초전도에너지 전송시스템에 따른 충방전 특성

(Charge-discharge properties by the superconducting energy transfer system)

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Abstract

It describes a design analysis and test results of an energy transfer system which consists of two 0.5 MJ superconducting coil and three Inverter-Converter Bridges(hereinafter called ICB). A point of design is to satisfy the required stored energy capacity rather than magnetic field density with minimum energy transfer time using the calculation results of state-space averaging methods instead of Fourier series. It is proven that the considered methods are effectively through system experiments.

1. 서 론

The energy transfer proreties between two similar 0.5MJ superconducting magnet coils which are coupled with DC-AC-DC power converter for energy transfer and an AC-DC power converter for initial charger was verified in its storage system. Once the superconducting magnet coils are charged to a preset level, charging and discharging between the source coil and the load coil is repeated until both coils reach a presetted minimum energy level. The minimum cycle of energy transfer is designed to be 2.0 sec..

2. 본 론

2.1. 주요 시스템

The main circuit diagram of the whole system is shown in Fig. 5, in which control system means built-in control system interfaces.
The built-in control system has three setters : initial charging current level I_0 setter for source coil, phase difference ϕ and operating frequency setters for three phase ICB.

Once the source coil is charged at a presetted values by the initial charger, energy transfer direction is changed by the control system when the current of discharging coil decreases to about 50A. And when the maximum current values fall below 100A, the energy transfer operation is terminated and the remaining energy in the quench protecting resistor circuit is discharged.

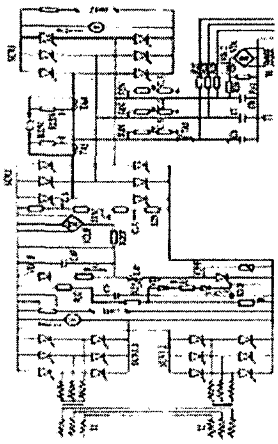

Fig. 1 Main circuit diagram of system

2.2. 실험 결과

2.2.1. Superconducting coil characteristics

1) Inductance L
- *Calculated inductance : 0,41[H]*
- Measured inductance : 0.42[H]

2) Central magnetic flux density B_0
- Calculated : 2.94[T], at 1550[A]
- Measured : 2.99[T], at 1550([A]

B. Energy transfer characteristics

Characteristics between two coils are measured and plotted in Fig. 8 when operating frequency f and phase difference are varied with a fixed initial current 1300A of source coil.

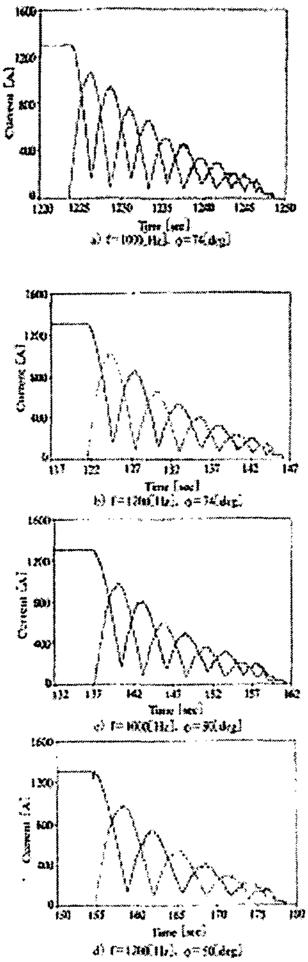

Fig. 2 Energy transfer operation

In Fig. 2 .a slightly different values of energy transfer time t_d can be seen. T_d is the time interval between the time when the current reaches peak and the current decreases to the minimum.

Fig. 3 shows the measured and calculated energy transfer time. the energy transfer time is related not to the initial current value but to f and Φ. The energy transfer time t_d is calculated by the results derived using state-space averaging methods as follows :

$$t_d = \frac{\pi}{2}\frac{\sqrt{L_s L_L}}{K} \qquad (1)$$

where

$$K = f(\phi)$$

$$K = \begin{cases} \frac{3}{2\pi wc}\left(-\phi^2 + \frac{4\pi}{3}\phi\right), & \text{for } 0 \le \phi \le \frac{\pi}{3} \\ \frac{3}{\pi wc}\left(\phi^2 + \pi\phi - \frac{\pi^2}{18}\right), & \text{for } \frac{\pi}{3} \le \phi \le \frac{2}{3}\pi \\ \frac{3}{2\pi wc}\left(-\phi^2 + \frac{2\pi}{3}\phi + \frac{\pi^2}{3}\right), & \text{for } \frac{2}{3}\pi \le \phi \le \pi \end{cases}$$

$$I = I_0 \cos\left(\frac{K}{\sqrt{L_s L_L}}t\right), \qquad \frac{K}{\sqrt{L_s L_L}}t_d = \frac{\pi}{2}$$

I_0 : initial current of discharge coil

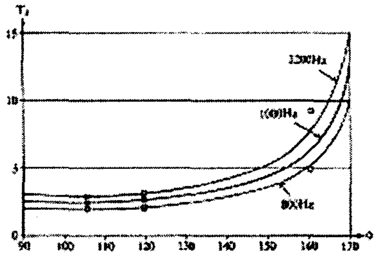

Fig. 3 Energy transfer time by f and Φ
(□ : measured value)

Fig. 2 shows with a 1300A of initial charging current, that the energy transfer time t_d affects the number of repeating discharge- charge but does not affect duration time until initially stored energy decreases to the presetted minimum level due to system losses and discharge-charge steps.

These loss characteristics are shown in Fig. 8. The losses seem to occur mainly due to copper loss of connection cables and forward voltage drop loss of thyristors.

Fig. 4 represents the accumulated values by lapse time. To calculate the loss, we take the equivalent circuit with regard to Fig. 1.

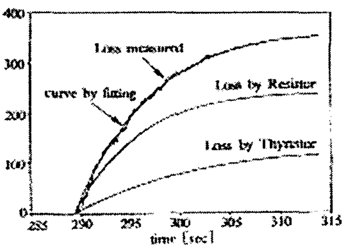

Fig. 4. Loss characteristics

3. 결 론

Design and analysis methods for superconducting energy transfer system to be effective through experiment are as follows.

· Superconducting coil design for minimum wire quantity satisfying the required stored energy capacity.

· ICB design satisfying the required energy transfer time.

· Loss analysis of ICB operation.

· Relationship of various factors affecting the energy transfer time.

참 고 문 헌

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