MATE 313

Fall 2019

Homework # 6

It is due 5:00 pm on January 2nd, 2020

No late submissions!

Group submission (up to 3 students per group) is allowed.

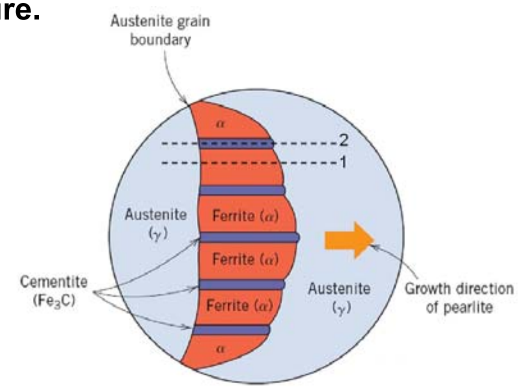
Question 1:

For a plain carbon steel, calculate the minimum possible interlamellar spacing (S^*) in nm if the bulk free energy change for the eutectoid transformation (austenite to pearlite) is -16.5×10^6 J/m^3 and the ferrite/cementite interface energy ($\gamma_{\alpha/Fe3C}$) is 0.8 J/m^2 at some temperature. Ignore the density differences.

Hint: The minimum possible interlamellar spacing (S^*) corresponds to a value where the driving force for bulk transformation is just equal to the total interfacial energy required to create the lamellar structure (i.e. eutectoid product).

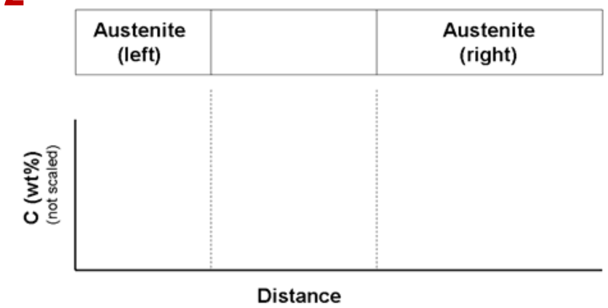
Question # 2

Consider the pearlite formation in an Fe-C alloy with 0.76 wt.% C. Based on the schematic drawn below, <u>plot the variation of the carbon composition along the lines "1" and "2" on separate diagrams</u>. <u>Indicate the exact carbon compositions when possible</u>. Assume that pearlite is forming isothermally just below the eutectoid temperature.

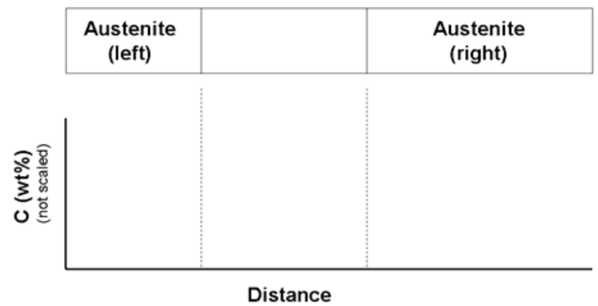


Question # 2

Line 1



Line 2



Question # 3

Discuss the effect of austenite grain size on the TTT curve for a given steel. That is, how does the austenite grain size affect the kinetics of eutectoid transformation? *As compared to a steel with smaller austenite grains, does a steel with larger austenite grains require more or less time for the completion of the transformation?*

Question # 4

An Fe-C alloy containing 1.13 wt.% C has a microstructure consisting of 98% pearlite and 2% proeutectoid cementite.

a) Are these the amounts of the constituents to expect if the sample had been slowly cooled from the austenite region?

b) If not, draw a schematic TTT diagram for this steel and <u>show how such a microstructure could be obtained on the diagram.</u>

Question # 5

Using appropriate sketches describe the formation mechanisms of upper and lower bainite. Emphasize the difference between the two structures.

Question # 6

What are the six differences between martensitic and pearlitic (eutectoid) type transformations in steels?

Question # 7

Calculate the maximum movement experienced by atoms during Bain model of FCC-BCT transformation. Take the lattice parameter of austenite as 0.358 nm, and those of martensite as 0.297 nm and 0.286 nm for "c" and "a", respectively.

Question # 8

Consider an Fe-C alloy with 0.65 wt.% C.

a) How many unit cells are present in 1 mm^3 of this alloy in the austenite phase?

b) What will be the new volume if 1 mm^3 of austenite of this alloy is completely (100%) transformed to martensite?

c) What is the percent change (increase or decrease) in volume?

Lattice parameter for austenite: a = 0.3555 + 0.0044***X** nm

Lattice parameters for martensite:

c = 0.2866 + 0.0116***X** nm and

a = 0.2866 – 0.0013***X** nm where **X** is the carbon content in wt.%.

Question # 9

Discuss the role of austenite grain size on the martensite formed in steels. Do not hesitate to include sketches to make your point.

Question # 10

- In physical metallurgy, martensite is a term used to describe any ………………… transformation product,
- While the austenite grain size does not affect the …………………… of martensite nuclei in a given volume, it affects the final martensite ……………………..
- Pseudoelasticity is a mechanical analogue of one-way shape memory effect with the difference that the driving force for the formation and reversion of martensite is ………………….. rather than ……………………
- The rate of a civilian transformation is interface controlled if the product and parent phases have ....
- .... temperature corresponds to that temperature below which further cooling does not increase the amount of martensite.
- Martensite formed at higher temperatures or slower rates grows by .... mechanism, while martensite formed at lower temperatures and higher growth rates grows by a .... mode.
- The high strength of ausformed steels is thus due to the combined effect of i) …………………, ii) ……………………… and iii) ………………………