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On the determination of the microscopic residual stress in aluminum alloys

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A procedure to separate the (average) microscopic residual stress, m-RS, from the total residual stress (sum of the macroscopic residual stress, M-RS, and the m-RS) in monolithic (one-phase) alloys from measurements conducted by synchrotron radiation diffraction is proposed. The method focuses on stress equilibrium at different scales and the assumption that grains with different orientations are treated as different phases. Due to crystal anisotropy, the elasto-plastic behavior of individual grains in a polycrystalline aggregate depends on its orientation with respect the applied stress state. Texture of materials is required in the analysis to take into account the different phases involved and the intensity of each one. Two different cases are here presented for which specific measurements were conducted:
1.- Cylindrical samples machined from a bar of extruded 2014 aluminum alloy in which both M-RS and m-RS develop upon quenching from high temperature. The un-stressed lattice spacing value required in the calculation of the RS is obtained from the equilibrium of the M-RS across the sample. The measurements for this experiment were conducted on EDDI instrument at BESSY synchrotron, Berlin, which operates in energy dispersive mode, in the range 10-150 keV. Here, the signal from several hkl planes is obtained simultaneously at a given diffraction angle 2□. The m-RS among grains 311, 111, 220, and 200 can be up to some 20 MPa
2.- A "comb"type of sample machined from a sheet of rolled 2024 aluminum alloy. In this case, the M-RS is assumed to be relieved. Only the presence of the m-RS resulting from the rolling process must be considered. These measurements where conducted on MSPD instrument of ALBA synchrotron, Barcelona, which operates with a monochromatic radiation of □ = 0.31 Å, corresponding to the energy of 40 keV. Here, the signal from several hkl is obtained by adjusting 2□ accordingly (Bragg´s Law). In this case, the maximum m-RS obtained among grains belonging to different texture component is of about 100 MPa.

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