

Problem M25

In addition to chapters 4-7 of Ashby and Jones Engineering Materials. You may also find the chapters on polymers in Ashby and Jones, Engineering Materials 2, helpful (this is a green covered book, available in the Aero-Astro library).

- a) Define the term *polymer*; list three engineering polymers. A polymer is a large molecule made up of smaller repeating units (mers). Typically polymers have carbon “backbones” with side groups consisting of other organic atoms (C, H, O, N).
Engineering polymers: polyethylene, polystyrene, epoxy
- b) Define a *thermoplastic* and a *thermoset*. A thermoplastic softens dramatically with increasing temperature. A thermoset does not. Thermoplastics consist of long polymer chains with no covalent cross-links between the chains. The chains are bonded together by Van der Waals bonds. Thermosets have covalent crosslinks between the chains.
- c) Distinguish between a cross-linked and a non-cross-linked polymer. See above. Thermoplastics are non-cross-linked and Thermosets have covalent cross-links
- d) What is the glass transition temperature?. The glass transition temperature is the temperature at which the Van der Waals bonds melt. It is the temperature at which the elastic properties drop dramatically in thermoplastics.
- e) Explain the change in moduli of polymers at the glass transition temperature. The Van der Waals bonds “melt” at this temperature, i.e. the thermal vibration exceeds the ability of the bonds to hold the molecules together. Thermoplastics rely on Van der Waals bonds for their elastic response at low temperatures. If these bonds are removed, then the polymer behaves viscoelastically, with the elastic component coming from entanglements between the polymer chains.
- f) What is the range of temperature in which T_G lies for most engineering polymers?.
100-500 K.
- g) How would you increase the modulus of a polymer? Introduce covalent cross-links.

Increase degree of crystallinity. Increase alignment of polymer chains.