Principles of Metal Forming Technology
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Lecture - 29
Introduction and Classification of rolling processes

Welcome to the lecture on Introduction and Classification of rolling processes. So, now, we will move towards the discussion about the rolling process you must have the idea about the rolling process which we discussed sometimes that you know in the rolling process, we use the rolls which are normally you know cylindrical in nature. So, they are very very hard; extremely hard rolls and these rolls are rotating in opposite direction and the work is fed in between the rolls.

Now when they are going to touch the roll at that time you know they are touching in a larger you know there thickness is more; but because of the friction basically and since they are moving in opposite direction. So, because of the friction which is there in between the work piece and the roll, they are forced in into the basically what happens that you have the rolls, you have normally this way of circular rolls.

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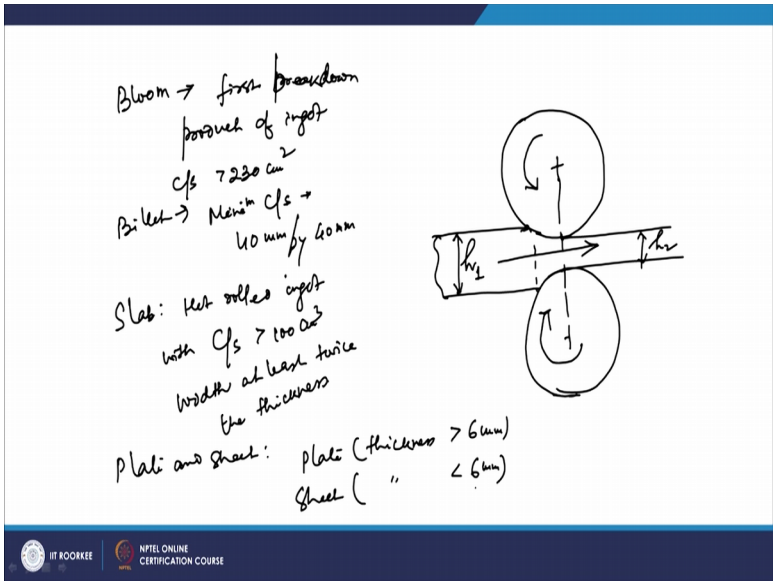

And what happens that these rolls; so, they will have this common center this is the center point and the. So, this will be rotating in the direction and this will be rotating in this direction.

So, this is basically in the opposite direction. This is moving in this direction; this is moving in this direction and the what basis basically fed from here and was it goes here also you we will have frictional force is acting at this place and because of this friction, the frictional force will be acting in that direction and this friction force basically will push this stock in to in between the rolls and ultimately the roll will come inside and then it will be going out.

So, while going out, it is thickness suppose here, it is this is h 1. So, this will be going as h 2. So, the height or thickness of the slab or this stock material is getting reduced and basically it is theatrically equal to the gap between these two rolls. So, this is roll gap.

So, this is normally a rolling process and these rolls are extremely, I mean hard they are made of hard materials and this is used for basically you know converting these ingots or to make this slab or slab, further to make billets or then and then finally, we are making the sheets also from these rolls.

So, based upon the temperature, we classify this rolling process as hot rolling or cold rolling depending upon the temperature at which we do this processing operation. So, if it is done at a temperature higher than its recrystallize and temperature, it will be hot rolling; otherwise it will be the cold rolling.

Now, in the industries you have if you talk about the large industries; even in earlier days or even now. So, now, they use to make the ingots, now these ingots basically are further processed and you make the different shapes of the products you know different cross section, difference are based upon the different sizes; you define those you know products.

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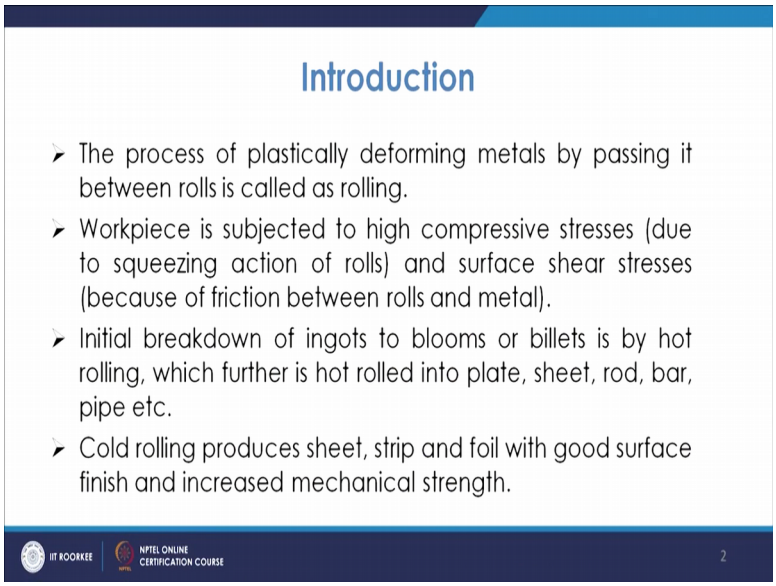

So, what we see is that the roll process of plastically deforming metals by passing it in between the rolls. So, that is known as rolling. Then Work piece is subjected to very high compressive stress due to the squeezing action of the rolls.

So, rolls are basically squeezing on the metal and because of that and the surface here stress, there will be you know shear stress developed and because of the friction between the roll and the metal and that basically is you know useful or responsible for doing the plastic deformation you know in the material.

So, initial breakdown of ingots; ingot is basically it will be breakdown to the blooms or billets. So, in that basically the degree of reduction is quiet high. You have to deform you know appreciably. So, in that that is done at the high temperature and that is basically under the you know umbrella of hot rolling processes. Because there it has to deform you know to large extent.

And then, further when you are going to define I mean to roll to get the final shape and size or so. And when the emotional accuracy is required finish is required, in those cases we go for the cold rolling. So, and when we can go for the hot rolling for so; first of all, you have to convert to the simpler shapes like blooms or billets. And then, you can go for you know making the plates sheets rods or bars or pipes.

So, they can be you know hot rolled and you have many a times you make many products by the rolling process by making the you know proper sign, you know type of roll; in that roll you have that type of rude geometry is there. So, based on that that kind of cross sectional product can be produced.

So, you have that is hot rolling and cold rolling will be producing the sheet strip and foil with good surface finish and you have the increased mechanical strengths. So, as you know that whenever we talk about the cold forming methods like cold rolling or any cold you know forming method, in those cases the you know it is done to finally, shape the material to very smaller, thicknesses.

And in that case basically because of cold forming the strength is increased. Because of the strain is hardening.

So, and also the finish is better because when you are at these lower temperature side; the chances of scale formation will be is smaller, the chances of surface oxidation will be smaller and that way we go for these cold rolling of the materials. Now based upon you know we try to define these products. So, you have like Bloom. So, the bloom is basically it is the when we first break down this ingot. So, that is known as blooms.

So, this is the first break down product; break down product of ingot. So, normally its cross sectional area is greater than 230 centimeters square and also its width will be equal to its thickness. So, and its cross sectional area will be you know more than 230 centimeter square.

So, that is what normally we specify the bloom as. Then, further when we do that reduction of a dimension of these bloom, then we get the billet. So, we get this billet and we have the minimum cross section area of these billets and that is 40 mm by 40 mm.

So, this way you have the smaller products, that is known as a billet. Similarly, you have the slab and slab is basically the, you know hot roll ingot with cross sectional area greater than 100 centimeter square and width is at least twice the thickness. So, this way these bloom billets and slabs they are you know defined.

And then comes the a sheet metals you know which are the very fine, you know less thick products and they are into the you know normally you will go for the finishing mill

products and they are you have you know plate and sheet, and so there you will get the this plate and sheet. Now plate has the thickness more than 6 mm and normally if it is less than 6 mm then you know it is sheet.

So, plate has thickness more than 6 mm and if it is sheet, it has thickness less than 6 mm. So, this is what the classification of the plate and sheet is and when we talk about the strip. So, normally the strip is also there are all product and its width is not more than 600 mm.

So, so that is what sheet is of you know larger width. So, that is known as the strip. So, the strip will be basically refer as the product with not greater than more 100, I mean 600 width; whereas, the sheet will be having the larger width then that.

So, this way you have basically the different types of products. There is also certain you know process known as powder rolling where the powder is in between the rolls and then, then they are basically you know they are in between these rolls and compacted into a green strip. And then, that is furthers interned and then that way you make these ha powder rolling of the materials.

So, this way you classify the different types of you know products which are made from these rolling you know processes. Now thing is that where the sop, where there is these are these machines are there, where the rolling process is carried out, they are known as the rolling mills. So, you have the set ups where the rolling process is being carried out and it will be consisting of the rolls.

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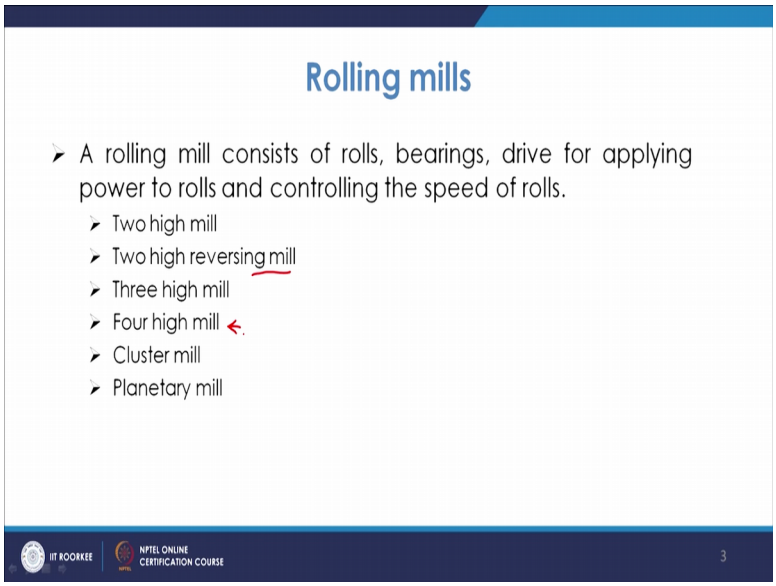

So, the rolling mill will become consisting of rolls, bearings, drives for applying power to rolls and controlling the speed of rolls. So, that is a way set up will be there. As we know that in the rolling mill you have you must have the means to rotate these rolls.

So, for that you have the, you know drive for the applying power to the rolls, then you may have to control this speed of these rolls. So, sometimes you have to control because at what speed the, you know material is coming or stock is coming from one side. So, based on that you have to control the speed of the rolls, you must have the controlling mechanism for the speed and ah. So, this is what a rolling mill and that place where these machines are there; where the rolling processes is going on continuously. So, that is known as the, you know Rolling mills. Now coming to the different types of th mills; as we know that in the case of rolling as we have seen if you take the simplest type of rolling mill.

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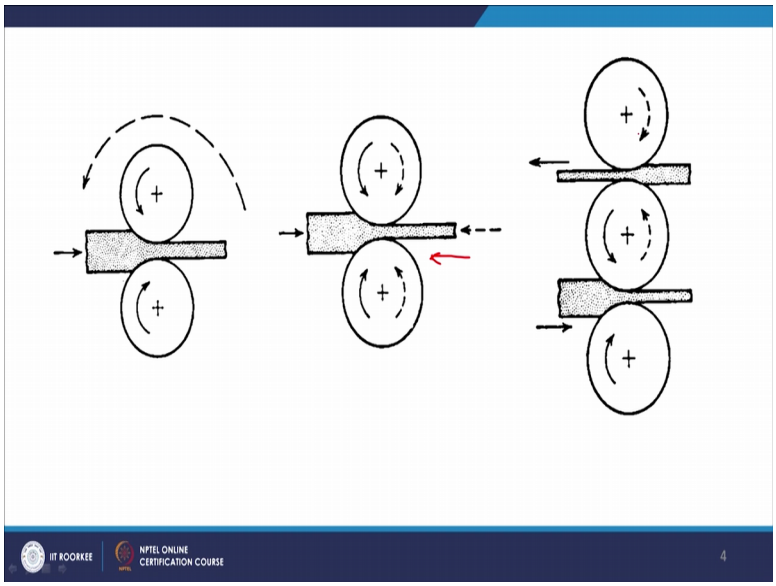

Now you see here.

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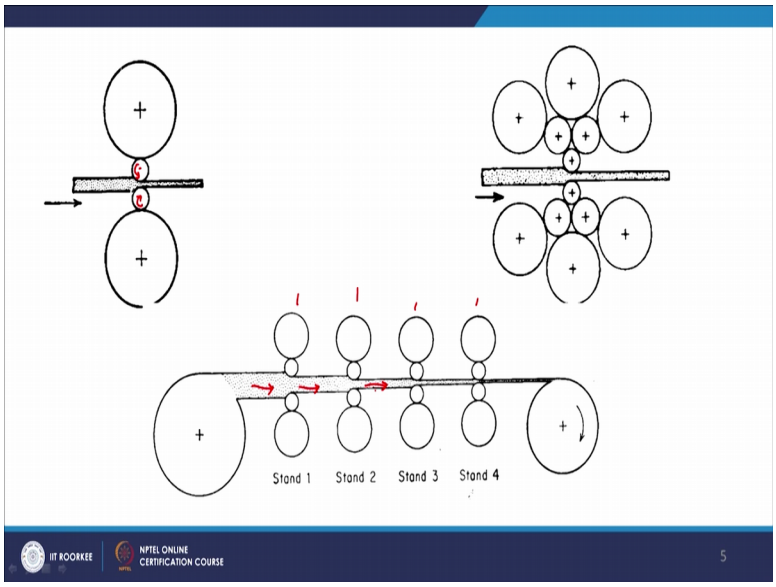

So, now in this case in now here. So, in this case these are the two rolls and they are as we see, they are rotating in a opposite direction. This is rotating in the anti clock wise and this is rotating the clock wise direction. So, and then you as you see we have seen that your stock which is there.

So, it will be coming from this side and ultimately to it will be coming out. So, they are known as the two high rolling mill because you have 2 rolls which are used for you know

deforming the work piece ah. So, that is why it is known as two high roll mill. Then there is two high reversing mill. Now the thing is that in this case there is only entry from these sides.

So, the material which is rolled in this direction; now it has to be further fed into you know at this place only. There is no feeding from this side. Because the speed you know is of the direction of the you know movement of this rolls is fixed.

So, these is the moving in this direction. So, we have only to feed from this direction. So, it is known as too high where as if we if we try to save the time. Because you have to if you have to further change it's you know do the reduction you have to bring this side and then do it..

Now in this case what we do is you have two this in this you can seeing that you have feeding from both the sides. So, you feed from this side its reduction is done; you can adjust its gap between the rolls and then, further you can give the entry you know from this side.

So,. So, this way your in one go itself. So, from here it will go, then you have to reverse its you know direction of rotation. So, it will you start rotating now in this direction and this will be rotating in this direction. So, and the metal will be fed in this direction. So, depending upon the gap in between the roll which is adjusted after one stage, you will have the further you know reduction of it is dimension and it will be reduced to the smaller size. So, this is known as two high reversing mill and that is what it is? This is two high reversing mill.

Then coming to the three high mill. So, now in the case of three high mill as we see that this in this these there are rolling process going on at these two places and you are using the three rolls and if you look at this. So, if you see that this is rotating in one direction and this will be opposite to it and this will be opposite to this.

So, ultimately this is and this; so, this is moving like this and this is moving like this. So, they have similar you know movement direction. They are rating in the same direction, but whereas, this is opposite to both because the metal will be coming suppose from this side and it will go here and from here it will move it will go here.

So, basically we have not to reverse the, you know direction of the rotation of the rolls. But you can see that they are fed from one side and they are fed from other side. So, this way the you can have two places the there is movement of the you know. So, this slabs or the billets which is getting reduce; this is known as three high you know rolling mill, where the three rolls are used for the deformation.

Then you have this is known as the Four high rolling mill. So, this is here this is four high rolling mill. Now if you look at the four high rolling mill again it has 4 rolls which are used for the deformation.

Now in this case what happens that if suppose you have these two rolls, they are the rolls which do the deformation; whereas, these are the rolls which are the backup rolls. They are basically giving the support; they are they give the support to originative rigidity to these rolls.

So,. So, that is why abstinence you are using this these 4 rolls, we call it as the four high rolling mills and this way you have because this will be certainly moving in in these direction and this will be moving in this directions.

So, that way, they will be taking the, you know stock from this side and then, then the finish product will be going in the you know other side. Another example of may the you know the rolling mill is the cluster mills. So, it is a cluster arrangement and in this case it is being supported by all these rolls and then, this you know you know this type of reduction takes place in such mills known as cluster mill.

So, what we see suppose in this cluster mill or if you look at the 4 high rolling mills, here actually the size of the roll which is doing the deformation is small and basically the smaller rolls, the power requirement will be you know smaller. But then, it is it has to be given it will have lesser strength; it will be given that strength and rigidity support by these you know backup rolls and they are supported by these large die metal backup rolls in such cases.

Coming to another kind of you know, now what this is a case of you know the here you see that this is a you know continuous continuously you see that this ingot is coming when it is of larger dimension and this not ingot by here may be slice billeters slab and they are ultimately you see at its converted into strip.

So, this is basically a continuous type of mill. Now see that you have many mills; this is one mill, this is second mill; this and the have further mill. So, you have continuous you know mill and you ultimately make the strip. So, this is basically a strip rolling mill and basically otherwise you have to take from here to next mill and then, further arrange further you know the next one or so.

But you can have such kind of a arrangement which is known as the continuous you know mill; where if you look at this dimension is getting changed every after passing every you know mill and you have ultimately you see that you get these strip being produced of a very small thickness.

So, this is known as the you know you know continuous mill for finding the a strip and here you must be having certain concept about it. Because you must be knowing that when it goes basically its speed will be larger than the speed of the rolls.

So, then this speed at which it will be moving this will be the in coming velocity, while entry. So, what happens in the rolls it did not discuss that way that when we talk about the rolls.

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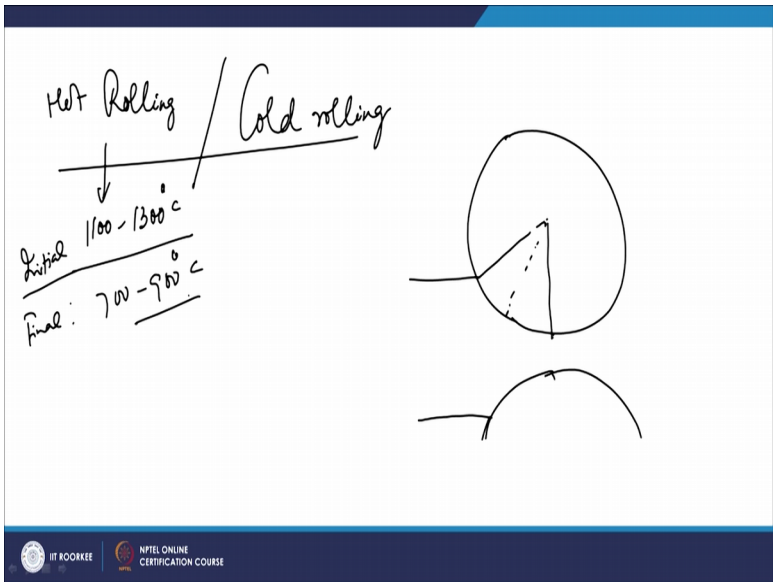

Now, in the case of a rolls when we see now in such case is suppose now, this is how the roll is. Now what happens that now if this is a center.

So, this is yours this angle which is there that angle is known as the angle of byte. The thing is that when it is coming inside; now it because of friction, it will be going you know towards this side and then while it is leaving and because of the you know you know constancy of volume, what happens that the velocity with which it is moving, it will be you know smaller I mean larger because if the width is you know same.

So, the cross sectional area and the velocity that will be your volumetric flow rate. So, the since the thickness is reducing. So, and width is the same.

So, in that case your velocity has to be maintained. So, velocity will be more while exist; while coming, it will have lesser velocity because the frictional force is acting. It means that one point you will have a plain at which the velocity will be same as the velocity of the roll and that is why that plain is known as the Neutral plain. Now this is known as the angle of byte.

So, basically this way what we mean to say that the velocity will be changing. Now in the case of this continuous rolling mill where we directly find get the strip, in that case you will have to have you know the, you know calculation to see that that what velocity is coming here and with what velocity it is going out. Now the velocity with which it is going out will be the entry point for this roll and then that velocity will be different here.

So, this way you will have to have that calculation and based on that you will have the rolling speed to be maintained and you can get these you know type of you know strips, in one go you are getting from this roll you know shape to strip production.

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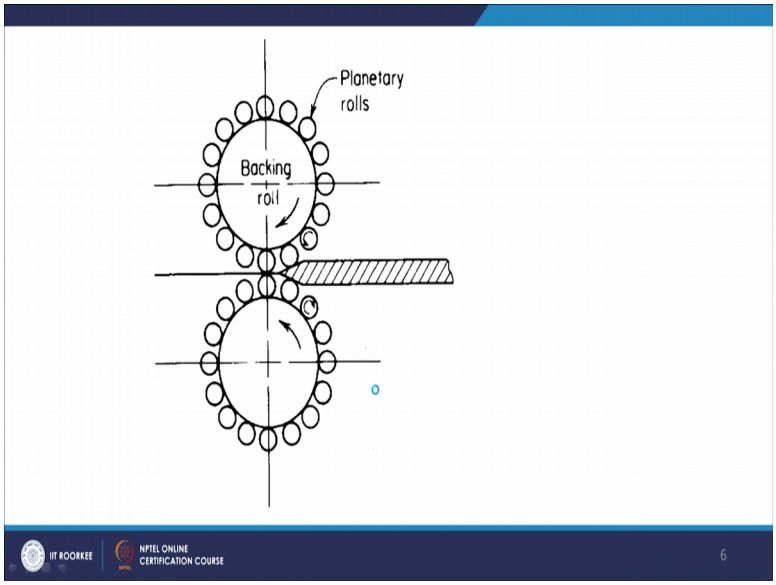

Then you have another kind of you know rolling, where we use these planetary rolls and this is known as the planetary rolling mill. So, this is planetary mill.

Now in this case as you see these rolls you see that this is the backing roll and these are the rolls which are doing the deformation. And basically as you see that there movement direction is also shown and this, what happens that, this is directly converted into a very thin sheet or strip.

Now what happens that slowly this will be coming up then after that another will come. So, they. So, this way you will have it is you know at this point the clearance between these 2 rolls is very very small. So, based on that basically you can have the production of very thin you know see its possible by the use of these planetary rolling mills.

Because this like a planet it is these rolls are there on the backing rolls; that is why it is name is planetary roll. And this way, you can get these you know formation of very thin you know product in the rolling operation. So, basically it is also something like you know it is like a forging process because it will come, it will forge and then it will move.

So, that way now also it is like forging rather than rolling process you can say in such cases. Now as we discussed that depending upon the temperature, we try to defined this rolling process also as the either hot rolling or the cold rolling. So, now when to use the

hot rolling and when to use the cold rolling now, as we know that in case of hot rolling, we will adopt these hot rolling normally you have the roughing mills are there.

So, when your de ref reduction has to be quiet high initially you ingot is to be converted to slab and the you know surface finish is not the criteria; basic criteria is to reduce the you know cross section, to reduce the thickness in that case you go for the hot rolling.

And normally what we do is normally we use that 2 high reversing mills for these hot rolling and the you know roll die metal is from 0.6to 1.4 meter of the you know that roll and you have you know reversing you know you know planning mills. So, in those cases normally the purpose is that as we discussed that in the case of hot rolling, since we do at higher temperature..

So, in these cases the surface roughness will be there because there will be chances of surface oxidation; there will be chances of certain you know because we have discuss that in these process what happens that when we go for subsequent you know rolling, in that case because the scales are formed on the surface they may be trapped in between the rolls surface and so, there may be the trapment of these oxides in between the metal surface and the rolls.

So that, that may be you know in between. So, there may be indentation on the you know surfaces of the metal and so where we go for hot rolling, whenever you need to. So, that is why basically roughing operation basically. And the cold rolling basically is normally you have the finishing operation.

So, you have you know high speed four height and mills are normally used. So, with 3 to 5 strands are use for the cold rolling of a steel, aluminium or like copper alloys and in the plant you will see that these thinner sheets which are used as you know in place of the especially sheets you can see at least corrugated sheets are there.

Now they are made by these you know cold rolling mills; they are not made by the hot rolling. Whereas, when we are try to deform, where the degree of the deformation is larger; in those cases you go for the hot rolling mill and you can have different type of rolling mill arrangement which can do these hot rolling. Normally, you have two high and two high reversing which is used for the you know rolling mills.

And once you are further converting the ingot; ingot to bloom or then to slab or the billet and all that so, that is done in the succession. The temperature which is done in the case of hot rolling for the steel is normally 1100 to 1300 degree centigrade. So, as you know that at this high temperature, you will have more chances of formation of the scales.

So, we you have to see that where to finish the last finishing strand; what should be the temperature? Because you cannot do the finishing at a larger temperature range; larger temperature side because that will lead to the growth of the grains inside the structures.

So, normally we try to see that the last finishing stand, the temperature should be from 700 to 900 should be there. So, initial this will be initial temperature and in the final you know you know final finishing stages, you have 700 to 900 degree centigrade is a kept. So, that you have fine you know (Refer Time: 29:59) grains which are to be obtained.

Now, in the you know degree of reduction will be you know achievable more in the case of hot rolling; whereas, in the case of cold rolling the degree of reduction is normally less may be from 50 to 90 percentage reported in the case of the cold rolling.

And also you have to see that you know you have to see that how much should be the reduction in every stage because during the cold rolling your strain earning you know takes place.

So, how much you should do the cold rolling that is required to be you know analyzed; otherwise that may lead to basically the, you know bitten less of the sheet and that may you know develop the entropy in the material and that may lead to the failure of the material.

So, so that way you have to balance, you have to see that how much degree of reduction is required; you know in the last pass to permit the better control of flatness, gaze or the surface finish in the case of cold rolling.

So, this is about introduction about the hot rolling and the cold rolling operations. We will discuss about the analysis part in our next subsequent lectures.

Thank you very much.