Lecture 23-24 : Iron Carbon Phase diagram

Questions:

1. FCC is a more close packed structure yet solubility of carbon in austenite which is FCC is higher than that in ferrite which is BCC. Why it is so?
2. Sketch the microstructure of 0.2% C steel. Calculate %Pearlite % cementite, % proeutectoid ferrite and % total ferrite.
3. Estimate the ratio of the widths of ferrite and cementite plates in lamellar pearlite.
4. Sketch the temperarture – time diagram during the heating cycle of a 0.8% C steel. Use standard Fe-Fe3C phase diagram.
5. Estimate %Cm in Ledeburite just below eutectic and just above eutectoid temeratures. What is its structure at room temperature?
6. If an eutectoid steel is kept at 700^{o}C what change do you expect?
7. What is the limitation of phase diagram?
8. If a piece of steel having 0.8 % carbon has martensitic stucture can it be converted to fully pearlite structure by holding it at 700^{o} C?
9. Suggest a method of getting a mixture of Pearlite, Bainite & Martensite in an eutectoid steel.
10. Which microstructure in eutectoid steel has maximum hardenss? Give reason.

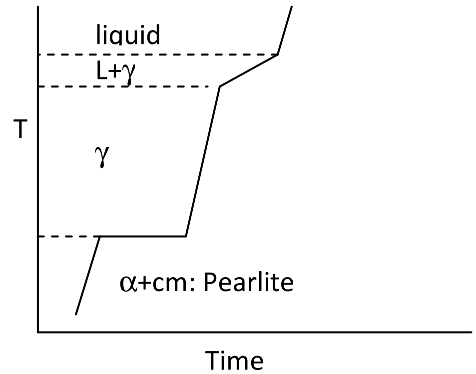
Answer:

1. There are 2 types of interstitial sites octahedral & tetrahedral. In FCC the former is significantly larger than the latter. Whereas in BCC these are nearly same. The total open space is shared by more number of sites. Therfore interstitial gap in BCC is much smaller than that of FCC. This is why carbon which occupies interstitial site has higher solubility in austenite (FCC).

2. The stucture would consist of proeutectoid ferrite and pearlite. Assume solubility of carbon in ferrite is negligible. Refer to phase diagram to get % Pearlite in 0.2% carbon steel = $\frac{0.2-0}{0.8-0} \times 100 = 25$ Balance 75% is proeutectoid ferrite. % Cementite = $\frac{0.2-0}{6.67-0} \times 100 = 3\%$ and total ferrite = 97%.

3. Assume density of ferrite and cementite to be same (Note that in reality density of cementite is a little higher than that of ferrite). % ferrite in pearlite = $\frac{6.67-0.8}{6.67-0} \times 100 = 88$. Balance 12% is cementite. Therefore the ratio of the widths of the two = 12/88. This is approximately equal to 1:7.

4. 0.8 % carbon corresponds to an eutectoid steel. It would first transform into austenite and then it starts melting when the temperature reaches its solidus temperature. It becomes totally liquid when temperature goes beyond its liquidus. Shematic heating curve is as follows:



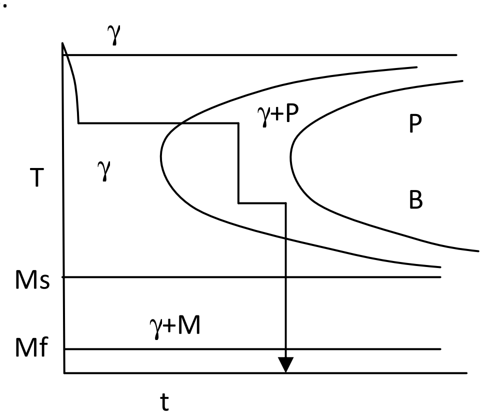
5. Assume % C in eutectic = 4.3. % Cm just below eutectic temperature = $\frac{4.3-2.0}{6.67-2.0} \times 100 = 49\%$and just above eutectoid $= \frac{4.3-0.8}{6.67-0.8} \times 100 = 60\%$Between eutectic to eutectoid temperatures proeutectoid cementite precipitates from austenite in eutectic. On subsequent cooling the austenite transforms into pearlite. At room temperatutre what we have is transformed eutectic.

6. Lamellar structure is unstable as it has large surface area. Initially the cementite plates would break down in to globular structure. Size of the globule will grow with time. Cementite is also metastable on prolonged thermal exposure it breaks down in to ferrite and graphite.

7. Phase diagram does not show the effect of cooling rate. It gives the expected phases in an alloy at a given temperature under equilibrium condition.

8. No. To get pearlitic structure it must be heated back to austenite state then cooled slowly.

9. This is possible through two step isothermal transformation in Pearlitic & Bainitic region followed by queching. The cooling scheme is shown below. Note that no transformation takes place during quenching (fast cooling: the virtical step in cooling curve) if temperature is above Ms.



10. Martenstic structure has the maximum hardness. This is because of the presence of carbon atoms in the interstices is far in excess of its normal solubility in ferrite lattice. This results in tetragonal lattice distortion. This makes dislocation movement very difficult. This in conjuction with extremely fine microstructure account for the high hardness of Martensite.