THEORETICAL STUDY OF BiSn EUTECTIC ALLOY SOLIDIFICATION IN DROP TUBE

FREITAS, F. E.*; TOLEDO, R. C.; TENÓRIO, P. I. G.; FUMACHI, E. F.; AN, C. Y.; BANDEIRA, I. N.
Instituto Nacional de Pesquisas Espaciais – INPE, Associate Laboratory of Sensors and Materials – LAS

1. Introduction

The microgravity research has a great significance to understand weightlessness interaction in materials processing. Drop tube is a technique to reproduce reduced gravity in containerless solidification of metals and alloys during free fall with rapid cooling (few seconds) [1].

2. Theory

The study of the heat transfer during free fall is important to optimize the working conditions of the drop tube. In this work, we adopted for BiSn eutectic alloy a model developed by Toledo [2] for the heat transfer conduction in PbSn in order to validate the model for other alloys. For this we used the model appropriated equations (Figure 1) and obtained the graph of the solidified fraction (fs) versus time (Figure 2).

$$F = P - F_D \rightarrow dv = \left[g - \frac{3}{4} \frac{\rho_{fluid}}{\rho_{sample}} \frac{\nu_{fluid}^2 C_D Re^2}{D^3} \right] dt \quad (1)$$

$$\frac{dQ}{dt} = \pi k_{fluid} D (T - T_0) \left\{ 2 + \left(\frac{C_{pfluid} \mu_{fluid}}{k} \right)^{0.4} \left[0.4 \left(\frac{D}{\nu_{fluid}} \right)^{\frac{1}{2}} v^{\frac{1}{2}} + 0.06 \left(\frac{D}{\nu_{fluid}} \right)^{\frac{2}{3}} v^{\frac{2}{3}} \right] \right\} \quad (2)$$

$$Q = \dot{m} \Delta H = m f_s \Delta H \rightarrow f_s = \frac{6Q}{\pi \rho_g D^3 \Delta H} \quad (3)$$

Fig. 1. *Heat transfer equations.*

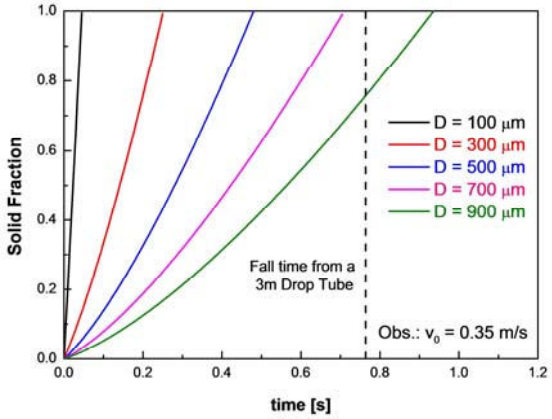
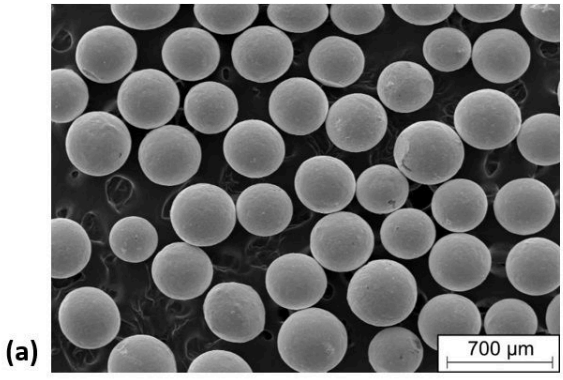


Fig. 2. *Solid fraction versus time for different diameters of samples.*

3. Results and Discussions

The solidification experiments were performed in the LAS/INPE 3 m drop tube. A mass of 1.0 g of the alloy is put into a quartz tube with a 200 µm diameter nozzle at its tip. The quartz tube is fixed in a furnace located at the top of the drop tube. Before melting the alloy, the drop tube is evacuated to a pressure bellow 5 Pa and partly filled with inert gas. The alloy melt is dispersed into small droplets by introducing inert gas in the top of the quartz tube. Droplets are solidified during their free fall and collected at the bottom of the drop tube. The Figure 3 shows the droplets of BiSn with diameter in the range of 100 to 750 µm were obtained. The conduction heat transfer model was consistent with the experimental results.



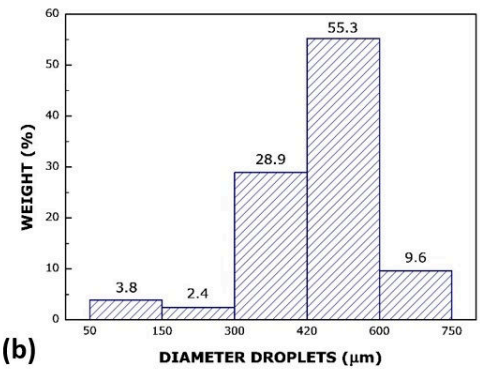


Fig. 3. (a) *Samples investigated in this work;* **Fig. 3(b)** *histogram of the droplets size distribution.*

4. References

[1]- R. J. Naumann and H. W. Herring, *"Materials processing in space: early experiments"*, NASA, (1980).
[2]- R. C. Toledo, *et al*, Microgravity Science and Technology, **26**, 119-124, (2014).

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*Corresponding author: filipe.estevao@las.inpe.br