Amorphous Alloy for Energy Efficient Distribution Transformer

Features

- Principal uses, application range and versatility: Energy efficient transformer (oiled, dry and mold) for electric power distribution.
- Energy efficiency and energy conservation: The amorphous transformer contributes to the reduction in power loss in the power distribution grid since it has small no-load loss (equivalent to the standby power) at approx. 1/3 of the no-load loss of a cold-rolled grain-oriented electrical steel transformer. It also contributes to the reduction in CO2 emission in the power generation, because it uses electric power efficiently.
- Innovative with price advantage: Initial costs of amorphous transformer is higher than the conventional transformers that use cold-rolled grain-oriented electrical steel, but since the loss of electric power is lower, the running costs are less and therefore in terms of life cycle costs the amorphous transformer is cheaper *2.
- Weather resistance and durability, etc: Equivalent to cold-rolled grain-oriented electrical steel transformers.
- Ease of material procurement: Materials being mass produced by Metglas® Yasugi Works of Hitachi Metals, Ltd., as well as at Metglas® *3 in the United States (our wholly owned subsidiary).

Basic Concept or Summary

Features of amorphous (non-crystalline) alloys

<table>
<thead>
<tr>
<th>Cold-rolled grain-oriented electrical steel (crystal)</th>
<th>Amorphous (non-crystalline) alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Regular atomic arrangement →Crystalline magnetic anisotropy</td>
<td>● Irregular atomic arrangement →Non-crystalline magnetic anisotropy exists</td>
</tr>
<tr>
<td>● Electric resistivity (0.50μΩ・m) →Equivalent to or less than half of the amorphous alloy</td>
<td>● Electric resistivity (1.20μΩ・m) →More than double the thickness of cold-rolled grain-oriented electrical steel</td>
</tr>
<tr>
<td>● Thickness (0.23 to 0.35mm) →About ten times thickness of amorphous alloy</td>
<td>● Thickness (0.025mm) →About one tenth thickness of cold-rolled grain-oriented electrical steel</td>
</tr>
</tbody>
</table>

Comparison of magnetic characteristics for amorphous core and cold-rolled grain-oriented electrical steel core (50Hz)

No-load loss of amorphous core is about one-third that of cold-rolled grain-oriented electrical steel core.
Our amorphous alloy Metglas® 2605SA1 and 2605HB1M can significantly reduce the losses that occur with transformers during electric power transformations, in comparison with cold-rolled grain-oriented electrical steel, due to superior soft magnetic characteristics (amorphous structure and thin), which contribute greatly to energy conservation and reducing carbon dioxide emissions.

- No-load loss of transformers is about one-third that of cold-rolled grain-oriented electrical steel transformers.
- Superior melting and casting technologies achieve a mass production of highly reliable wide and thin amorphous ribbon.

Furthermore, the new material Metglas® 2605HB1M makes it possible to reduce the size of amorphous transformers which is made from 2605SA1 (conventional amorphous alloy).

### Comparison of no-load loss among transformers

![Comparison Chart]


*The closest standard transformer capacity based on the average capacity of consumer oil-filled transformers, according to the results of a survey conducted by Hitachi Industrial System.

### Estimation of energy conservation effects from amorphous transformer

**2009 All AMT**

1. **Effect when all industrial transformers in Japan are replaced to amorphous transformers**
   1) Reduction of NLL: 1,123 MW → 9.84 TWh/yr
      (Corresponds to 1.1% out of total demand (858.5TWh/yr) in 2009)
   2) Electricity cost reduced by around 108 Byen/yr*
   3) Reduction of CO₂ emission: 4.08 M ton CO₂/yr**
      (Corresponds to 0.34% out of total CO₂ emission (1201M ton CO₂/yr) in 2009)

2. **Effect when all pole-type transformers in Japan are replaced to amorphous distribution transformers**
   1) Reduction of NLL: 409 MW → 3.58 TWh/yr
      (Corresponds to 0.42% out of total demand (858.5TWh/yr) in 2009)
   2) Reduction of CO₂ emission: 1.49 M ton CO₂/yr**
      (Corresponds to 0.12% out of total CO₂ emission (1201M ton CO₂/yr) in 2009)

*Electricity price for calculation: ¥11/kWh
**Emission factor of Utility (2009) for calculation: 0.415 kg - CO₂/kWh

### Installation in Practice or Schedule

#### Domestic

- **Overseas**

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity Installed (MVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>236,000</td>
</tr>
<tr>
<td>India</td>
<td>69,500</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,800</td>
</tr>
<tr>
<td>Mexico</td>
<td>19,800</td>
</tr>
<tr>
<td>USA</td>
<td>65,700</td>
</tr>
<tr>
<td>Canada</td>
<td>9,100</td>
</tr>
<tr>
<td>S. Africa</td>
<td>100</td>
</tr>
<tr>
<td>S. Korea</td>
<td>13,700</td>
</tr>
<tr>
<td>Philippines</td>
<td>5,200</td>
</tr>
<tr>
<td>Vietnam</td>
<td>4,200</td>
</tr>
<tr>
<td>Taiwan</td>
<td>7,700</td>
</tr>
</tbody>
</table>

Unit: MVA (Million VA)

#### Developing market

- **Developed market**

- **Developing market**

Capacity of amorphous transformers installed in each country as of the end of 2017 (our estimate). Transformer capacity varies in each country.

### Contact

Hitachi Metals, Ltd.,
Sales Department, Soft Magnetic & Components Business Unit, High-Grade Metals Company
Shinagawa Season Terrace 23F, Konan 1-2-70, Minato Ward, Tokyo 108-8224
Tel: +81-3-6774-3401 / Fax: +81-3-6774-4308