Modelling of Surface Tension and Viscosity Measurements by the Oscillating Drop Method Applied to Measurments with an Electromagnetic Levitation Device on Board Parabolic Flights

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Microgravity conditions offer certain advantages for the application of the oscillating drop method for the measurement of the surface tension and the viscosity of metallic alloys in an electromagnetic (em) levitation device. As compared to ground based em-levitation the positioning forces are reduced resulting in a spherical specimen shape and the absence of turbulent fluid flow which is a necessary condition for the evaluation of the dynamic viscosity from the decay time constant of the surface oscillations. While, ideally, under these conditions the surface oscillation spectra exhibit a single non-shifted oscillation peak and an exponential decay of the surface oscillations, in many experiments the specimen exhibits a rotational movement including precession and nutation. These movements result in more complicated oscillation spectra and a modulation of the measured decay of the surface oscillations which complicate the evaluation of the surface tension and viscosity.

In order to improve on the evaluation of the surface tension and the viscosity in the presence of sample rotations, a computer image of a specimen exhibiting various rotations and oscillating in different Y_{2m} modes was created. This image was analyzed with an image analysis software under different viewing directions and using different criteria for quantification of the shape oscillations such as the time variation of a radius measured in a fixed direction, or the radius sum and difference of two perpendicular radii. The resulting signals as a function of time of time were then anlyzed by the maximum entopy method and by conventional Fourier analysis. The complex experimental spectra could be very well reproduced improving the determination of the surface tension from real experiments and, as such, increasing the success rate of parabolic flight experiments. The maximum entropy method yielded higher resolution spectra allowing the evaluation of the damping time constant from the width of the spectrum including the case when the spectrum was rotationally split. This analysis method was applied to experimentally measured spectra obtained in parabolic flight experiments resulting in an improvement in the determination of the decay time constant in the presence of sample rotations. Very good agreement between damping time constants obtained in the time and frequency domain were obtained. The conditions for which such an analysis can still provide good results in the presence of samplre rotations have been evaluated. The experimental approach is relevant for high temperature, reactive alloys such as TiAl or Ti64 which can not be measured by the sesssile and oscillating or rotating cup method because of container wall reactions.