A deformation mechanism to explain the effect of grain size on flow stress (and the role played by temperature and strain rate)

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Grain boundaries play a key role on the flow stress and strain rate. Grain refinement can either strengthen the material, which is known as Hall-Petch effect, or it can soften, an effect usually observed at high temperatures. Despite the great importance of this structural parameter on materials' mechanical behavior there is still much debate on the phenomenological reason behind the experimental observations. Our recent work has focused on the development and validation of a deformation mechanism model that can explain the relationship between the materials' fundamental properties (shear modulus, Burgers vector and diffusion coefficient), the deformation conditions (temperature and strain rate), the grain size and the flow stress. Our model follows from the deformation mechanism of grain boundary sliding and has shown good agreement with experimental data from over 30 different metallic materials tested at different conditions. In this talk, we critically examine recent advances in this topic, we discuss the dispersion in experimental data, describe the model of grain boundary sliding, show supporting evidence for the model and discuss the transition from grain refinement hardening at low temperatures to grain refinement softening and superplasticity at high temperatures.