Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title

Manufacturing Process Technology -Part-1

Module-01

by
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Hello and welcome to this lecture on manufacturing process technology module 1.

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This is part-1 module-1 and I am Shantanu Bhattacharya, I am an associate professor at the department of mechanical engineering at IIT Kanpur. And I will actually be teaching you or taking you through the whole sequence of steps which are needed to understand the manufacturing processes in great details. So let us have a sort of a brief introductory overview of what I am going to talk toady.

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I am going to actually tell u some of the manufacturing system approaches.

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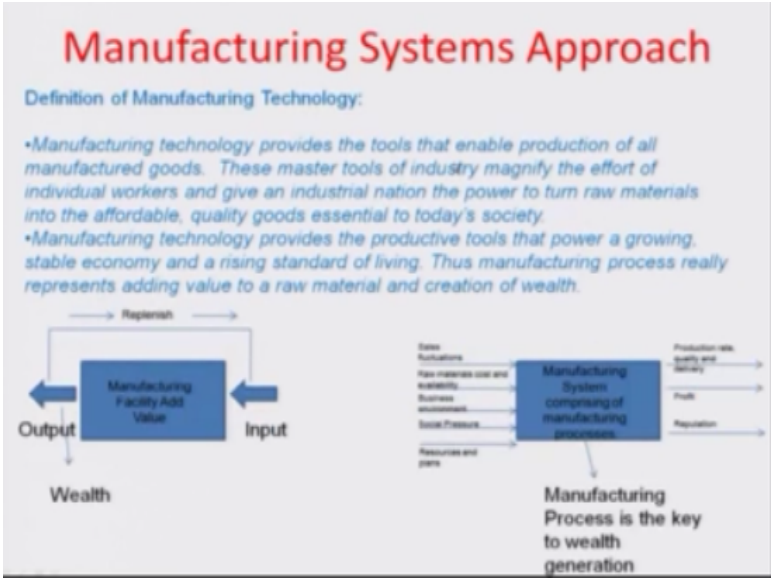

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Then I would also discuss some basic manufacturing processes like casting, forming, fabrication, material removal. I would also like to describe some of the advanced machining processes ECM, EDM, EBM, LBM, AJM, USM processes etc. And then micro manufacturing processes Etching, Deposition, Lithography, Replication and molding, Dip-pen lithography, Compression molding, Nano-imprint lithography so on so forth.

So this is only an introductive lecture it may go over several modules, and the idea is that you should able to know at a glance the processes before getting into the aspects related to the modeling of the process technology. This course could be actually intending to given insight into the people who are process designers and it would really be a parametric analysis of all these different processes.

But we have to organize the way that the processes are laid out in sequence and that is why this introduction lecture is very, very important.

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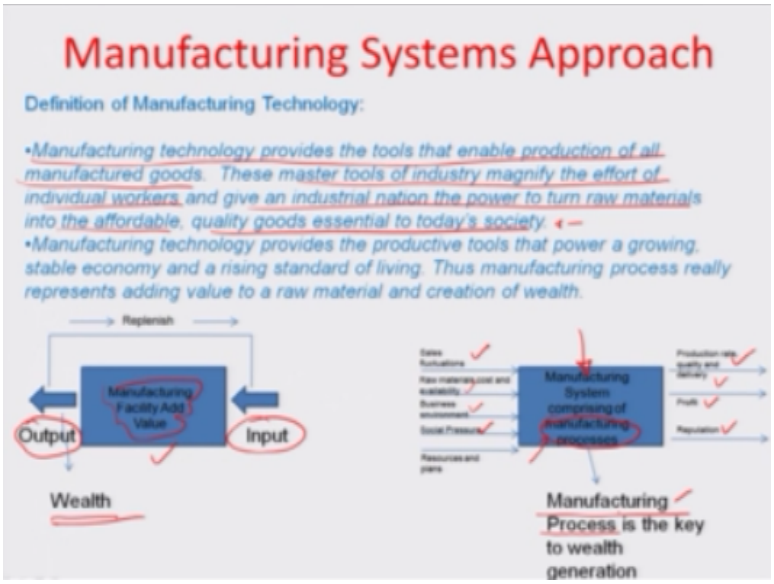

So when we talk about manufacturing through a system's approach what is important is that manufacturing facility is really a value adder okay. So as you can see here right in this figure, there is a facility which is adding value to an input material which is actually more in the form of a raw material which may not have otherwise any value. But once the value is added by the manufacturing facility the output which actually comes out of such a facility generates wealth because the output has some value coded in it.

And so therefore, it s very important to plan the facility in a manner, so that this value can be added according to the aspirations and needs of various sections of the society. And if you can add the value in the right manner then the product can be positioned in the right manner it will definitely generate a lot of wealth which is actually the reason why a manufacturing facility exists.

So a definition, manufacturing technology really provides the tools that enables production of all manufactured goods these master tools of industry magnify the effort of individual workers and give an industrial nation the power to turn the raw materials into affordable quality goods essential in today's society. So if I look at such a system which has this manufacturing facility it really comprises at the heart a set of manufacturing processes and really it is the processes which is the key to the wealth generation.

So one side there are various inputs like sales fluctuation, raw materials, cost and availability, business environment, social pressure, sources and plans and in other hand production rate and

quality, you have the deliverables which are actually the products coming out of the manufacturing system you also have profits and reputation to keep in business which is also important for such a system.

But really this system would be balanced at work well if the key to it or the heart of advanced manufacturing processes is well balanced and well designed. So therefore, in this current trade is no longer stenciled over emphases how important manufacturing is for our country and our society. And the processes there for automatically become the bread and butter for such manufacturing systems.

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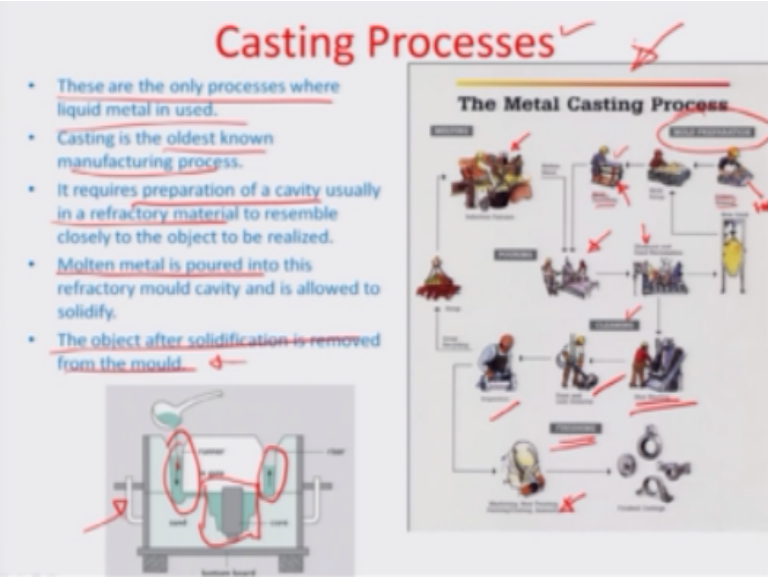

Let us talk about some of the very commonly available processes for example, if you really look at the paradigm of all processes the manufacturing processes can be split up into primary processes and secondary processes. The primary processes are really those were the overall shape or size of the object can be given. Let us say for an example, we talk about casting process which is the primary process or a forging process where there is a different shapes of iron, but you are actually heating it up and trying to shape it.

So that there is some overall shape which is incorporated or overall size which the material is constrained and so this overall shaping of the material is known as the primary manufacturing processes. The secondary manufacturing processes comes into play when you talk about such primary products coming out of primary processes in assembly. So that they can develop

something like a power in and power out kind of the system or alternately you may have some kind of joining exercise between two.

So that the complex shape can be created, but overall those process are categorized into the secondary manufacturing processes. So let us call the primary manufacturing process like casting process, these are the only process where liquid metal is used, so casting is one of the oldest known manufacturing process. And if I look at how the casting process is accomplished it is done by something called preparation of a mold, this mold is normally made out of sand but then are many other variance of the mould which can be used time again when the process is differ in terms of its output etc.

But the mould is basically something which is the negative of the shape that you want to produce using the casting, and the mould is needed because it is essentially a containment for the melt of the material which would then solidify and come out as a solid object of exactly the negative shape of the mould. So if you have to make a spherical ball you need a cavity which is the negative of a ball as the mould.

So the mould is prepared typically by using some kind of flasks which are also known as cope and drag, and the some material which is refractory material. So refractory material really is a material which retain its strength at high temperatures, sand is a very good refractory material for example. So what it do is that you have a flask set which is shown right here which will also you can see this is the assemble view of the whole mould with different flask set and you have different layers of this flask and each containing one flask and the flask there in containing refractive material.

So you start with such a flask this is one flask for example where you are actually pouring the refractive material sand and setting up the mould. So for doing that you really need something called a pattern, A pattern is really the shape or size that you want to cast. So you putting a pattern inside the sand, and then you trying to hammer the sand or compress the sand in the manner, so that is forms a mould around the pattern.

And such pattern can be in several pieces, so therefore different levels or different flasks would contain different pieces of the pattern. And thereby you have now when we take out the pattern for example, the pattern would actually create a cavity in the sand, and this is the cavity which

you really need to fill with the molten material. So once you do that then, obviously you have a something called a mould.

Now the mould has in addition to the pattern several other regions which is very important for the metal transfer process. So there is a liquid metal that you are pouring, so you have to run the metal through a substantial section of the mould before it enters the pattern so that the momentum etc, is reduced and the mould does not get damaged. So there is a riser, there is a runner and the risining section is normally because you need to have an indication from outside that the metal is also losing out after filling out the whole cavity.

So from one side the liquid metal is coming filling the cavity, the mould cavity and from other side the liquid metal is coming out. So there is a combination of this riser, runner and the mould, and then obviously into the runner you need getting device where you have pouring basin etc, where the metal is poured. So therefore, this is the process really where you are trying to guide the liquid metal within this system of the mould, so that the material goes and comes into a cavity which is of the shape of/ negative shape of the material or of the part that is to be produced the size that is to be produce. And that would really create the mould.

So once the mould is ready, on the other hand if you have liquid metal so obviously you will have to heat the pieces of metals together in a furnace and take it to the melting point, so that the material gets flowable or fluid or liquid in nature and then this material can be further super heated also if you wanted the solidification process to be more controlled etc. So therefore, the liquid metal is poured into the mould and the pouring of this liquid metal in the mould.

The mould is taken off after the solidifications of the materials happens and so the material is extracted, the solidified material is extracted from the mould, and the mould is reused so you can reclaim the sand of shaking out the mould and you can use the sand after some more preparation for modified for other application into other mould flask and so on. And what comes out is basically a component where you have to clean the component.

So you have to sort of stream of the component, let us see is figure for example. So in this figure you are pouring the molten material through a ladle into this section which is the runner and it goes all the way into this particular part where the part is again filled with some kind of a core. The core is normally used if you want to create a hollow casting, so the material moves around this core and comes back into the riser size.

And that is how when you get this solidified metal it will be having the basic part which is probably the part in this particular region plus the runner side. Because this is also going to get solidified and the riser side, so you have to remove the risers and the runners from the part so that you can extract the basic part, you can also do a short blasting, so that whatever small sand impurities are left on the surface of the materials actually goes away.

And then finally you do the inspection and you can add a secondary manufacturing process like machining here or may be even it treating it further through certain thermal cycles, so that it gets heat treated and the strength gets modified according to the requirement. So that is how you can finish a casting part. So typically a casting process is necessitating the preparation of a cavity in a refractory material, and also a step where there is a molten metal being poured into that cavity.

Further followed by the material in the cavity getting solidified because of heat transfer across the mould and then the object after solidification is finally removed and processed, so that you can have a shape, overall shape given to the object that is why it is a primary manufacturing process. So this is a overview of how a casting is done, but there are many intricacies and many modalities in terms of process modeling where you can actually figure out what is going to be the length of the runner versus raiser, what is going to be the time it takes for the liquid metal to reach and during that time what is the impact of solidification on the material.

Or for example, when the gets to fill the cavity after that what is the impact of the solidification into the overall green structure, all these aspects need to be revealed in great details when we do the section of the casting area or process modeling for the casting. The other process that we would be studying in great details is pertaining to the secondary manufacturing process at least this particular part or module that is how I have structured the material. And this secondary process is related to material removal really.

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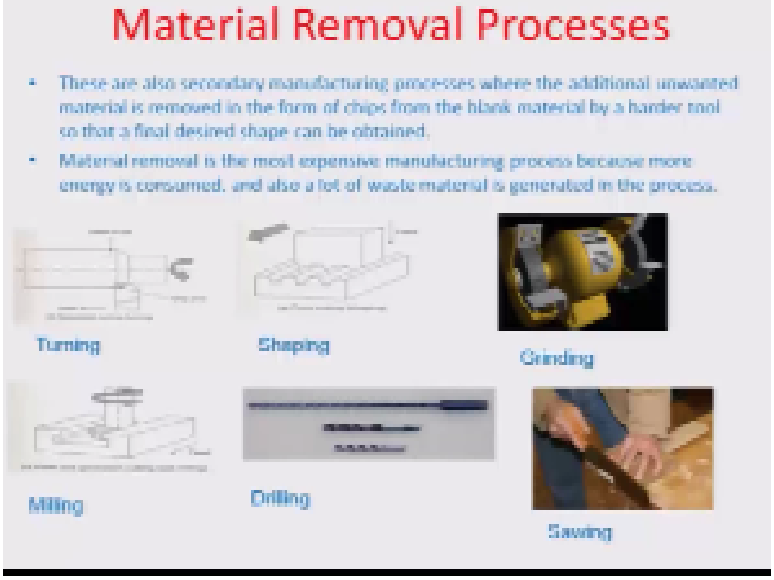

So it is all about machining process, and here the idea is whenever there is a primary shape being incorporated either by the casting are else we see later to forming processes, the engineering parts that are so made have to go into assemblies or structures where more than one parts are put together for having some sequences which would do for example motion transfer or power transfer. And that is how machine is realized.

So therefore, for such material removal processes are very important because there is an issue of fitment with respect to each other and there has to be certain processed tolerance or certain fitted tolerance that are needed between the different parts which come out. So that they can be put together in an assembly, so therefore the material removal process become very important they are secondary manufacturing processes where additional unwanted material is removed and they are removed in the form of chips from blank material.

And typically by using a harder surface which is also called the tool and the harder surface actually heats into the softer material and that is how the chips are being processed, so that the final desired shape can be obtained that manner. So material removal is the most expensive manufacturing process because more energy is consumed, and a lot of waste material is generated in the process of manufacturing of the material using this secondary process.

So there is an impatient of course, nowadays that can be really do without the need for this secondary material removal wasteful expensive process, and that is why people are going into a additive manufacturing and components made as is in the finished state which is actually one

advancement over whatever this conventional way is of casting followed by machining, so that material goes into this.

So there are many process that we discussed would be turning process which is typically done lathe machine, where the work piece is rotated and the tool moves and linear manner with respect to the work piece either radially or parallel to the axis of the rotating work piece. We will talk about shaping where there is going to be , let say this operation here is illustrating form cutting, there is a tool which is in a shape or a form and produces the counter shape by scribing on the material surface.

And so there is a downward feed that the tool has while the surface is moving back and forth against this in a perpendicular direction to that particular feed. We will also talk about milling processes where there are multiple point cutting tools which are being utilized, so that there is material removal. We will talk about drilling processes, grinding, and sawing. And apart from that probably we will try to see some basic understanding into the chip formulation technique.

How the material can be peeled off by taking the material to really the ultimate yield strength of the material where there is a peeling off in from of chips from the material. So that is how the scribing process causing the material coming out as chips happens okay. And so that is a very important process, so this is the section that we will cover in such conventional material removal processes and machining processes.

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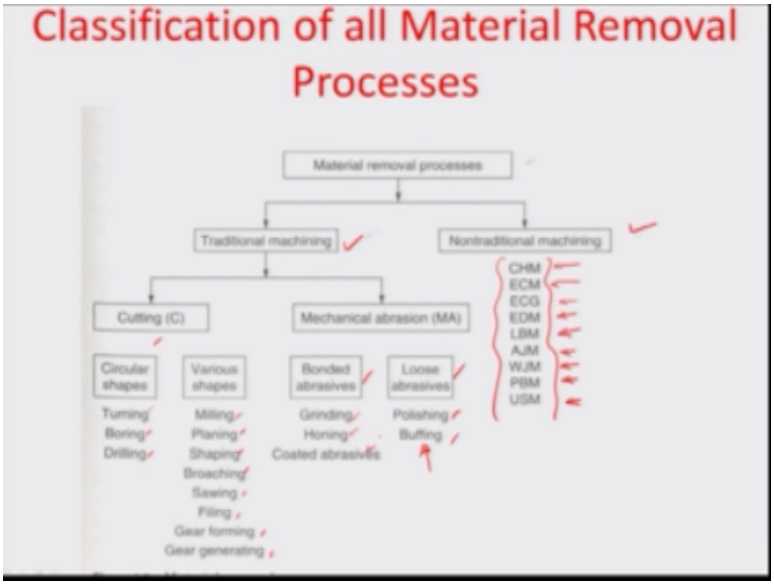

So the other material removal processes which are available are also called the nontraditional and nonconventional processes where there is no really, not really direct metal to metal scribing action per se which is there. But it is a set of processes which other uses at various forms of energy like mechanical, thermal, electro chemical, chemical energy, but to be actuated on the surface the material which you want to get removed by virtue of that energy.

And although there is some kind of a mechanical energy which may seemingly look like what happens in conventional machining where there is scribing and reaching of the material to the ultimate yield strength value of the material. But in this particular case the energy mechanical is given by impingement, and this impingement is normally achieved by throwing a set of sand grains or a set of abrasive particles at a very high velocity to the surface which can create little fracture.

And these processes have generated because there were a lot of requirements for a different range of material classes including ceramics, or metals where the conventional machining process particularly ceramics etc. The conventional machining process would not work that efficacy, so in general all such material removal process that you can see right about here is classified into traditional and nontraditional processes.

These classes would also be covered during this course which talks about chemical machining, electrochemical machining, electro chemical grinding, electro discharge machining, laser beam machining, compression jet machining, water jet machining, plasma beam machining and ultrasonic machining and so on so forth.

And the traditional machining would have really cutting where you have circular shape through turning, boring, drilling and various shapes through milling, planning, shaping, broaching, sowing, filling, gear forming , gear generating so on so forth and impression using bonded abrasives or loose abrasives like in case of polishing and buffering use loose abrasives. And this is very important particularly for the painting processes and the finishing processes of the applied paint waterproof and others engineering products.

And then you have the grinding, honing coated abrasives which are more bonded abrasive process. So I am going to sort of when we talk about material removal processes, I go across all these different domains with an insight into how the removal process is taking place, what is the

kind of limitation of parameter design for the process which is needed for this chip formation to happen and get activated.

And what is going to be the outcome once the chips gets generated in terms of temperatures of the substrate or for example, the surface finish of the average roughness of the surface. So these aspects we are going to cover when we talk about these material removal processes. So in a nutshell what we are trying to do here is to cover with one primary and two sub secondary processes.

One is obviously the conventional and the non-conventional material removal process. In the part 2 of this lecture we will probably try to cover the remaining manufacturing processes like the joining processes or forming processes in great details. So I am going to close on this module in the interest of time, but in the next module I will start with the history of machining and how machining came into existences.

And then what are the kind of tolerances which are achieved as machining grew or progress starting from the first machine tool which was power driven all the way to now some of the advanced CNC machine systems. So with this I will close on this module, thank you.

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