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Studying the Ash Deposition Characteristics in an Aeroengine-based Optical Pyrometer Based on CFD modelling of Particle Impaction

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Extended Abstract

The optical pyrometer installed in aeroengines collects specific optical signals from turbine components and converts them into temperature signals using post-processing techniques, supporting the measurement of turbine inlet temperature. Ash particles in the aeroengine may deposit on the optical elements, causing measurement errors and potential damage to the elements[1]. Therefore, to improve the measurement accuracy and protect the optical pyrometer, it is necessary to refine the internal structure that inhibits the particle deposition on the optical elements, which makes the study of ash deposition characteristics essential. With the advantage of balance on accuracy and efficiency, computational fluid dynamic (CFD) model of particle impaction has been wildly used in simulating the impaction between particles and walls[2], [3], providing an effective method for studying the ash deposition characteristics in Aeroengine-based optical pyrometer.

A few research studies on the ash deposition characteristics in optical pyrometers have been reported in the past few decades. Kerr and Ivey[4] conducted a series of CFD simulations on the ash deposition characteristics in aeroengine-based optical pyrometers. Taccoli[5] analysed the particle deposition mechanism on the lens surface through finite element analysis method. However, without employing accurate model of particle impaction in the CFD simulations, both the researches simplified the impaction between particles and walls, which may cause inevitable deviation in the simulation and reduce the accuracy of ash deposition characteristics. Therefore, it is significant to develop a CFD model of particle impaction that reveals accurate ash deposition characteristics in optical pyrometer.

In this study, a CFD model of particle impaction was proposed to numerically investigate the ash deposition characteristics in the aeroengine-based optical pyrometer and provide a reference for refining the design of the pyrometer internal structure. The particle impaction model was developed based on the velocity, temperature, size and composition of particles, and validated against the experimental data[6]. Based on the particle impaction model, ash deposition characteristics in an aeroengine-based optical pyrometer were studied through CFD simulation, considering various sources of contamination existing in aeroengine[7]. Further, based on the ash deposition characteristics, a design scheme of improved optical pyrometer internal structure was proposed to prohibit the particle deposition on the optical elements. The ash deposition condition in the improved optical pyrometer internal structure was numerically studied and compared with which in the original structure. The results of simulation showed that, the particle impaction model shows good agreements with the experimental data. The particle deposition characteristics varied with different particle inertia. For particles with small inertia, such as soot particles, most of the deposited particles are carried to the optical elements by the backflow inside the pyrometer, while for particles with bigger inertia, such as sand particles, a considerable portion of them have rebounded at least once before deposited on the optical elements. After implementing the improved pyrometer structure, the number of particles deposited on the optical elements substantially decreased according to the numerical simulation, demonstrating the effectiveness of the improved pyrometer structure.

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