# Analysis of the water atomization process using a supersonic nozzle

K. Czernek[1], M. Ochowiak[2], S. Cempura[2], A. Krupińska[2], S. Włodarczak[2]

[1]Faculty of Mechanical Engineering, Opole University of Technology, Opole, 45-758, Poland
[2]Faculty of Chemical Technology, Poznan University of Technology, Poznan, 60-965, Poland
Keywords: supersonic nozzle, atomization, spray
Presenting author email: k.czernek@po.edu.pl

This study aims to analyze the process of water atomization utilizing a supersonic nozzle. The investigation focuses on understanding the key factors and mechanisms involved in the efficient dispersion of water droplets through the implementation of supersonic technology. The experimental setup includes a supersonic nozzle designed for optimal atomization performance. The analysis encompasses several parameters, such as nozzle geometry, inlet pressure, and temperature, which influence the atomization process. High-speed imaging techniques and computational simulations are employed to observe and quantify the breakup of the water stream into fine droplets. The findings contribute to a comprehensive understanding of the intricacies of water atomization with supersonic nozzles, providing insights into potential applications in various fields, including combustion, cooling systems, and industrial processes. This research facilitates the optimization of supersonic atomization techniques for enhanced efficiency and performance in water spray applications. (Cempura, 2024).

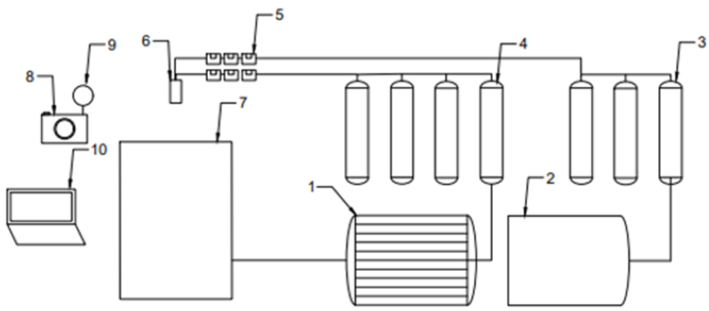



Figure 1. Experimantal set-up:
1 - pump, 2 - compressor, 3 - gas rotameters, 4 - liquid rotameters, 5 – thermometer/flow meter/pressure gauge, 6 - nozzle, 7 - tank, 8 - camera, 9 - flash lamp, 10 - computer.

In this study, research was conducted using a supersonic nozzle (Cempura, 2024) designed and manufactured at the Department of Chemical Engineering and Apparatus of Poznan University of Technology. The construction is similar to the nozzle presented by Zhang et al. (2020). The experiments were carried out on a station, the simplified schematic of which is presented in Figure 1. It consists of a CHI 2-30 pump delivered by Grundfos Pompy Sp. z o.o, a Metabo Mega 350-100D compressor, Krohne Messtechnik VA 40 rotameters, sensors connected to a programmable logic controller (PLC), a fermentation tank from Royal Catering, a stroboscopic apparatus and lamp from Drello, and a PC computer. Depending on the desired parameters of spray angles and droplet sizes, the Gas/Liquid Ratio (*GLR*) can be adjusted. The *GLR* is defined as the change in the ratio of gas mass flow rate to liquid mass flow rate:

$$GLR = \frac{\dot{m}_g}{\dot{m}_l}$$

In Figure 2, exemplary images of a dispersed water jet/spray are presented. With an increasing gas flow rate, the spray is characterized by progressively smaller droplets.

a) b) c)

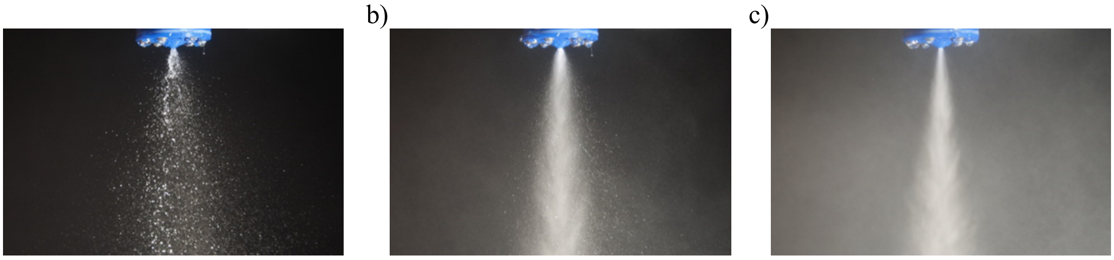
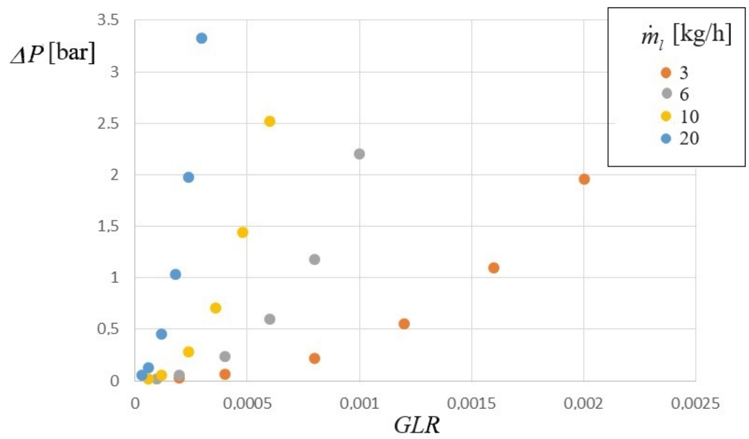


Figure 2. Visualization of the spray for liquid flow rate 20 l/h:
a) gas flow rate 1 $m^3$/h, a) gas flow rate 3 $m^3$/h, c) gas flow rate 5 $m^3$/h.

a)




b)

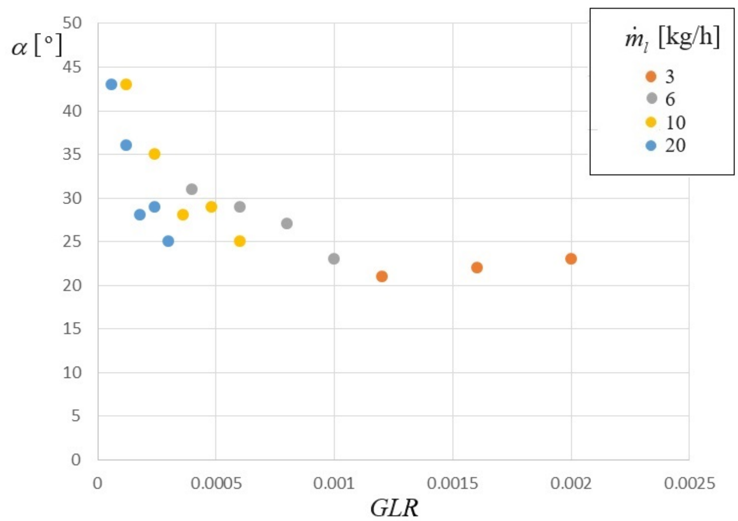



Figure 3. Exemplary plots:
a) dependence of pressure drop *vs*. *GLR* for different values of liquid flow rates,
b) dependence of spray angle *vs*. *GLR* for different values of liquid flow rates.

In Figure 3, exemplary results of the pressure drop and spray angle are presented. It has been shown that as the *GLR* increased, pressure drops also increased. The pressure drop is higher for higher values of the liquid mass/volume flow rates. The spray angle reached a certain maximum value (Figure 2a); up to this point, the formed spray was generated. Afterward, the spray angle decreased, forming a more compact spray (Figure 2c). With the increase in the *GLR*, the spray angle decreases; however, the liquid distribution within the jet becomes more uniform and compact. The largest observed spray angle values were approximately 45 degrees, while the smallest were around 20-25 degrees (at higher *GLR* values).

These conclusions pertain to the investigation of atomization using a supersonic nozzle. The observed trends in pressure drops and spray angle behavior with varying *GLR* values provide valuable insights into the dynamics of the atomization process, highlighting the delicate balance between spray uniformity and jet compactness. These findings contribute to a better understanding of the optimization parameters for efficient and controlled liquid atomization using supersonic nozzles.

References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Acknowledgments


This research was carried out under the SBAD program of the Ministry of Education and Science.