Principles of Metal Forming Technology

Dr. Pradeep K. Jha
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 31
Defects in rolled and forged products

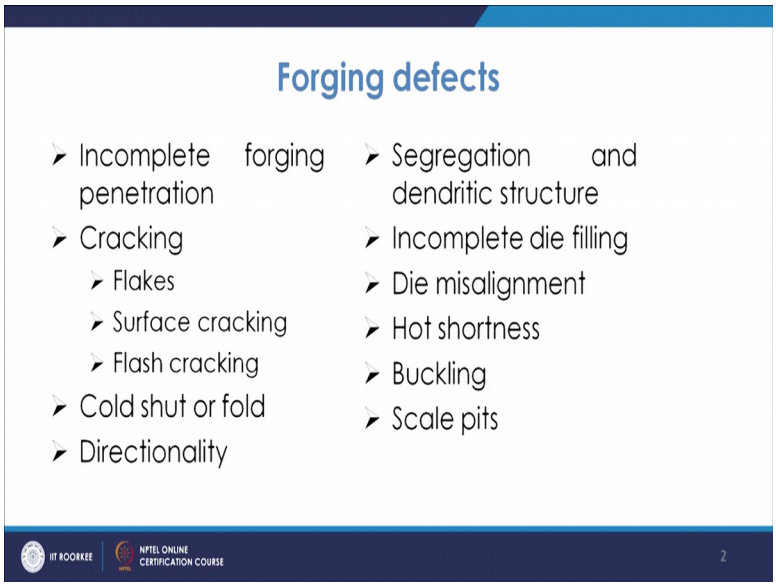
Welcome to the lecture on Defects in rolled and forged products. So, we have discussed about the processes of rolling and forging and, in this lecture we are going to discuss about the different type of defects, which are likely to come in the case of rolling and forging.

So, as you know we will start with the forging process and, in the forging process normally the type of defects which are common are like in complete forging penetration. So, this happens you know many a times because when the metals has to flow past the edges, or it has go into the cavities and, may be because of the improper temperature, or because of the improper design of the die, if you have not given proper fill it and corner ADI. In those cases there may be in complete forging penetration.

So, that is one of the defect then you have cracking now cracking is also very prominent and, it may be surface cracking or flash cracking or flakes. So, surface cracking as we know that there may be cracks on the surface produced and, there may be many reasons for that, then you have the flash cracking.

So, the flash cracking is basically found at the flash. So, the flash is we know that this is the extra portion of the forged product just like in casting you have raiser portions. So, here you have the flash portion. So, flash is the one which is outside the cavity of the you know of the forge product and so, flash goes out and there you may see the cavity in the flash.

(Refer Slide Time: 02:42)



So, there may be reason for it may be thin may too thin flash or so, the severity is there in the case of flash cracking is that is a cracking is there in the flash and, if it has extended to the you know casting then the casting will be you know rejected.

So, that must not propagate inside the; you know forged product. So, that is there then you have flakes are basically the internal, you know cracks internal ruptures in the materials. So, it is because of the imbalancement of the cooling of the forged product.

Now, what happens that when there is a forging going on the top surface of the forged product is in contact with the die which is normally at lower temperature and the middle portion is at higher temperature. So, you have a differential you know temperature gradient that develops and that may lead to such uneven cooling (Refer Time: 03:40) may lead to the formation of flakes.

In the same way, you have other you know cold shutter fold that is because of the improper bounding between the two you know, from the two directions the forging is you know in that is progressing and, they are not able to properly overlap or joined, then that is cold shutter fold directionality is there that is related to the direction of orientation of the grains, which certainly develop in the case of forging any and that is there so, (Refer Time: 04:20) this is a second time it has come.

Then you have segregation and dendritic structures so, that happens because what happens that, you may have the segregation of certain impurities are certain locations. Or many a times you try to see that dendritic structure should be removed maybe, but the in the inner internal part, because the compression force which you are applying that is limited to the top surface part.

So, that is you know not seen. So, this compression force is applied it is normally confined to the top you know surface layers. So, the dendritic structure which is there inside that is not you know broken. So, one of the purpose of doing these internal working processes is that the structure and needs to be improved, you have the dendritic structures so, they that also is broken when you heat them at high temperature in then, when you apply the you know compressive forces.

So, you are not able to control that you are not able to altered, or modify the structure. So, that is another defect which we are getting. incomplete die feeling again it will be because of the improper die design, or improper temperature because of which the die proper die feeling is not there you have also defect related to die misalignment or die shift.

So, many a times when you press the material, or when you are forging the material the top and bottom die, they may be misaligned because of many reasons. And if they are misaligned then that are the parting plane, or are the that plane where they are meeting there maybe you know defect that they are may not be proper you know structure.

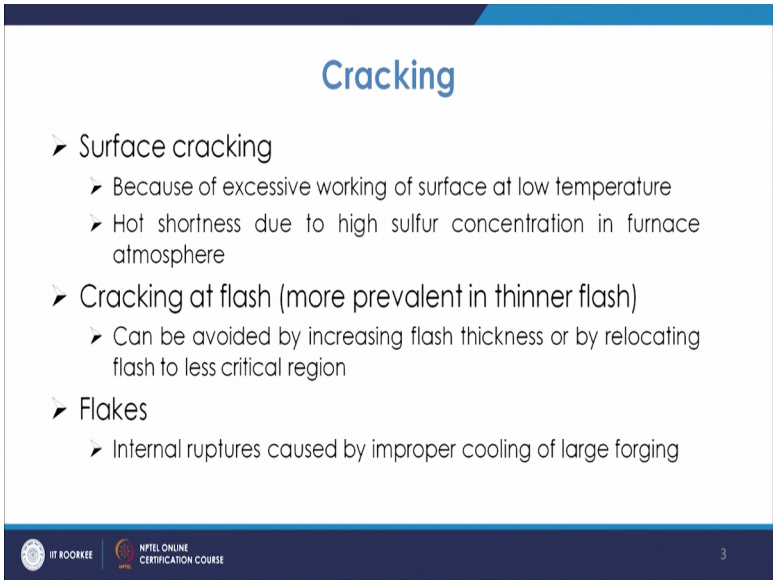
So, that may lead to the die I mean a shift at you know discontinues type of you know appearance at the plane, where the this two dies meet, hot shortness is another thing because of the sulfur environment many a times in the furnace atmosphere, we get such kind of defects that is hot shortness you have buckling also may be because of the you know improper, or incorrect you know length to width ratio of the specimen and, when you are applying the compressive force in that case there may be buckling effect.

So, that may be there and then you have a scale fits. Now, these scalp fits occur because of the scales which go in between the die and the work. So, what happens that in the case of hot working, or hot forging, when you take it from the furnace and the furnace is atmosphere is not controlled, then at high temperature there may be oxides are scales formed.

Now, what we do that we clean it in between and if you are not cleaning basically that scale is there. So, during the next operation these scales are embedded in between the die and the work you know work piece and, this is scales you know they are crashed and their impression is there on the work piece or work surface.

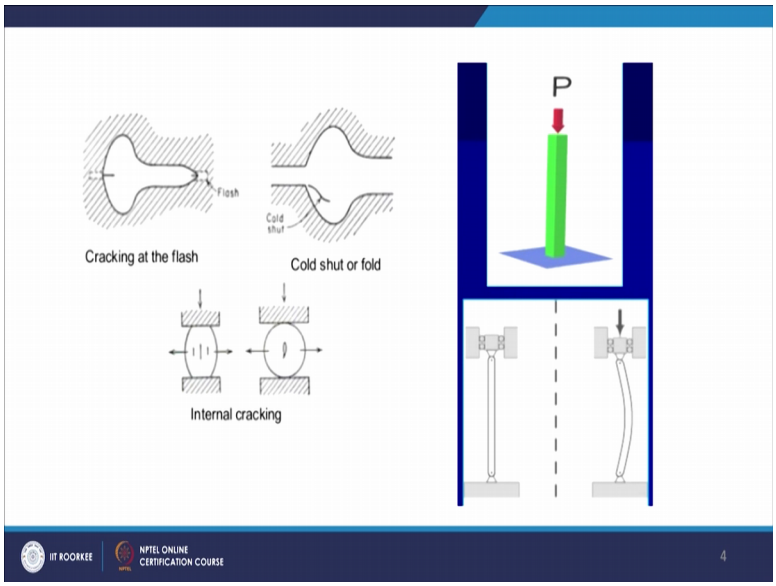
So, that creates a depression in the on the surface and that is known as scale fits. So, these are the different types of defects which normally occur. Now coming to the cracking; so, in the cracking normally you have the surface cracking cracking of flash get flash and flakes so, that is what we discussed earlier.

(Refer Slide Time: 08:34)



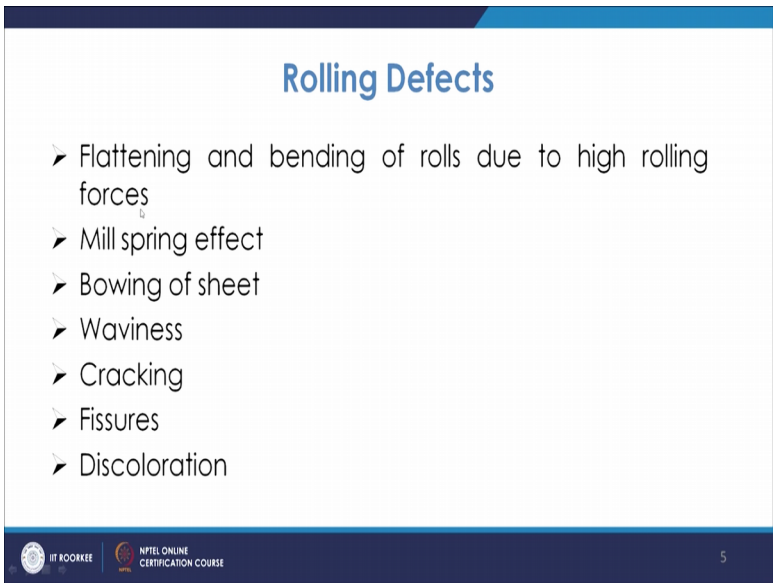
Now, the surface cracking is because of the excessive working of surface at low temperature and, also this hot shortness is due to the high sulfur concentration in the furnace atmosphere. So, that is what we see this these are the reasons, because of you know this the surface cracking takes place, cracking at the flash and this is more prevalent when the flash is thinner. So, normally you know the flash needs to be trimmed.

(Refer Slide Time: 09:11)



So, what we see here you can see that in this case, you have this is the flash and if this crack is there and this crack may be seen in the you know inside the casting itself.

(Refer Slide Time: 09:28)

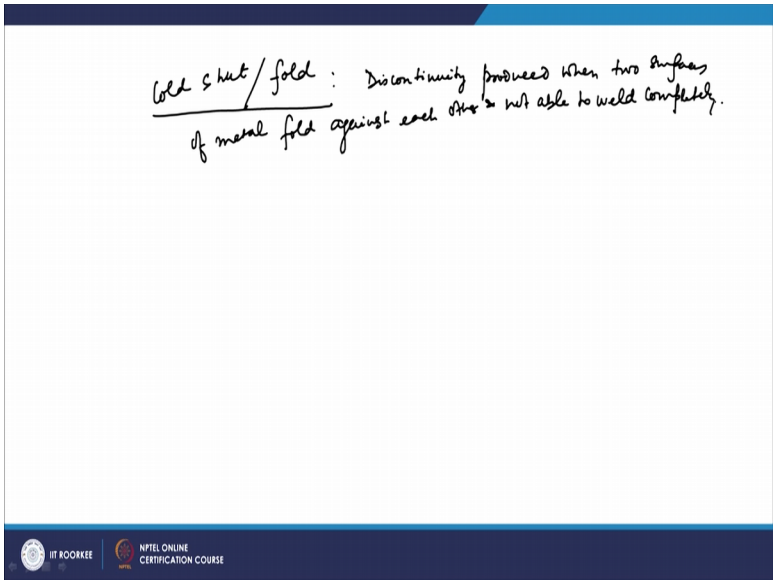


So, so, that is not desirable the flash as long as the crack is there till there, you know the end portion of the flash is fine, but if the charge is there then it goes into the body, then that may lead to the rejection of the you know forged part. So, normally what we do is that you have to increase the flash thickness. So, that the crack does not developed and,

otherwise also if you there your flash is to a very critical region, then you must try to relocate this flash region to a less critical zone. ah

So, that the chances of even if there is a small crack, it does not you know effect the overall performance of the product. The only once we see so, that is why we have to have ensure, I mean you must ensure that the flash should not be attached, or it is not be provided near very critical region to avoid any such you know problem. Apart from that we discussed that we have a defect known as a cold shut, or we also know no know it as fold.

(Refer Slide Time: 11:05)



Now, this is the basically discontinuity which is produced, when the two surfaces of the metal are folding in each other and, they are not welding completely. So, this will be the discontinuity produced when two surfaces of metal fold against each other and, not able to weld completely.

So, that there is known as the you know cold shut or fold so, that this name is synonymous to what happens also in the casting process. So, the thing is that from the two sides the metals are comings. So, they have to they have to just completely weld each other and, because of the very sharp corner or because of the excessive chilling this may happen, because what of the stream from the one side the metal, when it is coming and, it has lost it is heat suppose in that case they may not be able to weld completely.

And it may also happen when there is a high friction. So, that also may be the reason so, this leads to the formation of cold shut and, also you have is the die radius is very small in that case also you may have the formation of these cold shuts. Now, if you see the flakes, now this flakes are nothing, but they are the internal ruptures as we discussed that you have basically you know the differential cooling at the surface and at the centre.

So, that differential cooling basically leads to the formation of stresses inside the forged part, then that leads to the cracking of the you know forged product. So, that leads. So, that is known as the internal raptures. Then you have we had discussed about other type of defects like improper fiber structure is formed many a times the fibrous structure, which you are getting that is not proper, that is improper that maybe is the that may not be basically a suitable product.

Because as you may had discussed earlier that, if you are not able to get the fibers properly oriented, in that case you will not be able to get the proper you know you know property proper strength of the material.

So, these are normally the you know defects, which we on encounter in the case of this forging we discuss that we have hot shortness which is normally because of the presence of the (Refer Time: 14:47) environment in specially, when we deal with steel or nickel. In those cases these hot shortness is normally observed, when it is seen that you know that that may also we lead to the rejection of the forged products.

In proper flow lines as we discussed that is another you know I am [FL] defect that is that must be avoided, because flow line has to be you know proper. So, that you get the adequate property of the material. Next is the defect related to rolled products. So, as we know that in the case of rolling, you have two rolls and the material is going inside the roll the slave or the billet is going in between the rolls and, they are subjected to the compressive forces. The main thing is here that as we have already seen that there is a pressure back on the rolls.

So, the they will be roll separating forces and, also you have the deflection in the rolls. So, if the roll is not made of proper material, then you know in course of time the roll may lose the shape. And if the roll is loosing it is shape if the roll does not you know you know confirm to the actual shape, then in that case the same impression will be going on the product which is you know being made by these rolling process.

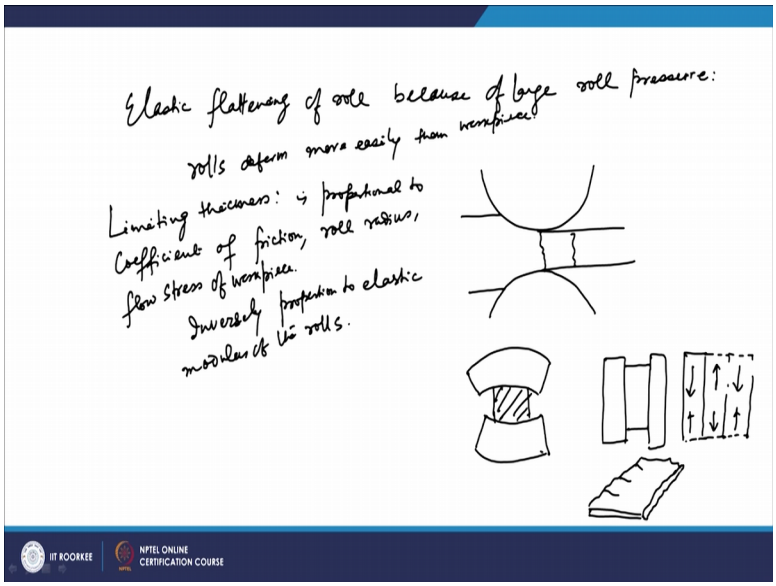
So, the thing is that you have the spring effect flattening and bending of rolls due to high rolling forces. So, the thing is that when there will be high rolling press forces and, since that reaction forces are there on the rolls. So, slowly they flatten and they also bend, there may be bending on the I mean you know of the rolls. And once you have the bending then that may lead to the improper you know shape of the product which is being formed.

So, so, that may lead to improper amount of stresses or the forces which you are generated on the sheet which is going under the rolls and, in that case the different part on the you know product different part on the sheet, will be subjected to different type of stress it at some place it may be subjected to tension where as are some place, it may be subjected to compression.

And that may lead to the formation of cracks, you know wherever there is a tensile type of stress which is developed inside, then that may lead to the formation of cracks at some places, or in may fracture some fracture may also be seen. So, that is the you know backdrop of the flattening and bending of the rolls due to high rolling forces, then you have mill spring effect, but the thing is that when you have the rolling mill and since being it has certain elastic constant.

So, so what will happen now the material which is going it has some elastic constants. So, it will be under that compressive force from the rolls and, once it goes out of the rolls than that part is basically recovered and that is why the dimension which is there so, you expect that the final dimension will be the same as the roll gap or the distance between the two rolls, where as when you will have so, what will happen that if you if you look at this.

(Refer Slide Time: 19:06)



So, we know that in a case of rolling so, what we expect that to you have this sedan and then ultimately it will go like this. Now, the thing is that this we expect it to be the final thickness, where as because of the mill spring effect, because spring back effect. Now, that will happen that this dimension will not the same as it should be.

So, in those cases the dimension will not be the actual and actual one and, you will have to know the elastic constant of these rolls and also, because of these you know mills, or the rolls and accordingly you will have to set the gap so, that you ultimately get the thickness or the height of the you know of actual dimension.

So, that may be the you know problem with this roll product, that may lead to the bowing of sheet waviness cracking and, then you have a fissures and discolorations are the another you know problem in the case of rolling, where you have discoloration taking place on the sheet, or you have internal you know the fissures which are formed in the roll products so, that is also seen.

Now, what are the reasons for these you know flattening, or bending of the rolls. So, as we discussed that you have you know since the pressure roll pressure is quite high, now that leads to these you know rolls basically actually deforming.

So, you have elastic flattening of roll, because of large roll pressure. So, due to this what happens that rolls default more than the you know material itself so rolls. Now, another

thing is that when we try to deform and, specially the thinner sheets. In those cases normally we use the smaller rolls and, also you have the limiting thickness you cannot decrease the thickness beyond certain limits. So, that also is the limitation when you are doing the rolling process and, also that will be depending upon certain parameters like what is the coefficient of friction, then what will be the roll radiation all that. So, you have what we see that you have the limiting thickness.

So, below that you cannot roll and, this limiting thickness it will be is proportional to so, you will have the some parameters like coefficient of friction, then you have the roll radius and, then you have the flow stress of the work piece, but it is inversely proportional to the elastic modulus of the rolls.

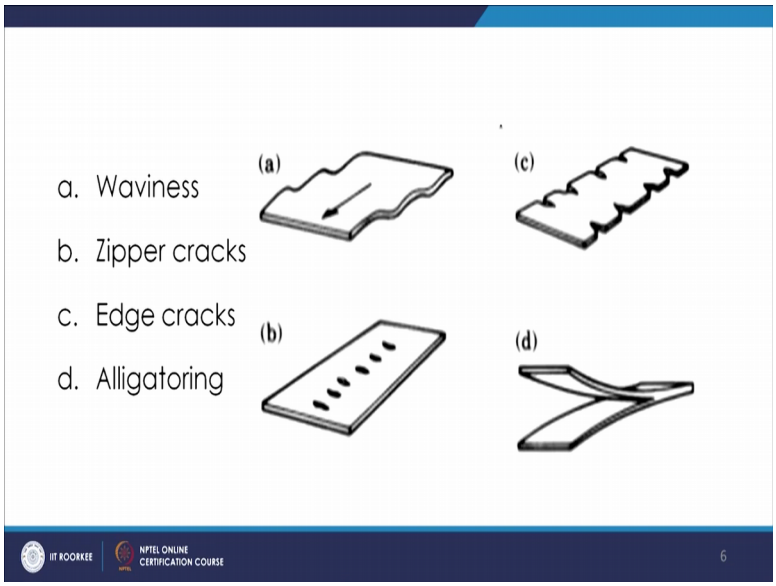
And it is inversely proportional to elastic modulus of the rolls. So, so that is why you need to have a proper you know knowledge about the coefficient of friction, also you must know that what will be that limiting thickness, because that they depend upon all these parameters and based on that you will have to control these dimensions.

So, that you get the proper geometry or proper dimension of the roll product which you get finally, also many a times what we see is the because we assume that these all gap which is there in between you know the rolls, they must be parallel ideally we assume that the roll gap, which is there in between the rolls they have to be you know parallel.

Otherwise what will we happening that you will have the edges of the sheet it will be decreased more, you know in thickness than the other so, at one point you will have more thickness and, another point you will have less thickness. So, that way you cannot get the sheet thickness to be uniform, if your gap between the rolls are not the same so, because you have the constancies of volume.

So, if at one place you have any you know you know decreasing the width that has to be a companied by restrain in the other regions and, this leads to you know the basically improper dimension of the products. So, that is normally you have to control you have to see that the roll gap is same at all the places, the what we see in the case of rolling that if you look at these pictures.

(Refer Slide Time: 25:31)



Many times we get some kind of a waviness also and this waviness is nothing, but the lack of flatness. So, you know sheet being remaining so, what we discussed that if you have you know if you have the improper roll gap at the different positions, then in that case you will have this formation of these waviness, or you will have because the strain has to readjust among themselves.

And this kind of you know appearance is seen in those cases. Now, this can better be understood by referring to certain figures like, if suppose many a times you have rolls like, they are coming like this portion. Now, in such cases if you rolls are like this, then what happens that if your body is which is to be compressed here.

Now, what you see that in this case the other side portion that side the middle portion will have will be basically compress. So, that will be that will be leading to you have you know such kind of you know sheet will be develops.

So, you have this will lead to basically formation of the stresses and, if you see the different regions, what we see that in this portion this portion will be under the tension and this portion will be under compression. And in that case you may see that on the edges you will have the you know, you know waviness or you have the cracks which develop or they basically adjust.

So, on the edges you will see that you have such kind of appearance which is found on the edges. So, adjust the strain energy adjustment leads to the formation of such kind of also cracks, which is observed we have already seen that you have the cracks also coming at the central portion also. So, these are normally the you know type of rolling defects, which normally encounter we encounter in the case of rolling processes.

Thank you very much.