<u>**Design of Machine Elements – I**</u>

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<u>Lecture No - 04</u>

<u>Engineering Materials</u>

good day

ah as you know that we have been discussing about the engineering materials and uh we will continue the same today

so today's lecture is lecture number four and uh it will be again on engineering materials

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now [Noise] you see we have already discussed about the type of materials normally we use in engineering practice that is ferrous and non ferrous metals and we have a ah discussion in the last class about this one about all those materials

now today ah you see uh if you look at the slide you can see the heading is non metals

so there are numerous non metals that are actually in engineering practice however we will be discussing about the those non metals which are very common in engineering practice

now why we use the non metals {ur} (00:01:50) or why it finds its use in machine design because ah one thing is that normally the non metals are ah what you call it is a low cost materials it has got the flexibility and also you know it has got a good resistance to heat and electricity

now [Noise] one of the very important non metal that is timber so this timber is relatively a very low cost material and it has it is a good {elast} (00:02:28) it has good elastic and frictional properties however it is very bad conductor of heat and electricity

so always you will be finding out that uh due to these two aspects particularly the first one the timbers are used in various ah engineering applications

moreover what is happening that we use a timber normally you know in the cases of uh even ah water lubricated bearings foundry patterns okay

and also you will see the normal structures are also sometimes made up of timbers uh and ah this are the major uses of timber in the machine design

you know in certain cases also what happens for some temporary machine elements timbers are also used as to manufacture temporary machine elements ah

but in a very true sense of what you understand (( )) (00:03:36) machine element not in that way some wheels or some shafts or all the sort of temporary devices are sometimes also made of timber

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now we go to another one which is leather as you know this is also widely used in engineering for its flexibility and wear resistance characteristics mostly

now ah always that leathers are used as in pure form ((no)) (00:04:12) is not the case what happens that the leathers are also ((impregnated)) (00:04:16) with some other materials okay

sometimes you know um uh it can be ((impregnated)) (00:04:23) with ah some uh um cords made of nylon etcetera and also it can be ((impregnated)) (00:04:31) with some other alloying materials also to give it a more strength etcetera

however the leather finds an application ah as an non metal in machine design

and one of the widest used of leather what we can think of is the belt drives i think all of you have seen the belt drives and ah if you look at the belt drives you will be seeing the belts are mostly made up of leather

well when you talk about this belt drives you learn more about the other materials but however the leather is one of the very common material for belt drives washers and some other similar applications gaskets okay sometimes are made of leather type but mostly rubbers and other material but these are also can be used in certain aspects ah for ah uh for use as an machine element [Noise]

now [Noise] another situation or another uh situation comes into picture that is the non metals which are the rubbers

now as because ah this rubber has high bulk modulus ah this also is has got an advantage in machine element designs and it is used again for drive elements sealing vibration isolations again gaskets in the pipelines and many more

to mention about the rubber one should see that the rubber is also available with ah various other impregnated elements inside this particular uh pure rubber material to render strength and other properties which ah could be useful for ah typical applications

so or in other words depending upon the applications various forms of {rathers} (00:06:37) rubbers are also in use

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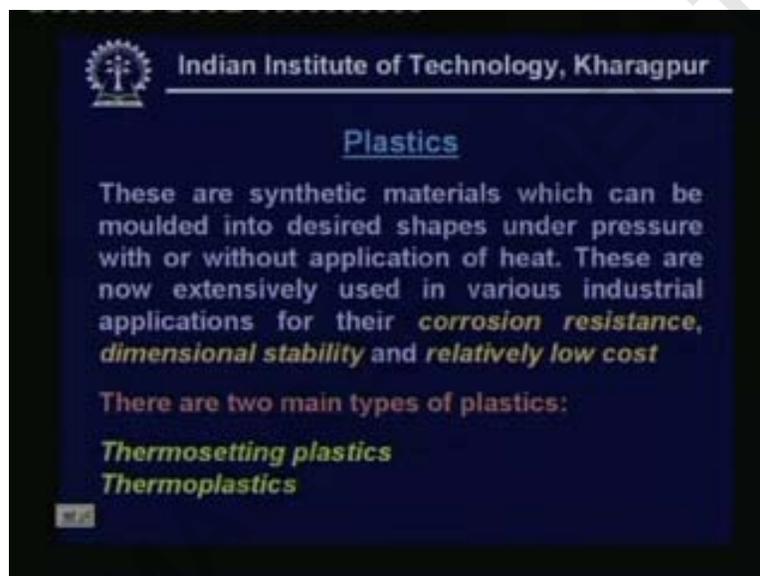
so we go for other non metals and this {oua} (00:06:49) one is what we call as a plastics

plastics i think do not need any introduction in the modern day and ah the use of plastics again in different forms are widely accepted as an very good alternate machine element material

now a days if you see any machine elements okay ah if you consider simply a car seat

now starting from its may be from it's ah structure the body covering okay and the inner mouldings inner interior decorations everything are been made of plastics

 why

because it has ah very good strength as well as it has a very low weight compared to metals so that the ratio of strength to weight is quite high in case of the plastics

so thereby what happens to reduce the weight of the machine elements one can ah think of the plastics uh for for typical designs

now what are the plastics you just have a look

these are synthetic materials which can be moulded into desired shapes under pressure and this ah requires with or without application of heat means you can make it to the desired shapes pressure is required always but it can be without heat or it can be moulded with heat

as i told you that these are extensively used in various industrial applications for their properties what i did not mention right now the properties are ah like this

it is a corrosion resistance ah it has got a dimensional stability and relatively low cost okay

that means dimensional stability you understand that means it's ah affect on to the expansion etcetera are relatively very less ah compared to the other ah metals

now although we call as a common word as plastics it has got the two names

as you can see there are names comes out in this form thermosetting plastics and thermoplastics

so depending upon the manufacturing and the ((respectetive)) (00:09:35) property you all can have the thermosetting plastics and the thermoplastics

what are these two

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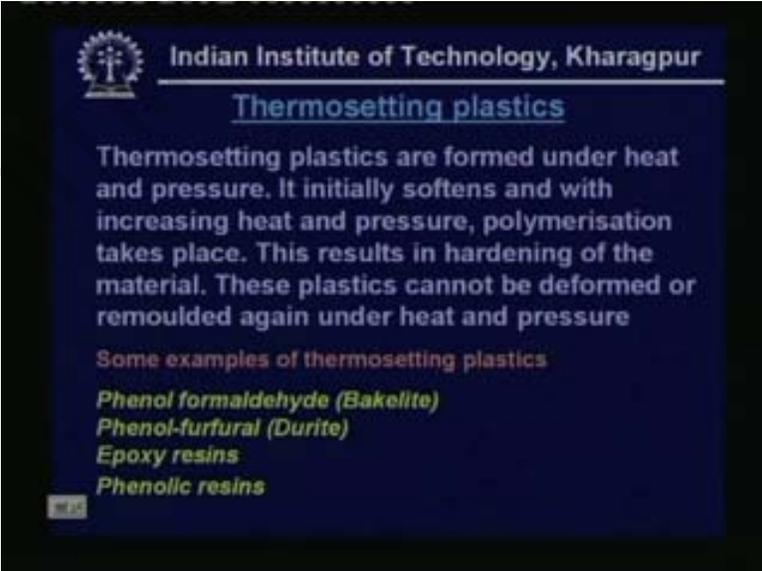
let us see that when you talk about the thermosetting plastics then this thermosetting plastics are formed under heat and pressure

that means here is one case what we discussed earlier case heat with or without pressure no it requires a heat i am sorry pressure is required with heat or without heat now in this case we have to utilize heat and pressure

it initially softens and uh with increasing heat and pressure polymerization takes place so basically ah one way this is also called different grades of polymers this results in hardening of the material

and uh this plastics cannot be deformed or remoulded again under heat and pressure that means it gets a permanent state

so ah once you take up these type of thermosetting plastics then you apply heat and pressure to give a mould ah shape and once the mould shape is final then you cannot retrieve back in any other shape under application of heat or pressure once its hardens

now what are the {exa} (00:10:59) oh what are the examples for thermosetting plastics

you can see the phenol formaldehyde which is the name and very commonly known as Bakelite

so Bakelite you know it's a very heat resistance material and also quite hard and it has a wide used in electrical appliances

then phenol ah furfural well what is called duarite then epoxy resins and phenolic resins

as a matter fact the epoxy resins if we talk about these epoxy resins are used for {na} (00:11:38) you know ah you know the common name ah which we use in the ah market is ariel like or some sort of things which are under epoxy resins

and as a matter of fact epoxy resins with a proper amount of chemical treatment that is called hardener you can ah really make out different shapes and then different you can make the moulds and from which you can pour this epoxy resins and get varieties of ah machine elements having different shapes

so very and and if you ah mix up with this some other ah um fibers glass fibers and other carbon uh fibers etcetera it gives an attractive strength property also and that's the reason epoxy resins are very widely used for ah mould purposes

ah one of the situations ah what i just told you ah are you can see are we {u} (00:12:36) utilized very much ah particularly in the laboratories when you do some experimental setups then you will be finding out that epoxy resins added with the ah carbon fibers or the glass fibers will be uh utilized to make some laminates or setups having {d e} (00:12:59) different mould shapes

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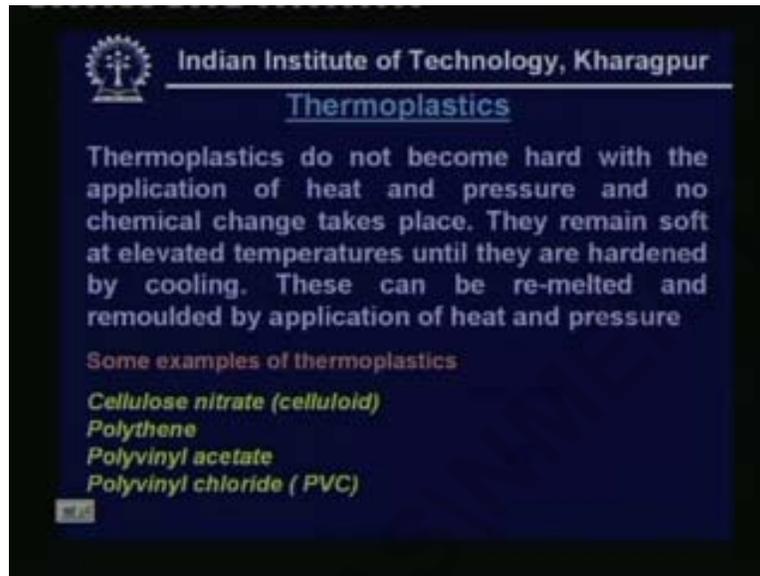
the next one is the thermoplastics

thermoplastics do not become hard with the application of heat and pressure and no chemical change takes place

they remain soft at elevated temperatures until they are hardened by cooling this can be remelted and remoulded by application of heat and pressure

so that means the you understand these thermoplasts uh actually are relatively softer material than the thermosetting

now the advantage is that this thermoplastics can be again remelted and remoulded by application of heat and pressure

now here you can see some names that are the cellulose nitrate that is called celluloid then polythene polyvinyl acetate and polyvinyl chloride PVC

so if we if we once see the name PVC do you understand that ah what is the use the of the PVC

you have seen in the ((avt live)) (00:14:20) we talk about PVC pipes one of the um one of the very modern pipelines uh made of plastics basically these thermoplastics which are widely used in any water pipelines etcetera where you can find out its application because if its light weight once again to say cheap and mostly the corrosion resistance

you by long uses we do not have a iron (( )) (00:14:50) form on the pipeline so that is why it is an attractive situation for the ah hum the transportation of drinking water etcetera

however ah some questions sometimes is being raised ah regarding the transportations of water through PVC pipes ah particularly for the drinking waters uh of course the most suitable one ah should be the stainless steel ah but {ss} (00:15:18) still that part if we just omit out for the time being then we find that the PVC has got an excellent applications in particularly in water pipelines what you have seen in our everyday life

other than that what happens that there so many PVC components are utilized in ah making the uh different type of machine design elements ah because that is in concept with same corrosion resistance attractive weight ah strength to weight the ratio that is one of the very beautiful features

however you know ah because nowadays what happens that all the machine elements which are made of the PVC or the plastics in general if we see then uh these are somewhat an use and throw type of things that means you normally you do not repair any plastics products

if it is thermosetting you know that it cannot be repaired because it cannot be remoulded ah

again all the PVC 's can be remelted remoulded but normally what happens all the machine elements made {outs} (00:16:29) of plastics are in general ah use and throw types that means ah that means that's the reason what happens the maintenance for the say in cars or other things has become very cheap and fast means you just simply change the components of course ah if it is ah plastic components

and at the same time what i would like to say that they use the car manufacturers are particularly are using day by day more and more type of this type of ah plastic you know machine elements just to reduce the weight so thereby you have a good amount of real efficiency

so [Noise] these are the uses of the plastics and the two types of plastics already i have told

and as the matter of fact ah there are this type of situations are endless endless situations will come into picture whenever we talk of the plastics

now ah for this particular course of machine design i think that the mention of the material plastics is good enough at least you have a some idea is that how you can use plastics for different machine elements

however ah one has to resort to a ah use an amount of you know literatures if you ah really look for the ah entire range of plastics that are being used for design of machine elements

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so if we ah talk about very quickly what we have gathered about engineering materials then ah you just very quickly ah go (( )) (00:18:21) to the last class you when so you we understand that we {good} (00:18:27) we have the important ferrous materials of cast iron wrought iron and steel

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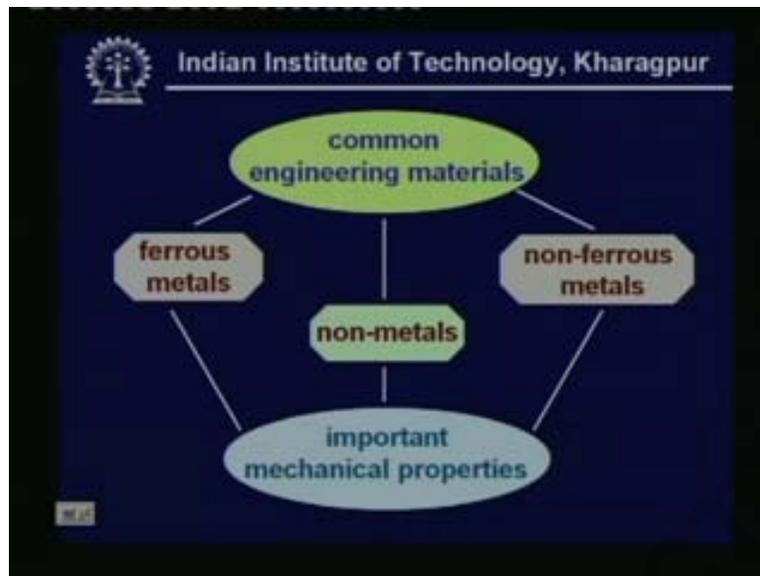
before that you know the ferrous metals non metals and non ferrous materials okay

these three are ah widely used and for all these (( )) (00:18:43) we do have the important

mechanical properties to learn

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so ah cast iron wrought iron and steel we have learnt we have learnt about different types of cast

irons and their uses

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we know about the {geyl} (00:18:56) grey cast iron

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white cast iron

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malleable cast iron

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then graphite nodular graphite cast iron

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austenitic cast iron

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ah and abrasion resistant cast iron

so you have seen that so many varieties of cast irons are there ah um what we have just picked up um very few ah which are is a is a normal materials which are used in machine design design of machine elements
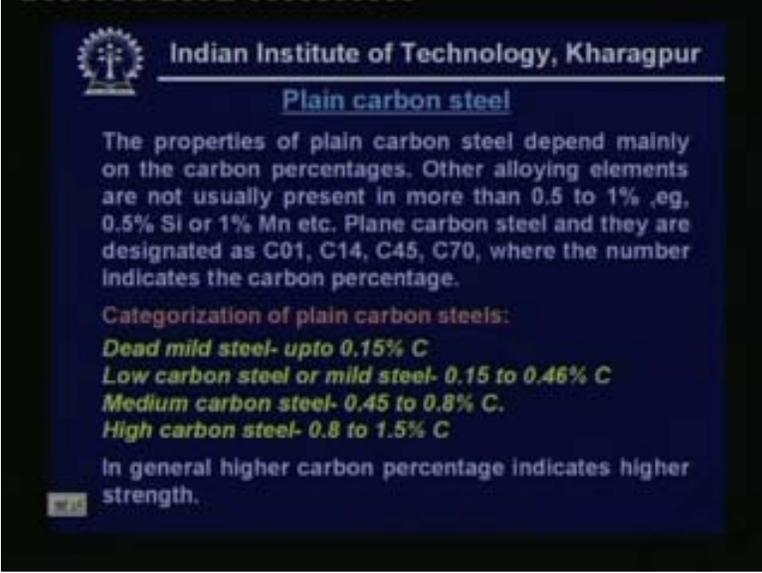
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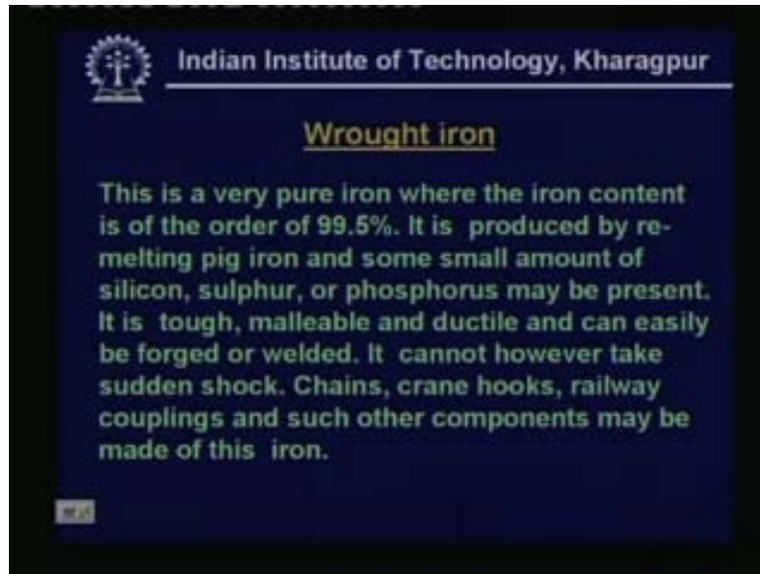
you can have the cast irons you know you can have cast iron ah uh sorry wrought irons

ah which is a very pure iron

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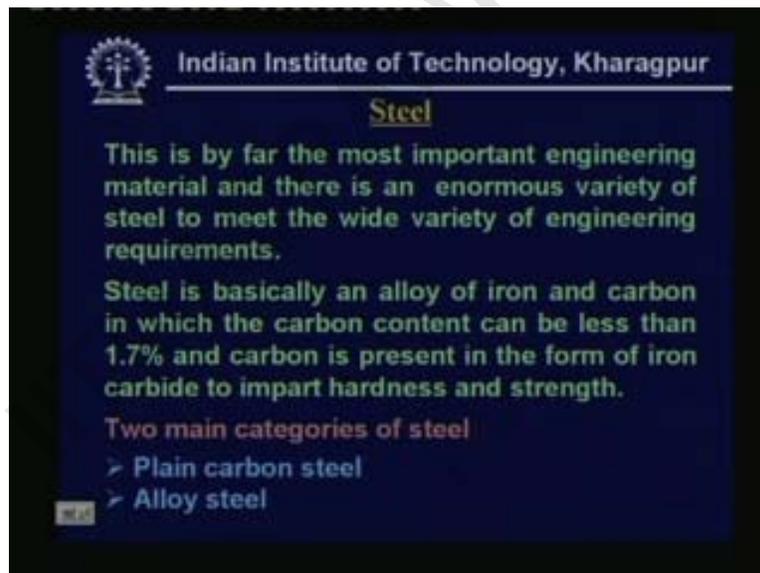
and the steel one of the major ah ferrous material which is having an wide range of ah you know

alloying elements and thereby you get the different type of steel

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so if it is plain carbon steel uh that means you do have the uh carbons only and very less amount um of other materials i mean other elements

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however there are [Noise] nickel chromium tungsten vanadium manganese silicon cobalt molybdenum

these are the ah alloying elements put up into steel to make alloy steels

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one of the very widely used steels in engineering design

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so about the non ferrous metals

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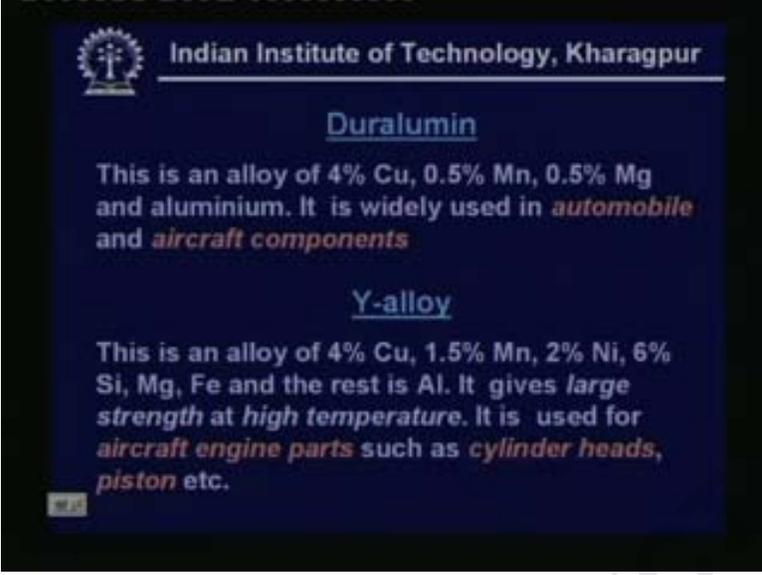
we have learnt about aluminum its varieties like duralumin y-alloy

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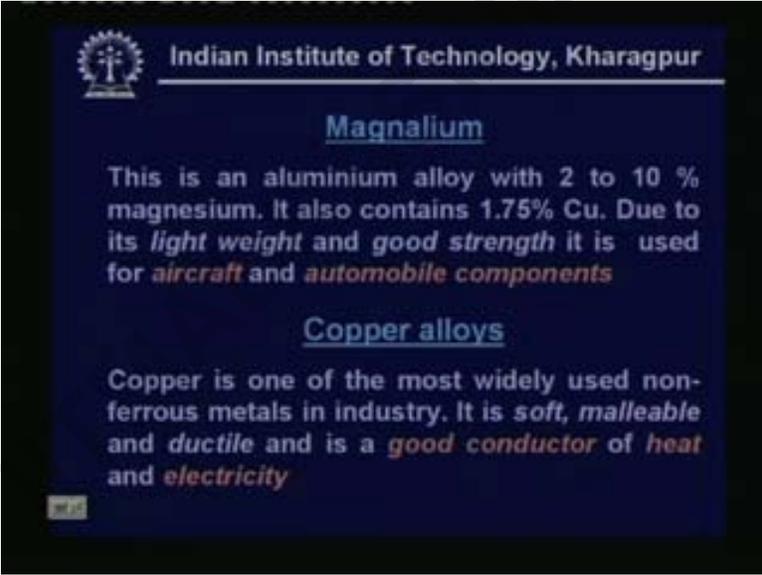
magnalium

then we have learnt about the copper alloys which are also ah very useful [Noise]

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then [Noise] ah out of this copper alloys we have one brass and other is the bronze

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we have got another variety called gun metal

and this today's lecturer we have learnt about some of the non metals like the timber leather rubber and ah last but not the least that plastics which are widely used as i told you

now after coming over the plastics we have learnt about the thermosetting plastics and we have learnt about the thermoplastics

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now we come down to one of the important things that is the mechanical properties of common engineering materials

why we talk about the mechanical properties of materials

the reason is very simple ah you know that to be in a very very simple case we design a machine element the primary situation comes out to be like that that stress equals to load divided by area that all of you know

now machine design you will be finding out you will be concerned with basically finding out the (( )) (00:21:56) or dimensions of the machine element

to be very simple in this thing i mean simple in design considerations

so what we know we know the load onto a machine element that is that one has to know because you know the application ah uh and as you know the application you know the loading pattern you know the load

so thereby to determine the dimension of the machine element to take up that load what we require

we require the value of the stress

now in this case how we define stress

means in this case stress we define the stress means the value of the material stress at which it fails okay

so once we know the material property at which the material fails then immediately we can find out the dimensions of the machine element

so what you understand that if it is in addition to this particular stress what we are talking about you have other mechanical properties which will be somewhat if i consider as an synonymous to the stresses are also responsible for breaking the material or for the failure of the material ah in a bit of sense if we talk about the failure the of material under different situations

as a matter of fact what we understand that if we consider a load which is static or quasi static means very slowly if you are giving a load to a machine element then what we normally we will be calling as an static load

then our ah our material property which will be very important is the one of the situations is that the each point on the proportional limit what you called about okay there is a difference

we will be coming shortly okay to discuss these things

anyway ah what um happens that in that way if it is an sudden impact then you will be finding out some other properties that are important

if we find out that the machine element is acted upon by an fluctuating or a variable load instead of a static load then some other material property is important

so if it is uh in the similar line if we consider the material is under a a constant load a delivery temperatures or something like that some other material properties are also important

so we should know some of the mechanical properties ah or at least we have some understanding of the mechanical properties because when we will be considering the design aspects or when we will be designing then we should keep those material properties in mind uh to use it effectively or for an effective use in a machine design

now the first and foremost of that what we understand is the elasticity

this is the property of a material to regain its original shape after deformation when the external forces are removed all materials are um {re} (00:25:30) ah ah removed

all materials are plastic to some extent but the degree varies for example both mild steel and rubber are elastic materials but steel is more elastic than rubber

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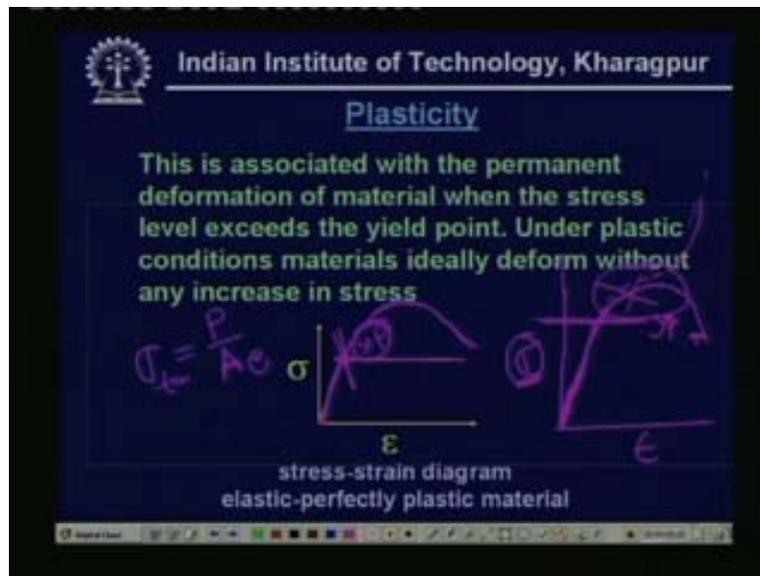
now ah once we talk about the elasticity and the associated term we can see is also the plasticity

this is associated with the permanent deformation of material when the stress level exceeds the yield point

under plastic conditions materials ideally deform without any increase in stress

so here we find that uh we can talk about the ah this particular curve you know you can see this curve that the stress strain diagram elastic perfectly elastic materials that means what is the perfectly sorry perfectly plastic material

now conventionally we know that if we plot a stress strain diagram then it comes something like this and it goes like this

ah okay i just draw it in a bold line something like this

now in this case [Noise] when you are considering the situations as elasticity and plasticity then we know that somewhere this is the yield point what we consider this is the yield point

within the yield point we consider the material to be elastic that means the definition is that if you apply a force and then release it it comes back to the original shape so that is the elastic region

and when we go to the plastic region there is an permanent deformation and the idealist situation is what is shown in the figure you can see that it goes as a straight line

so this basically from here onwards this is called the plastic zone what you are getting so this is called plastic zone of the material and this curve is an idealized figure

now ah in this respect ah what happens that normally if we draw the stress strain curve i understand that you remember the different load this is the stress and this is the strain

now what you know that this stress we call you should know we call it as an engineering stress why engineering stress

because if we consider the stress expression then this sigma the value of sigma okay i write out here something load divided by area

now when we talked about engineering stress then what happens that we do not consider the change of area taking place due to the deformation

suppose if you are having an tension test okay then this is a typical and tension test curve what i have plotted over here

then the area will be gradually reducing and thereby P by A will be more and more it won't be following this particular path

however it has been seen experimentally that if we consider up to the yield point really the change in area is so small that engineering stress and the true stress other one if we consider the change in area means if i write AC then the sigma two means actual area A actual if we consider then we will be considering every time a change in the sigma true sigma

now here the true sigma will be quite appreciable i am still i am drawing an very exaggerated that moment it comes over like this

that means when the area becomes very small at the fracture point then the true stress will shoot up that is uh quite evident from the expression

however ah in the most engineering situations for the design we consider this zone to be a failure zone isn't it because normally we will be taking up the material property up to the yield point

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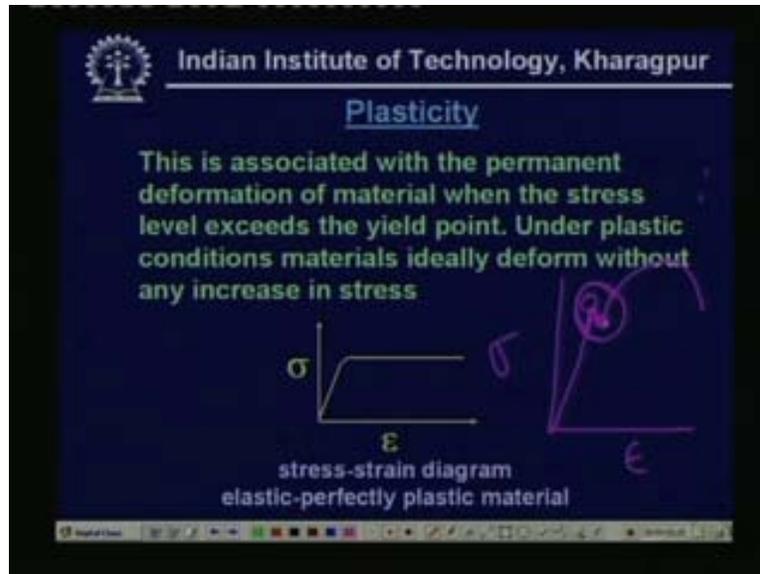
now another part what comes into the mind is that you can see that when we consider a stress strain diagram sigma epsilon in the textbooks you might be seen something like the curves that comes like this where we consider as an upper yield point and as a lower yield point

but if you do the experiment you will be hardly seeing this type of phenomenon's {en oh} (00:31:05) uh as a matter of fact these phenomenon's are mostly i mean very prominent for the mild steel ah materials and that too if the strain rate is very slow

so if it is having an low strain rate then and then only you can come across these type of higher yield point and lower yield point

nevertheless ah we consider ah general stress strain diagram of the nature as i just drawn earlier

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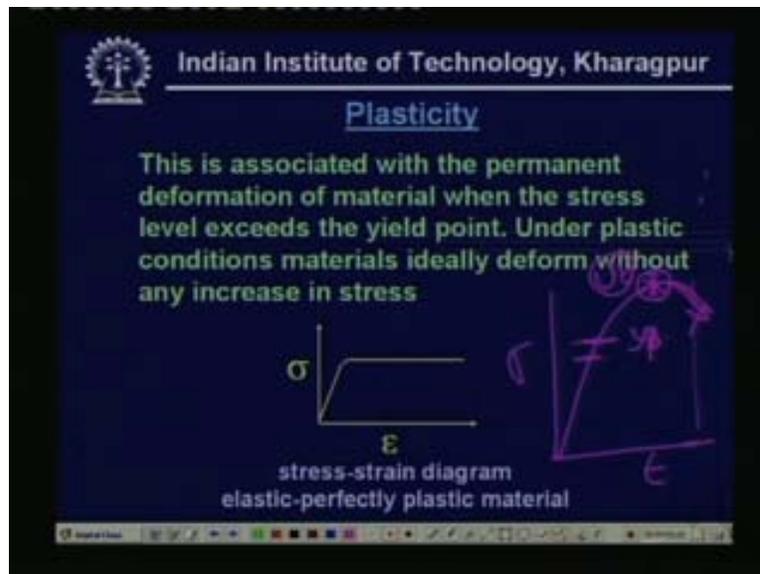
so let us consider it is general stress strain diagram i draw {ha} (00:31:42) haven drawn the earlier diagram because you should not make a confusion that that is a general (( )) (00:31:47) that particular one is an typical one for the {eh} (00:31:51) you know ah mile {steege} (00:31:52) sort of materials and that too at the low strength that you must be understanding that particular part

otherwise if you look at the ah slide once again then you can see that normal corps will be as i have drawn over here

here we consider a yield point basically before yield point we do have a point called a proportional limit means what is the difference

proportional limit is a perfectly the point till (( )) (00:32:25) material is elastic

and yield point means already very small amount of deformation has set in although we know the material property based on yield points are the one which is widely used

and another point we also utilize in the machine design is this ultimate {stre} (00:32:27) ultimate stress okay ut okay so this ultimate stress and this is yield point stress and this is the Bracken's stress

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now [Noise] in some cases what happens that ah or if you get a diagram of this type of ah this type of nature then it is very difficult for one it is very difficult for one to get exactly the yield point because the the transition of linear to this non linear situations in actual curve is very difficult to find out

so you must be knowing just a recapitulation i am giving you

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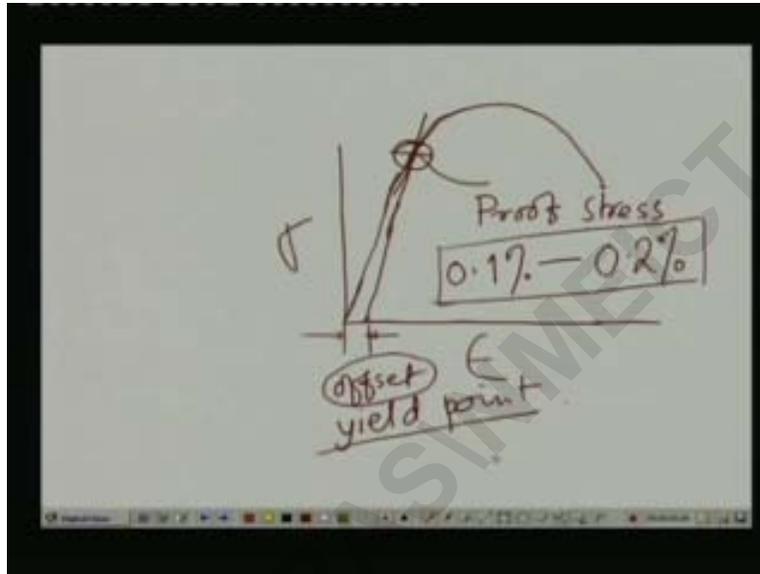
that if you have a sigma epsilon plot just as i have seen right now ah ah i am drawing into a blank sheet ah you you you find out that yield point breaking point uh sorry breaking point and the ultimate point etcetera

but as you can see that it is very difficult in actual practice to find out that where this line this linear zone has gone up to just entered the plastic zone

so here it is being done in this way that to draw the linear zone and take an certain amount of offset to fed this

and taking this point you draw a line parallel to the original parallel line and then you get a point like this means intersection of this curve and the parallel line gives you ah world sometimes it referred to as proof stress

sometimes it preferred to as also offset yield point

so this is one of a very convenient way to determine the yield point of a material in cases

how much should be the offset

offset is normally zero point one percent to zero point two percent

however ah this particular choice of value ah is also determined by the designer who is taking this material property for his design

try to derive the values from the results obtained in simple tensile test

so that is a design in all the courses the students are exposed atleast to a material testing test namely as tensile test which gives you the important properties like yield point and ultimate stress values because these are widely used in design

and that we will be discussing in the course and uh i have told you some already their utilities in deriving other material properties

well [Noise] once we have some idea about this plasticity and the elasticity then ah let us see another equation

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Indian Institute of Technology, Kharagpur

Mises-Henky criterion

Gives a good starting point for plasticity analysis

$$\left(\sigma_1 - \sigma_2\right)^2 + \left(\sigma_2 - \sigma_3\right)^2 + \left(\sigma_3 - \sigma_1\right)^2 = 2\sigma_y^2$$

where σ_1, σ_2, σ_3 and σ_y are respectively the three principal stresses at a point for any given loading and the stress at the tensile yield point
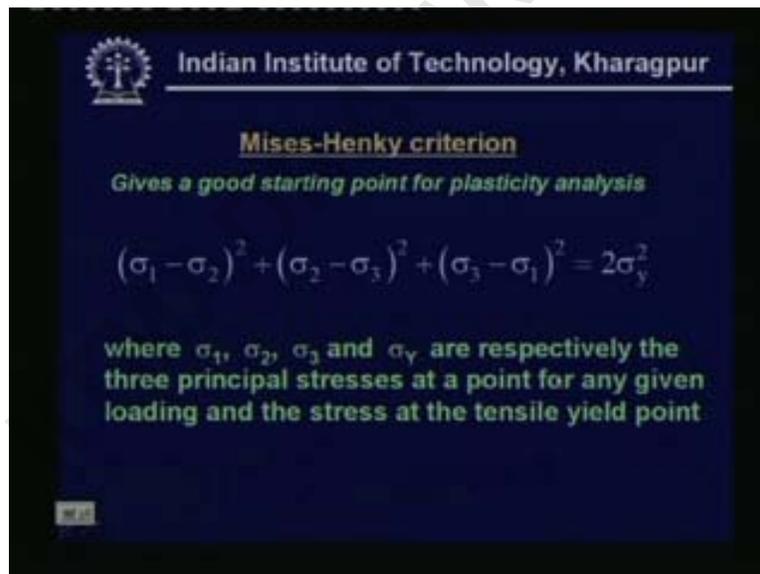
this equation will be taking up {shu} (00:36:55) in the ah after one or two lecturers

now this is called Mises Henky Mises Henky criteria

this gives a very good starting point for plasticity analysis

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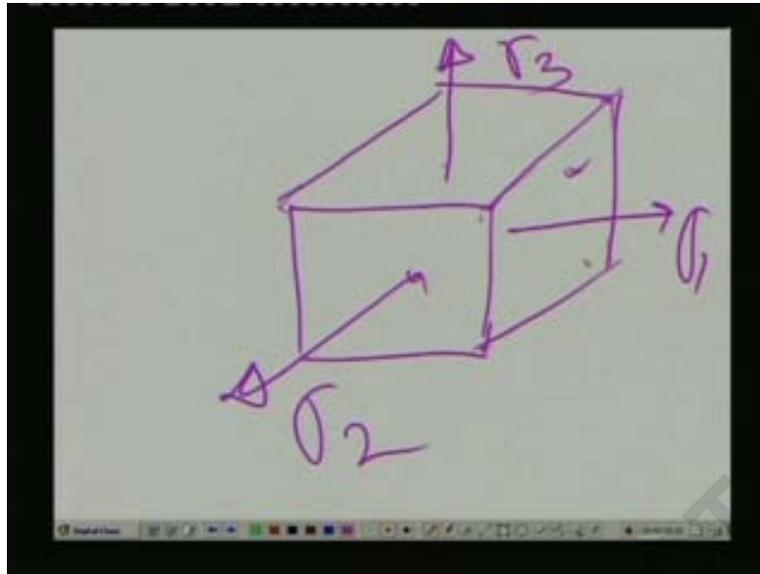
means if a material is acted upon by the principle stresses in an three dimensional conditions

that means if we consider a three dimensional case we can ah understand that ah we consider uh we will be considering something like this

so say sigma one sigma two sigma three whatever may be the load we can compute

you can see electron that is sigma one sigma two and sigma three are the principle stress onto an material for an very small (( )) (00:37:51) small cube

so in that case what is happening

that if we consider the fact then once you get this sigma one sigma two then this ((gives)) (00:38:01) a relationship which from which you can predict

and that what will be the initiation of the plastic analysis or plasticity analysis

and this you know the tensile yield point

then you ah go back to them go to about the next slide

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here also ah it is called an indentation test also which gives the ah you know the examples of plastic flow

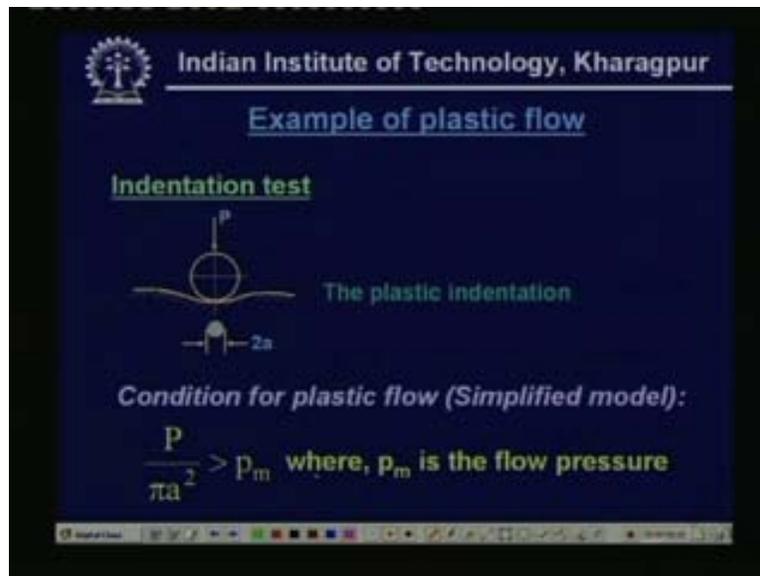if it is an {materia} (00:38:41) you can see on to a body ah some shear sort of is acted upon by the load and you will find out the deformations which is if you measure that is the deformation is something like that whose diameter is two a

then in a very simplified model one can say that condition for plastic flow

so P divided by pi a square that means P only the stress available should be greater than the Pm the the stress where Pm is the flow pressure

pressure means that unit is also having some of the stress sort of things

so this is also a condition by indentation test one can say that this is the condition for the plastic flow

how much just we understand that a stress where you you can have a plastic flow

so we uh we can understand that two situations are coming into picture that if we have the plastic flow then then you are having this ah Mises Henky criteria and also ah simple model for the plastic flow which gives P by pi a square greater than Pm that is the flow pressure

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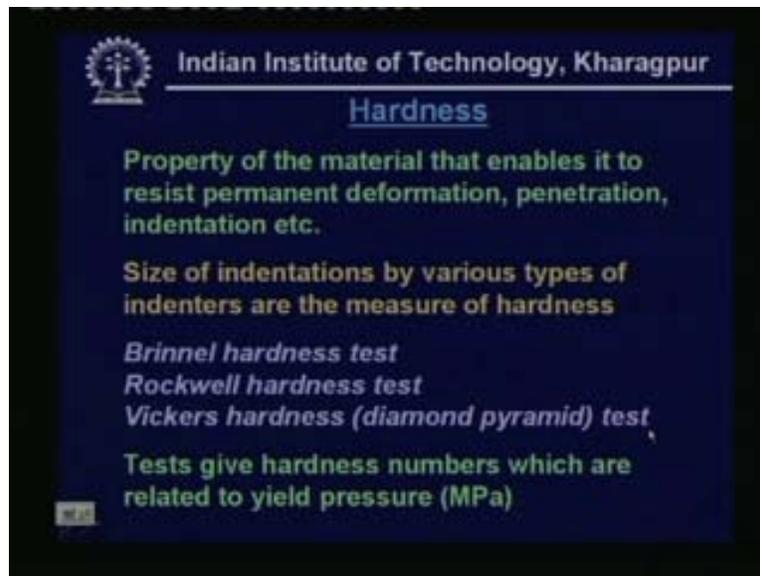
now um other important properties are one is a hardness

the property of the material that enables it to resist permanent deformation penetration indentation etcetera are called the hardness

the size of indentations by various types of indenters are the measure of hardness

you know ah this enables resistance resist permanent deformation penetration indentation etcetera

so you know the normally ah you {mi} (00:40:49) you will hearing that uh material is surface hardened and other like an word like surface harden

the situation something like comes the outer surface of a machine elements are ah exposed that means it is prone to accidental loads on coming into it

so thereby it might create an indentation penetration etcetera was just as been told to you

so ah what is a measure

the measure is primarily done through an hardness test

so if we find out the indentation ah or the penetration what is being taken up or uh what is uh what is being caused on to the machine element gives the some sort of hardness number and that hardness number is a {me} (00:41:44) is the measure of hardness of an engineering material by which the machine elements are made of

what are those tests

you know that these tests will be uh if {u} (00:41:58) if you might be doing {ors} (00:42:00) or you have done that is called Brinnel hardness test Rockwell hardness test Vickers hardness test so there is an Vickers the diamond pyramid test

so in all the cases whether it is {britel} (00:42:14) ah uh Brinnel hardness or a Rockwell hardness test or a Vickers hardness test everywhere you will be finding out that what is happening that some sort of indenters are there and the machine is applying a load onto the material to be tested through the indenter

then what we will be getting

just you have seen the um model of the plastic flow in the earlier slide

similarly you will be getting the indentation onto that material surface and by microscope or by some other means if you can find out what is the diameter of the indentation or the date of the indentation then what will you be finding out

you can find out a relative hardness numbers and those hardness numbers are the measure of hardness of a material

so the tests give hardness numbers which are related to yield pressure as we told of the yield pressure ah uh that is a that that is particularly related by some means

and uh if you do those tests then you will be learning more about how you relate the numbers to find out the hardness of a material

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ductility ah this uh is a property of the material that enables it to be drawn out or elongate to an appreciable extent before rapture occurs

now here you are once again it will be an repetitions of uh somewhat and what i earlier told you about the elastic and plastic zone if you again {con} (00:44:09) look into this type of graphs then what you can see

this is a stress strain graph we know this particular part

so in one word ductility is the property by which how much you can go to the plastic zone all right in one word i can say like that that means how we can elongate more and more elongate if we do not elongate then it is not an ductile

what is the measure of ductility

percentage elongation or percentage reduction in area before rapture of a test specimen

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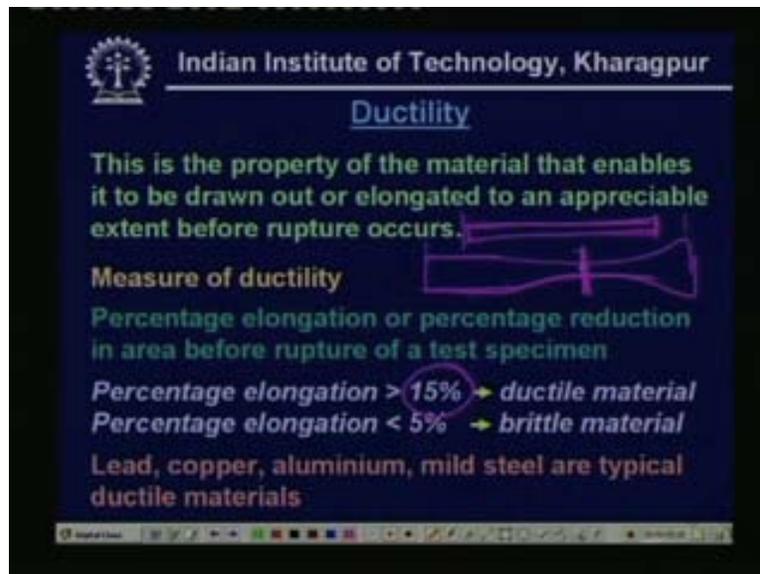
that means the ah {ss} (00:44:53) same thing is that you can have [Noise] if you take an original material if you go this is the size of the material if you take under tension test then what happens

the material will not only elongate [Noise] well it will be also thin down that is this is the reduction in area and this is the overall increase in length just a schematic view

so how much it has elongated with respect to the original specimen is called a percentage elongation

how much reduction area means the area has reduced with respect to the original area is called the percentage reduction in area

so this is called percentage in reduction in area

so somewhat these both the situations will give you an idea of an ductility of the material more the percentage elongation or percentage reduction in area more the material is ductile

now ah here ah the percentage elongation somewhat more than {fifty pe} (00:46:32) fifteen percent is ah referred to as an ductile material and percentage elongation less than five percent it is called an brittle material

so i i think we have not yet used the word brittle material the brittle means obviously it will be the opposite of ductile means it do not have the property to extend under the load means it will be suddenly failing

now lead copper aluminum mild steel are typical ah ductile materials that one use one can name about

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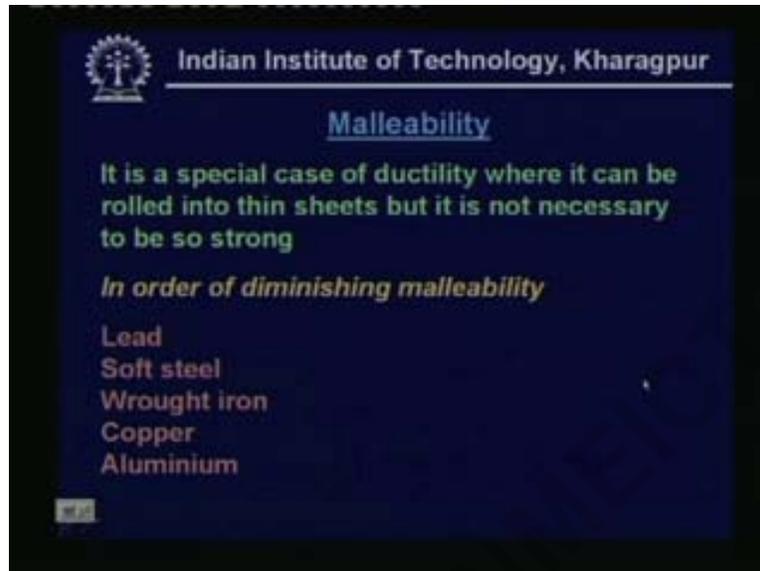
now you in a similar manner this one what we call malleability it is a special case of ductility where it can be rolled into thin sheets but it is not necessary to be strong

here is some examples of malleability that is a lead soft steel wrought iron copper aluminum so it is in the diminishing malleability that means lead is the most malleable

whereas in this range of example aluminum is the least one

and uh i think uh one of the situations you know ah the gold is a very good malleable material that's the reason a small amount of gold can be made into an beautiful ornament having a very light weight

so you require an light weight ah as an ornament otherwise the person won't feel comfortable so that's the reason you require a material uh which has {ps} (00:48:14) very small weight but it has got a good spread ability that is a called what we call as malleable

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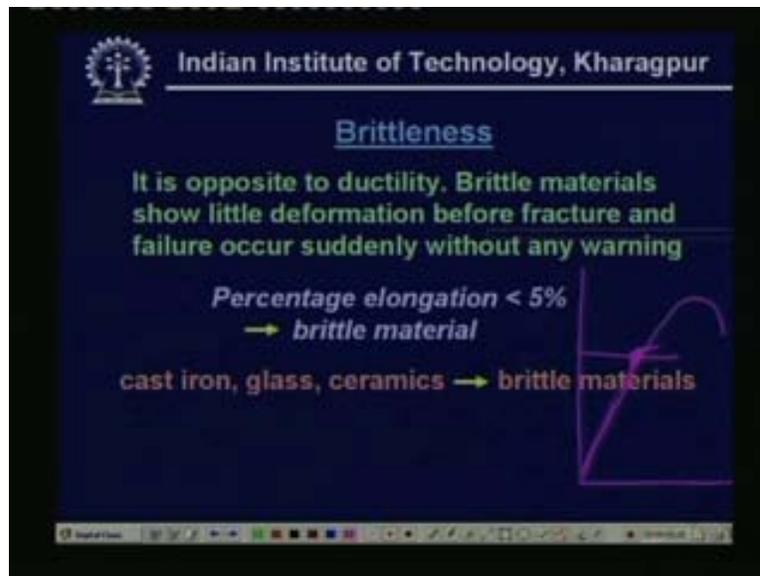
now that is the one what i just talking about is the brittleness it is opposite to ductility

so if you consider ah a cast iron then these are a very brittle materials

so ah well ah not this part okay if you consider then if you again {we} (00:48:47) i draw this particular diagram then cast iron will just go may be little up to that one majority of cast iron i should say and it will just break over here

and in general the cast irons thereby are called about the brittle materials that means these do not have any elastic i mean any property of plasticity that means {yous} (00:49:14) cannot simply elongate under the action of load

so percentage elongation when it is less than five percent it is called an brittle material as i told you and ah this definition is already uh i think i have told but let me read it out once again

it is opposite to ductility brittle materials show little deformation before fracture and failure occur suddenly without any warning

so this is a very important in ah design so the {mesh} (00:49:49) machine elements which will be normally ah taken up the shock loads or the vibrating loads should not be made of cast iron ah because it will just break without any deformation and there where it will be an kind of (( )) (00:50:06)

so cast iron glass ceramics are all these are the brittle materials which we know

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then another important property is called the resilience what is resilience

this is the property of the material that enables it to resist shock and impact by storing energy

the measure of resilience is the strain energy absorbed per unit volume

so what you can see that an idea i mean ah (( )) (00:50:49) is that what i have ah what is being drawn over here okay so it has got a linear displacement

so what is the area under the curve

half base into altitude

so we consider the once we have stretched now (( )) (00:51:10) this is up to the yield point you can stretch up to yield point above proportional limit what's this we can call half P is the load part and delta L is deformation delta L is the deformation what has been

i just plotted here is deformation so delta L will be change in the length we call the (( )) (00:51:30) this is the delta total deformation

so if it is deformation is considered as a delta L over a length L okay specimen of length L this is a specimen length then half P into delta L

so half we simplify divide by A by LA so we get is you can understand P by A is a stress and delta L by L is a strain and A into L the area of cross section gives you the volume

so if i divide it by volume then we get the half delta sigma

so this is the expression for strain in a cheaper unit volume and this sometimes is also called the coefficient of resilience

so this is the property by which you know one can um absorb the energy all right that is shock energy

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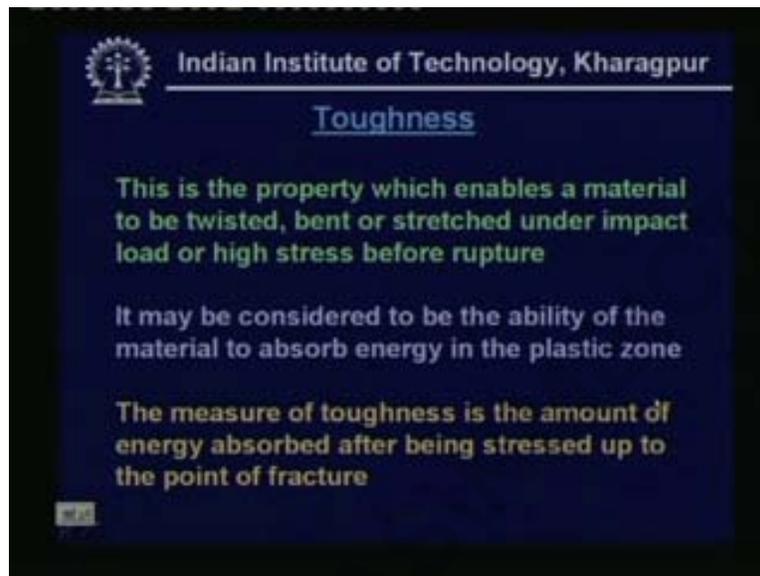
in the similar manner if we consider if we consider a material property this is also called the toughness

so toughness means this is the property which enables a material to be twisted bent or stretched under impact load or high stress before rapture

it may be considered to be the ability of the material to absorb energy in the plastic zone

the measure of toughness is the amount of energy absorbed after being stressed up to the point of fracture

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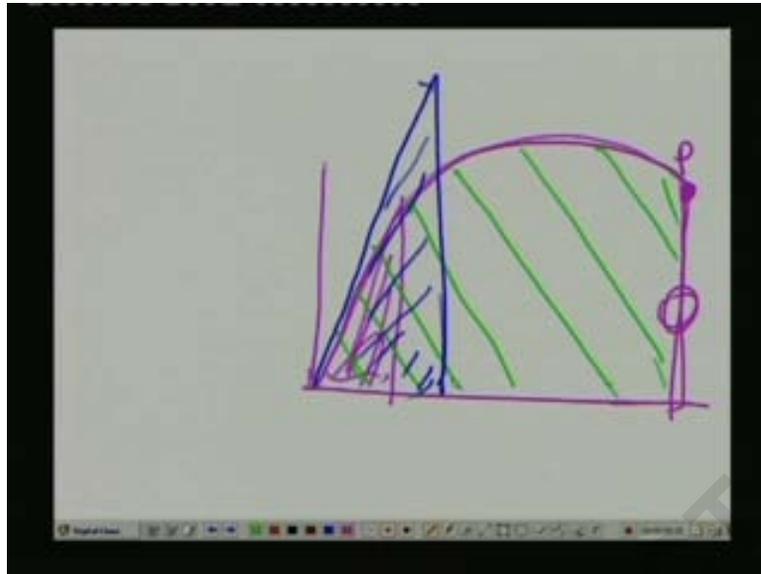
you know ah once again if i ah try to draw this aspect i have already told you say this is a strain energy

so if we talk about this energy per unit volume we consider the absorbing capacity as the word by resilience

now instead of that if we consider the entire stress strain diagram up to the point of rapture this P say point of rapture and you go up to this point and you take up the entire area all right

then this also gives you the total amount of energy absorbed and this comparison for different materials will give you the toughness of the material

say you have another material which breaks like this a typical example of something like you know brittle

it can have a go high but it suddenly breaks do not go much into the plastic zone so this is again the area for another material so if you compare this pink one and if you this is pink curve with an green shade and another one if you compare the blue curve with blue shade then this two areas gives you comparison of the toughness

now in this case how you determine the toughness you should know that the method of determining this particular toughness are by the test something like you know you know the impact test sorry this impact test which is called IZOD test which is or sorry Charpy c h a r test

like that the tests are done for the impactness of the materials which gives an idea of the toughness of the material

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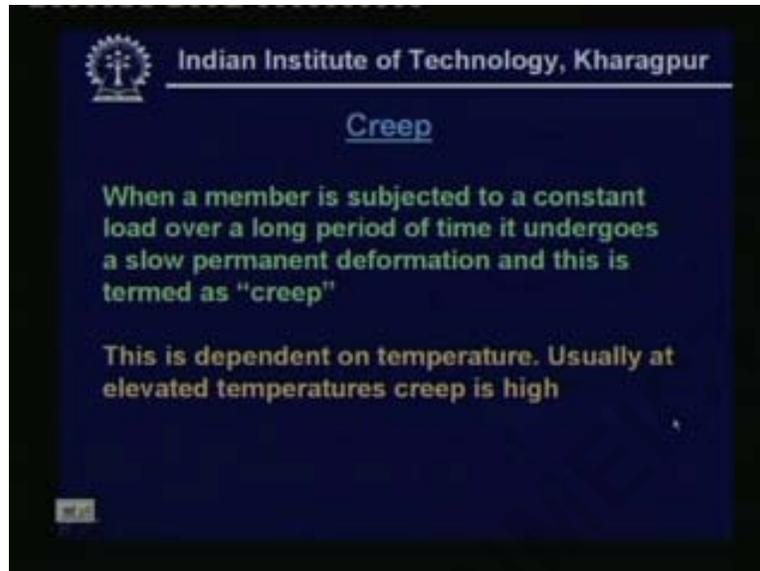
you know the other one coming out to be the creep

when a material is subjected to a constant load for a long period of time it undergoes a slow permanent deformation and this is termed as creep

now this is dependent on temperature usually at elevated temperatures creep is high so this is also a material phenomena whenever a machine design is ah machine element has to be designed for a load and temperature okay for a long period of time then you know the one has to take into consideration of the creep

so ah here we have learnt about some material properties of course one has to do some experiments on to the material properties to find out ah the actual uh ah values which is the ideal situation

means if you want to have the material properties you should do an experiment to find out its values

however ah you will be finding out in later cases that uh we do use some relationships to find out one material property from other material properties of which tensile test is the most important one which gives ah from which we can get the idea of other material properties

however one has to go for the hardness test to find out the hardness one has to go for the impact test to find out the impact strength and uh of course in this manner you can take out that i mean you can consider the {me} (00:57:21) ah engineering tests for the to find out material properties

so this ends our lecture about the common engineering materials

thank you