Droplet absorption by a capillary channel for microgravity phase separation

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Introduction

The Rankine cycle plays a key role in generating most of the world’s electrical power. This technology would have a significant power-to-weight ratio advantage over solar cell technology for power generation on spacecraft, but is not currently used because of difficulties with phase separation under microgravity conditions. For power generation and other life-support technologies, NASA is interested in developing efficient methods of liquid-gas phase separation for long-duration manned missions to the moon or Mars.

Materials and methods

A helically-supported capillary channel is being investigated for capturing drops from a flowing two-phase mixture. A 1/8” diameter, steel spring was suspended horizontally and connected at both ends to a water reservoir that allows a stable channel of water to be established inside the spring. When the water reservoir is positioned below the channel, a colliding droplet will have a higher pressure than the channel and be sucked in. The mass fraction of falling droplets absorbed by the channel was measured as a function of the offset of the drop trajectory from the axis of the channel.

A high-speed video camera and a MATLAB program were used to analyze the trajectory of a droplet before and after the collision. Lastly, a camera with high zoom capability was used to analyze the shape the channel takes at different pressures.

Results

As desired, the helical channel absorbs a large portion of colliding drops. Optimum absorption conditions include:
- Zero offset (Δx = 0 mm)
- Low drop velocities (< 1 m/s)
- Lowest stable channel pressure

As drop speed increases, absorption decreases

Fig. 6 As the reservoir is lowered and channel pressure is decreased, more drop mass is absorbed. However, the channel is more unstable at lower pressures and therefore more likely to break.

Conclusions

When fully developed, this technology will consist of an array of springs that will achieve phase separation by absorbing water droplets in an air flow. Since this technology is still in the beginning stage, there is extensive research to be done before we know if it will be useful in outer space; we should continue to understand the basics of this system. Hopefully, this technology will aid in furthering space exploration and be useful in applications both on Earth and beyond.

References

