Question A3, 1997:

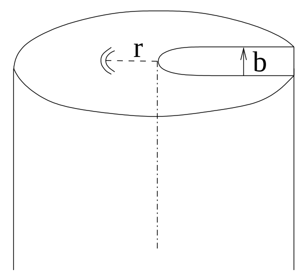
Screw dislocation: dislocation for which the Burgers vector is parallel to the dislocation line (line marking the boundary between slipped and unslipped regions of the crystal)

Edge dislocation: dislocation for which the Burgers vector is normal to the dislocation line.

Burgers vector: vector describing the magnitude and direction of the displacement due to the passage of a dislocation.

Slip system: the combination of slip plane (hkl) and slip direction [UVW] lying in this plane.

Energy of a screw dislocation:



we consider the cylinder formed by the material between r and $r + \mathrm{d}r$, its shear strain is:

$$\gamma = \frac{b}{2\pi r}$$

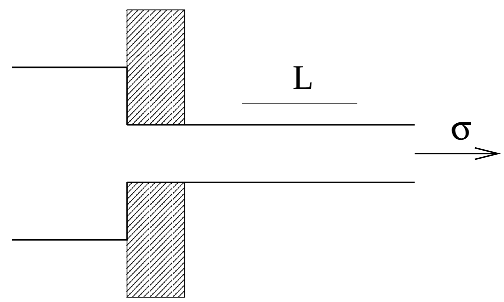
Given its volume $2\pi r L \mathrm{d}r$ where L is the length of the dislocation, the strain energy in this cylinder is:

$$\frac{1}{2} G \gamma^2 \; 2\pi r L \mathrm{d}r$$

by substituting γ and integrating between r_0, lower limit where the strain is no longer elastic, and R, which can, for example, be half the distance to the next dislocation, the energy per unit length of dislocation is:

$$U = \frac{Gb^2}{4\pi} \int_{r_0}^{R} \frac{\mathrm{d}r}{r} + \text{core energy}$$

Cold drawing of Al:



Consider a length L of the Al after drawing. The work required to produce it is obviously:

$$\sigma A L$$

where A is the cross section of the wire. The increase in dislocation density ΔN is associated with an energy increase given by:

$$\Delta N \times AL \times \frac{1}{2} G b^2$$

identifying this quantity to 1% of the work done leads to:

$$\Delta N = \frac{0.02\sigma}{G b^2}$$

Al being a fcc metal, $b = a/\sqrt{2}$. ΔN can then be estimated:

$$\Delta N \sim 1.7 \times 10^{14} \mathrm{m}^{-3}$$

The rise in temperature is obtained by identifying:

$$0.99\sigma = C_v \Delta T$$

giving:

$$\Delta T \sim \frac{\sigma}{C_v} \sim 7\mathrm{K}$$

Therefore the temperature rise is not expected to be a limiting factor. The mechanical deterioration of the wire is more likely to be (must keep σ below the universal tensile strength).