DETAILED PROJECT REPORT
ON
ENERGY EFFICIENT OIL FIRED PIT FURNACE (300 KG)
(JAMNAGAR BRASS CLUSTER)

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Bureau of Energy Efficiency

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ENERGY EFFICIENT OIL FIRED PIT FURNACE (300 KG)

(JAMNAGAR BRASS CLUSTER)

BEE, 2010

Detailed Project Report on Energy Efficient Oil Fired Pit Furnace (300 kg)

Brass SME Cluster, Jamnagar, Gujarat (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.: ***JAM/BRS/EOF/08***

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Winrock International India

New Delhi

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List of Abbreviations

MT	Metric Tonne
kWh	kilo Watt Hour
GoI	Government Of India
MSME	Micro Small and Medium Enterprises
GHG	Green House Gas
BEE	Bureau of Energy Efficiency
DPR	Detailed Project Report
O&M	Operational & Maintenance
NPV	Net Present Values
ROI	Return on Investment
IRR	Internal Rate Of Return
DSCR	Debt Service Coverage Ratio
PBT	Profit Before Tax
PAT	Profit After Tax
ID	Induced Draft
FD	Forced Draft
DBT	Dry Bulb Temperature
MoMSME	Ministry of Micro Small and Medium Enterprises
SIDBI	Small Industries Development Bank of India

EXECUTIVE SUMMARY

Winrock International India is executing BEE-SME program in Jamnagar Brass Cluster, supported by Bureau of Energy Efficiency (BEE) with an overall objective of improving the energy efficiency in cluster units.

Jamnagar is known as the brass city of India, it has been an important industrial centre since long for brass related parts. 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. Hence this cluster was chosen for energy efficiency improvements by implementing energy efficient technologies, so as to facilitate maximum replication in other brass clusters in India.

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.

The function of oil fired pit furnace in brass industries is melting of raw material, which is subsequently used in for pouring into different moulds to obtain different shapes. 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.

Implementation of new energy efficient oil fired pit furnace of capacity 300 kg having efficiency higher than the conventional furnace, will lead to reduction of 21000 liter furnace oil per year.

This DPR highlights the details of the study conducted for assessing the potential for replacement of conventional oil fired pit furnace by new energy efficient oil fired pit furnace , possible energy saving, and its monetary benefit, availability of the technologies/design, local service providers, technical features & proposed equipment specifications, various barriers in implementation, environmental aspects, estimated GHG reductions, capital cost, financial analysis, sensitivity analysis for three different scenarios and schedule of Project Implementation.

This bankable DPR also found eligible for subsidy scheme of MoMSME for "Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises" under "National Manufacturing and Competitiveness Programme". The key indicators of the DPR including the Project cost, debt equity ratio, monetary benefit and other necessary parameters are given in table:

S.No	Particular	Unit	Value
1	Project cost	₹(in Lakh)	3.74
2	Fuel saving	litre/year	21000
3	Monetary benefit	₹(in Lakh)	5.73
4	Debit equity ratio	Ratio	3:1
5	Simple payback period	years	0.65
6	NPV	₹(in Lakh)	17.21
7	IRR	%	116.68
8	ROI	%	30.37
9	DSCR	Ratio	6.09
10	Process down time	Days	7
11	CO_2 reduction	Tons/year	62

The projected profitability and cash flow statements indicate that the proposed project implementation i.e. energy efficient pit furnace with existing pit furnace will be financially viable and technically feasible.

ABOUT BEE'S SME PROGRAM

Bureau of Energy Efficiency (BEE) is implementing a BEE-SME Programme to improve the energy performance in 25 selected SMEs clusters. Jamnagar Brass Cluster is one of them. The BEE's SME Programme intends to enhance the energy efficiency awareness by funding/subsidizing need based studies in SME clusters and giving energy conservation recommendations. For addressing the specific problems of these SMEs and enhancing energy efficiency in the clusters, BEE will be focusing on energy efficiency, energy conservation and technology up gradation through studies and pilot projects in these SMEs clusters.

***Major activities in the BEE -SME program are furnished below*:**

Activity 1: Energy use and technology audit

The energy use technology studies would provide information on technology status, best operating practices, gaps in skills and knowledge on energy conservation opportunities, energy saving potential and new energy efficient technologies, etc for each of the sub sector in SMEs.

Activity 2: Capacity building of stake holders in cluster on energy efficiency

In most of the cases SME entrepreneurs are dependent on the locally available technologies, service providers for various reasons. To address this issue BEE has also undertaken capacity building of local service providers and entrepreneurs/ managers of SMEs on energy efficiency improvement in their units as well as clusters. The local service providers will be trained in order to be able to provide the local services in setting of energy efficiency projects in the clusters

Activity 3: Implementation of energy efficiency measures

To implement the technology up gradation projects in clusters, BEE has proposed to prepare the technology based detailed project reports (DPRs) for a minimum of five technologies in three capacities for each technology.

Activity 4: Facilitation of innovative financing mechanisms for implementation of energy efficiency projects

The objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion

1 INTRODUCTION

1.1 Brief introduction about Cluster

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 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. 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

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

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.

1.1.1 Existing production process

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.

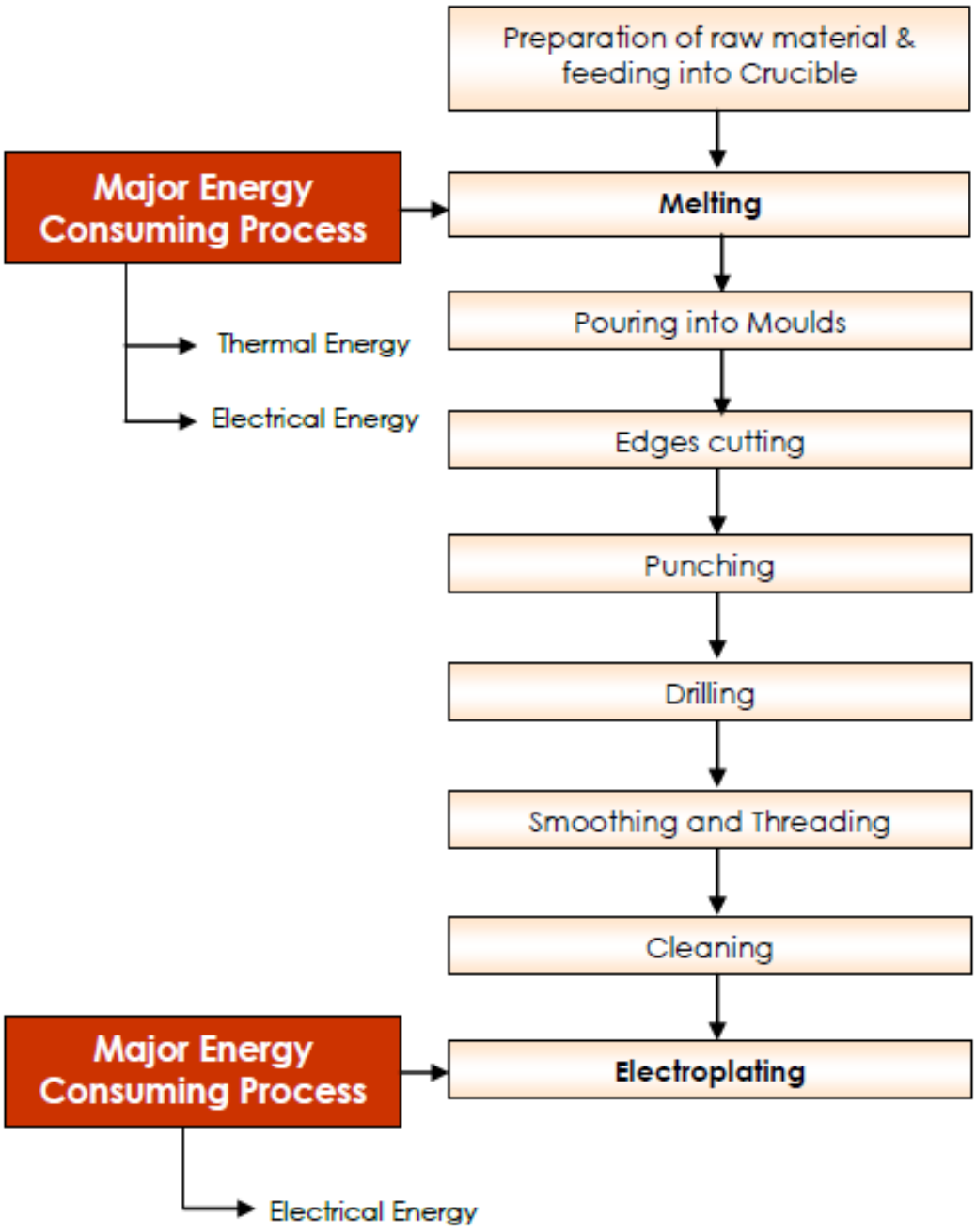


Figure 1.1: Process flow chart

1.2 Energy Performance Jamnagar Brass 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.

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 below bar chart

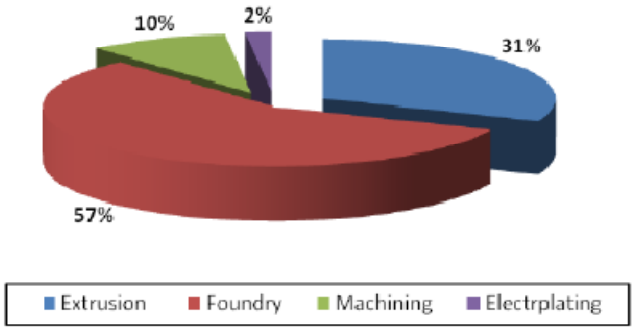


Figure 1.2: Percentage of energy consumption in different type of unit

1.2.1 Specific energy consumption

Specific electrical and thermal energy consumption in brass unit is varying on the final product manufactured in that unit. Specific energy consumption specific energy cost in different brass unit is shown in Table 1.1 & Table 1.2 below:

Table 1.1 Specific energy consumption in various brass units

S.No.	Type of units	Unit	Value
1	Brass foundry unit	kCal/kg of brass rod	1013-1057
2	Brass extrusion unit	kCal/kg of brass rod	1037-1186
3	Brass machining unit	kCal/kg of final product	473.04
4	Brass electroplating	kCal/kg of final product	875.21

Table 1.2 Specific energy cost in various brass units

S.No.	Type of units	Unit	Value
1	Brass foundry unit	₹/kg of brass rod	3.17-3.02
2	Brass extrusion unit	₹/kg of brass rod	5.64-5.194
3	Brass machining unit	₹/kg of final product	3.24
4	Brass electroplating unit	₹/kg of final product	5.99

1.3 Identification of existing technology/ equipment

1.3.1 Description of equipment

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. Performances of various oil fired pit furnace in Jamnagar Brass units are evaluated and analyzed the quantum of various losses in oil fired pit furnace were analyzed. It was observed that oil fired pit furnace has poor efficiency due to poor combustion space, improper location & size of burners and improper capacity of blower system etc. It is recommended to replace conventional oil fired furnace with energy efficient oil fired furnace.

Figure1.3 Existing furnace operations

From energy use and technology gap audit studies in various brass industries in Jamnagar brass cluster, below mentioned things are identified:

- Energy efficiency improvement opportunities
- Environment and safety improvement of workers
- Design flaws in the conventional oil fired pit furnace
- Operational & maintenance practices in conventional oil fired pit furnace

1.3.2 Technical gap in conventional oil fired pit furncae

Technology gaps/design flaws in conventional oil fired pit furnace system are identified and described below in detail

- **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. The energy audit study reveals that the amount of heat loss in flue gas of pit furnaces is around 35% of total energy input.

- **Preheating of charge/air**

In majority of the systems it was observed that, there is no system to preheat the charge and / or 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 is with locally available firebricks. The locally available firebricks contain low alumina and 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 insufficient to hold 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 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.

1.3.3 Role in the process

The function of oil fired pit furnace in brass industries is melting of raw material, which is subsequently used in for pouring into different moulds to obtain different shapes. From the above sections it is clear that melting is one of the major energy and time consuming process in the overall manufacturing process in brass industry. Apart from the energy and time, final product quality will depend on time and temperature of melting of raw material.

1.3.4 Need for up gradation of existing equipment

From the above sections it is clear that melting cost is one of the major costs in the overall production process of brass, in typical brass industry which comes out to be 28 ₹/Litre, this is approximately 20% of overall energy cost. Apart from the high energy cost, melting time is one of the major time consuming process in brass industry, this would be around 1.2–1.5 hours per melt.

Advantages of replacing the conventional oil fired pit furnace with Energy Efficient pit furnace are:

- Reduction in specific energy consumption
- Improved productivity and product quality
- Reduction in specific energy cost
- Improves working environment
- Preheating of charge will reduce the fuel consumption
- Improved and efficient waste heat recovery system

1.4 Baseline energy consumption of existing equipment

Energy consumption in oil fired pit furnace would depend on below mentioned things:

- Melting time and temperature
- Fuel consumption
- Operational and maintenance practices in agitator system
- Location and size of burner

Energy use and technology audit studies were conducted in various units of Jamnagar brass cluster to establish the baseline energy consumption of oil fired pit furnace and the reports of same are attached in Annexure – 1.

1.4.1 Design and operating parameters

Major operational parameters improvements in oil fired pit furnace performance are:

- Improve heat and mass transfer area
- Capture waste heat through waste heat recovery system
- Appropriate burner size and location of the burner
- Installation of temperature control device
- Choose appropriate size of blower system

1.4.2 Specific fuel consumption

Fuel consumption of typical oil fired furnace of capacity 150 kg is around 130 litre/tonne of production. Performance of existing oil fired pit furnace was evaluated and same is presented in Annexure 1.

1.4.3 Energy audit methodology

Predefined methodology was adopted to evaluate the performance of oil fired pit furnace, same was furnished below:

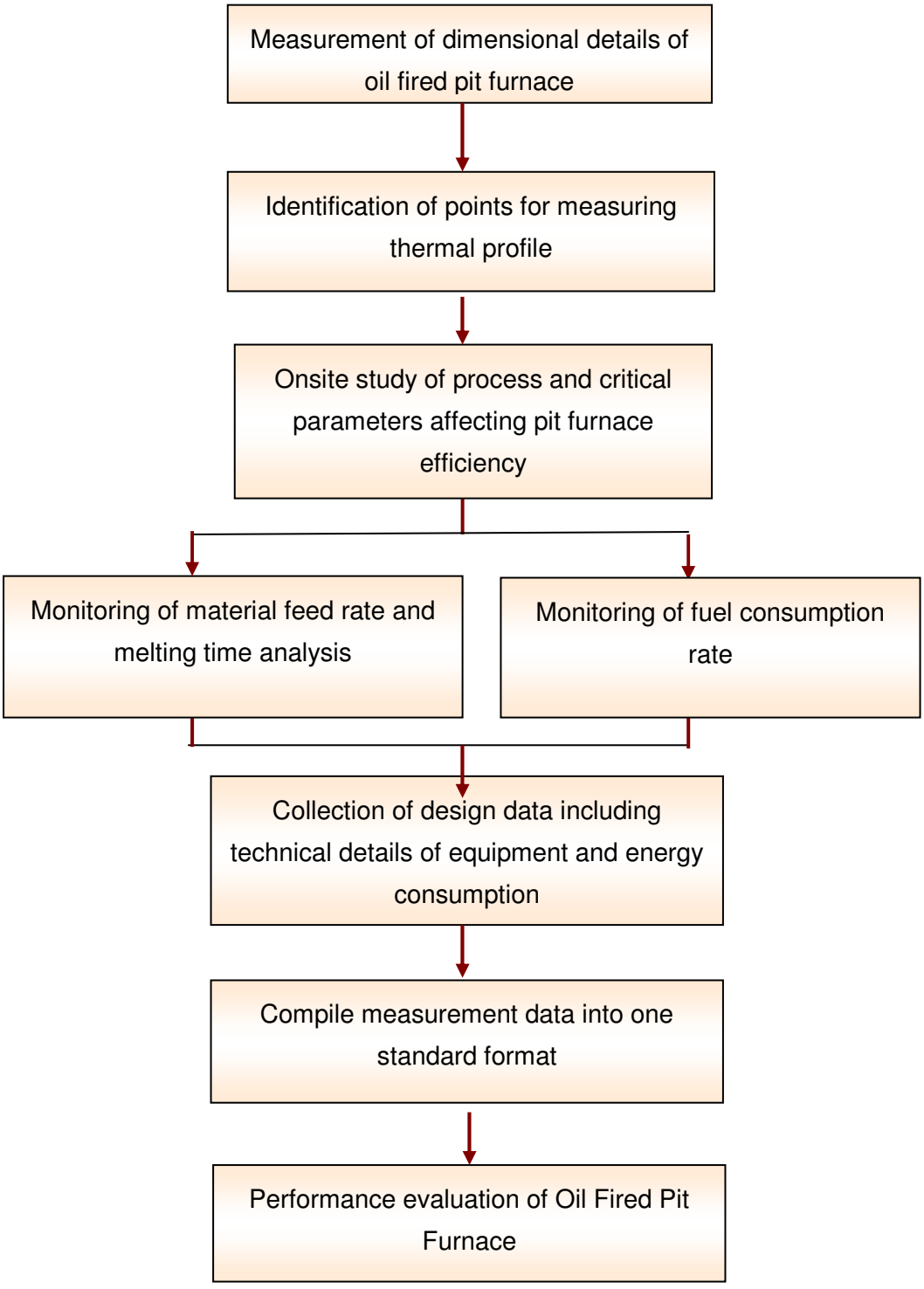


Figure1.4: Energy audit methodology

1.5 Barriers in adoption of proposed technology/equipment

The processes to do with technology and innovations in SMEs are different from those that take place the 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 are stressed less emphasis on technology due to cut the initial cost of plant /machinery. Major barriers in the up gradation of technology in the cluster are non availability of technology; distrust on technology supplier, lack of information about energy efficiency among small and medium enterprises still persists, preventing increased adoption of efficient technologies and non availability of skilled manpower and cost of new technologies. Details of the other barriers in the implementation of energy efficient technologies/equipments in the Jamnagar Brass cluster are presented in below sections.

1.5.1 Technological Barrier

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 and 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.

1.5.2 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.

1.5.3 Skilled 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.

1.5.4 Non availability of 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.

2 EQUIPMENT OPTION FOR ENERGY EFFICIENCY IMPROVEMENT

2.1 Description of proposed equipment

Energy efficient Oil fired pit furnaces are available with variable speed blowers and adjustable pulley. They are energy efficient, safe & reliable. Some of the salient attributes energy efficient oil fired pit furnaces are as follows:

- The burners can be operated with LPG/natural gas, LDO, LSHS, HSD.
- Energy efficient burner and combustion system manufactured with latest technology such as Pulse firing technology using fast acting solenoid valves operated by time proportionate PID (Proportional Integral Derivative Controller) system to maintain the furnace temperature uniformity of +/- 5° C.
- Automatic temperature controller and paperless recording system to record time Vs temperature curve.
- Auto and manual air/oil ratio control system with 100% stoichiometric firing.

2.1.1 Comparison of conventional pit furnace with new pit furnace

Technical, economic, Environmental, safety aspects of conventional pit furnace and energy efficient pit furnace are compared on life cycle of equipment, same is presented in Table 2.1 below:

Table 2.1 Comparison of conventional equipment and proposed equipment

S. No	*Details*	Conventional oil fired pit furnace	Energy efficient oil fired pit furnace
1	Fuel consumption	High	Low
2	Environment pollution	High (*partial combustion & more fuel consumption*)	Low (*Complete combustion & less fuel consumption*)
3	Safety of workers	Poor	Good
4	Maintenance	High	Low
5	Operational cost	High	Low
6	Availability of local service providers	Yes	Yes
Technical comparison			
7	Fuel combustion	Partial	Complete

8	Control of air/fuel combustion	No	Yes
9	Temperature monitoring & control	No	Yes
10	Radiation losses	More	Less
11	Heat transfer between hot gasses and cold air	Less (Single path flue gas); Heat transfer efficiency is less	More (Three path flue gas); heat transfer efficiency is more
12	Radiation heat in combustion chamber	Not utilized	Utilized in the transfer of heat

From the above table it is clear that Energy efficient oil fired pit furnace has significant advantages in Energy, Environmental, Economic & safety aspects. It is technically justifiable to install energy efficient oil fired pit furnace in place of conventional oil fired pit furnace.

2.1.2 Suitability over existing system

The proposed equipment is completely replaced the existing system and suitable with the existing process.

2.1.4 Technical specifications

Specification for energy efficient oil fired pit furnace varies from industry to industry and can be provided to vendor as per the need. General specification of oil fired pit furnace is given below:

Table 2.2 Technical specifications

Parameters	*Details*
Capacity	To accommodate Crucible of capacity 300 kg of Brass.
Max. temperature	1050 Deg. C
Normal	950 Deg. C
Fuel	Diesel/Ldo
Thickness of outer shell	5 mm M.S.
Thickness of top plate	12 mm
Type of Insulation	Energy saving Ceramic Fibre Blankets along with refractory bricks at bottom of the furnace and element holding bricks.

2.1.5 Superiority over existing system

Energy efficient Oil fired pit furnaces are available with variable speed blowers and adjustable pulley. They are energy efficient, safe & reliable.

2.1.6 Availability of proposed equipment

The technology identified for implementation is available locally and are indigenously produced. The technology/ equipments will be procured from local equipment suppliers. The proposed equipment is locally manufactured by well known vendor in Jamnagar brass cluster for making energy efficiency equipments in cluster.

The technology identified is available in the State of Gujarat (Jamnagar) and implemented successfully in few units in the cluster. The investment required for implementation of the identified measures has good financial returns and the proposed measure is technically and financially viable.

2.1.7 Equipment providers

Technology/service provider selected for implementation of the proposed energy efficiency project has long years of experience in implementation of energy efficiency projects. This technology/service provider is having in house R&D team to develop the new technologies / equipments, which are energy efficient & eco friendly. Recommended supplier having the trust in cluster on products developed by them. Details of equipment suppliers are furnished in Annexure 7.

2.1.8 Terms and conditions in sales of Oil fired pit furnace

The terms and condition of sales of new energy efficient oil fired pit furnace from the proposed supplier is given at Annexure 8.

2.2 Process down time during implementation

The process down time for implementing the replacement of conventional oil fired pit furnace with energy efficient oil fired pit furnace will take one week. The implementation can be taken up during weekly holiday, or other holidays, so that the process down time can be reduced.

2.3 Suitable unit for proposed equipment

Proposed energy efficient furnace is suitable for unit having production 300 kg/hr.

3 ECONOMIC BENEFITS OF NEW EQUIPMENT

Energy use and technology audit studies were conducted in various units of the Jamnagar brass cluster to evaluate the performance of existing furnace, technical gaps in existing furnace and analyzed energy, economic, environmental and social advantages of energy efficient pit furnace over conventional pit furnace.

3.1 Energy & monetary benefits

3.1.1 Fuel Saving

From Energy use and technology audit studies it was observed that energy consumption of oil fired pit furnace depends on the type of fuel, number of burners and temperature of furnace. Analysis was carried out on conventional oil fired pit furnace average fuel consumption from various energy use and technology audit studies in brass units in Jamnagar brass cluster; it comes out to be 130 litre/tonne. Fuel consumption of proposed energy efficient oil fired pit furnace is 95 litre/tonne. Hence, Implementation of this system would save about 21000 liter furnace oil annually for production of 600 tons.

3.1.2 Electricity saving

Project implementation will not save electricity while its implementation will increase electricity consumption of about 2984 kWh per year.

3.1.2 Monetary benefit

Annual monetary savings due to implementation of energy efficient pit furnace is about ₹ 5.73 lakh per annum. Details of monetary saving and fuel saving calculation are furnished at Annexure 3.

3.2 Environmental benefits

3.2.1 Reduction in fuel consumption

Most of units in the cluster are using furnace oil for oil fired pit furnace; by implementing the proposed energy efficient oil fired pit furnace in place of conventional furnace will reduce consumption of furnace oil. In proposed energy efficiency oil fired pit furnace, oil consumption is low compared to conventional oil fired pit furnace.

3.2.2 GHG emission reductions

Fuel consumption of proposed energy efficient oil fired pit furnace is 27% less than conventional pit furnace; it automatically leads to reduction of GHGs emissions by implementing proposed energy efficiency oil fired pit furnace in-place of conventional

furnace. Reduction of GHGs emissions leads to improved environment and better compliance with environmental regulations.

3.2.2 CDMability of the project

The proposed project saves about 21000 litres of oil per year for oil fired pit furnace. This roughly corresponds to 62 tonnes of CO_2 emission reduction or 62 CERs. Considering at the cluster level 200 units implement the technology yielding to a total savings of about 12400 CERs per annum which can be a suitably sized small scale CDM project.

3.3 Social benefits

3.3.1 Impact on working environment

Replacement of conventional oil fired pit furnaces with energy efficient fired oil fired pit furnaces will reduce furnace skin temperature, closed combustion chamber & temperature control of oil fired pit furnaces, all those things will improves the working condition & safety of workers near to oil fired pit furnace.

3.3.2 Impact on manpower skills

Proposed energy efficient oil fired pit furnace components were procured from other companies and also generate employment during installation and commissioning. As training will be provided by equipment suppliers will improve the technical skills of manpower required for operation of the equipment.

3.3.3 Impact on wages/emoluments

The awareness among the technologies and training retained during implementation of the project will lead to increase the wages of the employees indirectly, as it improves the technical skills of the workforce during operation and maintenance of equipments. Further, the remuneration will improve in the market or in other companies for the work force.

3.4 Other benefits (If any)

3.4.1 Productivity improvements

Due to improved design of oil fired pit furnace will improves melting temperature; this automatically reduces melting time of brass. It was observed that melting is one of major time consuming area, melting time reduction in brass manufacturing unit will improves productivity of brass units in Jamnagar brass cluster.

3.4.2 Quality improvements

Most of the brass manufactured in Jamnagar brass industries is temperature sensitive. As already discussed in above Chapters that inbuilt design of automatic temperature control

system in energy efficient oil fired pit furnace will control temperature of material inside the furnace, this automatically improves quality of material.

3.4.3 Reduction of production costs

Melting is the one of major contributor to overall energy cost in brass unit. Melting cost in typical brass manufacturing unit in Jamnagar Brass cluster using conventional oil fired pit furnace is around 3.64 ₹/kg of final product. Implementation of energy efficient oil fired pit furnace in-place of conventional oil fired pit furnace reduces drying cost to 2.66 ₹/kg, this will reduces production cost significantly and reduces energy cost by 27%.

3.4.4 Easy operation& maintenance

In energy efficient oil fired pit furnace was designed such way that easy access to regular operational and maintenance in oil fired pit furnace.

4 ECONOMICS & IMPLEMENTATION OF NEW SYSTEM

4.1 Cost of project implementation

4.1.1 Equipment cost

Technical and financial quotations of proposed energy efficient pit furnace are collected from reputed vendors. Cost of energy efficient oil fired pit furnace having annual production capacity of 150 kg is ₹ 3.40 lakh only as per the quotation provided at Annexure 8.

4.1.2 Other cost

Erection & commissioning cost is ₹ 0.34 lakh only. Details of project cost are furnished in Table 4.1 below:

Table 4.1 Details of proposed equipment installation cost

S.No	Particular	Unit	Value
1	Equipment cost	₹ (in Lakh)	3.40
2	Erection & Commissioning cost	₹ (in Lakh)	0.34
3	Other misc. cost	₹ (in Lakh)	0.00
4	Total cost	₹ (in Lakh)	3.74

4.2 Arrangement of funds

Proposed financing for the replacement of conventional furnace with energy efficient furnace is made considering a debt equity ratio of 3:1, which is normally allowed by financial institutions for financing energy efficiency projects. On the basis of debt equity ratio of 3:1 the promoter's contribution works out to 25% of the project cost and the balance would be term loan from the Bank / FIs.

4.2.1 Entrepreneurs contribution

Total cost (Equipment and erection& commissioning) of project works out to be ₹ 3.74 lakh. Out of which entrepreneur's contribution is 25%, which work out to be ₹ 0.94 lakh.

4.2.2 Loan amount

75% of the project cost would be available as term loan from the banks/financial institutions, which works out to be ₹ 2.81 lakh.

4.2.3 Terms & conditions of loan

The interest rate is considered at 10% which is SIDBI's rate of interest for energy efficient projects. The loan tenure is 5 years excluding initial moratorium period is 6 months from the date of first disbursement of loan.

4.3 Financial Indicators

4.3.1 Cash flow analysis

Profitability and cash flow statements have been worked out for a period of 8 years, being period, with in which the entire term loan would be repaid. The financials have been worked out on the basis of certain realistic assumptions, which are outlined below

- The project is expected to achieve monetary savings of ₹ 5.73 lakh per annum.
- The operational and Maintenance cost is estimated at 4% of cost of fixed assets with 5% increase every year to take care of escalations.
- The erection and commissioning charges is estimated at 10% of the total project cost for the plant and machinery
- Interest on term loan is estimated at 10%. The tenure of the loan is considered 5years and repayment starts after 6months from the first date of disbursement of loan in 60monthly installments.
- Depreciation is provided as per the rates provided in the companies Act.
- Income tax provision is made as per IT Act 1961.
- Based on the above assumptions, profitability and cash flow statements have been prepared.

4.3.2 Simple payback period

Simple payback period of replacing conventional furnace with energy efficient furnace is 0.65 year.

4.3.3 Net Preset Value (NPV)

The Net present value of the investment on project is at @10.00% interest works out to ₹ 17.21 lakh.

4.3.4 Internal rate of return (IRR)

After tax Internal Rate of Return of the project is works out to be 116.68%. Thus the project is financially viable.

4.3.5 Return on Investment (ROI)

The average return on investment of the project activity works out at 30.37%.

Details of all the financial parameters for the replacement of conventional furnace with energy efficient furnace are presented in Table 4.2 below:

Table 4.2 Financial parameters of energy efficient furnace

S. No	Parameter	Unit	Value
1	Simple payback period	Years	0.65
2	NPV	₹ in lakh	17.21
3	IRR	%age	116.68
4	ROI	%age	30.37
5	DSCR	Ratio	6.09

4.4 Sensitivity analysis

In different situation fuel saving may increase or decrease on the basis of this scenarios a sensitivity analysis in realistic, pessimistic and optimistic scenario has been carried out which is as under

- Fuel saving increased by 5%
- Fuel saving decreased by 5%

Table 4.3 Sensitivity analysis

Particulars	IRR	NPV	ROI	DSCR
Normal	116.68%	17.21	30.37%	6.09
5% increase in fuel savings	122.23%	18.24	30.53%	6.40
5% decrease in fuel savings	111.10%	16.17	30.19%	5.79

Assuming all provision and resource input would remain same during sensitivity analysis

4.5 Procurement and implementation schedule

Total time required for implementation of proposed project is about 15 weeks from the date of financial closure. Detailed procurement and implementation schedules are furnished at Annexure 6.

ANNEXURE

Annexure-1 Energy audit reports of conventional pit furnace

Oil fired pit furnace is the one of the major energy consuming equipments in production process of brass Unit.

There are two methods to find out the efficiency of the furnace i.e.

- Direct method
- Indirect method.

The indirect method covers various heat losses like dry flue gas loss, radiation loss, loss due to hydrogen in fuel etc. However, it was not possible to calculate the efficiency by indirect method due to lack of proper arrangements and poor design. Therefore, the furnace efficiency has been calculated by Direct Method only.

Efficiency of existing furnace

Efficiency of Conventional oil fired pit furnace		
Total Material Heated	kg/hr	150.00
Temperature of Material at Furnace Entry	^{O}C	30.00
Temperature of Material at Furnace Exit	^{O}C	900.00
Specific Heat of the Material	kCal/kg-^{O}C	0.09
Heat Absorbed by the Material	kCal/hr	11745
Fuel consumption	Litre/hr	19.50
Specific gravity of fuel		0.88
Calorific Value of the Fuel	kCal/kg	10500.00
Total Heat input to the Furnace	kCal/hr	180180.00
Furnace Efficiency	% age	6.5

Observations:

- High fuel consumption is observed in conventional oil fired pit furnace due to improper burner location.
- No temperature monitoring and control system in conventional oil fired pit furnace.
- High melting temperature is achieved for efficient and effective in energy efficient oil fired pit furnace.
- Inefficient burners and leaking from the burner joints in conventional oil fired pit furnace.

- More maintenance is required in conventional oil fired pit furnace as compared to energy efficient oil fired pit furnace.
- Poor combustion system in conventional oil fired pit furnace
- In conventional oil fired pit furnace the blowers are of local make, there is no specification on rated capacity CFM and pressure
- Reason for poor heat transfer efficiency in oil fired pit furnace are small heat exchange area and short contact time between flue gas and air.

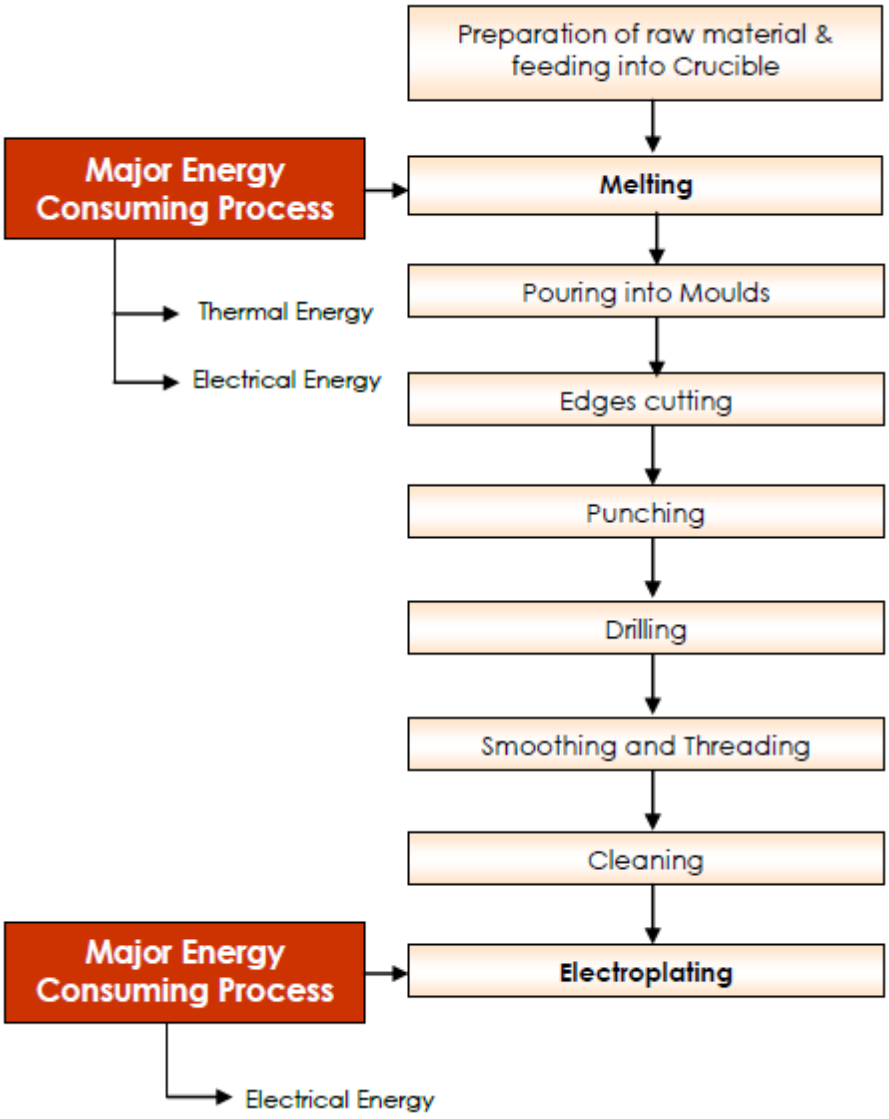
Calculation of energy efficient oil fired pit furnace efficiency by direct method at Unit-1

Efficiency of Conventional oil fired pit furnace		
Total Material Heated	kg/hr	150.00
Temperature of Material at Furnace Entry	^{O}C	30.00
Temperature of Material at Furnace Exit	^{O}C	1000.00
Specific Heat of the Material	kCal/kg-^{O}C	0.09
Heat Absorbed by the Material	kCal/hr	13095.00
Fuel consumption	Litre/hr	14.25
Specific gravity of fuel		0.88
Calorific Value of the Fuel	kCal/kg	10500.00
Total Heat input to the Furnace	kCal/hr	131670.00
Furnace Efficiency	% age	10

On replacing conventional oil fired pit furnace with the energy efficient oil fired pit furnace it is observed that the efficiency improves from 6.51% to 10%. The fuel consumption reduced by 5.25 litres.

Annexure 2 Process flow diagram

Process flow diagram of typical brass industry in Jamnagar Brass cluster is furnished in figure below:



Annexure-3 Detail technical assessment report

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.

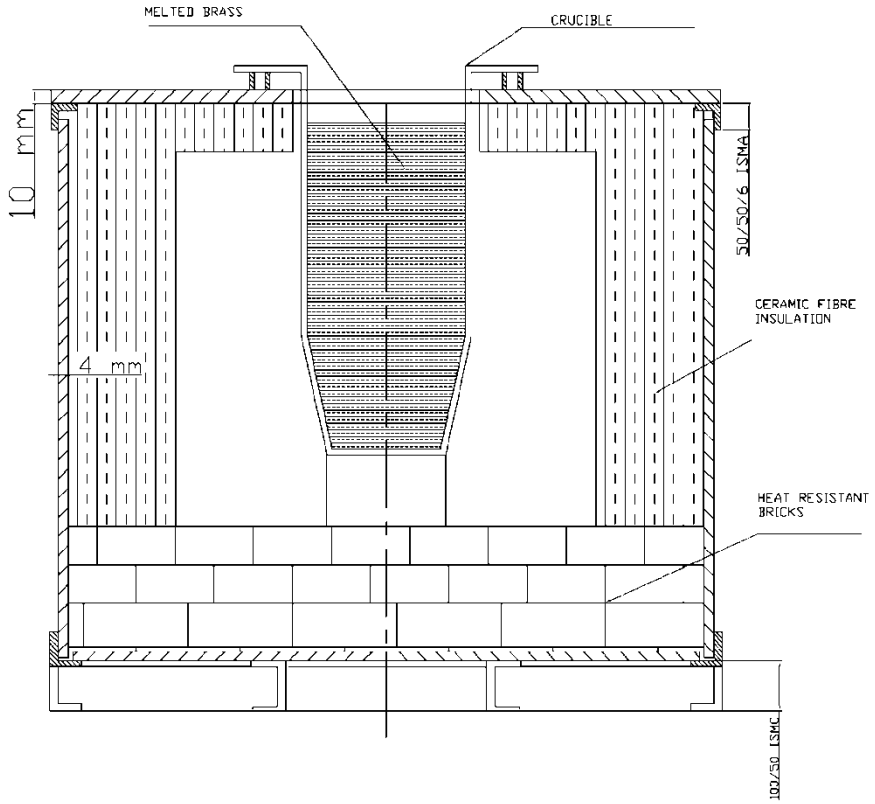
There is a tremendous need for this industry to modernize/upgrade its technology and adopt energy efficient technologies in some of the areas. Further, as per the discussions made with the some of the progressive managements, they are interested to improve the efficiency of their units by replacing the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

The various factors which influence the management towards implementation energy efficiency and energy conservation projects in brass unit in Jamnagar Brass Cluster are:

- Energy efficiency and energy conservation is a low cost investment option which reduces energy consumption
- Low capital investment
- The energy efficiency improvement will enhance the plant management to be competitive in local and global markets by reducing production cost
- To conserve depleting fossil fuels
- The energy efficiency and conservation reduces GHG emissions because of low carbon dioxide and particulate emissions
- Energy efficiency and conservation is a viable strategy to meet future energy needs of the expanding plans in the industry

Parameter	Units	Value
Total material heated	kg	150
Fuel consumption for process 150 kg	Liter	19.5
Specific fuel consumption of conventional oil fired pit furnace	litre/tonne	130
Efficiency of existing oil fired furnace	% age	6.5
Fuel consumption in proposed furnace for process 150 kg	litre	14.25
Specific fuel consumption of energy efficient oil fired pit furnace	litre/tonne	95
Fuel saving	litre/tonne	35
Total operating hours	hrs	2000
Annual production capacity	tonnes	600
Total fuel saving	Liter/year	21000
Cost of fuel	₹/litre	28
Total connected electrical load	HP	2
Total electricity consumption	kWh/year	2984
Annual electricity cost @ ₹ 5 per unit	₹ lakhs	0.15
Annual monetary saving	₹ in lakh	5.73
Implementation cost of energy efficient oil fired furnace	₹ in lakh	3.74
Simple payback period	years	0.65

Annexure-4 Detail drawing of energy efficient furnace



GENERAL ARRANGEMENT DRAWING OF BRASS MELTING FURNACE

Annexure-5:Detailed cash flow evaluations

Name of the Technology	***Energy Efficient Furnace***		
Rated Capacity	***300 kg***		
Details	***Unit***	***Value***	***Basis***
Installed Capacity	Kg	300	Feasibility Study
No of Operating Hours	Hrs.	2000	Feasibility Study
Proposed Investment			
Cost of plant & Machinery	₹(in lakh)	3.40	Feasibility Study
Erection & Commissioning (10% of plant machinery)	₹(in lakh)	0.34	Feasibility Study
Total Investment	₹(in lakh)	3.74	Feasibility Study
Financing pattern			
Own Funds (Internal Accruals)	₹(in lakh)	0.94	Feasibility Study
Loan Funds (Term Loan)	₹(in lakh)	2.81	Feasibility Study
Loan Tenure	Years	5	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	66	Assumed
Interest Rate	%	10.00	SIDBI Lending rate
Estimation of Costs			
O& M Costs	%(on Plant & Equip)	4.00	Feasibility Study
Annual Escalation	%	5.00	Feasibility Study
Estimation of Revenue			
Fuel savings	Liter/Annum	21000	-
Cost of fuel	₹/Liter	28	-
Electricity consumption	kWh	2984	-
Cost of Electricity	₹/kWh	5	-
St. line Depreciation	%	5.28	Indian Companies Act
IT Depreciation	%	80.00	Income Tax Rules
Income Tax	%	33.99	Income Tax Act 2008-09

Estimation of Interest on term loan ***₹(in lakh)***

Years	Opening Balance	Repayment	Closing Balance	Interest
1	2.81	0.12	2.69	0.33
2	2.69	0.32	2.37	0.26
3	2.37	0.48	1.89	0.21
4	1.89	0.64	1.25	0.16
5	1.25	0.76	0.49	0.09
6	0.49	0.49	-0.01	0.01
		2.81		

WDV Depreciation ***₹ (in lakh)***

Particulars / years	1	2
Plant and Machinery		
Cost	3.74	0.75
Depreciation	2.99	0.60
WDV	0.75	0.15

Projected Profitability ***₹ (in lakh)***

Particulars / Years	1	2	3	4	5	6	7	8
Revenue through Savings								
Fuel savings	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Total Revenue (A)	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Expenses								
O & M Expenses	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21
Total Expenses (B)	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21
PBDIT (A)-(B)	5.58	5.57	5.57	5.56	5.55	5.54	5.53	5.52
Interest	0.33	0.26	0.21	0.16	0.09	0.01	-	-
PBDT	5.26	5.32	5.35	5.40	5.46	5.53	5.53	5.52
Depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
PBT	5.06	5.12	5.15	5.20	5.26	5.33	5.33	5.32
Income tax	0.77	1.60	1.82	1.83	1.85	1.88	1.88	1.88
Profit after tax (PAT)	4.29	3.52	3.33	3.37	3.40	3.45	3.45	3.45

Computation of Tax **₹ (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	5.06	5.12	5.15	5.20	5.26	5.33	5.33	5.32
Add: Book depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Less: WDV depreciation	2.99	0.60	-	-	-	-	-	-
Taxable profit	2.26	4.72	5.35	5.40	5.46	5.53	5.53	5.52
Income Tax	0.77	1.60	1.82	1.83	1.85	1.88	1.88	1.88

Projected Balance Sheet

Particulars / Years	1	2	3	4	5	6	7	8
Liabilities								
Share Capital (D)	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Reserves & Surplus (E)	4.29	7.80	11.14	14.50	17.91	21.36	24.81	28.26
Term Loans (F)	2.69	2.37	1.89	1.25	0.49	-0.01	-0.01	-0.01
TOTAL LIABILITIES (D)+(E)+(F)	7.91	11.10	13.96	16.68	19.33	22.29	25.74	29.19
Assets								
Gross Fixed Assets	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
Less Accm. depreciation	0.20	0.39	0.59	0.79	0.99	1.18	1.38	1.58
Net Fixed Assets	3.54	3.35	3.15	2.95	2.75	2.56	2.36	2.16
Cash & Bank Balance	4.37	7.76	10.81	13.73	16.58	19.73	23.38	27.03
TOTAL ASSETS	7.91	11.10	13.96	16.68	19.33	22.29	25.74	29.19
Net Worth	5.22	8.74	12.07	15.44	18.84	22.29	25.75	29.19

Particulars / Years	1	2	3	4	5	6	7	8
Debt Equity Ratio	2.87	2.53	2.02	1.33	0.52	-0.01	-0.01	-0.01

Projected Cash Flow: ***₹ (in lakh)***

Particulars / Years	0	1	2	3	4	5	6	7	8
Sources									
Share Capital	0.94	-	-	-	-	-	-	-	-
Term Loan	2.81								
Profit After tax		4.29	3.52	3.33	3.37	3.40	3.45	3.45	3.45
Depreciation		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total Sources	3.74	4.49	3.71	3.53	3.56	3.60	3.65	3.65	3.64
Application									
Capital Expenditure	3.74								
Repayment Of Loan	-	0.12	0.32	0.48	0.64	0.76	0.49	-	-
Total Application	3.74	0.12	0.32	0.48	0.64	0.76	0.49	-	-
Net Surplus	-	4.37	3.39	3.05	2.92	2.84	3.16	3.65	3.64
Add: Opening Balance	-	-	4.37	7.76	10.81	13.73	16.58	19.73	23.38
Closing Balance	-	4.37	7.76	10.81	13.73	16.58	19.73	23.38	27.03

IRR **₹ (in lakh)**

Particulars / months	0	1	2	3	4	5	6	7	8
Profit after Tax		4.29	3.52	3.33	3.37	3.40	3.45	3.45	3.45
Depreciation		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Interest on Term Loan		0.33	0.26	0.21	0.16	0.09	0.01	-	-
Cash outflow	(3.74)	-	-	-	-	-	-	-	-
Net Cash flow	(3.74)	4.81	3.97	3.75	3.72	3.69	3.66	3.65	3.64
IRR	116.68%								

NPV	17.21

Break Even Point

Particulars / Years	1	2	3	4	5	6	7	8
Variable Expenses								
Oper. & Maintenance Exp (75%)	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16
Sub Total*(G)*	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16
Fixed Expenses								
Oper. & Maintenance Exp (25%)	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Interest on Term Loan	0.33	0.26	0.21	0.16	0.09	0.01	0.00	0.00
Depreciation *(H)*	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sub Total (I)	0.56	0.49	0.45	0.40	0.33	0.26	0.25	0.25
Sales (J)	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Contribution (K)	5.62	5.61	5.61	5.60	5.59	5.59	5.58	5.57
Break Even Point (L= G/I)	9.98%	8.79%	8.09%	7.17%	5.98%	4.65%	4.44%	4.49%
Cash Break Even {(I)-(H)}	6.46%	5.27%	4.56%	3.64%	2.45%	1.11%	0.90%	0.94%
Break Even Sales (J)*(L)	0.57	0.50	0.46	0.41	0.34	0.27	0.25	0.26

Return on Investment **₹ (in lakh)**

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Total*
Net Profit Before Taxes	5.06	5.12	5.15	5.20	5.26	5.33	5.33	5.32	41.77
Net Worth	5.22	8.74	12.07	15.44	18.84	22.29	25.75	29.19	137.56
									30.37%

Debt Service Coverage Ratio ***₹ (in lakh)***

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Total*
Cash Inflow									
Profit after Tax	4.29	3.52	3.33	3.37	3.40	3.45	3.45	3.45	21.36
Depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	1.18
Interest on Term Loan	0.33	0.26	0.21	0.16	0.09	0.01	0.00	0.00	1.06
Total (M)	4.81	3.97	3.75	3.72	3.69	3.66	3.65	3.64	23.61

DEBT

Interest on Term Loan	0.33	0.26	0.21	0.16	0.09	0.01	0.00	0.00	1.06
Repayment of Term Loan	0.12	0.32	0.48	0.64	0.76	0.49	0.00	0.00	2.81
Total (N)	0.45	0.58	0.69	0.80	0.85	0.50	0.00	0.00	3.87
Average DSCR (M/N)	6.09								

Annexure-6:Details of procurement and implementation plan

Procurement and implementation schedule of energy efficient furnace are presented below.

Activity	Weeks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Energy data reconfirmation															
Technical discussion & finalization															
Collection of vendor quotes															
Order placement															
Material receipt															
Installation & Commissioning															
Measurement of savings															
Certification of savings															

Annexure-7:Details of equipment and service providers

Name of company	**EM EM ENGINEERS**
Name of contact person	MANISH KUMAR SOOTA
Address of company	5/6, Road No. 1, Mundka Industrial Area (South Side), New Delhi-110041

Name of company	**The Wesman Engg. Co. Pvt. Ltd**
Name of contact person	Sudeep Dhar
Address of company	Wesman Center, 8 Mayfair Road, Kolkata – 700019

Annexure 8 Quotations of energy efficient furnace

EM EM ENGINEERS

Address: A-4/235, PaschimVihar, New Delhi-110063 (INDIA)

Date: 19-Oct-10

TECHNICAL DATA

Capacity	:	To accommodate Crucible of capacity 300Kgs of Brass.
Max. temperature	:	1050 Deg. C
Normal	:	950 Deg. C
Fuel	:	Diesel/Ldo
Thickness of outer shell	:	5 mm M.S.
Thickness of top plate	:	12 mm
Type of Insulation	:	Energy saving Ceramic Fibre Blankets along with refractory bricks at bottom of the furnace and element holding bricks.
Price with Silicon Carbide Crucible and Automatic Temperature Control Panel.	:	Rs.3,40,000/- (Rs. Two Lac Fourty thousand only) each, ex-our works, New Delhi

DESCRIPTION

The Furnace consists of Indigenous Silicon carbide Crucible enclosed with a refractory / ceramic fibre chamber.

The outer casings of the equipment are made out of substantial steel framework with welding and screw joints wherever required.

SCOPE OF SUPPLY

FURNACE DULY LINED WITH CERAMIC FIBRE BLANKETS, REFRACTORIES,FITTED WITH 1 NO. AUTOMATIC TEMPERATURE CONTROL PANEL , 1 NO. SILICON CARBIDE CRUCIBLE.

Trust you will find our offer in line with your requirement. However if you need any further information / clarification, please get in touch with us and we would be pleased to attend to the same.

We assure you of our best services at all times.

Thanking you

Yours Truly

For **EM EM ENGINEERS**

(MANISH KUMAR SOOTA)

BE (MECH), MBA

GENERAL TERMS & CONDITIONS

PRICES

Prices quoted by us are ex-our works, Delhi

PAYMENT

50% value of the order will be payable as advance along with the order and balance upto 100% value of each consignments along with full value of taxes, duties and any other levies as applicable at the time of dispatch will be payable against the Performa invoice prior to dispatch.

PACKING & FORWARDING

The charges shall be **extra at actual.**

INSURANCE

If desire by the customer we can cover the goods to be dispatched against transit insurance at an additional charge of 0.75% of the insured value.

TAXES & DUTIES

Central / State Government Sales Tax, Octroi and /or other statutory levies as applicable at the time of delivery will be charged extra and to be borne by the client. At present Central sales tax in is 2% against form 'C' OR 12.5% VAT whichever is applicable.

EXCLUSIONS

Our services does not include any civil engineering works such as Water Tank, Baskets, cabling from main to panel, panel to transformer, transformer to furnace, Water connections, other utility connections, pipe lines etc. although consultancy regarding the above jobs can be given or any other item not specifically mentioned in our offer.

ERECTION & COMMISSIONING

The equipment will be completely assembled and will be ready for use prior to dispatch from our works. There are only to be installed at client's premises with the various utility connections like power, oil line, water etc. as applicable. These connections will have to be done by the client we shall however, provide necessary drawings, instructions and manuals. In case the client desires the visit of our engineer for the commissioning of this ready assembled equipment we can dispatch our Engineer on chargeable basis. Our charges for the visit of our Engineer will be Rs. 1,500/- per day, including his days of travel, both To & fro Third AC Railways fare, both ways, local conveyance, lodging boarding expenses at actual.

For safety and better performance of our equipment, we recommend making use of our engineer's services.

DELIVERY

The delivery will be done within 6-8 weeks, subject to delays due to reasons beyond our control. All delivery schedules subject to delays by customers for payment, drawing approval and other obligations by customer.

During erection and commissioning of equipment, the services of unskilled labour, gas cutting /welding sets, standard tools, chain pulley /crane, suitable material handling facilities, water supply, power and /or other utility, oil/gas supply have to be provided free of cost by the client.

Bureau of Energy Efficiency (BEE)
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066
Ph.: +91 – 11 – 26179699 (5 Lines), Fax: +91 – 11 – 26178352
Websites: www.bee-india.nic.in, www.energymanagertraining.com

Winrock International India

788 Udyog Vihar, Phase V
Gurgaon – 122 001, Haryana
Tel: +91-124-4303868
Fax: +91-124-4303862
Website: www.winrockindia.org

India SME Technology Services Ltd
DFC Building, Plot No.37-38,
D-Block, Pankha Road,
Institutional Area, Janakpuri, New Delhi-110058
Tel: +91-11-28525534, Fax: +91-11-28525535

Website: www.techsmall.com