Defect Control of Ceramic Core via Stereolithography Additive Manufacturing

Xiantian Meng*, Qiaolei Li, Chaowei Zhang, Jingjing Liang, Yizhou Zhou, Xiaofeng Sun, Jingguo Li
Institute of Metal Research, Chinese Academy of Sciences, 72 Wenhua Road, Shenyang, Liaoning, 110016, China
* E-mail: xtmeng@imr.ac.cn, jgli@imr.ac.cn

Abstract: Stereolithography additive manufacturing technology is used to prepare complex double-walled ceramic core. In order to study and control the defects of complex double-walled ceramic core, the slurry flow in printing process is simulated. The defects of double-wall core of complex structure are observed, the causes of defects are explained, and the corresponding solutions are put forward. The effects of placement position and different parameters on complex double-walled ceramic core are studied. The results show that the placement position has a significant effect on the yield of complex ceramic core. The optimization of process parameters such as slurry viscosity, slurry spreading speed, laser moving speed and irradiation time can significantly reduce the defects of core green body. Based on the systematic observation of complex core structure, the defect prediction, evaluation and process optimization of ceramic core green bodies are proposed.

Keywords: additive manufacturing, ceramic core, defect, simulated, control method

1 Introduction

Hollow turbine blades are crucial components of aeroengines[1-3]. In order to improve the thrust-weight ratio of the engine, higher requirements are put forward for the turbine inlet temperature of the aero engine. In the investment casting process, the ceramic core is the key to forming complex cooling channels inside the blade. Traditional hot injection moulding process cannot meet the increasingly complex cooling channel requirements. The emergence of SLA technology makes it possible to prepare ceramic cores with complex structures[4-5]. In this paper, the defect factors and control methods of SLA technology for preparing complex double-wall ceramic cores are studied.

2 Experimental procedure

The experiment will use a silicon-based ceramic slurry consisting of a premix consisting of an active monomer (HDDA+PPTTA), a photoinitiator and a dispersant, and a ceramic fraction. High purity fused quartz powder and zirconia are used as the powder composition for preparing complex ceramic core. The powder is screened by 1000 mesh. The samples are heated to 600℃ at 1℃/min and degreased by holding for 120min. Then the temperature is raised to 1250℃ at 1℃/min, and the heat is kept for 600min for sintering. The complex structure ceramic core is prepared by CeraBuilder100Pro equipment. Fluid simulation analysis is carried out by simulation software. The microstructure of the sample is observed with Zeiss AXIOVERT200MAT optical microscope.

3 Result and discussion

1. Influence of slurry viscosity on defects and solution

Slurry viscosity is one of the key factors to determine the success of core printing. In the SLA equipment printing process, the viscosity is too low will make the slurry backflow, cannot control the thickness of the material, resulting in each layer of printing thickness thicker, accumulated will make the scraper scrape down the part [6-8]. Figure 1 shows this. The appropriate viscosity range can avoid defects and make the equipment operate efficiently.

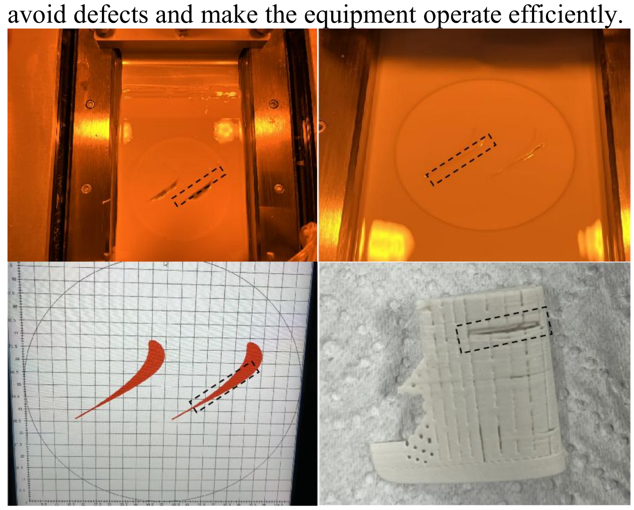

Fig. 1 Ceramic core defects.

2. Influence of model placement on defects and solutions

The mode of model placement is also one of the key factors affecting the success of core printing, and some special structures in complex structural core have an impact on the laying process. The influence of model placement mode can be found in time through the fluid simulation of the laying process by simulation software[9]. The effect can be reduced or eliminated by modifying the display mode. Fig. 2 shows the influence of model placement on defects and solutions.

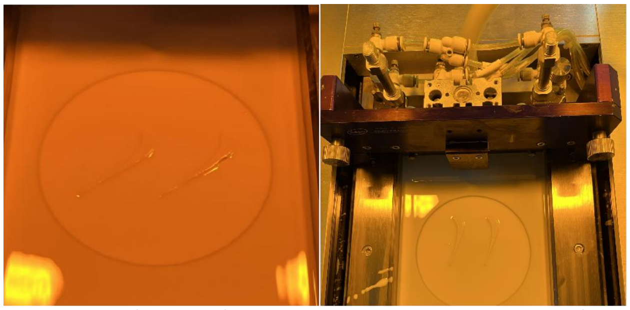
Fig. 2 The influence of placement mode on ceramic core defects.

3. Influence of process parameters on defects and solutions

Parameters such as the moving speed of the scraper and the size of the laser spot are also key factors affecting the success of core printing, and the combination of the appropriate slurry viscosity and the corresponding laying speed can avoid the production of defects in the printing process. The laser parameters not only determine the success of printing but also affect the accuracy, and the appropriate laser parameters will determine the size of the printing window period.

4 Conclusion

The defects in the preparation of double-walled ceramic cores with complex structure by SLA technology may be caused by slurry viscosity, model placement and process parameters. Through simulation and analysis, corresponding measures are adopted to reduce or eliminate the defects and improve the printing success rate.

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