Manufacturing Guidelines of Production Design

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Lecture-25
Design Guidelines for Power Metal Processing

Namaskar friends, welcome to session 25 of our course on manufacturing guidelines for product design. As you were well aware that we are discussing the product design guidelines based on various manufacturing processes. In the current week that is week number 5 we have focused our attention on compression moulding, injection moulding, extrusion, machining and today we are focusing on the another process which is also very important process that is powder metal processing.

In which we may use of metallic powders and we try to give them the desired shape as per requirement. So, powder metallurgy or the powder metal processing technique is also very important for materials which are otherwise difficult to process using the normal processes or the standard processes such as casting, machining, forming. So, we have a specific set of materials which are difficult to process using the standard processes.

And therefore we need to develop design conceptualize newer and newer processing techniques for these difficult to process materials. So, there are difficult to machine materials as we have seen in the previous session that it is difficult to machine these materials using the standard machining processes. Similarly there are difficult to process materials which are difficult to process using the standard manufacturing processes.

The process can be casting or it can be machining or it can be deforming, so depending upon the categories of the materials there are a select group of materials which are difficult to process. And therefore we need to understand the concept of powder processing and once we are making a product by powder processing technique what are the design guidelines that we must keep in mind, how we must design our product what are the features that we must avoid, what are the features that we must definitely include in our design.

So, that the design is successful, the product is made successfully using the powder processing technique. So, that is the basic summary of what we are going to cover today, we are not going to cover in detail that what are the various steps involved and what is the process mechanism of powder processing technique. But we are going to see that if the product has to be made what are the guidelines that we must keep in mind for the product which is going to be made using the powder processing technique.

So, quickly now let us see as is now become a practice that first we talk about 2 or 3 slides about the process. So, that even the learners who have no idea about the process can first get a brief idea about the process and then can relate the guidelines with the process. Now in powder processing what do we do.

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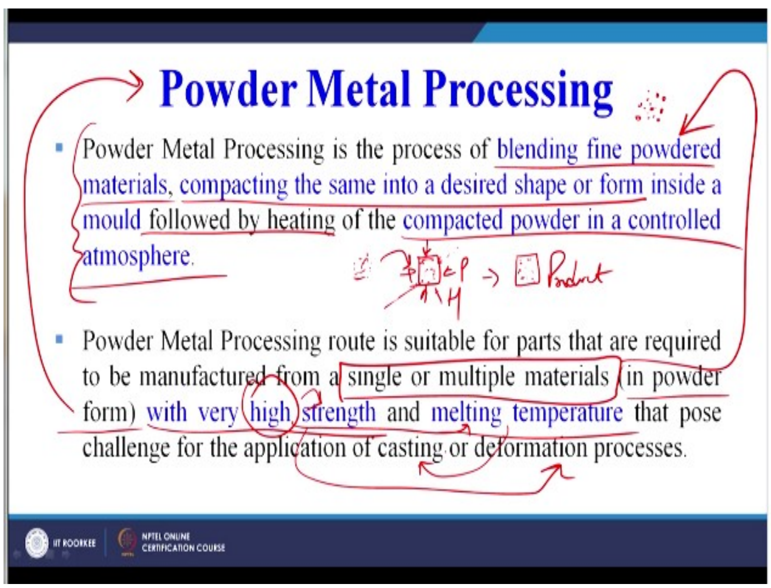

In powder metal processing we do the blending of the fine powdered materials, so basically the raw material in case of powder processing are the metal powders. So, in powder metal processing we process it by blending the fine powdered materials compacting the same into a desired shape or form followed by heating of the compacted powder in a controlled atmosphere.

So, what we are doing, we have powdered material we want to give it some shape we put it in a mould so that the shape is fixed we may apply pressure means compaction and we supply heat.

So, heat and pressure is applied and then it takes the shape of the final product, so this is our product. So, this is the basic process of powder metal processing again I will read whatever is given in the very first point.

Because it is summarizes the whole process, powder metal processing is the process of blending fine powdered materials. So, the raw material is fine powdered material, so it can be combination of 2 powders also it can be combination also, it is not only single powder. So, blending fine powdered materials who can blend 2 or 3 different types of powders compacting them into a desired shape or form in the mould or die followed by heating of the compacted powder in a controlled atmosphere.

So, we do this compaction under the controlled atmosphere, now powder metal processing route is suitable for parts that are required to be manufactured from a single or multiple materials already this has been highlighted single or multiple materials you can see here blending of fine powdered. So, it is not that you will be using a single powder only you can use definitely but for getting the specific properties or functionality of the product.

Many times we may require to blend 2 or 3 different powders together to make our plot or the product. So, powder metal processing route is suitable for parts that are required to be manufactured from a single or multiple materials. Materials are in the powder form which is clearly indicative of the name of the process with very high strength. Now these powders are made up of metals which have very high strength and high melting temperature.

So, high is denoting both, strength also and the melting temperature also, so the materials which have very high strength which have very high melting temperature that pose challenge for application of casting or deformation process. So, these materials which have very high strength difficult to process by deformation process, very high melting temperature difficult to process by casting.

So, the materials which are difficult to process by casting or by deformation processes or sometimes these materials maybe extremely hard, so they are difficult to machine also. So, that materials which are difficult to machine, the materials which are difficult to melt because of high melting temperature the materials which are having very high strength or difficult to deform we can give them a shape in the powdered form.

So, first thing is we need to produce the powders of these materials and then these powders can be blended together depending upon the functional requirement of the product. Then in the mould or the die they can be put, so that they take the shape they are compacted there, finally they are centered that is they are in simple language we can say baked at very high temperature and then they take the shape of the die or the mould and finally the product is ready.

So, this is the basic concept of the powder metal processing technique, now how the powders are made there are number of processes that can be use for making the metallic powders that we are not going to cover in today's session.

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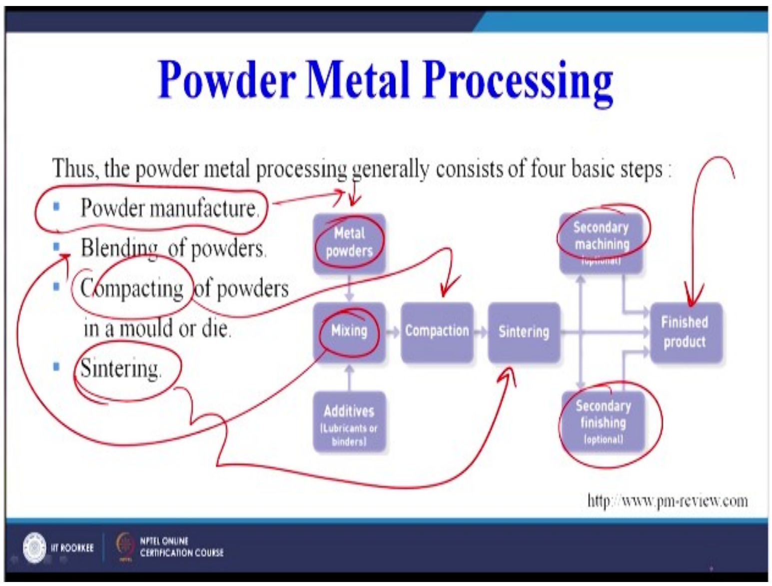

Now the powder metal processing generally consist of the 4 basic steps, now this basic steps are mentioned here as I have already told we are not going to discuss that how the powders are manufactured. But we assume that there are processes available which can produce the metal powders, blending of powders that is the mixing. So, first you have the metal powders then you blend the powders together then there is compaction of the powders in a mould or die this is compaction.

And finally the sintering process and sintering process is here, so you have metal powders, you blend them together, you compact them then you sinter them. Sinter means you heat the elevated temperatures and your product is ready, once your green compact or your sintered part is ready or sintered product is ready you can do the secondary machining of the part. Sometime some finishing operations can be done and finally you get your finished product.

So, this is basically the standard approach of producing the parts made by the metallic powders. So, the 4 basic steps are you have a powder, you mix the powder, you compact it and then you sinter it. So, compaction will give it shape, sintering will give it the bonding and the strength, now what are the design guidelines for powder metal processing parts, we have seen that there are parts.

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Now this is suppose 1 powder metal part, what are the design guidelines for this, what are the shape requirements, what are the limitations, what are the we can say criteria when we are going to design a part. So, what are the important geometrical guidelines that we must keep in mind when the part has to be made using the metallic powders that is what is the target of our course maybe in the last 7, 8 minutes.

Now we have understood how the products are made by metal powders, now let us see what are the design guidelines.

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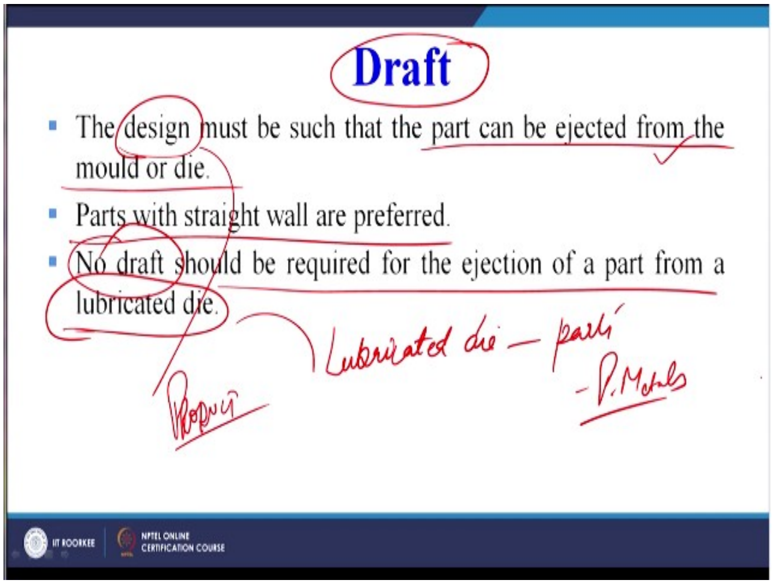

So, first design guideline is related to the draft and draft usually we say whenever the mould or die is used. We must ensure that the moulded part comes out of the die easily and for that we always provide a draft. But in case of powder metallurgy the design, so the design here what we are talking about is the product design. The product which is to be made by the metallic powders, the product design must be such that the part can be ejected from the mould or the die easily.

So, that is the first thing that must be taken into account the part must be so design that it can be ejected from the mould or the die easily part with straight wall are preferred. Usually in case of our metallic parts or in case of our parts we have suggested that there must be a draft in order to provide easy removal of the part from the die. But here parts with straight walls preferred if you see no draft should be required for the ejection of a part.

So, when the part has to be ejected specially in case of metal parts which are made by metallic powders, no draft is required. But there is additional requirement from a lubricated die, so if you are using a lubricated die in that case you need not provide any draft on the parts which are going to be made from the powdered metals. So, basically we can see that draft is the essential requirement in case of the parts made in metals as well as in plastics.

But in case of powder metallurgy we can make straight parts but the only condition is that lubricated die must be there.

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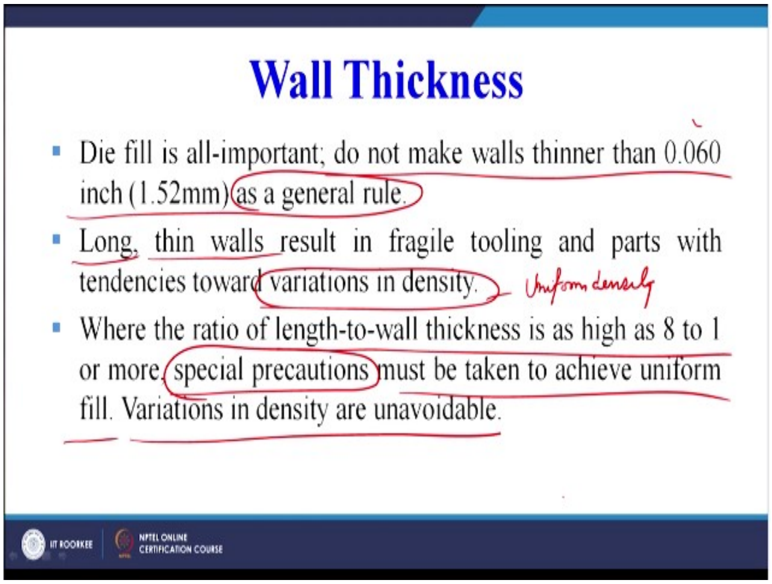

Then coming onto the wall thickness which is very important in most of the product design guidelines for metals and polymers we have seen that wall thickness is an important criteria. An injection moulding process we have seen for plastic parts can produce parts with very low values of wall thickness or thin parts or thin wall parts can be easily made using the injection moulding process.

So, die fill is all important, do not make walls thinner than 0.060 inch as a general rule, so we can see that this is a general rule. In general rule this is the value which is given here you can see die fill is all important, so do not make the walls thinner than 0.06 inch, the values are given in millimeter also this is the general rule. Again 2 times I have read the sentence to make it clear that 1.52 millimeter must be kept in mind, walls must not be thinner than 1.52 millimeter in case of powder parts or parts made by metallic powder.

Long thin walls result in fragile tooling and parts with tendencies towards variations in density. So, what is our requirement, we want uniform density all around but if we make parts which are long thin walls are there, so the density may not be uniform. So, there may be gradient of density along the length of the product which is not desirable. So, therefore when we are designing a part we must ensure that the part is not very very long, so that the part is having different density.

It which is going to affect it functional performance during the service, where the ratio of length to wall thickness is as high as 8 to 1, so the length is long, thickness is less. Where the ratio of the length to wall thickness is as high as 8 to 1 or more special precautions must be taken to achieve the uniform fill variations in density are unavoidable. So, we have to avoid the variation of density specially in case of powdered metal parts.

And how that can be avoided, that can be avoided by selecting the length of the part, the wall thickness of the part. In such a way that we ensure that the uniform density is there across the section of the powered metal part.

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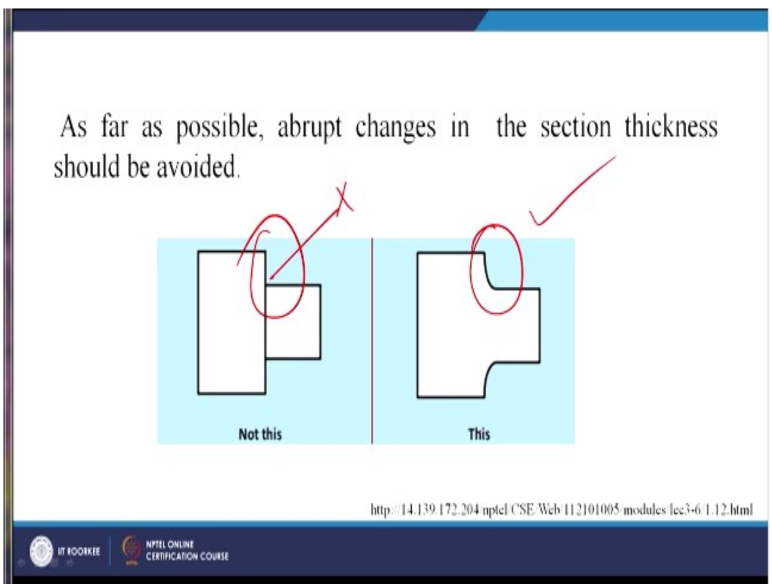

Now as for as possible abrupt changes in the section thickness should be avoided, so this type of abrupt changes are not recommended for the parts to be made by powered metal. And this is what is recommended, this is a common we can say guideline for most of the parts. So, this is standard only for metals also we have seen for polymers also we have seen and for powdered metals also we are seeing the same guideline.

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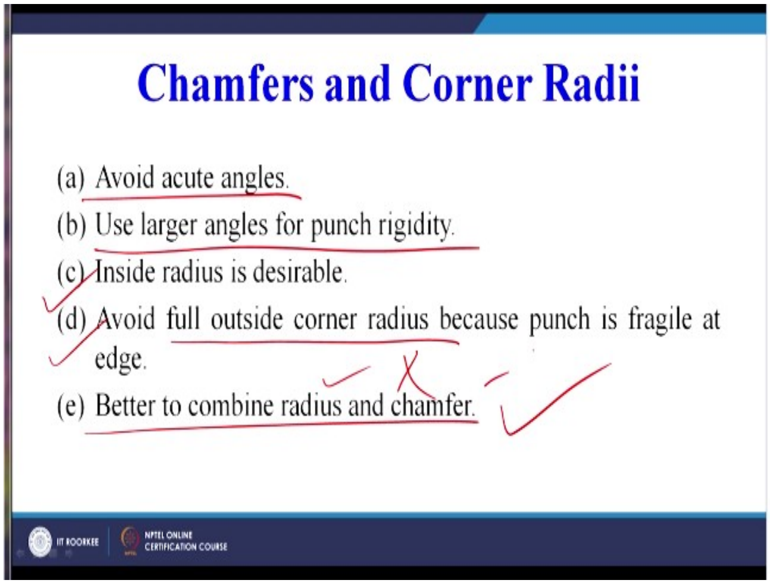

Now coming to the chamfers and corner radii, so we will try to understand this with the help of images in the next slide, we must avoid the acute angles.

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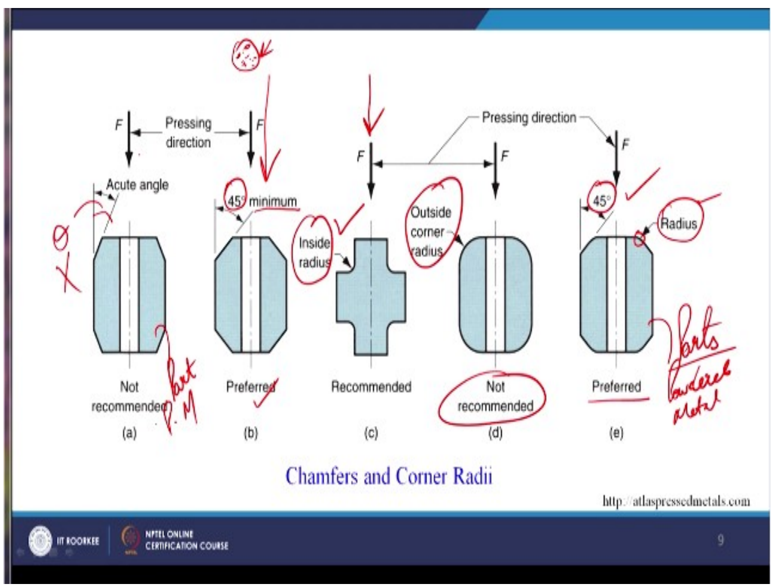

Now let us see with a help of a diagram this is a part which is made by powdered metal, so we can see at this is the acute angle here maybe we can call it theta. So, acute angles must be avoided, so this is not recommended, so this is 45 degree here. So, minimum 45 degree this can be preferred here, so this is the direction of pressing as we have seen that we have metallic powders we blend them 2, 3 different types of powders.

Then we put them in a mould or a die then we apply pressure, we compact them, so this is the direction of compaction which we must keep in mind. So, when we are pressing them in this direction this theta if it is acute must be avoided maybe 45 degree or more than 45 degree is preferred, so this is the first guideline acute angles must be avoided. Then use larger angles for punch rigidity, so we must avoid acute angles and we must prefer larger angles for punch rigidity.

Inside radius is desirable, so we can see this is the inside radius, so this is desirable it is recommended. So, this is the direction in which the forces applied, this is another guideline inside radius is desirable. Avoid full outside corner radius because punch is fragile at the edge, so full outside corner radius must be avoided because the punch that is going to punch it or compact this powdered metal is fragile at the edge better to combine radius and chamfer.

So, wherever possible radius and chamfer can be combined, so this is the outside corner radius which is not recommended. Because the punch that is punching is fragile at the corners and then we can see the radius this is preferred, this 45 degree is preferred, this radius is also preferred at this point, so this is preferred. So, these are parts which are going to be manufactured using powdered metals by blending compaction and sintering.

So, we can take advantage avoid the acute angle provide the inside radius avoid the outside corner radius. Then if we follow these guidelines our part will be manufactured successfully without any problems during the processing. So, these are the guidelines related to chamfers and the corner radii.

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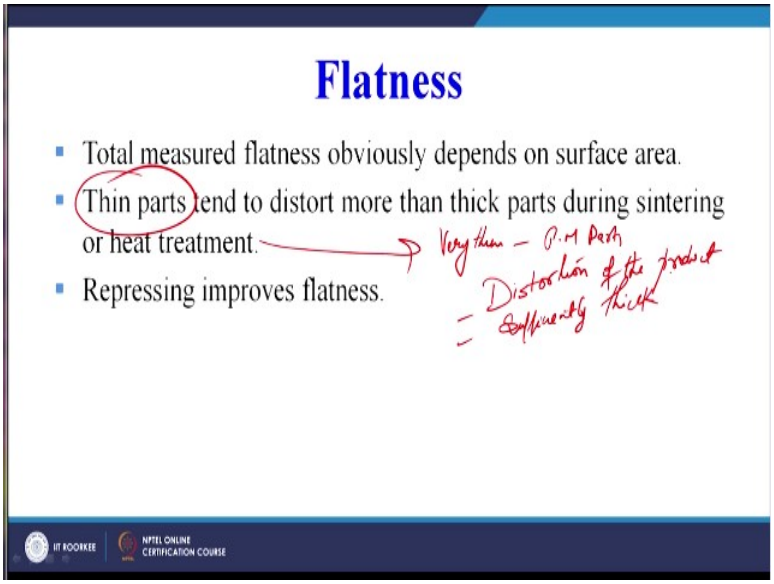

Now regarding the flatness, total measured flatness obviously depends on the surface area, thin parts which is important tend to distort more than the thick parts during sintering or heat treatment. So, this is a guideline that very thin cross-sections must be avoided specially for the PM parts. So, thin parts tend to distort more than the thick parts during the sintering or heat treatment.

So, in order to avoid distortion of the product during sintering we must make it sufficiently thick. So, wherever possible we can choose what must be the thickness of the part which has to be made by the powdered metal using the powder metal processing technique repressing. So, we can do the repressing or re-compaction, repressing improves the flatness.

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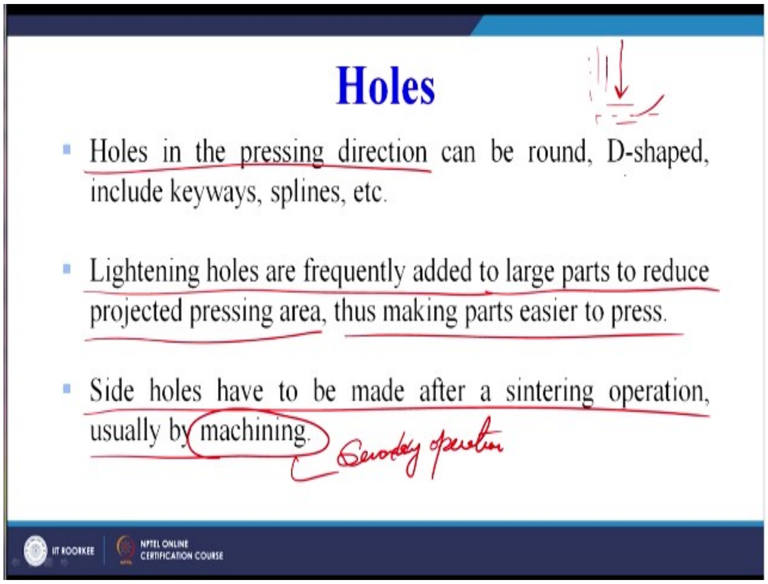

Now what are the guidelines for the parts which have to made by powdered metal by compaction and sintering if the holes are going to be there in the part. So, holes in the pressing direction can be round, D-shaped include keyways, splines etc. So, holes in the pressing direction maybe round, lightening holes are frequently added to large parts to reduce projected pressing area thus making the parts easier to press.

Side holes have to be made after a sintering operation usually by the machining which is a secondary operation as we have seen. That once the part has been sintered when we do the machining or we do maybe some other secondary operations, so all those will fall under the secondary category. So, the summary of these 3 lines is that side holes, side hole means where the excess of the hole is maybe perpendicular to the pressing direction.

So, suppose as we have seen this is the pressing direction as we have seen the previous slide and this is suppose the excess of the hole. So, these type of holes have to be made after the sintering process but if the holes are in the direction of the pressing as a holes in the pressing direction can be round, D-shaped and include keyways and spline. So, in the direction of pressing you can make the holes during your powder metal processing technique only.

Across the pressing direction or in direction perpendicular to the pressing direction, you have to machine the holes at a later stage by any of the machining operations. Now let us see what are the other design features or design attributes related to the shape of the parts that have to be made by the powdered metal using the powder metal processing technique, so one of those are the bosses.

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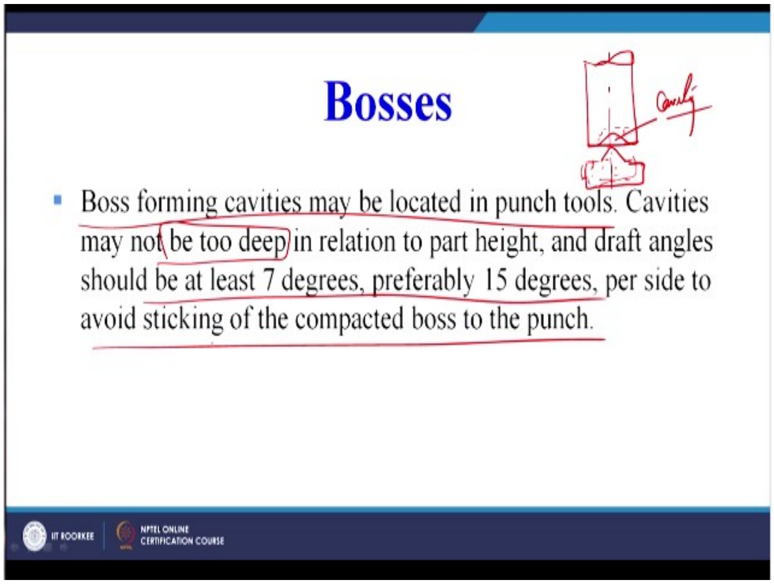

So, boss forming cavities maybe located in the punch tools, so in the basically what we are going to do, we are going to compact the powdered metal. So, the compaction will be done with the punch, so the boss forming cavities maybe located in the punch tool. So, suppose this is my punch, so I can have a boss forming cavity here and then I can compact the metal powder. So, boss forming cavities maybe located in the punch tool, cavities may not be too deep in relation to the part height.

And draft angle should be at least 7 degrees preferably 15 degrees per side to avoid sticking of the compacted boss to the punch. So, suppose this is my normal punch and if I want to produce maybe a boss in this metallic powder I can make a cavity like this or depending upon the shape of the boss I can make cavity here. And this is suppose my punch and this is the direction of pressing, so this is the cavity that we are talking about.

So, boss forming cavities maybe located in punch tools, cavities may not be too deep in relation to the part height. So, the cavities must not be too deep, draft angle 7 degree preferably 15 degrees to avoid the sticking of the compacted boss. So, the boss will be compacted here on top of the part, so it must not get stuck to the punch in order to avoid that we must provide the proper draft.

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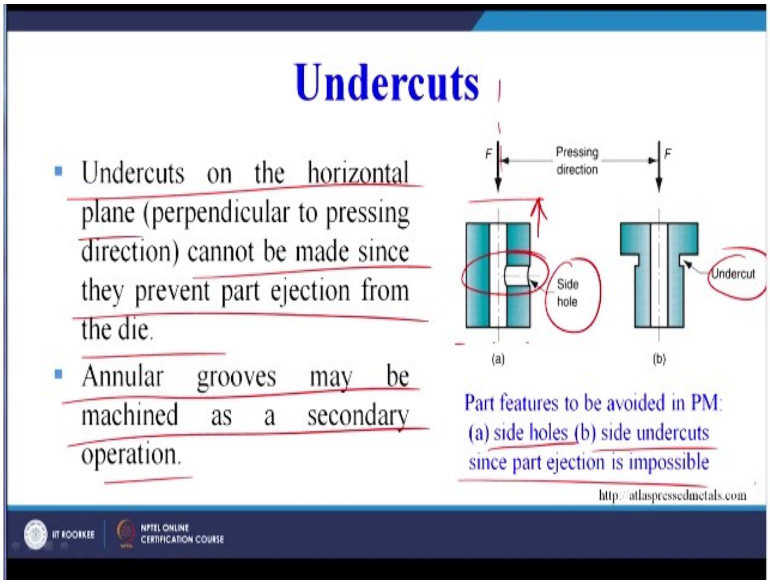

So, undercuts, undercuts on the horizontal plane, this is the horizontal plane, this is we can say the vertical plane undercuts on the horizontal plane that is perpendicular to the pressing direction. So, this is a pressing direction, this is the direction perpendicular to the pressing direction cannot be made since they prevent part ejection from the die. So, if we have undercuts somewhere here the how the part will be ejected it will become difficult.

So, the undercuts on the horizontal plane cannot be made since they prevent part ejection from the die, annular grooves maybe machined as a secondary operation. So, undercuts this type of undercut, this type of side hole, side holes can be made at a later stage after the sintering operation. So, part which has to be avoided in the powder metal processing technique side holes must be avoided, side undercuts must be avoided since part ejection is impossible.

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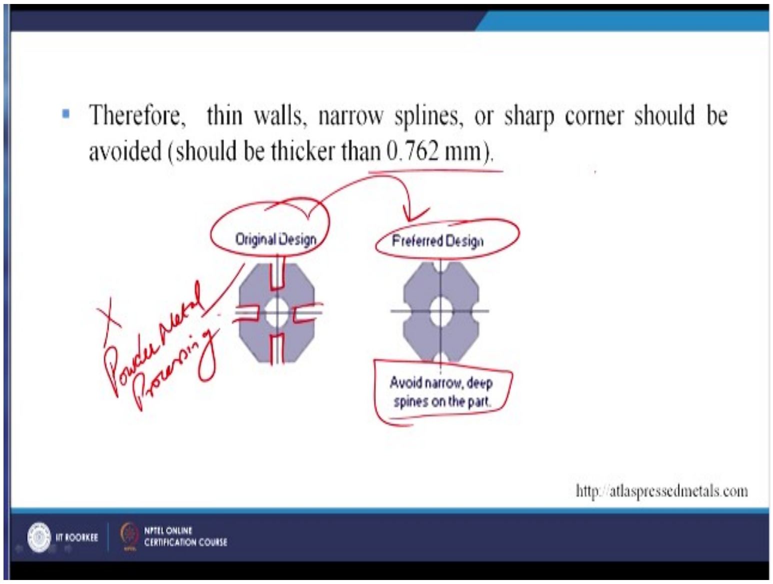

So, therefore thin walls narrow splines, so these are the narrow splines here, so this is the original design it will be difficult to make by powder metal processing technique, difficult to make these type of splines. So, what we can do, we can redesign we can make our new design, so this is a preferred design same avoid narrow deep splines on the part. So, therefore thin walls narrow splines or sharp corner should be avoided this must be thicker than 0.762 millimeter.

So, we can see that we can redesign our part in order to satisfy the functional requirement as well as making it easier to be made by the process that we have selected for making our product. So, therefore we can see there are number of guidelines related to the design of the parts which are to be made by powder metal processing technique and similarly the tolerance values are also very important.

So, as a general guideline as a product designer we must take into this account this fact that we must not specify very tight tolerances on the parts that we are producing unnecessary tight tolerances have an effect on the tooling cost as well as the manufacturing cost of the product. So, therefore very close tolerance in the direction of compression should be avoided.

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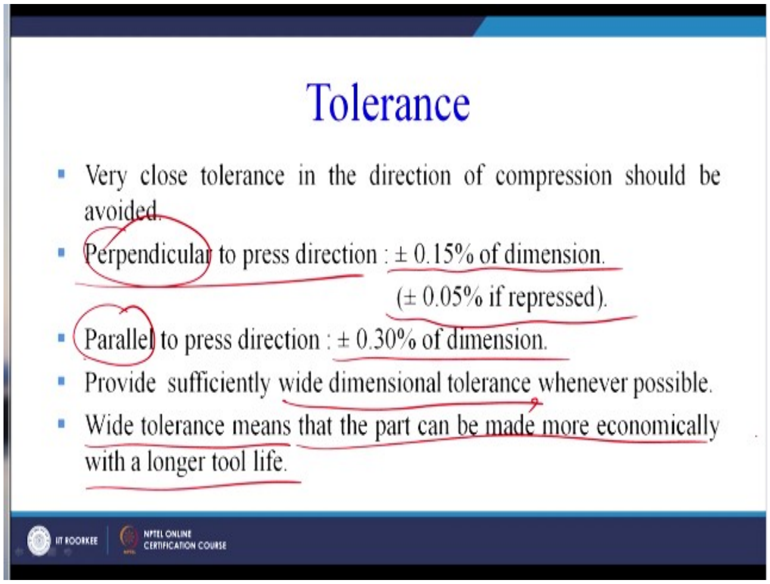

Perpendicular to the press direction, general guidelines are given +/- 0.15% of the dimension maybe again 0.05% if it is repressed. Parallel to the press direction this is perpendicular to the pressing direction, parallel to the pres direction +/-0.30% of the dimension provide sufficiently wide dimensional tolerance whenever possible. So, we must not be very very rigid or very very stringent about the dimensional tolerances we must be quite relaxed as well as lenient while specifying the dimensional tolerances.

Wide tolerance means that part can be more economically with the longer tool life. So, wide tolerance which means that our tool life will be longer and the part can be made in a more economical manner. So, with this we conclude this session number 25 and discussion for week number 5 and today we have discussed the product design guidelines that must be kept in mind when we are making the or deciding the geometry of our part which has to be made by pressing of metal powders maybe first we blend the powders together.

Then we compact them, we sinter them and thereby we get our final product, so wherever holes have to be made internals plains are undercuts are required, what are the design guidelines that we must keep in mind. In our next week we will focus our attention on other manufacturing processes which are usually used and what are the design guidelines from the product design point of view.

That must be kept in mind in order to perform our processes more efficiently, more effectively and in nutshell more productively, thank you.