Design and Development of a System for Optimizing Boundary Conditions and Thermophysical Parameters in Casting Simulation

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Abstract: Casting process numerical simulation can predict casting defects and performance,improving the efficiency of casting product process design and optimization. However, the accuracy of casting process numerical simulation results is affected by boundary condition parameters and material thermophysical parameters. Unreliable boundary condition parameters and material thermophysical parameters can lead to deviations between the calculated results of casting process numerical simulation and actual situations. To obtain reliable boundary condition parameters and material thermophysical parameters, this paper aims to design and develop a casting simulation boundary condition/ thermophysical parameter optimization system to improve the accuracy of casting process numerical simulation. Firstly, the overall requirements analysis and overall structural design of the parameter optimization system are carried out. Secondly, according to the requirements analysis, the design and construction of the system hardware are carried out, including the design of a standardized temperature acquisition model and the construction of temperature acquisition equipment. Then, according to the requirements analysis, the development of system software is carried out, including temperature acquisition control software and a parameter optimization calculation platform. Finally, experiments verify that the optimized boundary conditions and thermophysical parameters obtained by the system significantly improve the agreement between the simulation results and actual castings, proving the effectiveness of the system.

Keywords: numerical simulation;boundary condition; thermophysical prameter;designs and development of system

1 Introduction

The numerical simulation technology of casting process can achieve the prediction of casting defects and performance in computers, providing strong basis for casting structure design and casting process design, greatly improving the quality of casting products and the efficiency of casting process optimization. However, the boundary condition parameters and material thermal properties parameters used in casting numerical simulation calculations often differ significantly from the actual values, greatly reducing the reliability of casting numerical simulation results. In practical applications, experimental measurement and manual reverse calculation methods are generally used to obtain reliable values of corresponding parameters, but there are drawbacks such as limited applicability and high empirical dependence. Therefore, this article designs and develops a casting simulation boundary condition/thermal property parameter optimization system.

2 Experimental Procedure

The casting simulation boundary condition/thermal property parameter optimization system built in this article aims to achieve fast and simple optimization of relevant target parameters by measuring the temperature curve of the standardized temperature acquisition model, combined with the parameter optimization algorithm based on multi strategy improved particle swarm optimization [1]. The main requirements of the system are as follows:①Design a standardized temperature measurement model to facilitate the conduct of temperature measurement experiments;②Build temperature data collection equipment to achieve stable and accurate collection of temperature data for different types of materials; ③ Implement temperature data analysis function, which can process the collected temperature data and simulated temperature data, analyze and extract valuable information, such as the characteristics of casting cooling curves in each temperature curve;④Implement task setting and optimization calculation functions, capable of setting parameters for casting simulation boundary conditions, thermal properties, optimization algorithm control parameters, and other parameters.

The developed casting simulation boundary condition/ thermal property parameter optimization system includes four parts: ① Standardized temperature acquisition model [2], which is based on the thermal analysis sample cup as a reference, as shown in Figure 1(a). Its upper and lower surfaces are both square, with a height of 60mm. Two temperature acquisition points are set, one at the geometric center of the lower bottom surface of the model and the other at the sand mold 10mm away from the edge of the bottom surface of the model The integrated temperature acquisition device, as shown in Figure 1(b), adopts the cDAQ9174 data acquisition system, a temperature data

acquisition module of model 9211, an industrial control microcomputer with anti-interference and vibration resistance, an AC-DC power module with a rated power of 150W, and a box made of thickened aluminum alloy sheet Develop temperature acquisition and control software based on LabVIEW platform, as shown in Figure 1(c). ④An intelligent parameter optimization calculation platform has been developed based on the Qt framework, as shown in Figure 1(d). It has the functions of setting target curves, setting calculation tasks, parameter optimization calculation, and displaying calculation results.

Figure 1Casting simulation boundary condition/thermophysical parameters optimization system

Conduct parameter optimization testing using a standard temperature acquisition model, with the alloy material grade of ZG24Mn6. Based on the calculation results of Huazhu CAE database and JMatPro software, the initial values of simulation boundary conditions/thermal properties parameters used in numerical simulation were determined. The initial parameters were simulated and calculated. The comparison between the simulated temperature curve and the measured temperature curve is shown in Figure 2(a). Using the optimized parameters for further simulation calculations, the results are shown in Figure 2(b).

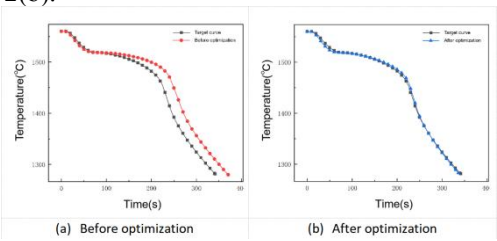

Figure 2 Comparison between simulated temperature curve and measured temperature curve

To verify the application effect of optimized parameters in numerical simulation, a test piece was designed for pouring test, and the pouring results of the test piece are shown in Figure 3.

3 Result and Discussion

Using the parameters before and after optimization, numerical simulation calculations were conducted on the test piece. Comparing the two simulation results with the actual pouring results, it can be concluded that the calculation results using the parameters before optimization were poor, only simulating the defects in the left cylindrical structure of the test piece, and there were significant differences in the overall shape, type, and actual situation of the defects, as shown in Figure 4(a); The calculation results of optimized parameters were used to simulate the defects at the root of the right cylindrical structure, and the shape, type, and actual situation of the defects in the left cylindrical structure are highly similar, as shown in Figure 4(b).

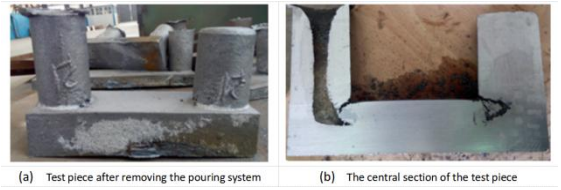

Figure 3Test piece and its defects

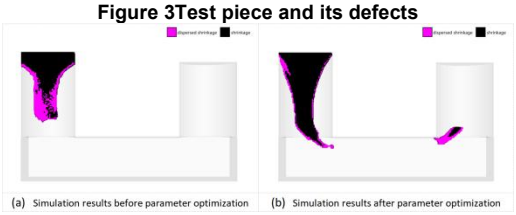

Figure 4Simulation results of test pieces before and after parameter optimization

4 Conclusions

(1) Developed a casting simulation boundary condition/thermal property parameter optimization system that combines software and hardware. The system includes a standardized temperature acquisition model, temperature acquisition equipment, temperature acquisition control software, and parameter optimization calculation platform.

(2) The experimental results show that this system can achieve the optimization calculation of boundary condition parameters and thermal properties parameters in casting simulation, greatly improving the accuracy of casting numerical simulation.

Acknowledgment

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