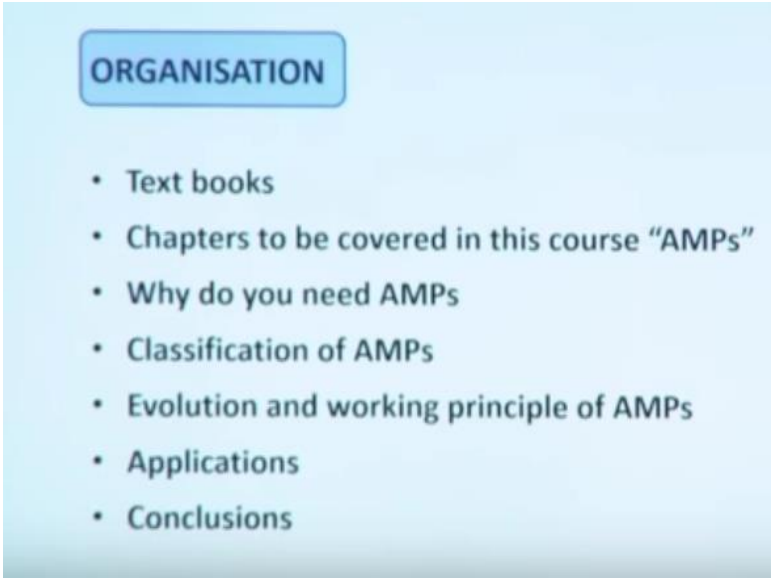
Advanced Machining Processes
Dr. Manas Das
Department of Mechanical Engineering
Indian Institute of Technology Guwahati
Module - 01
Lecture - 01
Introduction to advanced machining processes

So welcome to the course of advanced machining processes. Today we shall we shall going to discuss the introduction to this advanced machining process. So this is the organization of my lecture.

(Refer Slide Time: 00:23)

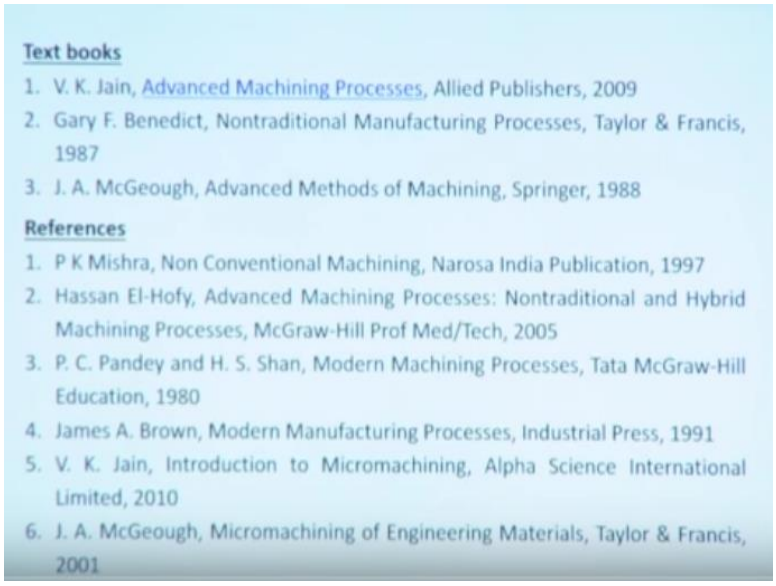


First I shall discuss about the different text books and reference books which I am going to use for this course. So then chapters to be covered in this course in this advanced machining process what are the different chapters we are going to discuss.

Then I shall discuss why we need this advanced machining processes and after that we shall discuss what is the classification of different classification of advanced machining processes and then we shall discuss the evolution of and working principle of advanced machining processes and then different applications of this process and we shall conclude the total session.

Okay now we are going to discuss what are the different text books we are going to use in this process in this in advanced machining processes.

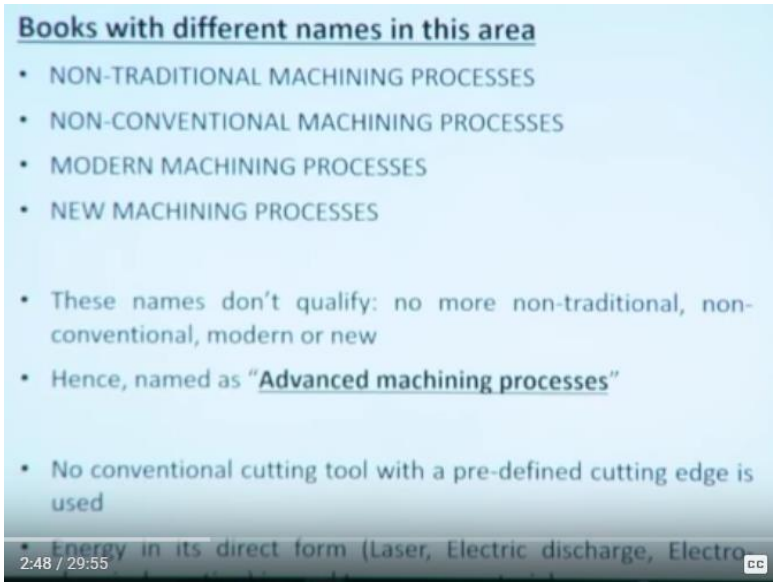
(Refer Slide Time: 01:12)



So first one is the V. K. Jain written by V.K. Jain, Advanced Machining Processes published by Allied Publishers in 2009. Second one is the Gary F. Benedict by Nontraditional Machining Processes by Taylor & Francis in 1987. Third one is the J.A. McGeough written by J.A. McGeough so its name is Advanced Methods of Machining. It is published by Springer in 1988 and other references are P.K. Mishra, Non Conventional Machining Process, Narosa Publishing House 1997 then Hassan El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes by McGraw-Hill. It is published in 2005.

Then third reference is that written by P.C. Pandey and H.S. Shah, name of the book is Modern Machining Processes by Tata McGraw-Hill Education in 1980. Then James A. Brown, Modern Manufacturing Processes, Industrial Press, 1991. Then V.K. Jain, Introduction to Micromachining Process, Alpha Science International Limited, 2010. Then J.A. McGeough, Micromachining of Engineering Materials, Taylor & Francis, it is written in 2001.

(Refer Slide Time: 02:48)



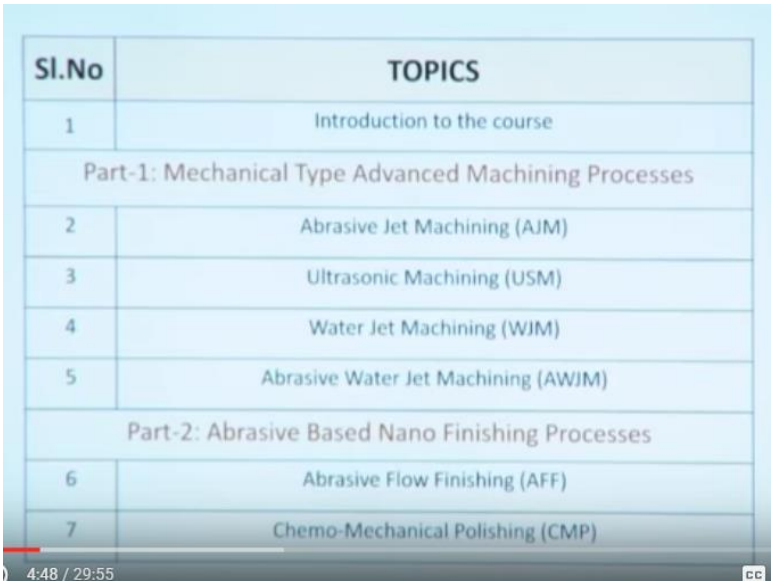
So if we see that different books actually they refer different names of this area. Okay some book they write that Non-traditional Machining Process, some book they write that Non-conventional Machining Process, and some book they write that Modern Machining Processes and few book they write as New Machining Processes. But these names do not qualify no more non-traditional work. So

this process is no more non-traditional because most of these processes are now industrially they are usually used in industries. So they are no more non-traditional.

So that is why these processes nowadays they are called as advanced machining processes. So earlier these processes are actually nontraditional because long back it was not popular at that time so now most of the processes are usually used utilized in industries okay so that is why these process are no more non-traditional machining okay.

So that is why these processes we are going to refer these processes as advanced machining process and that is why I have written I have given the name of this process as in this course as advanced machining processes. So here no conventional cutting tool with predefined cutting edge is used. Energy in its direct form is used for machining like laser, laser beam is used for machining of material like in EDM process energy in the form of spark or arc is used for machining of material okay. So here energy in its direct form is used for machining. So that is why it is called advanced machining process.

(Refer Slide Time: 04:46)

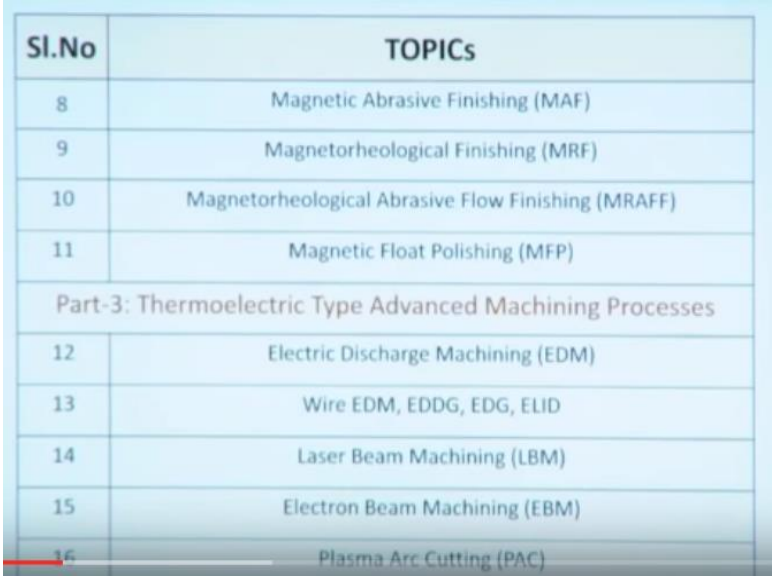


So what are the different topics we are going to cover. So first the first we shall introduce the this course okay. So after that we shall discuss different topics of this advanced machining process okay. So Part-1 is the Mechanical Type Advanced Machining Processes. So here we shall discuss Abrasive Jet Machining or AJM. Second one is the Ultrasonic Machining Process.

Third one is the Water Jet Machining Process or better known as WJM. Then fourth one is the Abrasive Water jet Machining Process okay or AWJM. Second part we are going to discuss as Abrasive Based Nano Finishing Process. So these processes are used for finishing purposes also.

So there are different advanced finishing processes are used for polishing or nano finishing purposes like Abrasive Flow Finishing Process or AFF. Chemo-Mechanical Polishing or CMP process or Magnetic Abrasive Finishing Process or MAF process. Magnetorheological Finishing Process or MRF process or Magnetorheological Abrasive Flow Finishing Process MRAFF process.

(Refer Slide Time: 05:52)



Sl.No	TOPICs
8	Magnetic Abrasive Finishing (MAF)
9	Magnetorheological Finishing (MRF)
10	Magnetorheological Abrasive Flow Finishing (MRAFF)
11	Magnetic Float Polishing (MFP)
Part-3: Thermoelectric Type Advanced Machining Processes	
12	Electric Discharge Machining (EDM)
13	Wire EDM, EDDG, EDG, ELID
14	Laser Beam Machining (LBM)
15	Electron Beam Machining (EBM)
16	Plasma Arc Cutting (PAC)

So it is a hybrid process. In hybrid process the concept of both the 2 processes are actually utilized. So that is why it is called hybrid process. So these 2 processes maybe 2 or 3 processes this maybe non-conventional machining or conventional machining so any kind of process they are combined together and these advantages of both the processes are taken in case of in hybrid processes. Another process is the polishing process is Magnetic Float Polishing, so it is used for polishing of bearings.

So Part-3 is the Thermoelectric Type Advanced Machining Process. So this is there are different processes are there like Electro Discharge Machining Process EDM Process, Wire EDM Process, Electro Discharge Diagonal Grinding, Electro Discharge Grinding Process, ELID Process so Electrolyte In-Process Dressing okay so that is ELID Electrolyte In-Process Dressing, Laser Beam Machining Process or better known as LBM, Electron Beam Machining Process or it is known as EBM Process, Plasma Arc Cutting or PAC Plasma Arc Cutting Process.

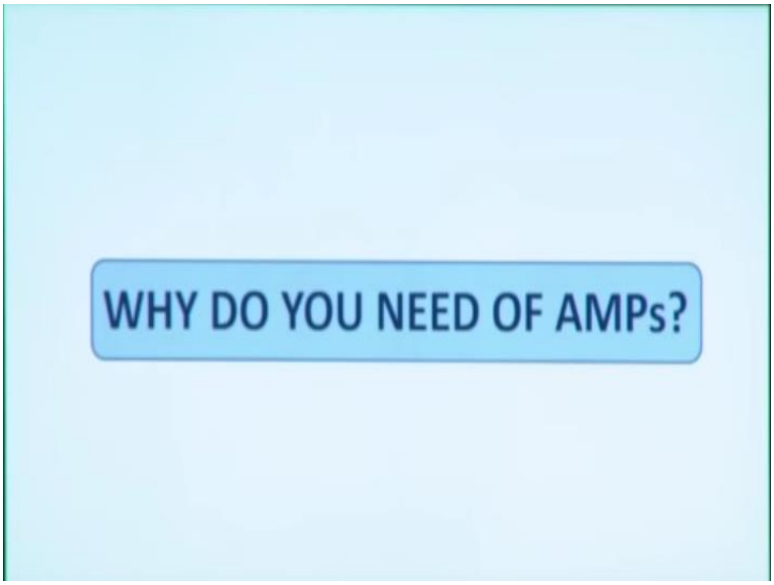
The fourth part is the Chemical and Electrochemical Type Advanced Machining Processes like Electrochemical Machining ECM, so we shall discuss about the theory of ECM. Tool Design of in ECM Process, Electrochemical Dividing Process, Chef Tool Electrochemical Machining Process and Electro-Steam Dealing Process. Chemical Machining and Photochemical Machining Process.

(Refer Slide Time: 07:56)

Sl.No	TOPIC
	Part-5: Miscellaneous Topics
23	μ-ECM, μ-EDM, μ-LBM, μ-EBM
24	Focussed Ion Beam Machining
25	Selection of Machining Process
26	Concluding Remarks

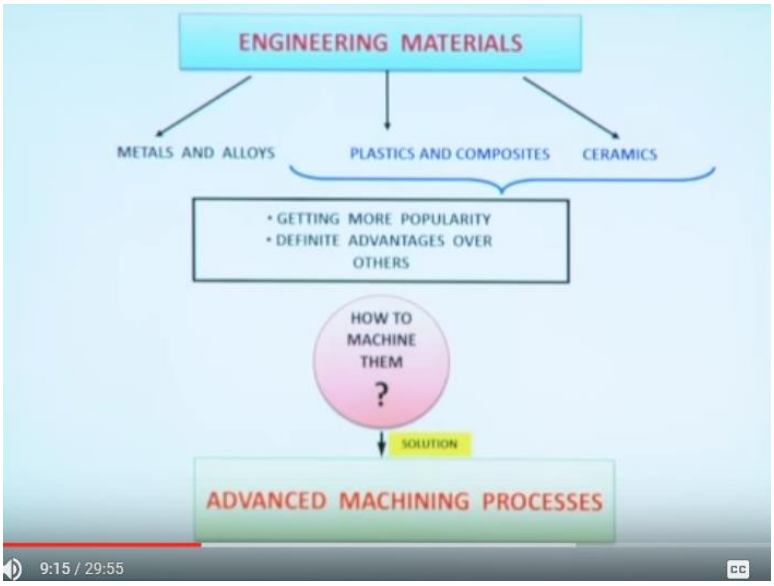
Fifth topic is the Miscellaneous Topic like Micro-ECM, Micro-EDM, Micro Laser Beam Machining, Micro Electron Beam Machining, Focussed Ion Beam Machinings, Selection of Machining Processes and Concluding Remarks.

(Refer Slide Time: 08:03)



So my question is that why do we need this advanced machining processes?

(Refer Slide Time: 08:10)

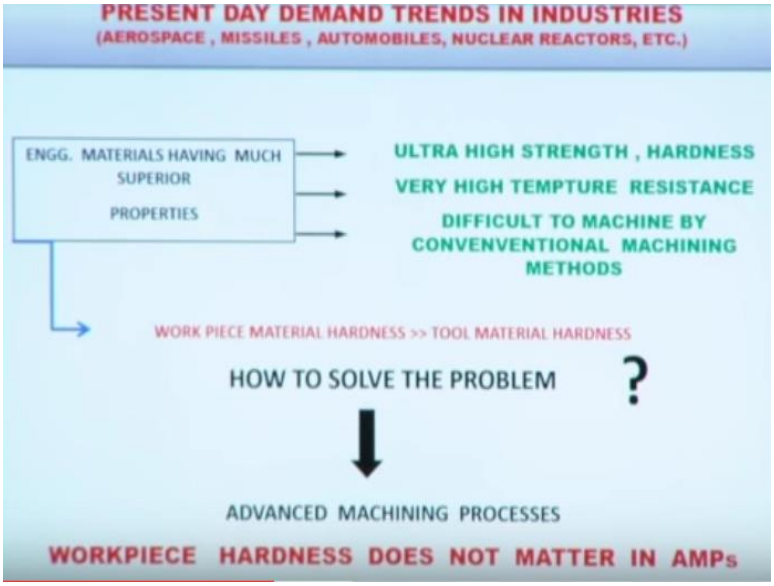


So engineering materials can be classified as metals and alloys, plastic and composites, and ceramics. So these are the 3 different types of engineering materials we can classify. So nowadays this getting this plastics and ceramics are getting more popularity. So it has a very definite advantages of over other materials okay.

So now how to machine these ceramics. In conventional cutting process like in lathes and milling operation we use we cut hard materials okay. So we cut hard materials like hard materials by using this ceramics. Now we are if we are going to cut the ceramics okay so our or tool material should be harder than the ceramic but we do not have any tool material harder than the ceramic so in that case how to cut how to machine these ceramics okay.

So solution is that advanced machining process. So we cannot go by conventional machining process. We cannot machine this these are the this kind of hard materials. So we have to go for this advanced machining processes. So this present day demand trends in industries are aerospace industry, missile industries, automobile industries, and nuclear reactors. They are very hard material, they are using very hard materials, new materials, high strength temperature resistant materials okay. So these are the different materials they are using in present day.

(Refer Slide Time: 09:52)

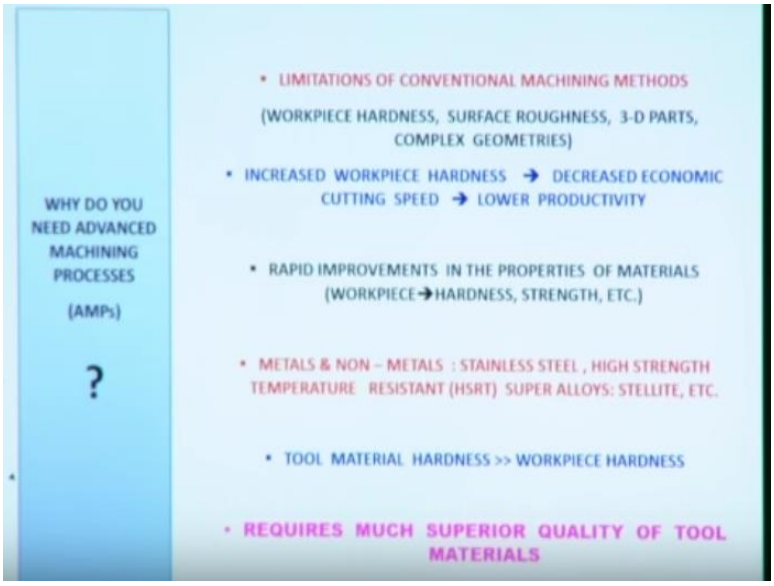


So engineering materials having much superior properties okay as high ultra high strength, ultra high hardness. So these materials are high strength temperature resistance material okay. So one of the materials of this high strength temperature resistance material is used in turbine blades okay where minimum temperature is attained as 1100 degree centigrade okay.

So at that temperature you have to your material has to be has to withstand that temperature. So difficult to machine by conventional machining methods. So these are the materials cannot be machined by conventional machining methods okay. So orifice material hardness in conventional machining method the concept is that your tool material hardness would be very very higher than the orifice material hardness. Then only you can cut the orifice okay.

So how to solve this problem? When your orifice material is very hard, very high strength, very hard, and high strength temperature resistance of this kind of materials are there. So in last few decades these kind of materials are actually evolved or developed okay. So how to how to carve these materials, how to machine these materials. So solution is that advanced machining process okay. So orifice hardness does not matter in case of advanced machining process.

(Refer Slide Time: 11:14)



So why we need advanced machining process again. So limitations, there are limitations in conventional machining process like orifice hardness would be or tool hardness should be greater than higher orifice hardness okay and surface roughness also one of the one of the reason why we go for this advanced machining process.

Supposing some in nowadays we need a nanometer range in angstrom range surface roughness. Suppose in missiles whatever the lenses are used their surface roughness is in the angstrom range. So how to get that surface roughness or surface finish in that into the range of nanometer or angstrom range. So advanced machining advanced nano finishing processes is the solution for that case for getting extra (()) (12:16) surface roughness okay.

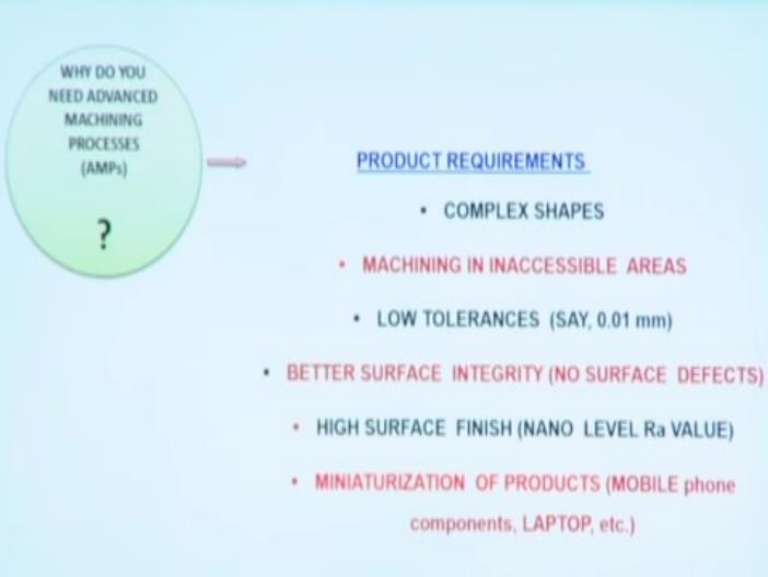
So now 3-D parts like complex freeform surfaces are there like suppose if you want to machine a freeform surface like knee joint so whatever knee joint we have we in old days actually these knee joints are actually replaced. Suppose you want to replace this knee joint in human body so these knee joints has to be manufactured. So this knee joint if you see it is a very complex surface. It has a very complex freeform surface. How to machine this kind of freeform surfaces okay.

So in case of orifice hardness and decreased economic cutting speed if we increase the orifice hardness your economic cutting speed will decrease and productivity will reduce. So rapid improvement in the properties of this materials so orifice hardness, strength all these things are actually increasing. Metals and nonmetals like stainless steel this high this the few examples of this high strength temperature resistant and high hardness materials are stainless steel high

strength temperature resistant material, super alloys, stellite, etc okay. So we have to machine these kind of materials. So tool materials hardness should be higher than this orifice material and how to solve this problem.

So if our orifice surface is very high we need a superior quality tool material okay to machine these kind of hard material but we do not have this superior quality tool material for machining. So definitely we have to go for this advanced machining process that is the solution.

(Refer Slide Time: 14:01)



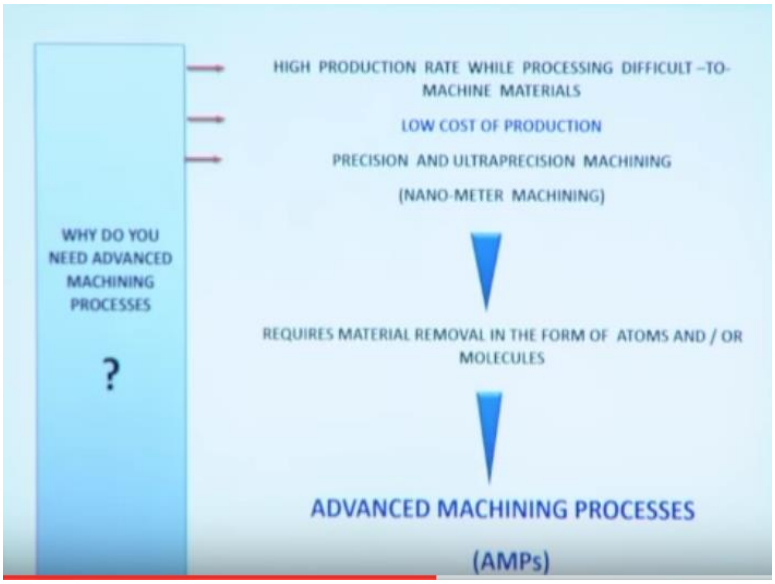
So why we need advanced machining processes? Here product requirements are complex shapes machining of inaccessible areas. Suppose some inaccessible areas are there, there we have to do the machining operations. So the only possible solution is that advanced machining process okay. So suppose we have to gain the very low tolerances say 0.1 mm so we cannot achieve very low tolerances in case of conventional machining process.

Better surface integrity or surface integrity means they have very less surface damage, no surface damage is there also your surface roughness is very less. So these are the requirements, high surface finish nano level surface roughness is required. So advance machining process is the solution. Miniaturization of the products.

Nowadays these mobile phones are very small okay. So earlier days if you see that big big phones are actually used but now you want mobile phone many things are actually included. Your phone is included here, your recorder tape recorder is also included here the FM radio is also included into that mobile phone.

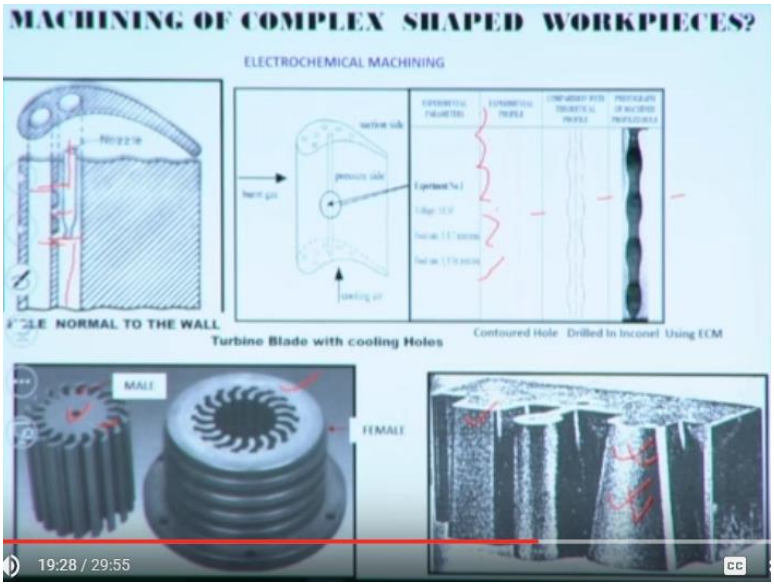
So many things are actually included inside a very small mobile phone. So how to manufacture the different components of this mobile phone? How to manufacture the cameras? How to manufacture the lenses used in mobile phone camera? Laptops so nowadays these laptops are very small. Earlier this big pieces are actually used. So now how to manufacture the components of these laptops? So advanced machining process is the solution.

(Refer Slide Time: 15:55)



Showing in high metal removal rate also. So high production rate while processing difficult machine materials, low cost of production and then precision and ultraprecision machining, nano-meter machining will lead to the requirement of material removal in the form of atoms and molecules okay. So now the solution is that advanced machining process.

(Refer Slide Time: 16:28)



Now we are going to give some examples of this advanced machining process like complex shaped orifices. So you can see here this is the cross-section of a turbine blade. So here you can see you can see here so this is the these are the holes you have to make in this turbine blades. So here one hole is here so this is the one hole is there. In this hole and parallelly you have to make this kind of holes at this wall.

So no conventional machining process can make these kind of holes. So here we have to use electrochemical machining process which is a non-traditional or advanced machining process. By using machine you can make these hole as well as this perpendicular to this wall you can make holes. So these holes actually you can see to make that to increase the hit transfer rate you have to put the cooling channels, these cooling channels.

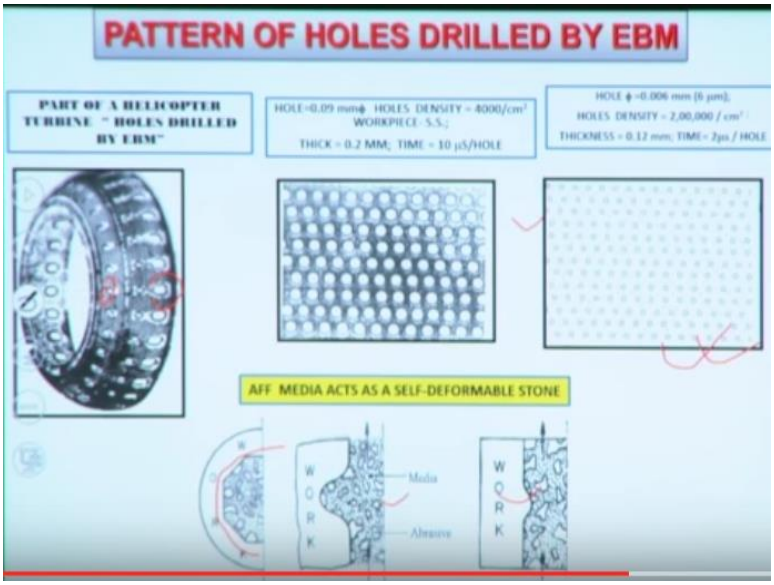
So these holes are actually made because of this you have to flow the water because used temperature is generated to reduce the temperature of this turbine blades you have to flow the cooling water, cooled water okay. So to increase the hit transfer rate you have to generate the components into that water okay. To generate the components this kind of cross-section actually cross-section of this holes are actually generated.

So how to make this kind of holes, small diameter holes, how to make this kind of small diameter holes into this turbine blade. So advanced machining process is the solution. So you can see different kind of cross-sections are actually generated into the turbine blades. Now here you can see this is the male part and this is the female part okay. So this male part actually generated for this female part.

Okay how to make this kind of this kind of parts, how to make this kind of male part okay. So which is used in some complex machines okay. How to generate this kind of this kind of parts. So advanced machining process is the solution. Here you can use wire EDM, wire electro discharge machining okay so by using wire electro discharge machining you can use this kind of parts okay.

Suppose you have to make this kind of dyes while inclined walls are there vertical wall, inclined wall, circular cross-section, rectangular cross-section this kind of inclined walls are there. So these dyes are generally made by EDM process. Here these these dyes actually can be made by wire EDM process okay. So wire EDM is the solution for making this kind of dyes for a very hard material.

(Refer Slide Time: 19:32)



So patterns of holes are generated. So this is the part of a helicopter turbine. You can see at the surface of this turbine different types of cross-sections of holes are generated. So these cross-sections and these cross-sections are entirely different. So this kind of thousands of holes are actually generated at the surface of this turbine.

How to make this kind of holes. So electron beam machining is the solution for making this kind of holes of different cross-sections into the orifice that too on a very thin shape, thin sheet of metal. So here you can see hole diameter is 90 micron and hole density is 4000 holes per cm

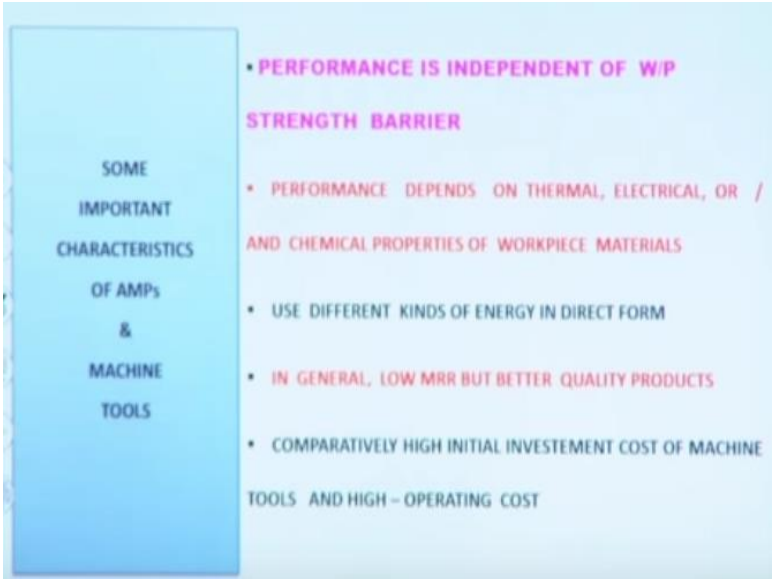
square and orifice is the stainless steel and thickness of this orifice is 0.2 mm and you have to make per hole. Time for making per hole is 10 micro second per hole okay.

So this kind of high density holes are actually used in textile industries in filters also they are also used. In food processing industries also this kind of filters are used okay. So these holes can be generated by electron beam machining process. Here also we can see hole density is more, here 2 lakh holes per cm square and hole diameter is 6 micron and thickness of this orifice material is 12 milli 0.12 mm and time is 2 microsecond per hole.

So for making 1 hole is 2 microsecond. So electron beam machining is the solution for making this kind of holes. Now these kind of complex cavity you have to polish. So you can see here this is the circular cavity, here convex cavity, concave cavity, here convex cavities are there.

So these kind of convex cavity in inaccessible areas how to generate, how to polish this kind of convex cavities in some inaccessible areas. So we have to use abrasive flow machining process or abrasive flow finishing process for making this kind of complex cavities. So this kind of nano finishing process you can use.

(Refer Slide Time: 22:04)



So these kind of thousands of examples are there okay. So this abrasive machining processes performance is independent of the orifice material strength okay. So there is no strength barrier is there. Performance is depends on the thermal or electrical or chemical properties of the orifice material. So material hardness does not matter.

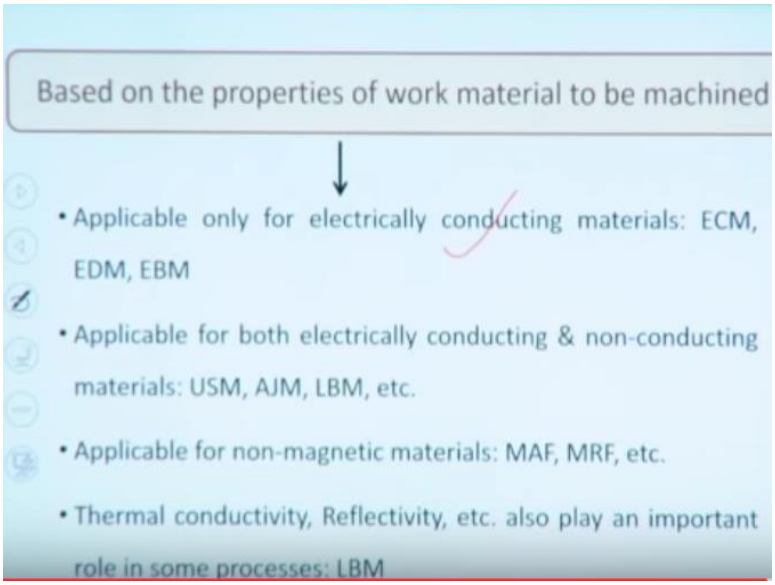
Does not create any problem in case of advance machining process but performance of this process is dependent on the thermal property, electrical property, or chemical property of this orifice material because in this advance machining processes energy in its fuel form is used for machining purposes. So use different kinds of energy in direct form. In general low material removal rate by greater product quality okay.

So metal removal rate in general in the advanced machining processes like in laser machining laser beam machining process metal removal rate is very high and also efficiency of this process in laser beam machining is very less okay. So metal removal rate in case of laser beam machine is very less also efficiency is also very less but quality of the product, quality of the machine produced in case of this advanced machining process is very high.

So when your requirement of this quality of the product is very high, in that case you can use this advanced machining process. So in case of advance machining process comparatively high initial investment cost is there. Suppose (()) (23:49) can purchase with 10 lakhs in conventional machining process but one EDM machine he can purchase with 20 lakhs. So one EDM machine it cost maybe around 20 lakhs.

Suppose if you are you are purchasing one electron beam machining process so it cost around 2 lakhs sorry it cost around 200 lakhs and suppose if you are purchasing one focused ion beam machining that initial investment cost will be around 6 crores okay. So cost of these machines are very high but you will get achieve high quality products. Also operating cost also in case of this some of the advance machining process is high.

(Refer Slide Time: 24:45)

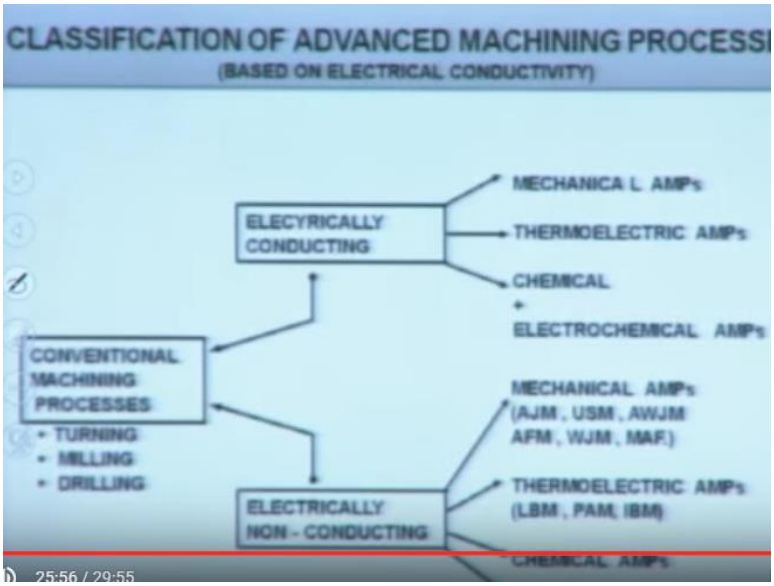


So this classification of advance machining process is based on this properties of this orifice materials of machine okay. So applicable only for electrical conducting materials like ECM, EDM, and electron beam machining process, applicable for both electrical conducting and non-conducting material okay. So these ultrasonic machining, AJM abrasive jet machining and laser beam machining it can be machined for both electrical conducting and non-conducting material.

But ECM, EBM, and LBM these machines IBM these machines are actually applicable for electrically conducting materials only. Suppose if you are polishing okay using magnetic field like magnetic abrasive finishing, magnetorheological finishing process so these processes are actually applicable for non-magnetic material.

So for a magnetic material these processes are not that much efficient. Thermal conductivity and reflectivity also matters. Suppose if you are using laser beam machining process and your orifice is highly reflective like aluminum in that case your metal removal rate would be very less.

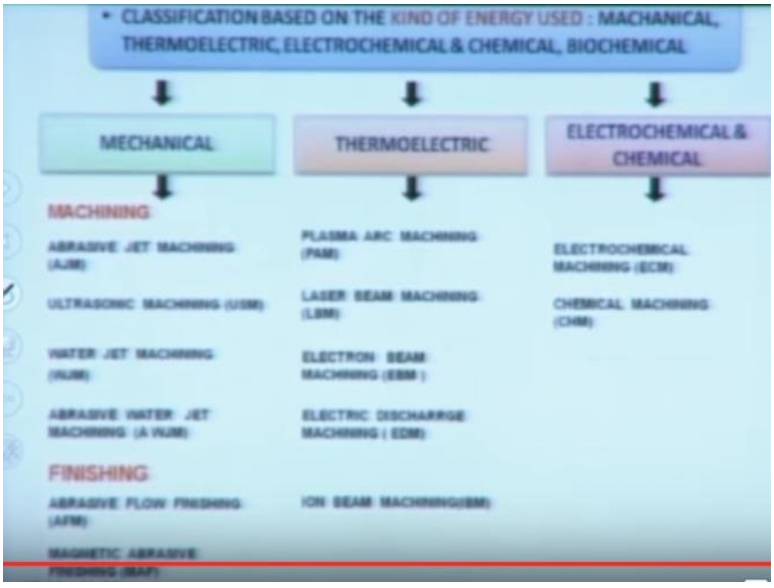
(Refer Slide Time: 25:56)



Now classification of this advanced machining process based on electrical conductivity like conventional machining process like turning, milling, and drilling operations and electrically conducting material okay so with this can be mechanical type advance machining, thermoelectric type, or chemical type electrical conventional process and electrical non-conducting material these are the process mechanical type AJM, ultrasonic machining, abrasive water jet machining, abrasive flow machining, water jet machining, and magnetic abrasive finishing.

Thermoelectric type abrasive machining process like LBM, Plasma-Arc machining, and IBM machining and chemical type abrasive machining process and one more process which is called biochemical process, biochemical machining process okay.

(Refer Slide Time: 26:50)

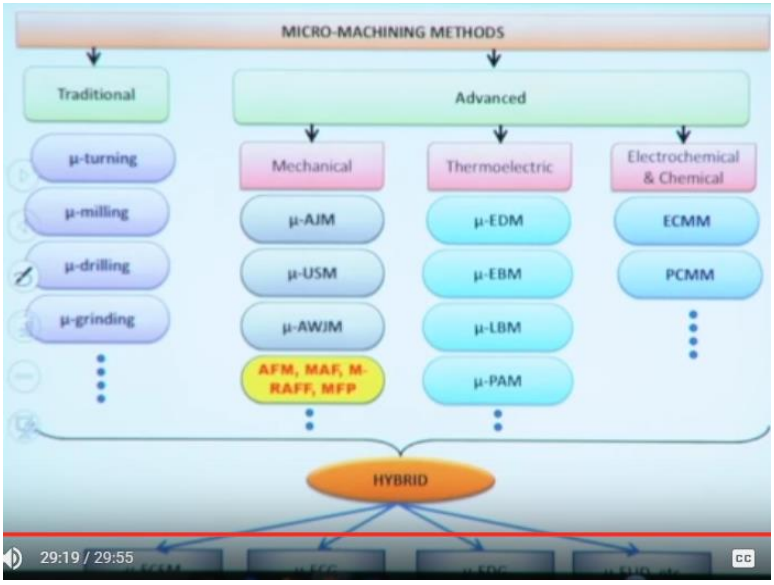


Classification based on this kind of energy we are using like mechanical type, thermoelectric type, or electrochemical or chemical type machining process.

Mechanical type advance machining process like abrasive jet machining, ultrasonic machining, water jet machining, abrasive water jet machining like finishing, abrasive flow finishing, magnetic abrasive finishing okay.

Thermoelectric type advance machining process like plasma-arc machining, laser beam machining, electron beam machining, electric discharge machining, ion beam machining. So these are the thermoelectric type (()) (27:28) process. So here electrical energy is directly used for machining purpose and electrochemical type advance machining process are electrochemical machining and chemical machining okay.

(Refer Slide Time: 27:43)



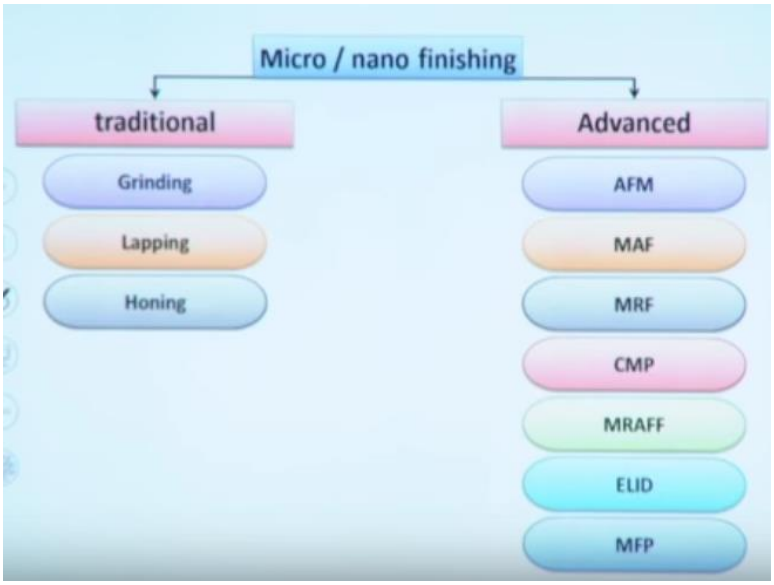
So micro-machining methods different micro-machining methods, traditional micro-machining which are used like micro-turning, micro-milling, micro-drilling, micro-grinding okay. So micro-machining advance type of micro-machining processes also like mechanical, micro AJM, micro ultrasonic, micro abrasive water jet machining, abrasive flow finishing, magnetic abrasive finishing, magnetorheological abrasive flow finishing, magnetic flow polishing okay.

So here work is dimensions are in the micron range is in the 1 to 999 micron in that range working dimensions are advance type processes, thermoelectric process like micro-EDM, micro-EBM, electron beam machining, micro laser beam machining, micro plasma-arc cutting, and

others etc. and electrochemical type electrochemical micro machining PCMM photochemical micro-machining okay.

There are some hybrid processes also there. In that hybrid process advantages of both the process 2 or 3 processes are taken care of okay. So like some of the hybrid machining process are electrochemical spark machining like electrochemical grinding, like electro discharge grinding process okay like micro ELID, micro say ELID process okay so these are the different hybrid processes are there.

(Refer Slide Time: 29:32)



So nano finishing also traditional nano finishing process like grinding, lapping, honing operations are there and advance nano finishing process like AFM abrasive flow machining, magnetic abrasive finishing, magnetorheological finishing, chemomechanical polishing, magnetorheological abrasive flow finishing, electrolyte in-process dressing. So these are the advance type and then magnetic float polishing.

Thank you.