MANUAL ON ENERGY CONSERVATION MEASURES
IN
BRASS CLUSTER
JAMNAGAR

Bureau of Energy Efficiency (BEE)

Ministry of Power, Government of India

Prepared By

Winrock International India

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Contents

ANNEXS

Annexure 1: Detailed technology assessment report

Annexure 2: Details of technology / service providers in Jamnagar Brass Cluster

Annexure 3: Techno commercial bids from service / technology provider

Annexure 4: Policy guidelines/subsidy schemes available with State governments for improving energy efficiency in cluster

Annexure 5: Financial schemes available with local banks for improving energy efficiency in cluster

List of Tables:

List of Figures:

Abbreviations

MSME	Micro Small and Medium Enterprises
SMEs	Small and Medium Enterprises
GOI	Government of India
BEE	Bureau of Energy Efficiency
EE	Energy Efficiency
IRR	Internal Rate of Return
DPRs	Detailed Project Reports
tpa	Tonnes Per Annum
MTOE	Metric Tonnes of Oil Equivalent
mkCal	Million Kilo Calories
kW	Kilo Watt
hp	Horsepower
kWh	Kilo Watt Hour
GEDA	Gujarat Energy Development Agency
SDA	State Designated Agency
GHGs	Green House Gasses
LSPs	Local Service Providers

About BEE SME Program

Worldwide the Micro, Small and Medium Enterprises (MSMEs) have been accepted as engines of economic growth to promote and accelerate equitable development. The major advantage of this sector is its enormous employment potential at significantly low capital involvement. This can be established from the simple fact that the MSMEs constitute over 90% of total enterprises in most economies and are credited with generating the highest rates of employment growth and also account for a major share of industrial production and exports. In Indian context, MSMEs play a pivotal role in the overall industrial economy. In recent years the sector has consistently registered higher growth rate as compared to the overall industrial sector. With its agility and dynamism, the sector has shown admirable innovativeness and adaptability to survive the recent economic downturn and recession.

As per available statistics (the 4th Census of MSME Sector), this sector employs an estimated 59.7 million persons spread over 26.1 million enterprises. It is estimated that in terms of value, MSMEs have a 40% share in total industrial output at a huge volume of producing over 8,000 value-added products. At the same time, MSMEs contribute nearly 35% share in Direct Export and 45% share in the Overall Export from the country. SMEs exist in almost all-major sectors in the Indian industry such as Food Processing, Agricultural Inputs, Chemicals & Pharmaceuticals, Electrical & Electronics, Medical & Surgical Equipment, Textiles and Garments, Gems and Jewellery, Leather and Leather Goods, Meat Products, Bioengineering, Sports goods, Plastics Products, Computer Software etc.

However, despite the significant contributions made to towards various aspects of the nation's socio-economic scenario, this sector too faces several critical issues that require immediate attention. One such factor that falls in the ambit of this publication is the prevalence of age old technologies across the sectors and inherent inefficiencies associated with resource utilization, including, energy. The National Mission for Enhanced Energy Efficiency in Industry under the National Action Plan for Climate Change (released by Government of India on June 30, 2008) has emphasized the need for improving Energy Efficiency (EE) in the manufacturing sector. A number of sector-specific studies have also unanimously confirmed that energy intensity in the industry can be reduced with the widespread adoption of proven and commercially available technologies which will improve EE and produce global benefits from reduced Green House Gasses (GHGs) emissions.

As a result of increasing awareness towards efficient usage of energy and other resources, there has been a visible reduction in energy intensity in comprehensive Indian industrial sector. However, focusing the observation on the MSME sector reveals that the energy intensity per unit of production is much higher than that of the organized large scale sector. Since energy cost is significant contributor to the overall production cost of SMEs due to high and rising energy costs in current scenarios, it is required to increase the Energy Efficiency (EE) levels in order to ensure the sustenance of SMEs. One of the ways to reduce the inefficiencies is by replacing the conventional/old/obsolete technology with feasible and adaptable energy efficient technologies. This would not only contribute towards reduction in production cost, but would also improve the quality and productivity of MSME products. However, while knowing the way out, there are still numerous barriers (as listed below) and market failures that have prevented widespread adoption of new energy efficient technologies. .

Key barriers in promotion and adoption of EE technologies in Indian SME sector:

- Lack of awareness and capability on the part of SMEs to take up energy conservation activities
- Lack of scientific approach on monitoring and verification of performance assessment of installed equipments and utilities.
- Non availability of benchmark data for various equipments/process
- Low credibility of the service providers such as equipment suppliers and their technologies
- The SME owners are more concerned on production and quality rather than energy efficiency and conservation
- The key technical personnel employed in the SME units are based on their past experience in similar industries rather than technically qualified personnel and hence, they are not aware of the latest technologies or measures which improve energy efficiency
- Lower priority to invest in improving efficiency than in expansion (this may be due to lack of knowledge on cost benefit)

Majority of SMEs are typically run by entrepreneurs and are leanly staffed with trained technical and managerial persons to deploy and capture energy efficiency practice to reduce manufacturing cost and increase competitive edge. Therefore, it will be useful to build energy efficiency awareness in the SMEs by funding/subsidizing need based studies in large number units in the SMEs and giving energy conservation recommendations including short term energy conservation opportunities, retrofit/replacement options and technology up-gradation opportunities.

In this context, the Bureau of Energy Efficiency (BEE) has laid adequate emphasis on the SME sector as presented in the Working Group on Power for 11th Five-Year Plan (2007-2012)-Sub-Group 5. Consequently, the Bureau has initiated the Energy Efficiency Improvement program in 25 SME clusters in India.

1.1 PROGRAM OBJECTIVES

The BEE SME Program is aimed to improve Energy Efficiency in SME sector by technological interventions in the various clusters of India. The EE in SMEs is intended to be enhanced by helping these industries in the 25 energy intensive SME clusters of India by:

- Technology interventions
- Sustaining the steps for successful implementation of EE measures and projects in clusters
- Capacity building for improved financial planning for SME entrepreneurs.

The program also aims at creating a platform for

- dissemination of the best practices and the best available technologies available in the market for energy efficiency and conservation,
- to create awareness in the clusters, and
- to demonstration the new technology interventions/ projects to stimulate adoption of similar technology/projects in the clusters.

The BEE SME program has been designed in such a way so as to address the specific needs of the industries in the SME sector for EE improvement and to overcome the common barriers in way of implementation of EE technologies in cluster through knowledge sharing, capacity building and development of innovative financing mechanisms. Major activities in the BEE SME program are listed below:

- Energy use and technology studies
- Capacity building of stake holders in cluster for building EE projects
- Implementation of energy efficiency measures
- Facilitation of Innovative financing mechanisms for implementation of energy efficiency projects

The brief objective of each of these activities is presented below:

➲ ***Energy use and technology studies***

An in-depth assessment of the various production processes, energy consumption pattern, technology employed and possible energy conservation potential and operational practices in cluster by means of conducting detailed energy audits and technological gap assessment studies in a cluster is presented herewith. The energy audit study includes analysis of the overall energy consumption pattern, study of production process, identification of energy intensive steps/sub-processes and associated technology gap assessment for the individual units. The study also focuses on identifying the Best Operating Practices and the EE measures already implemented in the units.

➲ *Capacity building of stakeholders*

The aim of this activity is capacity building of the enrolled LSPs to equip them with the capability to carry on the implementation of the EE technology projects in cluster on a sustainable basis. The needs of the LSPs will be identified as a preparatory exercise to this activity, as to what they expect from the BEE Program in terms of technical and managerial capacity building.

➲ *Implementation of EE measures*

To implement the EE and technology up-gradation projects in the clusters, technology specific Detailed Project Reports (DPRs) for five different technologies for three scales of operation will be prepared. The DPRs will primarily address the following:

- Comparison of existing technology with feasible and available EE technology
- Energy, economic, environmental & social benefits of proposed technology as compared to conventional technology
- Details of technology and service providers of proposed technology
- Availability of proposed technology in local market
- Action plan for implementation of identified energy conservation measures
- Detailed financial feasibility analysis of proposed technology

➲ *Facilitation of innovative financing mechanisms*

Research and develop innovative and effective financing mechanisms for easy financing of EE measures in the SME units in the cluster. The easy financing involves following three aspects:

- Ease in financing procedure
- Availability of finance on comparatively easy terms and relaxed interest rates
- Compatibility and availing various other Central/ State Governments' incentive schemes like CLCSS, TUFF etc.

1.2 EXPECTED PROJECT OUTCOME

Expected project outcome of BEE SME program in clusters are:

➲ *Energy Use and Technology Analysis*

The outcome of the activity will include identification of the EE measures, potential of renewable energy usage, fuel switching, feasibility analysis of various options, and cost benefit analysis of various energy conservation measures including evaluation of financial returns in form of payback period, IRR and cash flows. The cost liability of each measure, including the capital and operational cost will also be indicated.

The identified EE measures will be categorized as per the following types:

- Simple housekeeping measures/ low cost measures
- Capital intensive technologies requiring major investment.

The sources of technology for each of the suitable low cost and high cost measures, including international suppliers as well as local service providers (LSPs)/ technology suppliers, in required numbers shall be identified. It is envisaged to create a knowledge bank of detailed company profile and CVs of key personnel of these technology sources. The knowledge bank will also include the capability statements of each of these sources.

The EE measures identified in the energy audit study will be prioritized as per their energy saving potential and financial feasibility. The inventorization survey would establish details like the cluster location, details of units, production capacity, technologies employed, product range, energy conservation potential along with possible identified EE measures and respective technology suppliers.

The specific outcomes of this activity will be as follows:

- Determination of energy usage and energy consumption pattern
- Identification of EE measures for the units in cluster
- Development and preparation of case studies for already implemented EE measures and Best Operating Practices in the units
- Evaluation of technical & financial feasibility of EE measures in terms of payback period, IRR and cash flows.
- Enlisting of Local Service Providers(LSPs) for capacity building & training including creation of knowledge bank of such technology suppliers
- Capacity building modules for LSPs
- Development and preparation of cluster manuals consisting of cluster details and EE measures identified in cluster.

➲ *Implementation of EE measures*

The aim of this activity is development and finalization of bankable DPRs for each of the EE projects which would presented before the SME units for facilitation of institutional financing for undertaking the EE projects in their respective units.

The activity will ensure that there is close match between the proposed EE projects and the specific expertise of the Local Service Providers (LSPs). These DPRs will be prepared for EE, renewable energy, fuel switching and other possible proposed measures during course of previous activities. Each DPR will include the technology assessment, financial assessment, economic assessment and sustainability assessment of the EE project for which it has been developed. The technology assessment will include the details of the design of equipment/ technology along with the calculation of energy savings. The design details of the technology for EE project will include detailed engineering drawing for the most commonly prevalent operational scale, required civil and structural work, system modification and included instrumentation and various line diagrams. The LSPs will be required to report the progress of the implementation of each such project to BEE PMC. Such implementation activities can be undertaken by the LSPs either solely or as a group of several LSPs.

➲ *Capacity Building of LSP's and Bankers*

The outcome of this activity would be training and capacity building of LSPs so as to equip them with necessary capacity to undertake the implementation of proposed EE projects as per the DPRs. Various training programs, training modules and literature are proposed to be used for the said activity. However, first it is important to ascertain the needs of the LSPs engaged, as in what they expect from the program in terms of technical and managerial capacity building. Another outcome of this activity will be enhanced capacity of banking officers in the lead banks in the cluster for technological and financial feasibility analysis of EE projects that are proposed by the SME units in the cluster. This activity is intended to help bankers in understanding the importance of financing energy efficiency projects, type and size of projects and ways and means to tap huge potential in this area. Different financing models would be explained through the case studies to expose the bankers on the financial viability of energy efficiency projects and how it would expand their own business in today's competitive environment.

➲ *Concluding workshop*

The outcome of this activity will be the assessment of the impact of the project as well as development of a roadmap for future activities. The workshop will be conducted for the representatives of the local industrial units, industry associations, LSPs and other stakeholders so that the experiences gained during the course of project activities including implementation activities of EE project can be shared. All the stakeholders in the project will share their experience relating to projects undertaken by them as per their respective roles. Effort from industrial units as well as LSPs to quantify energy savings thus achieved would be encouraged. This would lead to development of a roadmap for implementing similar programs in other clusters with greater efficiency and reach.

1.3 IDENTIFIED CLUSTERS UNDER THE PROGRAM & TARGET CLUSTER FOR IMPLEMENTATION

25 most energy intensive MSME clusters across different end use sectors have been identified to implement the BEE SME program for EE improvement. The details of industrial sector and identified cluster are provided in Table 1 below:

Table 1.1: ***List of clusters identified for BEE SME Program***

S. No.	Cluster Name	Location
1.	Oil Milling	Alwar; Rajasthan
2.	Machine Tools	Bangalore; Karnataka
3.	Ice Making	Bhimavaram; Andhra Pradesh
4.	Brass	Bhubaneswar; Orissa
5.	Sea food processing	Kochi, Kerala
6.	Refractories	East &West Godavari, Andhra Pradesh
7.	Rice Milling	Ganjam, Orissa
8.	Dairy	Gujarat
9.	Galvanizing	Howrah, West Bengal
10.	Brass& Aluminum	Jagadhari, Haryana
11.	Limestone	Jodhpur, Rajasthan
12.	Tea processing	Jorhat, Assam
13.	Foundry	Batala, Jalandhar & Ludhiana, Punjab
14.	Paper	Muzzafarnagar, Uttar Pradesh
15.	Sponge iron	Orissa
16.	Chemicals& Dyes	Vapi, Gujarat
17.	Brick	Varanasi, Uttar Pradesh
18.	Rice Milling	Vellore, Tamil Nadu
19.	Chemical	Ahmedabad, Gujarat
20.	Brass	Jamnagar, Gujarat
21.	Textile	Pali, Rajasthan
22.	Textile	Surat, Gujarat
23.	Tiles	Morbi, Gujarat
24.	Textile	Solapur, Maharashtra
25.	Rice Milling	Warangal, Andhra Pradesh

As a part of BEE SME program, one of cluster identified was the Jamnagar, Brass cluster. It was proposed to carry out energy use and technology audit studies in 75 units in the Jamnagar Brass cluster covering all types and sizes of the industries to understand/give valuable insight into the process of developing energy efficiency solutions relevant to the SME industries in the Jamnagar, Brass cluster.

Jamnagar Brass Cluster Scenario

2.1 INTRODUCTION

In India Brass metal industry are located mainly in the states of Gujarat, Haryana, Orissa, Assam and Uttar Pradesh. But there is a subtle difference between the products manufactured in these states. The products manufactured in Haryana, Orissa, Assam & Uttar Pradesh are mostly brass metal handicrafts and utility items made out of sheet metal components or single piece casting, whereas in Gujarat it is mostly brass-machined components. From the point of view of its application or usage pattern, the products manufactured in Uttar Pradesh, Orissa, Assam & Haryana are consumer products and are used as gift, utility or decorative items, whereas the products manufactured in Gujarat can be classified as industrial product and consumed by industries as a part/component of their final product. Unlike the above four states, the brass part products in Gujarat require a lot of machining activities like turning, milling, grinding, drawing, boring, threading etc.

Jamnagar known as the brass city of India, has been an important industrial centre since long for brass related parts. Jamnagar is inhabited by a various types of brass related work units which include Brass foundry; Brass parts manufacturing, Electroplating and Extrusion units. There are about 3500 brass related units alone in Jamnagar. Majority of these Brass units in Jamnagar are in operation since last 15 to 20 years. All these units are located in pockets of Shankartekri, MP Shah Udyognagar, Patel colony and Dared areas.

Jamnagar Brass cluster like many other clusters was in dire-straits with regard to the energy efficiency and conservation. In almost all units, whether big or small, there had been no conscious effort to take up energy conservation and energy efficiency measures as a part of day to day operations. Many a times, the small scale entrepreneur was not even aware of measures that could bring down the percentage energy cost, which automatically brings down the manufacturing cost. Some of the bigger units had experimented with few parameters to improve energy efficiency in the units, but the results and outcome was confined to them only. All the units in Jamnagar Brass cluster had been operating in traditional conditions and most of equipments/utilities using in cluster were procured from the local suppliers. They are making the equipments on their traditional expertise, which had remained unchanged over the years.

Till now there has been very little focus on energy conservation activities in the units. Also, there have been no concrete external interventions as well to help the small units come out of their shell and rise up to the necessary energy efficiency benchmarks.

2.1.1 Raw material used

The raw material requirement of the Jamnagar Brass cluster is met mainly from the following three sources:

- Old brass, copper and bronze utensils
- Imported brass scrap and honey
- Brass scrap from ship breaking yard

Majority of the raw material requirement in Jamnagar Brass cluster is met through imports. The countries from which it is imported are USA, Singapore, Gulf and European countries. The imported raw material is available mainly in three forms i.e. Honey scrap, Dross of brass & Pale in the form of strips.

Figure 2.1: ***Raw material using in Jamnagar*** Brass cluster

The quality of brass scrap and honey varies widely and its composition is not uniform. Most of the times, this scrap is made of two to three different metals and the job of the worker is generally to separate other metals (like aluminium, iron) from the copper and brass. It is a tedious process but still practice in Jamnagar. Moreover the separating process can never be 100% accurate and a lot of impurities and other metals reach the foundry for melting. As a result the quality of casting is affected.

Technically speaking brass is an alloy of Copper and Zinc and ratio of these products is 60:40 respectively. For getting the right products and good quality, it is important that this composition is maintained. However, due to the heterogeneous nature of the scrap (honey) and different alloying of the base metal, it becomes almost impossible to maintain this ratio. As a result, the quality of the final product varies, defects are produced and the rejection rate increases.

Apart from the Brass scrap; copper, zinc, led, other metal alloys and clay etc are used as raw material depends on the final product requirement.

2.1.2 Products manufactured

Major products manufactured in Jamnagar Brass cluster are:

- Building hardware like Door & Window Hinges, Stoppers, Knobs, Studs, Handles
- Sanitary & bathroom fittings Like Venetian Blinds, Hangers, Taps, Curtain fittings
- Electronic & Electrical accessories Like Socket pin, Battery terminal, switches, tester, computer sockets
- Automobile & Cycle tube valves, Industrial control valves
- Agricultural Implements like Tractor accessories
- Brass jewellery and Buttons like Necklace, Ear rings, Bracelet, Rings, Bangles
- Various other precision machine components as per customers specification
- Pen parts

The products manufactured in the Jamnagar Brass cluster weigh in a range from 1 gm to 10 kg and in terms of its length and diameter it varies from .05 mm to 60 cm. The following figure shows the classification of Brass part manufacturing units based on type of manufacturing product.

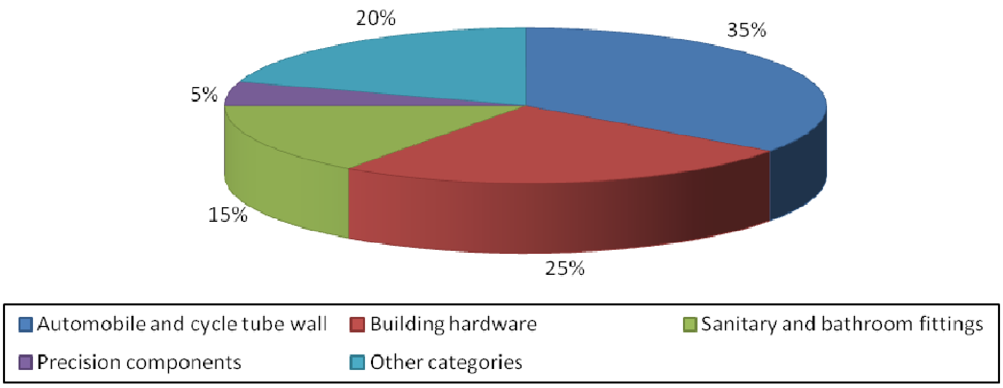

Figure 2.2: ***Classification of Brass part manufacturing units in Jamnagar Brass cluster***

2.2 CLASSIFICATION OF UNITS

Brass units in Jamnagar are classified based on the type of operation of the units and as well as production capacity.

2.2.1 Type of operation

Brass units in Jamnagar Brass cluster are engaged in three different types of operations; those are:

- Casting (Brass foundry & Extrusion)
- Machining
- Electroplating

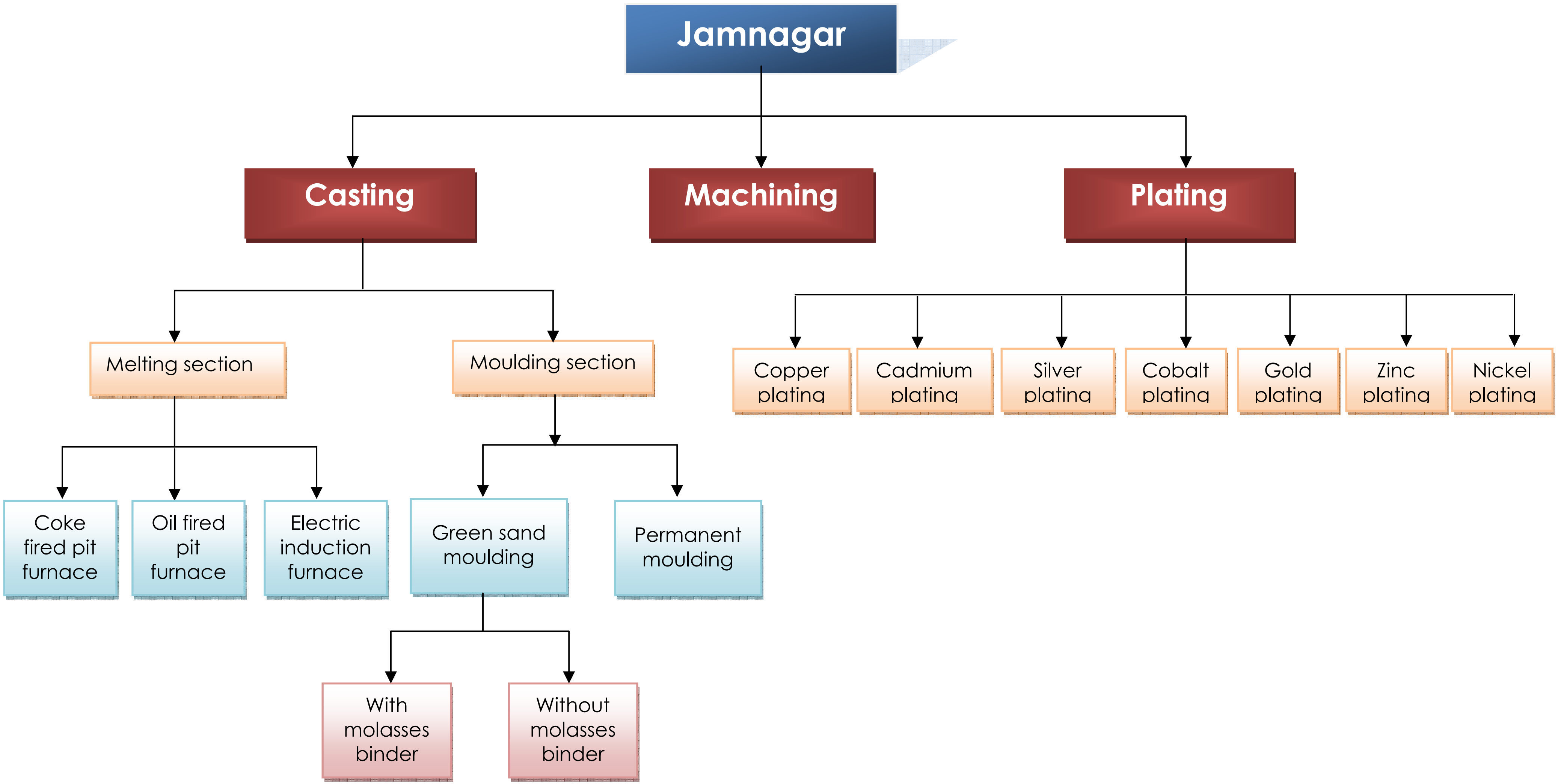

Figure 2.3: ***Classification of Brass units in Jamnagar Cluster based on type of operation***

There are around 3500 units in Jamnagar Brass cluster, out of which 2100 are Machining units, 900 are foundry units, 350 are electroplating units and 150 are extrusion units. Percentage distribution of different type of operational units in Jamnagar Brass cluster is furnished in figure below:

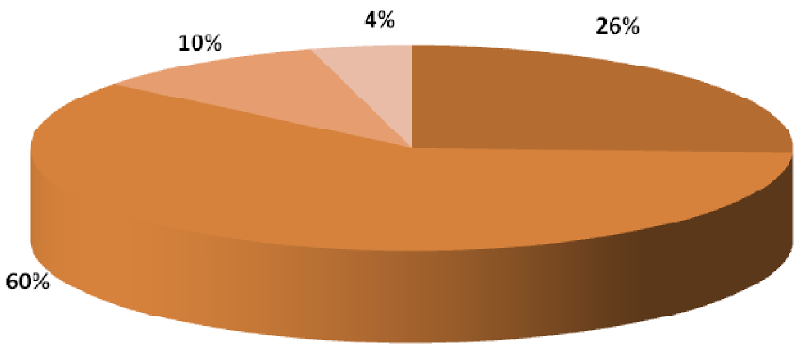

Figure 2.4: ***Percentage distribution of different type of operation in units in Jamnagar Brass cluster***

2.2.2 Production capacity

Annual production capacities of Brass units in will depend on the type of operation; Brass units in Jamnagar under each type of operation are classified based on production capacity. Following figures shows the percentage classification of Brass Foundry and extrusion plants based on production capacity:

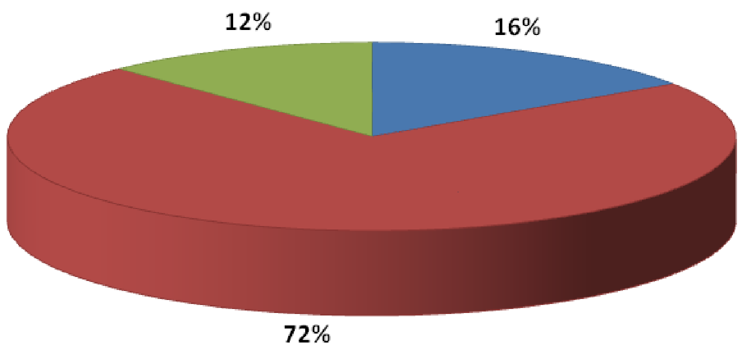

Figure 2.5: ***Classification of Brass foundry units based on production capacity***

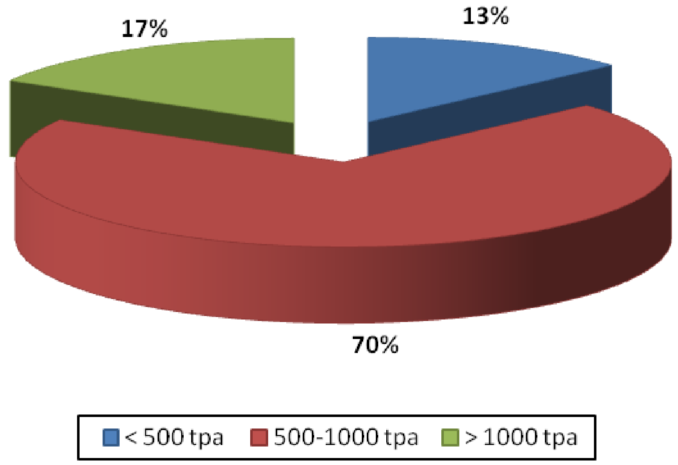

Figure 2.6: ***Classification of Brass extrusion units based on production capacity***

2.3 ENERGY SITUATION IN CLUSTER

Major energy sources being used in manufacturing of Brass parts in Jamnagar Brass cluster are electricity and fuels such as Coal, Furnace Oil and Liquid petroleum gas. This depends on application of technology, process requirement, availability, and economic and safety point of view. The two forms of energy being used in manufacturing of Brass parts in typical Brass unit are electrical energy and thermal energy. Electrical energy is being used in melting of Brass in induction furnaces, operation of electrical utilities and thermal energy is being used in Brass melting operation.

Availability and consumption of various fuels in typical Brass manufacturing unit is presented in below sections.

2.3.1 Type of fuels used in Jamnagar Brass cluster

Details of fuels used in Jamnagar Brass cluster is presented in table below:

Table 2.1: ***Details of fuels used in cluster and its prices***

S. No	Name of fuels	Cost of fuel (Rs)	Units	Gross Calorific values
1	High grade coal	17	kg	6500 kCal/kg
2	Liquid Petroleum Gas	24	Nm^3	9500 kCal/Nm^3
3	Furnace oil	28	liter	9300 kCal/kg

2.3.2 Energy consumption in typical brass unit

Energy consumption (thermal energy & electrical energy) in Brass unit depends on type of unit and final product manufacturing in unit. Annual Electrical energy and thermal energy consumption in typical Brass foundry, Extrusion unit, Machining and Electroplating unit is presented in tables below:

Table 2.2: ***Annual Energy consumption in different capacities of Brass Foundry units***

Parameter	Unit	<200 tpa	200-400 tpa	>400 tpa
Annual electrical energy consumption	kWh per annum	3300	3800	12300
Annual electrical energy consumption	kCal per annum	2,890,800	3,328,800	10,774,800
Annual coal consumption	tpa	28	40	129.2
Annual thermal energy consumption	kCal per annum	182,000,000	260,000,000	839,800,000
Annual production capacity	tpa	175	250	840
Total annual energy consumption in one unit of different capacity	kCal	184,890,800	263,328,800	850,574,800
Total annual energy consumption in one unit of different capacity	MTOE	18.48	26.33	85.05

Table 2.3: ***Annual Energy consumption in different capacities of Brass Extrusion units in Jamnagar Brass cluster***

Parameter	Unit	<500 tpa	500-1000 tpa	>1000 tpa
Annual electrical energy consumption	kWh per annum	280,000	810,500	1,126,785
Annual electrical energy consumption	kCal per annum	245,280,000	709,998,000	987,063,660
Annual furnace oil consumption	liters per annum	13,000	37,000	55,000
Annual thermal energy consumption	kCal per annum	127,400,000	362,600,000	539,000,000
Annual production capacity	tpa	360	1000	1500
Total annual energy consumption in one unit of different capacity	kCal	372,680,000	1,072,598,000	1,526,063,660
Total annual energy consumption in one unit of different capacity	MTOE	37.26	107.25	152.60

Table 2.4: ***Annual Energy consumption in Brass machining units in Jamnagar Brass cluster***

Parameter	Unit	Value
Annual electrical energy consumption	kWh per annum	27001
Annual electrical energy consumption	kCal per annum	23,653,333
Annual production capacity	tpa	50

Parameter	Unit	Value
Total Annual energy consumption one unit	MTOE	2.36
Total Annual energy consumption in all machining units in cluster	MTOE	4968.6

Table 2.5: ***Annual energy consumption in Brass electroplating units in Jamnagar Brass cluster***

Parameter	Unit	Value
Annual electrical energy consumption	kWh per annum	29,973
Annual electrical energy consumption	kCal per annum	26,257,142
Annual production capacity	tpa	30
Total Annual energy consumption one unit	MTOE	2.625
Total Annual energy consumption in all electroplating units	MTOE	919

Annual energy consumption in different type of units is calculated and details of the same are presented in same below:

Table 2.6: ***Annual Energy consumption in different type of Brass units in Jamnagar Brass cluster***

S. No	Type of Unit	Energy consumption (MTOE)
1	Extrusion	15822
2	Foundry	29061
3	Machining	4967
4	Electroplating	919

Total annual energy consumption in cluster is around 50,770 MTOE (Metric Tonne of oil equivalent). Percentage of total energy consumption in different type of units in cluster is presented in figure below:

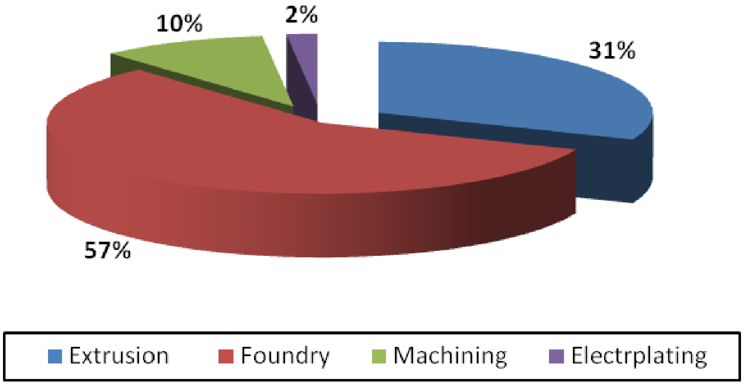

Figure 2.7: ***Percentage of total energy consumption in different type of units in Jamnagar Brass cluster***

2.3.3 Value of specific energy consumption of typical Brass unit in Jamnagar Brass cluster

Specific electrical energy and thermal energy consumption in typical Brass units in Jamnagar cluster depends on type of unit and final product manufacturing in that unit. Specific electrical energy and thermal energy consumption in typical Brass foundry unit, Brass extrusion unit, Machining unit and Electroplating unit in Jamnagar Brass cluster is presented in tables below:

Table 2.7: ***Specific energy consumption of typical Brass foundry unit***

Parameter	Unit	<200 tpa	200-400 tpa	>400 tpa
Electrical specific energy consumption	kWh/kg of brass rod	0.021	0.015	0.014
Electrical specific energy consumption	kCal/kg of brass rod	17.52	13.31	12.26
Thermal specific energy consumption	kg of coal /kg of brass rod	0.16	0.16	0.15
Thermal specific energy consumption	kCal/kg of brass rod	1040	1040	1001
Total specific energy consumption	kCal/kg of brass rod	1057.52	1053.31	1013.26
Thermal energy consumption	%	98.34	98.74	98.79
Electrical energy consumption	%	1.66	1.26	1.21
Specific energy cost	Rs/kg of Brass rod	3.17	3.14	3.02

Table 2.8: ***Specific energy consumption of typical Brass extrusion unit***

Parameter	Unit	<500 tpa	500-1000 tpa	>1000 tpa
Electrical specific energy consumption	kWh/kg of brass rod	0.84	0.81	0.77
Electrical specific energy consumption	kCal/kg of brass rod	735.84	700.81	674.52
Thermal specific energy consumption	kg of oil /kg of brass rod	0.05	0.04	0.04
Thermal specific energy consumption	kCal/kg of brass rod	450.80	392.00	362.62
Total specific energy consumption	kCal/kg of brass rod	1186.64	1092.81	1037.12
Percentage of thermal energy consumption	%	37.99	35.87	34.96
Percentage of electrical energy consumption	%	62.01	64.13	65.04
Specific energy cost	Rs/kg of Brass rod	5.64	5.44	5.194

Table 2.9: ***Specific energy consumption of typical Brass machining unit***

Parameter	Unit	Value
Electrical specific energy consumption	kWh/kg of final product	0.54
Electrical specific energy consumption	kCal/kg of final product	473.04
Specific energy cost	Rs./kg of final product	3.24

Table 2.10: ***Specific energy consumption of typical Brass electroplating unit***

Parameter	Unit	Value
Electrical specific energy consumption	kWh/kg of final product	0.99
Electrical specific energy consumption	kCal/kg of final product	875.21
Specific energy cost	Rs./kg of final product	5.99

2.4 MANUFACTURING PROCESS OVERVIEW ON TYPICAL BRASS PART MANUFACTURING UNIT

The production process mentioned in the below chart is almost similar to most of Brass part manufacturing units in the Jamnagar Brass cluster. However, depending on the final product, quality of final product manufacturing unit and raw material properties, stated process flow is altered to suit the requirement of industry.

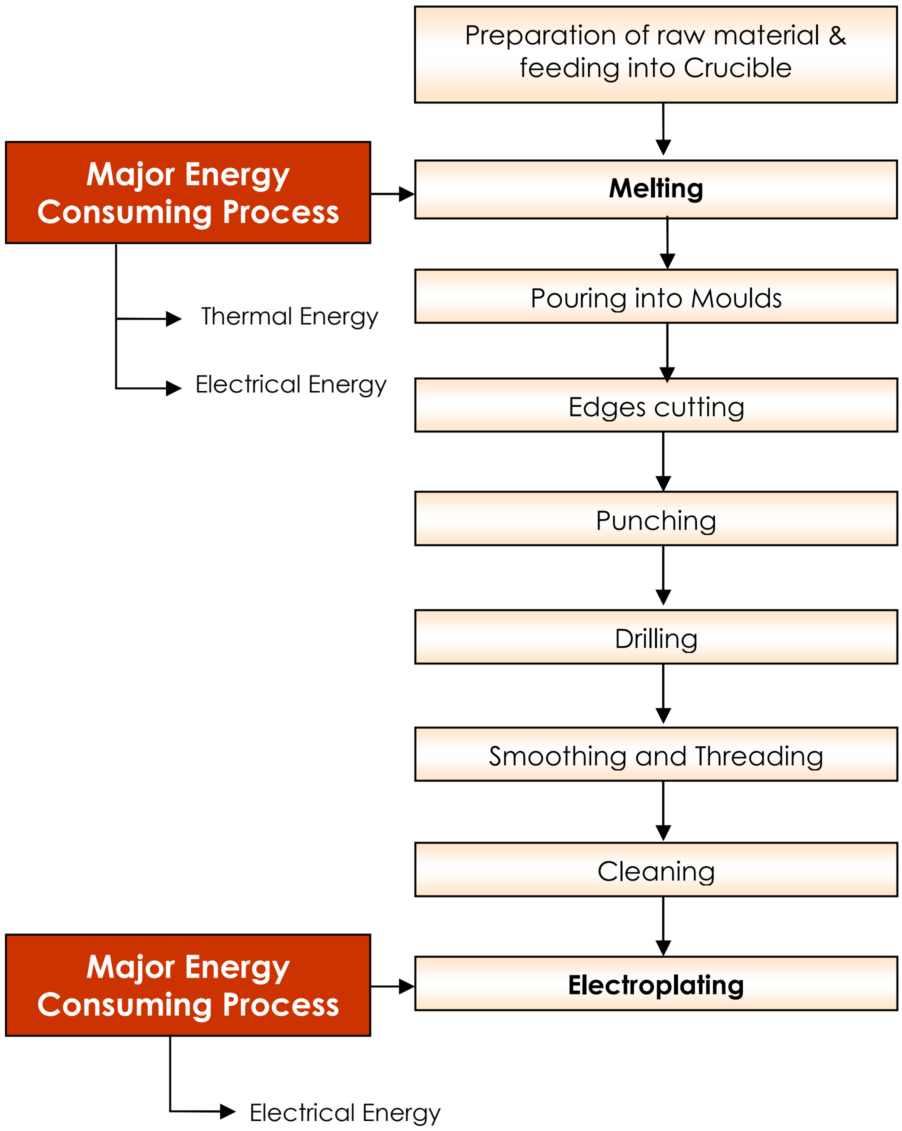

Figure 2.8: ***Process flow chart and important energy consuming stages of manufacturing of Brass part in typical unit in Jamnagar Brass cluster***

2.5 ISSUES RELATED / BARRIERS IN IMPLEMENTATION OF ENERGY CONSERVATION MEASURES / TECHNOLOGY UPGRADATION

The processes to do with technology and innovations in SMEs are different from those that take place in large firm context. Technology in the SME sector has an increasingly complex or combinative character, most of the SMEs units in cluster are regarded for their labour intensive and the capability work with local resources. In the past, SME entrepreneurs have given less emphasis to technology in order to reduce initial cost of plant /machinery. Major barriers in up-gradation of technology in the cluster are:

- Lack of awareness on energy efficiency
- Lack of organizational commitment

- Narrow focus on energy
- Not clear about their existing level of operations and efficiency, due to lack of instrumentation & non availability of energy consumption data
- Limited manpower
- Cost of energy conservation options
- Orthodox mind set of entrepreneurs
- Non availability of clean fuels

Details of the other barriers in the implementation of energy efficient technologies / equipments in the Jamnagar Brass cluster are presented in below sections:

2.5.1 Technological Barrier

Majority of the Brass units entrepreneurs in Jamnagar Brass cluster do not have any in depth technical expertise and knowledge on energy efficiency, and are dependent on local technology suppliers or service companies, who normally also rely on established and commonly used technology. The lack of technical know-how has made it difficult for the Brass unit owners to identify the most effective technical measures.

Most of Brass units in Jamnagar Brass cluster have been established several years ago when energy efficiency was not important issue for the operation of a plant. They are operating with outdated technology and low end technologies.

As majority of the entrepreneurs in cluster are not aware of the energy losses in the plant, there may be a strong feeling that the energy efficiency initiatives in manufacturing facility can have a cascading effect of failure in critical production areas directly or indirectly connected if the intended performance of the replaced / retrofitted equipment falls below design values.

There is a strong feeling in the Brass unit entrepreneurs that, energy efficiency initiatives are difficult and they do not wish to take the risks such as business interruption due to production loss vis-a-vis the drive to save energy. These can however be overcome by motivating them to attend the awareness programs and use the detailed report on the benefits of the measures identified and cost benefit analysis. Further, sourcing of expertise on maintenance service provider or training by the equipment supplier will definitely overcome the barriers.

2.5.2 Financial Barrier

Significant amount of investment is not commonly seen in most of Jamnagar Brass industries. Further, from the business perspective for any industry owner, it is more viable, assured and convenient to invest on project expansion for improving the production capacity, rather than make piecemeal investment in retrofit and replace options for energy savings. Investment returns on large capacity addition or technology adoption shows up prominently in terms of savings and helps in benchmarking operations. Further, there is a strong feeling among the industry owners that, energy conservation-initiatives of replacement and retrofit nature is not a common practice as it involves large capital investment against low returns. In view of this, and given the limited financial strength of entrepreneurs from Brass units in Jamnagar, they would not take the risks to invest in energy efficiency measures.

2.5.3 Manpower

Skilled workers are locally available to run the machines available in Jamnagar. However, there is hardly any engineer employed in these enterprises and the production process remains traditional. This is one of the lacunae of the Jamnagar Brass Parts cluster.

Specialized training with local service providers for better operation and maintenance of equipments, importance of the energy and its use will create awareness among workforce. These programs should be organized with equipment suppliers.

2.5.4 Non availability of clean fuel

The existing foundry units are using coal and furnace oil as sources of energy for melting and casting operation. This creates a lot of environmental and health problems in cluster. Majority of the industries in Jamnagar are ready to shift to clean fuels such as Natural gas because of environmental, social and economical reasons. Due to non availability of clean fuel in Jamnagar cluster implementation of clean fuel technology operation in cluster has taken a backseat. Since a long time people in Jamnagar are trying to get the gas (CNG) pipe line, but till now they have not succeeded.

Energy use and Technology Assessment in Cluster

3.1 METHODOLOGY ADOPTED FOR ENERGY USE & TECHNOLOGY AUDIT STUDIES

A well planned methodology was adopted to execute the energy use and technology audit studies and to achieve the desired project objectives. Major steps which were followed during the energy use & technology studies of the project are mentioned below:

- Discussion with the industry representatives/local industry association
- Inventorization of the units so as to understand their energy consumption pattern
- Selection of suitable representative units for carrying out energy use and technology assessment studies

The primary objective of the energy audits is to quantify the existing fuel consumption pattern and to determine the operating efficiencies of existing systems. The key points targeted through energy audits were determination of specific fuel consumption, various losses, operation practices like hot metal temperature, existing air-fuel ratio, blower and burner parameters etc. Pre-planned methodology was followed to conduct the energy audits. The following sections describe details of methodology adopted in energy use and technology audits in Jamnagar Brass cluster.

3.1.1 Pre-energy use & technology audit studies

Brass industries in Jamnagar area have organized themselves into one association called The **Jamnagar Factory Owners Association**. The following table gives the coordinates of the association.

Table 3.1: ***Details of the Jamnagar Brass units association***

Name of the association	Jamnagar Factory Owners Association
Contact Person	Shri Ramjibhai A. Patel
Profile	President-Jamnagar Factory Owners Association
Contact Details	Plot no: 370/372, GIDC Industrial area, Shankar Tekri, Udyognagar, Jamnagar- India Email: jfoa@sancharnet.in

The association provides a platform for development of mutual understanding among the industries and discussion relating to common problems and identification of viable solution. Therefore, as a first step for making inroads in the cluster, the association and its office bearers were approached. Detailed discussions with the association were held on apprising the association about the objective of the project, tentative schedule of the activities being undertaken and expected project outcome.

The office bearers of associations were apprised about benefits of the project for the industries and cluster. The association took up the task of dissemination of all this information among their respective member units. The outcome of this activity was introduction of project concept to the association and later on to the industry. This helped in identifying progressive and interested entrepreneurs in the cluster.

3.1.2 Preliminary energy audit studies

53 Preliminary energy audit studies are conducted in Jamnagar Brass cluster. Methodology followed in preliminary energy audit study is presented below:

- Collection of past energy consumption details and energy bill
- List out major energy consuming areas of the plant
- Existing technology of various processes and utilities (latest or old, crude or efficient, local or reputed company make etc)
- Identification of the areas for special attention for low cost measures with quick payback period
- Understanding the detailed process with energy and material balance
- Establish specific energy consumption, if possible for the each typical equipment/process
- Identify the areas for detailed energy audit study and measurements required

3.1.3 Detailed energy audit studies

22 Detailed energy audit studies are conducted in Jamnagar Brass cluster. The methodology followed in detailed energy audit study is presented below:

- Collection of past energy consumption details and energy bill
- Listing of major energy consuming areas of the plant
- Identifying existing technology of various processes and utilities (latest or old, crude or efficient, local or reputed company make etc)
- Status of instruments installed in the plant and necessary instrumentation required for the detailed study
- Identification of the areas for special attention for low cost measures with quick payback period

- Understanding the detailed process with energy and material balance
- Monitoring & measuring of different parameters of various equipment / machines to evaluate performance
- Collection of operational data from various measuring instruments / gauges installed in the plant
- Compilation of design data/name plate details of various equipment from design manuals and brochures
- Discussions with concerned plant personnel to take note of operating practices and shop-floor practices being followed in the plant and to identify specific problem areas and bottlenecks if any with respect to energy consumption
- Critical analysis of data collected and parameters monitored
- Identification of energy wastage areas and quantification of energy losses
- Identification of suitable energy conservation measures for reducing energy consumption

3.2 OBSERVATIONS MADE DURING ENERGY USE AND TECHNOLOGY AUDIT STUDIES

Observations made during the energy use and technology audit studies in various processes/equipments are presented in the below sections:

3.2.1 Manufacturing process and technology/equipments installed

Brass part manufacturing in Jamnagar Brass cluster comprises three main operations; those are Casting, Machining & Electro plating.

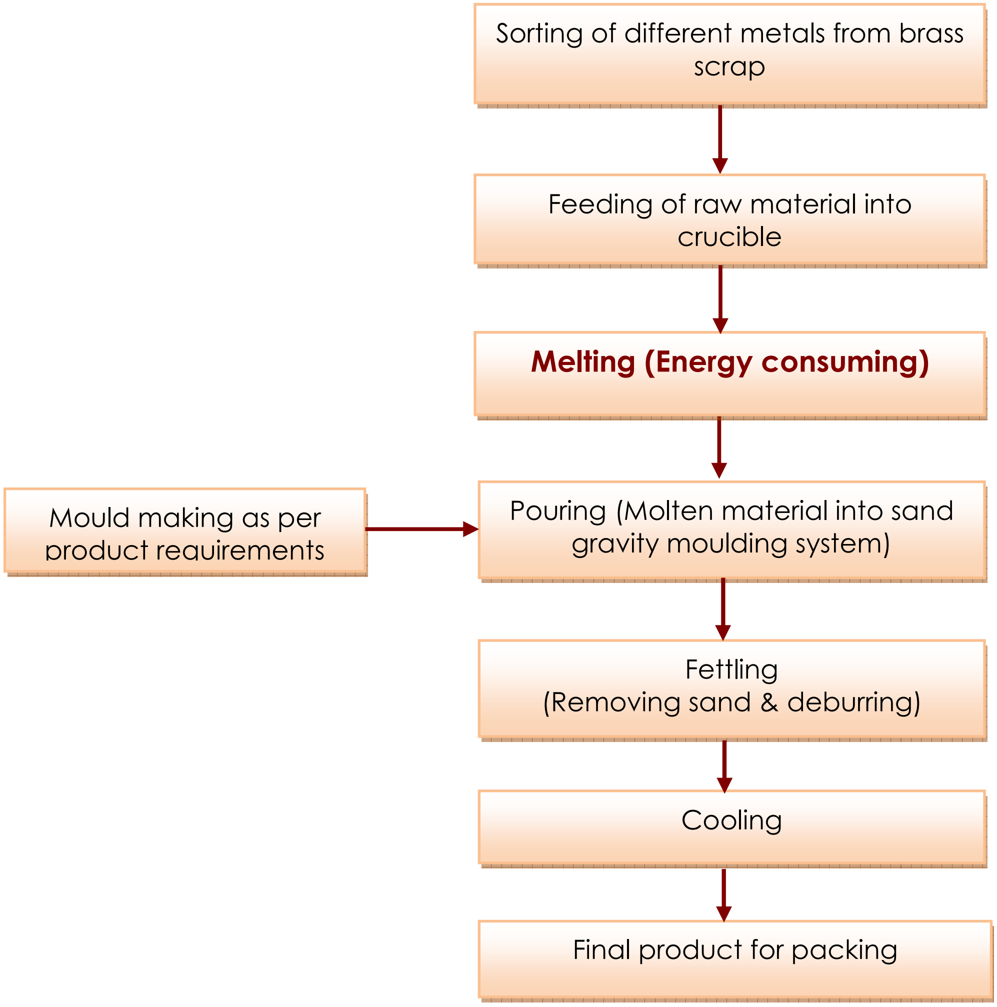

Figure 3.1: ***Manufacturing process of Brass rods at typical Brass foundry unit***

Majority of the Brass foundry/casting units in Jamnagar Brass cluster use coal fired pit furnaces. Brass scrap is used as major raw material for melting; it is mixed with the in-house cuttings and turnings. The scrap is fed manually into the melting crucible while the furnace is kept on the firing mode. Brass scrap is completely melted at 1100 deg C. Generally it takes from 1.2 to 1.5 hours for the material to melt completely. Molten metal is drawn from the crucibles; same is poured in a mould to get the final casting.

From the above process flow diagram it is clear that melting is major energy consuming process in the overall manufacturing process of Brass rods. Brass Melting is done in crucibles made of silicon carbide, better known among the industry as "**Graphite crucibles**". The crucibles are kept inside a round pit and coal is feed into the annual space between crucible & furnace. Annular space between the crucible and the furnace serves as the space for combustion.

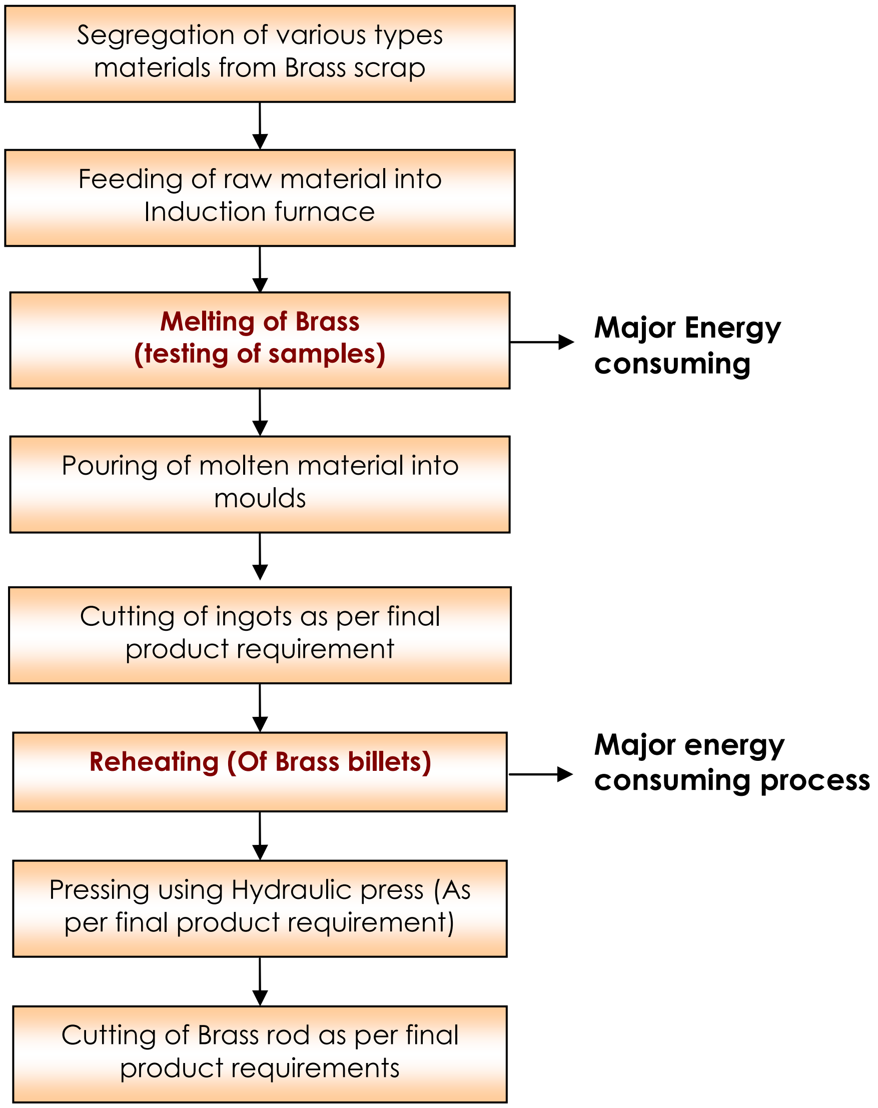

Figure 3.2: ***Manufacturing process of Brass rods at typical extrusion unit***

Around 150 of the Brass foundry/casting units in Jamnagar Brass cluster use Electrical induction furnaces for melting of Brass. Brass scrap is used as major raw material for melting; it is mixed with the in-house cuttings and turnings. The scrap is fed manually into the melting crucible while the furnace is kept on the firing mode. Brass scrap is melted by electrical energy. It generally it takes from 1.2 to 1.5 hours for the material to melt completely. Molten metal is drawn from the crucibles and the same is poured in a mould. After the Brass billets are reheated in the reheating furnace, extruded brass rods are out from the hydraulic press as per the final product requirements.

From the above process flow diagram it is clear that melting and reheating are major energy consuming process in the overall manufacturing process of Brass rods. Brass Melting is done in electrical induction furnaces and reheating of billets is done by using oil fired reheating furnaces.

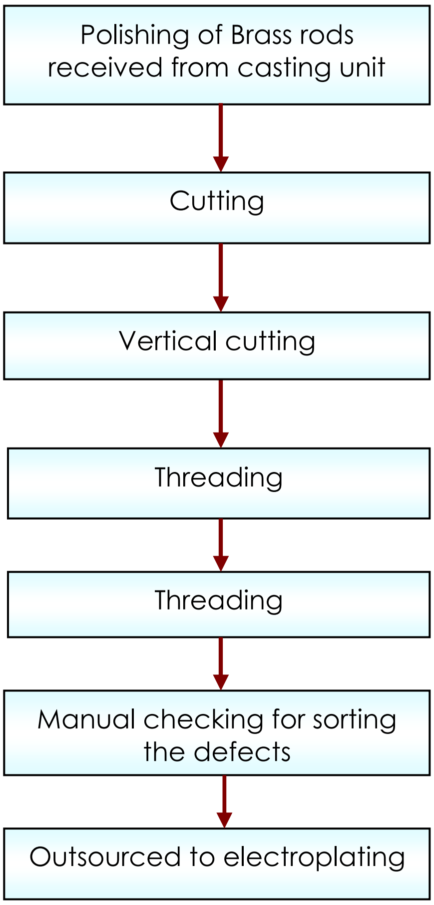

Figure 3.3: ***Manufacturing process of Brass parts at typical Machining unit***

The cast brass rod/wire then goes through various machining operations like drawing, cutting, milling, threading etc. The machining process is job specific and varies from one product to another. Major energy used in all operation is electrical energy.

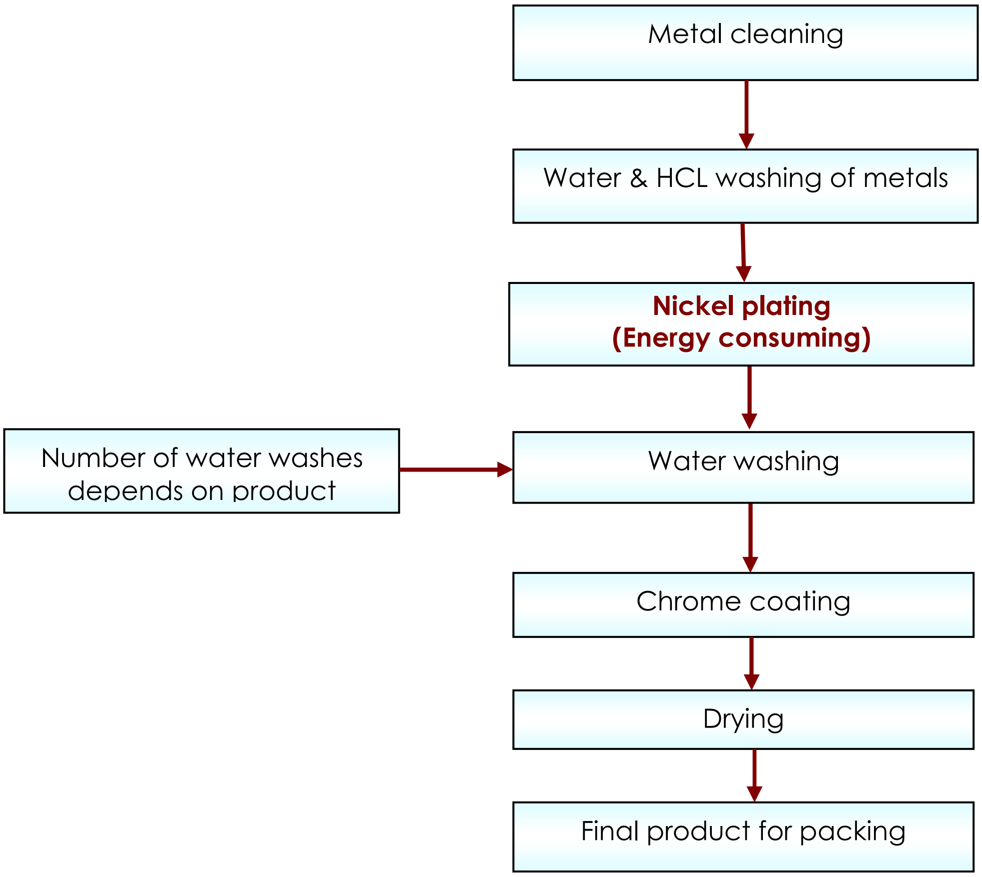

Figure 3.4: ***Manufacturing process of Brass parts at typical Machining unit***

The parts for machining are then sent to plating shop for electroplating. Some of the plating operations done in Jamnagar are - Nickel plating, Zinc Plating, Copper plating, Cadmium plating, Silver plating, cobalt plating and gold plating.

The main process of electroplaters is electroplating and this is an electro-mechanical process. In this process the plating bath is media for ion exchange process. For electroplating DC Power source of low voltage and high current is required. This high DC current will flow in one direction simultaneously; metal ions will flow in other directions. In electro plating process the plating metal is linked with cathode of DC source and anode of DC source is linked with job on which plating is required. This complete system is mounted in a tank with solution and this chemical solution is media for ion exchange process. Quality of the plating merely depends on the retention time of material in process tank and intensity of DC source.

Initially they will set received jobs on the jig with the help of copper wire for hanging the job in the electroplating tank. After that material is cleaned in the metal cleaner tank followed by mild acid tanks followed by water tanks depends on the product requirements. Now the job is ready for Nickel plating and the material is hanged in Nickel coating tank followed by water washing. At this stage material is ready with nickel coating and if the requirement is only of Nickel coating then material directly goes to drying process. Otherwise the material will go to Chrome coating tank for chrome plating. In this tank jobs are hanged through jig on anode of DC source for certain definite time. Finally it goes to drying operation to remove the water particles in it. From the above process flow diagram it is clear that Nickel plating is major energy consuming process in the overall electroplating operation. Generally total process of electroplating operation will take around 1 to 3 hours; it depends on type of material and customer requirements.

➲ *Energy consumption profile of various utilities in typical Brass units*

The major energy consuming equipments installed in typical Extrusion plant in Jamnagar Brass cluster are:

- Induction furnaces
- Reheating furnaces
- Hydraulic presses
- Motors
- Other utilities

The percentage energy consumption of various utilities in typical extrusion plant in Jamnagar Brass cluster is presented in figure below:

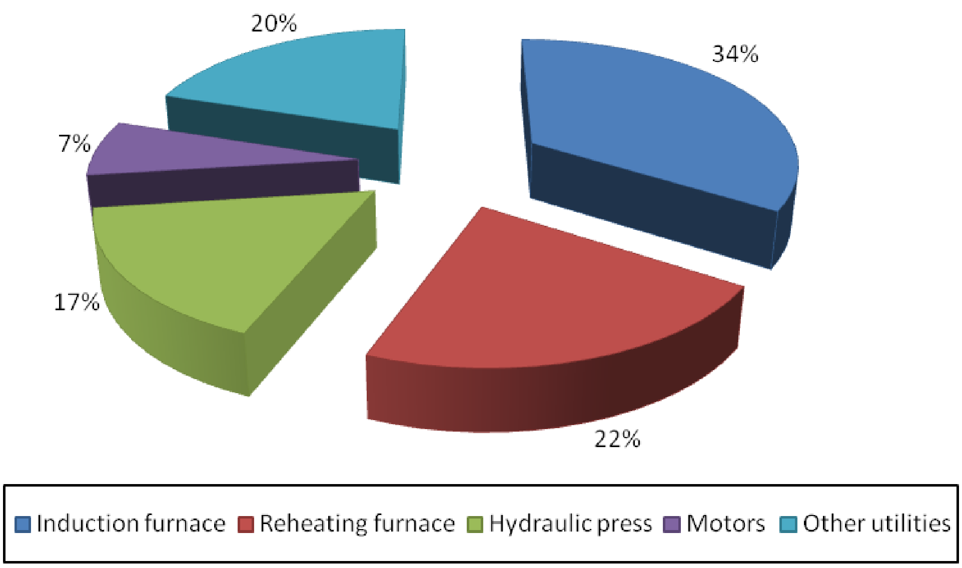

Figure 3.5: ***Percentage energy consumption of different utilities in typical extrusion plant in typical Jamnagar Brass cluster***

From the above figure it is clear that Induction furnace will consume 34% of overall energy, reheating furnaces are consuming around 22% of total energy and remaining utilities are consuming around 34% of total energy.

3.2.2 House keeping Practices

Majority of the Brass industries in Jamnagar Brass Cluster are maintaining very poor operational practices in different utilities in their units. There are no specific procedures followed in any of the units for the operation of the various equipments/utilities in industries. Either the workers or the management doesn't have the knowledge on energy conservation and efficiency. There is no monitoring of fuels or electricity on daily basis in any of the units surveyed.

By improving the operational practices in various utilities in Brass units, efficiency will improve by around 2-5%. Some of the suggested house-keeping practices in Brass industries are presented below:

- Reduce charging time in melting furnace
- Reduce Holding time in melting furnaces to ensure minimum fuel/ electricity consumption while holding (non-productive operation)
- Production planning and scheduling for furnace operation, especially batch melting furnaces, should be done is such a manner so as to have minimum cold starts of the furnace. Each cold start consumes 10 – 20% higher energy than regular furnace running and also leads to premature wear of refractory
- Controlling air infiltration through furnace openings in reheating furnace
- Maintaining proper combustion air pressure in reheating furnace
- Regulate combustion air blower opening with change in fuel supply rate in reheating furnace
- Turn off combustion air supply with cut off in fuel supply regulated by thermostat. Both combustion air and fuel supply should be interlinked with the auto cut operation of thermostat.
- Fuel storage should be done in accordance with the available guidelines for storing that particular kind of fuel.
- Fuel supply lines and the storage should be checked for leakage once in a week for any leakage and blockage
- Burner flame should never directly impinge on the material or the refractory. It increases scale losses, reduces refractory life and causes inefficient heating.
- Digital temperature indicators and automatic controllers in place of human monitoring further reduces the chances of overheating of material and subsequent energy& material loss
- Furnace gates should be opened only when required for material flow. In case of heat treatment furnaces, use of proper digital temperature indicators are recommended as it eliminates the unnecessary opening of furnace gates for checking temperature
- Minimization of bath drag out and water evaporation from hot baths to maintain constant conductivity

3.2.3 Availability of data and information

A majority of the units in Jamnagar cluster are do not have any instrumentation or data monitoring systems to monitor various operational parameters in Processes/equipments/utilities. Few instruments are installed in some of the units in the cluster for monitoring of operational parameters in their units. Accuracy of readings from these instruments is also poor.

Most of entrepreneurs in Jamnagar Brass cluster are not interested in sharing the energy consumption data, due to various reasons. Very few entrepreneurs share their energy consumption against production data in the respective months/annum.

3.3 TECHNOLOGY GAP ANALYSIS IN BRASS INDUSTRIES

Brass manufacturing units in unorganized sector has these characteristics; low engineering, limited technology innovation, poor R&D base, low level of human resource on knowledge of technology and operational skill etc. This sector also faces deficiencies such as the lack of access to technology, technology sharing, lack of strong organizational structure, professional attitude etc

Majority of Brass units in Jamnagar Brass cluster are using low end technologies in their processes and utilities. The performance of those processes/equipments is poor as compared to the technologies available in the market. There are various technological gaps which were identified in units as under:

- Lack awareness on the technologies available
- Lack of awareness on quantum of energy loss and its monetary benefit
- Lack of awareness among the workforce etc.

There is a tremendous need for this industry to modernize/upgrade its technology and adopt energy efficient technologies in some of the areas. Further, as per the discussions made with the some of the progressive managements, they are interested in improve the efficiency their units by replacing the conventional technology with energy efficient technologies in market.

From technology audit studies conducted in Jamnagar Brass cluster, below mentioned areas were identified for technology up gradations; those are:

- Conventional pit furnaces for Brass melting
- Conventional reheating furnaces
- Molding system

Technical gap analysis in above mentioned areas is presented in the following sections:

3.3.1 Conventional oil fired pit furnaces

Technology gaps/design flaws in conventional coal fired pit furnace system are identified and same is presented in details below:

- **Waste heat recovery system**: From energy use & technology audit studies it was observed that, there is no waste heat recovery system to recover the heat losses from hot flue gasses in pit furnaces. Major amount of heat is lost in flue gasses in pit furnaces. This amount to around 35% of total energy input.
- **Preheating of charge/air**: In majority of the systems it was observed that, there is no system for preheat of charge/air. Preheating of charge to around 200-300 deg C will reduce the energy consumption by 5-8%.
- **Insulating material:** Furnace lining of the existing furnace was 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 pit furnace was usually done with locally available red bricks, which do not serve the purpose of insulation.
- **Combustion space:** From Technology audit it was observed that combustion space in existing system is not sufficient for proper combustion, which causes poor combustion system efficiency**.**
- **Burners:** Majority of units are using locally fabricated burners for the combustion of fuel oil. These burners were either a far copy of a properly designed burner or sometimes substandard and locally designed. Many times, oil could be seen leaking from the burner joints.
- **Selection and size of Blower system:** A proper capacity blower is necessary for combustion air to be delivered at correct pressure and in appropriate volume. The existing blowers in majority of the units are either locally fabricated without any proper design parameters or are under/over- sized without any consideration for correct air pressure.
- **Inadequate sizing of heating and pumping unit:** In most of the units it was observed that heating and pumping system 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.

3.3.2 Conventional coal fired Pit furnaces:

Technology gaps/design flaws in conventional coal fired pit furnace system are identified and same is presented in details below:

- **Waste heat recovery system**: From energy use and technology studies it was observed that, there is no heat recovery system to recover heat from hot flue gasses in coal fired pit furnaces. Major percentage of heat is lost in flue gasses in pit furnaces, which amounts to 35-45% of total input energy; which causes poor efficiency of pit furnaces.

Figure 3.6: *Coal fired brass melting furnace* operation

- **Insulating material:** Furnace lining of the existing furnace was done with the locally available firebricks. The firebricks with low alumina content tend to get worn out in a short duration.
- **Preheating of charge**: In majority of the systems it was observed that, there is no system for preheat of charge. By preheating of charge to around 200-300 deg C will reduce the energy consumption by 5-8%.
- **Poor mixing of material in crucible:** From technology audit studies it was observed that, there is temperature difference between upper and lower portion of material in crucible due to air pockets between dust & ware and poor mixing of material in crucible. This is affecting the efficiency of furnace as well as burning loss in furnace.
- **Working environment is not safe:** During pouring operation operators are directly exposed to high temperature furnace.

3.3.3 Conventional oil fired reheating furnaces (Billet heaters)

Technology gaps/design flaws in conventional oil fired reheating furnace system are identified and details are described below:

- **Air-Fuel ratios:** From energy use and technology studies it was observed that, air fuel ratio is not proper. This reduces the furnace efficiency by3-5%.

Figure 3.7: *Operation of conventional oil fired Billet heater*

- **Location of chimney:** In majority of industries, chimney was located at centre of reheating furnaces; this causes the poor heat transfer between flue gasses and charge; this automatically leads to poor heat transfer efficiency between flue gas and reheating material.
- **Waste heat recovery system:** This is the one of the area where major amount of heat energy is lost; in majority of the units is not installed waste heat recovery system to recover the heat from flue gasses. In a few cases it was observed that efficiency of existing waste heat recovery system is poor. Around 35% of heat input energy to reheating furnace is lost in the flue gasses.
- **Preheating of charge and combustion air:** In majority of the systems it was observed that, there is no system for preheat of charge and air.
- **Insulating material:** Furnace lining of the existing furnace was 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 pit furnace was usually done with locally available red bricks, which do not serve the purpose of insulation.
- **Burner:** Majority of units are using locally fabricated burners for the combustion of fuel oil. These burners were either a far copy of a properly designed burner or sometimes substandard and locally designed. Many a times, oil could be seen leaking from the burner joints. Same types of burners were used for a large range of fuel flow rates.

- **Selection and size of Blower system:** A proper capacity blower is necessary for combustion air to be delivered at correct pressure and in appropriate volume. The existing blowers in the majority of the units are either locally fabricated without any proper design parameters or are under/over- sized without any consideration for correct air pressure.
- **Inadequate sizing of heating and pumping unit:** In majority of the units it was observed that heating and pumping system 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.

3.3.4 Sand gravity based moulding system

- **Quality of product**: In Energy use and technology audit studies it was observed that quality of product from sand gravity based molding system is poor compared to other technologies available in market.
- **Rejection rate:** Around 10-20% of final casting is rejected due to improper mixing of sand, variation of moisture content in sand, improper making of moulding system etc.
- **Pouring time:** Time being taken to pour the molten material in system is high - this reduces the productivity.
- **More metal loss:** Manual pouring of molten material in molding system will take around 45min - this increases fuel consumption and metal loss.
- **Working environment is not safe:** During pouring operation operators are directly being exposed to high temperature furnace.

3.4 ENERGY CONSERVATION PROPOSALS

Various energy conservation proposals are identified for Brass units in Jamnagar Brass cluster. Details of identified energy conservation proposals along with its cost benefit analysis and issues in implementation of each proposal are presented in following sections.

3.4.1 Replacement of conventional Reheating furnace with energy efficient reheating furnace

➲ Background

Existing reheating furnaces being used in majority of the industries are 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 reheating furnace with energy efficient reheating furnace.

Figure 3.8: ***Operation of Energy efficient reheating furnace***

➲ Benefits of proposals

Major advantages of replacing conventional reheating furnace with energy efficient reheating furnace are presented below:

- Improved product quality
- Saving in reheating time - it automatically leads to energy savings
- Improved working environment
- Productivity improvements

➲ Cost benefits analysis

Cost benefits analysis of the replacing the conventional reheating furnace system with energy efficient reheating furnace system in typical Brass industry is presented in table below:

Table 3.2: ***Cost benefits analysis of replacing of conventional reheating furnace system with energy efficient reheating furnace system***

Parameter	Units	Value
Efficiency of existing reheating furnace	%	17.59
Specific fuel consumption of conventional reheating furnace	liters/tonne	37.03
Efficiency of energy efficient reheating furnace	%	28.00
Specific fuel consumption of energy efficient reheating furnace	liters/tonne	23.26
Savings in fuel consumption	liters/tonne	13.77
Annual production capacity	tonne	500
Annual fuel savings after replacing conventional reheating furnace with energy	liters/annum	6885