Introduction to Materials Science and Engineering
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Lecture - 71
Proportion of phases present in the system

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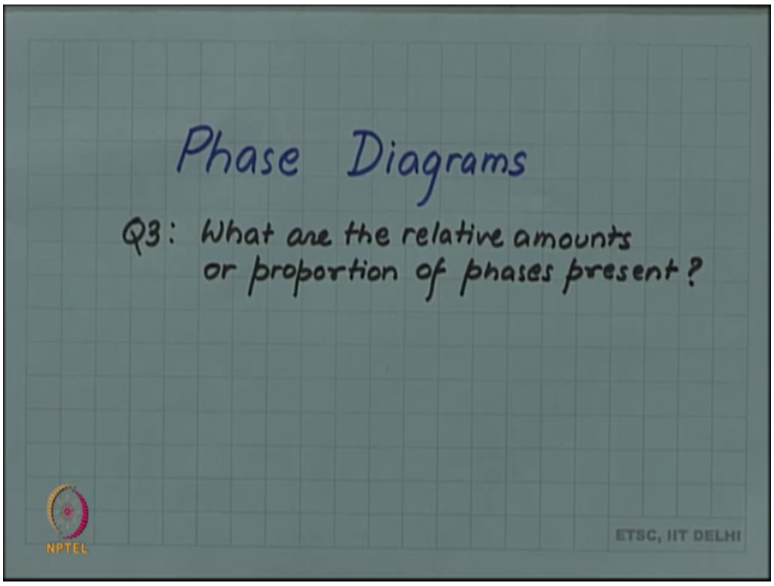

So, let us now take up the third and the final question from our list of questions which we stated which our phase diagram can help us answering. So, the third question is what are the relative amounts or proportions of the phases present.

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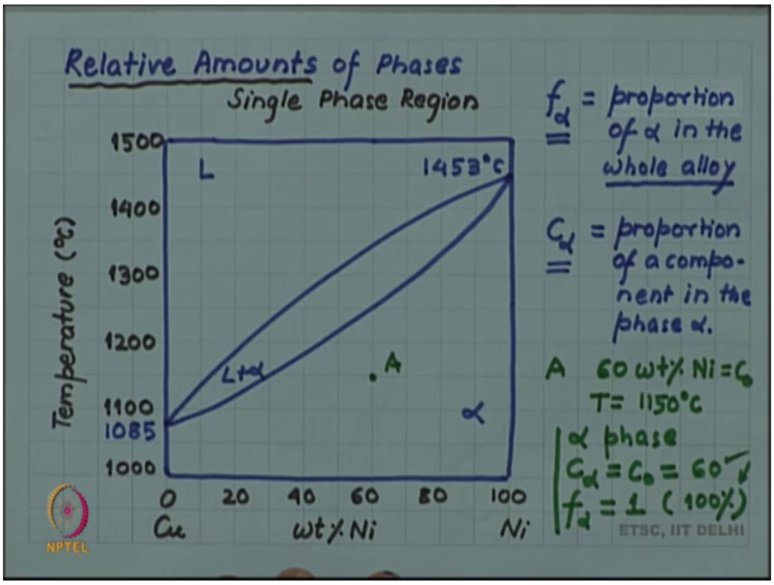

So, let us look at this question first of all it is very important to understand the distinction between composition and the relative amount at the beginning a student this itself sometimes causes some confusion.

Because both of them are expressed as percentages or fractions, but the two are actually having very different meanings. So, when we say a relative amount, we mean suppose I want to say a relative amount of any given phase f alpha. So, by this we mean proportion of alpha and for relative amount we will always use this symbol f. So, proportion of alpha in the whole alloy whereas, when I say C alpha which is the composition.

So, this is proportion of a component proportion of a component in the phase in the phase alpha. So, here the reference is whole alloy and we are trying to find out or we are talking about what proportion of the whole alloy is as alpha phase. Whereas, here the focus is on alpha phase and we are trying to find what is the proportion of let us say in this example copper and nickel in alpha phase.

So, proportion should be distinguished from a composition relative amount should be distinguished from composition, although both are a kind of proportion and both can be expressed as fraction or percentage. So, if we have a single phase the question is quite trivial. So, if we have a single phage suppose. So, if our constitution point was this. So, we have point which is 60 weight percent nickel. So, that is the alloy composition C naught and the temperature is 1150 degrees Celsius we have seen simply by reading the phase diagram, we find that alpha phase is present.

So, it is a single phase alpha and then we also saw that the composition of alpha has to be the same as the alloy composition because this is the only phase present. So, this will also be 60 weight percent nickel. And finally, the proportion of alpha of the fraction of alpha in this case since again since it is a single phase the entire alloy is alpha. So, alpha occupies whole of the alloy. So, it is fraction is 1 or in percentage 100 percentage

We usually we write the same symbol and we do not use different symbol for fraction or percentage depending on what we have written, we understand whether we are writing the fraction or we are writing the percentage will always be written with a percentage symbol.

So, for a single phase region all the three all the three questions are very simple to answer that it is a single phase directly readable from the phase diagram composition same as the alloy composition. So, readable from the diagram if the point is given and the fraction is 100 percent or one again simply by the mass balance.

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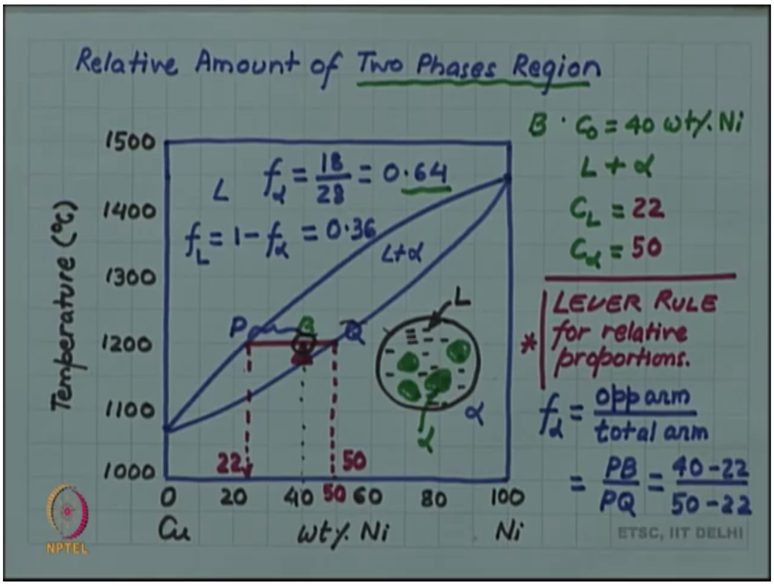

Now, the question becomes interesting if we take a point in the two phase region. So, let us consider a two phase region, let us consider this point now the point B. So, for point B in this diagram we have C naught is equal to 40 weight percent nickel, phase since it is in the two phase region it is both liquid and alpha and we have seen that in this case the phase composition C L and C alpha are not the same as the alloy composition, they are different and they are given by what is called the tie line rule.

So, for that we draw a tie line which is in horizontal isotherm running from one boundary to the other boundary defining the two phase field. And then by reading the composition of the liquid end we get liquid composition. So, C L in this case let me say we are getting something like 22. So, C L is 22 from my tie line and this is let me say is 50. So, C alpha is 50.

Now, I want to calculate the fractions. So, this is given also by again by the tie line by a rule, which is very important rule and is called lever rule. Lever rule for relative proportions and what is this lever rule? The tie line is assumed to be a sort of leaver with two arms, one arm is on the liquid side and another arm is on the alpha side. So, let me call this point P and this point Q.

So, the lever rule tells us that a fraction of any given phase let me say, that I want to find the fraction of alpha age. So, I write f alpha. So, for any given phase the fraction is opposite arm magnitude of the opposite arm of the lever by the total arm. What we mean here let us see alpha is on this side on the right hand side. So, opposite arm of the lever is P B, the opposite arm of the lever is P B, the overall arm of the lever is P Q and the length of these arm this is actually horizontal isotherm. So, it is parallel to the x axis.

So, these lengths are actually expressed as compositions. So, P B is representing the length of P B is 40 minus 22 divided by length of P Q is 50 minus 22. So, if we continue our calculation here of f alpha we will find 40 minus say 22 is 18 divided by 50 minus 22 is 28. So, that is the fraction of the alloy which will be in alpha and since it is a two phase alloy then; obviously, since it is a two phase alloy; obviously, the other phase the liquid phase will be 1 minus f alpha.

So, if you if you do the calculation, this comes out to be 0.64 and correspondingly this will come out to be 0.36. So, this tells us that. So, what will really happen let me try to create a schematic structure, what is expected at this point B. So, if I have. So, I have a mass of alloy then that alloy will have both liquid phase and solid phase.

So, let me represent the solid phase by these chunks and the liquid phase with these dashed lines. So, alloy is divided into a liquid phase and the alpha phase and the proportion of alpha phase in the whole alloy as calculated by the lever rule will be about 64 percent and the proportion of liquid in the whole alloy will be 36 percent.

So, that is a very important rule lever rule, this rule originates from simple mass balance because you can see the overall alloy composition has to be 40, and if we have alpha of 50 percent and liquid of 22 percent, they have to be mixed in a given proportion they cannot be mixed arbitrarily. If we mix them arbitrarily the overall composition of forty will not be achieved. So, they have to be mixed in a fixed proportion and that is the proportion which we are calculating.

Here only if we take 64 percent of alpha and 36 percent of beta in the alloy, then the overall composition will turn out to be 40. So, the lever rule is actually a rule of mass balance, we will actually try to derive this in the next video.