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The effect of minor element concentrations on the strain rate sensitivity and ductility of commercial purity aluminium sheet*

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Minor element levels vary considerably in commercial purity (*ca.* 99.5 % Al) aluminium alloy sheet obtained from various sources. Minor elements may be present in solution or as second phase particles formed during solidification or subsequent processing. The present work is largely concerned with the effects of elements in solution on strain-rate sensitivity and ductility. Recent treatments of plastic instability in tensile tests incorporate the strain rate sensitivity and note its importance in determining the strain at which instability occurs (Ghosh 1977; Marciniak 1974).

Tensile properties have been determined on a range of aluminium sheet samples. The results show that small increases in solute concentration can result in a change from positive (flow stress increasing with strain rate) to negative strain rate sensitivity. The rate sensitivity was found to be strain dependent and this had led to a reconsideration of the effect of strain rate sensitivity on ductility. The work suggests that it is not the absolute value of the rate sensitivity that determines its effect on the strain to plastic instability, but rather the sign of its variation with strain. If this is positive then the strain to instability exceeds that expected in the absence of rate sensitivity; if the slope is negative the opposite trend is observed.

In an annealed aluminium, post-yield deformation behaviour is characterized by the development of a dislocation cell structure. Cross slip is an important mechanism enabling the formation of such structures and it is believed that much of the strain rate sensitivity is associated with cross slip processes. Minor elements affect dislocation motion by diffusing to dislocations – a process that occurs quite readily in aluminium at room temperature, particularly when the vacancy concentration is increased following many dislocation interactions. The relative magnitude of the effects of solutes on work hardening and dynamic recovery processes are not yet known but an interpretation in terms of an impeding of cross slip appears to be in agreement with the experimental results.

If proper account is taken of the strain rate effects, tensile tests can give a good indication of performance in some forming operations (e.g. bending). The results show that residual solute levels are important in determining the strain rate sensitivity and forming behaviour of aluminium but that the effects are complex and require further investigation before they are fully understood.

References (Parker)

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Marciniak, Z. 1974 In *Aspects of material formability*. McMaster University, Canada.

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