Mathematical Modeling of Manufacturing Process
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Lecture - 36
Packaging, Micro-Finishing and Micro-Manufacturing Process

So after discussing microscale and nanoscale joining or welding processes now we will try to look into that other manufacturing processes at micro scale. So the development also happens in even in case of casting process.

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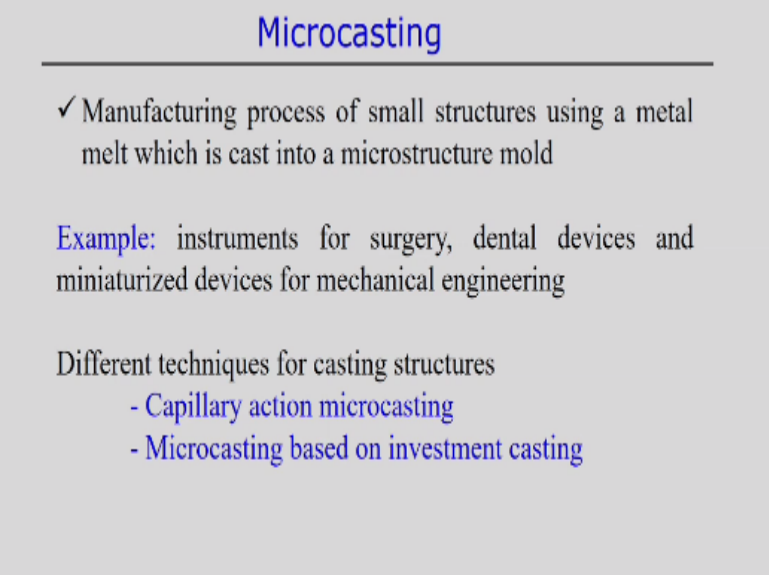

So that is we generally call the Microcasting process. So in this cases the manufacturing process of small structure using a metal melt which is cast into a microstructure mold. So very small mold we have to put this molten material and accordingly we need to solidify it such that we can produce some kind microcasting structure. So the challenges here that what way we can give this very small amount of the metal.

Or maybe you can say the molten metal transferred to this specified volume. So the example we can get the microcasting process the instruments for surgery, dental devices and miniature devices for even for mechanical engineering. So it is very small components or micro scale components can be produced by following the microcasting process. So actually this micro casting process is basically based on these two aspects.

That means development of this process. So one is that capillary action microcasting definitely when we want to push very small scale and we had to (()) (01:56) a very small channel then capillary action may be significant here for the development of the microcasting process. Second one is the microcasting based investment casting. So conventionally investment casting exist.

But the similar case it is possible to develop down scaling of this investment casting process even in the micro scale casting processes. So based on this two mechanism the microcasting process has been developed.

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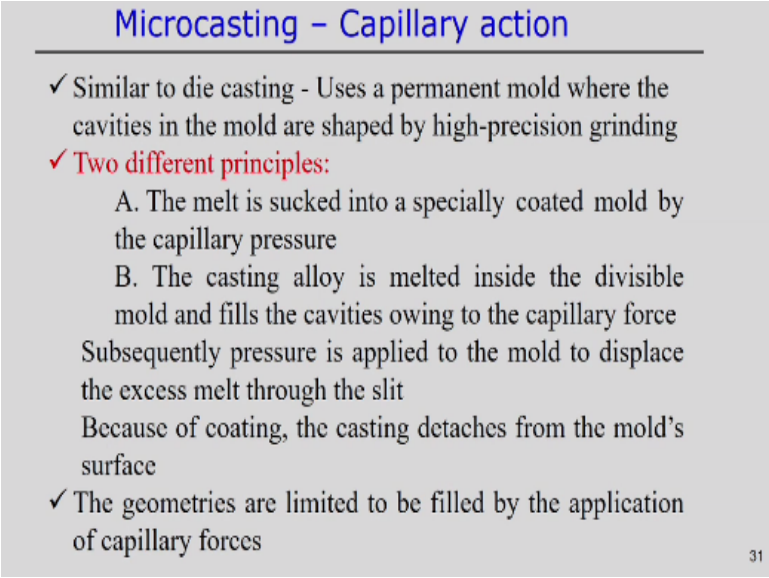

If we look into in general the microcasting following the capillary action here we can see it is a similar kind of the die casting process. So in the die casting process we use the permanent mold and then where the cavities of the mold is created according to the shape of the high-precision grinding. So basically the cavity is produced following the very high precision grinding process to obtain the very good surface finish of the cast product.

Two different principles we follow when there is a capillary action based microcasting process. One is that the melt volume of the molten material can be sucked in a specially control mold and through the by the capillary pressure. So that way we can suck this it is possible to suck the molten material to the casting volume or in other way also the casting alloy is melt inside and inside the divisible mold and fill the cavities then inside the mold.

And fill the cavities according to the capillary action or capillary force based on this thing. So both way the capillary action based microcasting process can be developed, but of course in this cases if we put the it is necessary to put the subsequent pressure such that mold the applied to the mold so that displaced to the excess mold had come out from these things through the slit.

And normally we use the casting volume with the coating with the different kind of material such that this coating is actually helps smoothly removal of the cast product. So that is the purpose of using the coating of the surface and the geometries, but one of the limitations of the our capillary action based microcasting process is the shape of the geometry. So actually geometry is limited by the application of the capillary forces.

So it is a very complicated geometry may not be possible to produce if we follow the microcasting process and by the principle of the capillary action.

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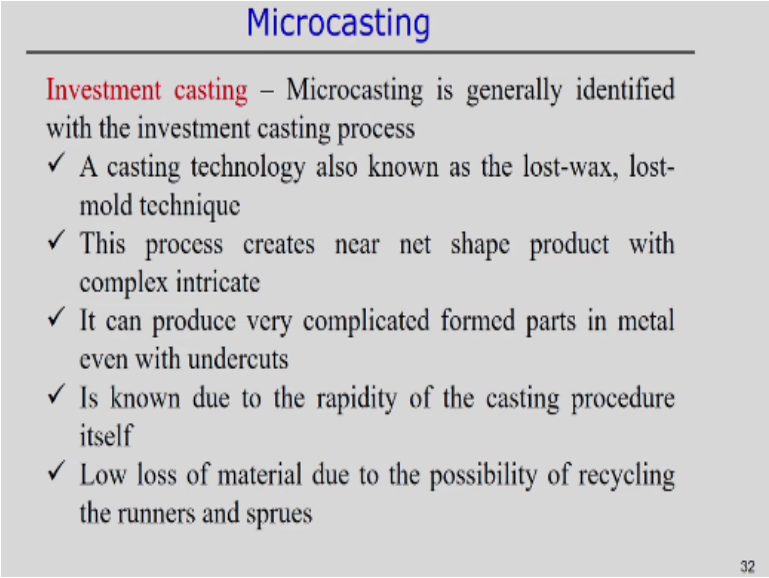

So in that case the investment casting has been developed and in at the micro scale that is called microcasting based on the investment casting process. So microcasting is generally identified with the investment casting process in general we wax it is a kind of casting technology we know that it is a low wax slow mold technique. We just simply remove the wax from this cavity and that is filled by the molten material.

So actually this process is very accurate and near net shape product can be possible to produce by following the investment casting process and even it is possible to create it is a

very complicated shape near net shape product with a very complex intricate and that is why complicated formed part metal even with the undercut also it is possible to produce in this cases.

And other advantage of this investment based microcasting is it is a very rapid process and very rapid process as compared to the other that means capillary based processes and low loss of material because the possibility of recycling the runners and sprues in this cases. So that is why this basically two different methodology has been developed in the micrcasting process just we discuss in these cases.

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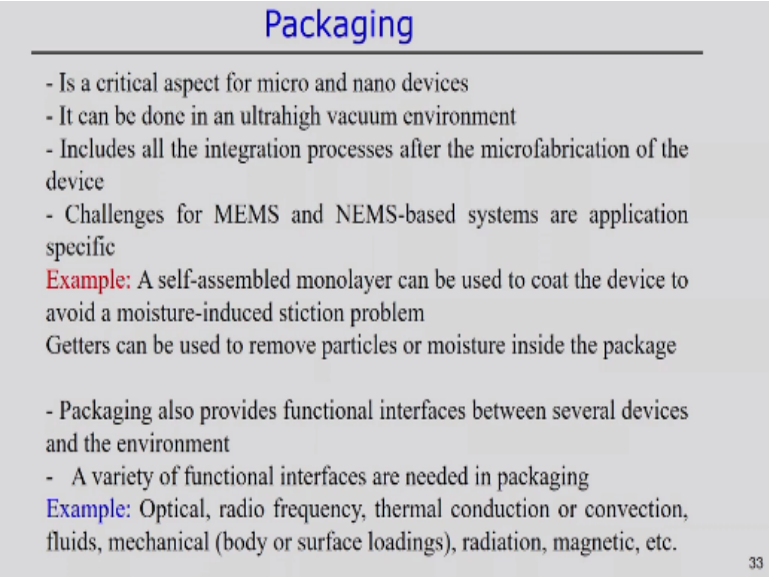

Now we look into the another micro scale manufacturing process we can say the packaging, packaging means it is a kind of normally understand the packaging in the micro scale manufacturing processes that what way we can package the micro and nano devices. So from that purposes we can use this packaging terminology here. So definitely in case of it is a very critical aspect in case of micro or nano scale devices.

To brings the package or interconnection between the different components by creating the functioning interface between these two components of the particular devices. So let us look into what way we can do the packaging normally follow in mostly associated with the MEMS or NEMS process. MEMS was a micro electromechanical system or nano electromechanical system.

So that is here the mostly the packaging can be done using in the vacuum environment ultra-high vacuum environment possible to do. So may be when we try to produce the packaging of a nano or micro devices so it is become very costly when we try to follow this at ultra high vacuum environment and packaging it also includes the terminology the integration of this processes after the microfabrication.

What way can integrate that comes under that is that depends on the effective packaging of the different components, but of course challenge remains even micro electromechanical system what are the different components can be added or packaged and at the same time for the nano electromechanical system and of course these challenges actually arises based on the specific application and which it is very difficult in generalized way.

We can look into the example also for example the self-assembled monolayer can be used to coat with the devices to avoid the moisture induced sticking problem then in that cases this monolayer this packaging by application of the coating the packaging can be done also and apart from that getters can be used to remove the particles or moisture inside the package this is also another part of the packaging system.

And of course the packaging also provides the functional interface. So interface is very important when we try to intricate the small, small components in a particular devices and that small components needs to handled at the micro scale or nano scale devices. So, therefore functional interface is important to take care of during the packaging process. So we sometimes the functional interface can be created by following the specific packaging techniques.

And what were the functional integration between the two device, two components of a particular device or one devices to the between the devices and the environment what way it is interact. It depends at it actually influenced by the packaging system for a particular micro or nano devices. So in general a variety of the functional interfaces are needed in packaging and sometimes at different scales also.

So example optical we can see that sometimes the interfaces may be optical, radio frequency response thermal conduction or convection, fluidics and the mechanical when body or surface loadings radiation magnetic interfaces. So that type of different functional interfaces it is

necessary to produce when we make a complicated or kind of MEMS or NEMS based system or micro or nano system.

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Now another part of these things already we have little bit discussed about the machining processes and we see that different conventional, non-conventional processing can be lower the scale and it is also applicable at the micro scale also. So development of the micro (()) (09:57) micro milling machine, micro (()) (09:59) processes also. So that has been discussed about the when we try to discuss the different mostly in the introduction part.

But here apart from this machining process the finishing is also important in case of micro scale manufacturing processes. So sometimes the finishing may be requirement at the micro scale such that surface roughness is necessary to produce at the micro scale or a nano scale. So therefore (()) (10:31) based on that micro or nano finishing processes has been developed. We can see that traditional micro finishing may be look into that grinding process.

Lapping process, honing processes we can achieve up to certain the surfaces finish of the micron level a micro scale, but if we look into that advanced finishing operation we can get the different processes normally used for the advance finishing operation process. AFM abrasive flow machining then the MAF magnetic abrasive finishing that is also one kind of the advanced micro or nano finishing processes.

Then magnetorheological finishing process, chemical mechanical polishing process. So magnetorheological abrasive flow finishing. So in this cases we use the magnetic particles

here that means flow of the particles should be influenced by the a magnetic field then electrolytic in the process dressing that can also be used.

And then magnetic float polishing and that also has that process has also been developed. So here we can see to achieve a very good surface finish which sometimes required in a very precision we want to develop micro or nano devices. So sometimes the finishing process is also important aspect there. So to achieve particular finishing a particular surface roughness of a machines or manufacture product we normally follow the different finishing processes.

Just I have mentioned all the different types of the micro or nano finishing processes, but of course if we want to achieve the micro finishing probably we can go for traditional grinding, lapping and honing process, but if we want to go nano finishing process so many processes has been developed that here we have discusses and all listed in the right hand side here.

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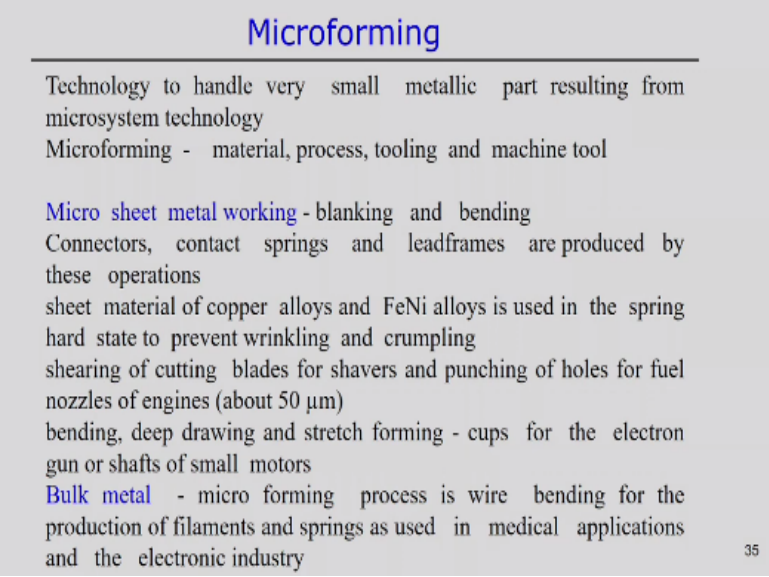

So apart from the micro finishing then there is another manufacturing technology at the micro scale development happens in case of Microforming processes. So a metal following process we understand that we try to deform the particular material with the desired getting the desired shape that is in general called the forming processes, but when it is technology to handle very small intricate particle metallic particle resulting from the microsystem technology.

They are also necessary to particular bending or maybe some sort of other product can also be developed and that is done by the microforming processes. So in general micro following

processes associated in the four basic steps what material we were handling for the microforming process then what are the processes, processes mean well this is bending or other forming processes.

And design of the tooling and then die all this is necessary to design and the what machines we are using. So all these four parts associated with the micrforming processes. So if we look into the micro sheet metal working processes normally blanking and bending processes. So examples is the connectors, contact spring, lead frames and which is produced by this micro sheet metal working processes.

So in this cases mostly metals are associated with the copper alloy and iron nickel alloy is used basically the spring hard state to prevent wrinkling in a crumpling. So in that cases this type of metal normally handle and we just get the application of the microforming processes. So shearing of the cutting blades for the shapes and punching of the holes for fuel nozzles of engines around the other kind of this blanking process.

So here it is possible to creates the hole about the 50 micrometer diameter in that range it is possible to produce by following the microforming processes. Bending, deep drawing stretch forming these are the different types of the processes has been used in even for the sheet metal micro metal working processes, but in this case is the example is the cups for the electron gun or shafts for a small motors.

Where we have to produce that actually associated with this kind of manufacturing processes bending, deep drawing and stress forming of course all these cases and that is in the micro scale process. Even bulk metal is also possible to handle by micro forming process. So in this cases micro forming processes wire bending for the production of the filament if we see the filaments and the springs as used in the medical applications and the electronic industry. So there from the bulk metal this micro forming process is also applied for this particular application.

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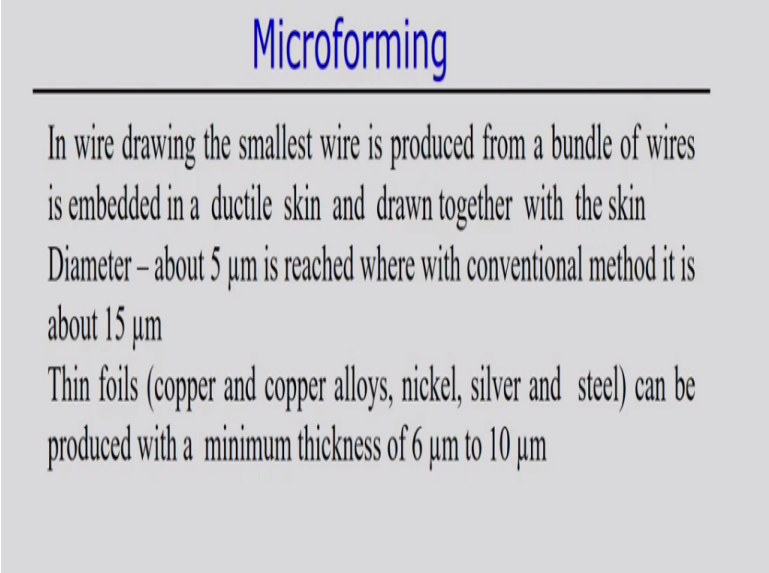

Apart from that even its wire drawing process is the very small production of the very small wire is very challenging tasks, but in this case it is produced from a bundle of the wires which is embedded through a skin and is drawn together with the skin. So about 5 micrometer diameter is possible to drawn by following the micro drawing processes and it is possible and where the conventional method it is about 15 micrometer.

So that if we use the specific process in this cases. So it is possible to achieve around 5 micrometer wire diameter as compared to the conventional 15 micrometer diameter is possible to produce in case of micro forming process. Even thin foil if you see the copper, copper alloy nickel, silver alloy can be produced with the minimum thickness of the 6 micrometer to 10 micrometer is possible to produce by following the micro forming process.

So that is why thin foils is normally follow it is possible to produce from the micro forming process. So in principle it is already discussed the different forming processes, but in this cases we just try to highlight that these are the different processes and even it is possible to develop all this micro scale forming processes just we have discussed few of them. So thank you very much for your kind attention.

So in this module normally we discuss that micro and nano scale manufacturing process, but I have tried to give some overview of this process. So thank you very much.