Semisolid processing originates with the research at MIT on the viscosity behaviour of tin/lead alloys during solidification, published by Spencer, Mehrabian, and Flemings in 1972. The original purpose was to examine the shear stress of semisolid structures with a view to shedding light on hot tearing mechanisms in solidifying alloys, but it was discovered that the process of shearing clearly altered the microstructure, changing the dendritic morphology of the solid into more spherical form that brought about a dramatic fall in shear stress and viscosity. This is of course the phenomenon of “Thixotropy,” well known to ceramicists and polymer scientists, but until then not observed in metallic systems. This discovery at MIT initiated an in-depth study of thixotropy in alloys, and the awareness that stirred semisolid alloys could be injected as in die casting into molds with certain advantages: The controlled higher viscosity flow meant that less air was entrapped in the casting and that the finer equiaxed grains formed on solidification, both would result in better mechanical properties. The work carried out in the last 40 years in industry and laboratories around the world and published in the Biennial International Conference Proceedings on Semisolid Processing of Alloys and Composites, as well as in academic journals, has borne out these expectations: There is now a thriving industry in the production of thixofomed components in aluminum and magnesium alloys for automotive components, and also in the electronics and telecommunications industries. However, this is still a small proportion of all castings produced by more conventional processes, and this restriction is mainly due to the cost of the preformed thixoformed billet and the inability to recycle scrap in-house. Both these problems could be overcome by the recent development of the new slurry generating technologies permitting rheocasting (that is integrating the formation and injection of slurry on site, see Industrial Chap. 10), obviating the need to partially remelt a preformed slug and providing important production savings – thus allowing direct competition with conventional high pressure die casting.

The subject matter in this monograph is discussed in three parts. The first part (A) deals with the microstructure of semisolid slurries resulting from nucleation and dendrite fragmentation (Chap. 1), and the changes that occur during subsequent isothermal heat treatment (Chap. 3). This is followed in Chap. 4 by an account of the more recent advances in generating slurries in-house, thus allowing significant economies in component production. The rheology of alloy slurries is examined
in Chap. 6 and the modeling of semisolid flow is outlined in Chap. 7, providing a tool to optimise die design and prevent defect formation. Finally the industrial applications of semisolid processing are dealt with in Chap. 10, in which different techniques are discussed for reheating and partially melting preformed billets, followed by isothermally heat treating them before thixoforming. Chapters 11 and 12 describe the practical considerations of process control and die design, and the empirical rules that have been established as a guide to produce sound castings on a regular basis.

I wish to acknowledge the efforts of the authors in providing a balanced, self-contained, and up-to-date account of semisolid alloy processing that follows. It must be admitted that this monograph was begun some years ago but has been delayed in completion by the remarkable progress in the industrial technology. Hopefully with the advent of new rheocasting technologies, one phase in development has been completed – that is for light alloys. Copper based alloys for the production of intricate shapes must now be an achievable goal and this should stimulate the development of semisolid forming of high melting point alloys, such as stainless steels, nimonics, and titanium alloys using special die materials.

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