Mesh Segmentation Method for Casting Simulation Based on Boundary Mesh Projection

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Abstrac: Mesh segmentation is an important part of the casting numerical simulation process, many of the current casting simulation software in the processing of complex castings with sloped and curved surfaces are still unable to effectively avoid the jagged error at the boundary, resulting in the loss of the casting slope information, thus affecting the accuracy of the subsequent computational simulation. For this reason, this paper proposes a mesh segmentation method for casting simulation based on boundary mesh projection. Firstly, the STL file of the 3D model of the casting is read and the defects are processed, then the casting is structured as a whole, the boundary grid is obtained by differentiating the inner and outer grids of the casting, and finally the boundary grid is projected. Application examples show that this method can get the mesh file that fits the shape of the casting 3D model, which is of great significance for the improvement of casting CAE accuracy.

Keywords:numerical simulation of casting; structured mesh sectioning; boundary meshes; jagged errors; projection processing.

1 Introduction

Casting moulding is a process in which the metal is melted and poured into a casting pattern, cooled, solidified and cleaned to obtain a casting of a predetermined shape, size and properties[1,2]. Traditionally, this complex process relies on a large number of experiments, which is both time-consuming and costly[3,4]. With the development of computer technology, numerical simulation technology in the casting of the increasingly wide range of applications[5]. The numerical simulation system includes three modules: pre-processing, intermediate calculation and post-processing. Pre-processing involves three-dimensional solid modelling and mesh splitting, mesh splitting quality directly affects the calculation accuracy and speed.

Pang et al.[6] and Hou et al.[7] used adaptive Cartesian grid and immersed boundary method to achieve non-uniform mesh dissections, respectively, but these two methods suffer from high computational complexity and numerical errors when dealing with complex geometries.Owen et al.[8] proposed a parallel raster method-Sculpt algorithm, but with a poor overall structure.

Based on this, this paper proposes a mesh sectioning method for casting simulation based on boundary mesh projection based on the pre-processing system of the home-made EasyCast software independently developed by the group, which is based on reading the STL file and performing structured mesh sectioning, dividing the casting interior and boundaries, obtaining the mesh file that fits the shape of the three-dimensional model, and improving the simulation accuracy of the complex castings.

2 Boundary mesh projection processing algorithm

The mesh dissecting method proposed in this paper for casting simulation includes six main steps: firstly, read the STL file and and use the ray method to deal with the defects, then use the slicing method to carry out structured mesh dissections, then divide the interior and boundary of the casting model to obtain the boundary mesh, and project the boundary mesh to match the shape of the casting, and finally, save and output the mesh file for subsequent simulation use.

3 Examples of boundary mesh projection algorithms and analysis and discussion

In order to verify the effectiveness of the proposed mesh sectioning method for casting simulation based on boundary mesh projection, this paper carries out boundary mesh projection processing for a common partition piece (Figure 1), the casting has a diameter of 32 cm, a height of 8 cm, and a sectioning size of 0.5 × 0.5 × 0.5 cm. Processing is carried out in sequence according to the method proposed in this paper, and Figure 2 is the structured mesh sectioning of the casting as a whole, and Figure3 shows the sectioning result map after being processed by the boundary mesh projection algorithm. Comparison of the two results shows that the method has a great advantage in dealing with the castings with rounded and bevelled surfaces, which effectively avoids the "jagged error" and improves the accuracy of the subsequent casting simulation.

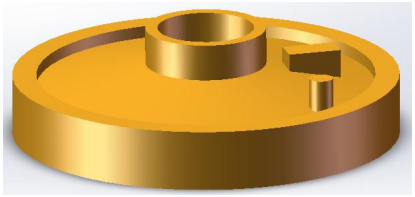

Figure 1CAD drawing of partition parts

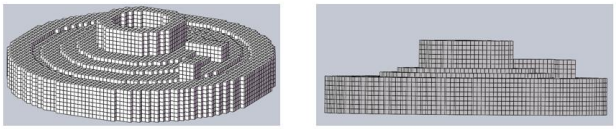

Figure 2 Schematic diagram of the results of structured grid division

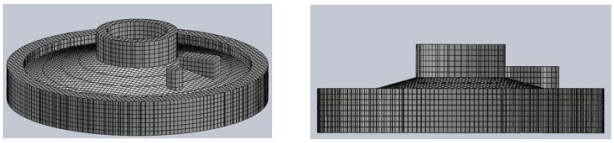

Figure 3 Schematic diagram of partition results afterboundary grid projection processing

4 Conclusion

This paper proposes a boundary mesh projection-based method for casting simulation and simulation grid partitioning to address the issue of jagged edge errors when dealing with complex castings with inclined and curved surfaces. The method involves reading the STL file of the casting's 3D model and performing defect processing, conducting structured grid partitioning, and dividing the internal and boundary of the casting to obtain boundary meshes. Finally, it performs projection processing on the surface boundary mesh. The generated hexahedral mesh maximally preserves the structural information of the casting, effectively avoids the loss of casting slope information, enhances the simulation accuracy of casting CAE, and is of great significance for optimizing casting processes.

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