RTRI Develops magnetic-fluid vacuum seal for high-speed rotating shaft used for superconducting flywheels

- Possibility of large-capacity power storage systems with superconducting flywheels -

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RTRI succeeded in developing a vacuum seal for a high-speed rotating shaft which has the world's highest allowable rotating speed, in cooperation with Eagle Industry Co., Ltd. and Matsui Kozai group companies. It is expected that this vacuum seal can increase the capacity of the superconducting-flywheel power storage systems.

outer part inner part
Vacuum seal for high-speed rotating shaft

Flywheel power storage systems are capable of storing electricity in the form of kinetic energy by rotating a flywheel, and converting the rotating power to electricity, if necessary. Since this rechargeable battery does not deteriorate over time, it can be used for many purposes. For example, being combined with rather unstable power-generation systems such as photovoltaic or wind-power generation, it can help stabilize power supplies. It is also possible to apply this system to railways in order to prevent regenerative cancellation. RTRI is currently developing superconducting-flywheel power storage systems. In these systems, the rotating bulk is floated by superconducting magnetic bearing without contacting anything. Thus the power loss is only limited even if a large flywheel is used, and therefore, they are very practical systems because stable power generation is possible over a longer period.

In flywheel power storage systems, it is necessary to house a flywheel in a vacuum vessel in order to prevent energy loss by air resistance. Meanwhile, it is better for a generator motor which converts electric energy to kinetic energy to be placed outside of the vacuum vessel, that is, in the open air in terms of maintenance and cooling efficiency. Thus, vacuum seals for high-speed rotating shafts are necessary in order to mechanically connect the generator motor and the flywheel, and to perfectly seal the vacuum vessel while the shaft is rotating with a high speed.

RTRI has developed a vacuum seal for high-speed rotating shafts which allows world's highest rotating speed, 36.6 m/sec, and at the same time, established a method to

manufacture dissimilar-metal-composite shafts with good thermal conductivity which are required to stabilize the temperature during high-speed rotation. When applied to 100 mm-diameter rotating shaft, this technique enables a large-capacity flywheel power storage systems which allow maximum rotation speed of 7000 rotation /minute. Furthermore, this technique can be applied to a broad range of products such as superconducting motors and generators, and contribute to commercial manufacturing of these products.

In this project, RTRI developed the basic design of flywheel-power-storage systems, and based upon the design, Eagle Industry Co., Ltd. designed and manufactured the vacuum seal mechanism using magnetic fluid. RTRI designed the structure of composite shafts as well, the core part of this high-performance vacuum seals, and Matsui Kozai Group manufactured them.

The details of this technical development will be presented at the 90th cryogenic and superconducting engineering technical meeting scheduled on November 5th, 2014. In fiscal 2015, at Komekurayama in Yamanashi Prefecture, RTRI plans to start tests to confirm grid-connection between a megawatt-class solar power system and the large-capacity superconducting-flywheel power storage system using this vacuum seal technology. RTRI has promoted this development in cooperation with Furukawa Electric Co., Ltd., Kubotek Corporation, Mirapro Co., Ltd., and the Public Enterprise Bureau of Yamanashi Prefecture, as part of the project “the Technical Development for Safe, Low-Cost, Large-Capacity Battery System” by the New Energy and Industrial Technology Development Organization.

Glossary

1. **Superconducting flywheel power storage system**

A flywheel is a device that converts electrical energy into kinetic energy and store that energy on a high-speed rotating body. It can input and output the electric power at high-speed and also repetitively. In conventional systems, a large amount of mechanical bearing loss was produced and it was difficult to operate the system for a long time due to bearing wear. However, by using superconducting magnetic bearing combining superconducting magnet and bulk which RTRI has developed, the rotating body can be lifted without any contact and realize a maintenance-free power storage system with minimum energy loss. Furthermore, since the superconducting magnetic bearing is capable of lifting and supporting a heavy flywheel without contact, a larger-capacity power storage system can be realized compared to systems with other types of bearing.

Since a generator-motor produce heat while working, it is difficult to efficiently cool the superconducting bearing and to keep it maintenance-free. In RTRI's superconducting flywheel power storage system, we have made it easier to cool and maintain by placing the generator-motor outside the vacuum vessel. At the same time, it is also easy to increase the capacity of the generator-motor.

2. **Yamanashi Prefecture Komekurayama mega solar power plant**

Since Yamanashi Prefecture gets a lot of sunshine, the prefectural government constructed the "Komekurayama Solar Power Station" in Kofu City jointly with Tokyo Electric Power Company, as the core part of its action plan to prevent global warming. With around 80,000 solar panels installed on a hill in the area covering 44.7ha, it generates 1,200 kWh per year, which is equivalent to the power used by 3,400 households. The government constructed a 1,000kW-class photovoltaic power plant as well in order to conduct grid connection tests with super conducting flywheel and started its operation in August 2014. Currently, basic data for confirmation tests are being obtained here. The flywheel for the confirmation tests is made for short-period power storage aiming at stabilizing power grid and designed to have 100 kWh capacity.