Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 1

Module- 09

by
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Hello and welcome to this manufacturing process technology part 1, Module 09.

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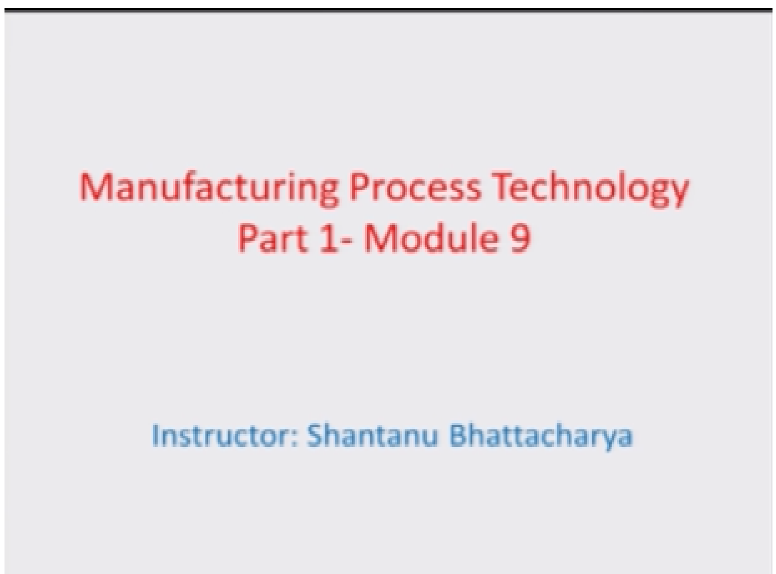

We just like to recap what we have done so far.

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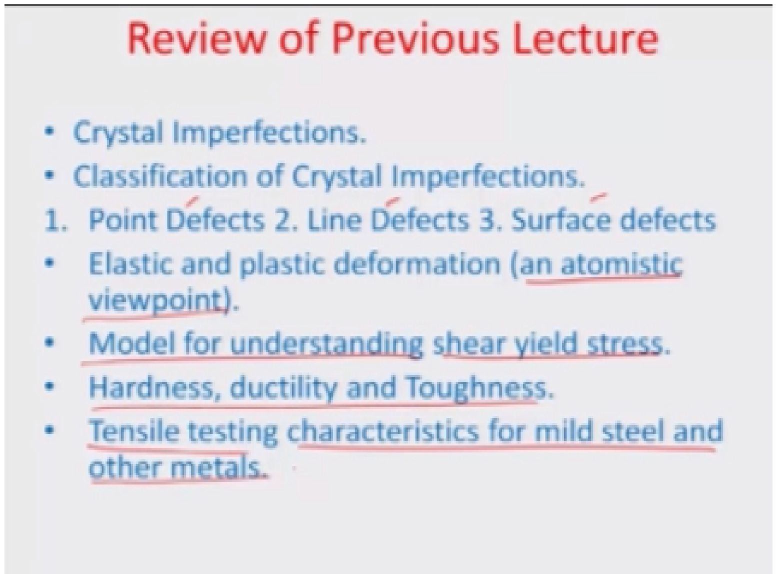

We learned about crystal imperfections we also talked about point defects for example the you know the different kind of crystal imperfections like point defects line defects, surface defects etc… we also discuss about the elastic and plastic deformation from an atomistic point view point of view by understanding at two atoms system we further considered the model for understanding shear yield stress and found that really it depends on the dislocation what is going to be the ultimate shear yield streets then talked about hardness ductility and toughness some of these parameters and also discussed in details about.

How do you do the tensile testing for mild steel and some other metals were we did models of if we try to just understand models where the behavior of the metal could be an idealized rigid plastic behavior or idealized elastic plastic behavior or as a matter of fact elastic linear strain hardened behavior so on so forth. today we are looking to going to look at another very important property which is related to all the machining.

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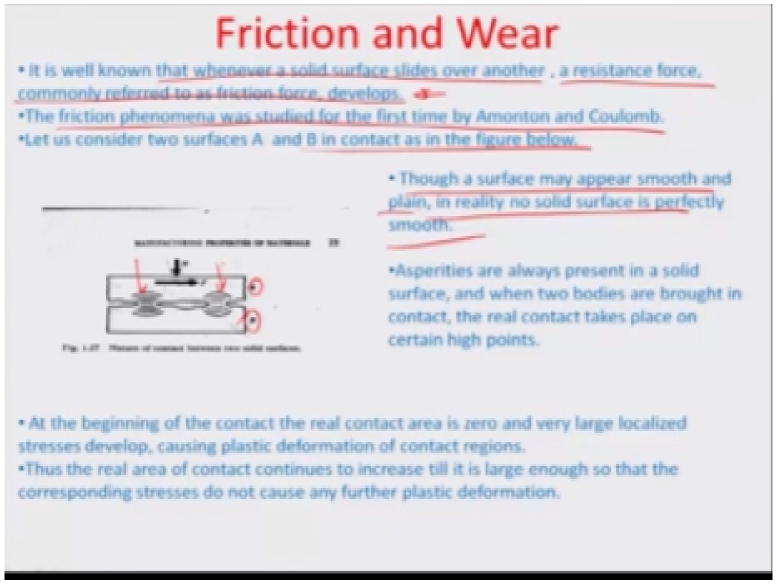

Which is called friction and wear okay so it is well know that whenever a solid surface slides over another resistance force commonly referred to as a friction force develops the friction phenomena was studied for the first time by Amonton and Coulomb let us consider these two surface for example A and B in contact as in the figure below so though a surface may appear smooth in plane really it is not so it is a you know there is no surface which can be recorded as being perfectly smooth.

There are going to be as asperities in the surface and when asperities are touch each other there are going to be some shear deformation because obviously the area of contact which happens because of an asperity touching an asperity of two surfaces which are mating each other I want to be very small and so therefore the overall you know plastics state of stress is attained very fast because of the small area, stress level goes very high and you can think of it that as the plastic stress happens the there is a some kind of a cold weld which develops between both materials and in the process of it the area increases the area of contact increases.

So these small asperities would have a smaller area but as the plastic flow starts really the you know interfacial area between two asperities which have mated they would start to increase because of the plastic deformation so these kind of build up the cold welds and these cold welds you know when you want to remove or might I mean sort of move one material over the other would have to be broken down in order for the material to have relative movement with each other on that interface and that is what really is friction.

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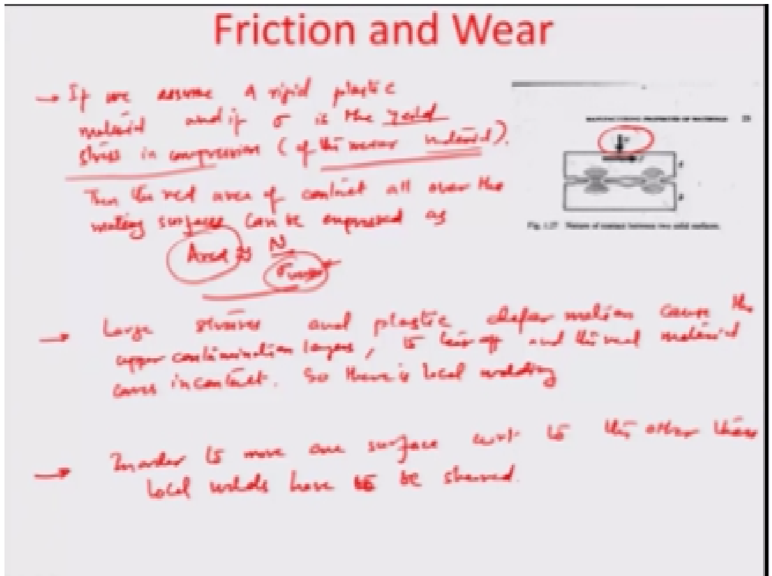

So in a nut shell if we assume a rigid plastic materials and if σ is the ultimate yield stress in compression of I can say the weaker material because obviously if the materials are same then there is no problem because they are going to be the same yield stress but supposing there is a generic model of two different materials sliding over each other then obviously the weaker material would be the one which would be talking about in terms of the yield stress of the compression which would be achieved so of the weaker materials so obviously the stronger material will try to sort of you know affect more by deforming more the weaker material.

Okay so then the real area of contact all over the mating surfaces, and can be expressed as A real which is equal to the normal force N by the σ of the weaker material so that is how you can calculate or back calculate the real area had a certain is since of time and you can assume that this particular σi is e already reached ultimate yield strength of the weaker material assuming that the weaker starts the forming faster obviously because the harder material would deform the weaker material.

And already this critical limit Y has been reached beyond which the weaker material goes into the plastic flow state so that is how the real area can be calculated so large stresses and plastic deformation or the upper contamination layers to appear of and the real material comes in contact, so there is local welding so in order to move one surface with respect to the other these local valves have to be sheared which is really what the friction force would be.

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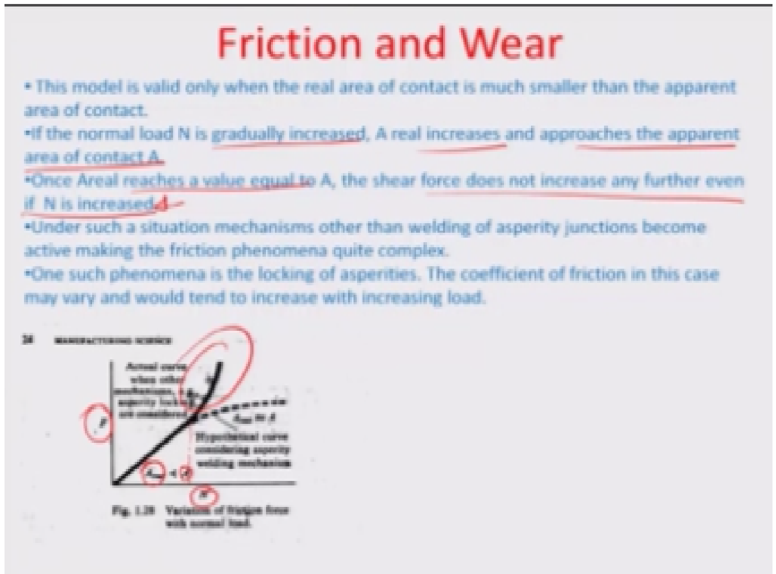

So here if we consider that τ is the yield shear stress of the weaker material then the force required top shear of a junction with a total area and let us called interfacial area because this is what the post welded situation is A real let us suppose is F = τ times of A real so this shearing force is the force of friction as we have already illustrate and obviously we defined this coefficient which is the ratio between F and N which is nothing but the τ times of A real divided by σ times of A real. So it is basically the ratio between the ultimate shear stress to the ultimate and sail stress of the weaker material.

So that is how you understand friction so the model is valid only when the real area of contact is much smaller than the apparent area of contact and if the normal load N is gradually increased.

The areal increases and approaches the apparent area of contact and areal once reaching a value equal to A the shear force does not increase any further even if the normal forces and it increase and such a situation there would be many other mechanisms which will come in to play like inter locking of the asperities is and you know may be the local welds among those inter-locking which would actually result in a lot more different condition and lot more unpredictable behavior in comparison to till and untill this phenomena of a asperity welding or this physics of us asperity welding is obeyed.

So if I really look at the variation of the normal force for a normal force corresponding you know to the force beyond which the apparent area would go higher than A real the frictional behavior is completely bizarre. And till and till you can have a situation of a asperity welding and shear deformation of the welding this kind of limit the friction obeys the normal Coulombs law of F = μ times of normal reaction N. So that is how friction can be studied, let us look at where so where is something which is when a solid slides over another.

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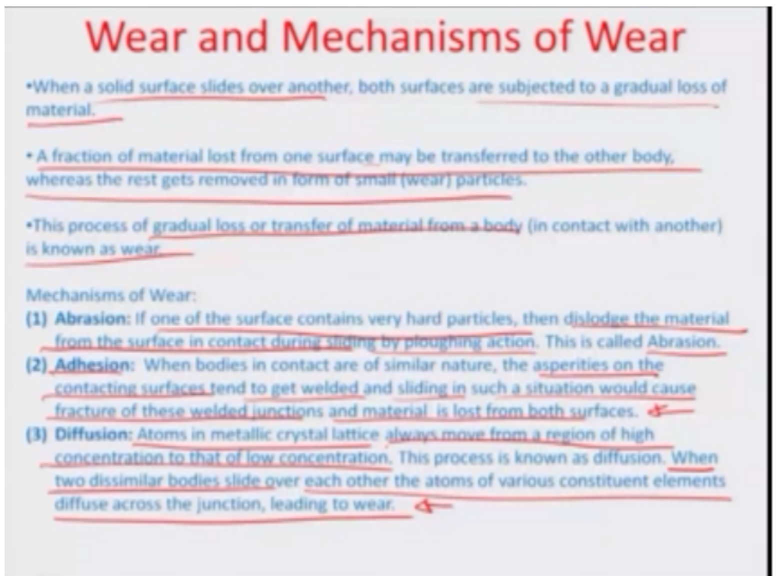

Obviously the surfaces would be subjected to a gradual loss of the material so where it suppose friction a phenomena where when we want to dislocate the or when we want to shear the local welds in the process of doing that obviously there would be a breakage of the weaker material for the flowing of the top portion or the stronger material over the weaker material.

So if there is a breakage And if there is a chunking action on the top of the weaker material because of the continuous shear force automatically the material loss would be there from the surface of the weaker material which we also known as wear. So a fraction of the material loosed from one surface may be transfer to the other body for example as we saw in the case of friction or it may just be dislodged in to the medium because there is a sort of a brittle fracture and a chipping action which happens.

So if the process is a gradual loss you know then you can call it frictional wear. So there are many mechanisms and which wear can take place abrasion is one of the mechanisms and which one of the surfaces contain very hard particles and it dislodge the materials from the surfaces in contact during sliding by ploughing action for example you can look at what happens when you use emery paper or sand paper you know different graders so there are many, many abrasive particles which are adhering to this paper.

And once you ploughing these adhesive particles or abrasive particles into this softer material it is going to break and damage and embedded material and you know take away a lot of the material this way so you dislodged some of the material from the softer materials surfaces and so we called that the softer materials is being wear because of that so that is abrasion okay.

Because of hard particles being adhesively bonded to one surface dislodging the other softer surfaces over which this surface is being rubbed the other mechanism is adhesion when the bodies come in contact are of similar nature the asperities on the contacting surface tend to get welded and sliding in such a situation would cause fracture of this welded junctions and materials is lost in both the surfaces.

So you can call it frictional wear or additional wear and there is a third type of wear which would happen because of a presence of diffusion gradient say for example if there is let us say atoms and metallic crystals always you know which represent in some concentration distribution so always there will be a movement from a region of high concentration to that of the lower concentration.

So there is going to be dC by dX set up between both the surfaces because of the higher concentrating or higher concentration metals would move to it or higher concentration of the metals would kind of balance by moving into a lower concentration region but that is actually mass transfer or mass transport and would be recorded as wear.

So when two dissimilar bodies slide over each of the other the atoms of various constituent elements diffuse across the junction just a by dC by dx concentration gradient so this can be to the wear so basically you have three different mechanisms which we have discussed one is abrasion where there is a set of abrasive particles hard enough bonded to a surface time to dislodge physically and another is adhesion where there is a let us say weaker and harder materials in contact whether is a asperities locking or asperities welding.

And then you have a forced shear so that material from the softer surface comes off and third is diffusion where there are two different kind of you know concentration of a single material which is allowing dC by dx to promote the mass transport of the material from the softer surface to the harder surface and so on so forth.

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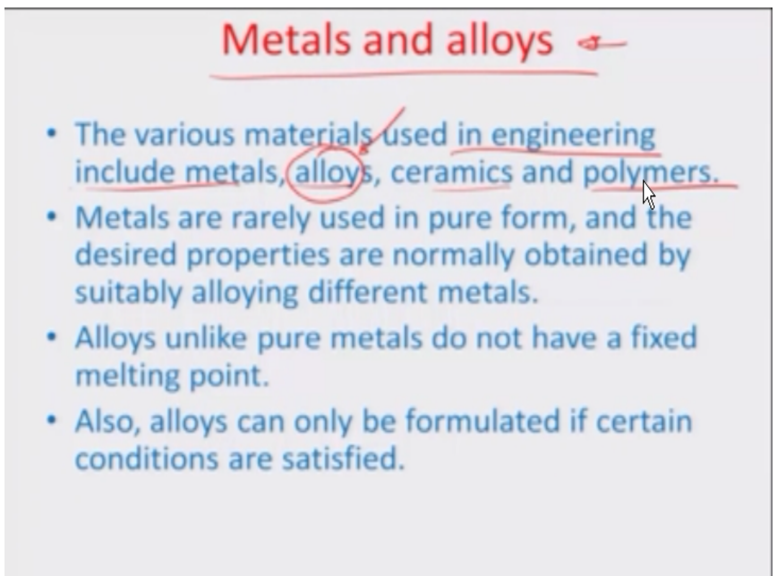

So that is wear let us know look at the metals and alloys because we want to do casting etc in a later modules and we need to understand some of these two phase or multi phase materials how there are made. So you know that various materials used in engineering today they include metals, they include alloys ceramics and polymers so on so forth.

Alloys are a major component of the engineering material because of the increased or enhance property because of the various properties brought in by two or more participating metal atoms. so in engineering applications metals are hardly used in the pure form and is always you know show about using suitably alloyed materials so that increase engineering properties can happen.

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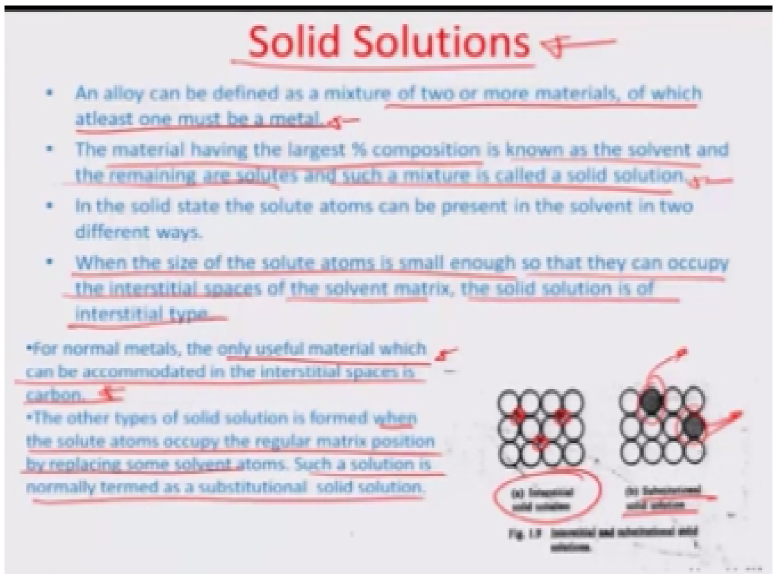

How do we formulate the alloys is a big question for that we need to decipher something called solid solutions which is basically something like you know it is the same model as liquid in a solution a liquid solution you have something which is dissolver and then there is solid right so the dissolver is also known as solvent which is in larger in bulk quantity and the solute is in probably in smaller quantity and you put the solute inside the solvent and dissolve the solvent, along with in the same manner an alloy can be defined as mixture of two or more materials of which at least one must be a metal.

So in case of for example, steel as you know the other face which is the solute in that case is the carbon okay and it is less than 2% carbon which makes a qualifier to be steel. The other part is of course the liquid metal which is the iron okay. So the material having the largest percentage composition is typically know as the solvent and remaining are solutes, so in iron carbon case the carbon is solute, iron is the solvent and such a mixture is often know as a solid solutions.

Only difference here is the room temperature is no longer would remain liquid and they would freeze up and they would formulate, organize you know poly crystal lines structure, which is the difference in this particular case. In the case of solution you have the luxury of having them in the liquid state, in the room temperature itself okay. So you can predict their behavior much more easily but once if it is solidified and complete stoppage of all the moments, over and above the dislocations carry forward.

It becomes very difficult and it becomes you know, you have to treated as one, sort of fixed structure and static structure, unless there are some associated process which come up. So when the insight of the solute atom is small enough, so that they can occupy the interstitial space to the solvent matrix, the solute solution is over the interstitial type. So you can see the interstitial occupying spaces and if supposing the solute atoms are large, so that they have does displace actually the atoms from the crystal and occupy the position, substitution type.

So in this case there are smaller, let us say carbon is much smaller, so they have a tendency to get into the interstate or the voids between the metal atom and crystal structure and in case the metal is to big it has to substitute, the parent metal in order to get into the crystal structure. So you can categorize industrial and substitution. So for the normal metals the only useful material which can be accommodated in industry is carbon, as we see in the steel and I am going to do a lot of detailing in this area.

And some other types of solid solutions is formed when the solute solution occupies regular matrix position, so such a solution is known as substitution solid solution. I would like to now sort of go and close on this particular module, but in the next module we will learn the details about these solute solutions and how they behave on temperature scale, as a function of temperature and transformation in time thank you so much.

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