Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

HIGH-SPEED THERMAL INFRARED ANALYSIS OF PORTEVIN-LE CHATELIER EFFECT IN ALMG ALLOYS

Antoine Dumont[1*], Jean-Philippe Gagnon[2], Silke Klitschke[2]
[1]Telops, Quebec City, Canada
[2]Fraunhofer IWM, Freiburg, Germany
*antoine.dumont@telops.com

ABSTRACT

Portevin–Le Châtelier (PLC) bands are a classic indication of plastic instability occurring in metal deformation. The serrated behaviour of the stress-strain plots can be visualized in the material by using digital correlation techniques on samples during the tensile test, but such technique reveals a limited amount of information on the energetic exchanges of the phenomenon. As these dislocations are intrinsically exothermic, it is possible to monitor the PLC bands displacement and specific energy output with a high-speed infrared camera. This can enable improved modeling of material behaviour and properly isolate the heat produced by the PLC effect, discerning between the three main sources of heat in strained materials: (i) thermoelastic coupling, (ii) the mechanical dissipation due to homogeneous plasticity, (iii) the heat source due to the PLC effect. The high-speed thermal data on an AlMg alloy was obtained at the Fraunhofer IWM institute in Germany with a Telops FAST M3k camera. The acquisition was done at a rate of 31 000 Hz with a window of 128x36 pixels. The unique displacement of the PLC strain bands as well as their specific 55° angle were clearly observed through the M3k image with a high temporal resolution. The unstandard fracture point following the PLC bands movement is also studied, demonstrating a two-step increase in temperature and an asymetrical energy release from either side of the gauge region. While the PLC bands dynamics does not require a particularly high frame rate, the high-speed imaging from these measuremetns enables the in-depth study of the fast fracture process following the oscillating band displacement and unveils its unconventional features. The thermal imagery will also be compared to digital image correlation (DIC) that is more predominantly used for strain field observations, and the usefulness of combined infrared-DIC measurements for such phenomena will be discussed.