ALUMINIUM ALLOY AND COMPOSITE POWDER PRODUCTION THROUGH ULTRASONIC ATOMISATION FOR ADDITIVE MANUFACTURING

INTRODUCTION

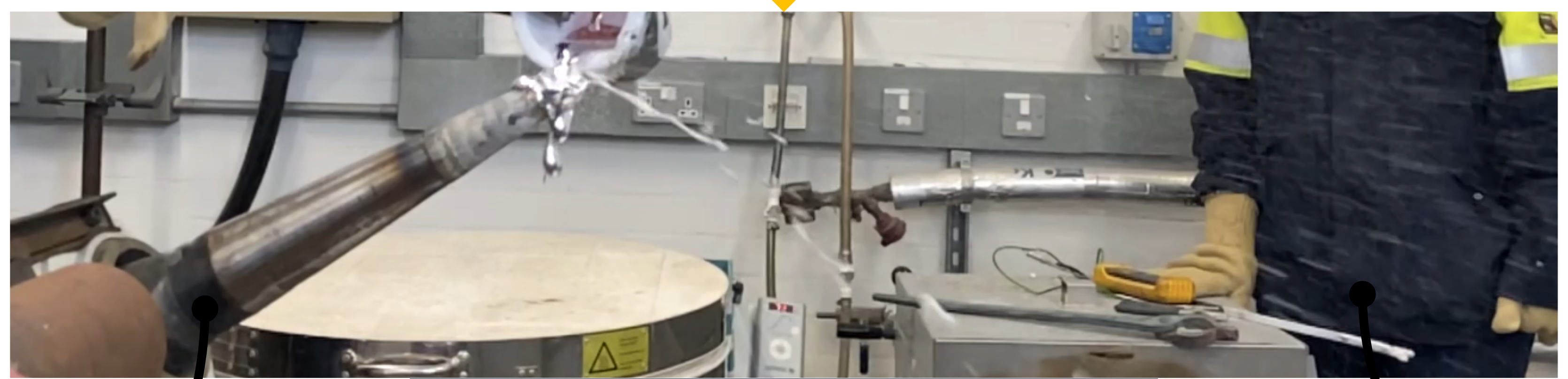
Production of metal powders for additive manufacturing (AM) has been continuously studied to further improve the quality whilst maintaining the cost effectiveness of the product. One of the main challenges experienced by metal additive manufacturing companies is achieving uniform spherical shape and sizes of metal powders, ranging from 40 —150 µm [1], to meet the requirement of the specific parts to be printed, which can be solved via atomisation. Ultrasonic (US) atomisation is the formation of droplets through ejection from the film of a liquid surface. This phenomenon can be supported through two theories; **capillary wave** and **cavitation**.

AIM

To develop a method of producing powder alloys and composite using US atomisation by utilizing gas and element mixture.

ULTRASONIC ATOMISATION

Superheated molten aluminium poured at 720 °C



Ultrasonic energy react with liquid film

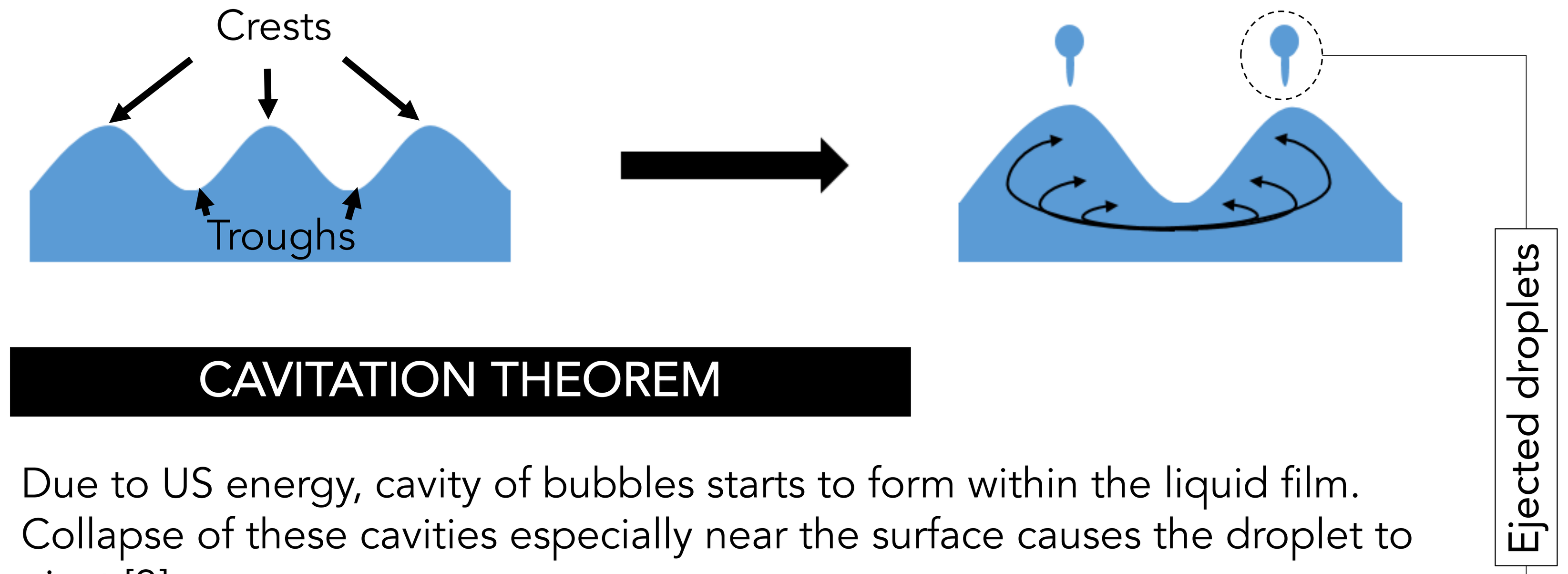
US transducer @ 17.8 kHz + 20 mm sonotrode

In-flight rapid solidification

Atomised metal powder

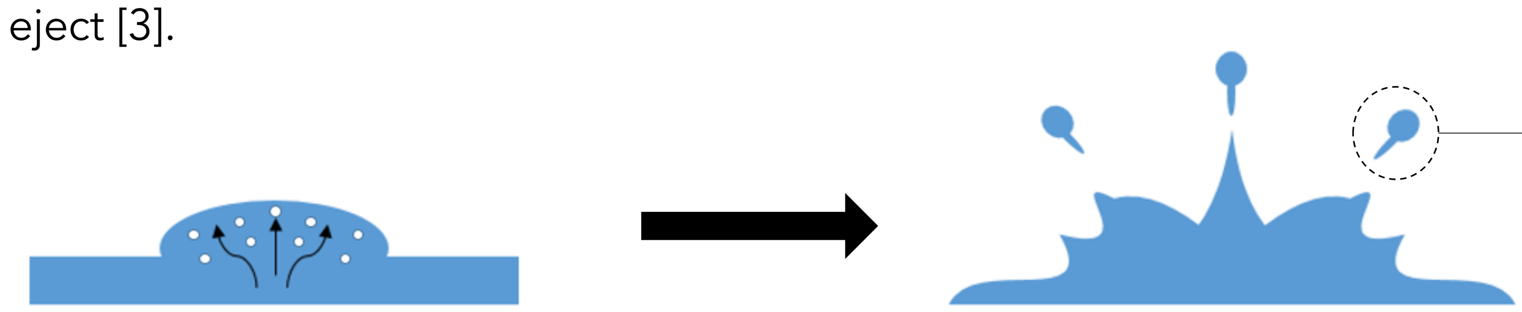
CAPILLARY WAVE THEOREM

Based on Taylor instability [2], it induces atomisation through US wave propagation, the splitting of wave peaks after reaching a certain amplitude at the surface of the liquid film.

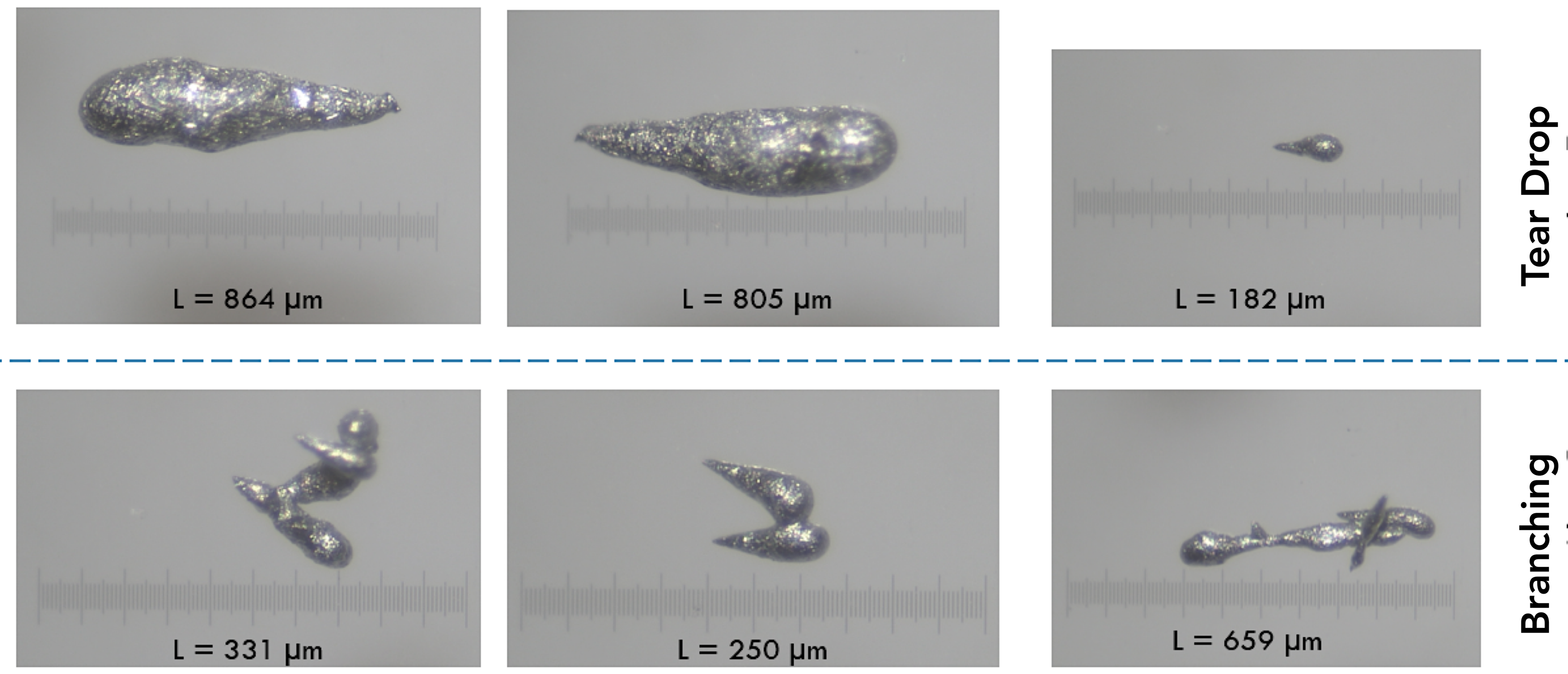


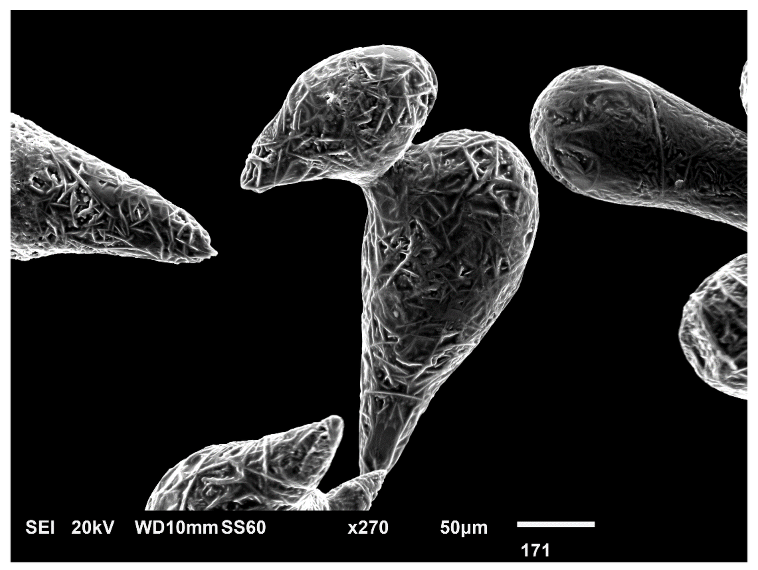
CAVITATION THEOREM

Due to US energy, cavity of bubbles starts to form within the liquid film. Collapse of these cavities especially near the surface causes the droplet to eject [3].

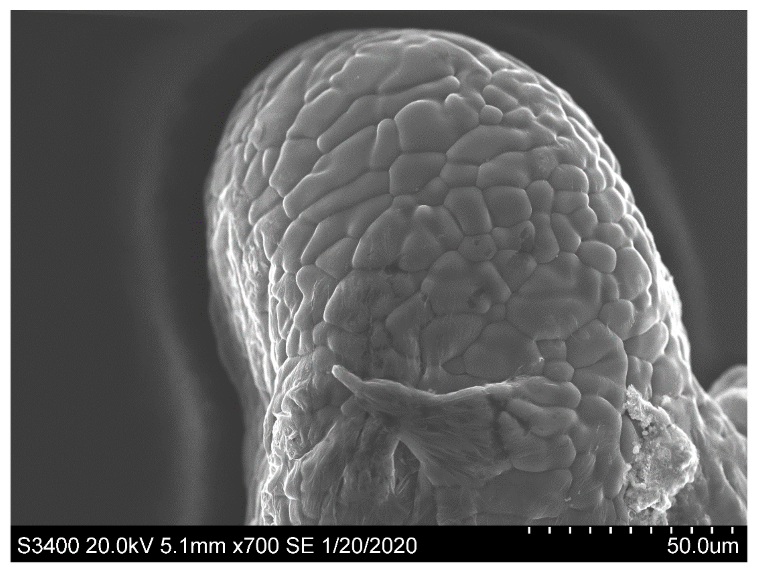


FORMED POWDER MORPHOLOGY





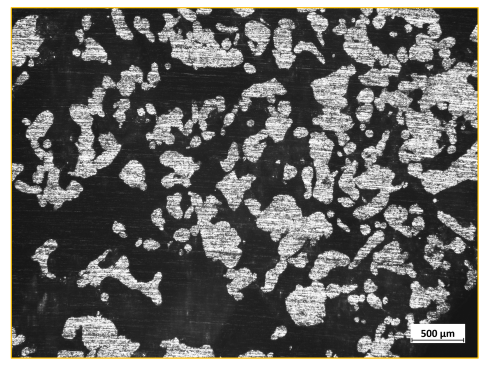
$AlSi_{11}Fe_4$

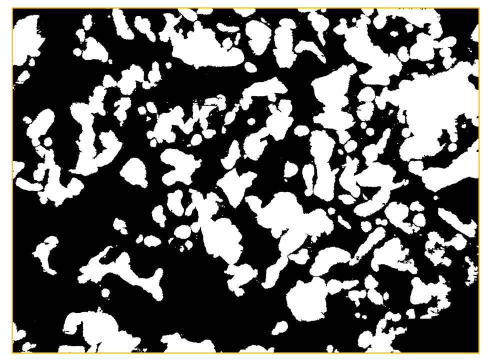


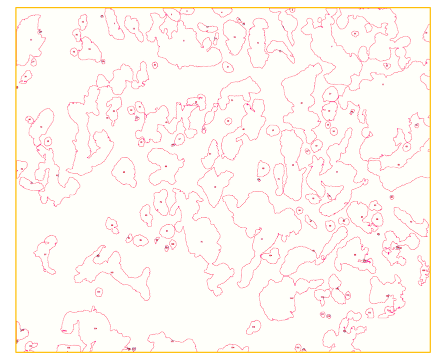
Pure Aluminium

PARTICLE SIZE DISTRIBUTION (PSD) THROUGH PHOTOANALYSIS

Powders were encapsulated and polished, before images are captured microscopically. Using ImageJ software, the powder particles were then analysed.



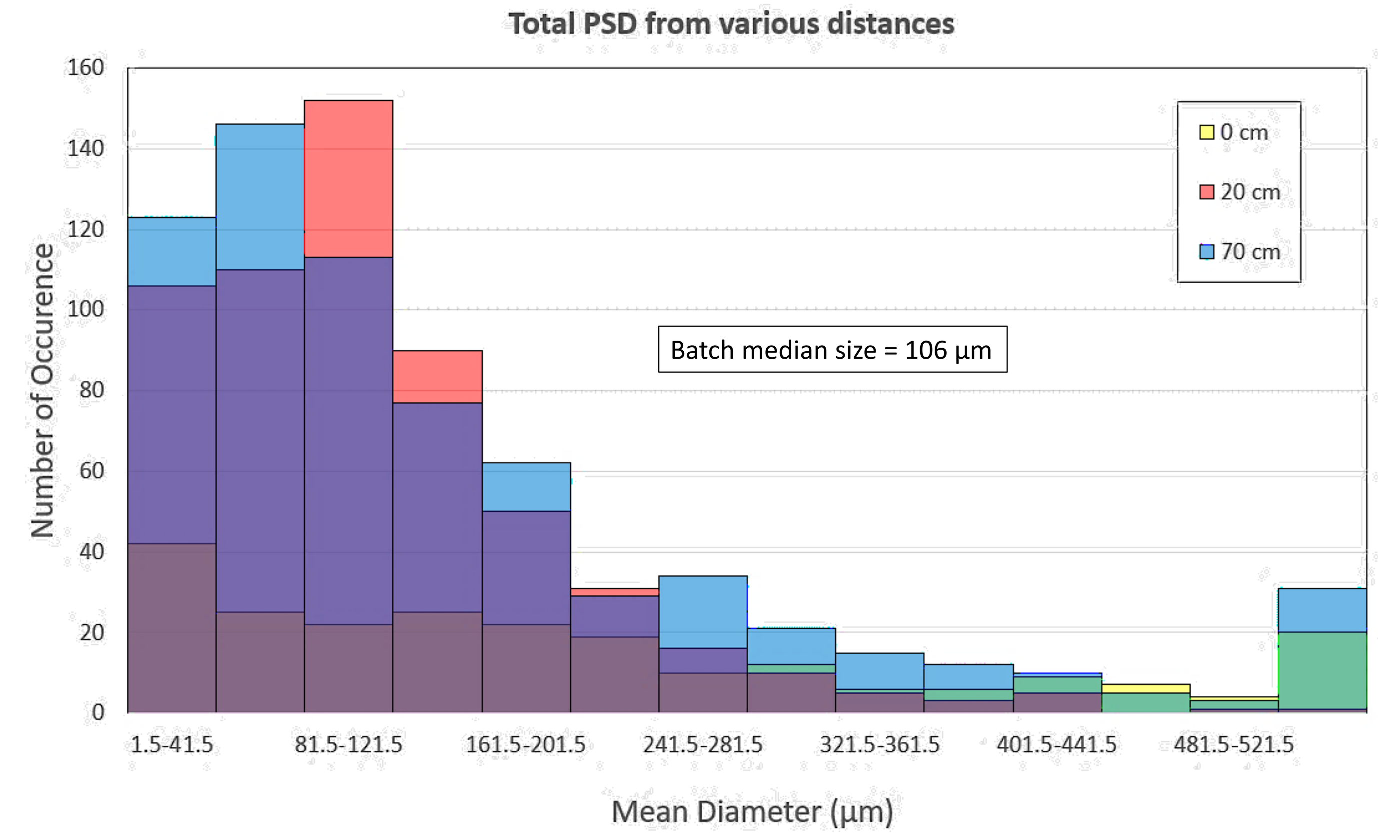




Microscope → Binary → Analysed

DISCUSSION

- Melt flow rate must be improvised and controlled, in order to achieve optimum minimum thickness of liquid film.
- The cooling rate of the atomised melt should increase to reduce the elongation (tear drop) of the powder during rapid solidification process.
- The flight path should be better controlled to reduce the formation of branching (collision with other powders mid solidification).
- The target number of particles analysed must be increased to improve the data statistics.



FURTHER WORK

- Design and build a melt pouring system that would be able to deliver optimum minimum thickness of liquid film, able to withstand the high temperature of the melt, and maintain repeated melt flowability.
- Design and build a sealed chamber so that atomisation can be performed in vacuum and various gaseous element.
- Using a high speed camera to better capture the atomisation and in flight solidification.

References

[1] A. T. Sutton, C. S. Kriewall, M. C. Leu, and J. W. Newkirk, "Powders for Additive Manufacturing Processes: Characterization Techniques and Effects on Part Properties," *Solid Free. Fabr. Proc.*, pp. 1004–1030, 2016.

[2] R. L. Peskin and R. J. Raco, "Ultrasonic Atomization of Liquids," *J. Acoust. Soc. Am.*, 1963.

[3] D. G. Eskin *et al.*, "Fundamental studies of ultrasonic melt processing," *Ultrason. Sonochem.*, 2019.

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