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Evaluation of eddy currents dependent on excitation pattern in design of pulse electromagnets.

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In order to design a pulsed electromagnet, it is necessary to consider eddy currents that depend on the pattern shape of the pulse excitation, and to design the structure and set the operating parameters considering the fluctuation of the magnetic field distribution and its effect on heat generation. Evaluation tests of a new bump magnet for the J-PARC RCS showed that the magnetic field distributions at the rising edge of the trapezoidal pattern and at the flat top are different from each other. This was also confirmed by the 3D dynamic magnetic field analysis of OPERA-3d. Since the skin-depth due to eddy currents depends on the time variation of the waveform, the effect is the same as changing the shape of the coil. From the relationship between the trapezoidal excitation pattern and the change in the magnetic field distribution confirmed in this study, it became possible to optimize the coil shape and a flat top time to match the pulse width of the injection beam and with less heat generation due to the excitation time. The measurement of the magnetic field distribution fluctuation was verified and evaluated using a flux meter, search coil, and Hall probe with different measurement principles. The heat generation of the electromagnets was also evaluated by trapezoidal patterns with different rise and flat top times. Furthermore, the effect of the residual magnetic field on the field distribution and the cancellation test were also evaluated. The results of the evaluation and verification necessary for the design of the electromagnets are presented here.

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