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HIGHLY EXPANDED FLASHING LIQUID JETS IN VACUUM ENVIRONMENT

Abstract

In some situations, a pressurized liquid may suddenly be exposed to a low-pressure environment. If the environmental pressure is lower than the corresponding saturation pressure at the injection temperature, the liquid will undergo a fast phase transition process, commonly known as liquid flashing. Fundamental knowledge of the mechanism of flashing liquid jet plays an important role in environmental control systems of space vehicles. In the present study, liquid jets into a vacuum environment are studied experimentally. A long, straight stainless steel capillary with an inner diameter of 0.23 mm and a length of 17.0 mm is used as the nozzle, which is connected with a syringe. Through a solenoid valve, a test vessel is connected with a vacuum chamber with a volume of about 800 times bigger than that of the test vessel. Distilled water of about 1 mL is filled in the syringe at first, while the syringe is open to the ambient. Then, opening the solenoid valve, the air inside the test vessel will be evacuated quickly, resulting in a quick depressurization and a low backpressure inside the test vessel. The water in the syringe is then driven by the difference between the ambient pressure and the backpressure, to form a high-expanded flashing liquid jet into the test vessel. For the case of low initial temperature and high backpressure, there is no evaporation, and then the flow of the liquid jet from the nozzle exit section remains intact and follows a straight path. On the other hand, if the initial temperature is high and/or the backpressure is low enough to lead a superheated exit condition, evaporation will take place, irregular evaporation waves around the liquid core are visible, and the jet shattering occurs. On further decreasing the backpressure, the liquid jet shatters giving rise to a cloud of droplets with a spray angle usually bigger than 90 degree, indicating a large number of nucleation sites and rapid bubble growth. It is also shown that there is flow choking behavior as the flow rate becomes constant and insensitive to pressure reduction below some backpressure threshold. It's also evident that the boundary of the flashing liquid jet is under a highly unsteady state. Regular and steady shape of the flashing liquid jets with evaporation wave and shock wave presented in the literature may be not suitable in the present cases.