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THE COMBINATION OF THREE-DIMENSION INVERSE DESIGN AND OPTIMIZATION METHODS FOR HELIUM CIRCULATOR'S IMPELLER OPTIMIZATION IN HTR

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Abstract: The working environment for Helium Circulator in HTR (high temperature gas-cooled reactor) is especial, high temperature about 523K and high pressure about 7MPa. So the efficiency of the Helium Circulator's impeller is extremely important. In the optimization process, the key is how to choose the optimization parameters. At present, the blade loading parameters and meridional geometry parameters are obtained easily through the 3D inverse design methods and the widely used Bessel curves. The optimization design strategy was built by combining the Three-dimension inverse design method, CFD analyses, Design of Experiment (DOE), Response Surface Methodology (RSM), Multi-Island Genetic Algorithm (MIGA) on the basis of the isight platform. The optimization objective is the impeller efficiency at the design condition. The input parameters are related to the blade loading, blade lean angle at high pressure side and the meridional channel shape. For simplification, the optimization was divided in two steps. In the first step, Blade loading parameters and blade lean angle at high pressure side were selected as the input parameters to find the main influencing factors. Then, the main influencing factors with the meridional channel shape parameters were set as the independent variables. And the optimized impeller is obtained through the RSM model and MIGA optimization method. The results show that the SLOPEH, NCH and THETA1 are the main blade loading influencing factors. And YH and THETA2 are the main meridional geometry influencing factors. The best blade loading distribution is the positive SLOPEH of high value combined with the negative SLOPES. The positive NCH on the hub and shroud will improve the blade loading at the blade leading edge. Small blade lean angle at high pressure side will promote the work at the trailing edge of the impeller. The curve with the relative reduced curvature on the shroud is beneficial to the performance of the impeller. The efficiency of the optimized impeller is 0.93% higher than the original impeller and blade loading distribution on the blades is more uniform. So, the coupled methods turns to be an efficient way for the complicated rotating machinery optimization.