Theory of Production Processes

Dr. Pradeep Kumar Jha
Department of Mechanical Engineering
Indian Institute of Technology, Roorkee

Lecture - 28
Classification of metal working processes

Welcome to the lecture on classification of metalworking processes. So, we will now start discussing about the metalworking processes, different type of metalworking processes we will analyze the mechanics of the processes, and also different aspects related to different metalworking processes. So, what is the purpose of going for metalworking that we are hopefully known to that; during casting basically you get the defects like blow holes air inclusions or so, many a times or many a times you need to have specific properties. So, what you do is you work the metal.

So, you work the metal for controlling some of its mechanical properties for us imparting certain mechanical properties which you specially desire to have. So, that is why these metalworking operations are important. So, basically metalworking processes when the term is used it means that you are giving a particular shape, a different types of shapes can be obtained using the plastic forming processes. So, you have those forming processes which results into plastic deformation. So, we know we have studied about the strains stresses generated and we know that when we talk about the plastic deformation we talk about the true stresses, true strains more specifically for the analysis of the processes or finding the stresses.

So, basically the meaning is that for controlling the mechanical properties, we use these plastic forming processes. So, this way you have improved properties like a many a cases your impurities are especially the shrinkage I mean gaseous defects or blow holes, or the air inclusions which are there inside they are welded. So, this this type of properties are improved many a times the strength is improved, ductility is improved, fracture toughness is improved. So, all these properties are improved and basically only for improving the property, we go for metalworking and also for shaping in certain cases.

So, for that also you go for, but during that process the mechanical properties usually improves so, in many ways. So, the process are basically classified on different basis like the different types of forces applied, like you sometimes you apply the compressive

forces, you apply the compressive forces or the tensile forces also and so, type of forces and bending forces or so. So different types of forces which are applied, then the temperature the temperature at which the working has to take place. So, the temperature basically if it is higher temperature then it is known as hot working or if it is lower, then it is known as cold working and if it is in between then it is known as warm working.

So, which temperature means normally it is the recrystallization temperature, which defines all these ranges. So, if the working is done above the recrystallization temperature, you go for you call it as the hot working processes. If it is done below the recrystallization temperature then we call it as the cold working processes, and if it is in between then it is you call it as warm working where you have the benefits of both hot and cold working. So, we will discuss about the different aspects of the, these you know different basis on which the different types of metalworking processes are defined.

Then you have the cases you can also define the that in certain cases you have a strain hardening taking place, in certain cases you do not have strain hardening taking place. So, that is basically in hot and cold working in hot working the strain hardening does not take place whereas, in cold working, the strain hardening takes place. So, this way you can classify the metalworking processes in different ways you can categorize them, and we will discuss one by one. So, first of all depending upon the type of forces which is applied, now the type of forces based on that which is applied you have the direct compression type forces.

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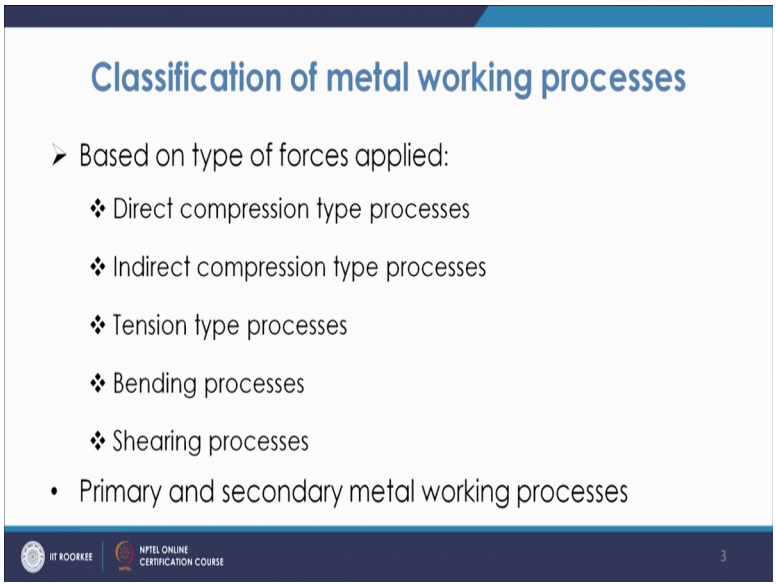

So, if you have the direct compression type forces means, the compressive stress compressive force is directly applied to the surface of the body, and in that basically the metal will flow at right angles to the direction of compression.

So, basically you have a job and you apply the compressive stress compressive forces from the top and bottom both. So, that the direction of compressive forces are suppose in vertical direction. So, metal will flow in the horizontal direction. So, that is the. So, that way we basically define these direct compression type of forces. So, the examples for this direct compression type of I mean direct compressive type processes, because you use the direct compression forces they are basically forging and rolling. So, you must be conversant with the process of forging and rolling.

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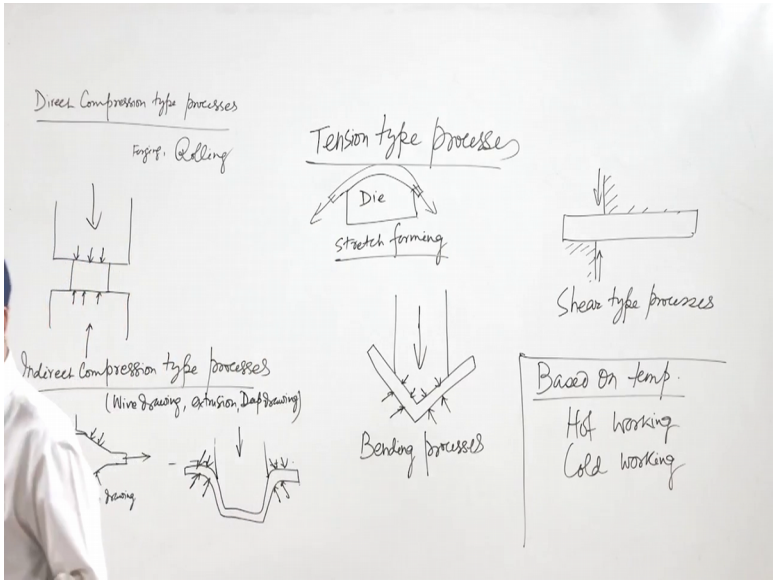

So, if you look at so, you have the direct compression type processes.

So, in that you have forging or rolling. So, in forging what we do you have a die and you have a workpiece. So, you have two dies and then you apply the direct compression on this work piece. So, your forces are applied in this case, and then the metal which is here it experiences the compressive forces from both the directions, and then it flows in the in this as well as in this direction. So, it flows and in the direction perpendicular to the direction of the force. So, this way these are the processes. So, forging and rolling are the examples of such type of direct compression type of forces, then you have the indirect compression type forces.

Now, what happens indirect compression type of forces the examples are like wire drawing tube drawing rod drawing or so. So these are the types of examples of indirect compression type of processes. So, basically in these cases the primary applied forces are normally tensile, but the indirect compressive type of you know forces, they are developed because of the reaction of workpiece with the die, and that reaches very high values. So, that is why it is known as indirect compression type because you apply primarily the tensile type of forces, but then the compressive stresses which are developed at the die and you know the job interface there. So, it gives the stress value which is quite higher and then material plastically flows.

So, basically because of this reaction, you have a complex state of stress acting in such cases and then you have basically quite a high value of compressive stress in one of the principal directions. So, because of that you have the flow of material in those directions. So, basically you have the examples like wire drawing or you have the extrusion or you have deep drawing these are the examples of these direct compression type indirect compression type of processes.

So, you have indirect compression type processes. So, in that suppose what you do is if you take the example of wire drawing, what you see is that you have the rod of larger diameter on this side and from this side you basically open it, and then you have a die conical die which is no stopping it, and it which is basically giving the constraint it to flow through a very small orifice.

So, that way this wire is drawn. So, basically you are applying directly primarily the tensile force, but then at this point where it comes to wants to come out at there because of the reaction, you have the compressive stresses reached and at that point you have the compressive state of a stress. So, because of that basically your. So, basically what happens you have such type of you know in the case of wire drawing. So, you have here, here you are. So, you are basically. So, you are what you do is, you apply this tensile forces and then you are basically once you apply the tensile forces, in that case here because of this constraint you are these in indirect compressive stresses are developed at this interface and that is how they result into this smaller wire diameter.

So, this is known as wire drawing. Similarly you must have seen the process of extrusion; in the process of extrusion what you do is you apply the force and then it goes out, but then there is compressive stresses developed on the sides. So, this way because of that compressive state of a stress as well as you are applying the force. So, there is tensile stresses developed tensile forces develop at the exit, then because of these combined or complex state of stresses, the material flows through the die opening. So, that is known as extrusion.

Similarly, you have. So, here in that case you have wire drawing extrusion bending. These are the example of these indirect type compression type processes similarly you are bending. So, what you see in bending. So, you have basically the, you know no this is not bending basically you have this deep drawing not bending, bending you have a

separate kind of separate classification. So, you have that deep drawing. So, in the deep drawing what you see is that, you have a cup shaped product you are making by deep drawing, but then in that case the height up to which you are basically going for that is larger. So, you apply the forces in that case and then add these from both these sides basically.

So, what happens? So, you have like this. So, this is height becomes quite you know larger and what you do is you apply the forces and then the reaction forces develop on the size. So, here basically you are giving some constraint you are having some here also some weight and or so, so what happens you have stresses which are generated here. So, because of that the material flows. So, here you have plastic deformation taking place and then metal takes this shape, under the application of this you know force.

So, this type of methods because you are applying one force here in this direction it goes. So, they are the examples of indirect compression type forces, then the next kind of processes are the tension type of processes. So, you apply the tensile forces basically, and here the example is stretch forming. So, basically what you do is that you have a form block you put the seat and then you apply this tensile force from both the sides. So, what happens because of the tensile forces. So, you have supposed a form block. So, like that you have the form block and then your seat will be like this. So, your seat will be like this, and then you apply the forces like this.

So, once you apply the forces. So, you have this as the. So, it will go like this and then you apply these forces and then. So, this way is the stretches. So, basically this stretch forming this is known as a stretch forming. So, basically depending upon this the shape of the form block or the die you can say here in this case this is a die, when we use this in the case of using the lathe or. So, then we call it as the form block, but then this is a die. So, you are giving that seat and then you are applying these tensile forces from both the sides, and basically depending upon the shape that that will be stretched on both the sides that is known as stress forming.

So, this is the use of the tension type processes. So, this is under tension type processes. So, in that your this process comes out, now you have the next example is bending. Now in the bending basically you this involves the application of bending moments or to the seats. So, you have the seat and you apply the bending moment. So, that it comes and

takes the. So, bends from both the directions. So, that way you get a bent specimen. So, you have a specimen like this. So, before that you have a tool and then this tool has such shape and then it applies the pressure in this direction.

So, once it applies the pressure in this direction, you see that you have the forces or stresses acting and that under the action of these stresses basically. So, it will do like this and then you will get to see that the takes into this form. So, this is the application of bending process, then next is the shearing process. Now in the case of shearing process what we do is you have the shearing action taking place. So, you will have on one side you have. So, normally you have a plate which is to be sheared, then you have a blade from the top and from the bottom and then because of the action of shear forces the plate is cut or so, it will rupture the metal in the plane of shear.

So, that way it will the metal will be ruptured and the shearing action takes place. So, suppose you have the plane plate. So, you have one and here. So, one plane is here and another plane is here. So, it will rupture this. So, you it will apply the pressure in this direction it will apply the pressure in the opposite direction, and then it will do the shearing. So, that way shear type of processes work. So, this is shearing. So, shear type processes. So, shearing action takes place in those cases. So, this is the based on the different types of processes, which are basically applied and then you can see you have these different kinds of processes. Further they can also be classified based on the primary and secondary metalworking processes.

So, many a times we call this term as primary metal a metalworking processes or we also call it as processing, and then you have a secondary metalworking processes which is co known as fabrication. So, basically when you are the reducing the maximum of the deformation you are putting on the material, when you make the ingot and you have to further convert to slab or billets or so, then in that case the deformation rate is quite high at that time your primary aim is to deform to give large and large reduction to the dimension of this specimen.

So, basically and then you are basically converting to simple sail shapes like plates bars or so, so that kind of processes are known as the primary metalworking processes, and when we talk about giving the final shape or finishing then that is known as the secondary metalworking processes.

So, basically all your so, that that is also known as fabrication, so, all the sheet metal operations they come under such cases wire drawing or tube drawing these are basically the these secondary metalworking processes where basically that those processes are done after the primary of operations are done. So, that is for final you know getting the final product the finally, finish finished product is used. So, that is known as secondary metalworking processes. Now another classification which is done for the metalworking processes as we discussed that it may be based on the temperature.

So, based on temperature we normally categorize them as either hot working, hot working or cold working. So, based on temperature so, you have hot working and cold working. Now there is basic difference between these two, the hot working refers to those processes where the working is carried out at a temperature which is above the recrystallization temperature. So, in this case the degree of deformation possible is more because as the temperature is more, less flow stress is required to do the deformation plastic deformation.

So, in that case because the essential difference between these two is that in this case of hot working the recovery takes place simultaneously. So, material does not strain harden and that is why you do not require as long that is it temperature is above the recrystallization temperature, the flow stress requirement is not very high. So, this is the basic trait of the hot working processes and all the primary working processes, which we discussed where we intend to bring initially the material to a simple shape or the degree of deformation is somewhat larger. In those cases the hot working is preferred and depending upon the type of process you apply, I mean type of a specific processes like if the forging is done at a temperature above the recrystallization temperature, then it is hot forging.

Similarly if it is done below the recrystallization temperature it is known as cold forging. Now this temperature what is the recrystallization temperature, this temperature is somewhere close to 0.5 to 6 or 0.7 multiplied by the melting temperature of the body. So, the material. So, that will be normally the hot working. So, for certain materials very high temperature may be the hot working. So, for certain materials like tungsten which has a very high melting point very large will be the hot mode temperature hot working temperature range whereas, for certain materials even the room at room temperature or somewhat only some high temperature may be the condition for hot working.

So, like that. So, it depends upon the melting temperature of the material. The in the cold working what happens if the temperature is less it is done normally for the finishing operations and also giving the strength. So, in these cases what happens, the material is deformed and the plastic deformation takes place and during that basically the strain hardening takes place. So, as the strain hardening takes place slowly the flow stress requirement for the further reduction in the cross section is increasing continuously. So, that is why there will be a limiting extent, there will be a limit up to which you can cold work the material. So, after that the when the stress you know value reaches quite high that material may fail if you are still try to cold work.

So, there is basically a limit up to which so, that is why when we have to see the cases where you have not to deform the material to higher degree of reduction, in those cases the cold working has to be done also the temperature will tell that whether it is to be hot world or cold world. So, for the material which is ductile you can be hot world or it can be worked even at lower temperatures, but then even as we discussed that many a times the temperature also tells that there will be a temperature, at which some when better materials will try to behave as the soft material. So, ductile materials only because of the temperature.

So, the that is the different aspect, but then there are other aspect of hot working and cold working, that in the hot working the challenge is to have the surface finish. So, because you have the working at a very high temperature so, there are rest form I mean oxide formation at the surface because at the high temperature you have quite high reactivity. So, you have the chances of oxide formation at the surface, but then in that case that problem is not there in the case of cold working. So, this is how they are basically categorized, then again the based on the strain rate. So, you may have the strain rate, you have sometimes very large very large velocity the working goes on. So, that way time velocity will be quite larger. So, you have normal processes which some processes with like H E R F is there where very high at high very very high velocity this very rate the deformation takes place.

So, that also is one of the parameter that basically classifies the different types of metalworking processes. Now the thing is that when we talk about these processes, then we are basically I mean thinking of a zone in which basically this deformation takes place. So, when the deformation has to take place, you have to see that there should not

be local fracture or something you know at certain condition you will have the failure starts or the deformation starts. So, you may have a specific conditions, but then there are certain things, which need to be seen and now we are focusing basically on the zone where the deformation takes place.

So, that is how you have a deformation zone. So, when the force is applied by the dies on the surface of the material, in that case what happens you have a zone which is in contact with the die. Now what happens that, you have the die which applies the pressure on the job. So, if you look at a typical deformation process.

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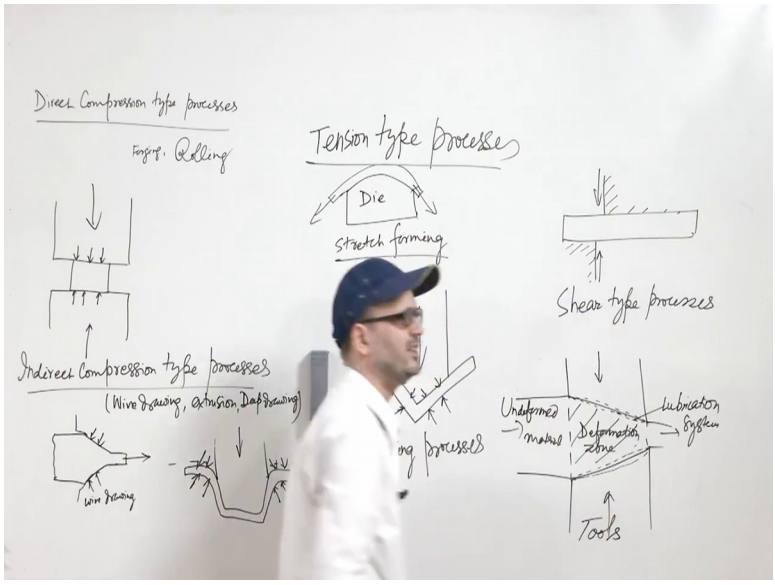

So, suppose you have a similar type of such type of die, now in this case if you have. So, you have suppose one this and which goes like this, now suppose in this case here you have one envelop forming, and then you have these are the dies which apply the pressure and this is going.

Now, this zone which is there which is in between the die, this is known as the deformation zone. Now what is this deformation zone the zone where this deformation processes take place where the deformation process takes place that is basically the deformation zone. You have this area as the where the lubrication takes place and there will be movement of the, this take place. So, you have this as lubrication system. So, you have the, because your must be. So, you will have the friction acting there, and then that basically will assist. So, even friction also which acts here, that also helps in getting the

deformation here, here you will have the frictional forces because of which this will go into this cavity.

So, this is the basically principle of the some of the operations like rolling operations. Now from this side this is your undeformed material and then after deformation this is the deformation zone and then this is the deformed material which is going out. So, basically these are known as the deformation zone, now you have friction acting there at in this system, you have the tool and die. So, what happens we must know that what is this deformation zone, and you have to view the whole system as the total system. So, so coming to this point where we see and that you have the as we discussed that you have many parameters which talk about which must be kept in mind, while discussing about the, this situations.

Like you have the strain rate, you have basically the distribution of stresses, all these are important to see that how the performances the processes performed. So, that is what about these deformation mean processing of this particular. So, this map which talks about that tells like deformation processing. So, this when we talk about all these aspects into account, and we have the graph we have the picture of all the things, the effect of all the parameters in a well organized matter manner then they are known as deformation processing. So, this process is known as deformation processing. So, in that basically it is assumed or it is thought to be useful that the stresses should not create any local yielding ok.

So, we assume that the stresses must not create any local yielding, yielding has to take place, but then local yielding should not be there and the strain hardening and recrystallization and fracture, these are the important you know part of this deformation processing. But then they are basically discussed when you have specialized condition of high strain rate and or high temperature. So, what happens that the workpiece is basically in contact with these nondeforming tools, as we see you have these tools this is these are the tools.

So, these tools are in contact with I mean the work species in contact with these you know tools which are nondeformable. So, lot of things are going on at this interface, you have heat transfer going on, you have friction which is working. So, all these are to be basically understood and what is the mechanism so, to understand the whole process. So,

this is basically known as deformation processing when we discuss about this basically as a whole we call as deformation processing. So, you have the deformation processing maps, different types of graphs, different types of you know parametric analysis and all that. So, they are known as deformation processing maps or so. So this is all about the classification of metalworking processes.

Thank you very much.