Overview

Rapidly solidified powder (RSP) technology is an exciting recent advance in metallurgical processing. There are many advantages of rapid solidification powder processing over conventional ingot processing. It gives the metallurgist much more freedom in alloy design. During conventional casting of alloys that form two or more phases in the solid state, large primary crystallites of intermetallics may form which are deleterious to mechanical properties. During rapid solidification, extended ranges of solid solution are obtained. In addition, any primary crystallites that form are very small in size, 0.5 μm or less in diameter, and are generally beneficial to the mechanical properties. Thus, there are alloy compositions of interest for rapid solidification powder technology which would not be feasible for ingot technology.

Impurities, which give rise to large undesirable inclusions or constituent particles, may be tolerated in RSP alloys because, again, the resulting particle size is small. After consolidation and rolling, forging, or extrusion, much smaller grain sizes may be achieved by RSP processing than by mechanical deformation of ingots. Such small grain sizes give increased yield strength as well as improvements in other properties. Of course, an advantage of rapid solidification (RS) as well as of all powder metallurgy processing is that shapes near the final shapes are achievable with much reduced metal removal costs.

All of these factors have led to a great interest in RSP technology and in development of special RSP alloys. The current literature contains a large number of papers on the subject, and many industrial laboratories are busily engaged in development.

It was apparent to ASTM Committee B-9 on Metal Powders and Metal Powder Products, chaired by Leander F. Pease III, that RSP technology is an emerging technology which should be considered in light of establishing testing procedures and establishing standards. This committee, through Joseph Palmer, approached the editors of this publication in the fall of 1982 with the request that they organize an ASTM symposium on rapidly solidified powder alloys. The decision was made to restrict the symposium to aluminum alloys since this topic would make a coherent program and allow full coverage of the subject. This publication is based on that symposium.

The present volume begins with introductory invited papers establishing the need for RSP alloy development for use in aerospace and land vehicles. Tutorial papers on solidification theory and stereological characteristics follow.

The ensuing sections are on the topics of powders, consolidation and processing, and, finally, characterization and properties. Each consists of several invited papers followed by contributed papers. The number of contributed papers attests to the high level of research activity on RSP alloys, even though the symposium was restricted to aluminum alloys. Approximately 150 individuals attended the symposium.

Introductory Papers

In the opening paper, *Quist and Lewis* emphasize that the main reasons for interest in developing new aluminum alloys by RSP or conventional techniques for aerospace applications are (1) increased toughness in high-strength alloys, (2) increased stress corrosion resistance in high-strength alloys, (3) a higher stiffness-to-density ratio in alloys of all strength levels, and (4) improved high-temperature strength and creep resistance. A "rivalry" exists between aluminum alloys and composites with the use of aluminum alloys at present being threatened by composites. Material properties and cost will make the final determination.

Waldman discusses the use of RS aluminum alloys in land vehicles.

The fundamentals of rapid solidification are reviewed by *Glicksman and Singh*, with emphasis on what factors determine the resulting as-solidified microstructure. For quantitative description of the complex microstructures of RSP two-phase alloys, *DeHoff* points out the importance of the integral mean curvature and the distribution of curvatures of the interfaces.

Powders

Many interesting results are reported in the section on powders, which contains contributed papers. *Sater et al* characterize and categorize the actual microstructures produced by RS. *Gayle and Vander Sande* show that cubic Al_3Li precipitates on and diffuses into previously existing cubic Al_3Zr particles. The paper by *Zindel et al* describes some very interesting results on rapidly solidified microstructures produced by surface melting using a laser beam. This is a convenient and quick way to obtain RS microstructures for evaluation. *Skinner et al* report results for a very promising Al-11Fe-2.5V elevated-temperature alloy, while *Vidoz et al* report on Al-Li-Be alloys with much improved stiffness-to-density ratios. Other papers in this section deal with other aspects of RS powder technology.

Consolidation and Processing

In an invited paper in the third section, *Griffith et al* emphasize the importance of degassing to remove volatile species prior to consolidation. The as-atomized aluminum alloy powder contains an oxide coating, which introduces a fine dispersion of oxide into the alloy after processing. Both alumina (Al_2O_3) and magnesia (MgO) were found. Control of these oxides is likely to be the key to improved mechanical properties. In a contributed paper, *Sears et al* report results on aluminum alloy powder prepared by mechanically breaking up melt spun ribbon. The amount of oxide introduced is much reduced by this process. Other papers in this section also discuss topics related to consolidation and processing.

Characterization and Properties

In the final section, *Ping* reports that a damage-tolerant RSP powder metallurgy alloy with copper, magnesium, zinc, iron, and nickel is ready for commercialization. Improved corrosion resistance is also reported. *Pickens* reports that stress-corrosion cracking in RSP aluminum alloys is faster under Mode I loading than Mode III loading because of the presence of triaxial stresses with Mode I. *Langenbeck et al* report improved corrosion resistance of an elevated-temperature Al-8Fe-3.5Ce alloy over that of conventional alloys. Further aspects of characterization and properties are discussed by other papers in this section.

Concluding Remarks

In summary, this volume, which has resulted from the symposium on rapidly solidified aluminum alloys, is an excellent presentation of the state of the technology and science in the field. It is of interest not only to engineers and scientists concerned with aluminum alloy development and processing but also to those concerned with alloy development and processing in general. Enough has been accomplished to date with aluminum alloys (as well as other alloys) to show the RSP processing will play an increasingly important role. There are enough differences between RSP alloys and products produced by conventional means that some new testing procedures need to be introduced for quality control and improvement, but the final product must stand up to standardized tests that have been established or will be established for all classes of materials.

Edgar A. Starke, Jr.

University of Virginia, Charlottesville, VA 22901; symposium cochairman and editor.

Morris E. Fine

Northwestern University, Evanston, IL 60201; symposium cochairman and editor.