Investigations on superheated atomization

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Abstract

Superheated atomization utilizes thermal energy in addition to low pressure energy in order to enhance the disintegration of fluid media. The dispersity of the spray is among other things greatly influenced by evaporation effects. An optical access into the nozzle capillary where a partial evaporation takes place is given by glass nozzles. A shadowgraphy method is applied to analyze the phenomena taking place inside the nozzle. In addition the generated spray is analyzed regarding droplet velocity (Particle Image Velocimetry (PIV)), morphology (Shadowgraphy) and pulsation (acoustical measurements).

Introduction

The additional energy component applied in this process (thermal energy) enhances the dispersity of the product spray in comparison to a pure pressure atomization. [1, 2] Evaporation processes, nozzle geometry, entrainment of surrounding gas phase and process parameters are among the influencing parameters. The resulting spray offers a fine droplet size distribution and moderate droplet velocities without having to apply an additional gas phase. The scope of this work includes the combined investigation of flow phenomenon (mass flux measurements) with evaporation events (shadowgraphy) and the analysis of the resulting process spray (PIV).

Materials and Methods

The superheating of the applied process media is generated in a pressure vessel via heating jackets. The pressure is introduced by pressurized air. The investigated nozzle is located in the lower part of the vessel. The spraying process is initiated by opening a hand valve. The mass flux is continuously measured by a weighing method. The optical analysis of the spray is carried out using PIV and Shadowgraphy. The last named includes the application of a Long-Range-Microscope in order to allow the investigation of micro-processes. Acoustic measurements are done by applying a microphone.

Results and Discussion

Shadowgraphy pictures of the flow capillary of glass nozzles have been captured and analyzed regarding the location of the first evaporation effects. The higher the process temperature the sooner the evaporation starts since the driving force (vapor pressure) for vapor generation is enhanced. The increase of pressure yields a reversed trend. The more pressure energy is applied the later vapor bubbles are generated. The retardation time inside the nozzle capillary is reduced since most of the pressure energy is converted into kinetic energy resulting in a lower growth time for vapor bubbles. In addition, the possibility to reach the vapor pressure inside the nozzle capillary and by this allowing evaporation to happen is reduced. The generated spray morphology is mostly dependent on the applied temperature rather than the pressure. By enhancing the thermal energy input the spray angle is widening, the droplet velocity profile flattens and smaller droplets are produced. An important topic regarding spray events is pulsation. In this work inhomogeneities in the spray over time are investigated mainly by applying an acoustic system. An enhanced process temperature yields a higher pulsation frequency since more vapor bubbles are contained in the liquid which burst when they come into contact with the surrounding.

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References

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