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New "Industrially Relevant" Cyclic SPD Processes

with Controlled Properties

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Industrially relevant *Cyclic SPD* *Controlled Properties*

Abstract

Several severe plastic deformation processes have been introduced in the past to get fine grained material. While there is a large increase in the strength of the material when the grains are refined, a significant concomitant loss in ductility is mostly there. SPD processes also pose challenges in making them industrially relevant because of the small sizes produced, the degree of strain that can be imparted, and the speed of production. We are trying to address these key challenging issues.

Two new severe plastic deformation processes are presented here:

1) High Pressure Compressive Reciprocating Shear (HPCRS)
2) Cyclic Friction Assisted Lateral Extrusion Process (CFALEP)

As the first process has been patented, details will be presented. Concerning the second, only results will be presented because the patenting process is to be completed.

Both processes have been demonstrated at laboratory scale and can be ramped up to industrial scale products. In HPCRS, billets of 25 mm x 25 mm x 5 mm of aluminum and magnesium have been deformed to a 125 mm x 25 mm x 1 mm plate. The process involves shearing of the material within a constrained die (to generate hydrostatic stresses) in a cyclic way (figure 1). The applied normal load was about 350 kN, and the shear load in the range of 175 kN. The machine enables applying the shearing force at various frequencies and amplitudes. Tensile test results for aluminum and magnesium sheared with an amplitude of 2 mm and various frequencies up to an equivalent strain of 45 are shown in figure 2. The positive aspect of the process is that the strain rate of deformation can be controlled. This in turn controls the heat generation and the temperature increase in the sample. At low frequencies, the temperature was around 40 ^{0}C, and at high frequencies, the temperature was estimated to be around 300

^{0}C. Strong textures have been developed in both aluminum and magnesium. A high degree of grain refinement controlled by the frequency of deformation was also seen.

These new processes are opening an avenue of industrial applications for light weighting of metal structures.

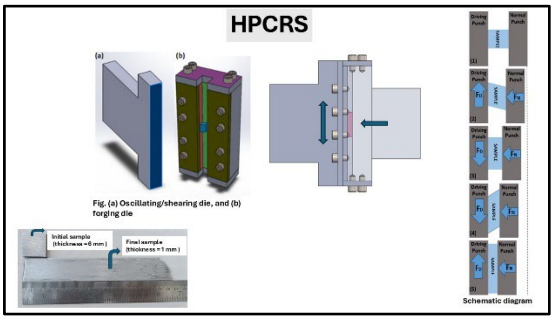

Figure 1 *– High Pressure Compressive Reciprocating Shear*

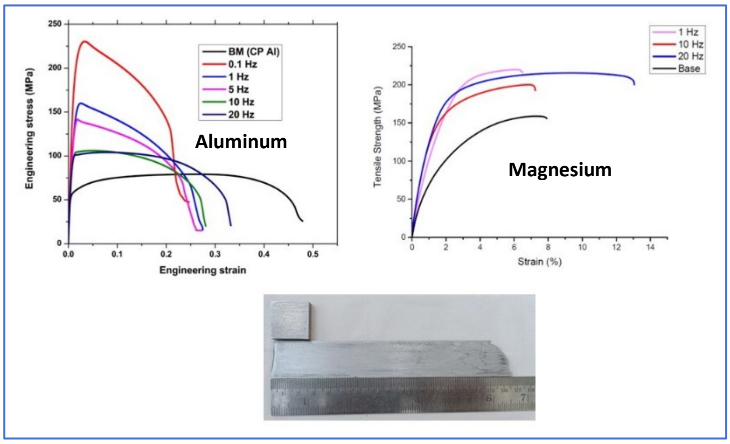

Figure 2 *– Stress – Strain curves of Al and Magnesium*

Figure 3 - A magnesium strip developed by the new process, called CFALEP