High flow-rate ultrasonic seeder for continuous operation

A. Lozano*, A. Rodríguez, J.A. García, E. Calvo, J. Barroso,
F. Barreras, A. González-Espinosa
LITEC, CSIC – Universidad de Zaragoza
María de Luna, 10, 50018 Zaragoza, Spain
alozano@litec.csic.es, juanto@unizar.es, calvober@unizar.es, jbarroso@unizar.es, felix@litec.csic.es, agonzalez@litec.csic.es

Abstract

Application of optical techniques to gaseous flows usually requires the previous seeding of the fluid with adequate tracers. To obtain satisfactory results, the tracers have to follow the flow as accurately as possible. Rapid response to fluctuations can be characterized by the Stokes number, St, and is strongly dependent on the marker diameter. Hence, small tracers are desirable, especially for highly varying flows. As compared to solid particles, small droplets are sometimes preferred because they can be generated *in-situ*, avoiding storage and agglomeration problems.

Popular devices for seeding purposes are fog generators, in which small droplets are produced by evaporation and re-condensation of specific fluids, usually glycerol, silicone oil or other mineral oils diluted in water. Liquid absorbed from a deposit is evaporated in a heat exchanger and expands in a nozzle, usually impelled by the pressure built up during vaporization. Without the aid of an auxiliary propellant gas, this operation principle prevents the device from operating in a continuous manner, because it requires a certain time to evaporate the liquid and allow its pressurization.

Here, an alternative is proposed in which droplets are generated by ultrasonic atomization. Ultrasonic atomization is common in household humidifiers, but the low flow rates of most commercial devices do not satisfy the needs imposed by many gaseous flows. This work describes the design and manufacture of a seeder based on ultrasonic atomization capable of operating in a continuous way with high atomization rates. It includes a dozen commercial piezoceramic disks that oscillate at 1.65 MHz, generating droplets with SMD in the range of 4-5 μm with rates over 0.6 g/s when operating with water. The twelve resonators are excited by individual oscillators connected to a common power supply that can give a maximum of 80 V, below the safety limit that could damage either the disks or the power transistor in each electronic oscillator circuit. The system has a float switch that disconnects the power if the fluid level decreases below a determined minimum so that the disks never operate without being immersed in liquid. This is very important, because without this cooling effect, they disks would get damaged instantly. Finally, the system has been designed to maintain a fixed liquid level over the disk surfaces, in a similar way as a bird drinking fountain.

To test its performance, the device has been used to seed a simple free air jet issuing from a 3.5 cm diameter nozzle with exit velocities of 2.9 m/s, 5.8 m/s and 8.7 m/s, corresponding to Re numbers of 6322, 12622 and 18944 respectively. Initially the seeding density is very satisfactory, but if only water is nebulized the droplets evaporate in a short time and the concentration becomes too low when moving downstream. The situation can be greatly improved if a small percentage of glycerol is mixed with the water (here 5% vol. has been tested), although the atomization rate strongly decreases when increasing the viscosity, as demonstrated in previous experiments using a single atomizer disk.

* Corresponding author: alozano@litec.csic.es