Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title

Manufacturing Process Technology -Part-1

Module-02

by
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Welcome to this manufacturing process technology part -1 module-2.

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Last module we were discussing about the briefs of some of the processes that we are going to cover in this particular course. Today we will actually look a little bit into the history of machining and how machining had evolved right from the Paleolithic to the new Paleolithic times and then to the modern times. So really If you look at some of the historical facts earlier about 2.5 and 2.6 million years ago.

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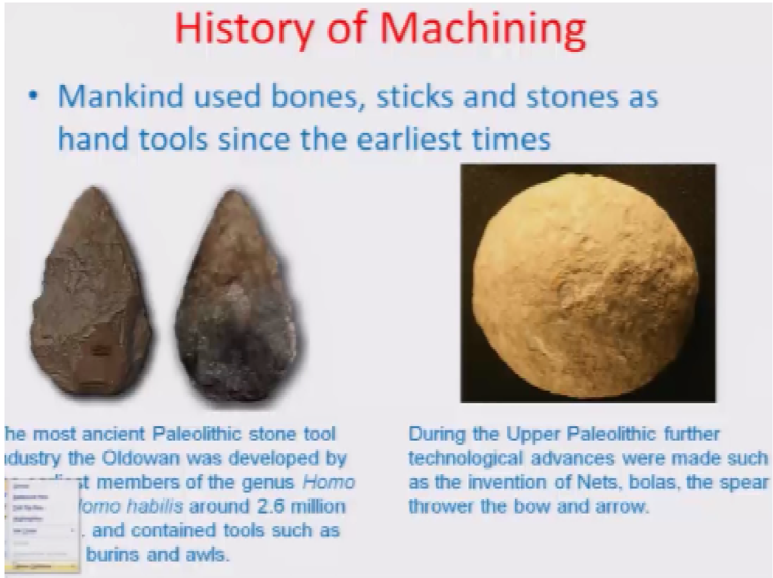

The genus called Homo habilis used to use these choppers, burins, halls and these are some of the most ancient Paleolithic stone tools that a person can think off. Then obviously during the upper Paleolithic age also there were certain modifications made to these sort of primitive tools and the nets and bolas were invented. And also the spear thrower the bow and arrow. And so these bolas are basically typically held in a rope.

So the rope is tied around this and then there is a hurling action so that it moves in a round path and then you throw it because this gathers momentum and this momentum is suddenly, the rope is suddenly released. So the body can fly tangentially to the circular path that it is taking and it hits the concerned target once it is been thrown. So see these are some of the very, very early applications history of what you can call tools okay.

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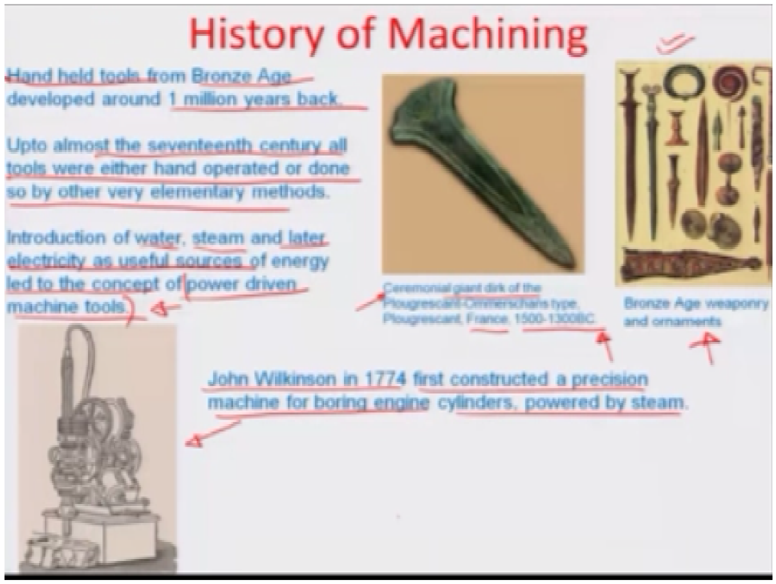

Now obviously the age changed and you know the Bronze Age came and you have several hand held tools that you can recover from the bronze age of one million years back. This for example, is this Bronze Age weaponry and ornaments there are certain all different types of shapes and sizes that had been made possible. So the mankind could know how to actually make the metal bronze, and they could also know how to cast all this into different implements on tools.

So almost up to the seventeenth century all the tools were either hand operated or done so by other elementary methods. This for example is a ceremonial dirk which was obtained in France and it belongs to an age 1500-1300 BC for Christ, it very, very old again some were around same time as this Bronze Age.

So, the introduction of powered tools from the hand held tools really came after the seventeenth century and you know there were various energy source like water, steam, and later electricity which were used as useful sources of energy and which lead to the concept of power driven machine tools.

So basically we are talking about now not normal manual operated systems, but also power operated systems. So in fact if you look historically John Wilkinson in 1774 first constructed a precision machine for boring engine cylinders and this was powered by steam that is shown here.

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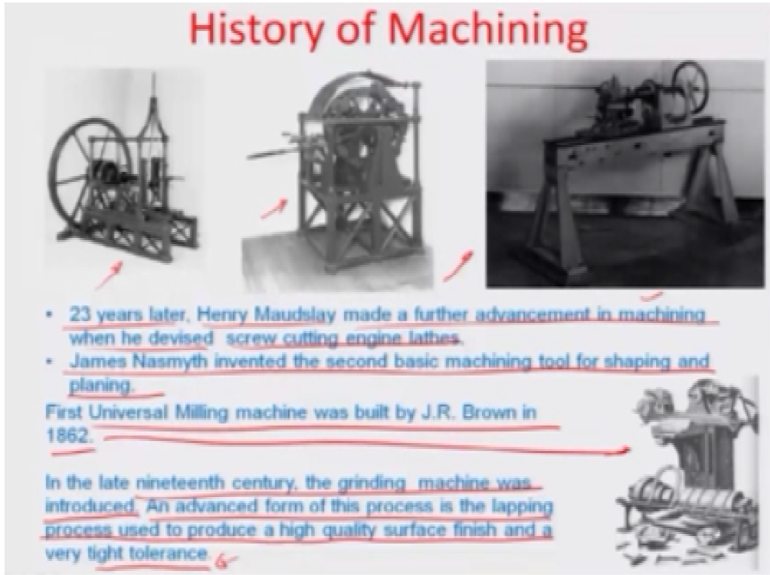

Then obviously if you go further you have 23 years later Henry Maudslay who made further advancement in the machining when he devised screw cutting engine lathe okay. James Nasmyth invented the second basic machine tool for shaping and planning. So you can see some of these tools here the screw cutting engine lathes or the basic shaping and planning tools. And so this is how the machining industry sort of developed.

So the first universal milling machine was built by J.R. Brown and that was in 1862. This is the snap shot of how the milling machine really looks like. And in the late 19th century the grinding was finally invented with change the paradigm quite a bit because it could actually now use the grinding for doing finished machine parts which would go into again assembling etc… So the advanced form of this process grinding is also known as the lapping which was used to produce a high quality surface finish and a very tight tolerance.

There were various sort of you can say variance of the grinding process which actually evolved were there would be either loose abrasives or bonded abrasives, and then there will be honing on one side and lapping or buffing or polishing or another. And so, these would all typically do the same job or finishing super finishing of surfaces which was a very, very critical requirement of the industry.

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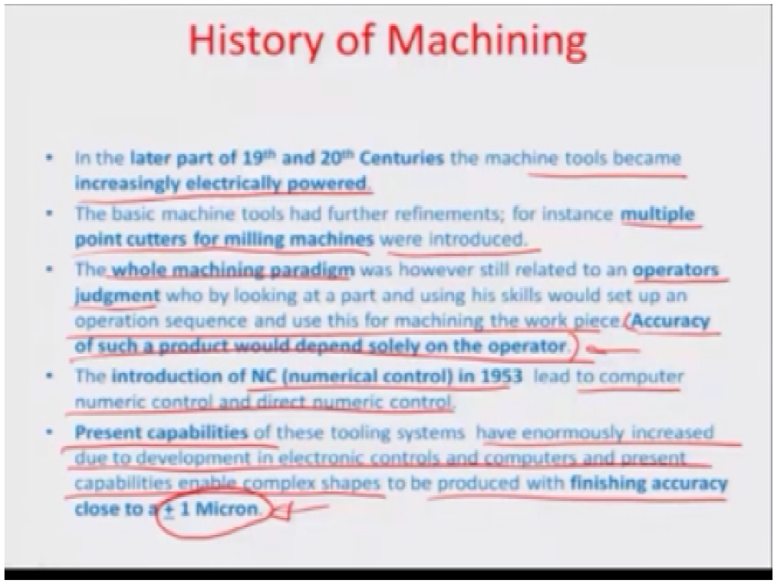

So that is how the machining paradigm kind of historically emerged, and so if you look beyond the early part of the nineteenth century or even twentieth century the machine tools became increasingly electrically powered. The basic machine tools had further refinements, for instance multiple point cutters for milling machines were introduced. The whole machining paradigm was however still related to the operators judgment who by looking at a part and using his skills would set up an operation sequence and use this for machining the work piece.

Accuracy of such a product would develop solely on the operator. And this was the major problem for the industry, because when we are talking about human angle in it is a matter of perception and the two different operators may have a different perception of how to carry out machining or they may even have different skill sets and there would not be a large variability at the outcome which is the product.

So in order to able to curtail that it is important that we could sort of organize all this and it would shift from manual controlled to machine control, and that would give you a repeatability or accuracy of the performance of these machines. So that is why the numerical control was introduced that is in1953, this lead to the direct control of machine tool by numeric's, so you either had computer executing, the numeric control, or direct numeric control system.

And in the present capability of these tooling system if you look at enormously increase due to development in electronic controls, probably computers, or high speed computers. And the present capabilities in able complex shapes will be produced with finishing accuracy as close as

plus minus 1 micron. So the walk way from early seventeenth century all the way to the current day has lead to the emergence of increase of flexibility almost these days you can do anything using machining and that would surface finish level of about plus minus 1 micron.
So that is the historical walk of the machining industry.

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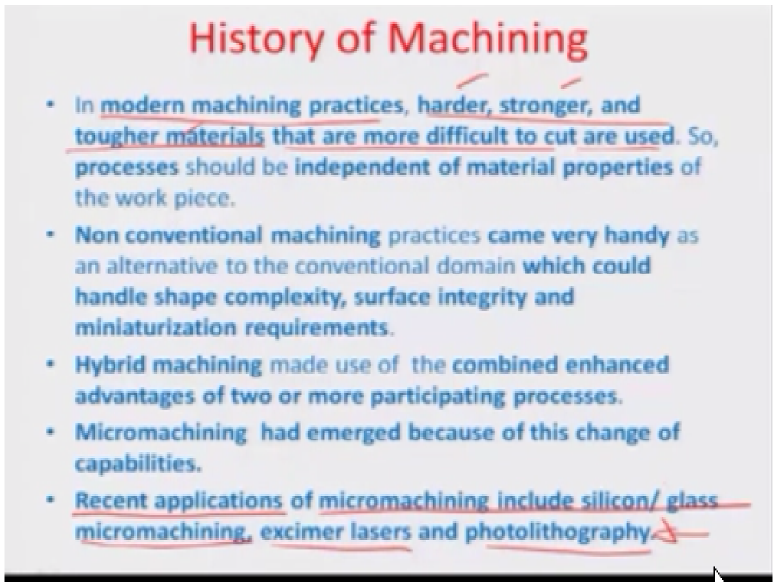

Then evolve the modern machining practices and this is some were we want to really model and look into different processes were these modern machining activities really emerged because of a lot of requirement of the industry in terms of new materials, new composites, new high strength systems etc… and there was a lot of harder, stronger and tougher materials which were increasingly being designed by the engineering tools of the requirement of the growing industries which were either automotive or aerospace or things like that.

And it was very difficult to cut such systems with the conventional machining paradigm and therefore, there was a need for giving some other nonconventional or nontraditional way of removing the machining which would make the machining independent of the material properties that are being deployed for various applications.

So now these nonconventional machining tools would use energy in some form which could either be mechanical, or thermal, or chemical, or electro chemical, and the mechanical energy per se is the energy which was not because of a direct metal to metal contact, but because of throwing grains or in pinching grains onto the surface, the grains would be an abrasive grain which would create a little fracture.

So mechanisms like for example, abrasive jet cutting or abrasive jet water machining emerged and there were lot of flexibilities again which paned over different domains of materials to be cut in different complex shapes, different surface integrities and this whole new business of nontraditional machining were started. Slowly people realize that they could actually have a hybrid strategy were you would actually need to machine something using a combination of processes be it conventional or non conventional.

And these days the most important aspect which is emerged out of all this is so quality hybrid machining approach and which can be translated over different domains of even scales there is a scale of machining which is particularly done at dimension of the object that we are considering is probably in the micron at least one of the dimensions is in the micron range and that is called micro machining.

People have gone further beyond the micron range where they have been able to reduce the size of at least one of the dimension of the component to less than a micron and this is called the sub micron machining or the mesoscale machining systems. So a lot of these have evolved they are very recent applications which have come up in micro machining, which includes silicon glass micro machining , excimer lasers, photolithography a bunch of different processes.

And this have been also in new of the fact that another industry called the electronics industry generated during the late 60's and continued. And some of the processes were really geared to making small things miniature things for that particular industry. So now you can have the different generations of this machining listed up to the most recent times when you can actually be able to do all sort of micro nanomachining using different routes and that is all the historical machining has evolved.

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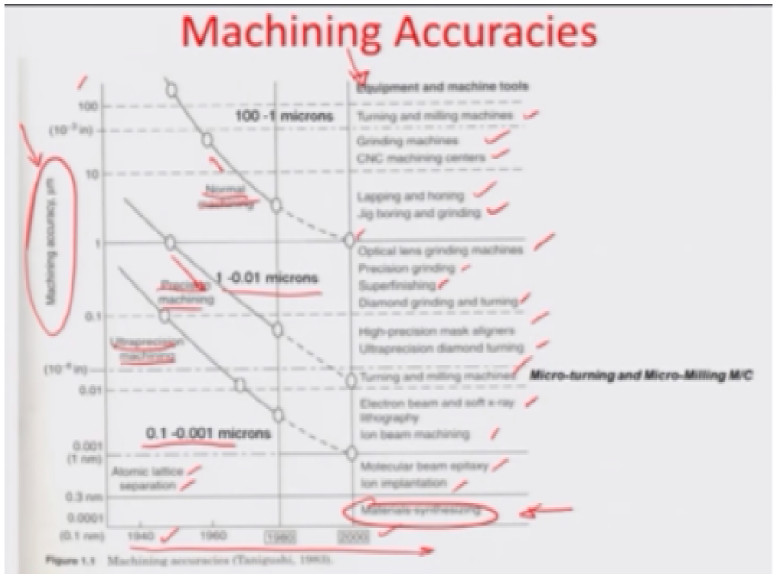

So if I look at some of the machining accuracies and if you look at year wise break up of this accuracies. So on the right here I have made the equipments and machine tool that are being deployed on the left side here is basically the accuracy in terms of microns of the machining. And then you can see year wise break up here in this scale really talks about the different years along which the machining has generated.

And you can see that the machining accuracy if you look at for the different domains have really increased in almost all the domains. For example, if we talk about these set of equipments were turning and milling machines, graining machines, CNC machining centers, lapping and horning, jet boring, and grinding these systems they have sort of reduced the machining accuracy from about 100 micron all the way to 1 micron.

So this is the normal machining paradigm if we talk about precision machining which talks about 1 to 10^{-2} micron range we have difference systems like optical lens grinding machines, precision grinding, super finishing, diamond grinding and turning examples, and then obviously again you can see that there is a change in the machining accuracies from 1 to 0.01 microns which start from 0.1 microns and go all the way to .001 microns that is about 10^{-3} or 1 nanometer.

And there are various different machines here which are deployed for example, high precision musk liners, ultra precision diamond turning tools, turning and milling machines, electron beams and soft x-ray lithography, ion beam machining and then, obviously you can have a atomic and latest separation based again built up systems which concerns with molecular beam project CD or iron implementation so and so forth.

There is this whole new paradigm of self assembly processes were materials get self synthesized and that can give you again atomic spacing or atomic layers. So now you can really manipulate the materials to the level of the atoms and be able to produce such a system of accuracy. So that is how the machining accuracies are evolved through the different years from starting from 1940 to 2000 as it can be reflected in the particular curve.

And so having said that we now have covered historically what was the walk way for the machining industry which is come to the most latest processes and we have also given a brief glimpse of machining accuracies as the function of number of years for different processes.

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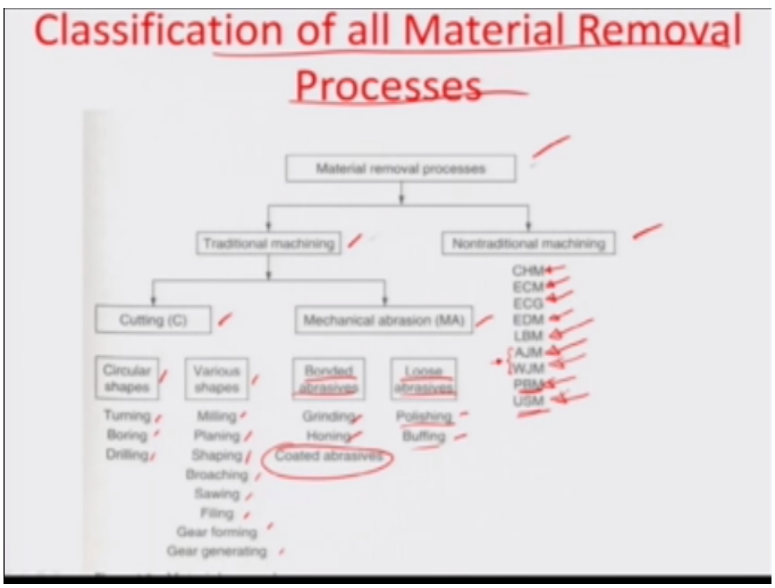

So in brief if we really want to categorize all the material removal processes, they can be either traditional processes or nontraditional processes. Traditional processes again deploy cutting which can have various shapes like circular shapes or other various shapes, circular shapes are typically were either the tool or work piece one of them should actually move or actually rotate along the axis, and the other either the tool of the work piece move in relation to the rotating work piece or the rotating tool.

So that is how circular shapes are created other various shapes for example flaxier etc.., can be done by plaining, shaping you can also do complex profiles on the surface by using milling. The other processes broaching, sawing, filing, gear forming, and gear generating processes where we you can do complex topologies, complex gear shapes etc. So this can be again done by traditional machining you have a section of a traditional machining which concerns with mechanical abrasions were you have either bonded abrasives that means the abrasives bonded either to a wheel or a stick.

So you can actually call them either grinding or honing operations or these are normally with coated abrasives okay. And then, you have loose abrasives based processes for example policing and buffing where you have a slurry, abrasive slurry and there is a tool which actually comes very close to the slurry which is on the surface to be finished and rubs the abrasive grains by dragging them along in the slurry.

So the grains per se are lose, but then the tool forces them to go around in round paths or some define trajectory while scribing along the overall work piece and make good surface finish. These are the traditional side or the nontraditional side either uses chemistry to do machining which is called chemical machining, you do electro chemical. So make one of the surfaces anode the other cathode.

And you can either do electrode deposition or you can do electro chemical subtraction or electro chemical machining. You can also do electrochemical grinding by allowing some mechanical action and a majority of it electro chemical action on the machining surface you can also do electro discharge machining. So here you use the thermal means to erode the material where there is a spark which is created, and the spark is at a very high frequency.

And this actually generates a local melt in the material, because the spark gets generated in this way. And then this material melt is the main cause for the material removal action in this particular case. You can also talk about laser beam machining where again the thermal energy is utilized by the beam of the laser, so there is a photon to phonon conversion, and there is some kind of lattice vibrations which are induced because of this, and it basically tries to locally heat a small place away.

So it can be melted and then later on vaporize. You also have abrasive jet machining which is basically the pining grain action throwing grain action, you have water jet machining were a jet of water loaded with abrasives are used for again perform brittle fracture with the materials ceramics for example, are in lot machine with these two processes per se. You have the plasma beam machining were we talk about the thermal temperature increase by the plasma beam, very hot beam of ions and electrons.

And you can basically raster the beam on the surface and perform local heating at the various places of the surface where there is melting and vaporization which happens, so that is another way of doing machining. And then you have ultrasonic machining which takes care of abrasive particle coming between the vibrating head and the work piece and causing brittle fracture in random to the work piece. So that you can actually have the machining.

So these are the variety of the nontraditional machining processes that look at. So we have covered the history of the machining and we have also the classification of the different machining processes. So we hereby close this module 2, and then we will be doing more about nontraditional machining domain etc., in the next the next module, thank you.

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