Influence of Portevin –Le Chatelier effect on ductile tearing: Experiments and simulations

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ABSTRACT

This study is motivated by an earlier work on several Al-Cu aluminium alloys revealing the presence of multiple slant strain concentration bands in the material bulk around the notch area of a compact tension specimen during ductile tearing. These were measured by *in situ* 3D imaging and Volume Correlation [1-3]. The slant strain concentration bands through the thickness were found to be the precursors of strain localization, damage and final slant fracture. This result indicates that plasticity models need to be enhanced to reproduce these phenomena.

To clarify if the Portevin – Le Chatelier (PLC) effect, *i.e.* the interaction of solute atoms with dislocations at the atom scale, could be at the origin of these mesoscopic bands, experimental and numerical investigations were performed. Indeed, serrated flow has been observed but only during non-monotonic tensile tests of an Al–Cu aluminium alloy in the naturally aged state [4]. The associated propagative localisation bands were observed by digital image correlation (DIC). In particular, the Portevin-Le Chatelier (PLC) effect and also Lüders bands were observed in interrupted tests during which the specimen was held for a length of time and also in tests with partial unloading followed by a holding time. These observations indicate the existence of the PLC effect in this material which was formerly considered insensitive to it at room temperature under monotonic loading conditions. A strain ageing finite element model is used that captures the experimentally found PLC triggering effects.

Three-dimensional FE simulations using the strain ageing model demonstrated that the triggering effect of PLC effect after re-straining observed in tensile tests can also be noticed in CT specimens. Using the identified material parameters, multiple bands are produced after re-straining. These simulations support the idea that the strain bands observed by are possibly due to strain ageing. Unlike experiments, the simulated bands using the macroscopic strain ageing model show strong mobility.

Using generic parameters for the PLC model and a Rousselier damage model combined with Coulomb fracture criterion for slip systems the early strain fields and slant fracture were reproduced successfully [5].

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