DETAILED PROJECT REPORT
ON
ENERGY EFFICIENT GAS FIRED ROTOBERATORY FURNACE
(250 KG/BATCH)
(JAMNAGAR BRASS CLUSTER)

Bureau of Energy Efficiency

Prepared By

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ENERGY EFFICIENT GAS FIRED ROTOBERATORY FURNACE (250 kg/hr)

(JAMNAGAR BRASS CLUSTER)
BEE, 2010

*Detailed Project Report on Energy Efficient Gas Fired Rotoberyatory Furnace (250 kg/hr)*

Brass SME Cluster, Jamnagar, Gujarat (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.: JAM/BRS/EGR/04
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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
MoMSME Ministry of 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
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 coal fired pit furnace in brass industries is melting of raw material (Brass scrap), which is subsequently used in for pouring into different moulds to obtain various shapes. Performances of various coal fired pit furnace in Jamnagar Brass units are evaluated and analyzed the quantum of various losses in coal fired pit furnace were analyzed. It was observed that the coal fired pit furnace has poor efficiency due to poor combustion space, improper location & size of burners and improper capacity of blower system.

Implementation of proposed energy efficient rotobervatory furnace equipped with waste heat recovery system and automatic control system having efficiency more that existing furnace would save energy and replace total 64 tons coal consumption per year.

This DPR highlights the details of the study conducted for assessing the potential for replacement of conventional coal fired furnace by new energy efficient rotobervatory 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:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Particular</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project cost</td>
<td>₹(in Lakh)</td>
<td>8.80</td>
</tr>
<tr>
<td>2</td>
<td>Fuel consumption (coal) in base case</td>
<td>tons/year</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>Gas consumption in proposed case</td>
<td>Nm³/year</td>
<td>18750</td>
</tr>
<tr>
<td>4</td>
<td>Monetary benefit</td>
<td>₹(in Lakh)</td>
<td>6.95</td>
</tr>
<tr>
<td>5</td>
<td>Debit equity ratio</td>
<td>Ratio</td>
<td>3:1</td>
</tr>
<tr>
<td>6</td>
<td>Simple payback period</td>
<td>years</td>
<td>1.27</td>
</tr>
<tr>
<td>7</td>
<td>NPV</td>
<td>₹(in Lakh)</td>
<td>17.05</td>
</tr>
<tr>
<td>8</td>
<td>IRR</td>
<td>%</td>
<td>59.84</td>
</tr>
<tr>
<td>9</td>
<td>ROI</td>
<td>%</td>
<td>27.87</td>
</tr>
<tr>
<td>10</td>
<td>DSCR</td>
<td>Ratio</td>
<td>3.28</td>
</tr>
<tr>
<td>11</td>
<td>Process down time</td>
<td>Days</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>CO₂ reduction</td>
<td>Tons/year</td>
<td>128</td>
</tr>
</tbody>
</table>

The projected profitability and cash flow statements indicate that the proposed project implementation i.e. energy efficient gas fired rotoboratory furnace with existing coal fired 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 also 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.

![Process flow chart](image)

**Figure 1.1: Process flow chart**
1.2 Energy Performance in 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](image)

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**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type of units</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brass foundry unit</td>
<td>kCal/kg of brass rod</td>
<td>1013-1057</td>
</tr>
<tr>
<td>2</td>
<td>Brass extrusion unit</td>
<td>kCal/kg of brass rod</td>
<td>1037-1186</td>
</tr>
<tr>
<td>3</td>
<td>Brass machining unit</td>
<td>kCal/kg of final product</td>
<td>473.04</td>
</tr>
<tr>
<td>4</td>
<td>Brass electroplating</td>
<td>kCal/kg of final product</td>
<td>875.21</td>
</tr>
</tbody>
</table>
Table 1.2 Specific energy cost in various brass units

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

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 coal fired pit furnace in Jamnagar Brass units are evaluated and analyzed the quantum of various losses in coal fired pit furnace were analyzed. It was observed that the coal 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 coal fired furnace with energy efficient gas fired rotoberatory furnace.

![Figure 1.3 Conventional Coal fired furnace operations](image)

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 coal fired pit furnace
• Operational & maintenance practices in conventional coal fired pit furnace

1.3.2 Technical gap in conventional pit furnace

Technology gaps/design flaws in conventional coal fired pit furnace system are identified and same is presented in detail 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 gases 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 firebrick contains low alumina and gets 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. These burners were either a copy of a properly designed burner or sometimes substandard and locally designed.

➢ 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 temperature and pressure at the combustion stage and the benefits thereof.

### 1.3.3 Specification of existing furnace

Detail specification of existing coal fired furnace is not available.

### 1.3.4 Role in the process

The function of coal fired pit furnace in brass industries is melting of raw material (Brass scrap), which is subsequently used in for pouring into different moulds to obtain various shapes. It is evident that melting of Brass scrap 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 raw material melt.

### 1.3.5 Need for upgradation of existing equipment

The 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/kg, which 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 coal fired pit furnace system with Energy Efficient gas fired rotobulary 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 fuel consumption

### 1.4 Baseline energy consumption of existing equipment

Energy consumption in coal fired pit furnace would depend on items mentioned below:

- Melting time
- Temperature of melt
• 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 coal fired pit furnace and the reports for the same are attached as Annexure – 1.

1.4.1 Design and operating parameters

Major operational parameters improvements in gas 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 coal fired pit furnace of capacity 255 kg/hr is around 192.16 kg/tons of production. Performance of existing coal fired 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 coal fired pit furnace, same was furnished below:
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 in 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

A 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 issues maybe 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 furnace 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 EQUIPMENT OPTION FOR ENERGY EFFICIENCY IMPROVEMENT

2.1 Description of proposed equipment

Since the present process is an outdated process and consumes lot of fuel & emits very high volume of carbon in its different forms, this process should be gradually phased out with the alternate process which should be

- cost effective, with a very little payback period,
- technically simple & yet superior, easy to understand & adopt, and
- highly eco friendly

The rotoberyatory furnace fulfills all the above parameters compared to other technologies. The gas based (with a multi-firing option) rotoberyatory furnace brass melting process has many distinct advantages like,

- The exhaust gases are passed through the recuperator & utilize for pre-heating of raw material & thereby substantially saving the fuel.
- Due to pre-heating, slurry formation & rotary movements, the temperature increases uniformly & reduces the burning losses of precious metals by 70-75%.
- Direct firing eliminates use of crucible, hence fuel consumption goes down substantially compared to indirect firing.
- This furnace has a motorized or hydraulic tilting system, to pour the molten metal. This, not only avoids direct exposure of labours to high temperature & fumes but also eliminates the highly dangerous & tedious process of lifting of crucible to pour the molten mass after every batch and to clean the ash of coal daily from the underground furnace. The dust collector is also essential which is not incorporated in the present ongoing process.
- Automation of filling of moulds is necessary to synchronize the melting of each batch timings with downtime process. Otherwise, not only the time gap would be more between two batches, the fuel cost also increases due to loss of heat during the manual filling operations.
- The usage of gas in place of coal & proper slag removing system, will also improve the finishing & fineness of the finished products.
• If we cool & set the molten mass using water cooling technology, as adopted in aluminium & other metals, the problem of brass & other metals going into the dumping yard along with the moulding clay, could be solved.

• Contrary to recent ongoing, obsolete process & even newly adopted induction furnace (which is very costly) by few industries, this process is a closed process and thereby reduces the direct exposure of labours to heat, fumes, and poisonous gases.

• Gas is available in plenty in India and we don’t have to depend on foreign exchange, or on other countries. Due to domestic availability, the cost of fuel will not depend much on international market conditions.

All above mentioned factors justifies the process up gradation

2.1.1 Comparison of conventional with new rehating furnace

Technical, economic, Environmental, safety aspects of conventional furnace and energy efficient gas fired rotoberytary 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

<table>
<thead>
<tr>
<th>S. No</th>
<th>Details</th>
<th>Conventional coal fired pit furnace</th>
<th>Energy efficient gas fired rotoberytary furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel consumption</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Environment pollution</td>
<td>High (partial combustion &amp; more fuel consumption)</td>
<td>Low (Complete combustion &amp; less fuel consumption)</td>
</tr>
<tr>
<td>3</td>
<td>Safety of workers</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>4</td>
<td>Maintenance</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>Operational cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Availability of local service providers</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Fuel combustion</td>
<td>Partial</td>
<td>Complete</td>
</tr>
<tr>
<td>8</td>
<td>Control of air/fuel combustion</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Temperature monitoring &amp; control</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Radiation losses</td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td>11</td>
<td>Radiation heat in combustion chamber</td>
<td>Not utilized</td>
<td>Utilized in the transfer of heat</td>
</tr>
</tbody>
</table>

From the above table it is clear that Energy efficient rotoberytary furnace has significant advantages in Energy, Environmental, Economic & safety aspects. It is technically
justifiable to install energy efficient rotoberatory furnace in place of conventional coal 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 gas fired rotoberatory furnace varies from industry to industry and can be provided to vendor as per the need. A general specification of new furnace is furnished in Table 2.2 below:

Table 2.2 Technical specifications

<table>
<thead>
<tr>
<th>S. No</th>
<th>Details</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment</td>
<td>Rotobery Type Melting Furnace</td>
</tr>
<tr>
<td>2</td>
<td>Capacity</td>
<td>250 kg/Batch</td>
</tr>
<tr>
<td>3</td>
<td>Outer Size</td>
<td>Dia 1250mm height 1300 (Aprox)</td>
</tr>
<tr>
<td>4</td>
<td>Operating Temp.</td>
<td>1050° C</td>
</tr>
<tr>
<td>5</td>
<td>Max. Temp.</td>
<td>1350° C</td>
</tr>
<tr>
<td>6</td>
<td>Fuel</td>
<td>LPG/CNG/FO</td>
</tr>
<tr>
<td>7</td>
<td>Burner</td>
<td>6663-3</td>
</tr>
<tr>
<td>8</td>
<td>Gas Train</td>
<td>Semi automatic with 20 Cylinder Bank</td>
</tr>
<tr>
<td>9</td>
<td>Temp Control</td>
<td>Modulating Valve &amp;Ratio Control valve</td>
</tr>
<tr>
<td>10</td>
<td>Blower</td>
<td>1 HP /16”wg</td>
</tr>
<tr>
<td>11</td>
<td>Gas Consumption</td>
<td>40-45 kg/Ton</td>
</tr>
<tr>
<td>12</td>
<td>Chimney</td>
<td>10 Feet from Ground Level</td>
</tr>
<tr>
<td>13</td>
<td>Tilting Arrangement</td>
<td>Mechanical</td>
</tr>
<tr>
<td>14</td>
<td>Recuperator</td>
<td>2 HT</td>
</tr>
</tbody>
</table>

2.1.5 Superiorty over existing system

Energy efficient gas fired Rotoberatory furnaces are available with waste heat recovery and equipped with designed burners with air fuel ratio control which make proposed furnace more efficient.
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 equipment 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 Energy efficient rotoberationary furnace

The technology/ service provider are providing performance guarantee for the products supplied and warranty for a period of one year for any manufacturing defects. The terms of sales from the proposed supplier is presented in the table below:

Terms and conditions for sale of energy efficient gas fired rotoberationary furnace is furnished in table below:

<table>
<thead>
<tr>
<th>Table 2.3 Term and condition for supply of equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope of Supply</strong></td>
</tr>
<tr>
<td><strong>Taxes &amp; Duties</strong></td>
</tr>
<tr>
<td><strong>Payment</strong></td>
</tr>
</tbody>
</table>
### Delivery

<table>
<thead>
<tr>
<th>Delivery</th>
<th>M/C will be supplied within 6-8 weeks from the date of acceptance of order.</th>
</tr>
</thead>
</table>

### Exclusion

| Exclusion | All foundation bolts, civil engineering, foundation & electrical work of any nature whatsoever and materials required for such purpose. Detailed civil engineering drawing to suit soil conditions to be prepared by the client based on the foundation drawings showing pocket position and loading data supplied. |

2.2 **Process down time during implementation**

The process down time for implementing the replacement of conventional furnace with energy efficient 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**

The suitability of proposed unit depends upon client confirmation about the furnace capacity and physical properties of material to be melted. A furnace of 250 kg/batch is suitable for a unit with 333 tonnes per annum capacity.
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 rotoberatory furnace over conventional pit furnace.

3.1 Energy & monetary benefits

3.1.1 Fuel Saving

Energy use and technology audit studies it was observed that energy consumption of coal fired pit furnace depends on the type of fuel, number of burners and temperature of furnace. Analysis was carried out on conventional coal 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 192.16 kg/tonne. Fuel consumption of proposed energy efficient gas fired rotoberatory furnace is 56.25 Nm³/tonne. Total annual production capacity is 333 tons hence, total 64 tons coal consumption would be replaced by gas and total gas consumption would be 18750 Nm³ per year Nm³/tonne.

3.1.2 Electricity saving

Project implementation will not save electricity while its implementation will increase electricity consumption of about 1492 kWh per year.

3.1.2 Monetary benefit

Annual monetary savings due to implementation of energy efficient rotoberatory furnace is about ₹ 6.95 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 coal for pit furnace; by implementing the proposed energy efficient gas fired rotoberatory furnace in place of conventional furnace will eliminate coal consumption.

3.2.2 GHG emission reductions

Specific energy consumption of proposed energy efficient gas fired rotoberatory furnace is less than conventional furnace; it automatically leads to reduction of GHGs emissions by implementing proposed energy efficiency rotoberatory furnace in place of conventional
Energy Efficient Gas Fired Rotoberatory Furnace (250 kg/hr)

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 64 tons coal per year for one furnace. This roughly corresponds to 166 tonnes of CO\(_2\) emission reduction and the use of natural gas will generate 38 tonnes of CO\(_2\) (18750 Nm\(^3\) of gas consumption per year). The net CO\(_2\) emission reduction will be around 128 tonnes or 128 CERs. Considering, at the cluster level 200 units apply this technology then the total savings would be about 256 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 furnaces with energy efficient furnaces will reduce furnace skin temperature, closed combustion chamber & temperature control of gas fired rotoberatory furnaces, all those things will improves the working condition & safety of workers near to furnace.

3.3.2 Impact on manpower skills

Proposed energy efficient gas fired rotoberatory 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 gas fired rotoberatory furnace will improves melting temperature; this automatically reduces melting time of brass. It was observed that melting is one of major time consuming area, reduction in cycle time and specific fuel consumption in brass manufacturing unit will improve productivity of the 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 gas fired rotoberatory furnace will control temperature of material inside the furnace, this automatically improves quality of material.

3.4.3 Easy operation & maintenance

Operation and maintenance of new energy efficient gas fired rotoberatory furnace is easy and economical.
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 gas fired rotoheratory furnace are collected from reputed vendors. Cost of furnace having production capacity of 250 kg/hr is ₹ 8.00 lakh only as per the quotation provided at Annexure 8.

4.1.2 Other cost

Erection & commissioning cost is ₹ 0.80 lakh only. Details of project cost are furnished in Table 4.1 below:

Table 4.1 Details of proposed equipment installation cost

<table>
<thead>
<tr>
<th>S.No</th>
<th>Particular</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment cost</td>
<td>₹ (in Lakh)</td>
<td>8.00</td>
</tr>
<tr>
<td>2</td>
<td>Erection &amp; Commissioning cost</td>
<td>₹ (in Lakh)</td>
<td>0.80</td>
</tr>
<tr>
<td>3</td>
<td>Other misc. cost</td>
<td>₹ (in Lakh)</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>Total cost</td>
<td>₹ (in Lakh)</td>
<td>8.80</td>
</tr>
</tbody>
</table>

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 ₹ 8.80 lakh. Out of which entrepreneur’s contribution is 25%, which work out to be ₹ 2.20 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 ₹ 6.60 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 ₹ 6.95 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 5 years and repayment starts after 6 months from the first date of disbursement of loan in 60 monthly 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 1.27 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 ₹ 17.05 lakh.

4.3.4 Internal rate of return (IRR)

After tax Internal Rate of Return of the project is works out to be 59.84%. 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 27.87%.

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

<table>
<thead>
<tr>
<th>S. No</th>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simple payback period</td>
<td>years</td>
<td>1.27</td>
</tr>
<tr>
<td>2</td>
<td>NPV</td>
<td>₹ in lakh</td>
<td>17.05</td>
</tr>
<tr>
<td>3</td>
<td>IRR</td>
<td>% age</td>
<td>59.84</td>
</tr>
<tr>
<td>4</td>
<td>ROI</td>
<td>% age</td>
<td>27.87</td>
</tr>
<tr>
<td>5</td>
<td>DSCR</td>
<td>Ratio</td>
<td>3.28</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Particulars</th>
<th>IRR</th>
<th>NPV</th>
<th>ROI</th>
<th>DSCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>59.84%</td>
<td>17.05</td>
<td>27.87%</td>
<td>3.28</td>
</tr>
<tr>
<td>5% increase in fuel savings</td>
<td>63.53%</td>
<td>18.39</td>
<td>27.99%</td>
<td>3.45</td>
</tr>
<tr>
<td>5% decrease in fuel savings</td>
<td>56.15%</td>
<td>15.70</td>
<td>27.73%</td>
<td>3.11</td>
</tr>
</tbody>
</table>

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 13 weeks from the date of financial closure. Detailed procurement and implementation schedules are furnished at Annexure 6.
Annexure-1 Energy audit reports of conventional pit furnace

Energy Audit Report of Coal fired Pit Furnace Report at Unit-1:

Coal fired pit furnace is the one of the major energy consuming equipments in production process of brass in Unit-1.

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

**Calculation of coal fired pit furnace efficiency Industries by direct method at Unit-1**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Material Melt</td>
<td>Kg</td>
<td>295</td>
</tr>
<tr>
<td>Temperature of Material at Furnace Entry</td>
<td>deg C</td>
<td>34.2</td>
</tr>
<tr>
<td>Temperature of Molten Material</td>
<td>deg C</td>
<td>990</td>
</tr>
<tr>
<td>Difference in temperature</td>
<td>deg C</td>
<td>955.8</td>
</tr>
<tr>
<td>Specific Heat of the Material</td>
<td>Kcal/Kg dgec</td>
<td>0.09</td>
</tr>
<tr>
<td>Sensible Heat absorbed by the Material</td>
<td>Kcal</td>
<td>25,376.49</td>
</tr>
<tr>
<td>Latent heat fusion of Brass</td>
<td>Kcal/kg</td>
<td>35</td>
</tr>
<tr>
<td>Latent heat of molten Brass material</td>
<td>Kcal</td>
<td>10,325</td>
</tr>
<tr>
<td>Total heat absorbed in Brass molten material</td>
<td>Kcal</td>
<td>35,701</td>
</tr>
<tr>
<td>Total Fuel Consumption</td>
<td>Kg</td>
<td>43</td>
</tr>
<tr>
<td>Calorific Value of the Fuel</td>
<td>Kcal/Kg</td>
<td>6,500</td>
</tr>
<tr>
<td>Total Heat to the Furnace</td>
<td>Kcal</td>
<td>279,500</td>
</tr>
<tr>
<td>Furnace Efficiency</td>
<td>%</td>
<td>12.77</td>
</tr>
</tbody>
</table>
Energy Audit Report of Coal fired Pit Furnace Report at Unit-II

**Calculation of coal fired pit furnace efficiency Industries by direct method at Unit-II**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Material Melt</strong></td>
<td>Kg</td>
<td>255</td>
</tr>
<tr>
<td><strong>Temperature of Material at Furnace Entry</strong></td>
<td>deg C</td>
<td>30.7</td>
</tr>
<tr>
<td><strong>Temperature of Molten Material</strong></td>
<td>deg C</td>
<td>990</td>
</tr>
<tr>
<td><strong>Difference in temperature</strong></td>
<td>deg C</td>
<td>959.3</td>
</tr>
<tr>
<td><strong>Specific Heat of the Material</strong></td>
<td>Kcal/Kg deg C</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>Sensible Heat absorbed by the Material</strong></td>
<td>Kcal</td>
<td>22015.94</td>
</tr>
<tr>
<td><strong>Latent heat fusion of Brass</strong></td>
<td>Kcal/kg</td>
<td>35</td>
</tr>
<tr>
<td><strong>Latent heat of molten Brass material</strong></td>
<td>Kcal</td>
<td>8925</td>
</tr>
<tr>
<td><strong>Total heat absorbed in Brass molten material</strong></td>
<td>Kcal</td>
<td>30940.94</td>
</tr>
<tr>
<td><strong>Total Fuel Consumption</strong></td>
<td>Kg</td>
<td>49</td>
</tr>
<tr>
<td><strong>Calorific Value of the Fuel</strong></td>
<td>Kcal/Kg</td>
<td>6500</td>
</tr>
<tr>
<td><strong>Total Heat to the Furnace</strong></td>
<td>Kcal</td>
<td>318500</td>
</tr>
<tr>
<td><strong>Furnace Efficiency</strong></td>
<td>%</td>
<td>9.71</td>
</tr>
</tbody>
</table>
Annexure 2 Process flow diagram

Process flow diagram of typical brass unit is same even after implementation of proposed furnace
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 in improve the efficiency 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
- The energy efficiency and conservation places no financial and administrative burden as no separate manpower is required and only training of operation and maintenance of the technologies adopted is envisaged

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total Material Melt</td>
<td>Kg</td>
<td>255</td>
</tr>
<tr>
<td>2</td>
<td>Total Fuel Consumption</td>
<td>Kg</td>
<td>49</td>
</tr>
<tr>
<td>3</td>
<td>Specific fuel consumption</td>
<td>kg/tonne</td>
<td>192.16</td>
</tr>
<tr>
<td>4</td>
<td>Fuel consumption in proposed furnace</td>
<td>kg/ton</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>Density of gas</td>
<td>m3/kg</td>
<td>0.80</td>
</tr>
<tr>
<td>6</td>
<td>Gas consumption in proposed furnace</td>
<td>m3/tonne</td>
<td>56.25</td>
</tr>
<tr>
<td>7</td>
<td>Efficiency of rotoberatory furnace (Based on fuel consumption)</td>
<td>% age</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>Cost of coal</td>
<td>Rs/kg</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>Cost of gas</td>
<td>Rs/m3</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>Cost of fuel (Coal) in existing furnace</td>
<td>Rs/ton</td>
<td>3459</td>
</tr>
<tr>
<td>11</td>
<td>Cost of fuel (Gas) in proposed furnace</td>
<td>Rs/ton</td>
<td>1350</td>
</tr>
<tr>
<td>12</td>
<td>Cost benefit due to fuel change</td>
<td>Rs/ton</td>
<td>2109</td>
</tr>
<tr>
<td>13</td>
<td>Total operating hours</td>
<td>hrs</td>
<td>2000</td>
</tr>
<tr>
<td>14</td>
<td>Total batch time required</td>
<td>hrs</td>
<td>1.5</td>
</tr>
<tr>
<td>15</td>
<td>Total production</td>
<td>Tonne/year</td>
<td>333</td>
</tr>
<tr>
<td>16</td>
<td>Total coal consumption in base case</td>
<td>tons</td>
<td>64</td>
</tr>
<tr>
<td>17</td>
<td>Total gas consumption in proposed case</td>
<td>m3</td>
<td>18750</td>
</tr>
<tr>
<td>18</td>
<td>Total connected load</td>
<td>HP</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>Total Electricity consumption</td>
<td>kWh</td>
<td>1492</td>
</tr>
<tr>
<td>20</td>
<td>Cost of electricity consumption @ 5/kWh</td>
<td>₹</td>
<td>7460</td>
</tr>
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Annexure-4 Detailed cash flow evaluations
## Annexure-5 Detailed cash flow evaluations

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<th>Gas Fired rotoberyatory Furnace</th>
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<tr>
<td><strong>Rated Capacity</strong></td>
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<td><strong>Unit</strong></td>
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<tr>
<td>Installed Capacity</td>
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<td>Total operating hours</td>
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<td>Total production</td>
<td>Tons</td>
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### Proposed Investment

| Cost of plant & Machinery | ₹(in lakh) | 8.00 | Feasibility Study |
| Erection & Commissioning  | ₹(in lakh) | 0.80 | Feasibility Study |
| Total Investment          | ₹(in lakh) | 8.80 | Feasibility Study |

### Financing pattern

- **Own Funds (Internal Accruals)**: ₹(in lakh) 2.20 Feasibility Study
- **Loan Funds (Term Loan)**: ₹(in lakh) 6.60 Feasibility Study

### Loan Tenure

- **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

- **monetary savings due to fuel change**: ₹/Tonne 2109 -
- **Annual production**: Tonne/Annum 333 -
- **Electricity consumption**: kWh/Year 1492 -
- **Cost**: ₹/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

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<tr>
<th>Years</th>
<th>Opening Balance</th>
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<th>Closing Balance</th>
<th>Interest</th>
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### WDV Depreciation

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<td>₹(in lakh)</td>
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### Energy Efficient Gas Fired Rotoberatory Furnace (250 kg/hr)

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**Projected Profitability**

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**Expenses**

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**Computation of Tax**

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**Projected Balance Sheet**

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**Projected Cash Flow:**

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**IRR**

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**IRR**

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**NPV**

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**Break Even Point**

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<td>Sub Total(G)</td>
<td>0.26</td>
<td>0.28</td>
<td>0.29</td>
<td>0.31</td>
<td>0.32</td>
<td>0.34</td>
<td>0.35</td>
<td>0.37</td>
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<tr>
<td><strong>Fixed Expenses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oper. &amp; Maintenance Exp (25%)</td>
<td>0.09</td>
<td>0.09</td>
<td>0.10</td>
<td>0.10</td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Interest on Term Loan</td>
<td>0.76</td>
<td>0.56</td>
<td>0.44</td>
<td>0.32</td>
<td>0.18</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Depreciation (H)</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
</tr>
<tr>
<td>Sub Total (I)</td>
<td>1.31</td>
<td>1.11</td>
<td>1.01</td>
<td>0.89</td>
<td>0.75</td>
<td>0.61</td>
<td>0.58</td>
<td>0.59</td>
</tr>
<tr>
<td>Sales (J)</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
<td>6.95</td>
</tr>
<tr>
<td>Contribution (K)</td>
<td>6.68</td>
<td>6.67</td>
<td>6.66</td>
<td>6.64</td>
<td>6.63</td>
<td>6.61</td>
<td>6.59</td>
<td>6.58</td>
</tr>
<tr>
<td>Break Even Point (L= G/I)</td>
<td>19.65%</td>
<td>16.70%</td>
<td>15.10%</td>
<td>13.36%</td>
<td>11.39%</td>
<td>9.16%</td>
<td>8.83%</td>
<td>8.95%</td>
</tr>
<tr>
<td>Cash Break Even ((I)-(H))</td>
<td>12.70%</td>
<td>9.73%</td>
<td>8.12%</td>
<td>6.37%</td>
<td>4.38%</td>
<td>2.13%</td>
<td>1.79%</td>
<td>1.88%</td>
</tr>
<tr>
<td>Break Even Sales (J)*(L)</td>
<td>1.37</td>
<td>1.16</td>
<td>1.05</td>
<td>0.93</td>
<td>0.79</td>
<td>0.64</td>
<td>0.61</td>
<td>0.62</td>
</tr>
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</table>
### Return on Investment

<table>
<thead>
<tr>
<th>Particulars / Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Profit Before Taxes</td>
<td>5.37</td>
<td>5.56</td>
<td>5.65</td>
<td>5.76</td>
<td>5.87</td>
<td>6.01</td>
<td>6.01</td>
<td>5.99</td>
<td>46.21</td>
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<tr>
<td>Net Worth</td>
<td>7.57</td>
<td>11.56</td>
<td>15.13</td>
<td>18.77</td>
<td>22.49</td>
<td>26.30</td>
<td>30.11</td>
<td>33.90</td>
<td>165.84</td>
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27.87%

### Debt Service Coverage Ratio

<table>
<thead>
<tr>
<th>Particulars / Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Inflow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit after Tax</td>
<td>5.37</td>
<td>3.99</td>
<td>3.57</td>
<td>3.64</td>
<td>3.72</td>
<td>3.81</td>
<td>3.81</td>
<td>3.80</td>
<td>24.10</td>
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<tr>
<td>Depreciation</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>0.46</td>
<td>2.79</td>
</tr>
<tr>
<td>Interest on Term Loan</td>
<td>0.76</td>
<td>0.56</td>
<td>0.44</td>
<td>0.32</td>
<td>0.18</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>2.29</td>
</tr>
<tr>
<td>Total (M)</td>
<td>6.60</td>
<td>5.01</td>
<td>4.48</td>
<td>4.43</td>
<td>4.37</td>
<td>4.30</td>
<td>4.28</td>
<td>4.26</td>
<td>29.18</td>
</tr>
</tbody>
</table>

### DEBT

<table>
<thead>
<tr>
<th>Particulars / Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest on Term Loan</td>
<td>0.76</td>
<td>0.56</td>
<td>0.44</td>
<td>0.32</td>
<td>0.18</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>2.29</td>
</tr>
<tr>
<td>Repayment of Term Loan</td>
<td>0.54</td>
<td>1.08</td>
<td>1.20</td>
<td>1.28</td>
<td>1.56</td>
<td>0.94</td>
<td>0.00</td>
<td>0.00</td>
<td>6.60</td>
</tr>
<tr>
<td>Total (N)</td>
<td>1.30</td>
<td>1.64</td>
<td>1.64</td>
<td>1.60</td>
<td>1.74</td>
<td>0.97</td>
<td>0.00</td>
<td>0.00</td>
<td>8.89</td>
</tr>
</tbody>
</table>

Average DSCR (M/N) 3.28
Annexure-6 Details of procurement and implementation plan

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

<table>
<thead>
<tr>
<th>Activity</th>
<th>Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Energy data reconfirmation</td>
<td></td>
</tr>
<tr>
<td>Technical discussion &amp; finalization</td>
<td></td>
</tr>
<tr>
<td>Collection of vendor quotes</td>
<td></td>
</tr>
<tr>
<td>Order placement</td>
<td></td>
</tr>
<tr>
<td>Material receipt</td>
<td></td>
</tr>
<tr>
<td>Installation &amp; Commissioning</td>
<td></td>
</tr>
<tr>
<td>Measurement of savings</td>
<td></td>
</tr>
<tr>
<td>Certification of savings</td>
<td></td>
</tr>
</tbody>
</table>
Annexure-7 Details of equipment and service providers

<table>
<thead>
<tr>
<th>Name of company</th>
<th>Micro Hydraulic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Heating Systems</td>
<td>207, Vandaman Complex 8, Facility Center, Mayapuri Phase-II, New Delhi 110064, Phone no.: 91-011-28112315, 32914872 +91-09810520120 Email: <a href="mailto:services@advance-systems.in">services@advance-systems.in</a>, <a href="mailto:sales@advance-systems.in">sales@advance-systems.in</a></td>
</tr>
</tbody>
</table>
Annexure 8 Quotations of energy efficient rotoberatory furnace

TECH & EXCELLENCE :-
Quotation Of 250 Kgs Green Smelter – A Rotoberatory Furnace

Technical Specification For Green Smelter

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Rotaboratory Tilting Type Melting Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>250 kg/ Batch</td>
</tr>
<tr>
<td>Outer Size</td>
<td>Dia 1250mm height 1000 (Aprox)</td>
</tr>
<tr>
<td>Operating Temp.</td>
<td>1050° C</td>
</tr>
<tr>
<td>Max. Temp.</td>
<td>1350° C</td>
</tr>
<tr>
<td>Fuel</td>
<td>LPG/CNG/FO</td>
</tr>
<tr>
<td>Burner</td>
<td>6563-3</td>
</tr>
<tr>
<td>Ignition</td>
<td>Manual</td>
</tr>
<tr>
<td>Gas Train</td>
<td>Semi automatic with 20 Cylinder Bank</td>
</tr>
<tr>
<td>Temp Control</td>
<td>Modulating Valve &amp; Ratio Control valve</td>
</tr>
<tr>
<td>Blower</td>
<td>1 HP / 16” wg</td>
</tr>
<tr>
<td>Gas Consumption</td>
<td>40 45 kg/ Ton</td>
</tr>
<tr>
<td>Chimney</td>
<td>10 Feet from Ground Level</td>
</tr>
<tr>
<td>Tilting Arrangement</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Recuperator</td>
<td>2 HT</td>
</tr>
</tbody>
</table>

SCOPE OF SUPPLY
The scope will cover design, Engineering, Manufacturing, Supply, Erection & Commissioning of the above furnace consisting of the following:-

Furnace Shell
The outer shell / casing of the furnace will be CIRCULAR type in shape fabricated out of 5-6 MM thick Rolled Milled steel plates duly reinforced with adequate Channel and Angle for rigidity and sturdy construction. The construction of shell would be such that it can withstand operational stresses and thermal expansion that may develop due to high operating temperature.

Refractory Lining
The exposed layer of the main furnace shell will have 115 MM H.A.-75% Fire Bricks. Backed up with 115 MM I.S.-8 Fire Bricks, 75 mm Insulation Bricks & further backed up with 25 mm Hysil block with 5mm mill board. Roof lining 300 mm Ceramic fiber with SS strips and bar.

**Air & Gas Pipe Line**

Our scope of supply shall include complete Air Line from Blower to Burners and Gas line from Gas Train to Burners along with fittings.

**Price Rs. 8,00,000/- (Eight Lacs only)**

**Terms & Conditions**

**Payment Terms :**

50% advance with Purchase order and declaration form.

20% before dispatch.

20% after Refractory works

10% after successful commissioning.

**Taxes :**

Sale Tax / VAT : As Applicable

Cartage : To Pay

Packing Charges : Extra

Delivery Period : 5 To 6 Weeks

**General :**

- All Civil Foundation works will be carried out by you as per our design.
- Electrical Cable, Panel & Connection upto our panel board will be provided by you.
- Machinery Required for erection i.e. Welding set, Cutting set, Tools & Tackles
- Cranes for unloading etc. will be provided by you.
- Lodging & boarding for our Erection Team will be arranged & borne by you.
- You would provide all above at your own cost.
- Cost of LPG bank would be given separately, depending on the distance & space available at site.