# Plastic Working of Metallic Materials

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## Lecture 16
## Forging Die Design Consideration

Today we will be discussing about the forging die design consideration, in forging what is very important is the die design and die design is a very complicated job in forging, specially impression die forging or you called cross die forging but basically it should be called as impression die forging, one is designing of the die, second is manufacturing of the die, these 2 are important and your approach is entirely different if you are using a hammer forging then you have a particular type of a design.

If you are using a press where the deformation is at a slower rate then you are a die design is different you have to choose the materials, die material also accordingly. So, and like you make a small mistake somewhere the material has to flow into all the intricate shapes and it is supposed to the higher temperature gets heated up and then okay the die get softened and if you are not doing it in a proper way the metal flow will take place and it may result in the die ware and without much time maybe after doing some 500 or maybe 300, 500 pieces.

You may find that the die ware has taken place and it was like it cannot be acceptable then it becomes very complicated or if it is in the case of hammer forging then what happened after few cycles it may break. So, for a hammer forging you want the die material which should be very tough otherwise the impact it may break but whereas for the press the metal will be flowing slowly but it may result in because the material will get work hard that may ware the material.

So, what is required in the case of a die in a press forging when you are using a press where the movement is very slow ram displacement is very slow is that you should have a very high ware resistant surface okay, that toughness may not be that much of importance, because impact is not coming.  So it is solid toughness which you wanted high hard ware resistant surface that the die surface should be hard inside that and the thing is that most forging require a series of forming stages

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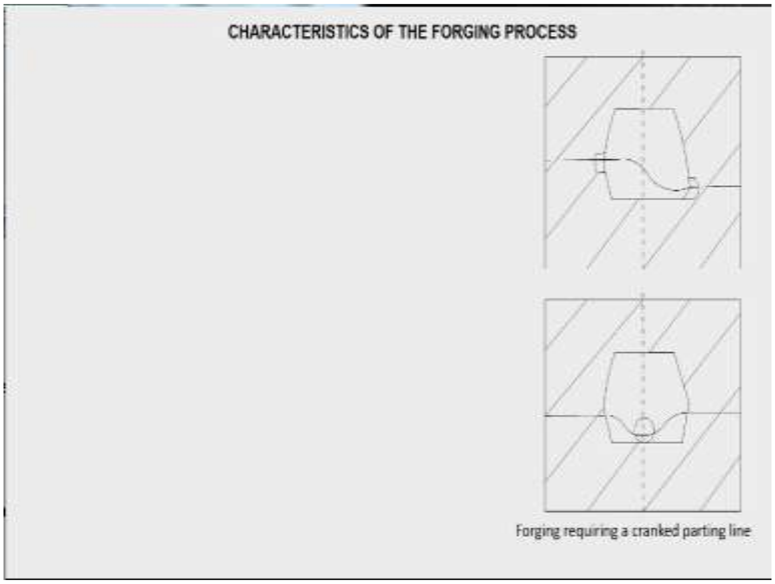


And this is called as a pre forms, pre forming operations because you are not going to get because your buildings are normally in a cylindrical piece or a rectangular piece depending upon that and then you are cutting from that and keeping in the furnace and then okay you are just keeping the furnace okay, it is not like that most of the case because the shape symbol shapes like spear and cylinder that is okay. But when you are going for components like a connecting rod, a crankshaft a spanner or a grains hook, then the shapes are different.

So, you cannot get that in one operation, you may have to have different pre form operation. These are called a pre forming operation and the number of preforms required depends upon several factors including that what is the overall shape, it is not really the shape see, there may be the components have different sizes at different places. So that means that the result in the complexity of the shape which we have discussed in our previous class classification based on complexity and third, the material itself if the material, work hardening to a great extend, then you have a lot of problem.

So, forging complexity is increased by several features and this includes the presence of thin sections in the path when this thin section is there on a path, then you have a lot of problem because it may not flow into that full length that is one, second thing is that these are results in hardening very high because large amount of deformation is regarding that case, third while rejecting there is every chance that it may break off. So, all these problems are encountered.

So, you will find that the complexity increases if there is a presence of thin sections, if there is a presence of complicated the shape also there is going to be a problem okay. And in cross sectional area, if there is a large variation in the cross sectional area, you are going to have problem the part shape that require die parting like here suppose know you want that part to have a different parting line like in this case, it becomes very complicated whereas here it is very simple. So, your parting line between the 2 dies, so that the crank the parting line when it comes then you will find that there is a lot of complexity increases.

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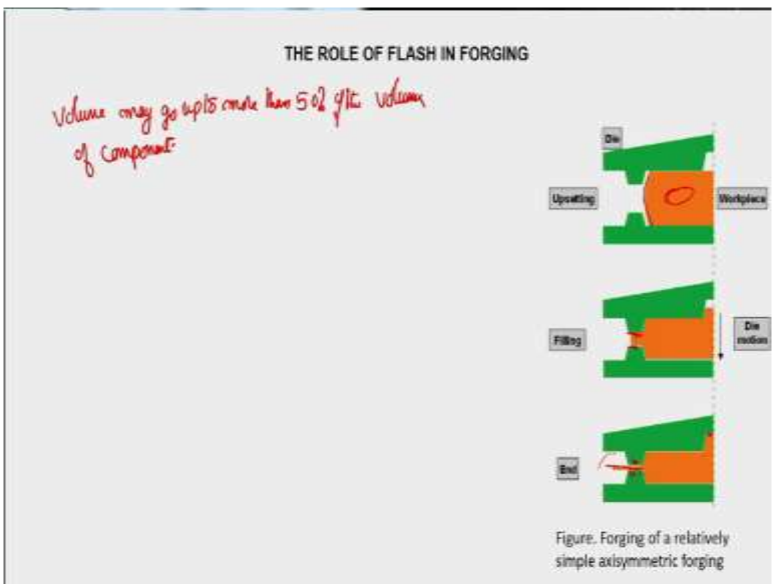


And when you come to the role of flash in forging I have already discussed earlier the flash is generated due to the crossed die forging. So, this flash which is generated it is basically an unwanted material because some photographs I have shown earlier, it is an unwanted material, which after the forging operation you have to remove it see, and most of the cases this flash material will have a considerable volume.

So, you may have that volume of the flesh may go up to more than 50% of the volume of the component, in that case your want to end up with a large wastage of material also. So, these type things are and the flash which is form the more complex the component is the flash will be larger. So, that is another important thing. So, for us simple component which are very there is not much of a complexity in the geometry.

Then the flash amount of flash may be less but for a large component where the complexity is very large, then the flash which is required also will be very large, the control of flash formation is very important, because you need the flash due to as I mentioned in the last class itself. So, the flash is required, because some he cannot cut the raw material exactly as what you require. Now, when you are going to heat it, there will be some scalars and other things.

So, that also has to be done. So, you may have to have some extra material. Next one is this act as a cushioning effect. So, it will take much of the impact when the forging is taking place. So, because the door die surfaces will not come in direct contact with that so that we have for the safe for the die, third if flash us not there the entire die filling may not be complete. So, sometimes under filling maybe taking place, sometimes there are over filling if it is there you have to remove the material excess material for that also comes out as a form of a flash only.

So, flash is a necessary, but the flash volume should not be very large you have to have minimum amount of flash. So, as the material we can said this is a case how the flash is forming this is one die, this is another die is a bottom day, this is the top die and this is your workplace material which you are having and when the top die is that which is a mobile die is coming down you see that it later barreling effect is barreling effect comes industry most sideways Okay, lateral forge takes place, but between the this is a cavity which is coming.

So, when it gets here it gets slowly as the die advances the thickness will come get reduce okay. So, a narrow flash is formed around the command this is only a section view because cylindrical piece, you will find that around the piece it is there the entire piece along the parting line it is coming. So, the material for sideways resulting in flattened the shape because it has to flow between these 2 areas of the Georgia so it will flatten the side.

But when the dice still further crosses this has to this will get reduced to more and in the meantime what will happen you see that here material is not filled, but as it comes down it will just flow and fill up the entire cavity section of that and here the metal will cut out the form of a flash this is how So, if this flash was not there, the die here and here is to die surfaces may come and made and then the larger amount of stresses which are develop, it may result in the die failure.

So, in the final stage of the die closer, you will find that the material gets extruded out through in this direction and this will be through the complete circumference of the piece because you have a section which is strong and so, this result in flash gutter and flesh land. So, this is the flash land and this part is a flash gutter. So, since we have not shown it completely so that is a thing.

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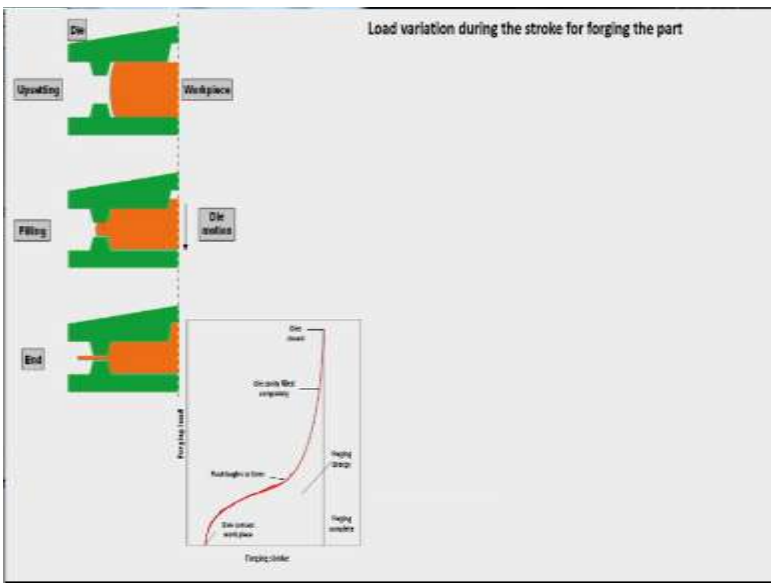


And now when you look at that you can also see how this when it is coming how this affects the forging load, I have discussed this but here I will still once again think is a when the die conduct die is the forging load which increases with the forging stroke. So, you may find that the when the dies contact the workpiece at this stage then the force started building up okay. And somewhere it goes constantly to the homogeneous deformation which is taking place of course some amount of fictional force is also coming.

But if you assume which is a well lubricated piece of it is like a constant thing and from somewhere see this flash start formation it touches this die surfaces and at that time you will find the load is load keeps on increasing here because you extra forces required for the deformation of the flash. So, that is a load case and as it comes down when the height keeps on decreasing you the load will increase in our derivation we have found that it has a direct relationship between the thickness.

So with the thickness increasing the load keeps on increasing like anything and when it is about when the die is completely filled you will reach here but you know that you can control it by your stroke adjustment. So, but towards that part, this is a complete die closing and you have everything flash which is coming but extra material which was there it has just flown out so that is the thing.

So, you will find that here pressure increases very much and for the material to choose between or extract between that the forces will be very large and when you look at this, you cannot avoid flash and flash gutter in and impression die for me. So, what is required is that the selection of appropriate levels of the flash, land and geometry is very much necessary.

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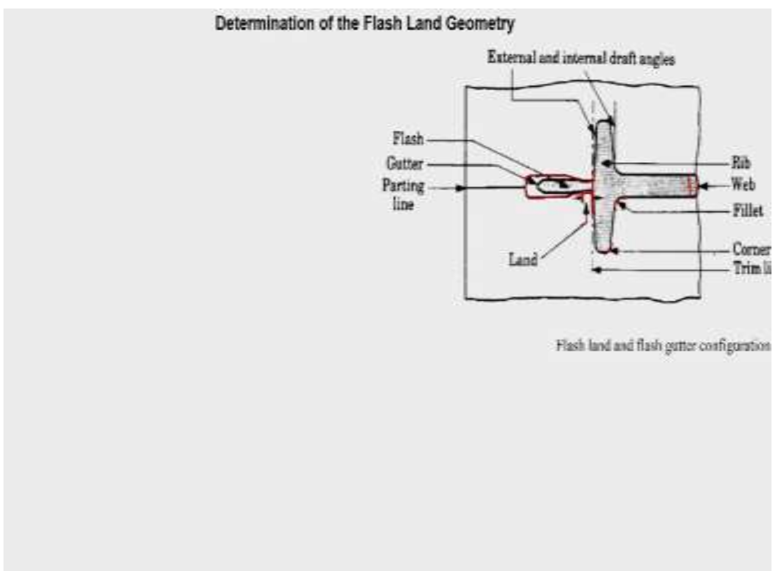


So the gap and the width so this is a typical something downloaded from the net. So, nomenclature for the flash and this is a material which is flowing this is a flash. So, this is a flash gutter which is shown where the extra whatever extra material is there it can flow and fill it up that you will make it into a very large case but this part up to here which is parallel it is called the flash land okay.

So, near the parting line this width apart is called as a web and should remember this is fillet radius and this is a corner radius, the external internal draft angles are required for otherwise you may find it difficult to eject it out. And so, after all these things are there this flash will be trimmed out from here. So, you need to have kept it into another die forging purpose because this flash land and this gutter is important because if excessive flash land is there the excessive material will be there you will be losing large amount of material in it.

But if it is less the die filling complete die filling may not take place, but you need to have an idea about what of the geometry of that this is very crucial. So, the gutter must remain large enough to accommodate the flash form because this gutter region the volume of the gutter has to be very large otherwise if you are by any chance if you are more material is there then you will have problem the component may go out of size okay over size it may come and then the resulting that it will get rejected.

But if it is less then another problem will come so gutter there is no question but flash you have to be careful with it. So, if the geometry is not correct diameter is not filled completely or the forging load will become excessive if the projected area of the flash in the flash land is usually included in the total projected area of the part for estimation on the forging load that is very important because we found that when the thickness of the sample is reduced the forging load will be very high.

So here when you are doing the large necessary for the forging operation, you have to consider the total projected area is not only of the component, but also it should include the flash area also at this flash land area is very important. So, you are so that means according to that really your load will be very high okay. So, you have to slightly reduce it otherwise your machine may not be able to deform it completely okay. So, determining the selectional and this also depends upon the selection of the process you may find that the large number of numerical a number of empirical relationships are available for this flash design.

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**Table** Selected Empirical Formulas for Flash Land Geometry

| Reference | Flash thickness, $T_f$ (mm) | Flash land ratio, $W_f/T_f$ |
|---|---|---|
| Brachanov and Rebelskii | $0.015A_p^{0.5}$ | - |
| Voiglander | $0.016D + 0.018A_p^{0.5}$ | $63D^{0.5}$ |
| Vierrege | $0.017D + 1/(D+5)^{0.5}$ | $30 / [D\{1 + 2D^2/(h(2r + D))\}]^{0.33}$ |
| Neuberger and Mockel | $1.13 + 0.89W^{0.5} - 0.017W$ | $3 + 1.2e^{-1.09W}$ |
| Neuberger and Mockel | $2W^{0.33}$ 0.01 $W$ 0.09 | $0.0038ZD/T_f + 4.93/W^{0.2} - 0.2$ |

$A_p$, forging projected area ($mm^2$); $W$, forging weight (kg); $D$, forging diameter (mm); $Z$, forging complexity factor.

Some of these are this which has been obtained from the literature select empirical formulas we can get it these are the others which are there and this first 2 form a relationship that is these 2 relationships it take no account of the forging complexity it is just for a simple diametrical or cylindrical piece where it is not for complex geometry for simple geometrical things it is taken. So, it dose not considered the complexity or the forging complexity of the component it has not taken place.

So, this is the flash thickness and this is the flash land ratio flash land by your width of the flash land by the flash thickness. So, that is this ratio in this case is not there, but here it is 63D to the power point 5 where D includes the projected area which includes the flash land region, the third formula is by considering limited number of access symmetric forgings So, this is basically for access symmetric forgings where you find that flash thickness T is equal to point 017D + 1 by D + 5 to the power point 5 okay.

$$T_f = 0.017D + 1/(D+5)^{0.5}$$

And the ratio is like the flash width that to a flash thickness ratio you are getting the relationship, now the fourth formula is used for more for the cost estimation procedure as it is symbol to evaluate and this takes care in terms of weight okay So, because this is very simple in terms of weight you can find out to determine the cost of this process. So, this fourth one can also be returned in terms of the volume also okay as supposed to the weight okay.

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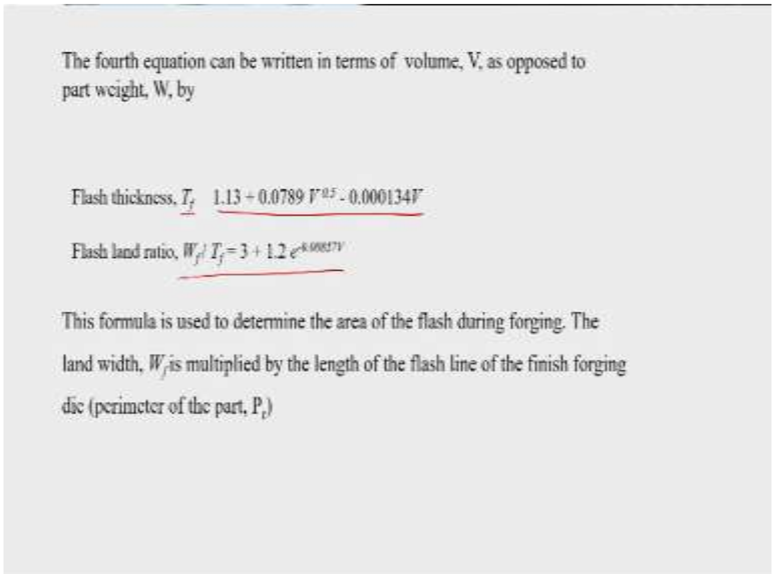


So, that is you can get that in this form instead of in terms of weight because here now what has been written is $W$ is your weight $A\,p$ is a projected, forging projected area which includes the flash land also $W$ is the forging weight $D$ is the forging diameter and $Z$ is the forging complexity factor which we have discussed last lecture.

And so flash thickness equation in terms of volume we can get this and flash land ratio in terms of volume. So, this becomes very symbol okay the land width the $W_f$ is multiplied by the length of the flash line for the finishing forging die. So that is the perimeter and other things okay.

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**Amount of Flash**

Flash Weight per Unit Length of Flash Line for Steel Forging

| Forging weight (kg) | Flash weight (kg/cm of periphery) |
|---|---|
| Less than 0.450 | 0.0047 |
| 0.450 - 2.273 | 0.0063 |
| 2.273 - 4.545 | 0.0098 |
| 4.545 - 6.818 | 0.0130 |
| 6.818 - 11.364 | 0.0168 |
| 11.364 - 22.727 | 0.0223 |
| 22.727 - 45.455 | 0.0324 |
| Above 45.455 | 0.0477 |

So, that way it is used. Now amount of flash as I mentioned, it may sometimes go to very high value also okay the cost of the material in forging is determined by the weight of the finished forging by the weight of that finished forging and if there is a material wastage then your cost of the forging will go very high. So, this loss of the material can be like in terms of flash as well as in terms of oxidation if it is a hard working oxidation which is taking place also. So, that way it is there and you see that for symbol errors it is okay.

But for very costly errors this becomes a real problem and then costly errors forging also becomes difficult okay. So, you have to have a minimum of material loss that is by from the flash produce during for the but further losses may occur due to scale formation for this material that oxidize significantly during the heat treatment for hammer forgings due to bar ends and so on in a hammer forging you have to all to get at one place and then get it so, that way also you end up with loss of materials.

So, there are a lot of but in impression life or thing when you look at it, you will find that the flash weight okay, that kg per centimeter of the peripheral length if you look at it is in so the forging weight is less than point 450 you will find the flash weight is around something around point 0047 okay. Kg per periphery that length and this is a say you will find that when this increasing this number keeps on increasing and above 45.455 kg you will find that the flash weight is very high compared to the other cases okay.

So, estimation of the flash for a particular forging is difficult and is usually based on experience with the manufacturer forgings of a similar type. So, most of the case know like you cannot arrive at certain conclusive that I am say that occur the flash rows will be this much many times the experience of the designer, the forging die designer that has an important influence on that. So, if he is very and that truth based on his past experience.

So, that is how we can but this is what all this data is available in the literature of this will give you a rough idea about it, the amount of flash produce to various with the shape of the part, there are 2 basic one is by statistical data from our lab the number of experiments and from experience you can get it how much it will be and another is the average value of the flash amount per unit length of the flash length for so, that is what we have from here okay. So, this stroke cases are there. Now, when you are designing for the flash, there are webs.

See when you look you see that web is there, this is a piece which is there maybe it may be a flywheel or something so a web is there. So, these webs are thin section you know that

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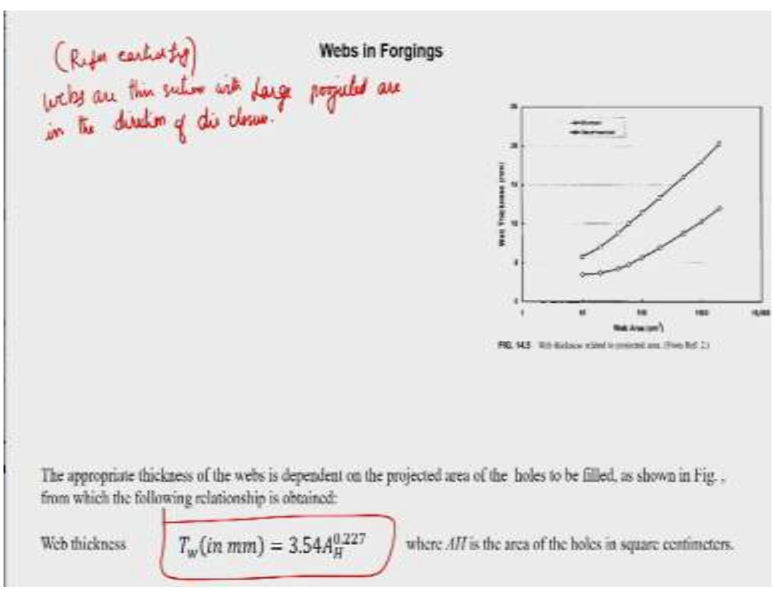


Webs are thin section, so refer the earlier figure, webs are thin sections with large projected area in the direction of die closure and this webs are designed into the path for strength and maybe other reason maybe you wanted to connect the rim with the hub okay. So then that is only way by having this web and usually this webs are thin very thin and very these thin and of the outer rim is very thick then you have a lot of problem okay, these webs add considerably to the load and you will find that the major area taken by that is due to the web rather of component or if it is fly wheel.

If it is a fly wheel the maximum area is taken by the web not by rim or by the hub. So, this because of this it adds considerably to the load requirement during forging operation because of this die conduct area and once it is thin and its area is very large, your forces has to be very large. So that is there. So, if the finished part has throw holes to be forging land then this must be filled with the webs are with the die forging length, so that is another problem many times in the web world.

So not to reduce the way people may put some all sources then it becomes much more complicated. So material in this web is additional waste material and add to the material cost per part. So you can sell it the approximate thickness of the web, the web area and your web thickness know that certain from experience now, this is from literature only we can just get this information and the appropriate thickness is dependent upon the projected and area of the holes to be filled.

So, the web thickness you can get it like this simple relationship these are all this from experience okay. So T w web thickness in millimeter is equal to 3.54 into A H where A H the area of the holes in square centimeters, so that even.

$$T_w (in\ mm) = 3.54 A_H^{0.227}$$

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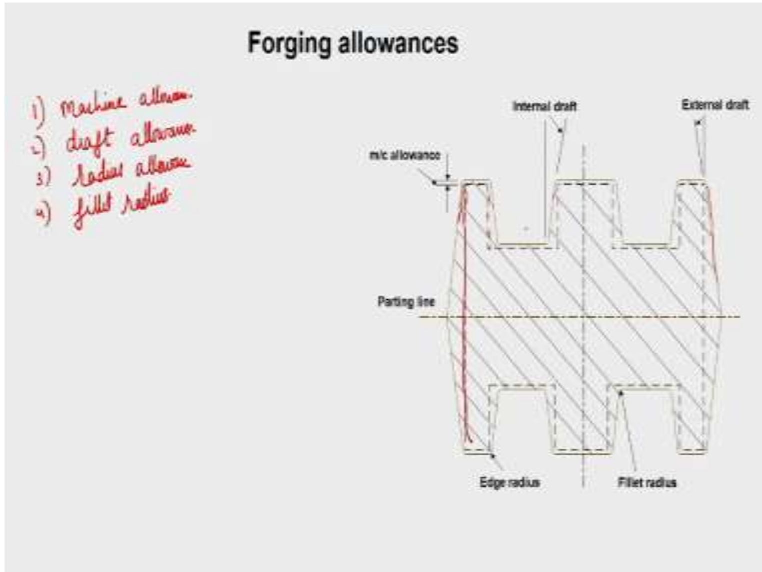


Now, another important thing design consideration is the allowance see your forging  finishing operation will not be exactly as what you wanted, because in the forging die design you have to provide allowances for many things, one is for machining allowance. So one is that machining allowance and next is your draft allowance that are internal draft as well as external draft allowance, otherwise the material will not come out of the die then you need that for radius allowance then you need for fillet radius.

So, this is that see this finger which is shown by this dashed line, this is your final component. This is a drawing of your component but when you are making the path is a sectional base you will have to provide extra one is you have to provide this surface has to be very good. So you need to have a machining allowance okay. So, you have to put extra material so that it should be machined off that is why it is called as machining allowance. So that is also called other finish allowance.

Okay, this amount is in addition to dimensional tolerances and must be sufficient to result in a clean surface okay. So, once your machine chop you are one to get clean surface So, that is one important thing we just because many times what happens is that during deformation when you are going to keep it in the final finishing die, see the material may be at in the heated condition and whether comes in contact with your air, it may get oxidizer also. So, that part has to be machine.

So machining allowance is required okay, the level of oxidization depends upon the material type and overall size of the forging. Now, next is your draft allowances okay, the draft it is in terms of angle. So, it is a tapper which is going to give if you are putting it straight as far this drawing if you are just a drawing like this, then what happens is our material fill you will find problem in rejecting it out okay. So, you have to have a high production rate.

Second thing here it makes stroke, you may find it very difficult to remove some times it may impossible without damaging the die. So the strength and so on for easy withdrawal of that you have to provide draft allowance. So, draft allowance is basically the external draft allowance is there the third surface. So, that will add to that and whereas the internal draft you are giving here, so, by with the dimension of this part gets reduced, here it gets increased, but ultimately that you have to machine it off after a wonderful song.

So, in general draft allowances on the inside surfaces, the whatever is this angle here provided is always greater than that on the outside surface that is what generally otherwise you may face problem because this might be very intricate shape or a complex shape and the other thing so, you might face problem in removing the material from the die. So, internal draft angles are provided are always higher than that are the external draft angle.

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TABLE Draft Allowances for Forgings

| Materials | Hammer dies | | Press dies | |
|---|---|---|---|---|
| | External | Internal | External | Internal |
| Steels<br>Aluminium alloys | 5-7° | 7-10° | 3-5° | 5-7° |
| Titanium alloys<br>Ni-based alloys<br>Tolerances in all cases | ±1° | ±1° | ±1° | ±1° |

So, this is a draft allowance if you look at this steel and alumina is in hammer die by the external draft allowance is 5 to 7 degree centigrade where are not degree centigrade, degree whereas are the internal surfaces the allowance is higher than this okay, there it is 7 to 10 similarly, and percentage also in there maybe 3 to 5 degree where are for external case 3.53 3 to 5 whereas for in general is 5 to 7 degree.

So, that is what you will find that all these cases your internal is generally higher and say maybe like you look at me Ni based alloys, Nickel based alloys, Tolerance and all these cases are + or - 1 degree and other things.

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Typical Minimum Edge and Fillet Radii for Rib/Web Type Forgings

| Material | Corner radius (mm) | Fillet radius (mm) |
|---|---|---|
| Aluminum alloys | 2.3 | 9.5 |
| Low alloy steels | 3.0 | 6.4 |
| Titanium alloys | 4.8 | 12.7 |
| Nickel-based superalloys | 6.4 | 19.0 |
| Iron-based superalloys | 4.8 | 17.0 |
| Molybdenum | 4.8 | 12.7 |

So, that is also that because those things are difficult to machine. Now, we have to look at the fillet radius see if you look at these 2 types of radius are the one is the edge radius and another is a fillet, fillet is internal part there you have to provide radius otherwise metal will not flows smoothly okay. So, the edges and corners in the part must have radii added to it, these radii are necessary to add material flow and ensure good die fillet if the radii are not provided the metal flow direction will change and then you may find that it is not filled properly.

And even if you are excess material is there and if it is going to fill properly, you may end up with certain defects or that bug because material will come and then join. So, due to that qualities are laps, laps will take place. So, for that you need a smooth flow of the metal in the plastic stage for that liberal radius are required actually and so sharp and second thing is that if in the die also sharp corners are there that will result in stress concentration both for the die as well as the work piece material.

So, in work piece material, the design engineer will say I want the liberal radius, but liberal radius means it will increase the material to be used. So, many times know this problem will be there and stress concentration effect will come so component may fail or during for forging operation your die may fail also because of the very high stress concentration which are there. So due to this to avoid these things and also to help in the faster forging

So your production rate can be increase you always provide sufficient radius both for the what you call it is a corner as well as for the fillet normally you will see the corner radius is much lower than the fillet radius okay. So, most of the case the fillet radius is higher than the corners radius, the terminology of the corner and the fillet is already shown in this figure it so here this is the fillet radius this part this is the fillet radius whereas the other is edge radius is here at the corner and this reference..

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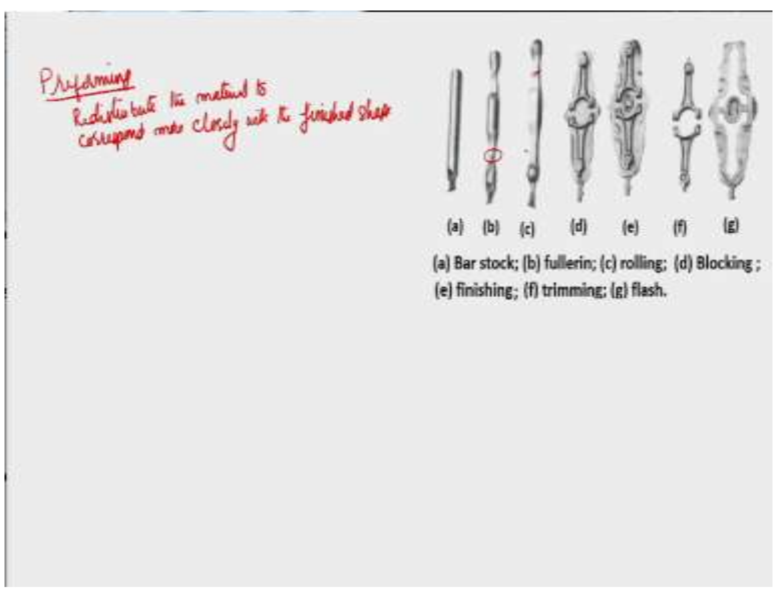


So, this you have to take care of this these are one of the some important things which you have to consider during the die design. Now, even this figure I have shown earlier also because very few forgings are produced in one stage this is the case for this figure shows the case for forging of a connecting rod okay. So the first stage you are having a fillet in this form cylindrical fillet and other things.

And then you are subsequently doing many operations like this is a fullerin operation and then you may have to reduce some section for which you may do a partial rolling operation all those things are sometimes splitting operation will be required, sometimes punching also may be required in all these cases you will find the different operations of the see unless it is a cylindrical piece or a square piece or something very simple case in that case it will not be a problem okay.

But in most of these cases where it is a component to be deployed in the field for as a part of an engine or part of a machine component, then most of the case multiple preforming operation is required for impression die forging and these are necessary. And the final operation is you called the finishing operations the one step before the final operation is called as a blocker die okay, the starting point of the forging is in a very simple shape either a length of round or a square section bar or a fillet is cut off from the bash row.

And this object of pre forming is to redistribute the stock. So, the pre forming operation is to the redistribute the material to correspond more closely with the finished reshape and the design of this pre forming dies is another thing there is no such a standard rules and other things how to do it. So, it is all comes by experience of the forging die designer. So, that is another important thing, but when you are designing it you have to take show care that the material is flying without least resistance and other things and complete die filling is taking place.

So, it is a sequence of the operation which takes place okay, progress has been made in the recently know, you will find a lot of finite element methods of there and CAD CAM packages are there where you can just design these pre forming dies in a very simple way okay. So, those type things are there. So, that type of advancement has taken place. Most of the flatter compact forgings it is starts from the fillet and can be usually be produced in 2 to 4 forming stages okay.

The first forging stage is a simple die, which may be a flat face called the scale breaking die when you because if it is in the hot condition you are taking from the burnets almost all metallic materials that will be oxidized even if it is steel it will get trusted and so, taking from the burners, we cannot stop it off. So, what they do is that they just put it in between a flat die and then just give us small impacts, so that this scale will just get separated from it and fall off okay.

For that provision should be there and most of the case the die will be all this preforming operation most of the case will be in a single die block itself ok. So, the purpose of this initial is to remove the scale formation. But if it is a too simple the material can be forging in the finishing by itself, but you will find that most of the case you may have to have because some it will not simple type and most of the case you may have to give a pre forming operation okay.

That is which is necessary and in the blocker which is just the operational problem just before the finishing operation is the most important thing okay, all other things you can do any rough work and other thing, but here it is very important. There are some well accepted design roles for blocker cross section area. So, typical blocker section relates to finisher cross section, we can see that in the final part has thin or tall feature.

Then a flow blocker may also they required and this will help thicker section in this particular case this finger you will see that there are 2 fullerin stages, after 2 fullerin stages and one edge or die okay edging is also taking place it results in a dumbbell shape See, you can see that it is in dumbbell shape with approximately around a cross section with an axial mass distribution similar to the finished product. So, around here it is come the initial mass distribution pre forming stages can be done on a reducer all.

So, these things this part and this part you can do on the using a reducer all, even this also we can do by reducer all which uses series of shaper all to a longer the pro down the first row. So from here, you will find that okay your length is also increasing when you are doing this rolling operation with the corresponding reduction in area in this case okay. After this the cross section of the part are there to be or to be formed to corresponding to finished shape, this is your finished shape.

So here you may have to get this shape and other things you see that is true connecting rod part in one single block that is what they are getting, okay, whether a blocker die is required is usually decided based on the experience.

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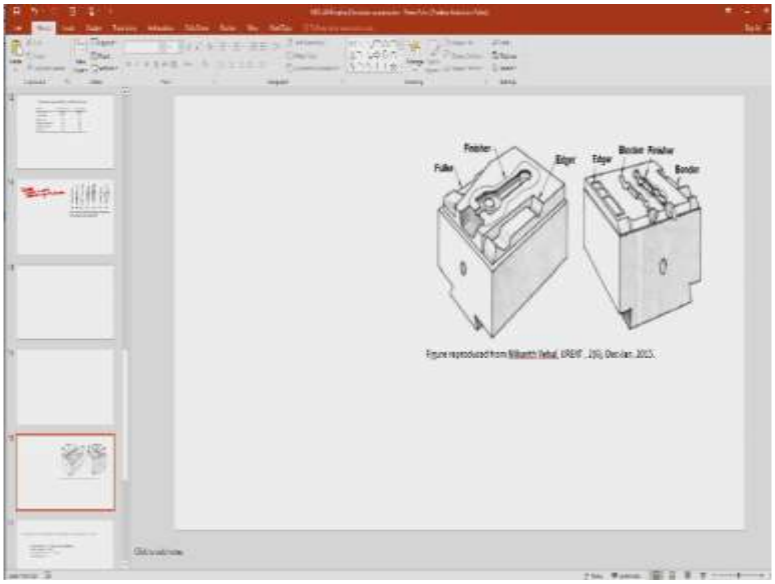


And the blocker forging cross sections are essentially as most out version corresponding sections in the finished forging okay, the blocker sections are designed by modifying the corresponding finished this section you will see that this is the blocker forging cross section and that so this is a simple die block which you look at it and all the operations are carried out in single die block not it is not that you will have different processes for different operation.

So, maybe when one ram displacement taking place you will remove your material from one to the other okay, other cavity. So, this is a fullerin die part, which is there and this is the edging dying part here. So, here you can increase this width and other things and this is the finishing operation here also edging is there the blocker is there than the finishing operation. So bender bending, edging, blocking, finishing these are the main part sometimes splitter also may be required in some cases okay, like that many operations have carried out.

So, the blocker sections if you look at the blocker sections, the blocker and the finisher, there is not much a difference, it is only a very small difference see there so that the blocker is designed such that in the finishing die the minimum amount of matter of it is statement only what is just a sufficient because if the dimensions goes out of this one in the blocker die it will not matter. But in finishing die the metal flow should be minimum.

If large amount of metal flow is taking place in the finishing die then after the number of forging operations you will find that the where is taking place that die is internal surface gets worn off and then material will become out of tolerance okay. So that is one within the out of limits and then okay you are the rejection. So, always say to that the finishing die the minimum amount of material forging taking place.

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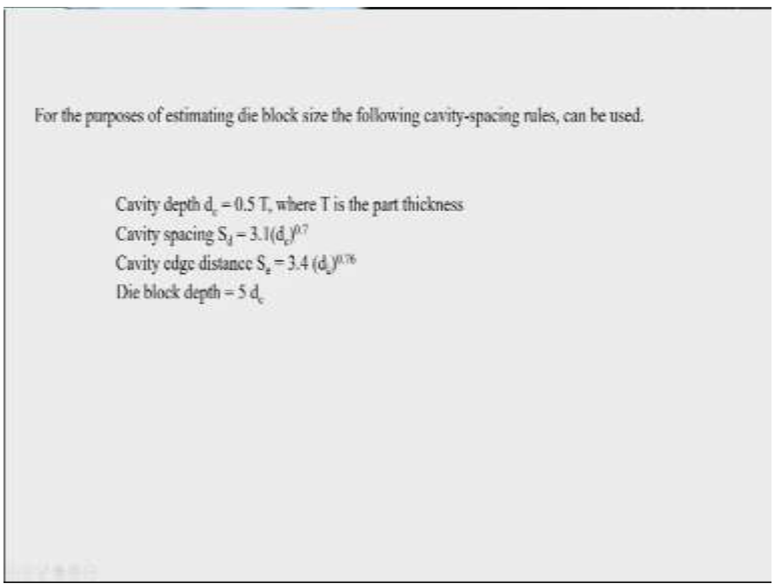


So, purpose of estimating the die block size the following cavity spacing ruling can be used these are all thumb rules okay cavity depth d c is equal to point 5 T, where T is the part thickness cavity spacing between these 2 die blocks it is 3.1 d c okay and that is a die cavity okay and cavity edge distance is this distance or the you have this type of thumb rules which are which are generally use if it is very large, then you your die block will be very large. So, your die cost will go to exorbitantly high but if it is very less than the die strength also has to be concerned for minimum distances to be maintained.

$$Cavity\ depth\ d_c = 0.5T, where\ T\ is\ the\ part\ thickness$$

$$Cavity\ spacing\ S_d = 3.1(d_c)^{0.7}$$

$$Cavity\ edge\ distance\ S_e = 3.4(d_c)^{0.76}$$

$$Die\ block\ depth = 5\ d_c$$

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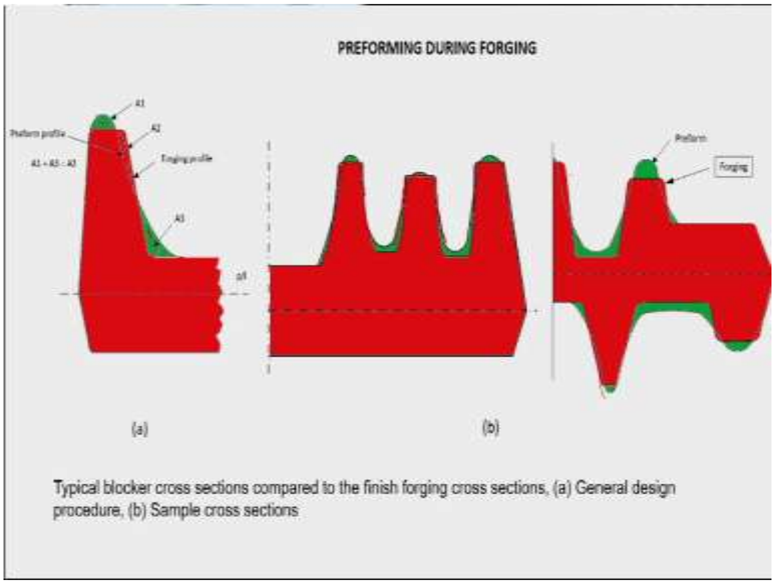


And during this gives an idea about So, being said trial and error type thing nowadays now all this with the CAD CAM packages we can do it but the principle is like this see this a racked area, it shows your component suppose this shows your component this will be your blocker die in the blocker die this is also at when the die process this metal will flow into maybe this region similarly, this is the blocker die region and when your die in the finishing the die is the metal from here to flow here that is this $A_2$ this region.

We will be the sum of this metal and this metal you will find that other part metal is not flowing but only from here it is going from here it is going so, both extruding inside and here it is extruding and it is being here just forging into this part. So, all a very small amount of metal flowing is taking place in that itself will take place as a die advances. Similarly, so, that means green volume green region is yours the blocker die design.

And of course this you have to flow it like this here also whereas the red one is a finishing die in the same case also you see that from here what was in the blocker die that will move here and it will reach up to here similarly from here it will move here from here it will metal will flow into this region from here metal will flow into this region from here metal flow here, here it will flow this will flow like that is how it comes.

And similarly here also when you look at it, you see that different geometry is there the green from here preform or maybe your broker die design and the red one is your final finishing operation. So, these are some of the things when you have to look at it. Now, in one die itself you may how sometimes for simplicity, if it is a complicated shape, you may incorporate more than one component itself

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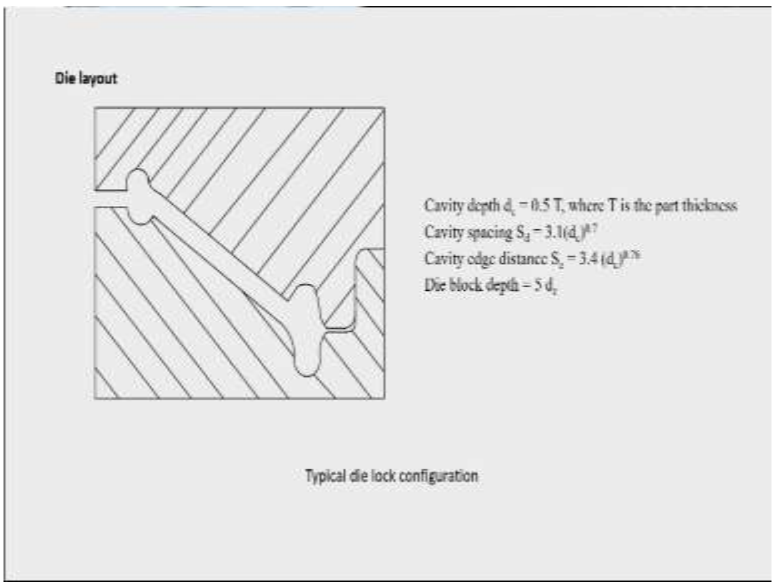


And then by the die design, if this type of a cranked die is there. So you take care of by locking itself, so that if this locking was not there, if it was straight like this, during pressing the metal is here. So, this die shift will take place in this way. So, to avoid that this is where the experience comes. So, you are you are automatically you are going to have a die locking device also configuration also inside this.

So that, choosing the parting plane is a very important thing in this die design first thing one has to look is how your parting line should be there for the die block. Basically these are all for with respect to your finished forging finishing impression die and blocker die or other cases it will not be much of a matter because die shift and other things should not take place. So there are certain things which he has to look into that. So you have to very carefully make the layout of the die okay.