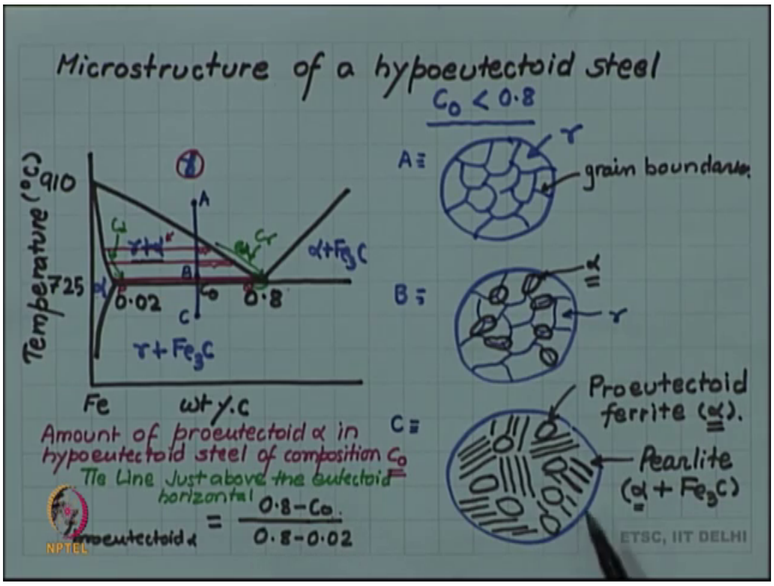
Introduction to Materials Science and Engineering
Prof. Rajesh Prasad
Department of Applied Mechanics
Indian Institute of Technology, Delhi

Lecture - 79
Microstructure of a hypoeutectoid steel

(Refer Slide Time: 00:06)



So, we saw in the last video microstructure of a eutectoid steel. Now let us look at micro structure of a hypoeutectoid steel and hypoeutectoid if you remember is a steel less than the eutectoid composition which is 0.8. The phases in our diagram is Austenite, Gamma, Ferrite, Alpha; this is a two phase region Gamma plus Alpha. Alpha plus F e 3 C and Gamma plus F e 3 C. I hope you are gradually becoming familiar with these phases and these nomenclatures names and symbols Alpha, Ferrite, Gamma, Austenite, F e 3 C, Cementite and so on. And the hypoeutectoid steel in our case is a steel less than 0.8. So, it will be in this side. So, let us take a vertical line corresponding to our hypoeutectoid steel.

So, let me take this line. So, this will be corresponding to a hypoeutectoid steel and let us consider the microstructure at A, microstructure at B and then microstructure at C. Corresponding to A, it is a single phase Austenite and you have already seen that that will be a single phase Austenite which will be a poly crystalline Gamma. So, you will have grains and grain boundaries, gamma and these lines which you see in the microstructural grain boundary. Now when you cross this line the Gamma, Gamma plus Alpha boundary then you enter into the Gamma plus Alpha phase field.

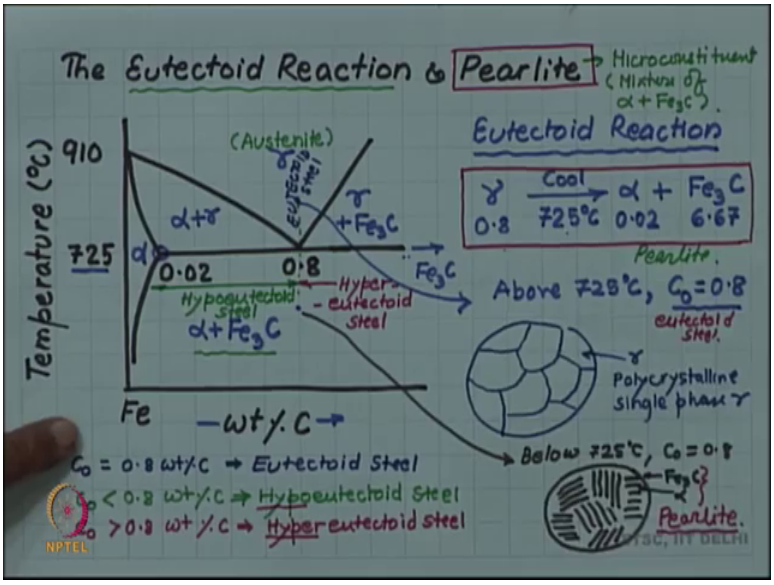
Notice that Austenite was already present, Austenite was already present. So, the new phase which is occurring is Alpha. So, which means if we cross this phase boundary Alpha will start forming.

So, to look at the microstructure at B which is in the two phase region, we can again start we can start with the Alpha phase. Sorry, we can start with the Gamma phase, the Austenite phase field we had that to begin with. So, this is our beginning Austenite, but then Alpha phase will start forming at various locations. And we will see when we discuss phase transformation that there is something called heterogeneous nucleation. A new phase which wants to form prefers to form at grain boundary. So, quite often the Alpha phase will form at the grain boundary. So, this is a new Alpha phase which is forming and i am showing that them to be forming at the grain boundaries. And as we cooled you have seen the Lever Rule, that as you cool at a given temperature. The fraction of Alpha phase will be the opposite lever arm and you can see that as we are cooling this lever arm representing the Alpha phase is increasing.

So, as we are cooling and we are approaching this eutectoid, horizontal of 725 more, and more Alpha phase will form and then certain amount of Alpha phase will be there when it has just hit the 725 eutectoid horizontal. So, this Alpha phase which has formed. So, this is now Alpha and the remaining original phase was Austenite and you have reached, let us say 725. You have also seen that the composition of Gamma, the Austenite will face a will follow the Gamma phase boundary the composition C Gamma will follow this line; C gamma. C Gamma will evolve along this line and C Alpha will evolve along this line the composition of the Alpha phase.

So, you can see when you hit 725, the gamma phase now has a composition of 0.8 weight percent carbon. So, this Gamma phase is at 0.8 weight percent carbon and is at 725 degrees Celsius recall the eutectoid reaction.

(Refer Slide Time: 05:44)



A Gamma phase of 0.8 weight percent carbon, at 725 degrees Celsius on further cooling will form Alpha plus F e 3 C and that was our Pearlite; this was the Pearlite. So, which means in this case, we now have lots of Alpha which have already formed in the Gamma plus Alpha phase field. But the remaining Gamma whatever is there at 725 degrees Celsius is of the right composition 0.8 weight percent carbon and at right temperature 725 degree Celsius for the eutectoid reaction to happen.

So, on further cooling this remaining Gamma will transform into Pearlite through the eutectoid reaction. So, at C we will expect a microstructure whatever original Ferrite, Alpha which you had formed will remain . These chunks of Alpha will remain, but the remaining Gamma will now transform into a mixture of Alpha and F e 3 C, the pearlite. Just like it happened in the eutectoid steel only differences in the eutectoid steel the entire alloy transformed into this pearlite. In this steel part of the alloy has transformed only into the Ferrite phase, the remaining is transforming into this mixture.

So, this microstructure then is labeled as whatever we see and you can see it in the real microstructure. I am drawing of course, a cartoon microstructure, but please access nice micro structures are available on the web. So, you can distinguish between these, chunky or blocky Alpha and to distinguish that. And they have formed also at a different time and by a different mechanism, they formed in the Gamma plus Alpha phase field. So, we designate this Alpha by a special objective pro eutectoid to indicate that this was not part of the eutectoid reactions.

So, we call it pro eutectoid Ferrite or pro eutectoid Alpha. Meaning; it formed before the eutectoid reaction and then you have these alternating plates of Alpha and F e 3 C. So, alpha is there in that also, but we name this entire mixture and that is we have already named this as Pearlite which is a mixture of again Alpha and F e 3 C. This alpha formed during the eutectoid reaction, this alpha form before the eutectoid reaction and that is why we give it a designation pro eutectoid Ferrite.

So, a hypoeutectoid steel will consist of the microstructure of hypoeutectoid steel will consist of proeutectoid Ferrite and Pearlite. Can we say how much proeutectoid ferrite and how much pearlite? Remember, we did this kind of a calculation also for the Lectin eutectic system and you can see that there is some similarity of the name also. There, the phase which formed before the eutectic reactions was called a proeutectic phase. So, there we use the phase proeutectic, here we are using the phase proeutectoid.

So, eutectic reaction and eutectoid reaction has a commonality and one should use the two phases carefully when we. I did not emphasize it here. So, let me do it now. The eutectoid is different from eutectic. In both cases, we have a single phase on cooling decomposing into two solid phases. But in eutectic which was there in the left in, the single phase which is decomposing, the high temperature phase was a liquid phase. So, if a liquid phase decomposes into two solid phases we call that a eutectic reaction and in the case of Austenite, which is a solid phase decomposing into two phases we call that a eutectoid reaction.

So, there we had proeutectic Alpha or proeutectic Beta, here we have proeutectoid Ferrite. But the way of calculating it, remember we should have a tie line because where was the proeutectoid Ferrite formed? It formed in the two phase field Gamma plus Alpha. So, if we want to find the amount of proeutectoid Ferrite, we should use a Lever Rule on a tie line which is just above the eutectoid horizontal. So, if I take this tie line, let me call that P Q. So, amount of, let me write amount of proeutectoid Alpha hypoeutectoid steel of composition C naught.

Let us say that its composition C naught. C naught will be somewhere less than 0.8. So, it will be between 0.02 and 0.8. So, if we want to find out for a general composition C naught, we can write the fraction. So, let us say tie line, tie lines should be just above the eutectoid horizontal, just above the eutectoid horizontal. So, if we now write f Alpha let us say f, let me use f proeutectoid Alpha. So, this will be the opposite arm; I am trying to find Alpha, so opposite arm.

So, it will be from my composition C naught to 0.8 because Alpha is on the left. So, I am taking the right arm. So, this will be 0.8 minus C naught divided by the full arm which in this case is 0.8 minus 0.02. So, this will give you the fraction of proeutectoid Alpha and this of course, will depend upon the composition C naught. And you can see that add C naught increases the amount of proeutectoid Alpha will decrease. So, as we start from 0.02, 0.02 will give you 100 percent proeutectoid Alpha because you are at this end.

And then gradually as you move the amount of proeutectoid Alpha will be decreasing, amount of Pearlite will be increasing. And at 0.8, we have seen at 0.8 the numerator becomes 0. So, amount of proeutectoid Alpha will become 0 and you will have 100 percent Pearlite, which is what we had seen in the case of eutectoid steel.