Numerical investigation of droplet dispersion in cross-flow applications

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Long Abstract

Introduction

The demand on flexible power supply requires new applications and technologies within the power industry. Wet compression has been in place for several decades and provides the gas turbine power plant operator with an option to increase the power in a very flexible manner. This technology is so far used with time constraints and therefore only in periods of very high energy prices. It is accompanied with a reduction of the service interval and therefore an increase of service cost due to erosion effects on the compressor blading. This is caused by droplets of the water spray especially big droplets with a diameter in the range of 100 micrometre damage the blades. Next to the droplet diameter also the distributions of the droplets within the surrounding air play a big role. To overcome this issue the droplets size and distribution need to be optimized to the requirement of avoiding collisions between the droplets and the rotating equipment (blades). This reduces the damage and the erosion of the blades and eliminates the downside of increased cost for using such a flexible system.
As a contribution to the challenge a numerical approach has been taken to investigate the droplet dispersion in cross-flow. By being able to predict the droplet behaviour after spray generation a conclusion can be drawn which droplet size and distribution is required to reduce the probability of having collisions between the droplets and the blades. It must be clear that there will be always collisions and damages and therefore the focus is to minimize this effect. The remaining damage can be mitigated by coatings which can be replaced based on regular service intervals.

1. Methods

The software used for the numerical study was ANSYS and in a first step the numerical setup has been validated with experimental results. As test specimen a hollow cone spray nozzle is used. The nozzle is placed in an environmental condition without cross-flow and fed with demineralised water at high pressure. The spray droplet distribution, the diameter and the velocities of the droplets are measured with PDA and compared to the numerical results. Figure 1 shows a plane perpendicular to the main orientation of the spray with the velocity out of plane which is the dominating velocity of the spray cone. This plane is placed 40mm downstream of the spray cone (other planes have been considered as well). As it can be seen the nozzle forms a water ring representing the hollow cone structure of such spray applications. At a first glance both figures (left measured, right is CFD) fit well together with some asymmetrical effects on the measured part (left).

After validating the numerical results the setup has been used to investigate the effect of cross-flow on the spray formation and droplet behaviour. This will be presented in detail in the paper.

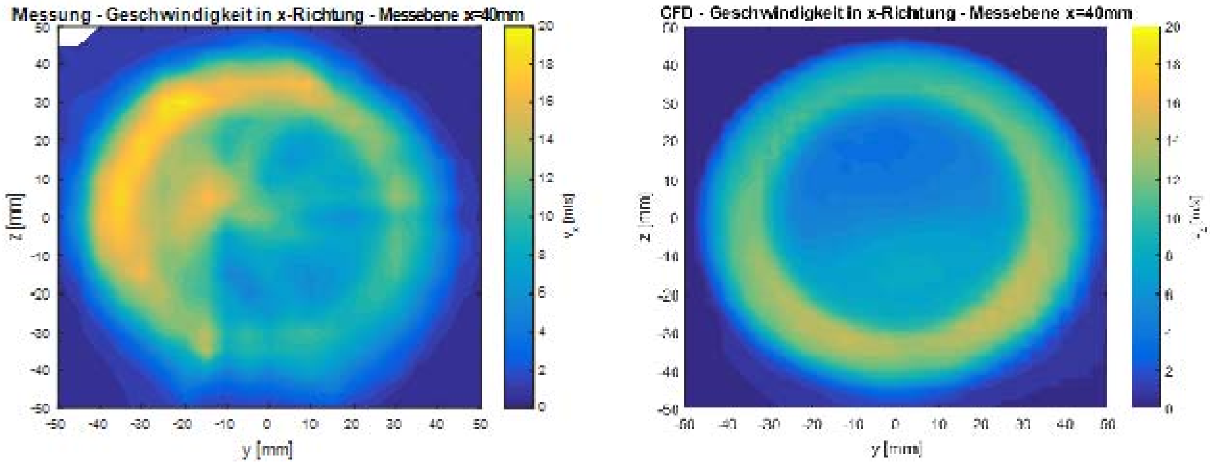

Figure 1 - Droplet velocity of spray; head-up view on hollow cone spray nozzle (left measurements; right CFD)

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