Hot tearing analysis in aluminium welding

J.-M. Drezet[1] and M.S.F. Lima[2]

[1] *Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*
[2] *Institute for Advanced Studies, Sao Jose dos Campos, Brazil.*

Hot tearing or solidification cracking is a severe flaw occurring during solidification. It appears in casting as well as in welding. The defect is the conjunction of tensile stresses which are transmitted to the mushy zone by the coherent solid underneath, of insufficient liquid feeding to compensate for the local volumetric change and of strain localisation due to delayed coalescence between highly disoriented grains. Each aspect is presented and discussed in the case of welding.

The so-called RDG (Rappaz Drezet Gremaud) hot tearing criterion, takes into account each of the aspect mentioned above to predict the appearance of hot tears in metallic alloys. This criterion is based upon a mass balance performed over the liquid and solid phases and accounts for the tensile deformation of the solid skeleton perpendicular to the growing dendrites and for the induced interdendritic liquid feeding. When tackling the problem of hot tearing in welding of aluminium alloys, the RDG criterion is used to rank the alloys with regards to their sensitivity to hot cracking and to study the risk of hot tearing using the local solidification conditions.

Finally, a new welding process employing two independent laser beams is presented. This process is able to produce crack-free welds in an AA6016 aluminium alloy for which conventional welding using a single laser source usually leads to extended cracks for overlapped joints. Indeed, the modification of the thermal cycle due to the combination of the two laser beams promotes the columnar to equiaxed transition (CET) and therefore efficiently eliminates hot cracks. Strain localisation in liquid films is also greatly reduced as the grain size is lower in the equiaxed microstructure. These effects are analysed using the RDG hot tearing criterion and a finite element model to quantify the thermal gradient obtained with the combination of the two laser beams.

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* *Laboratoire de Simulation des Matériaux, MXG-Ecublens, station 12, Lausanne, Switzerland. E-mail: jean-marie.drezet@epfl.ch.*