Principles of Metal Forming Technology
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Lecture - 32
Introduction and classification of extrusion processes

Welcome to the lecture on Introduction and classification of extrusion processes. So, we will discuss in this lecture about the important process such as extrusion in which what happens that you have a billet which is heated and you know, it is pressed from one side through a constricted region and then, the metal flows plastically deforms because of the you know being pressed at the die corner. And then, metal flows through that cavity.

So, we normally make the bars or even tubes also; the hollow you known parts are also made which are seamlessly made because if the billet is there so you can seamlessly make. So, if you press from one side you can get a you know seamless type of tubes or you can get a continuous rod which is extruded. And since, it is plastically deformed and it goes under that stress straight. So, because of the forming you know attributes and forming properties the property of the material is better.

So, you have, actually in extrusion as we discussed that the block of metal is reduced in cross section by forcing it to flow through a die or a face under high pressure.

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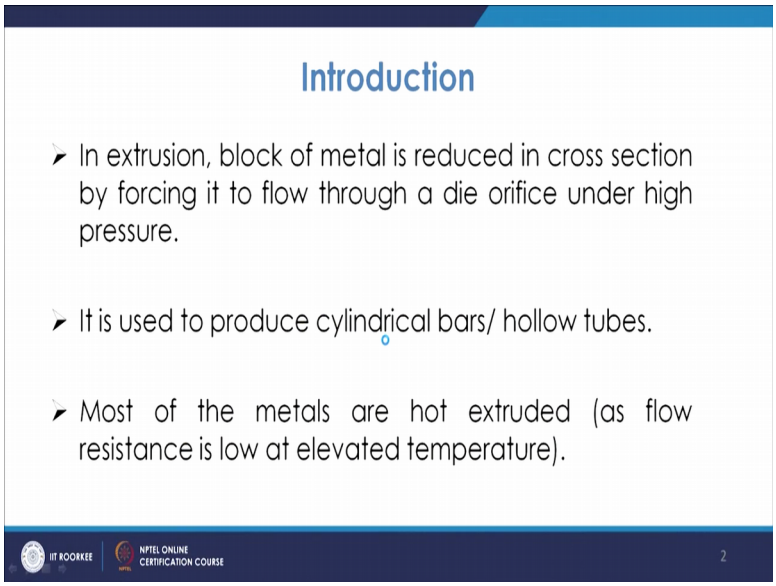

So, you are applying the pressure; you can apply the pressure from one side, and the metal will be extruded from the other side. So, for example, you have you know one container is there and you know this is something which is a billet, which is you know heated.

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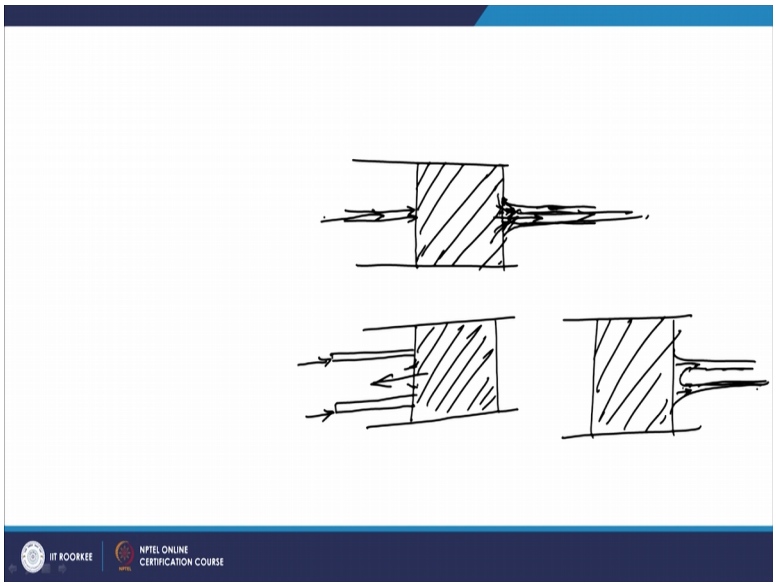

It is kept in this you know cavity and you will have lubrications on the walls so that you have the minimized the frictions or so.

Now, the thing is that once you are pressing it from this side then and so otherwise, this is a case of I have to study extrusion. If you are closing it because you will have the stresses from all the sides but then when you are giving a suppose constrained reason to basically flow it.

So, what happens that at these places as we have discussed about the direct and indirect type of you know compressive you know forces which are developed and direct compression type, indirect compression type forming processes; it comes under that.

So, what happens that because of the reaction which is there at this point, then there will be the deformation of the failure of the material at this point and then material will try to go through this region. And then, you can you can go on steadily where you applying the pressure from here and this you will get it continuously.

So, that is this product is known as the Extruded product. Now the thing is that when you apply the pressure initially this is this is length is larger. So, in this case, when it becomes smaller; now the thing is that the extrusion pressure will vary in certain process. Now that will be depending upon what type of extrusion process is there.

So, this is the example of extrusion, but the thing is that you are; so as we discussed that you are you know applying you were under high pressure. So, this is the, or if is and since you are applying the pressures from here by the RAM. So, under the pressure it will be metal will be coming out through this you know cavity and that is the process known as extrusion.

The thing is that when this the direction of the you know pressure which you apply or the Ram and also the direction of the extruded product which is coming out to through the orifice, they may be same or they may be different; they may be opposite to each other.

So, in another case what happen that you have the billet and what you do is you do some mechanism by which you apply this pressure from here there is a hollow Ram and then, what you do is when you apply this pressure from this side and if it will hollow and if you have a die opening here and then, metal will come out of this

So, what happens in this case? In this case basically the metal will be extruded or it will be coming out in the opposite direction. So, this is the example of a indirect extrusion. So, normally you have the direct extrusion and indirect extrusion and depending upon the cross section which is you have here at die, you will be getting that type of cross sectional product; normally it is round or you can have a triangular cross section.

But you can have irregular type of also cross section which can be produced by doing this extrusion process. Now this is very important process and it is used for you know extruding the rods or bars or the tubes also. And in the when you have to make the tubes then what happens that when you are applying the pressure and the metal is about to go out of the you know you have to go through that cavity at that time you are placing a mandrel in middle portion of the cavity so that that is here.

So, if suppose it is coming here, but if you are putting a mandrel here. So, if you putting mandrel, you can just see that if you are you know slab abilities there here and it has to

come through this and then, if you are putting a mandrel like this. So, if you are putting a mandrel, then the metal will only flow through these places.

So, you will get you know tube or a pipe of certain internal radius and external radius. This will be internal radius and that will be the external radius of the extruded product which is coming out. So, this way, you can get the product of different type may be it may be hollow; it may be solid and then, you will have the varieties that we will discussed.

So, it used to produce the cylindrical bars or hollow tubes and most of the metals are hard extruded because when you are doing the excursion at high temperature in that case the flow resistance will be low at that high temperature. So, flow stress as we know that once you increase the temperature at higher temperature, the flow stress requirement is a smaller. So, you required to put smaller pressure in those cases.

So, that is why we do the extrusion mostly the hot extrusion. Depending upon the again how we classify the farming process based on temperature you have; here also the classification is on the basis of temperature and you can tell it as hot extrusion or cold extrusion. So, most of the metals are hot extruded because of the you know low value of flow stress at higher temperatures coming to the hot and the cold extrusion.

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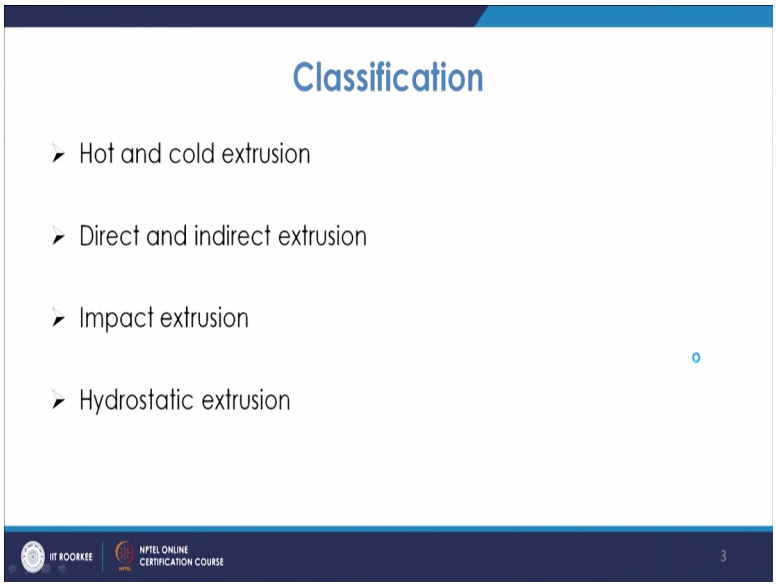

So, as we discussed that when we try to you know give a classification of the extrusion process, then you may you know classify as the at the basis of temperature, classify on the basis of temperature and if it is done at a temperature more than the (Refer Time: 09:06) stress in temperature, we call it as the hot extrusion; otherwise we call it as cold extrusion.

So, that is the you know classification based on the temperature. Then as we discussed that you may have the classification based on how you are taking the extruded product out in what direction.

So, on that basis you have the direct extrusion and the indirect extrusion you know. As we discussed that in the direct extrusion you have the direction in which we have apply the pressure on the Ram and also the, you know the movement of the extruded product they are basically same.

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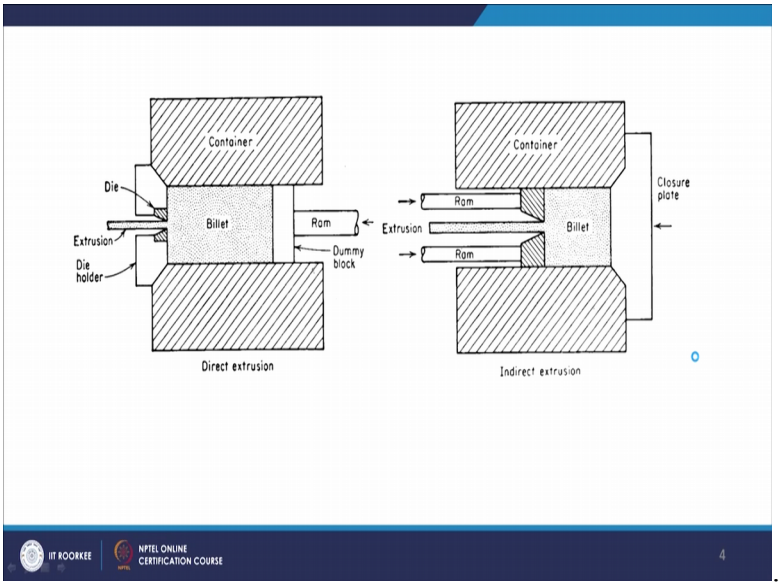

So, this is how we can understand the example of a direct extrusion and indirect extrusions; as we see that in this case you have a the direct extrusion, you have a die holder here and you are having the Ram here; you have a dummy block placed here.

So, that there is no indirect contact with this Ram wherever Ram will be too hot and then you will have this container and this is the die holders. So, die holder is there to support the die to be of. So, it holds the die into it and it give the rigidity to the die because there

is lot of amount of pressure which is there. So, a lot of force to which it will be subjected to.

So, then you apply this pressure on this Ram from this side and as we discussed that this billet which is heated one; since it is getting this constructed passage from here, it has only the way to exit. So, and also there as stresses reached at these corners as we discussed earlier that the kind of stresses which are you know generated at this points the metal flows through this point. And this is the example of the direct extrusion.

And if you come to the indirect extrusion at what we see is that we have the billet here and this is a hollow Ram and the you know this in between you have this portion from here the billet will be basically coming up; now there are differences between these direct extrusion and indirect extrusion processes.

So, now what we can see here? Now, in this case when the Ram is basically pressing this billet. So, this billet is getting pressed and there will be relative motion between the billet and the container wall. So, because of this friction which is there in between the billet and the container wall, you will have the requirement of pressure increased in such cases.

But, if you take the example of this indirect extrusion; in this case this Ram is kept stationary at its own position and the container along with the billet. This is basically moved. So, in that case there is no relative motion between this billet and the container wall in the case of indirect extrusion. So, the friction forces which are there in such cases are basically lower and so the power requirement will be smaller in the case of indirect extrusion.

So, that is the main difference between the, you know direct and indirect extrusion.

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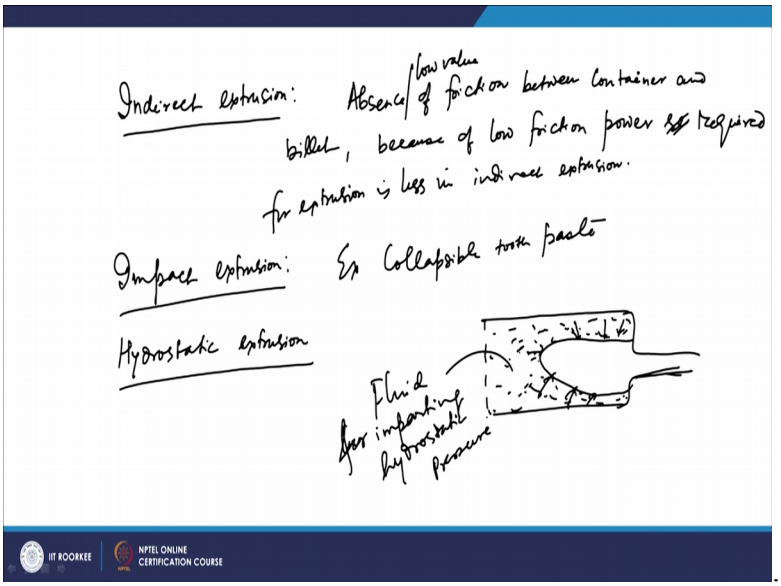

So, if you talk about indirect extrusion. So, the absence of friction between container and billet, because in this case the container along with billet that is basically pressed, there will not be any you know friction which is there.

And so you are; so, because of low friction, now we cannot say absence, we can have or low value. So, because of low friction, the power required for extrusion is less in indirect extrusion. But, what we can see that there is a limit of these you know process in the case of indirect extrusion because the Ram is hollow.

So, certainly the pressure which you apply certainly there is limitation and that is why you will have that limitation, how you can how much load you can apply in the case of direct extrusion. As we discussed that if you apply the mandrel, you can if you apply mandrel in the case of.

So, you know at the end you know here, if you apply the mandrel; then in that case when the metal is coming out due to that mandrel, you can have the hollow shaped product which is found in the case of you know this extrusion. So, you can get the hollow tubes and pipes by the use of mandrel. Now you have another process of extrusion that is impact extrusion.

Now, in the impact extrusion what happens that you know basically you have the extrusion which occurs because of the impact force which comes. So, the Ram will travel

from certain height under impact and then, the metal will flow in the opposites. So, it is basically a type of indirect type of extrusion.

So, normally very short length type of hollow shapes, you know are produced using these you know impacts extrusion and impact extrusion basically is used for making these hollow, you know tubes especially the collapsible toothpastes.

So, normally it is a direct can we when direct extrusion and it is normally done with the help of a mechanical press which is very high speed and they have you have very high deformation rate which is achieved in this case and normally what you can see that the toothpaste, you know tube which is there. So, they are made of very soft materials which are there.

So, that goes on that Ram and then, the metal extrusion the opposite direction normally. You can go even in the direct extrusion type also and it takes the shape once it is subjected to the impact force.

So, that is the example of impact extrusion. Another extrusion is the hydrostatic extrusion. Now what happens that in the case of hydrostatic extrusion, the pressure is created by the fluid. So, what we can say that if you have you know a normally it is used for the materials which are very limited ductility even brittle materials are you know extruded by you know this process.

So, suppose you have a billet or so or any material which is now in this case you have this as the hydrostatic fluid which is present and once you apply the pressure, this hydrostatic fluid basically is applying the pressure, this fluid is applying. So, you have application of pressure from all the sides equally you know you have hydrostatic stresses which are developed.

So, that is why you have forces which are developed on this material and then it it flows through this construction. So, basically you have the fluid for imparting hydrostatic pressure. So, that is how it is known as the hydrostatic extrusion. Next, we will discuss about the typical characteristics of this a extrusion process. So, when we talk about the hot extrusion; so, if you talk about the hot extrusion.

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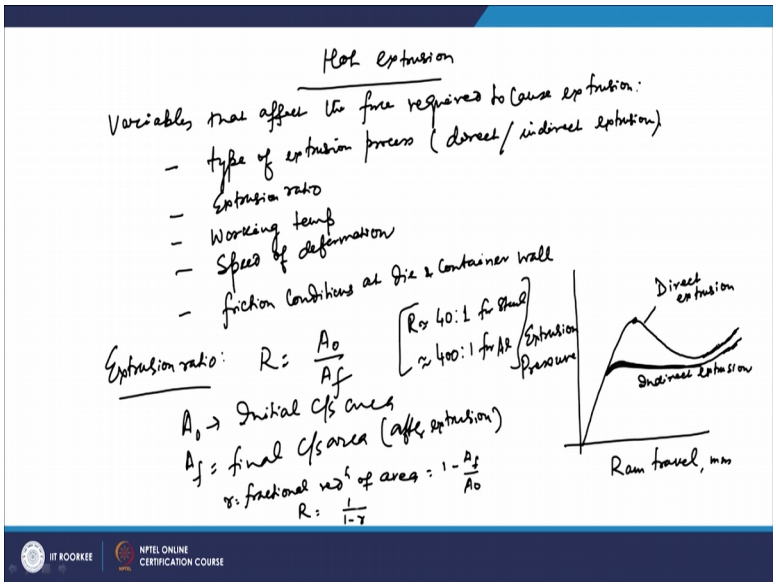

Now, there are many variables which have an influence on the force required to extrude the products. So, variables that affect the force required to cause extrusion. So, that will be first is type of a extrusion process. So, you may have the direct extrusion or you may have the indirect extrusion. Then you have the Extrusion ratio.

Now, what is the final area of the billet and what is the final area I mean what is the initial area which of the billet which is to be extruded and what is a final area of the extruded product? So, the ratio of these 2 areas is known as the extrusion ratio. So, certain extrusion ratio if it will be more, in that case you your requirement for the pressure will certainly be more.

Then you have the working temperature. Working temperature means at what temperature you are doing that extrusion and certainly if the temperature will be more the pressure requirement will be smaller. Then after working temperature, you have the speed of deformation and then, you have the friction conditions at die and container wall.

So, these are the variables like you have the friction is there at the die and the container wall; then certainly you will have the requirement of a large extrusion pressure for doing these extrusion work. So, what we do many a times, we apply the lubrication; we apply solid lubricant also. So, we apply the lubricants.

So, that there is minimum friction at the die and container wall inter face for that. Now if you apply, if you try to look at the variation or the pressure which is there in the case of extrusion process, what we see is that you have a rapid raise in the pressure requires if you try to see the graph between the Ram travel that is in m m.

And then, if you look at this as a function I mean this is with this how this extrusion pressure is going to vary. Then, it has been seen that in the case of direct extrusion the the curve goes like this and then, if you have the indirect extrusion; then the curve goes like this. So, so that way your, this is for the direct extrusion and this is for indirect extrusion.

Now what happens that when you initially compress this die? So, initially when you are applying the pressure on the billet. So, what we see is that there is initial surge in that pressure, in this initial region and this is because of because with the pressure the whole container which basically is going I mean whole that extrusion is going to start and basically this rapid rise is because of the initial impression of this billet to fill that extrusion container, it will be completely filling that.

So, when you are pressing it will be the container will be completely filled because of that the pressure is initially increasing. Then it is coming to this highest point in the case of direct extrusion and at this point basically the extrusion starts.

So, this point is known as the Breakthrough pressure and after that the metal starts deforming and then, metal starts coming out of the you know outlet or the out of the die and you get the (Refer Time: 24:53) product.

Now, after that you see that there is a decrease in the you know in the value of the extrusion pressure and in the case of direct extrusion because in the direction extrusion as you see that when it starts you know the product which starts going out of that die, then the you know the length to of the billet which is to be excluded at that will go on decreasing.

So,. So, as it is decreasing the pressure requirement will be smaller because you require lower pressure to you know give the force on the material. So, that it goes through that outlet. So, it will go on decreasing and in the end basically again, it is there is a increase in this value which is going very high. At high rate it is increasing just to ensure that the

Ram stops there and in the end, you have the, you know unwanted things which are there stop to this normally they are defects in the structures they are basically removed.

So, that is why at the end basically you have the stop being applied at this place. Now if you looked at this indirect extrusion curve, in this case it is start from here and you do not see much change in that extrusion pressure. Because there is no you know otherwise the friction between the billet and the container and it will be going on continuously at this point.

So, what we see is that you have the study kind value of kind of extrusion pressure for that. But then, you have as we discussed that there is limitation for this because once you use the hollow Ram, in those cases you have the limitation of how much pressure you can apply by using that hollow Ram. Now, as we discussed that there will be small discard in the end and that will be defects.

So, being the unwanted product that for that there is pressure is you know end of the pressure will be building up and then, there that will be leaving 1 small discard in that. The terminology which are you know otherwise important for this extrusion is one is the extrusion ratio. So, as we discussed extrusion ratio is basically the initial area upon the final area.

So, this is your A naught is initial cross section; cross sectional area and A f is the final cross sectional area that is after the extrusion. So, it takes value normally is 40 is to 1. So, if we take the value of R. Now R will be something like 40 is to 1 for steel for hot extrusion and it may go as high as about 400 is to 1 for softer materials like aluminum.

So, if you depending upon the type of metal, you have the collection of these extrusion ratio; you have you can also define this extrusion in the form of you know reduction in area. So, if your R is the fractional reduction of area. So, in that case R will be 1 minus A f by A naught.

So, you can have the expression for R as capital R as 1 by 1 minus R. So, this way they are normally used for you know for the analysis in the case of extrusion process. Now, once you know this you know A naught by A f; then, what has been seen that the pressure which is required or the extrusion force which is required.

So, that is normally related to the natural logarithm of these A naught by A f that is your extrusion ratio. So, your Extrusion force extrusion force is normally seen to be.

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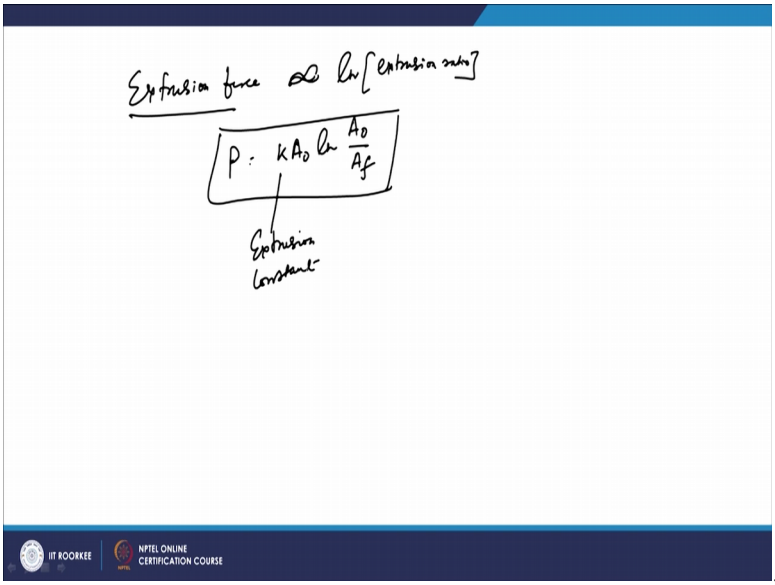

So, what happens that you know you have extrusion force; it is directly proportional to and natural log of the extrusion ratio. So, what has been seen that the P is k A naught and l n of A naught by A f. So, normally k is known as the extrusion constant and we know other factors A naught and A f.

So, that way also you have many a times you must know the range at which the extrusion process is carried out; you may have hot extrusion or you may have the cold extrusion. Hot extrusion is normally for steel it is done in the range of 1100 to 1200 degree centigrade and the pressure which is required is 800 to 1200 mega pascal. If you go for cold temperature will be smaller; then in that case certainly the pressure requirement will be larger and that is what mostly you depending upon because the problem with the higher temperature side is sometimes the oxidation. So, normally you provide you know the temperature which suitable plasticity so that you can get the extrusion with you know with minimum of this kind of defects like oxidation or so.

Also a higher temperature is the maximum temperature will be the temperature at which the hot sortness occurs. So, that way you have to take the temperature range in to which you should do the extrusion process.

Thank you very much.