Waste Heat Recovery: Case study of Indian Glass Industry Sector

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Industry is the largest consumer of commercial energy

Coal is the major energy source in the industry sector
Industry will remain leading energy consumers of the country
In industry sector coal will remain major energy sources
Industry Sector: Present Situation

- Industry sector accounts for more than half of total commercial energy consumption in India (2010/11)

- Large Industry sector
  - New plants: Mostly adopt energy efficient/state of the art technological options as per the global standard on their own. e.g. cement, fertiliser, etc.
  - Existing/old plants: Options exist for energy efficiency improvements
    - PAT scheme focuses on 478 Designated Consumers covering 8 sub-sectors to improve their energy efficiency levels
      - Target SEC reduction - about 5%

- MSME sector
  - 26 million enterprises
  - Existence of many energy intensive industrial clusters
  - Manufacturing 6000 products and employing 60 million people
  - Majority of units use obsolete technologies and unskilled manpower

- Glass manufacturing: highly energy intensive, represented in both large and MSME
# Indian Glass Industry

<table>
<thead>
<tr>
<th>Installed Capacity (tonnes per day)</th>
<th>Container glass – 7000, Flat glass – 4700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported Market</td>
<td>&gt; USD 1.5 billion</td>
</tr>
<tr>
<td>Major Players</td>
<td>HNG, Saint Gobain, Asahi glass, Piramal, AGI glasspac, Gujarat Guardian</td>
</tr>
<tr>
<td>Major Small-scale industry cluster</td>
<td>Firozabad (Uttar Pradesh)</td>
</tr>
<tr>
<td>Main Fuel</td>
<td>Natural Gas, Furnace Oil</td>
</tr>
<tr>
<td>Thermal energy share</td>
<td>80 % (approximately)</td>
</tr>
<tr>
<td>Average SEC (KJ/kg melted glass)</td>
<td>&gt; 5000</td>
</tr>
<tr>
<td>Estimated Energy Consumption</td>
<td>1.2</td>
</tr>
<tr>
<td>(million toe/yr.)</td>
<td></td>
</tr>
<tr>
<td>Future scenario</td>
<td>About 12% annual growth expected due to increase in packaging, construction and automobile sector</td>
</tr>
</tbody>
</table>
Glass Manufacturing & Types

Chemical Composition
- Soda- Lime glass
- Lead crystal and crystal glass
- Borosilicate glass
- Special glass

Market
- Container glass
- Flat glass
- Fibre glass
- Domestic glass
- Speciality glass

Glass Manufacturing: Energy Use

Energy Use in typical flat glass process

Furnace, 83%
Forming/Lehr, 5%
Cutting, 2%
Other, 10%

Energy Use in typical container glass process

Furnace, 79%
Mould cooling, 2%
Compressed air, 4%
Fore hearth, 6%
Lehr, 2%
Other, 6%

Energy Cost is more than 25% of total production cost
Glass Manufacturing – Energy Flow

Cross-fired energy efficient regenerative container glass furnace with 70-75% cullet ratio

(Source: Glass Manufacturing industry Council 2004)

Best Practice furnaces have efficiencies about 40%; Majority of primary energy input is wasted
Waste Heat Recovery (WHR)

- High temperature (1300 – 1500 °C) of glass melting furnace; high exhaust gas temperature;
- WHR – potential energy consumption reduction option
  - Preheat combustion air
  - Preheat batch and cullet material
  - Using Waste Heat Boilers for electricity generation

![Graph showing relationship between typical furnace size and average waste heat losses in different segment of glass industry.](image)

## Combustion Air Preheat

Increase in Furnace Efficiency with combustion air preheat

<table>
<thead>
<tr>
<th>Furnace Outlet Temperature</th>
<th>204°C</th>
<th>316°C</th>
<th>427°C</th>
<th>538°C</th>
<th>649°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,427°C</td>
<td>22%</td>
<td>30%</td>
<td>37%</td>
<td>43%</td>
<td>48%</td>
</tr>
<tr>
<td>1,316°C</td>
<td>18%</td>
<td>26%</td>
<td>33%</td>
<td>38%</td>
<td>43%</td>
</tr>
<tr>
<td>1,204°C</td>
<td>16%</td>
<td>23%</td>
<td>29%</td>
<td>34%</td>
<td>39%</td>
</tr>
<tr>
<td>1,093°C</td>
<td>14%</td>
<td>20%</td>
<td>26%</td>
<td>31%</td>
<td>36%</td>
</tr>
<tr>
<td>982°C</td>
<td>13%</td>
<td>19%</td>
<td>24%</td>
<td>29%</td>
<td>33%</td>
</tr>
<tr>
<td>871°C</td>
<td>11%</td>
<td>17%</td>
<td>22%</td>
<td>26%</td>
<td>30%</td>
</tr>
<tr>
<td>760°C</td>
<td>10%</td>
<td>16%</td>
<td>20%</td>
<td>25%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Indian Glass Industry: Electricity generation potential

Cumulative ORC potential for WHR (MW) in glass industry

Source: Market potential Study for ORC Technology in India, IGEF (2014)
Firozabad Glass Cluster

- Largest cluster in small scale glass sector
  - Annual Glass Production: 1.0 million ton/yr.
  - Estimated annual energy consumption: 0.2 million toe

- Major product - Bangle
  - Other products: colored decorative items, tableware, lab-ware, glass shells etc.

- Falls within the Taj Trapezium Zone (TTZ)

- Industry mandated to switch over to natural gas (1996 Supreme Court Mandate)

- TERI with support of SDC (Swiss Agency for Development and Cooperation) worked in the cluster to design, develop, demonstrate and disseminate energy efficient natural gas-based technologies for glass bangle industries
Demonstrated WHR – Recuperator Layout
Waste Heat Recovery – Recuperator

- Counter flow metallic recuperator
- 5 Stainless Steel modules
- Air preheat temperature: 550 – 600°C
- Energy Saving: About 25 – 30%
- Payback period: < 0.5 year
- Adopted by almost all cluster units
Thank You for your attention !!