Take Home Exam02D3: Problems Related to the Orowan Stress

Assigned: 03/01/2022 (Tuesday)

Due (as pdf by email) 03/04/2022 (Friday)

You may submit your answers in one of two ways:

(i) •For typed answers: as a .docx file (as is) or converted into a pdf file. (DO NOT SEND GOOGLE DOC)

•For handwritten answers: Please scan as images, and group together into one pdf file. Or you may hand them manually to my office (ECME-212)

(ii) Please send your submission via email starting with HWExam02D3 in the subject line.

HW 02D3.1

The mechanical properties of metals fall into two distinct categories:

(i) Metal forming (rolling, stamping etc.) which involves large deformation. In this case strain hardening is the issue.

(ii) Mechanical design of engineering materials (for example bicycle frame) where the 0.2% offset yield stress is important.

•Explain in words (less than two or three sentences) why the following equations

$\sigma_{yield} \approx \sigma_o \varepsilon^{1/2}$ and related equations $\sigma_{yield} \approx \sigma_o \varepsilon^{1/2}$ and $\sigma_{yield} \propto \sigma_o \rho^{1/2}$

$\sigma_{yield} \propto \dfrac{\sigma_o}{L}$

are important in metal forming operations (for example stamping doors for automobiles from sheet metal).

•Explain why the Orowan stress (again in two or three sentences)

$\sigma_{Orowan} = \dfrac{Gb}{\lambda}$, where λ is the spacing between particles that are engendered by heat treatments and alloying of metals in order to increase the yield stress, is important for end-use of metals in mechanical systems.

HW 02D3.2

The Orowan stress dictates that the spacing between the particles must be such that

$$\frac{b}{L} = \frac{1}{100}$$

in order to achieve a yield stress that is 1% of the shear modulus.

Let us say that $b = 0.2$ nm, then $\lambda =$ 20 nm.

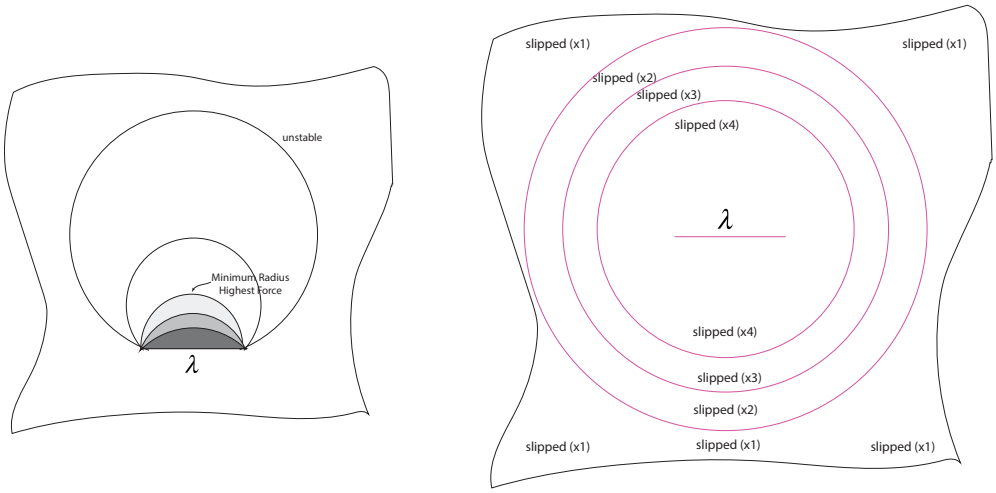
If the particles (which are assumed as spheres) have diameter a, and the spacing between them is λ.

•Derive an equation that relates the volume fraction of the particles, v_f to a and to λ

•Calculate the value for v_f if $a = 5\,nm$ and $\lambda = 20\,nm$ (for a yield strength equal to 1% of the shear modulus)

HW 02D3.3

The following figure was discussed for the continuous production of dislocations from a small pinned segment of one dislocation



Draw the sequence of expansion of the segment into larger circles until it bends all the way around to the bottom of the segment and pinches off to release the **first loop** restoring the segment to its original state.