Multi-objective Optimization Design of Repetitive Pulsed High Magnetic Field System

Introduction

- The development of frontier science technology makes new requirements to repetitive pulsed high magnetic field (RPHMF).
- However, the parameters of the magnet and power can’t match optimally in traditional design method, and could not meet the requirements of magnetic field, frequency and so on at the same time.
- This paper proposes an optimal design method of RPHMF system based on a novel multi-objective algorithm, and analyzes the relationship between magnetic field, temperature field, structure force field and design object.
- This design method helps to solve the mismatch between magnet and power parameters in traditional design method.

Multi-objective Algorithm of RPHMF

- RPHMF system have several design aims at the same time such as f, B, N.
- The design objects of the circuit and magnet aren’t independent.
- The designs are also limited by three physics fields as magnetic field, thermal field, structural mechanics together.
- There are complicated couplings in the circuit and magnet designs by the energy, temperature and stress.

Optimization Results

- As a design example, based on the requirements of RBWO, the multi-objective optimization model is built for its RPHMF system:
  \[
  \max \left\{ f_1(x), N_1(x) \right\}
  \]
  \[
  p_1(x) = 900 \ (h=60 \text{ mm})
  \]
  s.t.:
  \[
  \begin{cases}
  p_2(x) = 1 \text{ ms} \\
  T(x) = 400 \text{ K} \\
  \sigma(x) = 200 \text{ MPa}
  \end{cases}
  \]
  \[
  X = (c_1, c_2, U, C, t)
  \]
  Then solve the multi-objective model by the RK-GA, optimization results are represented in the Pareto frontier figure.
  - Select the optimal individual of the Pareto set by inflection-point method.
  - Design method proposed has 30% in frequency or 40% in the pulse times rise compared to the traditional.

Analysis of RPHMF System

- Design the cycle RK method to solve the problem of topology time-varying.
- Design genetic algorithm to quickly find global optimal solution.
- Avoid the disadvantage of the traditional common fundamental approximation calculation method.

Experiment and Conclusion

- The achieved 3T/20Hz RPHMF, verified the feasibility of the multi-objective optimization design method.
- This optimization algorithm can be applied to various power supplies, magnets and work condition. Therefore it has important application value for the design and optimization of RPHMF.

Fig. 1. Comparison of traditional methods and proposed methods
Fig. 2. Abstract of the multi-objective optimal design
Fig. 3. Relationship of each element in RPHMF
Fig. 4. Algorithm flowchart of RK-GA
Fig. 5. Solution result of Pareto frontier
Fig. 6. Prototype of RPHMF system
Fig. 7. waveform Results (a) Discharge circuit waveform (b) Magnetic field waveform