China Energy-Efficient Distribution Transformer
Development and Benefit

GUANGDONG HAIHONG TRANSFORMER CO., LTD.
Chapter 1 Company Profile

Overview

HAIHONG, renowned as China National Torch Plan High-tech Enterprise and mainly engaging in the R&D, manufacture, sales, installation and commissioning services of power transmission and distribution equipment, is today globally the largest 3D Wound Core Transformer Manufacturer. HAIHONG has been successively awarded China well-known trademark, China Top 500 Mechanical Enterprise, National Advanced Mechanical Industry Group, Guangdong Innovation Top 100 Enterprise and Guangdong Innovative Pilot Enterprise, and established long term strategic partnership with ABB Group, US DuPont, Germany Siemens and China WISCO, BAOSTEEL.

HAIHONG has VPI Dry-type Transformer R&D center and 63 authorized national patents, including 3 patents for invention. Annual sales turnover in the year of 2012 was around USD 100 millions.
With Headquarters located in Cuishanhu Industrial Zone Kaiping, 2 branch companies separately in Shuikou and Cangcheng and 1 joint venture in Malaysia, HAIHONG has now 750 employees, including 230 technicians, 69 qualified engineers as well as 600 sets of machinery.
Chapter 2 National Policy Influence on The Industry

Influence on The Transformer Industry

- After the Publication of Standard GB 20052-2013 Three Phase Distribution Transformer Energy Efficiency Limit Value and Grade:
  - Stricter Rules for Market Access
  - Low efficiency products are no longer allowed for production and sale.
  - Qualified Manufacturing enterprises enjoy significant competitive advantage.
  - Golden opportunity for some transformer manufacturers to get developed by complying with the new standard
  - Others who refuse or incapable of meeting the standard will finally be naturally eliminated from the market.
  - Transformer industry upgrading and evolution will then be achieved in a very short term.
### Performance Level Improvement

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Efficiency Grade</th>
<th>Model</th>
<th>Efficiency Level Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No-load Loss</td>
</tr>
<tr>
<td><strong>Oil-immersed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>S-M-RL-Ø/10-NX1</td>
<td>S13</td>
<td>30% lower than S11</td>
</tr>
<tr>
<td>Grade 2</td>
<td>S-M-RL-Ø/10-NX2</td>
<td>S13</td>
<td>30% lower than S11</td>
</tr>
<tr>
<td>Grade 3</td>
<td>S11-M-RL-Ø/10</td>
<td>S11</td>
<td></td>
</tr>
<tr>
<td>Below Grade 3</td>
<td>S11-M-RL-Ø/10</td>
<td>S11(+10%)</td>
<td></td>
</tr>
<tr>
<td>High Energy Consumption</td>
<td>S7-Ø/10 National Standard</td>
<td>36% higher than S11 (+10%)</td>
<td>22% higher than S11 (+10%)</td>
</tr>
<tr>
<td><strong>Dry Type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>SCB-RL-Ø/10-NX1</td>
<td>SCB13</td>
<td>30% lower than SCB10</td>
</tr>
<tr>
<td>Grade 2</td>
<td>SCB-RL-Ø/10-NX2</td>
<td>SCB12</td>
<td>20% lower than SCB10</td>
</tr>
<tr>
<td>Grade 3</td>
<td>SCB10-RL-Ø/10</td>
<td>SCB10</td>
<td></td>
</tr>
<tr>
<td>Below Grade 3</td>
<td>SCB10-RL-Ø/10</td>
<td>SCB10(+10%)</td>
<td></td>
</tr>
<tr>
<td>High Energy Consumption</td>
<td>SCB8-Ø/10 National Standard</td>
<td>25% higher than SCB10 (+10%)</td>
<td>25% higher than SCB10(+10%)</td>
</tr>
</tbody>
</table>
Chinese Ministry of Industry and Information Technology (MIIT) decided to gradually eliminate high energy-consumption transformers.

Statistically nowadays around 900,000 units of high energy-consuming transformers are running nationwide in China.

Excessive operating time results in aging insulation, higher failure rate, more maintenance cost and overloading problems due to unreasonable load distribution, consequently puts power grid security and power supply quality at risk.

If all to be replaced by energy-efficient transformers, the demand is huge.

When National Financial Subsidies Policy is introduced, it will greatly encourage users to turn to energy-efficient transformers.
Chapter 3 3D Wound Core—New direction for Energy Saving

Direction of Energy Conservation Technology Development for Transformer

- Back in the 19th century when 3 phase transformer was invented, it was commonly acknowledged that 3 identical core legs led to the best electrical performance.

- However due to technological difficulty and unpractical cost, much easier way as below was decided for mass production.

- Even nowadays after over 100 years, such traditional transformer manufacturing method is still dominating.
In the 1990s, some transformer manufacturers in China had tried to develop 3D wound core structure transformer. In 2002, completed products appeared in the market. However, subject to the weak R&D ability, production equipment and technology level, it stopped back there.

HAIHONG selected 3D wound core transformer as its developing direction:

- Following national Energy Efficiency policy guidance in recent years, the still ongoing R&D at HAIHONG has been greatly sponsored by various governmental authorities in many aspects, such as financial award, tax preference and loan with low interest, etc.
- HAIHONG is fully assured that 3D wound core transformer is definitely the ideal solution to a low-carbon future.
3D Wound Core Transformer

- Revolutionarily innovative core structure substantially decrease no-load loss and noise, significantly reduce raw material and is perfectly match for energy-efficient transformers.
- Such competitive advantage will be more significant by using better silicon steel.

- Three Phase Equilibrium
- Cost-effective
- Lower No-load loss & No-load Current
- Very low Noise
- Strong Anti-short Circuit Ability
- Low Electromagnetic Field
- Theft Proof
Amorphous alloy, a new and excellent soft magnetic material, is introduced to enhance efficiency of transformers.

Amorphous alloy of special crystal structure differs from silicon steel in better excellent EMC, lower unit iron loss and higher saturation flux density, etc.

Traditional amorphous alloy transformer adopts 3 phase-4 frame-5 leg 2D wound core structure with 3 single open frames arranged in a 2D style.
Chapter 3 3D Wound Core—New direction for Energy Saving

Direction of Energy Conservation Technology Development for Transformer

- Amorphous Alloy Transformer (3D Wound Core Structure)
- 3D Amorphous alloy transformer adopts 3 phase-3 frame-3 leg equilateral triangle structure. The 3D core itself is made of amorphous alloy combining 3 identical frames.
- Continuous wound, without air-gaps, reducing the magnetic reluctance
- Optimized utilization of core material in terms of magnetic flux distribution, also reduced no-load loss, harmonics, inrush current and sound level provide more competitive and environment-friendly solutions
Through analysis and calculation, under the circumstance of exactly the same core diameter, cross section, central distance and capacity, the use of silicon steel of China national standard S13 3D wound core transformer is 20%~25% less than the counterpart of EI structure.
3D wound core leg cross section space filling factor is quite high. Under same active area of core legs, diameter of 3D wound core leg is smaller, thereby decreases coil wire length. As a result, 3D wound core transformer consumes less conductors than the EI one.
### 3D Wound Core Transformer Energy Efficiency Effectiveness

**Taking 630kVA transformer for example, analyze the difference between energy-consuming and energy-efficient transformer:**

<table>
<thead>
<tr>
<th>High Energy-consuming Transformer</th>
<th>Energy-efficient Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td><strong>NNL (kW)</strong></td>
</tr>
<tr>
<td>SJ-63010</td>
<td>3.06</td>
</tr>
<tr>
<td>5-630/10</td>
<td>2.45</td>
</tr>
<tr>
<td>57-630/10</td>
<td>1.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Energy-consuming Transformer</th>
<th>Replaced by Grade 2 Energy-efficient Transformer</th>
<th>Replaced by Grade 1 Energy-efficient Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td><strong>Annual Operating Cost</strong></td>
<td><strong>Efficiency</strong></td>
</tr>
<tr>
<td></td>
<td>CNY</td>
<td>%</td>
</tr>
<tr>
<td>SJ-630/10</td>
<td>86147</td>
<td>97.46</td>
</tr>
<tr>
<td>5-630/10</td>
<td>73951</td>
<td>97.89</td>
</tr>
<tr>
<td>57-630/10</td>
<td>51134</td>
<td>98.33</td>
</tr>
</tbody>
</table>
### 3D Wound Core Transformer Energy Efficiency Effectiveness

#### Case Analysis:

Supposed a company has an oil-immersed transformer S7-800/10, it plans to replace the current transformer by Energy Efficiency Grade 1 or Grade 2 product.

As per “Energy Efficiency People-benefit Project”, separately CNY20/kVA subsidies for Energy Efficiency Grade 1 and CNY10/kVA subsidies for Energy Efficiency Grade 2, users invest in the new transformer but get subsidy from both the government and selling the old transformer.

<table>
<thead>
<tr>
<th>Item</th>
<th>S7-800/10</th>
<th>S-M·RL-800/10-NX2</th>
<th>S-M·RL-800/10-NX1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Category</td>
<td>High Energy-consuming Transformer</td>
<td>Grade 2 Energy Efficiency Transformer</td>
<td>Grade 1 Energy Efficiency Transformer</td>
</tr>
<tr>
<td>Recycling Price (CNY)</td>
<td>29561</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Selling Price (CNY)</td>
<td>——</td>
<td>95100</td>
<td>116900</td>
</tr>
<tr>
<td>Financial Subsidy (CNY)</td>
<td>——</td>
<td>8000</td>
<td>16000</td>
</tr>
<tr>
<td>Annual Operating Cost (CNY)</td>
<td>78490</td>
<td>49964</td>
<td>43767</td>
</tr>
<tr>
<td>Operating Cost Off Compared with S7 (CNY)</td>
<td>——</td>
<td>28526</td>
<td>34722</td>
</tr>
<tr>
<td>Investment Recovery Period (Year)</td>
<td>——</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Ten Year Benefit (CNY)</td>
<td>——</td>
<td>227718</td>
<td>275886</td>
</tr>
</tbody>
</table>

Note: Above selling price is not actual purchase price, but for example only.
HAIHONG Responds to National Policy

Under guidance of energy-efficient policy and standard set by Chinese government, HAIHONG formulates its development strategy.

From EU-CN Energy-efficient Transformer Promotion Project Initiation Meeting, HAIHONG’s noticed the current development of high-efficiency transformer and China’s determination to popularize the best, thus made up its mind to fully concentrate on the R&D of energy-efficient transformers.

HAIHONG’s ongoing R & D has verified the energy-efficient and cost-effective nature of 3D wound core transformer, especially by using higher quality silicon steel, in the meantime, HAIHONG works very closely with world-class material suppliers like WISCO, BAOSTEEL and Nippon Steel, to make good use of material advantages and optimizes product designs.

Through continuous R&D, the actual performance of 3D products have been greatly enhanced with slightly increase of production cost.

3D energy-efficient transformers of HAIHONG have been gradually widely tested (routine/special/type/efficiency tests, etc.)

Energy conservation and environmental protection has been gaining worldwide popularity and acknowledgement, so have the developing HAIHONG and its bettering products.
Chapter 4 Enterprises Respond to National Policy

HAIHONG Promotion Strategy

Apprehension of Governmental Policies
- Understanding rules for implementation
- Visit to relevant authorities

Promotion
- Pricing strategy
- Technical exchange
- Joint efforts of manufacturers
- Visit to large users

Services
- Project Analysis
- Recycling high energy consumption transformer
- Replacing by energy-efficient transformer
- Assistance in applying energy efficiency subsidy
Chapter 4 Enterprises Respond to National Policy

HAIHONG Developing Energy-efficient Transformer

Energy Efficiency Product

Oil-immersed Transformer

- Core Material
  - Silicon Steel
  - 30~1600kVA

Dry-type Transformer

- Core Material
  - Amorphous Alloy
  - 30~630kVA

- Insulation Type
  - Resin
  - 30~2500kVA

- Insulation Type
  - Open Ventilated
  - 30~2500kVA

Energy Efficiency Product

Oil-immersed Transformer

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Insulation Type

- Resin
  - 30~2500kVA

- Open Ventilated
  - 30~2500kVA
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Assistance to Partners

Full range of training performed in the partners'.

ABB Korea

Junqi Shanghai
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HAIHONG and High Energy Consumption Transformer Users Interchange Activity

- Hosted by Guangdong Energy Efficiency Association and organized by HAIHONG, the conference called up members of Energy Efficiency Association, high energy consumption transformers users and energy services companies, etc., HAIHONG shared energy efficiency transformer promotion experience as well as the booming business introduced by People-benefit Project.
- Days after the meeting, HAIHONG received lots of enquiries about how to replace and better their energy-killing transformers.

2013 Guangdong Energy Efficiency Product Promotion and Technology Interchange Activity – High Energy Efficiency Transformer Special Promotion and Introduction Conference
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Energy Efficiency Upgrading Project Cooperation

HAIHONG Researching in Shanxi
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3D Wound Core Transformer R&D Process in HAIHONG

- From 2005, HAIHONG fully devoted itself into the R&D of 3D wound core transformer and aimed to bring fresh and technical revolution to the already fierce and disordered market competition.

- At present up to 35 kV voltage classes and 20,000kVA Oil-immersed transformers and up to 5000kVA dry-type transformers are fully available.
Continuous R&D has been perfecting all the relevant manufacturing techniques and creating new varieties of 3D transformers.
Various specially-designed and home-made equipment by HAIHONG, such as Curve Slitting Machine, 3D Core Winding Machine, 3D Coil Winding Machine (Wire/Foil) as well as lots of different accessories and fittings, had been introduced in the year of 2007 and optimized since. Today the 5th generation has witnessed the gradual but obvious improvement on application range, production efficiency and automaticity of all equipment.
Chapter 4 Enterprises Respond to National Policy

HAIHONG 3D Wound Core Transformer R&D Process

3D Wound Core Single Foil Winding Machine

3D Wound Core Double Foil Winding Machine
Chapter 4 Enterprises Respond to National Policy

Large Capacity Breakthrough

SZ11-RL-20000/35/10
Transformer Core

SZ11-RL-20000/35/10
Transformer Coil Winding
Chapter 4 Enterprises Respond to National Policy

Large Capacity Breakthrough

SZ11-RL-20000/35/10 Transformer Active Part Assembly

SZ11-RL-20000/35/10 Transformer Delivery
Standing on the theoretical research and practical application of 10kV 3D wound core distribution transformer, 110kV oil-immersed one breaks through technology innovation. 3D wound core transformer technology features lower noise, better utilization of energy and material, if such advantages apply to 110kV power transformer, they will be more considerate. Currently what we have in the market of EI core is too noisy, energy-consuming and huge in dimension. However as a new type of environment friendly product, 110kV 3D transformer with a symmetrical 3phase magnetic circuit is comparatively of less energy and material consumption, reduced noise and weight, smaller foot print, reduced harmonic and inrush current, much better for urban power transmission substation.
Chapter 4 Enterprises Respond to National Policy

Higher Voltage Breakthrough

110kV 3D Wound Core Project Equipment Installation Site
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New Product Breakthrough

2012. March – The first unit of amorphous alloy transformer successfully developed and energized.

2012. July – All the 3 units of HAIHONG’s amorphous alloy 3D wound core transformer were spot tested and approved by China Southern Grid, as 1 in 4 among 43 attendants, namely only 9.3% were qualified.

2012. August 23 – One SH15-M·RL-630/10 3D Amorphous Alloy transformer of HAIHONG was type-tested and approved by China Medium & Low Voltage Power Distribution Equipment Quality Supervision & Inspection Center, all tests passed in a blink.

2012. March – Engineers discussing at the scene of the experiment
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New Area Development

ZGSL11-Z-G-1000/35
Qinghai Golmud Solar Power Plant 35kV Transformer Project
Chapter 5 Conclusion

3D Wound Core Transformer Promotion Advantages

1. Great Energy-efficient Potential for Future Growth
2. Additional Advantages aligned with the development of Silicon Steel
3. High Utilization of Silicon Steel and Material-effective
4. Best and Most Reasonable Structure to Maximize the Performance of Transformer
HAIHONG’s practical experience tells that the implementation of energy efficiency standard indeed does good to boosting a low-carbon society.

HAIHONG will as ever stick to the R&D and manufacture of energy-efficient transformers!
THANK YOU!

Boost Energy Efficiency

and

Benefit Human Society

Nov. 2013