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Design study of a superconducting dipole magnet with active shielding for a heavy-ion rotating gantry

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A superconducting magnet for a rotating gantry has recently been developed to reduce the size and weight of the gantry which is the core equipment of the heavy ion radiotherapy system. The superconducting magnet consists of a saddle-shaped superconducting coil surrounded by an iron yoke. The weight of one superconducting magnet can reach several tons, with the iron yoke accounting for most of the magnet's weight. The rotating gantry must have precise rotation control under the condition that several superconducting magnets are mounted on its frame. In this study, we propose a superconducting gantry magnet with active shielding to reduce the magnet weight, thereby simplifying the control system and the frame structure of the rotating gantry. An active shielding coil is used instead of an iron yoke to shield the stray magnetic field, which leads to a reduction in the magnet weight. The previous study indicated that the use of an active shielding coil in a superconducting magnet realizes a significant reduction in magnet weight compared with the use of an iron yoke. In addition, the study demonstrated the electromagnetic (EM) and structural feasibility of the magnet with active shielding. In the previous study, however, the three-dimensional configuration of superconducting coils was not taken into account. In this study, we conducted a design study of the three-dimensional coil configuration for a superconducting magnet, based on the coil cross-section designed in the previous study. This presentation reports the details of the designed coil configuration and the magnetic field distribution generated by it. Additionally, the influence of coil alignment errors on EM forces and the influence of cooling-down on coil deformation are discussed.

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