**Processing of Non-Metals**

**Prof. Dr. Inderdeep Singh**
**Department of Mechanical and Industrial Engineering**
**Indian Institute of Technology, Roorkee**

**Module - 3**
**Glass: Properties and Processing**
**Lecture - 5**
**Processing of Ceramic Parts – Pressing**

Very warm welcome to all of you in this lecture on processing of ceramic parts. And what we are going to focus today is one of the important aspects of the product development process that is ceramic part development process that is pressing. If you remember what we are covered in our previous lecture, we have seen that there are different steps involved in the processing of ceramic parts, and we have seen the some of the processes that are use for processing of ceramic part. But before going on to discuss this important aspects related to the ceramics, let us see that this particular lecture where it fits into our total course of processing of non metals.

As we are well aware that we are discussing the course on processing of non metals, which has been divided into seven different modules. We have already discussed or completed our discussion on two modules that is the introductory part to this particular course. And in the second module, we have seen the glasses and various techniques and tools that which are used for processing of glasses. In module number three, we have started our discussion on the basic aspects of ceramics, we have seen that how the ceramics are different from metals, we have seen that what are the basic fundamental aspects related to ceramics. We have seen that what are the important properties of the ceramics that makes them different from the metals and the polymers, and how these properties affect the processing of ceramic products. Then we have seen that it is very important to convert the ceramic raw materials into the ceramic powders in order to make the ceramic products.

Related to the ceramic products, we have seen that ceramics have got lot of applications ranging from the house hold or domestic applications to the aerospace as well as the bio ceramic applications. As well as the one of the important which is most commonly known to most of us that is the space shuttle application. So, depending upon the applications of the ceramics, different types of methods are there, but in order to convert

the ceramic raw materials into the final ceramic products, we require the production of ceramic powders. And in ceramic powders, we have seen that there are different types of tools or techniques which are use for processing of ceramic powders.

Basically, the tools and techniques that are used for processing of ceramic powders can broadly we classified into two categories, that is the mechanical type of processes and the chemical methods for processing of ceramic powders. In mechanical, we have seen ball milling, we have seen role crushing, gyratory crushing, jaw crushing. As well as in chemical methods, we have seen solid reaction as well as the precipitation method. So, we know some of the techniques now which are use for preparation of ceramic powder. So, once the ceramic powder is ready, it has to be given a shape. And once the shape has been given it has to be bagged or it has to be fired in order to gave it the required strength and to make it usable for different applications. So, we have got a series of steps that are require to convert the ceramic powder into the final products.

So, whatever we have discussed till now that I have briefly outlined or summarized till today's lecture, and now our focus now onwards may be right from today's lecture, our focus primarily would be to convert the ceramic powder into the final product. So, just we summarized what we have discussed in this module in just three to four lines, we have seen the basic properties of the ceramics, we have seen the applications of the ceramics, and we have seen the methods which are used for ceramic powders. So, these three important aspects we already discussed. Now our focus would be that how to convert the ceramic powders into the final products.

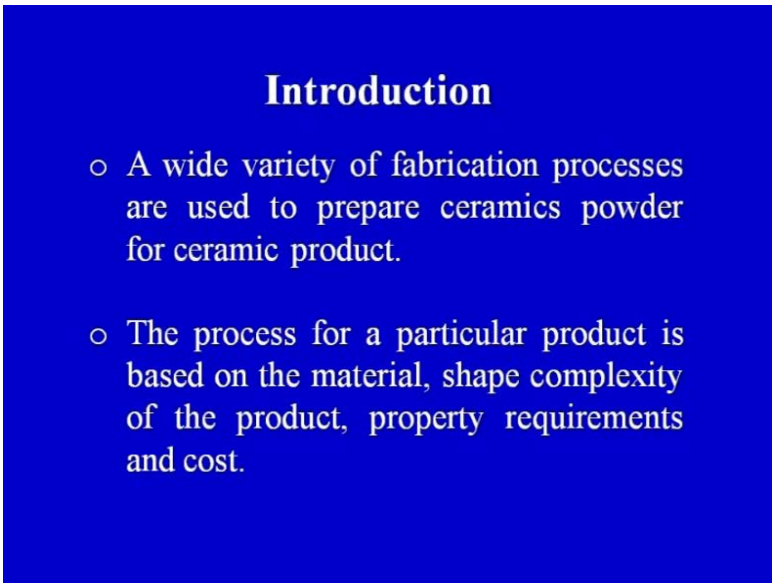
So, let us start our discussion for today's lecture, our focus would be on pressing. Basically, we have to make a give a desired shape to the ceramic products depending upon the requirement. Now we suppose to make a flower ways or a decorative item of a ceramic material then we have to first make a ceramic powder or a ceramic raw material and then we have to convert that raw material give it a particular shape. And finally, we have to fire dry fire that particular shape in order to get the final product. So, these three steps that we have already seen in the last slides of the previous lecture, that we will revised today that what are the three important steps that are involved in converting the ceramic powder into the final ceramic product.

One example, I have given as decorative item, to we will have raw material we will make a decorative item out of that, but what are the steps involved in that particular process that we are going to see. One of the important steps is the process of pressing. And in pressing, we will see that there are different types of techniques which are used for pressing like hot pressing, dry pressing, wet pressing and isostatic pressing. Each one of these have got their own advantages and limitations or disadvantages. So, we will see that what are the what are the silent advantages and the disadvantages of these processes.

So, let us now start our discussion with this introduction about our course. As I have told again and again we are emphasizing, because all these lectures are inter related to one another. So, first of all we have to establish that these particular lecture, this particular is falling under this particular modules. So, once before starting the discussion today, let me again tell you that this particular lecture is falling under module three of our course on processing of non metals. And in module three, our focus is on ceramics. And in first four lectures of this particular module, we have discuss the basic aspects of ceramics and methods that are used for production of ceramic powders.

So, for those who are just listening for this discussion, they can first go and have a view and other four lectures have already been delivered that, that address the basic aspects of ceramics, and how the ceramic powders are prepared. Now where we are starting our discussion with the understanding that all of us know that how the ceramic powders are made. Now ceramic powders are already available with us and now we are moving forward to convert that ceramics powder into the final product.

(Refer Slide Time: 07:49)




So, introduction: A wide variety of fabrication process are used to prepare ceramic powder for ceramic product. So, that we have already seen it is just a revision of what we have already covered, that a wide variety a number of processes are which we have already seen. A fabrication processes are used to prepare ceramic powders for ceramic product that already we know. Let me revise that there are mechanical type of processes, there are chemical methods or synthesis to convert the ceramic raw materials or the natural minerals into the usable ceramic powders. The processes for a particular products is based on the material shape, complexity of the product, and the property requirements as well as the cost. Now this particular slide is correlating the two things that we have already discussed and that we are going to discuss in our next lectures as well as this lecture.

Point number one, discuss is that there are wide variety of fabrication process is that are used to prepare ceramic powders for ceramic products. So, that we are already covered that is ceramic powder preparation one and ceramic powder preparation to two, two lectures already we have discussed. Coming on to with the ceramic powders now how to convert into the final product for that also there are number of processes. We have the ceramic powder now we have to somehow blend it with the additives that we will be seeing, and make the final product; for that also there are number of processes and some of those processes we will cover in the today's lecture and in the subsequent lecture.

The process for a particular product is based on the material. So, first of all the raw material we have to see what type of powder is there, what is the particle size, what is the particle size distribution, what is the chemical distribution of that powder, what is the phase composition of that powder, what is the state of agglomeration in that powder, all these desirable characteristics of the powders we will see, because these characteristics will defined the powder basically.

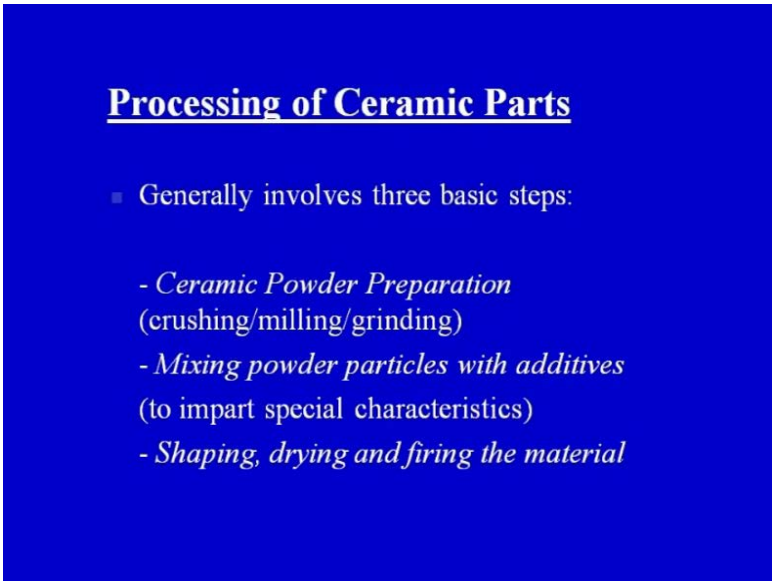
So, the process for the particular product, now whatever process we have to chose for making a particular product will be based on the raw materials. The raw material is a powder here that is a ceramic powder, and ceramic powder has got certain characteristics that I have already highlighted. Now what are those characteristics, we have a particle size, particle shape, particle size distribution, state of agglomeration, chemical composition phase composition, so all these characteristics we need to understand before choosing a particular process for making a ceramic path or a ceramic product. So, this fall under the material aspect.

Then a shape complexity of the product; so if the product is very very complex, we have to choose a definite process for that. And if it is a very simple product, there would be a different process that would be use to make that product. Shape complexity is one parameter; the raw material is second parameter, and the property requirements. Now finally, what properties are desirable from the product, for example, we may be requiring a certain degree of porosity in our final product. So, we have to choose that process which would be able to provide that much porosity or in other case we may be requiring a very dense product. So, for that case also we have to choose the process accordingly, so that we are able to get the uniform density in the final product.

And finally, the cost constraints are always there, because in business, cost effectiveness is one of the most important word. So, whatever process is chosen, it has to be cost effective, efficient and effective in converting the raw material into the final product. So, this particular slide, I can summarized in two important ways that first point highlights on the preparation of ceramic powders for making the ceramic products; and second point highlights, the importance of choosing a particular process for making up ceramic products with the desirable characteristics.

So, the process for the particular product is based on the raw material, shape complexity, as well as the final property requirements from the final product, as well as the cost effectiveness of the process. So, when we have to chose a particular process, we have to keep four things in mind. So, let us revised the four things, the four things are the material or the raw material, second is the complexity of the job, third is the property requirements of the product, and finally, the cost effectiveness of the process. So, if these four things we keep in mind, we would be able to chose the best process for converting the ceramic raw material into the final product.

(Refer Slide Time: 12:56)




Now, processing of ceramic parts this slide, I have taken from our previous lecture, where we have seen that how that ceramic powders can be converted into the final product. So, this was one of the last slides of previous lecture. So, the processing of ceramic parts generally involves three basic steps.

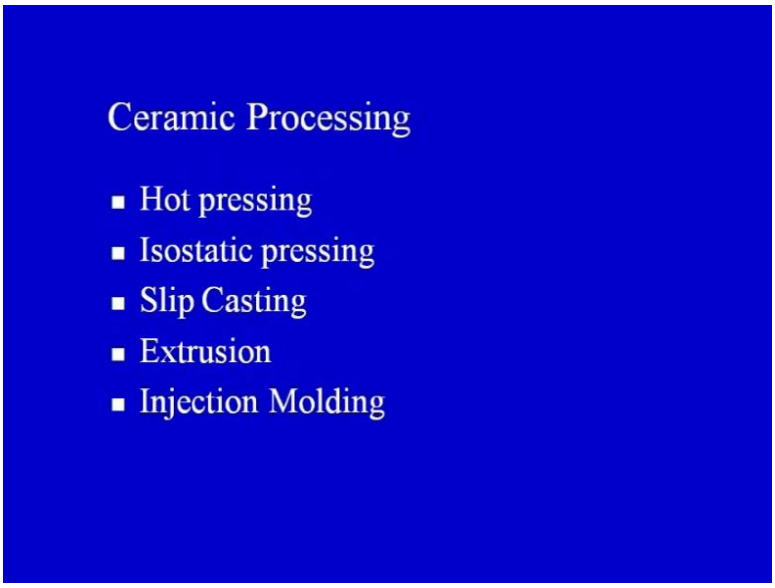
Now, what are these three basic steps we have seen. Step number one, on your screen, you can see, it is the ceramic powder preparation. It involves crushing, milling, grinding as well as the chemical method such as precipitation, co precipitation and emulsifier also sometimes used in the synthesis of the ceramic powders. So, basically, first step is the ceramic powder preparation. And we have already discuss this important aspect in the total processing aspects of ceramic parts. So, this is one of the first stage that we have already discussed.

Second step is mixing powder particles with additives. Why do we need the additives? Additives are there to give certain special characteristics to the final product. So, basically, we will add certain additives into the basic ceramic powders, and finally blend this two things together and then further do the subsequent processing in order to convert this mixture into the final products. So, the second step involved is mixing the powder particles with additives to impart special characteristics.

Last stage is the shaping, drying and firing of the material. Now shaping means that whatever mixture of or whatever blend we have generated of the ceramic powder and the additives. So, we have certain additives into the ceramic powder, we have got a mixture now that we can called as a blend. So, this blend is now given the desired shape, and for this process we would be using the dies and the molds, and particular shape would be given to the ceramic raw material.

So, ceramic raw material till now is made up of the ceramic powder and the additives which have been added to the ceramic raw material or ceramic powder to give the special or the desirable characteristics. And finally, the drying and firing of the material is done in order to give it the adequate strength and make it useable for certain engineering applications. So though, how to summarize this slide, there are importantly three things that are taken into account that point number one is the powder; point number two is the mixing of the powder with the additives. And the point number three is giving a shape to that mixture and then firing it in order to get the desired properties of the final product. So, these are the three steps that are involved, but in each step, there are number of processes or number of variants out of which we can choose the best variant. So, mixing the powder can be done in a number of vase, similarly shaping of the we can say raw material into the final form or final shape can also be done in a number of vase. And the drying and firing can also be done in a number of vase, but broadly these are the three steps that are used for processing of ceramic parts.

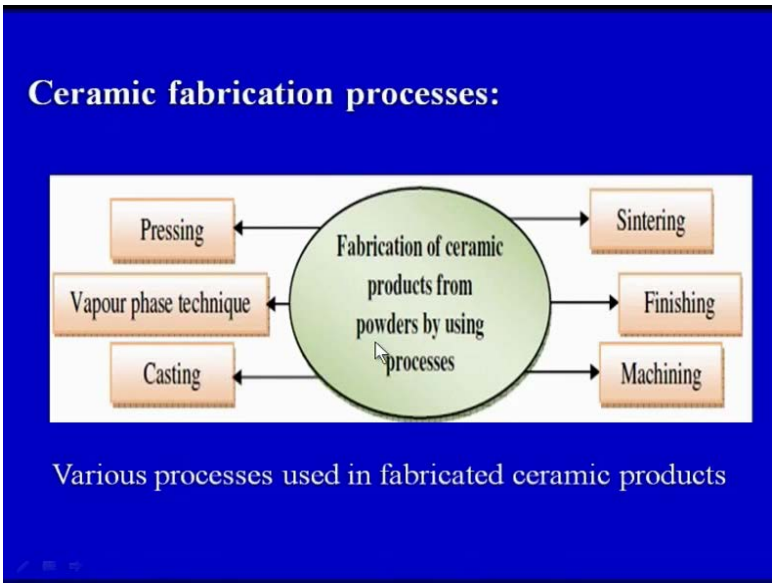
(Refer Slide Time: 16:27)




Now, what are the important types of processes that are used in these three steps? We can see first ceramic processing of parts, we can use hot pressing, isostatic pressing, slip casting, extrusion, injection molding. So, these are some of the processes which are relevant to our conversion process. Basically, our conversion process is form the ceramic powder into the final product or a solid final product. So, from a powder, we are getting a solid product, now this conversion process would be achieved with the help of number of processes.

Now what are those processes on your screen, you can see hot pressing, isostatic pressing, we can every one wet pressing, dry pressing that we are going to see today, slip casting, extrusion, injection molding. So, basically we want to give a particular shape to the blend that we have made by mixing the ceramic powder and the additives, and do give a particular shape all these process are important. So, basically all these processes will give a shape to the final product that is the third stage of shaping, firing, shaping, drying and firing. So, shaping will be done by any of these processes that is hot pressing, isostatic pressing, slip casting, extrusion and injection molding.

(Refer Slide Time: 17:53)




So, these are other details about the ceramic fabrication processes, towards the center, we can see fabrication of ceramic products from the powders by using these processes. Now what are these processes, pressing is one technique that we are going to discuss today, vapor phase technique is also there. Casting is another process; sintering that is heating at to a particular temperature, finishing and machining. So, these are various process used in fabrication of ceramic product. So, fabricated ceramic products would be made up of any of these processes.

So, these processes would be used at different levels we depending. If you remembering the previous slide, we have seen that the choice of the process will depend upon four important parameter. Let us revise those four important parameters. So, parameter number one is the raw material that is the ceramic powder. Point number two is the property of the final product that we want; point number three is the complexity of the final product or the inter cases or the design inter cases of the final product, and last one is the cost effectiveness.

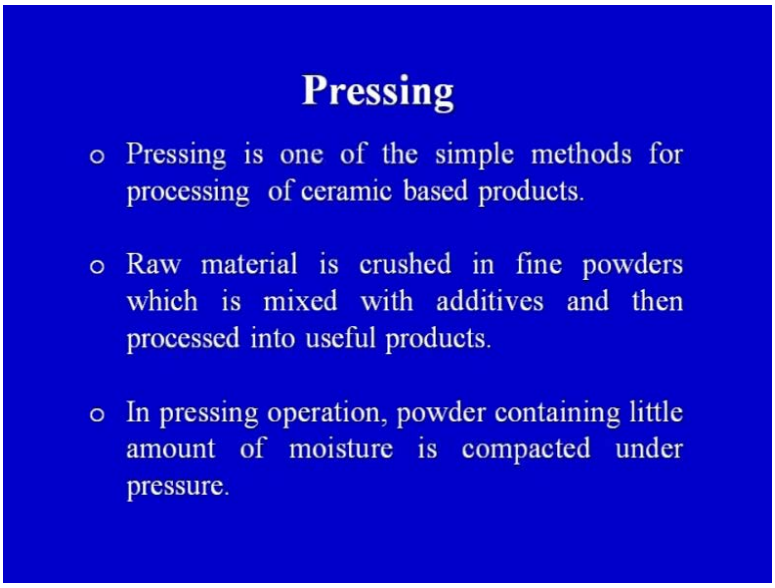
So, we have to chose out of a number of processes that which process we are going to chose, and the best process would give us the optimal results. So here, we have few processes which fall under the secondary processing of ceramic products. So, basically in ceramic secondary processing we will have finishing and machining. So, finishing and machining, we would do once our product is ready. So, primary forming, we will first

give a particular shape to our product, we will do a all these drying and firing, our product is now ready, but towards the end of this product development or product processing cycle, we will go for secondary processing which is in terms of finishing and machining. Sometimes we want a glaze surface some kind of finishing coating would be provided on the final ceramic product; sometime we want to machine it in order to make some holes; sometimes we want to make a slot in a ceramic product, so it has to be cut out. So basically, we have to see that they we sometimes secondary processing would also become inevitable.

So, instead of focusing only on the primary aspects we should also understand that in total product development or product processing our focus has to be on both the aspects that is the primary aspects that is giving shape to the final product. And the secondary aspect that is impregnating the final product with sometimes the oil or finishing the product were providing the specific layer or a coating on the surface or making some holes. So, all these three category of processes as I have just told the machining the finishing or the coating as well as the impregnating with certain oils or with certain additives or ((Refer Time: 20:55)). So, these all processes would fall under the secondary processing.

So, our focus would be to focus on the primary processing aspects of ceramic products as well as on the secondary aspects of ceramic products, and then only the product would be ready to be use for the application for which the product has been designed as well as it has been processed or fabricated. So, this particular slide gives us a overview of the type of processes which can be used for ceramics.

(Refer Slide Time: 21:39)




Now, we come on to the process, which is which we are going to discuss today that is the process of pressing. So, in pressing, you can see that pressing is one of the simple methods for processing of ceramic based products. So, basically, pressing is use for giving a shape to the product. So, we have the ceramic powders, we have added the certain additives or certain amount of moisture into the ceramic powder, and now we are compressing or compacting it, so that process we are calling as the process of pressing. So, pressing is one of the simple methods for processing of ceramic-based products.

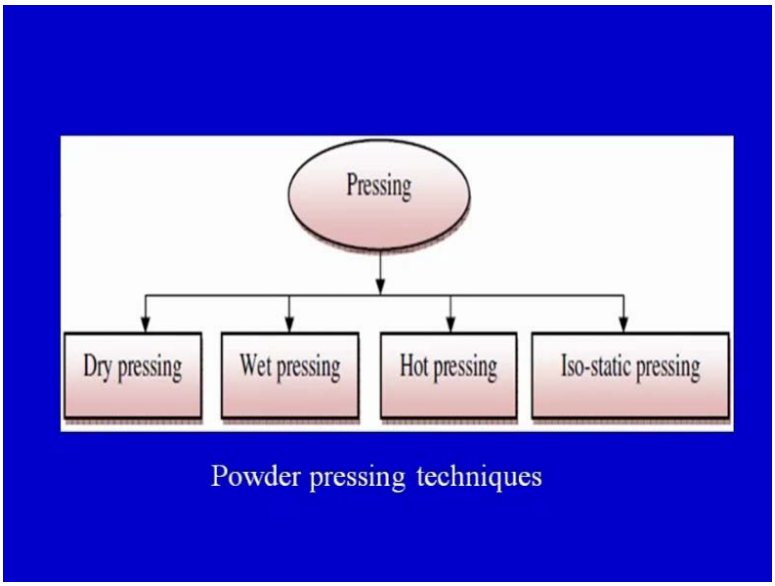
Point number two, now what is the raw material that is going into the process. The raw material is crushed in fine powders, which is mixed with additives and then processed into the useful products. So, in pressing, we have a ceramic powder, it has been mixed with the additives certain amount of moisture. Now this is taken to a equipment that we can call as a press, in that we are putting this in a particular bolt and then we are compressing it or we are applying the pressure in order to give it the desired shape.

The shape that we will get would depend upon the shape of the (( )) or the mold. So, basically we have a raw material, we are blending that raw material or the ceramic powder with the additives, and finally, we are applying the pressure. So, we will try to understand this with the help of a diagram also, but we first of all we have to understand that where this particular step is falling in that total cycle of converting the ceramic powder into the final product.

So, first stage is the ceramic powder preparation, which has been discussed earlier. Second stage is the mixing of the ceramic powder with the additives and the moisture, and the third step is giving it a particular shape. Now the shape can be given by different types of pressing mechanism or pressing techniques, that we are going to discuss in the subsequent slide. But first of all, we should understand what do we mean by pressing. So, in pressing it is one of the simplest way of converting the ceramic powder into the ceramic product; second is the raw material is crushed in find powder which is mixed with additives, and then processing to the useful product.

And in pressing operation, powder containing little amount of moisture is compacted under pressure. So, basically pressure is one of a important control variables in pressing. Also we will seen in hot pressing, temperature is also important control variable that has to be taken care of. Another important thing to know, there is the amount of moisture that has to be used for process of pressing that we can have a higher amount of moisture we can have a lower amount of moisture. So, pressing is we can say one of the important processes which is use for giving a shape to the ceramic product.

(Refer Slide Time: 24:45)

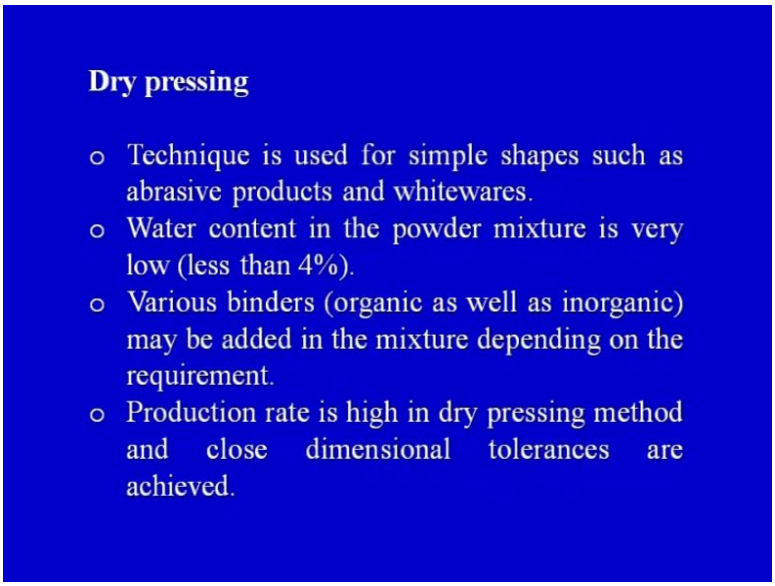



Now, pressing as we can see it can be done in a number of ways. So, we can do dry pressing we can do wet pressing. So, dry and wet can be distinguished on the basis of the amount of moisture that is present in the ceramic blend or the ceramic which has ceramic powder which has been blended with the certain amount of additives. So, if the moisture

content is more, we will say it is wet pressing; if the moisture content is less, we will say it is dry pressing. So, two important type of pressing is dry pressing and wet pressing then we have hot pressing, and finally, the isostatic pressing. So, we will see all four of this that how the ceramic powder which has been mixed with additives and moisture is compacted or press together to get the desired shape.

So, these are the powder pressing techniques not the powder processing techniques. The powder processing techniques, we have already studied in the previous lecture, where we have seen that the powder can be processed there are in the using the mechanical method of ball milling or roll crushing or the chemical method in which the reactions are use to generate the reaction products, which are finally crush to get the ceramic powders. So, these techniques are ceramic pressing technique, the powder pressing technique. So, we have a ceramic powder which has been blending and it has can be pressed in a number of ways, and four ways are four important techniques are there, for pressing of the green the pressing of the ceramic powder that is dry pressing, wet pressing, hot pressing and isostatic pressing.

(Refer Slide Time: 26:46)




Now, let us see dry pressing these four techniques, we are going to discuss now. And our focus would be to distinguish or differentiate between the four processes, and finally, see the advantages and the limitations of these processes and try to understand the basic working of one of these processes. So, dry pressing, this technique is used for simple

shapes such as abrasive products and white wares. So, basically, for abrasive products and white wares, we are going to use the process of dry pressing.

One important point to note on your screen, you can see point number one is that it is use for simple shape. So, if we want to make a complex shape then dry pressing is not advisable. So, if a complex shape is there then we will have to choose some other pressing technique. So, we have a with us four important pressing techniques, and there can be others also, but out of the four, there would be certain technique which would be advisable for complex products that we will see. But dry pressing is advisable for simple shapes, and it is advisable for certain important applications like formatting abrasive products, where we have we can have different types of abrasive products and the whitewares.

Now, let us see the amount of moisture that can be there. So, water content in the powder mixture is very low less than four percent. So, we can use or we use that in case of dry pressing very low moisture content. Various binders organic as well as inorganic may be added in the mixture depending on the requirement. So, this is three four steps whatever we have highlighted on the in this particular slide are related to the blending of the raw material together. The pressing would be done we can say the mechanism of pressing would be similar only, we would be applying pressure on this material that we are making or the raw material that we are creating for a final product. So, we can see point number one relate to the shape of the product and the applications of the products. Point number two, highlights towards the raw material that the raw material that would be use for dry pressing would have lower amount of moisture. Third point also highlights with the raw material, highlights the raw material that is the various types of binders that is organic as well as inorganic binders can be used that is they may be added to the mixture depending upon the requirement.

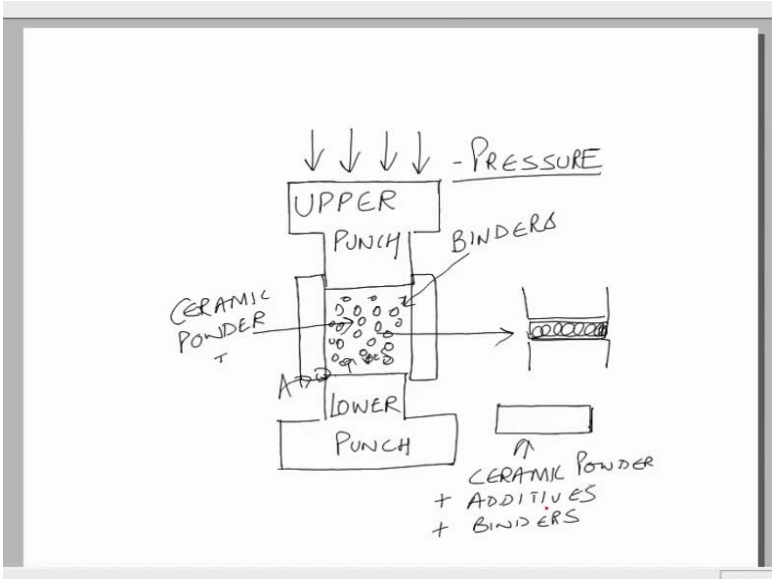
So, binder sometimes may be required, may not be required, now this relates to the final property of the product. Why I am highlighting these points, because in the very beginning of today's discussion we have seen that if we choose a particular process for a particular application, we have to satisfy at least three or four important criteria that for a particular type of a material a particular process would be chosen. For a particular type of shape, a particular process would be chosen and then for a particular property

requirement in the final product, we would be choosing a specific process, and finally, the cost effectiveness of process also has to be taken into account.

So, here we are see that depending upon the material this dry pressing would be done, when the moisture content is less. Binders may be add it, may not be add it, this depends upon the final requirements of the product that we are going to make after the dry pressing of that ceramic raw materials. And finally, the production rate is high in dry pressing method and close dimensional tolerances are achieved. So, this particular slide gives us the summary of the dry pressing technique. So, relate to the material aspects of dry pressing, related to the process aspects of dry pressing, we can see that this process is good as per as the dimensional tolerances are concerned, close dimensional tolerances can be achieved with the dry pressing, production rate is high that is related to the cost. That is the production rate is high, the cost of product would automatically come down, because it is it would be use for high production rates.

So, basically, in this particular slide, we have highlighted the dry pressing technique for converting the ceramic raw material, which has been mixed with various types of additives or binders like organic as well as inorganic binders. There is certain amount of moisture that is present in the ceramic powder, and this particular mixture is then subjected to the pressing, and finally, we are able to generate a particular shape of the ceramic depending upon the shape of the mould or the die.

(Refer Slide Time: 31:43)

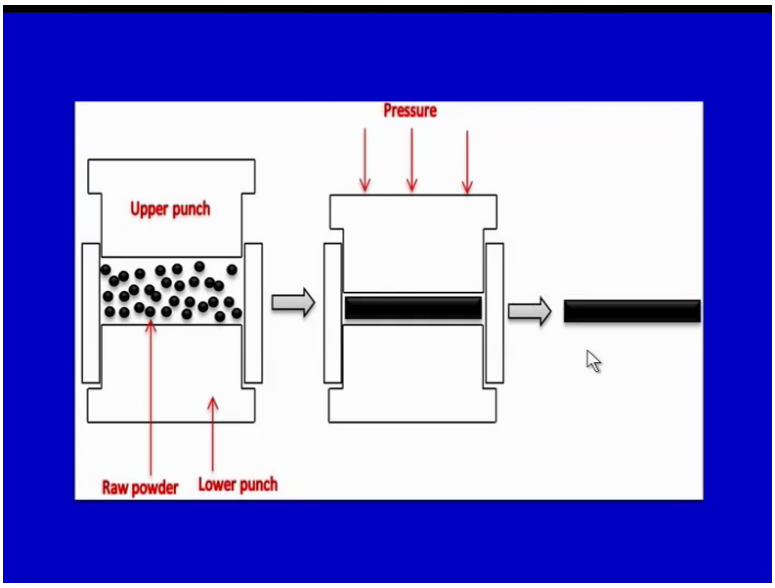


Now, let us try to understand this with the help of a diagram. So, on your screen, I am going to draw a very simple diagram; in which, we will see that how the actual action takes place. This is the upper punch, you can see this is the upper punch. So, we have a upper punch then we can have a simple representation of a die or we can see a mould and then we have a lower punch. So, we have a upper punch and we have a lower punch; now the upper punch, we can apply the pressure. So, this is pressure application and where is the raw material, the raw material is placed here.

Now what is the raw material, the raw material basically is the ceramic powder plus additives. Then what we can have additives are there, ceramic powder is there and then what we can have, we can have certain binders also. So, it may also have certain binders. So, we have binders, ceramic powder and the certain additives, and then these two upper and the lower punch would come closer, we can operate both or one can be operating and this we will get out of this, we will generating a particular shape. This is the process of dry pressing. So, finally, we will get this shape what has gone into this ceramic powder plus additives plus binders.

So, this is a we can say a simple representation of the dry pressing technique; in which, we have a upper punch, we have a lower punch and the pressure is applied the raw material is put inside the die or the mould. And finally, the pressure acts on that certain amount of moisture is always present, there are additives and the binders that are mixed with a ceramic powder now, this mixture is kept inside the die and the punch. When the pressure acts, we get a final shape. Now this particular shape is not, we can say directly in the usable form; certain other processes have to be carried out on this particular shape that has been generated here in order to make it a usable ceramic product. But dispersing is also one of the important processes that is required to make a ceramic product. From the raw material now, we have been able to generate a shape of a product. Now once the shape has been got subsequent processing on this shape would be able to give us the final ceramic product. So, we have seen the dry pressing technique.

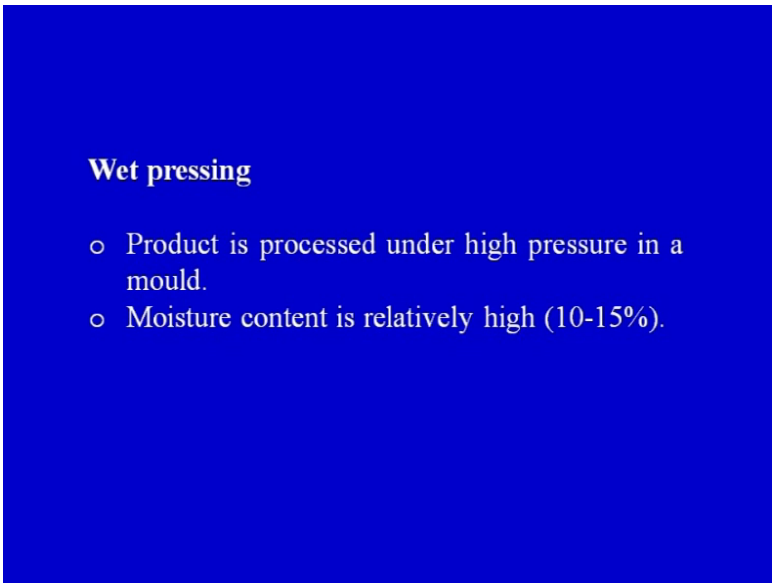
(Refer Slide Time: 36:13)




Now, let us see this, the same diagram that I have try to draw. We have upper punch, we have a lower punch; this is the raw material, which has ceramic powders, binders and additives. And once the pressure is applied by the upper punch where we can see this is converted into this shape, and this is the final shape which has been made out of the ceramic powder.

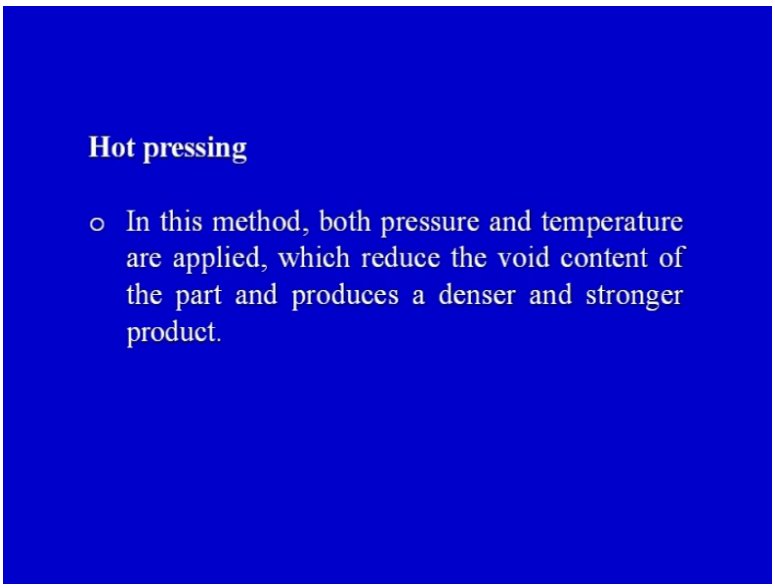
So, we have been able to make a shape from the ceramic powder. So, we have a solid shape in our hands now, and this shape now or this particular path now would be subjected to the subsequent operations to make it a usable ceramic product this is we can say a basic pressing mechanism. Now, let us now try to understand the other type of pressing techniques. There is a we can say the basic mechanism more or less remains same, but there are few differences that we would try to highlight.

(Refer Slide Time: 37:10)




So, in wet pressing, the product is processed under high pressure in a mould; moisture content is relatively high. So, we can see that in dry pressing, the moisture content was low, whereas in wet pressing, the moisture content is 10 to 15 percent. So, in wet pressing we can see that the moisture content is high, and therefore, the name wet pressing is coming into picture.

(Refer Slide Time: 37:40)

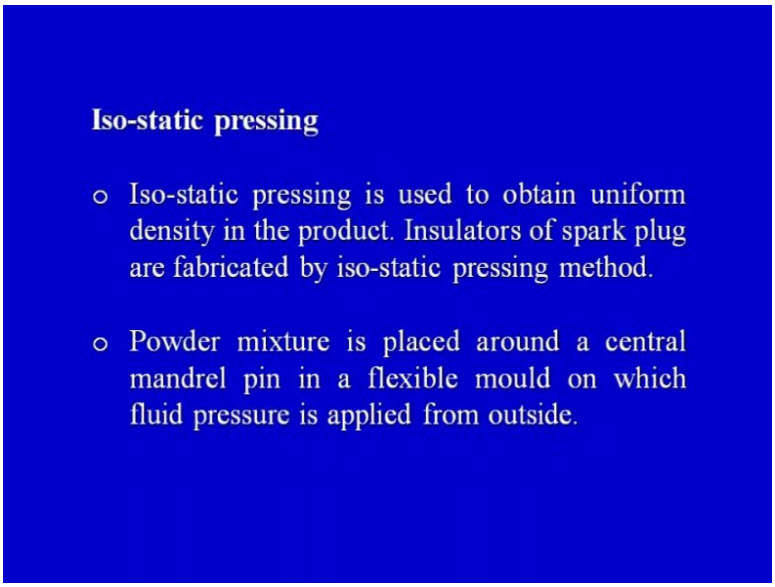



Next step is the hot pressing. In this method, both pressure, because if we have seen in dry pressing as well as in wet pressing, the pressure is applied, whereas the name of the

process also is pressing which means the pressure has to be applied. So, in hot pressing also the pressure has to be applied, but and rational process variable or the operating condition comes into picture that is the temperature. So, in this method, both pressure pressure has to be applied in wet and dry pressing also, in hot pressing also pressure is being applied, but the temperature is additional thing are applied, which reduces the void content of the part and produces a denser and stronger product.

Now, in previous cases, that is dry pressing as well as in wet pressing, we may not get a very dense product, specifically in case of dry pressing. But in hot pressing, because we are also applying the temperature along with the pressure, one of the important advantage that we would derive out of this would be that we will get denser and stronger products. But important point to note in hot pressing is that the dye that we are going to use it may be wearing out at a very faster rate. Why? Because the temperature is also there, the pressure is also there, as well as the ceramic particles also (( )) in nature. So, that die life is also an issue in case of the hot pressing technique.

(Refer Slide Time: 39:23)




Coming on to the iso-static pressing, sometimes in some of the pressing techniques, we may not be able to get a uniform density all around the bulk of the product, but in iso-static pressing is, it is use to obtain uniform density in the product. So, the problem of non uniform density in the total bulk of the product beside, some places we may have very dense, we can say path in other path or away from the place where the pressure is

applied, we may not get a adequate density. So, there is a density gradient that may be a stabilized in the ceramic product that is the point where the pressure is acting, we have a dense, we can say part away from a we can say away from the pressure application point we may not get equal density. So, there is the density variation in many pressing techniques, but in iso-static pressing, we would be getting the uniform density all around the ceramic product. So, iso-static pressing is used to obtain uniform density in the product.

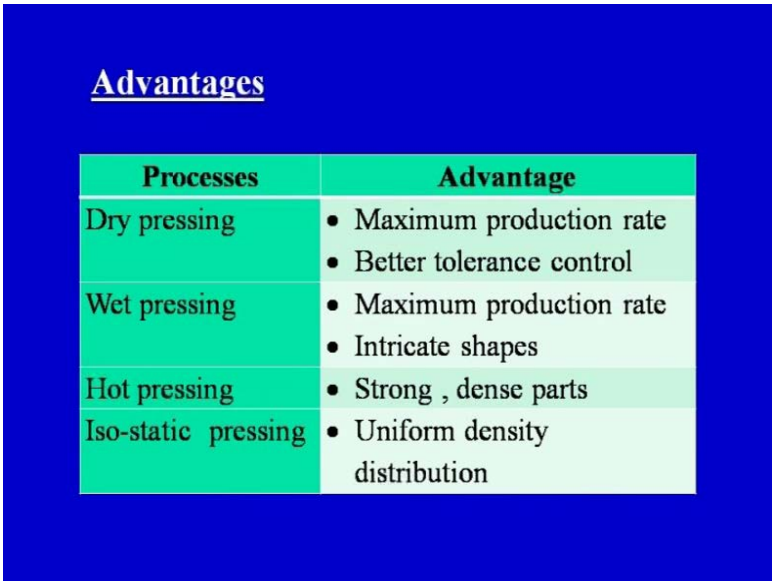
Insulators of spark this is the application for which the iso-static pressing can be used. Insulators of spark plug are fabricated by iso-static pressing method. So, the powder mixture is placed around a central mandrel pin in a flexible mould on which fluid pressure is applied from outside, this is the iso-static pressing, we have also covered when we discussed in phase one the powder metallurgy technique. In powder metallurgy also iso-static pressing is used and it was discussed in lot of detail there. So, in iso-static pressing, basically we apply the pressure through the fluid from all the direction. And when the pressure is applied from all the direction, the density in final product is very very uniform, so there is no density gradient through the product we get uniform density in the product.

So basically, in other processes, as we see that in case of dry pressing or wet pressing, if the size of the ceramic product is very large or if we say it has got a lot of height. And we are applying the pressure from top and bottom the density close to the pressure application sight would be high and the density away would be low. So, we do not want a density gradient, because when we are applying the pressure from top and bottom suppose from both side, so the density high in this region, high in this region, but is low in the central region. So, that we do not want and for to overcome that we may be a applying the pressure from all side from top bottom and from all the side through the fluid and then we will be getting a uniform density in the product and that type of pressing is called the iso-static pressing.

Now, let us come on to the advantages as well as the limitations of all these pressing techniques. So, let us first see all the four type of pressing that we have seen. We have seen dry pressing, we have seen wet pressing, we have seen hot pressing, we have seen iso-static pressing. Each one of these has got certain salient characteristics, one or two salient characteristics for each process we have seen. Like for dry pressing, the moisture

content is low, it is use for simple shape. We have seen what type of binders are added in to that process that is the salient characteristics of dry pressing; and wet pressing, the moisture content is higher; in hot pressing, temperature is also one of the variables. In iso-static pressing, we applied the pressure from all sides and we are able to get a uniform density throughout the bulk of the ceramic product. So, these are the salient characteristics of these pressing techniques, now this particular slide gives us a summary of the different pressing techniques that we have seen.

(Refer Slide Time: 43:27)




So, in dry pressing, the production rate is very high which was given in the slide also and tolerant control is also better. So, better dimension control or better tolerance control is there in case of dry pressing. Wet pressing, production rate is high as in the case of dry pressing, and this can be use for getting intricate shape. So, basically on the basis of shapes, if we have to take a decision that for simple shape which pressing mechanism should be use, we should always go for dry pressing. If the shape is the little bit a intricate shape intricate shape or a complex shape we should go for wet pressing. Why, because it is a we can say rule of thumb that when the moisture content is high, it becomes easily moldable, but there is the limitation to the moisture content also; a very high moisture content is also not desirable. So, for a intricate or a complex shape, we can use wet pressing technique.

Hot pressing, if we want strong and dense parts, because in this particular case, we will get very high-density. Iso-static pressing - if we want uniform density distribution, all through the bulk of the product. So, basically all these pressing techniques have got got their own salient advantages, and I have got their own advantages and specific application spectrum. So, depending upon the final product that we are going to produce from the ceramic powder, we can choose that which type of pressing technique we should choose. But apart from the advantages, each one of these has got certain limitations also. Because all processes cannot be use, there is no process which is universal in nature and can be applied to all types of conditions and requirements. So, there are process is which have got certain limitations, and these process is also have got certain limitations.

(Refer Slide Time: 45:37)

**Disadvantages**

| Processes | Disadvantage |
|---|---|
| Dry pressing | • Non-Uniform density, wear resistance of dies |
| Wet pressing | • For smaller jobs<br>• Dimensional accuracy |
| Hot pressing | • Controlled atmosphere<br>• Die life |
| Iso-static pressing | • Infrastructural cost high |

So, let us now comes to the come to the sorry disadvantages. Now, what are the disadvantages? Dry pressing, one of the disadvantage is non uniform density that can be overcome by the iso-static pressing, because in the iso-static pressing we get a uniform density distribution. So, dry pressing one important point is non uniform density then the wear resistance of the dies is also an issue in case of the dry pressing. In wet pressing, it can be use for smaller jobs; dry pressing can be used for simpler job, and wet pressing can be used for smaller job. It means that if there is very large job at hand that wet pressing is not advisable. Similarly the dimensional accuracy is also an issue related to

the wet pressing technique. So, the dimensional accuracy is also not very high in case of wet pressing.

Hot pressing controlled atmosphere, because a temperature is also an issue, therefore the pressing has to be done under the controlled atmosphere. And the die life has I have already indicated in an issue with case of in case of hot pressing, because the temperature is also high, and therefore, the life of the die becomes an issue. The dies that are use for hot pressing of ceramic powders will have shorter lives. Iso-static pressing means it is adding to the cost, because this pressing technique require a special set of equipment and that equipment would add to the cost of the we can say infrastructure required for converting the ceramic raw material into the final product.

So with this, we come to the end of today's discussion. The focus of today's discussion was pressing of the ceramic powder to generate a shape or to shape the ceramic part. Different methods can be used to generate the shapes that we have seen in the very beginning of today's lecture, number of process is were outlined. Our focus in today's lecture was pressing of the ceramic powder, ceramic powder mixed with additives and the binders. So, we have a mixture of ceramic powder additive and the binder, it has to be pressed to generate a particular type of shape. For that we have seen there are four types of pressing mechanism that can be used that is dry pressing, wet pressing, hot pressing and iso-static pressing. Salient feature of each one of these, we have try to understand, and we have seen what are the advantages and the disadvantages of each one of this pressing techniques.

In our subsequent lecture, our focus would be on the other techniques that can be used to give shape to the ceramic powder, and finally how the product can be made useable with the help of the other secondary processing techniques. So with these, we come to the end of today's lecture, and in our next lecture our focus would be the other processing techniques that can be used for processing of ceramic parts.

Thank you.