Introduction to Materials Science and Engineering

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Lecture – 103
TTT diagram of alloy steel

Till now we have discussed TTT diagram time temperature transformation diagram of plain carbon steel, by plain carbon we mean that; these steels have mainly carbon as the significant alloying addition, but there are steels which are alloy steels where apart from carbon there are other elements have been deliberately added to alter its properties. So, these steels are called alloy steels. So, let us look at how alloying modifies the TTT diagram.

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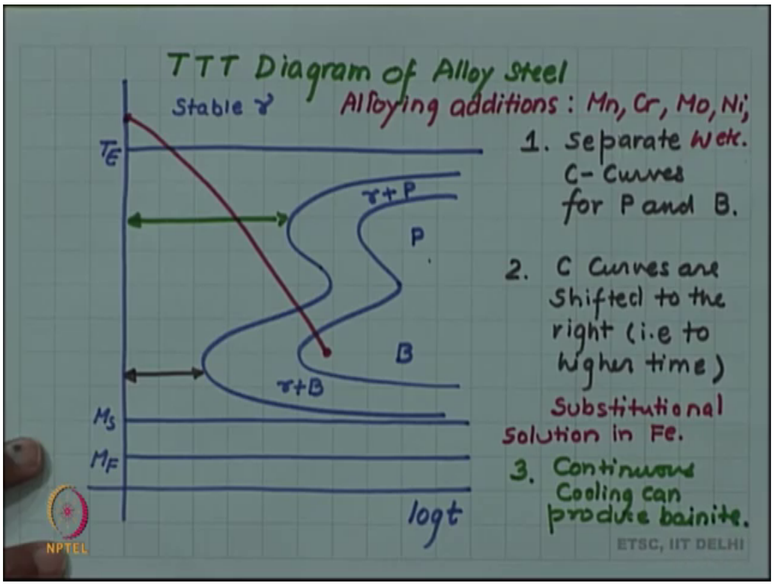

So, here is a example not of any particular steel, but a schematic one of how what the alloying does so to the TTT diagram. So, diagram of alloy steel first of all, you see that instead of a single nose which was there we now had seemed to have two noses. So, there are two separate C curves that is the C curve for pearlite and bainite have been separated. So, this is the first effect of alloying that they are separate C curves for pearlite and bainite. In the case of plain carbon steel ah, the C curves for pearlite and bainite. So, merged that the upper part was for pearlite and the lower part was for bainite.

And you had a single nose where they met, but now polite has its own nose and the bainite has its own nose. So, the first thing is that there are separate C curves for pearlite and bainite.

Also, the other effect is that the C curve has been shifted to the right that is to the higher time side. So, this time for example, is much longer than in the plain carbon steel. So, we can say C curves shifted to the right that is to higher timescales. That is formation of pearlite and bainite now become sluggish slower it takes longer for pearlite and bainite to form in an alloy steel than in a plain carbon steel.

This fact is related to what you studied in diffusion, because all the alloying additions most of the alloying additions let us note some of them. So, the alloying additions are some common alloying additions are manganese, chromium, molybdenum, nickel, tungsten etcetera. So, these alloying additions are substitutional solute for ferrite and cementite.

So, substitutional and you have seen and that carbon is interstitial solute and you have also seen in the diffusion chapter that substitutional solute diffused much slower than interstitial solute. So, because of the slower diffusion of of this additional alloying addition these transformations both pearlite and bainite transformation becomes slower, and gives you more time at the nose. Also, you can see that the suppression of pearlite is much more than that of bainite.

So, this exposes bainite nose below the pearlite nose and so in the case of alloy steel often it is possible to produce bainite simply by a continuous cooling. So, if I start with austenite and if I choose a cooling rate which avoids the pearlite nose, but enters into the bainite reason by continuous cooling I can produce bainite. So, this is another feature of alloying continuous cooling this was not possible in plain carbon steel.

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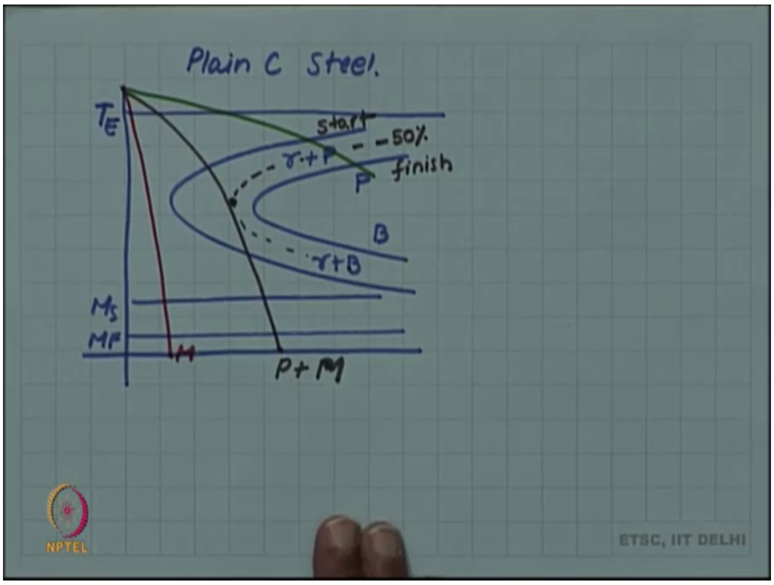

You can see that in the plane carbon steel since you had a single nose, since you had a single nose.

So, there was no way that if I cool slow, if I cool slow I form pearlite. If I cool very fast I form martensite, but there is no way for continuous cooling to produce bainite of course, I can have an intermediate cool some of you may be thinking it what will happen, if I cool at an intermediate rate like this in this kind of intermediate cooling also you can have, just like we have for a start we have seeker for a start and finish. You can have seeker for different amounts of transformation.

So, this will be let us say 50 percent transformation seeker for 50 percent transformation. And this black curve is touching the 50 percent transformation and the transformation is happening above the nose. So, this black curve will still produce 50 percent pearlite, remaining 80 percent is austenite and will not transform to bainite on continuous cooling, but will be transformed to martensite as it crosses MS and MF.

So, the microstructure produced here will be pearlite plus bainite, sorry pearlite plus martensite and there will be no bainite. So, bainite cannot be produced on continuous cooling in plain carbon steel, but here you are seeing that in alloy steel bainite can be produced by continuous cooling. So, these features of alloying and its effect on the TTT diagram should be kept in mind.