Experimental Investigation of Splashing Behaviour on Dry Solid Surfaces under High Parameters

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Abstract

Droplet impingement on dry solid surfaces occurs in case of wet compression and the expansion of wet-steam in turbomachinery at high splashing parameters, which have not been recorded yet. In order to investigate in this subject matter, a scaled experiment of a single droplet impact was conducted using similarity relations. During these experiments the primary and secondary droplet diameters and velocities are recorded by double frame Shadowgraphy. The first results gained from this setup are presented in this publication showing the strong relation of kinetic energy and surface structure on outcome of the splashing process.

Introduction

The droplet impingement on the blading in turbomachinery is related to wet compression operation of gas turbine compressors and condensation in steam turbines. In these high Mach number two-phase flow regimes, the span of characterizing non-dimensional parameters as yet measured is exceeded. Experimental data of the droplet flow field and the observed phenomena in a compressor cascade is available from [2]. Since the isolated impact of a single droplet at these conditions is not feasible, scaled experiments have been conducted using similarity relations. A review of the research carried out in this field is given in [1].

The scaled experiments are recorded by a double frame Shadowgraphy measurement system allowing an evaluation of doplet diameters and velocities. These investigations include different roughness structures as well as different primary droplet diameters and velocities. By means of the collected data, the secondary droplet sizes and velocities are estimated allowing conclusions regarding the turbomachinery conditions.

Materials and Methods

The experimental setup used for the investigations is depicted in fig. 1. The droplets are generated at the upper and of a downpipe. At the bottom of the downpipe a light barrier is mounted, triggering the image acquisition of the Shadowgraphy system. This optical measurement system consists of a double frame CCD camera illuminated by a laser flash light. By means of the Shadowgraphy system, the impingement of the droplets on the impact target is recorded. The diameters of the primary and secondary droplets are estimated by the size of the shadow objects, whereas the droplet velocity is determined by the displacement of the droplets in the two recorded frames. Due to the fact that an acquisition of more than two frames is not possible, statistics of the primary droplets and the secondary droplets were raised, to capture the velocities and diameters for both primary and secondary droplets.

The considered non-dimensional characteristics are the droplet Reynolds, Weber and Ohnesorge numbers as well as the threshold value K and the non-dimensional surface roughness γ. Except for the latter the similarity condition can be established by the droplet generation and acceleration. Therefore, the surface roughness γ is accounted for by the shape of the impact target, which consists of spheres. Similar to the conditions in turbomachinery the droplets are in the same order of magnitude as the surface roughness. The wettability of the surface is not considered as the disturbances due to the surface roughness are assumed to dominate the splashing process.

Results and Discussion

The main issue of the experiments is to evaluate statistics of the outcome of the splashing process by means of secondary droplet diameters and velocities. Since the camera is merely capable to record two images in the timeframe of interest, the statistics are raised before and after the impingement of the droplet on the target. The results at different K numbers show that a variation of the diameters is related to the number of secondary droplets generated in the splashing process, whereas the droplet velocity affects the secondary droplet velocity. The different shapes of the impact targets representing the scaled surface roughness have a strong effect on the

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splashing process due to the fact that the surface structure causes disturbances in the proceeding lamella (see fig. 2). As a consequence the secondary droplet diameters reach higher values for the case of a surface roughness in the order of magnitude of the droplet diameter than for the case of a large roughness relative to the droplet, which can also be interpreted as a curved surface.

Acknowledgement

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References

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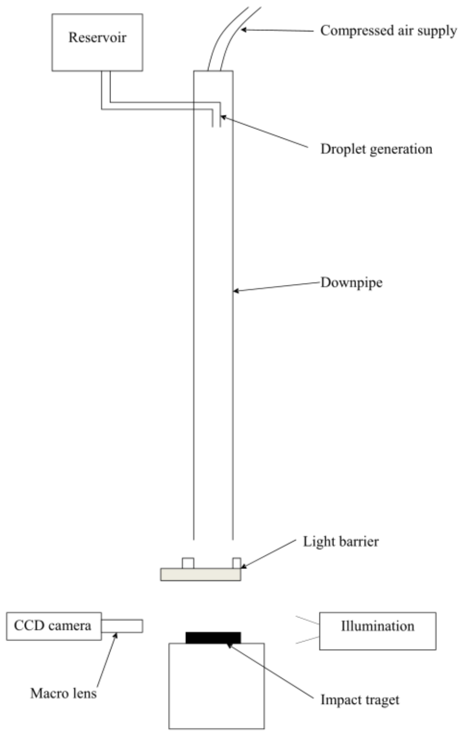

Figure 1. Experimental Setup

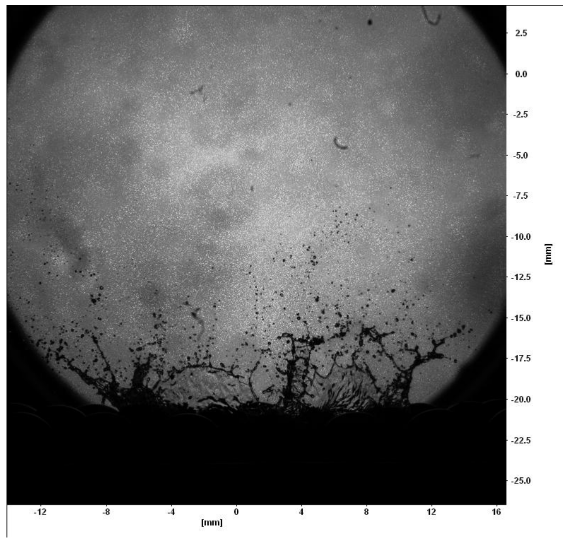

Figure 2. Droplet Splash on Impact Target