Development of a Highly Efficient Immersion Burner for Aluminum Holding Furnaces

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Table of contents

• Introduction

• Example of our energy saving activities
  - For heat-treatment plants

• Development of a highly efficient immersion burner
  - Developmental background
  - Features
  - Specifications and Uses
  - Performances
  - Future prospects

• Conclusion
• Toho Gas is a city gas provider that supplies natural gas to the Tokai region, in Japan
• Key industry of this region is the automotive industry
• We have been working on a number of energy conservation activities
Example of energy saving activities for heat treatment plants

1. Improving the heating efficiency of atmosphere heat treatment furnaces I ⇒ Recuperative radiant tube burner
2. Improving the heating efficiency of reforming furnaces
3. Saving energy by applying high-load immersion tube burners
4. Simulating heat transfer
5. Air ratio control to reduce exhaust loss

Example of heat treatment plant manufacturing metal parts
For heat-treatment plants

Improving the heating efficiency of atmosphere treatment furnaces

- Single-ended radiant tube burner: CSRT
- Regenerative radiant tube burner: RSTB

Appearance of CSRT

Appearance of RSTB
For heat-treatment plants

Improving the heating efficiency of heat reforming furnaces

- Cyclone twin regenerative burner : CTR

Appearance of CTR

Installation for reforming furnace
Developmental background

- We developed a **highly efficient immersion burner (Gas Immersion Heater: GIH)**
- GIH reduces energy consumption and CO₂ emissions of aluminum holding furnaces used in the molding process of aluminum parts

Example of aluminum parts manufacturing plants
About aluminum holding furnaces

• To keep the temperature of molten aluminum, holding furnaces are often used in the molding process.

Example of the production process of aluminum parts

1. **Melting**
   - Melt aluminum ingots by heat

2. **Holding**
   - Hold molten aluminum around 700°C

3. **Casting**
   - Heat to several hundred °C

4. **Heat treating**
   - Heat treating furnace

5. **Products**
   - Aluminum parts
Developmental background

- **Crucible type** and **immersion heating type** are commonly used.
- These methods **degrade the quality of molten aluminum poorly**.

**Crucible type**: A method which heats a crucible holding molten aluminum.

**Immersion heating type**: A method which heats molten aluminum by immersing a heat-transfer tube in the molten aluminum and placing a heat source in the tube.

Image of the crucible type and immersion heating type holding furnace.
Problems of existing immersion burners

1. Improvement of efficiency
   • Thermal efficiency of existing non-waste-heat-recovery burners is about 60%
   • Further improvement of efficiency is expected

2. Size reduction
   • Electric heaters often use heat-transfer tubes with relatively small diameters
   • Replacement cost to another tube with a larger diameter is required to replace an electric heater by an immersion burner

3. Improvement of safety
   • Used in the lower immersion method, safety measures must be implemented against the molten metal leakage, in case a tube is damaged
1. Energy-saving

- Simple **heat exchanging structure** in the burner body
- This enables exhaust heat to preheat combustion air
- **High efficiency, energy and CO₂ reductions** are achieved
• Newly developed **surface combustion technology with nozzle mixing**
• Creates **longer flame**
• **Long service-life of the heat-transfer tube** is expected
• **High temperature preheating** is possible

Flame by the surface combustion technology with nozzle mixing in glass tube

Example of flame of conventional tube burner
Features of GIH

2. Size reduction

- Heat-transfer tubes with smaller diameters is applicable
- Replacing from not only existing burners but also electric heaters became easier
3. Safety against the molten metal leakage

- **Filter structure** to use this burner in lower immersion
- **Prevents any molten metal leakage out of a furnace** in case a tube is damaged
- Actually conducted tube destructive tests and confirm **no molten metal leakage**

![Schematic of the filter structure](image)

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**Features of GIH**

- Normal state
- Abnormal state
- Exhaust pipe
- Filter
- Exhaust gas
- Molten Aluminum

Schematic of the filter structure
Specifications and Uses

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion capacity*</td>
<td>12 to 29[kW]</td>
</tr>
<tr>
<td>Combustion control method</td>
<td>Hi-Lo-Off Control or On-Off Control</td>
</tr>
<tr>
<td>Fuel gas</td>
<td>13A city gas**</td>
</tr>
<tr>
<td>Necessary gas pressure</td>
<td>5[kPa] or more</td>
</tr>
<tr>
<td>(at the inlet of a burner)</td>
<td></td>
</tr>
<tr>
<td>Immersion method</td>
<td>Upper immersion or lower immersion</td>
</tr>
</tbody>
</table>

*The combustion capacity varies depending on the diameters and lengths of heat-transfer tubes
**13A city gas is a natural-gas-based gas which is commonly-used in Japan

Uses

- Heat sources of immersion heating type molten metal holding furnaces with the retention capacity of about one to three tons
- For larger holding furnaces by installing multiple GIHs
Performances of GIH

Basic performance

- Thermal efficiency of GIH is greater than 75% (based on exhaust loss)
- Much better than existing non-waste-heat-recovery burners and electric heaters

Relationship between the combustion capacity and heat efficiency of GIH
Performances of GIH

Field test

• Use of GIH reduced the primary energy consumption by more than 40% compared to already operating furnaces with electric heaters

• CO₂ emissions reduction effect was also estimated to be more than 50%

Reduction effect of the primary energy consumption and CO₂ emission by GIH
Future prospects and Conclusion

Future prospects

• Produce a series of GIH for various size heat-transfer tubes
• Increase the capacity of GIH for melting purpose

Conclusion

• We developed a highly efficient immersion burner (GIH) targeting immersion heating type molten aluminum holding furnaces and confirmed the following

1. Use of the surface combustion technology with nozzle mixing method enabled preheating of combustion air and high thermal efficiency was confirmed

2. Safety against the molten metal leakage while being used with the lower immersion method was confirmed

3. Field test and other tests confirmed that GIH has sufficient energy efficiency and CO₂ emissions reduction performance
END