Influence of dendrite arm spacing on the thermal conductivity of an aluminum-silicon casting alloy

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The photoacoustic technique and the thermal relaxation method were used to determine the thermal conductivity of some representative samples obtained from an aluminum-silicon casting alloy A319. This material was solidified with an imposed unidirectional thermal gradient to obtain samples with different microstructures characterized by the secondary dendrite arm spacing, which increases as the solidification rate decreases. It was found that the thermal conductivity of the alloy decreases with an increase in the secondary dendrite arm spacing and a decrease in the integral dendrite perimeter.

I. INTRODUCTION

The importance of simple thermal diffusivity measurements is crucial in the use of several industrial alloys, in particular those which are subjected to thermal cycling, such as aluminum alloys employed in the manufacture of automotive engines, since power dissipation is an important mechanism in engine performance.[1]

The microstructure which is developed in a casting depends on its solidification rate.[2,3] In the case of the widely used hypoeutectic aluminum silicon alloys, the typical microstructure is composed of aluminum dendrites and a dispersion of the eutectic when made from aluminum and nearly pure silicon.[2,3] The secondary dendrite arm spacing (DAS) was found to be reduced as the solidification rate increased,[3,4] whereas the shape and distribution of eutectic silicon is affected by a series of parameters such as solidification rate and chemical composition.[5–7]

It is a well-known fact that the physical and mechanical properties of a material depend on its microstructure,[5,6,8,9] but the relationship between the thermophysical properties and microstructure is perhaps less studied, although some reports[9,10] indicate that the electrical conductivity depends on the microstructure.

The experimental methods commonly employed to determine the thermal diffusivity in materials are of three different types, depending on whether the measured heat flow is stationary, (conventional method[11]) transient or periodic. The American Society for Testing Materials considers as standard a version of the transient technique, the laser flash method,[12] to determine the thermal diffusivity. The periodic method was introduced in 1863 by Ångstrom,[13] and involves heating periodically one end of a rod-shaped sample and measuring the resulting temperature oscillations at another point of the rod. The phase lag between the thermal oscillations at any two points gives a precise determination of the thermal diffusivity. Another method, applied in this work, which is based on the photoacoustic (PA) technique[14] has been employed extensively[15–18] and has the advantage of requiring small quantities of the material to be analyzed, permitting the determination of the thermal diffusivity in localized regions of the material.

The aim of this work is to determine the possible correlation between the thermophysical properties and the position-dependent microstructure of a commercial aluminum casting alloy of the type A319.

