The Latest Technology for Expanding the Range of Applications for "MOLTRA"

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ABSTRACT

Fuji Electric's "MOLTRA" is a fire-resistant, maintenance-free, compact and lightweight molded transformer, that is also environmentally-friendly because it does not use oil. In new energy applications involving wind power systems, measures such as the use of smaller coils, removal of interphase barriers and barriers between primary-side panels, use of H-type insulation, and the application of a shielded structure for secondary terminals and inter-phase leads ensures 34.5 kV insulation performance and achieves a smaller size and lighter weight. For use in special power supplies for power storage devices, a transformer with approximately 4 times the overvoltage input tolerance as a general-purpose high-voltage MOLTRA has been developed. Moreover, the installation of Japan's largest MOLTRA in the electric room on an upper floor of a building was implemented by disassembling the MOLTRA, and using a jig to transport the disassembled pieces.

1. Introduction

Fuji Electric's "MOLTRA" series of molded transformers have been used in practical applications since the early 1970s. Highly regarded as a fire-resistant, maintenance-free, compact and lightweight, low loss, low noise, and moisture resistant transformer having excellent short-time overload capability and high reliability, the use of the MOLTRA became widespread in applications in which grade H insulation dry-type transformers had been used previously. Because of the abovementioned advantageous features, the MOLTRA has been used widely in power receiving and transforming facilities at public facilities, buildings, hospitals and other such places where many people tend to gather. In recent years, as part of its efforts to help protect the global environment and curb global warming, Fuji Electric has expanded the MOLTRA lineup to include the low-loss Top-Runner MOLTRA and the Super Efficiency MOLTRA. With the development of molded insulation technology and other various technologies, the dielectric strength and other performance criteria have reached levels equivalent or superior to those of an oil-immersed transformer, and the MOLTRA's dimensions and loss levels are becoming smaller year-by-year.

In recent years, the achievement of a significant reduction in greenhouse gas emissions has been set as a global goal, and as an alternative to traditional fossil fuels, a migration toward new renewable forms of energy such as wind power and solar power is underway.

Fuji Electric's MOLTRAs for new energy applications, such as for wind-generated power and energy storage systems, which feature improved dielectric performance and environmental durability as compared to a general MOLTRA for power applications are introduced below. Also described is an example of the delivery of Japan's largest-class capacity MOLTRA to the electric room on an upper floor of a large department store in which the MOLTRA was dissembled and transported in pieces.

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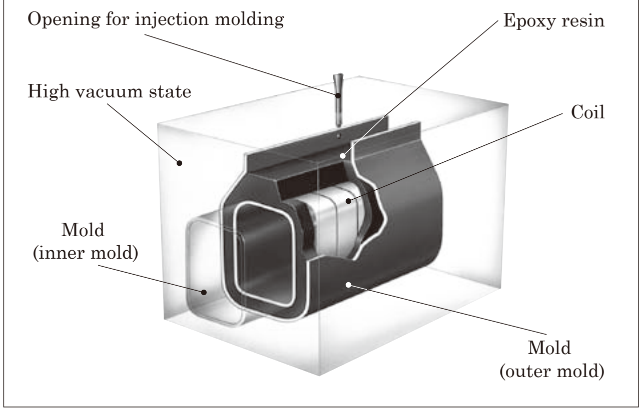
2. MOLTRAs for New Energy Applications

To ensure the dielectric performance of a molded transformer, it is especially important that there are no partial discharges. Fuji Electric's MOLTRAs use the following two technologies to ensure a high level of insulation reliability.

(1) Vacuum injection molding method

As shown in Fig. 1, a vacuum injection molding method using a mold is employed. With this method, as shown in Fig. 2, resin penetrates throughout the interlayer insulation in the windings, to form molded

Fig.1 Injection of epoxy resin in vacuum injection molding method



windings that are free of voids, have excellent corona characteristics and highly reliable insulation performance. Moreover, the smooth winding surface provides excellent moisture resistance and dust resistance.

(2) Sheet windings

With sheet windings, since the burden voltage between conductive turns is minimized, the insulation reliability, surge resistance and safety are maintained during operation. Also, sheet windings typically have a high space factor and are therefore advantageous for making more compact and lighter weight windings.

In addition, special insulation performance enhancements are realized in these MOLTRAs for new energy applications.

2.1 MOLTRA for wind-generated power applications

Fuji Electric produces a MOLTRA for boosting the voltage of a wind turbine generator to the system voltage level of 34.5 kV. The main specifications are shown in Table 1. Since this MOLTRA is installed inside a wind turbine (nacelle) at the top of a tower several tens of meters tall, the following features are requested.

(a) Compact size that can be housed within a limited space
(b) Reduced insulation separation distance when installed

Additionally, the following features are requested of the installation environment for a wind power plant.

(c) Environmental durability (resistance to salt damage, etc.)
(d) Insulation performance that supports high altitudes above 1,000 m

Responding above requests, by implementing the following measures, 34.5 kV insulation performance, which is the highest voltage class for molded transformers, can be ensured and small size and light weight can also be realized.

(a) Review of the dimensions of insulation inside windings in order to reduce the coil size
(b) Removal of interphase barriers and barriers between primary-side panels
(c) Use of H –type insulation
(d) Application of shielded structure to secondary terminals and leads between phases

Moreover, the characteristic vibration of a wind turbine nacelle also affects the transformer, and therefore in addition to verifying the design with respect to the requested specifications, a vibration test is also carried out with an actual turbine under the conditions listed in Table 2 to confirm that there are no problems.

Fig.2 Molded state of sheet windings

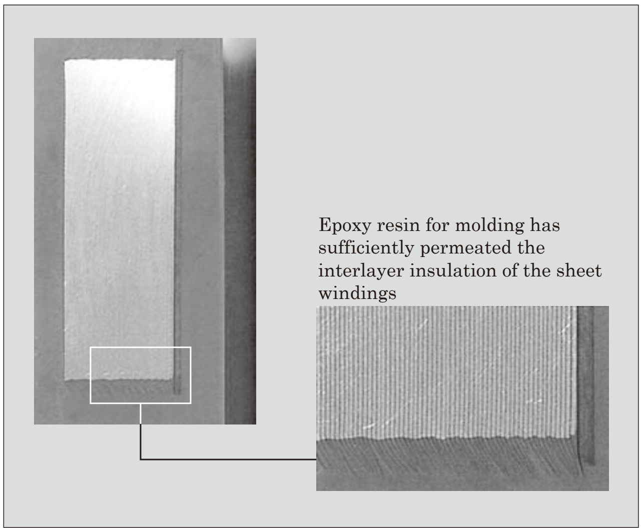


Table 1 Main specifications of MOLTRA for wind-generated power applications

Applicable standard	IEC-60076-11-2004	
Rated capacity (kVA)	2,700	
	Primary	Secondary
Rated voltage (V)	690	34,500
Frequency (Hz)	60	
Insulation class	H	
Max. ambient temperature (°C)	50	
Cooling method	Self-cooling	
Connection	Dyn11 (Δ/Yn)	
Dimensions (mm)	2,700 (W)×2,260 (H)×1,315 (D)	
Weight (kg)	6,500	

2.2 MOLTRA for energy storage system applications

Fuji Electric produces a MOLTRA that functions as a linking transformer between an energy storage system and a commercial grid system. The main specifications are listed in Table 3. So an inverter output could be connected without the use of a filter, insulation performance of approximately four times the overvoltage input withstand capability as that of a general high-voltage MOLTRA had to be realized in a compact size. A MOLTRA that satisfied the required specifications was developed by implementing the following measures.

(a) Application of a 22 kV class winding structure
(b) Review of insulation dimensions in order to reduce the size
(c) Analysis of electric field concentrations and measures to prevent

Table 2 Vibration test conditions

Vibration conditions	Acceleration 0.5 G (max. value for TR main unit: 3 G)
Frequency	5 to 100 Hz
Vibration direction	X, Y, Z directions
Post vibration test check	External appearance of structure, test of general characteristics

3. Larger Capacity and Disassembled Transportation of MOLTRAs

Data center buildings and shopping centers, for which demand has increased in recent years, are often equipped with indoor extra-high voltage facilities. Traditionally, oil-immersed or gas-insulated transformers had to be used because of the need for large capacity. However, to improve eco-friendliness and in support of disaster prevention measures, and also in response to requests for eliminating SF_6 gas and oil, the need for a large capacity MOLTRAs are increasing.

Below, an example of the delivery of Japan's largest-class capacity MOLTRA, as a transformer for the power receiving equipment of a spot network system, to the upper floor of a large department is described. Figure 3 shows the external appearance of the MOLTRA and Table 4 lists its specifications.

In this example, the onsite restrictions were severe with an allowable tower crane weight limit of 16 t, a height limit of 2,750 m along the transport route, and a 2-day transportation time limit. In order to comply with these restrictions, first, we had to design a MOLTRA structure that could be disassembled. To shorten the transportation time and improve the reassembly efficiency onsite, packaging for the disassembled parts was designed so as to minimize the amount of packaging and minimize the number of packages to

Table 3 Main specifications of MOLTRA for energy storage systems

Applicable standards	JEC-2440-2005, JEC-2200-1995	
Capacity (kVA)	1,200/2×600	
	Primary	Secondary, Tertiary
Rated voltage (V)	6,600	2×280
Frequency (Hz)	50	
Insulation class	H	
Max. ambient temperature (˚C)	50	
Cooling method	Self-cooling	
Connection	Dd0d0 (Δ/open Δ/open Δ)	
Dimensions (mm)	2,095 (W)×1,888 (H)×985 (D)	
Weight (kg)	4,900	

Fig.3 Appearance of Japan's largest class capacity MOLTRA

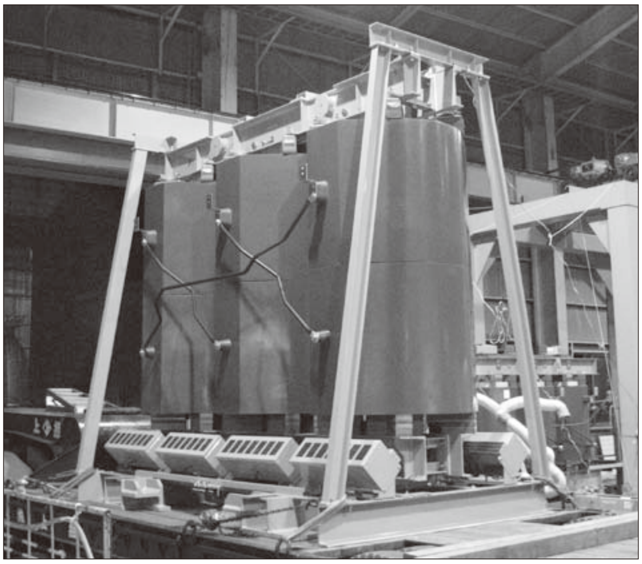


Table 4 Main specifications of Japan's largest-class capacity MOLTRA

Applicable standard	JEC-2200-1995	
Rated capacity (kVA)	13,000	
	Primary	Secondary
Rated voltage (V)	22,000	6,600
Rated current (A)	341	1,137
Test voltage value (kV)	LI95/AC50	LI60/AC22
Tap voltage (V)	F23000-R22000-F21000-F20000	6,600
Frequency (Hz)	60	
Insulation class	H (Avg. temperature rise of windings: 120 K)	
Max. ambient temperature (˚C)	40	
Cooling method	Self-cooling (13,000 kVA) Air-cooling (16,900 kVA: 8 hours, 3 times per year)	
Connection	Dd0 (Δ/Δ)	
Dimensions (mm)	3,545 (W)×3,592 (H)×2,300 (D)	
Weight (kg)	24,700	
Cooling fans	250 W×8 units	
Earthquake-resistant horizontal seismic coefficient	1.5	

Fig.4 Sketch of transportation of core

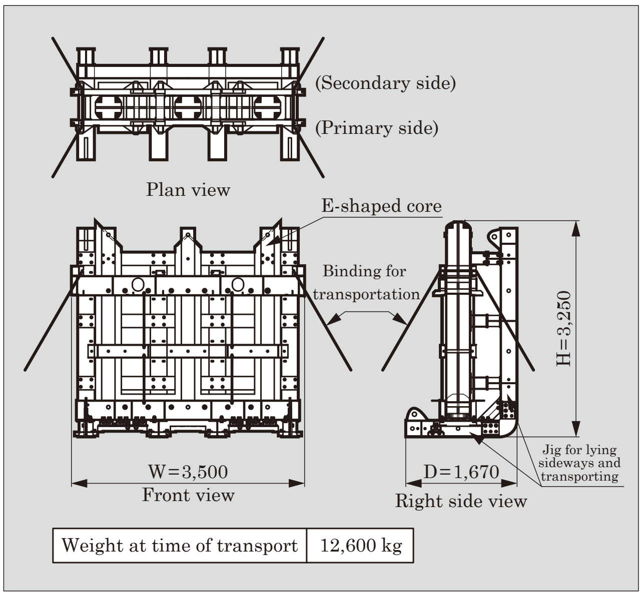


Fig.5 Schematic drawing of core being laid on its side

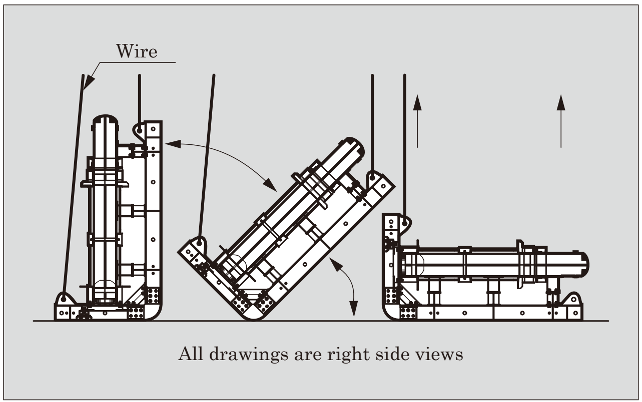


Fig.6 MOLTRA being assembled onsite

be transported. The core, which is the largest component, cannot be disassembled to reduce its height, and therefore we built an L-shaped jig as shown in Figs. 4 and 5 that enables the core to be laid on its side in order to comply with the height restrictions.

After the core was installed onsite, the MOLTRA was reassembled using a chain block as shown in Fig. 6 to hoist the coils and other components. Also, after the reassembly process was completed, the performance was verified with dielectric strength tests, phase displacement tests, transformer voltage ratio measurements and the like to confirm that there was no deviation from the factory test results.

4. Postscript

New technologies for expanding the MOLTRA application range have been presented.

Notwithstanding the trend toward more compact size and lower loss, there is increasing need for the ability to support higher voltages and higher capacities with a MOLTRA. Fuji Electric intends to continue to endeavor to expand the range of applications that can fully utilize the excellent eco-friendliness and disaster-prevention merits of these products, to intensify our efforts for improving insulation technology that will enhance the responsiveness of special products, and to continue to develop technology to realize superior MOLTRAs.

e-Front runners