“Preparation of general arrangements engineering drawings of energy efficient typical top fired pusher hearth re-heating furnace with furnace oil firing”

for the project

“Upscaling energy efficient production in small scale steel industry in India”

Submitted to:

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Submitted by:

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### ABBREVIATIONS:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>millimeter</td>
</tr>
<tr>
<td>tph</td>
<td>tonne per hour</td>
</tr>
<tr>
<td>kg/h</td>
<td>kilogram per hour</td>
</tr>
<tr>
<td>l</td>
<td>litre</td>
</tr>
<tr>
<td>l/h</td>
<td>litre per hour</td>
</tr>
<tr>
<td>l/t</td>
<td>litre per tonne</td>
</tr>
<tr>
<td>nm³/h</td>
<td>Normal cubic meter per hour</td>
</tr>
<tr>
<td>kW</td>
<td>kilo watt</td>
</tr>
<tr>
<td>NB</td>
<td>nominal bore</td>
</tr>
<tr>
<td>mmWC</td>
<td>millimeter of water column</td>
</tr>
<tr>
<td>Rs.</td>
<td>Indian Rupee</td>
</tr>
</tbody>
</table>
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EXECUTIVE SUMMARY

UNDP in association with Australian Aid Programme & Ministry of Steel, Government of India is implementing a project titled "Upscaling energy efficient production in small scale steel industry in India". The objective of this project, which was launched in July 2013, is to scale-up adoption of energy efficient technologies in small scale steel industry in India. In line with project’s continuous endeavor to provide inputs on energy conservation, a typical design of re-heating furnace, based on pulverized coal as fuel, was developed.

Re-heating furnace was designed based on most commonly prevailing operational practices in small scale steel industry in India. The basic design has been carried out considering “state of the art” technology and accessories. The capacity for design was considered as 15 tph as it was the mean average of varying capacity of re-heating furnaces in small scale steel industry in India and to provide inputs to larger section of the sector on ideal scenario. The overall designing and development of general arrangement drawings were done by aiming the best possible specific furnace oil consumption of 32 l/t. Further consideration on design of various systems of re-heating furnace is depicted in below table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat load &amp; location of burners</td>
<td>To attain temperature of 1250 °C in soaking zone &amp; heating zone-1 and 850 °C in preheating zone (unfired zone)</td>
</tr>
<tr>
<td>Combustion air supply system</td>
<td>To achieve flow of 7,000 nm³/h &amp; discharge pressure of 1,000 mmWC</td>
</tr>
<tr>
<td>Flue gas system</td>
<td>To overcome hydraulic resistance of its path &amp; attain required draft</td>
</tr>
<tr>
<td>Waste heat recovery system</td>
<td>To achieve combustion air temperature of 400 °C after waste heat recovery system</td>
</tr>
<tr>
<td>Refractory &amp; insulation</td>
<td>To attain skin temperature of furnace close to ambient temperature and to achieve targeted specific fuel consumption</td>
</tr>
</tbody>
</table>
As compared to conventional furnace oil fired furnace, this energy efficient furnace would ensure saving of atleast 8 l/t in specific furnace oil consumption. And such saving is projected by incorporating various energy conservation measures in re-heating furnace viz. installation of PID controller system for air fuel control ratio in soaking zone & heating zone-1 and on-off control system in heating zone-2, waste heating recovery system, optimum refractory & insulation etc. Overall investment for installing energy efficient furnace is arrived at by considering prevailing market rates for various equipment, structural steel & civil works. It is estimated that the investment for re-heating furnace can be recovered in 26 months and such calculation is done by considering difference in specific fuel consumption of conventional furnace & energy efficient furnace.
1. INTRODUCTION

1.1 Background:

UNDP in association with Australian Aid Programme & Ministry of Steel, Government of India is implementing a project titled “Upscaling energy efficient production in small scale steel industry in India”. The objective of this project, which was launched in July 2013, is to scale-up adoption of energy efficient technologies in small scale steel industry in India.

The project seeks to facilitate the diffusion of energy efficient low carbon technologies in the Steel Re-rolling Mill (SRRM) sector to bring down end-use energy level, improve productivity and cost competitiveness, and to reduce associated emissions of Green-House Gases (GHG) and related pollutant levels. There exists enormous potential for energy efficiency measures in the existing units and the new units. Almost 70% of the energy (thermal energy) is consumed in re-heating furnace. Thus the re-heating furnace forms the key area for energy efficiency intervention in a typical SRRM unit.

Considering a large potential for energy conservation in the SRRM sector, the project has identified a number of energy efficient technology options & packages, suitable for implementation in the small and medium scale SRRM sector. One of the core objectives of this project is to create an access for adopting energy efficient technologies for the SRRM units.

In view of the above, general arrangement drawings (with dimensions) for typical energy efficient furnace with furnace oil as fuel has been prepared, which will help to proliferate energy efficiency measures by extending support & facilitating knowledge inputs to the SRRM units and allow them to adopt energy efficiency in re-heating furnace area.

2. FURNACE DESIGN PARAMETERS

2.1 Design criteria:

A capacity of 15.0 TPH has been considered for designing the furnace. Nominal capacity of the furnace is related to (i) Size of the billets, (ii) Discharge temperature, (iii) Permitted temperature gradient across the billet height, (iv) Type of material (thermal conductivity) and (v) Heating regime. Therefore, the furnace has been designed taking
into consideration, certain typical operational practices prevailing in the SRRM sector.

The basic design data considered are as below:

### Table 1: Design parameters of the furnace

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Design capacity of the furnace</td>
<td>tph</td>
<td>15</td>
</tr>
<tr>
<td>b.</td>
<td>Biller cross-section</td>
<td>mm</td>
<td>100X100X1500</td>
</tr>
<tr>
<td>c.</td>
<td>Material</td>
<td>-</td>
<td>MS Grades</td>
</tr>
<tr>
<td>d.</td>
<td>Discharge temperature</td>
<td>°C</td>
<td>1100</td>
</tr>
<tr>
<td>e.</td>
<td>Permissible temperature gradient from top to bottom</td>
<td>°C</td>
<td>&lt; 30</td>
</tr>
<tr>
<td>f.</td>
<td>Fuel</td>
<td></td>
<td>Furnace oil with the following composition by weight (%): C=84.7; H₂=11.7; O₂=0.8; N₂=0.4; S=0.4; Water content=0.2%</td>
</tr>
</tbody>
</table>

#### 2.2 Discharge Capacity of the Furnace:

Depending up on the variations of the input parameters, the discharge capacity can be higher or lower than the specified 15 TPH, as mentioned in table 2.1 below:

### Table 2: Productivity of the furnace for MS billet heating

<table>
<thead>
<tr>
<th>Billet CS, mm</th>
<th>Production rate, t/h</th>
<th>Discharge temp, °C</th>
<th>Temp grad, °C</th>
<th>Heating regimes, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pre heating</td>
</tr>
<tr>
<td>100X100</td>
<td>15.5</td>
<td>1,130</td>
<td>15.0</td>
<td>850 to 1,050</td>
</tr>
<tr>
<td>100X100</td>
<td>18.5</td>
<td>1,117</td>
<td>25.6</td>
<td>850 to 1,050</td>
</tr>
<tr>
<td>125X125</td>
<td>15.5</td>
<td>1,130</td>
<td>21.6</td>
<td>850 to 1,050</td>
</tr>
<tr>
<td>125X125</td>
<td>18.5</td>
<td>1,101</td>
<td>38.0</td>
<td>850 to 1,050</td>
</tr>
</tbody>
</table>
The furnace can also be used for heating of alloy and SS grades. However, in such case production capacity will be lower.

### 2.3 Broad dimensions of the furnace:

The broad dimensions of the furnace are given below:

#### Table 3: Broad dimensions of the furnace

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Overall length of the furnace</td>
<td>m</td>
<td>20.23</td>
</tr>
<tr>
<td>2.</td>
<td>Effective length of the furnace</td>
<td>m</td>
<td>17.38</td>
</tr>
<tr>
<td>3.</td>
<td>Length of the soaking zone</td>
<td>m</td>
<td>3.20</td>
</tr>
<tr>
<td>4.</td>
<td>Length of the heating zone (two control zones)</td>
<td>m</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>Heating Zone-1 = 4.0 &amp; Heating Zone-2 = 3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Length of the pre-heating zone</td>
<td>m</td>
<td>6.58</td>
</tr>
<tr>
<td>6.</td>
<td>Overall width of the furnace</td>
<td>m</td>
<td>4.982</td>
</tr>
<tr>
<td>7.</td>
<td>Inside width of the furnace</td>
<td>m</td>
<td>3.6</td>
</tr>
<tr>
<td>8.</td>
<td>Height of the roof above the hearth</td>
<td>mm</td>
<td>1,250</td>
</tr>
<tr>
<td></td>
<td>At soaking &amp; heating zones</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At pre-heating zones (unfired zone)</td>
<td></td>
<td>850</td>
</tr>
</tbody>
</table>

#### 2.4 Type of roof: Flat roof with hanger bricks

#### 2.5 Combustion system:

The combustion system is divided into three zones viz. soaking zone, heating zone and pre-heating zone. Details are below:

#### Table 4: Details of combustion system

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Total heat load as per the heat balance:</strong> 510 kg/h of furnace oil</td>
</tr>
<tr>
<td>2.</td>
<td><strong>Designed heat load:</strong> 600 kg/h of furnace oil</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Parameter</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3.</td>
<td><strong>No. of burners:</strong></td>
</tr>
<tr>
<td></td>
<td>Soaking zone: 4 (Size: 45 l/h )</td>
</tr>
<tr>
<td></td>
<td>Heating zone-1: 6 (Size: 40 l/h )</td>
</tr>
<tr>
<td></td>
<td>Heating zone-2: 4 (Size: 40 l/h )</td>
</tr>
<tr>
<td>4.</td>
<td><strong>Location of the Burners:</strong></td>
</tr>
<tr>
<td></td>
<td>Soaking zone: On the discharge end wall</td>
</tr>
<tr>
<td></td>
<td>Heating zones: On the side walls; 5 burners on each side with staggering arrangement.</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Types of burners:</strong> IIP ENCON Film burners have been considered which works on low excess air with a large turn down ratio. They have a long and bushy flame which is most suited to such applications. In general, a saving of 5%-10% in such applications can be achieved over the normal LAP burners</td>
</tr>
<tr>
<td>6.</td>
<td><strong>Combustion air supply:</strong> Combustion air will be supplied by a centrifugal fan of below specifications:</td>
</tr>
<tr>
<td></td>
<td>Capacity of the fan: 7,000 nm³/h</td>
</tr>
<tr>
<td></td>
<td>Discharge pressure: 1,000 mmWC</td>
</tr>
<tr>
<td></td>
<td>Motor capacity: 35 kW</td>
</tr>
<tr>
<td>7.</td>
<td><strong>Pipelines:</strong> Pipelines for supply of combustion air are designed with sufficient reserve capacity so that pressure drop will meet the blower discharge capacity. Pipeline layout is done for easy access to orifices and control valves. The dimensions for various pipelines are as follows</td>
</tr>
<tr>
<td></td>
<td>Air pipeline (main header): 600 NB</td>
</tr>
<tr>
<td></td>
<td>Air pipeline (branch pipes for burners): 1. soaking zone: 300 NB</td>
</tr>
<tr>
<td></td>
<td>2. heating zone-1: 350 NB</td>
</tr>
<tr>
<td></td>
<td>3. heating zone-2: 250 NB</td>
</tr>
<tr>
<td></td>
<td>Oil pipeline (main header): 40 NB</td>
</tr>
<tr>
<td></td>
<td>Oil Pipeline (branch pipes for burners): 25 NB</td>
</tr>
<tr>
<td>8.</td>
<td><strong>Flue system:</strong> Exhaust system for evacuating flue gases is designed taking into account the hydraulic resistance of the flue path, as envisaged in the general layout.</td>
</tr>
<tr>
<td></td>
<td>Flue port is taken from the roof and the flue line will be above the ground</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Parameter</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>level. The flue duct before the recuperator is insulated with ceramic fibre board inside for minimizing heat loss. For 15 tph furnace, the dimensions of flue duct is : Circular 1,250 mm Dia The chimney has been designed considering pollution control norms’. The broad dimensions of the chimney are as follows: Height : 33,000 mm; Dia:1,000 mm</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td><strong>Waste heat recovery:</strong> Waste heat recovery is done through a convective type two pass metallic u-tube type recuperator with a capacity for preheating air to a temperature of 400°C. The recuperator will be located above the ground level. Detailed specifications are provided in the recuperator drawing</td>
</tr>
<tr>
<td>10.</td>
<td><strong>Refractory &amp; insulation:</strong> Refractory &amp; insulations forms a major role in minimizing heat losses from the side walls and roof. An optimum refractory &amp; insulation pattern has been suggested to minimize the heat loss due to radiation. <strong>High temperature zones (soaking &amp; heating zones):</strong> For the soaking and heating zone sidewalls, a refractory lining consisting of 230 mm thick H.H.D. firebricks (60% Alumina) followed by 115 mm thick light weight firebricks (hot face insulation) backed by 115 mm thick Mica insulation bricks (cold face insulation) backed by 75 mm thick Calcium Silicate block insulation has been considered. <strong>Low temperature zones (Preheating Zone):</strong> For the pre-heating zone, 230 mm thick H.D. firebricks (50% Alumina) backed by 115 mm thick light weight firebricks (hot face insulation) backed by 115 mm thick Mica insulation bricks (cold face insulation) backed by 75 mm thick Calcium Silicate block insulation has been considered. <strong>Roof:</strong> For the re-heating furnace roof, high alumina firebricks 58% Al₂O₃ 340 mm for anchored bricks and 225 mm for unanchored bricks partly backed by 65 mm thick Ceramic fiber blanket (128 kg/m³), 50 mm thick insulation castable and 50 mm thick Calcium Silicate block insulation has been considered.</td>
</tr>
</tbody>
</table>
11. **Control system:** The furnace has been provided with controls for the following.

1. Temperature control for all the three zones
2. Air to fuel ratio control.
3. Furnace pressure control

The furnace has been designed with three control zones. All the three zones will be with controls for temperature and air to fuel ratio. The control strategy is on proportionate basis for soaking zone and heating zone 1. For the heating zone 2, ON-OFF control strategy has been used. All the burners of this zone will be either in full firing mode or will be in totally off mode. By this firing strategy, cost will be minimized. The furnace has been provided with pressure control. All the instrumentation system will be located in a separate control room.

### 3. ENERGY EFFICIENT MEASURES IN THE RE-HEATING FURNACE

Furnace design is based on the scientific calculations using established mathematical models. Some of the energy efficient measures incorporated in the design are:

- Furnace length has been determined by heat transfer calculations. The furnace length chosen is neither too large nor too short. This selection will minimize cost and flue gases will be available at recuperator entry with good temperature for preheating the combustion air to 400 °C.

- Soaking zone firing will be axial and heating zones firing will be on the side walls. The location of the burners will create good turbulence and heat transfer inside the furnace.

- Three firing zones are chosen so that one firing zone (heating zone 2) can be stopped during short delays for minimizing fuel consumption. This zone is provided with ON-OFF control for easy operation and monitoring by the operators.

- Low thermal mass and low conductivity ceramic fiber is used as back up insulation for walls and total roof insulation in the preheating zone. This measure will minimize heat losses through walls and roof.

- PID based control system is provided in the design for precise control of temperatures in all the zones. This will provide temperature regimes for different operating conditions.
• Furnace pressure control has been envisaged for elimination of ingress of cold air into the furnace. Ingress of cold air not only cools down the furnace leading to higher fuel firing but also damages various equipments.

• Chimney height is selected for evacuating all the flue gases through the flue line with recuperator. This will ensure preheating of combustion air to the designed level of 400 °C.

• Optimum refractories and insulation has been suggested to minimize the radiation heat loss from the side walls and roof.

• High efficiency U-tube type cross-flow metallic recuperator has been suggested to maximize the combustion pre-heat temperature thus leading to optimum fuel consumption.

4. COST CONSIDERATION

The furnace cost consideration and its difference vis-à-vis a typical re-heating furnace of similar capacity is provided below:

(i) Control System: Expenditure towards control system will be about Rs 20.0 lakhs. Benefits of this facility are (a) reduction of fuel consumption by about Rs 15.5 lakhs and (b) reduction of burning losses about Rs 20.0 lakhs annually.

(ii) Better insulation of walls will lead reduction of heat losses through walls by about 1.25% of heat input. This reduction will lead to a benefit of Rs 9.0 lakhs annually. Additional cost of 75mm thick calcium silicate required for reducing heat losses through walls will be Rs 0.65 lakhs.

(iii) Through high performance recuperator air preheat temperature can be increased by about 150 °C. This increase in air preheat temperature can be realized by an investment of Rs 8.0 lakhs, which is likely to give a benefit of Rs 40.0 lakhs.

The total cost will of the energy efficient re-heating furnace will come to approx. Rs 1.85 crore.

5. PERFORMANCE INDICATORS AND PAY-BACK

On successful operations the furnace will be rated to produce within 10% of its rated capacity.

• The specific fuel consumptions shall be within 32 l/t of steel heated, during normal operation of the furnace.

• The availability of the furnace will be over 90%.

• The hearth life will be more than 2 years and the roof life will be around 3 years.

• Scale losses shall be less than 1.5% in ingots and 1.25% in billets.
• Compared to typical furnace, the saving potential envisaged for the energy efficient furnace is approximately 20%. Considering specific fuel consumption of 40 l/t in a typical furnace, conversion to energy efficient furnace will lead to a saving of 8 l/t.

• Considering the cost of furnace oil at Rs 40 / l, the investment towards energy efficiency can be recovered within 26 months.
NOTE:
1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. IIP ENCON FILM BURNERS CAPACITIES:
   SOAKING ZONE: 4A (NOMINAL FIRING RATE 45Lt/hr)
   HEATING & PREHEATING ZONES: 4A (NOMINAL FIRING RATE 40Lt/hr)

REFERENCE DRAWING NO.: VBMC/UNDP/RHF/02/01.01
NOTE:-

1. ALL DIMENSIONS ARE IN MM UNLESS SPECIFIED OTHERWISE.
2. FIRE AND INSULATION BRICKS REQUIRED PER IS STANDARD SPECIFICATION FOR FIRE BRICKS IS:1526, INSULATION IS:2042-1972
3. ALL CUT TO BRICKS TO BE CUT WITH BRICKS CUTTING MACHINE
4. MORTAR USED FOR LINING THE BRICKS SHOULD NOT BE THINK MORE THEN 2MM
5. SPECIFICATIONS OF BRICKS ARE GIVEN IN SEPERATE BOM (WORD DOCUMENT).
NOTES:
1. SOAKING ZONE & HEATING ZONE 1 ARE WITH PROPORTIONATE CONTROL SYSTEM
2. HEATING ZONE 2 IS WITH ON/OFF CONTROL SYSTEM
3. DETAILED ENGINEERING OF PIPES SHALL BE ShOWN IN MECHANICAL DRAWINGS
4. SPECIFICATIONS OF THE EQUIPMENT WILL BE PROVIDED IN SEPARATE DOCUMENT

LEGEND:
- GLOBE CONTROL VALVE
- THERMO-COUPLE PT/PT-138RH
- BALL VALVE
- PRESSURE TRANSMITTER
- PLUG VALVE
- BUTTERFLY TYPE CONTROL VALVE
- GATE VALVE
- ORIFICE WITH DP TRANSMITTER
- OIL FLOW METER
- SOLENOID VALVE
The drawings shown are indicative however actual will be provided during manufacturing.
Disclaimer:

The information contained in these drawings is for general information purpose only. The information is provided by UNDP and while we endeavor to keep the information up to date and correct, we make no representations or performance guarantee of any kind, express or implied, about the completeness, accuracy, reliability, suitability or availability with respect to the information, products, services contained here. Any reliance you place on this information is therefore strictly at your own risk. In no event will we be liable for any loss or damage including without limitation, indirect or consequential loss or damage, or any loss or damage whatsoever arising from the use of this information.