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Segregation in vacuum arc remelted ingots of titanium alloys

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Segregation in titanium alloy ingots has largely been treated as a macro-segregation problem. The alpha/beta alloy Grade 5 (“6/4”), for example, is sensitive to macro-variations in Al content due to the precise property requirements of the heat-treated structures. In VAR practice, the problem is mitigated through the use of multiple melting techniques, high quality alloys being remelted three successive times with ingot reversal. The mechanisms and outcomes in ingot composition changes have been modelled with the assumption that the solidification is always in a columnar-dendritic mode. However, in most melting practices, the energy input necessary to maintain a good ingot surface causes a substantial fraction of the ingot to solidify equiaxially. The practical and modelling consequences of this change are examined.
Some of the near-beta alloys (e.g. 10-2-3, Ti17, Beta-CEZ) are also sensitive to micro-segregation issues, principally freckle formation. The freckle problem, unlike the same issue in lower melting-point alloys, is not one of locally excessive primary precipitate formation. Instead it is instead one of composition variations which lead to transition temperature changes resulting in deleterious beta phase retention after heat treatment. Present freckle models do not appear to explain this phenomenon in titanium alloys. It is proposed that freckle formation in this alloy system is largely controlled by process instability deriving from the arc characteristics of the VAR furnace.

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