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Effect Of Airflow On The Trajectory Of Water Droplets in Rotating Disk Rig For Gas Turbine Application

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ABSTRACT

Water droplet erosion (WDE) has been a serious and persistent issue in the power generation industry. In gas turbines, WDE is caused by spraying ultra-fine droplets in order to cool the incoming air into the compressor. This leads to severe damage of the leading edge of the compressor blade. Also, different sections of the blades suffer varying degrees of damage. Here, the water droplets hit the rotating blades at different impact angles which could be attributable to the blade geometry and influence of airflow. Investigating this uneven distribution of water droplets and their trajectories due to airflow is paramount in understanding WDE.

This work presents a methodology for understanding the effect of airflows on the water droplets in a high speed rotating disk rig where typical condition in real-life gas turbine is simulated. Droplet size of 460 μm and impact speed of 150, 200, and 250 m/s are employed experimentally using ink coated samples. Ansys Fluent is used to verify and analyze the experimental results at 250 m/s. Here, the effect of airflows on the water droplets trajectory during WDE tests is investigated.

The simulation results, explanations revealed the presence of radial and axial airflows which could elucidate the experimental observations. The radial airflow presents in form of sample wakes. It moves the water streak radially outwards along the center of rotation and provides a radial velocity to the impacted droplets. Furthermore, the radial velocity inhibits the formation of droplet splashing on the side of velocity direction. These results are consistent with the experimental droplet splashing pattern. In terms of the axial airflow, it could be divided into two parts. The two parts of axial airflow are opposite in direction and therefore have different effects on the falling water droplets. On the top of the target material, the upward airflow decelerates the falling water droplets. This reduces the droplets speed leading to more droplets being impacted by the upper part of the sample. The downward airflow accelerates the falling droplets, which results in fewer droplets impacted by the lower half of the sample. Hence, the top of the sample erodes faster than the bottom and this is in accord with the experimental data in the literature. The axial airflow also influences the impact angle to some extent. It can be concluded from this work that the airflow could affect the trajectory of water droplets, thereby influencing the WDE performance.

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