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Study Made of Ductility Limitations of Aluminum–Silicon Alloys

The relation between microstructure and mechanical properties of cast 356 type aluminum alloys was studied to determine the cause of the variations in properties resulting from differences in solidification rate. It was found that variations in strength are a consequence of variations in ductility, and that ductility is inversely proportional to the dendrite cell size.

There are several ways in which the information gained in this study may be applied to improving the properties of weldments and castings. The most obvious is to reduce the dendrite cell size. In this study, cell-size control was by cooling rate. This method cannot always be applied for a variety of reasons, and some other way would be desirable. It is not clear that alloying additions used as grain refiners would perform this function, since cell size and grain size may not be directly related. For example, in this study, practically no difference in grain size was noted for the A356-T6 for the range of solidification times used. On the other hand, the grain size is certainly the upper limit to the dendrite cell size.

The effect of silicon particle size is not clearly defined. Decreasing the size would decrease the amount of strain required for their fracture, but many more fractures would be required to effect the same decrement of effective cross-sectional areas. A change in distribution of the silicon particles to the interior of the cells would be quite effective since the differential strain of the matrix across the particle would be very small. Decreasing the amount of silicon as particles, either by decreasing the silicon content or increasing the matrix solubility for silicon, should also be helpful.

As a consequence of studying in detail the interrelation of microstructure and fracture mode of 356 type alloys the following conclusions have been reached:

(a) Fracture occurs almost exclusively along dendrite cell boundaries, and initiates in the silicon particles present in those boundaries.
(b) The amount of elongation is inversely proportional to the diameter of the dendrite cells for all sizes smaller than some minimum value.
(c) Yield strength is not a function of dendrite cell size.
(d) Ultimate strength is controlled by the dendrite cell limitation on elongation.
(e) The maximum cell size for enhanced elongation is a functioning of the work-hardening rate of the matrix.

Notes:

1. Complete details of this study are contained in: *Ductility Limitations of Aluminum–Silicon Alloys,* by S. Frederick and W. A. Bailey, DAC Report 59518, Douglas Aircraft Co., Inc., August 19, 1966.
2. Copies of the above report are available from:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B67-10392

Patent status:

No patent action is contemplated by NASA.

Source: S. F. Frederick and W. A. Bailey
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Category 03

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