the motor, which can be determined only from no-load testing of the motor. In general, the capacitor is selected to not exceed 90 % of the no-load kVAR of the motor. (Higher capacitors could result in over-voltages and motor burnouts).

5.4. Do's and Don'ts in motor operations

The common do's and don'ts with regards to operation of a motor have been summarized in below table:

Summary of best operating practices for efficient operation of motors

Do's	Don'ts
• Properly sized to the load for optimum efficiency.	• Avoid misalignment in motor
• Use energy-efficient motors where economical.	• Avoid under-voltage & over-voltage conditions
• Use synchronous motors to improve power factor	• Replace, rather than rewind, motors when appropriate
• Provide proper ventilation	• Avoid slippage due to belt tension
• Demand efficiency restoration after motor rewinding.	• Eliminate variable-pitch pulleys.
• Use flat belts as alternatives to v-belts.	• Eliminate eddy current couplings.
• Balance the three-phase power supply.	• Do not run motors when not in use.

CHAPTER 6: Best Operating Practices – Optimizing Oil Fired Furnace Design

In Nagaur handtools cluster, majority of units are using oil fired furnaces in which burners are manually controlled which usually results in higher fuel consumption. Also, the investment in modification in existing furnace is much lower than installation of induction furnace.

6.1. Introduction

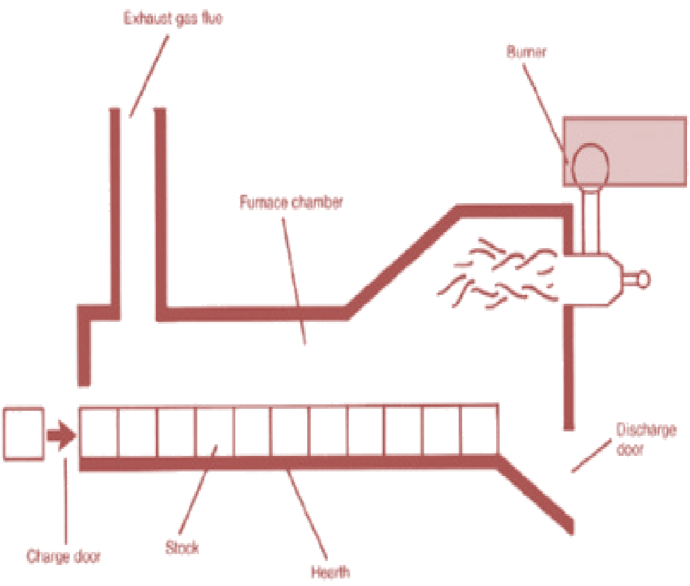
The re-heating furnace is a type of industrial furnace used for heating of metal to its re-crystallization temperature (suitable for plastic deformation) at which metal can be rolled to required shape and size. A typical re-heating furnace uses solid, liquid, or gaseous fuel to provide the required amount of thermal energy for the purpose of heating. Re-heating furnace varies in size from few kilograms to a hundred tones per hour (TPH) capacity.

Re-heating furnace used in hand-tool units

6.2. Operating principle

A re-heating furnace typically consists of a furnace chamber made of refractories and insulation. The heating process in a re-heating furnace is a continuous process where the steel stock is charged at the furnace entrance, heated in the furnace and discharge at the furnace exit. Heat is transferred to the steel stock during its traverse through the furnace mainly by means of convection and radiation from the burner gases and the furnace walls. The charging temperature of the steel stock may range from ambient temperature to 1200^{0}C. The target exit temperature of the steel stock is governed by the requirement of the process of rolling which is dependent on the rolling speed, stock dimension and steel composition. Steel quality aspects put constraints on temperature gradient and surface temperature.

The size of re-heating furnace is usually expressed as the capacity to supply the rolling mill with sufficiently hot steel from the cold stock and is expressed in tons per hour. The energy efficiency of re-heating furnace is usually defined as increase of steel stock heat content when heated from 10 ^{0}C to 1200 ^{0}C divided by the fuel energy (latent heat plus sensible heat) used for it. Many design features of the furnace affects the energy efficiency. These includes i) type of burners, ii) Furnace dimensions, iii) Number of furnace zones, iv) type of wall and roof insulation, v) skid design, and vi) preheating of fuel and combustion air in recuperators by the hot flue gases coming



Re-heating furnace block diagram

out from the furnace exit. An efficient furnace is designed in such a way so that in a given time the steel stock as per furnace capacity is heated to a uniform temperature with the least possible fuel and labour.

6.3. Types of re-heating furnace

The re-heating furnace classification can be done in several ways. These are described below:

- Based on the method of heating, a re-heating furnace can be combustion type or electric type. The combustion type furnace can be oil fired or gas fired.
- Based on method of charging, a re-heating furnace can be classified as batch type or continuous type. In batch furnaces the charged material remains in a fixed position on the hearth until heated to rolling temperature; while in continuous furnaces the charged material moves through the furnace and is heated to rolling temperature as it progresses through the furnace.

Re-heating furnace discharge door

- Continuous furnaces can be further classified based on the movement of steel stock inside the furnace. Based on this classification the continuous type reheating furnaces are pusher type, rotary hearth type, walking beam type, walking hearth type or roller hearth type.
- Based on heat recovery, the re-heating furnace can be either regenerative or recuperative.

6.4. Best operating practices in re-heating furnace

➲ BOP 1: Efficient fuel preparation

Furnace efficiency depends significantly on the type of fuel being used, its chemistry and quality. Different types of fuels have different preparation criteria, which affects the overall efficiency of the furnace.

- For oil fired furnace, pre-heat the fuel feed to attain the required viscosity level. Viscosity is the most important characteristic in the storage and use of fuel oil. Viscosity influences the degree of pre-heat required for handling, storage and satisfactory atomization. If the oil is too viscous, it may become difficult to pump to light the burner as well as tough to operate which causes poor atomization. Therefore pre-heating is necessary for proper atomization as it may result in the formation of carbon deposits on the burner walls.
- For gas fired furnaces, maintain correct discharge pressure of gas at burner tip to avoid carbon deposits in furnace.
- For solid fuel, like pulverized coal, a number of parameters like fuel quality (gross CV), moisture content in fuel, ash content etc. determines the combustion efficiency. Select correct composition of coal to attain optimum combustion efficiency in the furnace. Once, coal is received in the factory, maintain optimum coal fineness and consistency.

➲ BOP 2: Maintaining correct air-fuel ratios

In a re-heating furnace, if air fuel ratio is not properly maintained furnace efficiency decreases by 3-5%. High level of excess air in the flue gas results in excessive heat loss through flue gases, as well as cooling of the combustion chamber due to excess air. In a few cases it was observed that sometimes excess air present in re-heating furnace is less than excess air required for complete combustion. Both the cases lead to improper fuel combustion, which automatically leads to poor furnace efficiency. For optimum air-fuel ratio, following needs to be adopted:

- Determine the quantity of fuel required based on operational condition.
- Calculate corresponding amount of air required for stoichiometric combustion.
- Add percentage of excess air required for complete combustion.
- Determine optimum blower ratings based on manufacturer's recommendation.
- Air-fuel ratio to be monitored and controlled on a regular basis.
- Install automatic air-fuel ratio controller for better control.
- Periodically monitor oxygen percentage in flue gas. Optimum oxygen percentage needs to be maintained based on fuel type and composition.

➲ BOP 3: Selection and sizing of blower system

A proper capacity blower is necessary for combustion air to be delivered at correct pressure and in appropriate volume. Generally blowers are either locally fabricated without any proper design parameters or are under/over- sized without any consideration for correct air pressure.

- Select correct rating of blower as per manufacturers' recommendation
- Do not use locally fabricated blowers without any proper design parameters.
- Place blower near to the furnace to avoid transmission loss.
- Regular maintenance of blower impeller.

➲ BOP 4: Combustion air flow regulation by variable frequency drive

In a typical re-heating furnace, air flow is kept constant irrespective of temperature, draft and excess air in the re-heating furnace. It has been observed that due to inadequate supply of draft and excess air at times, the flames gushes out of the various openings of the re-heating furnace making the furnace operation unsafe. Various manual mechanism viz, damper control, suction control, pulley change etc. are employed for controlling air flow in the furnace which do not provide proper checks & balances for the system.

VFDs to regulate combustion air

- Air flow to be monitored regularly and controlled based on operational variations.
- Use variable frequency drives (VFDs) to regulate the air flow on continuous manner. VFD reduces the speed of the fan for reduced air flow demand, and this speed reduction is achieved by altering the frequency of input power. Hence, power consumption of FD fans will be proportional to the air-flow being delivered to the re-heating furnace.
- The feedback for VFDs can be taken from an online oxygen analyser installed in the flue gas line.
- Along with stoichiometric air required for combustion, a certain amount of excess air needs to be supplied and this excess air varies based on the type of fuel used in the re-heating furnace. E.g. for oil fired furnaces, excess air should be limited to 10% with oxygen limited to 2%. An oxygen analyser is used to monitor the oxygen percentage in the flue gas, It is pertinent to mention here that a 10% reduction in excess air would result in 1% fuel saving.

➲ BOP 5: Waste heat recovery through recuperator

In most of the re-heating furnaces, a large amount of the heat supplied is wasted in the form of exhaust flue gases. These flue gases are at temperature ranging from 400 - 700 ^{0}C, which can be recovered to a certain extent and can be used for pre-heating of the combustion air.

- Pre-heat combustion air using waste heat from flue gas. As a thumb-rule, with every 20^{0}C rise in the combustion pre-heat temperature leads to a fuel saving of 10%.
- Install recuperator of suitable design for pre-heating of combustion air. Efficiency of a recuperator depends on the material and surface area of heat exchange.
- Properly monitor waste heat temperature of flue gas and air pre-heat temperature on a regular basis.
- Frequently clean recuperator tubes for the soot or unburnt deposits. .

Waste heat recovery system

➲ BOP 6: Using optimum insulation and refractory for re-heating furnace

Around 5-8% of the total furnace losses accounts for wall and roof losses due to improper use of insulation and refractory. Furnace lining in a typical re-heating furnace are done with the locally available firebricks. The firebricks with low alumina content tend to get worn out in a short duration. Also, the insulation required for plugging heat loss through the furnace are usually done with locally available red bricks, which do not serve the purpose of insulation.

- Select optimum refractories and insulation based on manufacturers' recommendation.
- Maintain furnace skin temperature to < 60 ^{0}C.
- Minimize losses from openings such as pusher end, discharge door and inspection door.
- Use of ceramic fibre to be ensured for optimum thermal insulation.
- Furnace emissivity coating can be adopted for better thermal insulation.
- Refractory bricks of higher alumina backed by hot face & cold face insulation bricks and hysil blocks/ceramic fibre to be used in furnace side walls.
- High alumina bricks backed by hot face insulation and ceramic fibre blanket to be used in furnace roof.
- Minimum heat losses to be ensured after furnace shut-down.

➲ BOP 7: Installation of temperature gauge in re-heating furnace

It is important to maintain the correct furnace temperature regime for optimum furnace efficiency. In a typical furnace, the zonal chamber is usually 50^{0}C higher than the stock temperature. Over-heating of stock can lead to increased scale loss and melting of stock, whereas under-heating can lead to improper rolling condition.

- Maintain furnace zonal temperature regime to desired level.
- Install thermocouples in different zones of furnace (soaking, heating and pre-heating zone) with proper digital display.
- Furnace discharge temperature to be maintained at optimum level.

Thermocouples used in re-heating furnace

- Recommended reheating temperatures of different type of material in reheating furnace are presented in table below:

Recommended reheating temperatures different materials

S.No.	Type of material	Temperature (^{0}C)
1	Free cutting brass	700/750
2	Forging brass	700/750
3	Modify forging brass	600/650
4	High tensile brass	700/750
5	Lead free brass	800/850
6	IS319-II	800/850
7	DTP	800/850
8	SVF	800/850
9	CuZn40Pb2	800/850
10	C-3602	800/850
11	C-345	800/850

- Thermocouples to be selected based on temperature range to be monitored.
- It is recommended to install temperature gauges or thermocouples in re-heating furnaces for proper temperature control. This will lead to proper monitoring of the furnace temperature thereby leading to optimum furnace temperature control.

BOP 8: Maintaining optimum heating regimes

The importance of temperature control in the furnace for fuel economy and reduction of burning losses are well established. Heating regimes is the temperatures at which the furnaces are required to be controlled. The fundamental principle that governs heating of billet/ingot in a re-heating furnace is that the metal should reach the desired level of temperature and within the permissible temperature gradient from top to bottom when it reaches the discharge point.

- Maintain correct temperature regimes in different zones of furnace as per manufacturers' recommendation
- Material to be properly soaked for proper processing.
- Automatic furnace temperature control system to be installed for proper monitoring and control of furnace temperature.

BOP 9: Inadequate sizing of heating and pumping unit

In majority of the units the heating and pumping systems are not designed properly. This is mainly due to lack of awareness about the standard oil temperature and pressure at the combustion stage and the benefits thereof.

- Pre-heat feed oil to the desired viscosity level.
- Use properly designed heating and pumping unit.
- Regular maintenance of feed oil pipe to be done.

BOP 10: Replacement of conventional re-heating furnace with energy efficient re-heating furnace

Conventional re-heating furnace is of very primitive design; have poor preheating of charge, they do not have waste heat recovery system and poor heat transfer efficiency between hot flue gasses & billets. It is recommended to replace the conventional re-heating furnace with energy efficient re-heating furnace. The following parameters are to be kept in mind while designing a new energy efficient re-heating furnace:

- Complete combustion with minimum excess air.
- Proper heat distribution
- Operation at optimum furnace temperature
- Reducing heat losses through furnace openings
- Maintaining correct amount of Furnace draft.
- Optimum hearth capacity utilization.
- Waste Heat recovery from the flue gas.
- Minimum heat loss through refractory.
- Use of Ceramic Coatings
- Selecting right kind of refractory & insulation
- Control & Instrumentation of the furnace.

6.5. Do's & Don'ts in re-heating furnace operations

The table below summarizes the do's and don'ts related to the operation of a reheating furnace in a hand-tool unit.

Summary of best operating practices for efficient operation of re-heating furnace

Do's	Don'ts
• Use proper refractories to keep skin wall temperature at <60 ^{0}C	• Do not keep furnace doors open unnecessarily
• Maintain heating zone temperature at 10-50 ^{0}C above soaking or discharge temperature	• Do not overheat the furnace
• Recover maximum heat from the flue gases through suitable waste heat recovery systems.	• Avoid manual interference for control of furnace temperature, pressure and air-fuel ratio
• Heat the furnace oil to about 90-100 ^{0}C to reduce the viscosity of the oil	• Do not run furnace in negative pressure to avoid ingress of cold air from openings
• Maintain hearth productivity > 280 kg/m^2/hr	• Do not use locally fabricated blowers with no proper design parameters.
• Insulate all hot air pipelines	• Do not use air over desired excess air level.
• Use damper installed in the flue gas path for pressure control in the furnace.	• Do not use refractory of low alumina content.

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:

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