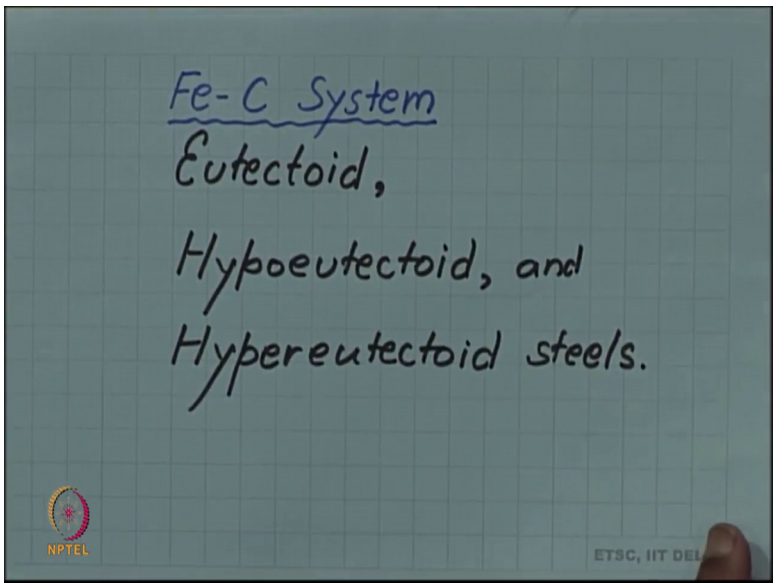
Introduction to Materials Science and Engineering
Prof. Rajesh Prasad
Department of Applied Mechanics
Indian Institute of Technology, Delhi

Lecture – 78
Eutectoid, hypoeutectoid and hypereutectoid steels

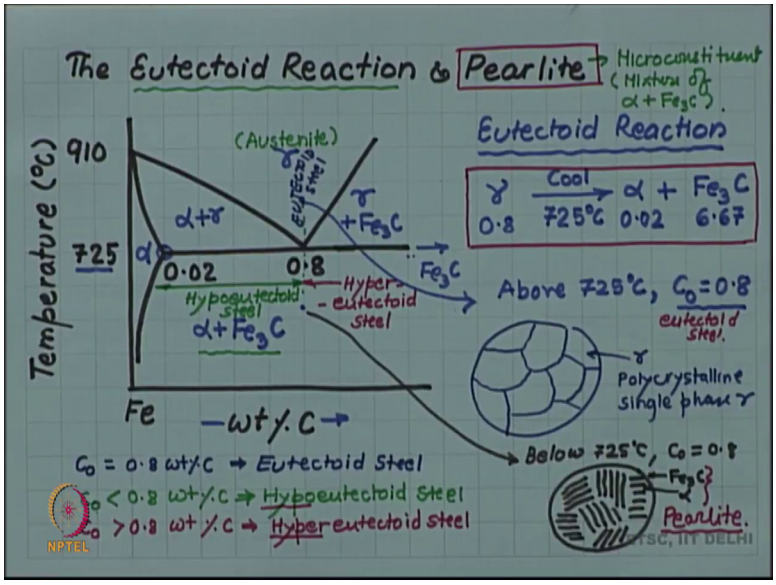
We are talking about the iron carbon system. In the last video, we saw the phase diagram of iron carbon alloy system. A very important alloy system because, iron carbon is what gives us steel and, that is the most important engineering alloy.

(Refer Slide Time: 00:27)



So, we looked at the entire phase diagram of the iron carbon system last time. And we saw that in that system there are three different invariant reactions a peritectic reaction at a very high temperature, then an eutectic reaction at an intermediate temperature. And finally, a eutectoid reaction at a lower temperature and, we said that that eutectoid reaction is one of the most important reaction from the point of view of control of microstructure, in iron carbon system. So, we will look at that in detail later.

(Refer Slide Time: 01:07)



So, at the moment let us look at what do we mean by this eutectoid hypo eutectoid and hyper eutectoid steels. So, this is the lower portion of the phase diagram which you saw last time and, this is the eutectoid horizontal at 725 degree Celsius. This is the eutectoid horizontal, the phases are above the eutectoid horizontal you have gamma.

Close to pure iron you have alpha and towards the right hand side you remember the phase diagram ended at Fe 3 C. So, these were this line is moving towards Fe 3 C which will come at 6.67 weight percent. So, we have not gone all the way up to that point. So, which means now by one to one rule you have alpha plus gamma here, you have gamma plus Fe 3 C here and, you have alpha plus Fe 3 C here in the 2 phase regions. So, you can see here that if we cool gamma and recall the names gamma was austenite. So, if you cool austenite of 0.8 percent carbon, gradually such that equilibrium is maintained, then above 725 it will remain austenite or gamma, but below 725 it will become alpha plus Fe 3 C, it will transform into alpha plus Fe 3 C.

So, this is the reaction which is called the eutectoid reaction, this is what we mean by eutectoid reaction. So, let us write down that reaction. So, we have gamma. So, eutectoid reaction means gamma that is the austenite of 0.8 percent carbon upon cooling at 725 degree Celsius will transform into a mixture of 2 phases one is alpha the ferrite and, another is a Fe 3 C the cementite. The alpha composition is given by this point here, that is 0.02 and Fe 3 C composition it is a compound and it is composition is 6.67.

All compositions are in weight percent carbon which is what we are using as the unit of composition. So, this is the eutectoid reaction and, this is we said that this is the most important reaction, most important invariant reaction in the iron carbon system out of the three reactions which are present in that diagram, this is the most important one.

Now, what will be the microstructure of the steel, which has been cooled through the 725. So, what will be the microstructure here and we can also talk about what will be the microstructure there. So, in the austenite phase field if you if you think of the austenite phase field that is above 725 above 725 degree Celsius. And let us take an alloy of composition eutectoid composition which is 0.8, then this is a steel 0.8 percent steel is what is called the eutectoid steel.

So, let us note down that nomenclature. So, if the alloy composition is C naught alloy composition C naught is 0.8 percent carbon, we call this eutectoid steel eutectoid steel. So, this vertical line which we are considering this is eutectoid steel eutectoid steel and, then alloys which will be less than if C naught is less than 0.8 weight percent carbon, we will call this a hypo eutectoid steel hypo eutectoid steel. So, in this range we will have hypo eutectoid steel.

And if the composition is more than 0.8 percent carbon, we call this hyper eutectoid steel hyper is more hypo is less so, hypo eutectoid is less than composition is less than the eutectoid hyper composition is more than the eutectoid. So, in this range you have hyper eutectoid steel.

So, this is the nomenclature. So, we are now currently considering the eutectoid steel that is 0.8 weight percent carbon. So, eutectoid our steel is eutectoid steel. And that steel if I look at the microstructure above 725, then I should have a single phase gamma, but you have now studied that although it is single phase it need not be single crystal, there may be many differently oriented crystal giving you what is called the grains and grain boundaries.

So, all grains are gamma, but it is polycrystalline. So, polycrystalline single phase austenite gamma. If you now cool then at 725 this reaction will proceed, and you will start forming alpha and Fe 3 C. So, if you now look at alpha plus Fe 3 C, we will we will get so, somewhere here let us say below 725 degree Celsius same steel eutectoid steel.

We will have a microstructure in which alpha and Fe 3 C both will form as alternate plates. Now the phase diagram does not tell us phase diagram does not tell us the morphology, phase diagram is only telling us that we will have a mixture of 2 phases alpha and Fe 3 c, but it so happens that if you look at the microstructure, then you get alternate plates of alpha and Fe 3 C and these plates will be oriented differently in different region, these are called different colonies. So, the microstructure which you get here is so, let us say that the dark lines the Fe 3 C and the white region in between is alpha.

So, you have mixture of alpha and Fe 3 C and this mixture has been given a special name in steel terminology, this has a special name and that is called pearlite. So, this mixture alpha plus Fe 3 C mixture this is what is called pearlite. So, which means a eutectoid steel which is cooled slowly through the 725 degree Celsius will show in it is microstructure pearlite, 100 percent pearlite entire microstructure will be pearlite, but note that pearlite is not a single phase it is not a name of a phase, but it is name of mixture of 2 phases, which have a certain appearance in the microstructure. So, pearlite is a micro constituent and not a phase. Let us note that here the micro constituent which means it appear it has a certain appearance in the microstructure, but it is a mixture of 2 phases, mixture of alpha plus Fe 3 C.