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Approach to the Shape Design Optimization of Racetrack type High Temperature Superconducting Magnet Using Response Surface Methodology

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1. INTRODUCTION

The value of I_c (critical current) in High Temperature Superconductor (HTS) tape has a great influence on $B_\perp$ (vertical field), therefore, in shape design of racetrack type HTS magnet used as field coil for the High Temperature Superconducting Generator (HTSG), a design to reduce the $B_\perp$ should be considered in order to maintain the stability and substantial improvement on the performance [1]. Generally, design problem is a natural process to optimize a solution versus specified requirement. The problem can be complex, because of the number of design variables that can be used and because these design variables have frequently a lot of interactions between them. Response Surface Methodology (RSM) is well adapted to make analytical model for a complex problem considering a lot of interaction of these design variables, and it is very suitable for the case of designing racetrack type HTS magnet shape. Additionally, there is difference between numerical model and manufactured racetrack type HTS magnet dimensions because of manufacturing tolerance. Therefore, shape design of racetrack type HTS magnet should be considered with variation of design variables. RSM is powerful method in this case and it can obtain the statistical approximation to provide for description of the relationship between the inputs and outputs of a given problem. Using RSM for design constraints in design optimization provides the designer with an overall perspective of the system response about variation of design variables within design space, and offers a systematize approach to study the effect of design variables on system performance by variance analysis. But, conventional optimization technique is not provided of these. For these advantages, there is growing interest in using RSM on optimal design [2].

2. ANALYSIS AND EXPERIMENTAL

RSM provides an approximate relationship between a response and independent variables. Generally, response surface approximations are expressed in terms of polynomials in the design variables. The formulation of a response surface model is defined with a second-order approximation of the polynomials at this paper. The response is generally obtained from experiment or computer simulation, thus computer simulation is performed at this paper. Among some of Experiment Design methods, such as small composite designs (SCD), central composite designs (CCD), Box-Behnken designs (BBD), CCD is used at this paper to avoid full factorial experiment. In order to verify the validity of this study, racetrack type HTS magnet has been tested in Keri. racetrack type HTS magnet was supplied DC by superconductor magnet supplier, which has 7.5 (V), 350 (A) capacity and 0.01 (A/sec) ~ 10 (A/sec) excitation speed range. I-V test was conducted while supply current was increased at 0.5 (A/sec) rate at LN_2 temperature and no external field.

3. RESULTS AND DISCUSSION

In this paper, RSM is applied to obtain the optimal design variables for the determination of racetrack type HTS magnet shape. The racetrack type HTS magnet shape should be designed to minimize the $B_\perp$ (vertical field) caused by Racetrack type HTS Magnet. Initial Shape of the racetrack type HTS magnet is shown in figure 1., and the relationship between design variables and response, which is obtained by RSM, is shown in figure 2. Finally, the analysis result at the optimal point is verified by comparison with experimental result.

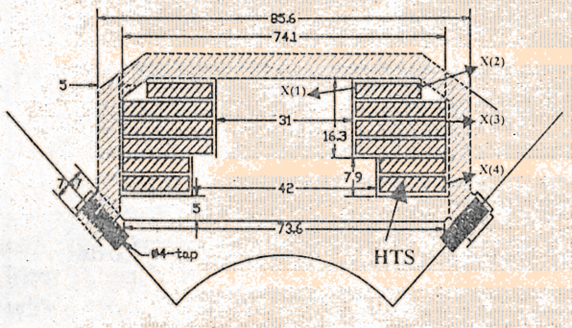

Figure 1. Initial Shape and design variables

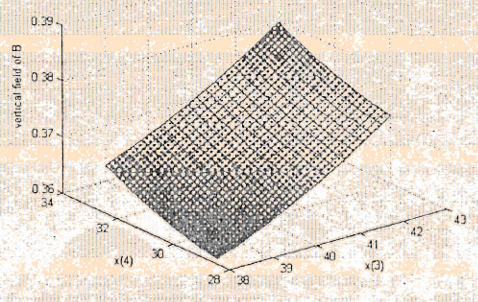

Figure 2. Response surface of $B_\perp$ (vertical field)

[REFERENCES]

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