Manufacturing of Composites
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Lecture – 17
Continued
Metal Matrix Composites

Metal matrix composite application.

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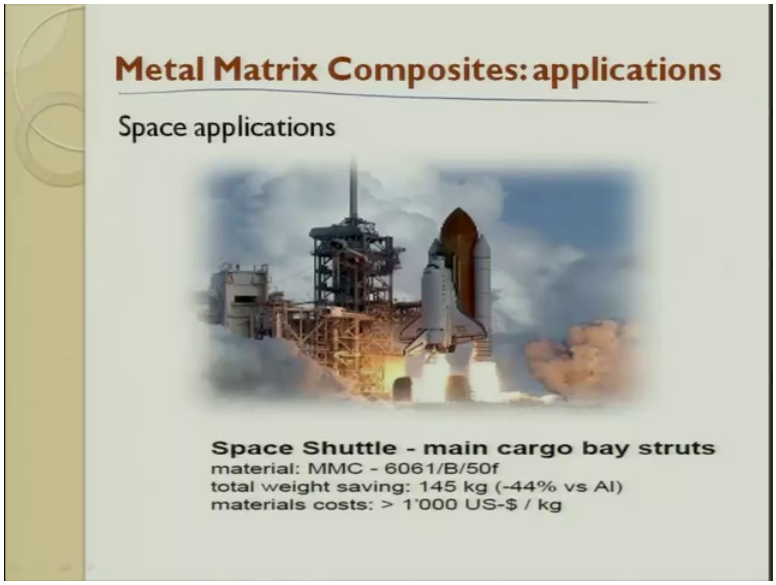

Metal matrix finds lot of application in automobile industry first it is in automobile and then it is in aerospace. Aerospace industry they wanted to have high strength. So, high strength they want and then they want high stiffness, they wanted to have low coefficient of thermal expansion and it has to be light weight. Because if you can reduce one gram or even five grams of weight here in aerospace industry you make a huge savings in your fuel because here you have to carry your fuel and go.

So, that is why in aeroplane and in rocket, they always try to replace all the metal parts by composites so that they can have lightweight material so that they can meet out their application. And here it is also very high temperature polymer matrix composite cannot be thought of in the first way because of the temperature and you can see the top of the rocket can be done the exit of the fire nozzle that also nowadays made out of composites. So, a huge application finds in aerospace industry where and which metal matrix

composite plays very important role here aluminium matrix is used, titanium is used, magnesium is used and high entropy alloys are also used so that they form composites.

So, at the total weight saving of 145 kilo that is 44 percentage of weight reduction happened and the cost material cost was it also gives a huge reduction.

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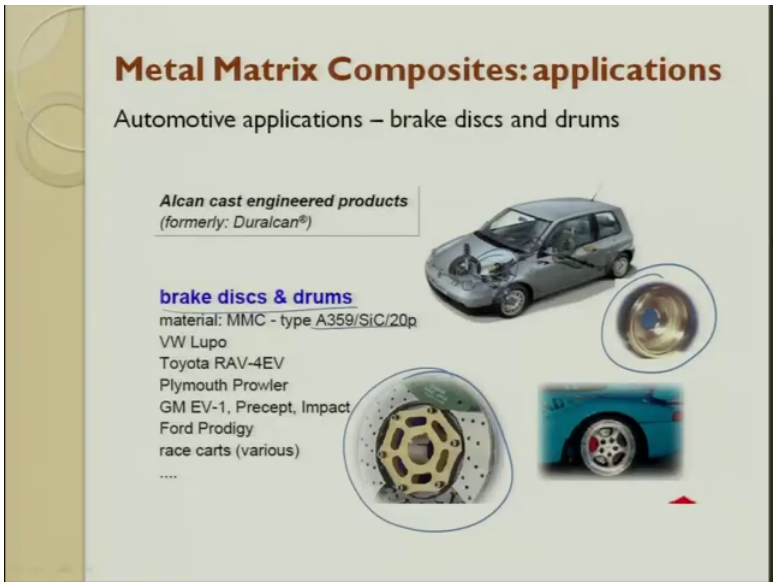

Next is automobile industry; automobile industry had a huge impact for a common man because they have fuel efficiency is one and then they also tried to enhance the stiffness. So, moment the stiffness enhances during accident or crash, these materials tries to yield and tries to transfer energy such that the passenger is slightly save. So, the brake drum is made out of metal matrix composite earlier it was made out of cast iron now it is made out of metal matrix, composite wheel rim titanium rim are coming up today with metal matrix composite and then you will have piston which is there for a long time which is coming out of metal matrix composites.

So, they make a through process called a stir casting which we will see later the different processes. So, and then they could make. So, basically if you can make a casting from a metal alloy then all these things can also be made through metal matrix composites. So, brake drum brake disc was a big advantage. So, there we used aluminium, and then we reinforce to with sic particles then we this is used in Toyota car company and all the major giants started pushing very hard. So, the engine is now made lighter the silencer is

made now lighter silencer are made out of today titanium alloys and this titanium alloys now more towards titanium composites.

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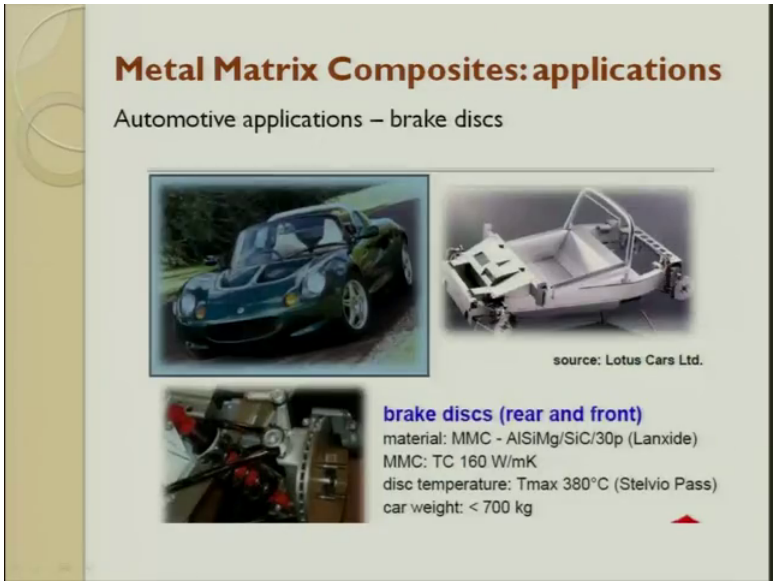

So, the other thing is you can see there front and rear discs completely these discs are made out of metal matrix composite, and when you talk about all these disc they are all made out of aluminium. So, this is aluminium alloy, aluminium si and mg this is an alloy in which we have reinforced the sic and it is having it is a particulate its particulate. So, that is what is told here. So, the moment they do it with this the disc temperature enhances moment the disc temperature enhances the efficiency of breaking enhances. So, the car weight is nowadays also reduced to.

So, moment you reduced the car weight the mileage goes high. So, that is what people are looking for. People are looking for because carbon footprint and other things people are looking for less pollution, longer distance of travel and safer travel. So, these are the things people are looking for. So, that is why composites are coming up in a very big way and wherever there is high temperature wherever there is a strength point of view coming a thermal point of view coming we place it metal matrix composite.

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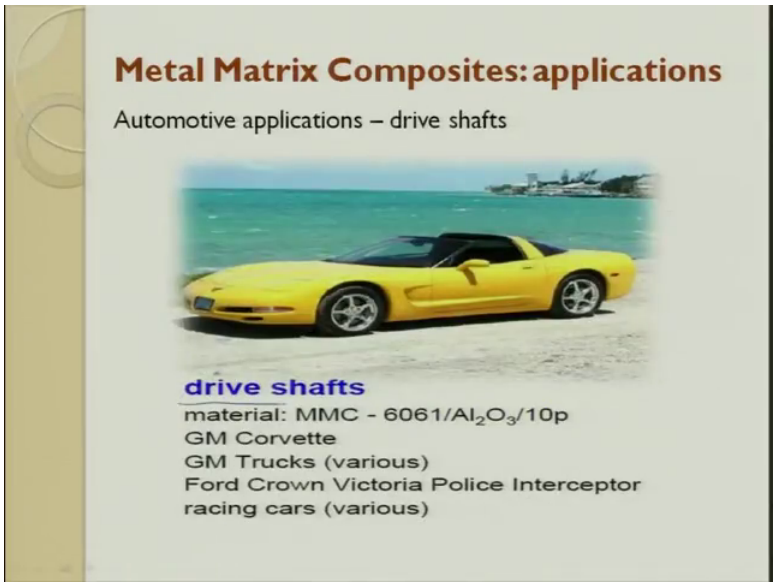

So, Drive shaft is another big example which is made out of today metal matrix composite. So, the six zero six one is the alloy they are reinforced with alumina with particulate size, and this is used by different companies GM ford all these people are using it for a their drive shaft. So, engine parts.

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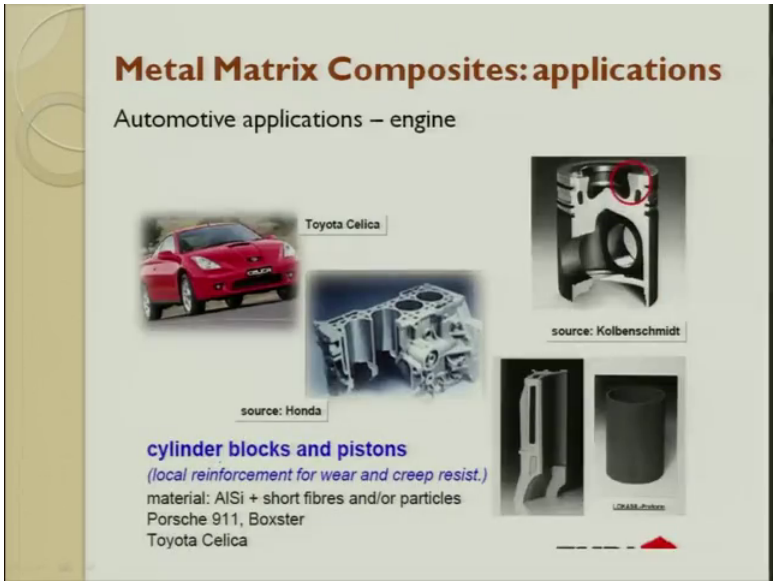

So, engine parts I told you this is a engine block which was earlier made out of it was made out of cast iron from there it went into aluminium today people are making it out of titanium, and from when aluminium and titanium are mixed are made. So, they are

slowly getting into the field called as metal matrix composites. So, here aluminium reinforced with sic is done, aluminium reinforce with alumina is done Ti with tic n t i n they are also tried. So, and then they try to mix and then try to get up and then here they also tried to reinforce with particle size or particulatee size or even short fibers, the only difference is aspect ratio.

So, length by diameter this will have a shorter fiber will have a longer in length you can also try to reinforce with this whisker. So, if you see here the rest of the portion the rest of all the portion will be made out of aluminium alloy and only the top portion will be made out of metal matrix composite, this portion alone will be made out of metal matrix composite where in which ceramic is reinforce. The ceramics what they do is they try to make something like a pre form and then the in the pre form there is lot of holes wends holes are there are some holes in between gap. So, through this gap the aluminium is push inside. So, we will see the process when you study the process in depth you will understand how do these applications have been made.

So, this is done by squeeze casting methods, these are liners which are used. So, there also made out of metal matrix composite all the big gaint ge gm Toyota Honda they are all trying to replace with metal matrix composites train.

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So, in train also, see today what today train these train the number of coaches in the train has increased from 16 coaches to 24 coaches at least in India there all 21 to 24 coaches

and if you talk about goods train it take 50 coaches. So, the biggest problem is breaking system moment you apply break it has so much of momentum it keeps pulling for almost a kilometer and then stop. So, if you want to have instant breaking and if you want to have the discs which can withstand very high temperatures, then metal matrix composites are all are tried there. So, breaking disc and breaking drums are today made out of metal matrix composite. So, they are made lightweight so that they can increase the mileage. So, lightweight is made and it can withstand high temperatures. So, the weight of the disc is 74 kilos which is replaced from cast iron they have got a weight reduction of 40 percent.

So, the total weight savings is 10 tons for a train if you can do. So, on successful testing they could go over one million kilometers. So, this in trains railway coaches they are also making railway coaches also there are make railway engine they are making copper based composite, to withstand high temperature and in the breakers circuit breakers they are all making out of today which was earlier bimetallic now they are all made out of copper alloys and discs are made out of aluminium there also made out of copper which is reinforced with graphite. So, that they give lubrication. So, all these things are now tried in a big way.

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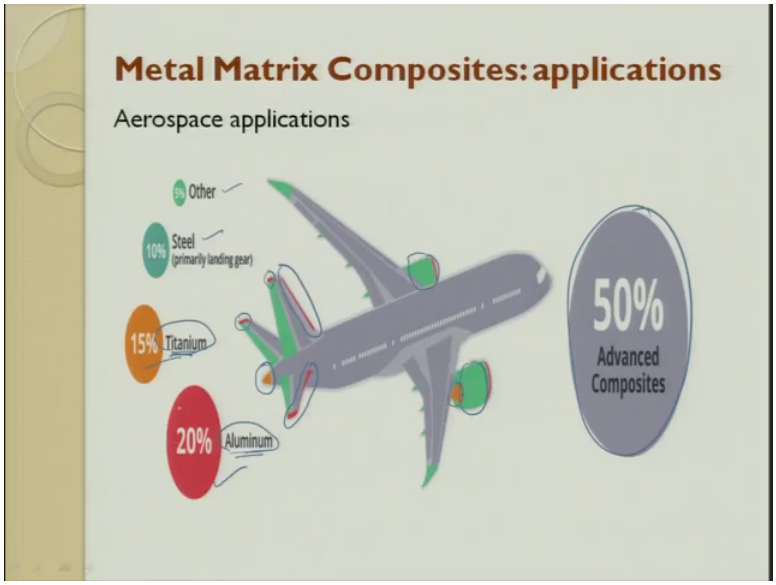

So, when you go to plane. So, 50 percent of them are now today wherever it was possible 50 percent of them are now made out of metal matrix composites, they are made out of

aluminium metal matrix. titanium steel and others right these are the applications. So, if you see titanium where we where do we go for titanium wherever there is a weight reduction you want, we go for titanium. But what is a biggest challenge why people are not going exclusively for titanium cast compared to that of aluminium processing of titanium is difficult. Titanium, titanium alloy, titanium mixing with particulate composite without having a reaction is a big challenge, but whereas, aluminium it is very easy. So, that is why people always prefer for processing of aluminium is easy.

So, aluminium is used as well as titanium used, titanium processing is little difficult. So, if you see this is what it is. So, now, all the exit you see titanium because high temperature titanium is used whenever there is not much of load, but still you need some amount of strength you see aluminium. So, these are the places where aluminium is used in a plane and you can see also steel even now steel is used and the. So, this is other composites and see where ever there is a hot exit air they always go for titanium alloys titanium alloys or titanium metal matrix composites right. So, these are something which you should make sure and when I see others it others small, this is these are all a rare type metal matrix composite which are used for particular application. So, aerospace industry it is also used.

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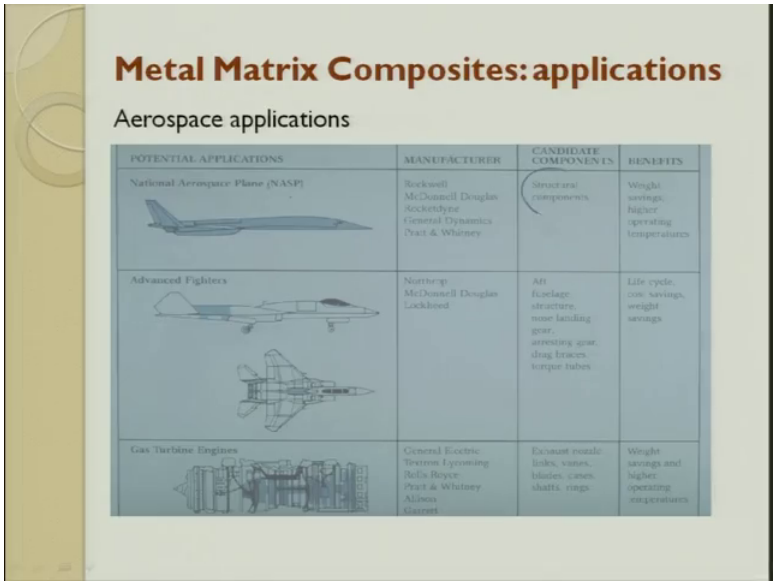

So, this is what we saw in a previous figure. So, you have fan exit guide vanes which are all made out of titanium today. So, look at man and look at the massive size of the

turbine whatever is used. So, look at massive it is Boeing 7. So, look at the size. So, this is made out of titanium and they have lot applications. So, this engine is Pratt Whitney engine 4 XXX series which is used in Boeing 77 7 light weight.

So, that is why people are making and here interestingly it whatever casting you made earlier the same process can be used, but you should keep it in mind now you up with the alloy you are adding some reinforcement which are lighter weight. So, there will be a difference in density. So, you should make sure that it is homogeneously distributed or if you want to have functionally graded that is also possible. Functionally graded means with respect to distance the property changes property whatever property you want if it you take this as 0 exposure to the surface, you can have a certain decline and other things. So, that you meet out the application. So, metal matrix composite using titanium. So, here are some of the other applications which we have put very clearly.

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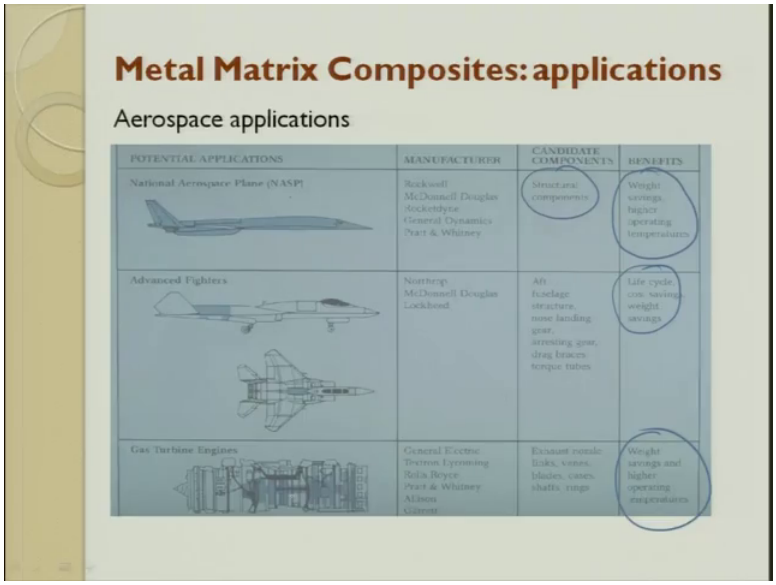

So, you have the potential application is national aerospace planes. So, here you see the rho is a manufacturer I have given here clearly, and who what are the candidate components and then what are the benefits we get. If you see here you see weight savings higher temperature higher operating temperature you always get same way with advanced aircrafts, you can see the life cycle cost savings. Life cycle costing is right you reduce the weight of the component and you start using it using a fuel, and if you could try to find out of break even when do you get back whatever investment you have made.

So, that is what does life cycle cost savings we see, and then you can see in gas turbine engines gas turbine engines is a big way.

So, the weight savings and you can go for higher temperature, when you can go for higher operating temperature you have a better combustion happening; this is pretty interesting.

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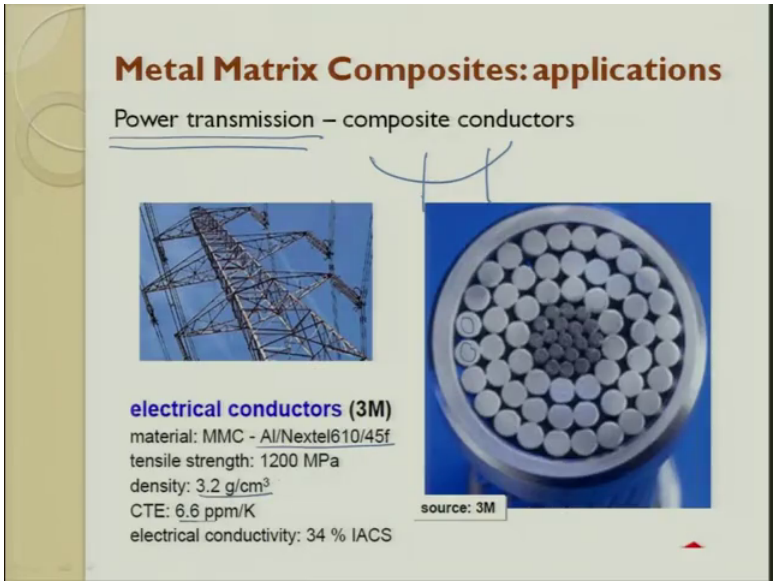

So, these are electrical conducting cables for power transmission which I just introduced in the previous class or in this class I introduced. So, here if you see there are some number of small wires, these wires are tied inside and then they put a sleeve on top of it right. So, these things what they does these are transmission towers and these are wires which run for several kilometers. In order to avoid the wire getting sad we support at several points.

So, each supporting point is made out of a tower which is huge investment cost it occupies land and then it occupies also huge investment to make this structure and whenever you have a natural disaster these structures are prone for failure and again doing it back relaying it back, takes have a lot of time that is why people of today nowadays gone for underground cables they are not going for overhanging cables they are all going for underground cable. So, that has its plus and minus. So, here coming to this cable, initially these cable were made out of conducting metal like copper aluminium and other things, but they figured out as and when the load on these why; that means, to

say the drawing power goes higher and higher and higher these material starts sagging. In order to avoid sagging to happen you have to add more and more towers.

So, now what has happened by the coming of metal matrix composite and if they could make it out of aluminium they the density went down drastically, the coefficient of expansion went down drastically the conductivity enhanced by this many person and now the number of towers are reduced and they have transmission of power with lesser loses which is the big bone for transmission industry power transmission industry.

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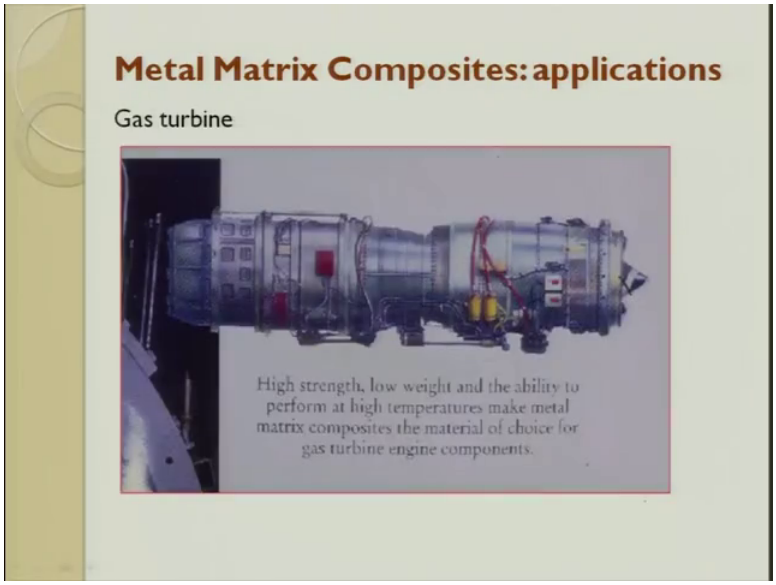

Gas turbine gas turbine can be used in aerospace; it can be used in marine industry. So, this I have already dealt. So, these are the advantage high strength, low weight ability to perform, at high temperature make metal matrix composite the material of choice for gas turbine engine components.

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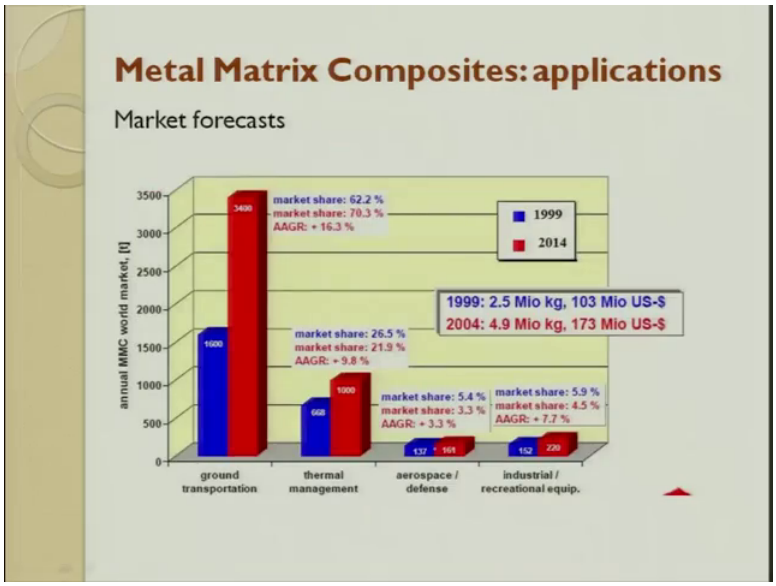

So, if you see the market force. So, you see in ground transportation which earlier was 16000, now tons it has gone up to 3400 1600 tons it has gone to 3400 tons, thermal management it when from 668 to 1000 and the this aerospace and defense it went to this. So, and then you see industrial other recreation work from 150 to 220 it went. So, you see in 1999 2.5 million kilos were used, in 2004 it is gone to 4.9 and in 2014 this is this is this is for 2014 we are showing and for 2004 also it has increased. So, now, they are finding lot and lot of applications for metal matrix composites in transportation industry and predominantly for thermal management.

So, with this we come to an end for the lecture and the where in which we have seen lot of applications and then we have seen the introduction of metal matrix composite. So, I have given enough of a basic knowledge for you to appreciate metal matrix composites. So, I would like to give an assignment.

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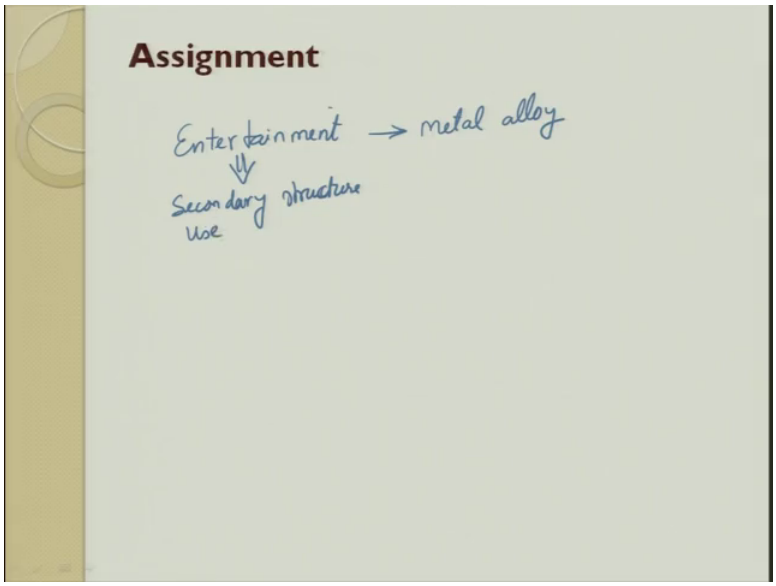

This assignment is like try to look at any entertain any entertainment industry and then you see where all they are used metal alloy; and people might ask what is entertainment industry where in which here where there are secondary structures use its secondary structure use there are lot of secondary structure used.

So, wherever there is metal alloy can you replace this metal alloy by composites if. So, what are what are the components what the components just try to make a list for yourself and then you will try to see whether it is worth making it and here keep in mind cost. Cost is a major factor you keep this in mind and then you look at all the entertainment parts entertainment compounds entertainment parts, and then see where are there, are used metal alloys can these metal alloy be replaced by composite and if. So, what are the components will you do and you see keep cost as a major thing so that is very very important and then you try to make a list with this, you try to do and you do not have to submit. So, you try to have an assessment for yourself and if you cannot find out from the live examples you can of course, use internet and start browsing in and understanding how do the people try to decide, whether this alloy has to be changed into metal matrix composite.

Thank you.