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

Lecture – 98
Austempering and Bainite

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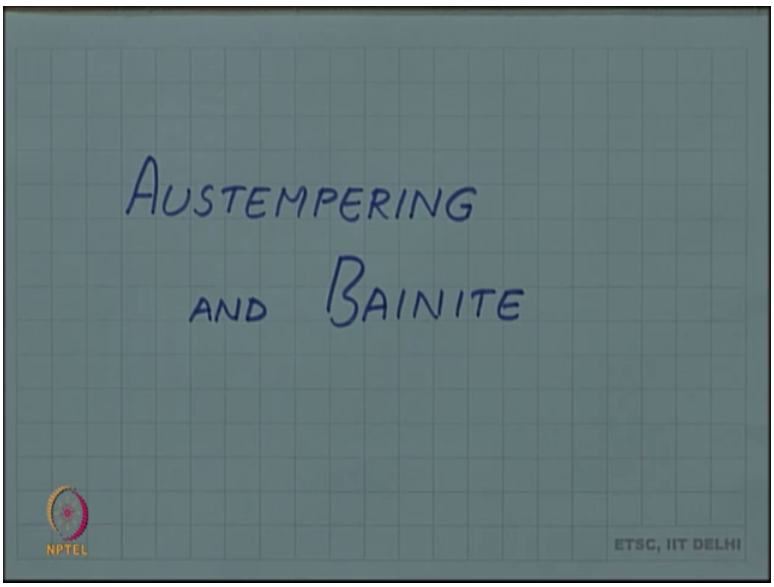

Let us discuss Austempering which is one of the heat treatments which we listed in our original list of the treatments. Austempering produces Bainite and this is what we will discuss.

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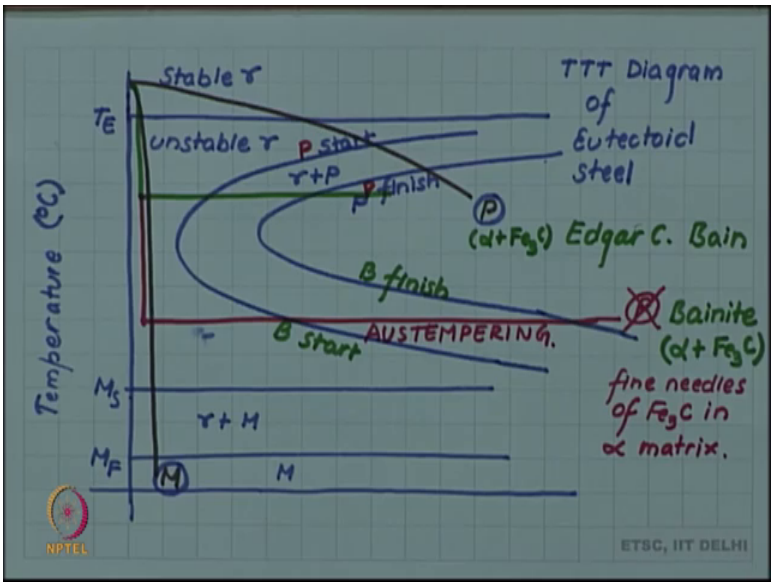

Now, so we are familiar with the TTT diagram now this is the TTT diagram of eutectoid steel, TTT diagram of eutectoid steel. And we have seen how slower cooling's will lead to formation of Pearlite either through annealing or normalizing coarse Pearlite fine Pearlite. And a very fast quench or a fast cool will lead us to martensite this whole business of TTT diagram this whole discovery or development of TTT diagram was done by an American metallurgist named Edgar C Bain.

And when he was forming or developing this diagram, he decided to isothermally cool austenite quenched from very high temperature so in fact, he was not continuously cooling as shown in these lines, but he was initially quenching, quenching fast and then holding for transformation.

And we saw that it is transforming to Pearlite, but when he carried this experiment to much lower temperature; So, if you cool to a low temperature and then hold it at that temperature for transformation to happen. Then he found that the transformed product did not resemble Pearlite this was not Pearlite.

So, this he was surprised with this because nobody had done in this norm annealing normalizing and quenching were all historical processes before Bain and people have tried this. So, Bain only given better explanation through his TTT diagram of these well-known heat treatment like annealing normalizing and quenching, but nobody had tried quenching to a temperature below the nose of the seeker curve and keeping it above the

martensite start temperature. So, at such an intermediate temperature below the nose and above MS austenite transforms and it transforms to a structure which does not resemble Pearlite.

This new structure later on in honor of Bain was named Bainite. So, really the start curve and finish curve below the nose are Bainite start and Bainite finished instead of Pearlite start and Pearlite finish. So, we can now label these start curves as Pearlite start and Pearlite finish whereas, these are Bainite start and Bainite finish. And why it was not resembling perlite; because Bainite was not having.

So, it was also consisting Bainite is also alpha plus Fe 3 C. In terms of the phases both Pearlite and Bainite are mixture of same two phases, but in terms of appearance under the micro microscope or in terms of the shape of the phases they are very, very different. We saw in Pearlite alpha and Fe 3 C form like alternating plates whereas, in Bainite that is not the case in Bainite we have very fine needles fine needles of Fe 3 C in alpha matrix.

This is a simple description of course, there are different forms of Bainite also depending upon the temperature close to the nose we have upper Bainite and lower down above MS we have lower Bainite and so on.

We will not go into those distinctions and there are differences in their microstructure, but one form of Bainite which we will accept for our purpose is fine needles of Fe 3 C in the alpha matrix. So, this is how Bainite differs from Pearlite which was alternating rates of alpha and Fe 3 C. This heat treatment as we have seen is named as Austempering. So, it is used for some steel and we will call this austempering.

So, austempering happens when an austenite is quenched below the nose of the C curve, but above MS and then that austenite is allowed to transform. The transformed product is alpha plus Fe 3 C, but it is not Perlite, but it is Bainite because of the different distribution of Fe 3 C and alpha.

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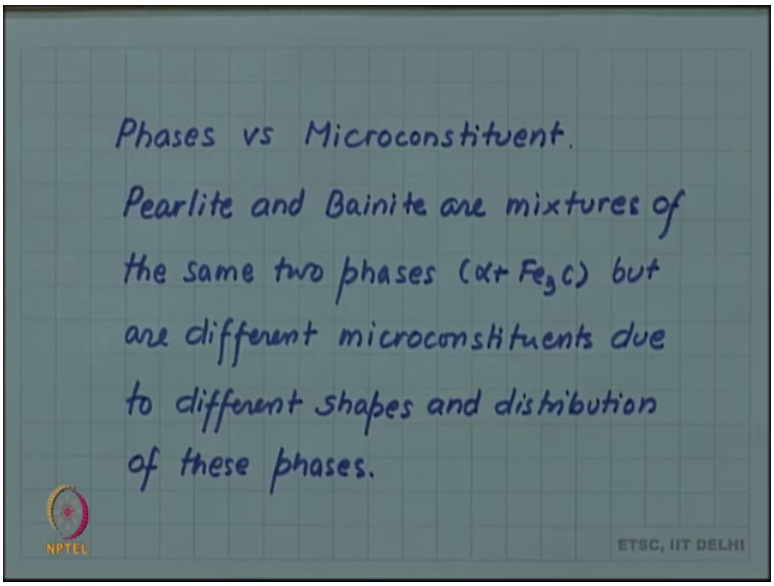

So, one important point here we should note is a distinction between phases and micro constituents. So, Pearlite and Bainite are mixtures of the same two phases, but at different micro constituents due to different shapes and distribution of these failures.

So, their appearance in the microscope is different. So, based on the difference in the appearance in microscope there are different micro constituents, Bainite and that why they have different name Pearlite and Bainite, but in terms of phases both of them are alpha plus Fe 3 C.