
Role of welding interfaces on the anisotropic mechanical response of a recycled material obtained through an extrusion process of aluminium chips.

Jason Perrin^{*†1}, Thomas Corre¹, Johannes Gebhard², Oliver Schulz², Théo Duchateau^{3,4}, Lola Liliensten⁴, Mathilde Laurent-Brocq³, A. Erman Tekkaya², and Bertrand Huneau¹

¹Institut de Recherche en Génie Civil et Mécanique – Ecole Centrale de Nantes – France

²Institute of Forming Technology and Lightweight Components (IUL) – Germany

³Institut de Chimie et des Matériaux Paris-Est – UPEC-CNRS, UMR 7182, Thiais, France – France

⁴Institut de Recherche de Chimie Paris – Chimie ParisTech – CNRS, UMR 8247, Paris, France – France

Abstract

Primary production of aluminium from ore is very energy intensive, and accounts for about 2 % of global CO₂ emissions (IEA, 2022). Recycling by melting requires about 20 times less energy (Das & al., 2010). Aluminium can also be recycled through solid processes, minimizing the environmental impacts and material losses even further, with respect to remelting routes (Duflou & al., 2015). Aluminium AA-6060 machining chips can be recycled by such means, for example see Schulze & al. 2022. The extrudate keeps, however, a specific thermo-mechanical history. The chips display, at their interfaces, strongly anisotropic welding seams which may affect the mechanical response.

Some mechanical properties in the quasi-static regime have already been investigated for such a material (Corre & al. 2024). This study showed that the tensile and shear responses of a chip-based material are similar to that of a material which is not made out of chips. An anisotropic response was however observed, the welded chips being strongly elongated in the extrusion direction.

CT (Compact Tensile) specimens will be machined from extrudates of rectangular section to investigate more thoroughly the anisotropic response of the material. Such specimen will be used to evaluate the anisotropic tensile toughness of the material. They will also be used to study fatigue cracks' propagation in various directions. Particular attention will be given to the crack path with regard to the specific microstructure induced by the extrusion of aluminium chips.

IEA, 2022. Co₂ emissions in 2022, IEA Paris, France.

Corre, T., Perrin, J., Gebhard, J., Duchateau, T., Liliensten, L., Laurent-Brocq, M., Tekkaya, A. E., Huneau, B., 2024. Tensile and shear behavior of recycled AA 6060 aluminium chips by direct hot extrusion, Mater. Sci. Technol., doi: 10.1177/02670836241287768.

*Speaker

†Corresponding author: jason.perrin@ec-nantes.fr

Das, S.K., Green, J.A., Kaufman, J.G., Emadi, D., Mahfoud, M., 2010. Aluminum recycling-an integrated, industrywide approach. *JOM* 62, 23–26.

Dufflou, J.R., Tekkaya, A.E., Haase, M., Welo, T., Vanmeensel, K., Kellens, K., Dewulf, W., Paraskevas, D., 2015. Environmental assessment of solid state recycling routes for aluminium alloys: Can solid state processes significantly reduce the environmental impact of aluminium recycling? *CIRP Annals* 64, 37–40. doi:10.1016/j.cirp.2015.04.051.

Schulze, A., Hering, O., Tekkaya, A.E., 2022. Production and Subsequent Forming of Chip-Based Aluminium Sheets Without Remelting. *International Journal of Precision Engineering and Manufacturing-Green Technology* 9, 1035–1048. doi:10.1007/s40684-021-00395-8.