Enclosure Design of Electronics Equipment
Prof. N V Chalapathi Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture - 22
What can be done in the lab Bending

So allow me to continue from where I left off last time. If you remember we went out into the work shop and we are trying to fabricate this space.

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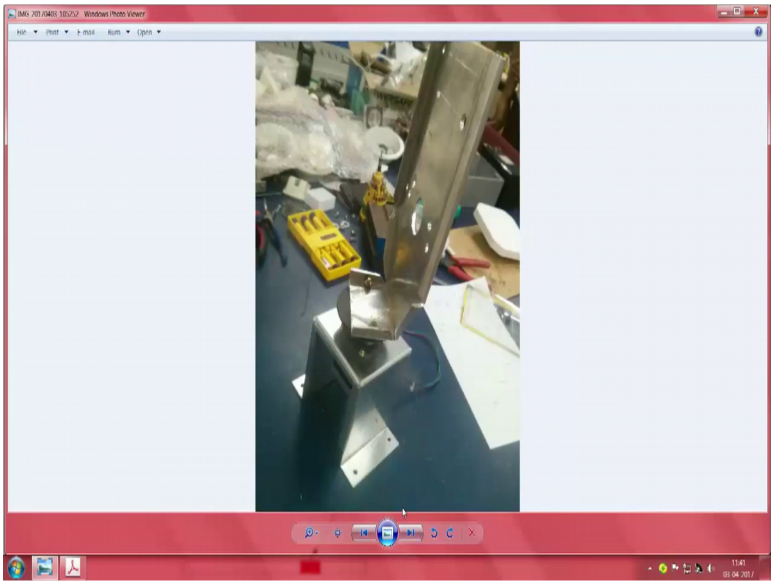

This space was; we see a little carefully bottom part of a antenna assembly. So, I have here this is the one the day in the in our fabrication show of my colleague try to fabricate it and show you.

This is the a real piece. Part of it in the real piece what you see is you see here on the corners here this is the small this thing this one we saw here and then this small step here is intended because of the sheet metal that machine what we they have there. We have a folding machine which has clapping fingers and then the bottom job part of it there is a limitation about the depth width which we can go, hence this cut out has necessitated when we tried it last time.

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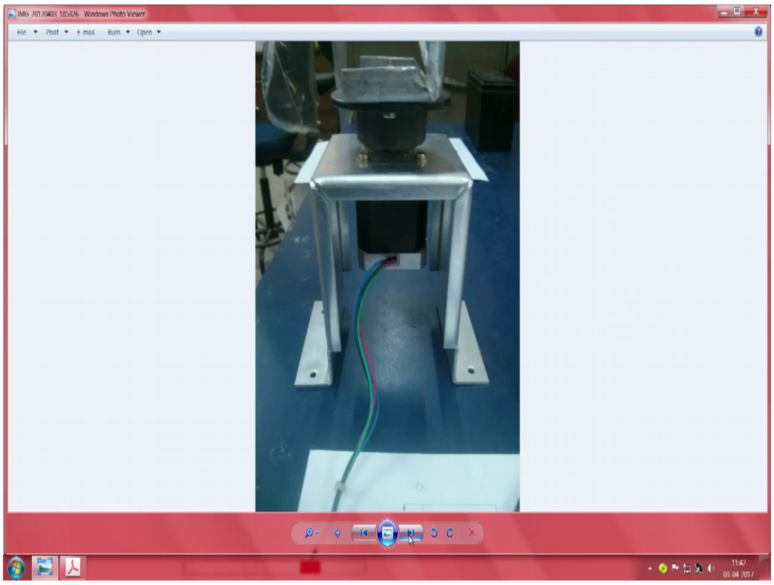

So, eventually the piece looked a little like this, but you see it is not as clean and as flush and natural as it looks; however, in real life it is expected when these things are delivered to you and then especially if you are a consumer or not an industrial consumer. All these small imperfections have to be accounted for when you make the design, and now if you go to the top portion of this. See here it did not come out to well for some reason somebody could not properly account for all those small imperfections which are likely take place in the case of the fabrication there, have you seen it little issue with it.

There is a reason why we expect engineers to start their work to be familiar with fabrication process. This whole thing was cut out on a 90 degree notching tool and then we attempted to bend it, it turns out that it is not a 90 degree bend there are some other issues with it hence you ended up with what look like obvious flaws in the design. These are not necessary flaws in the design it is just that they all have been adjusted at the constraints in production, which are specific to the machine, specific to the various conditions of bending and so on.

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So, you have further drawings here I think I showed you this drawing already, seeing here right from the front we have a small flange here there is a motor and then it is part of some antenna or something which needs to be rotated and so on.

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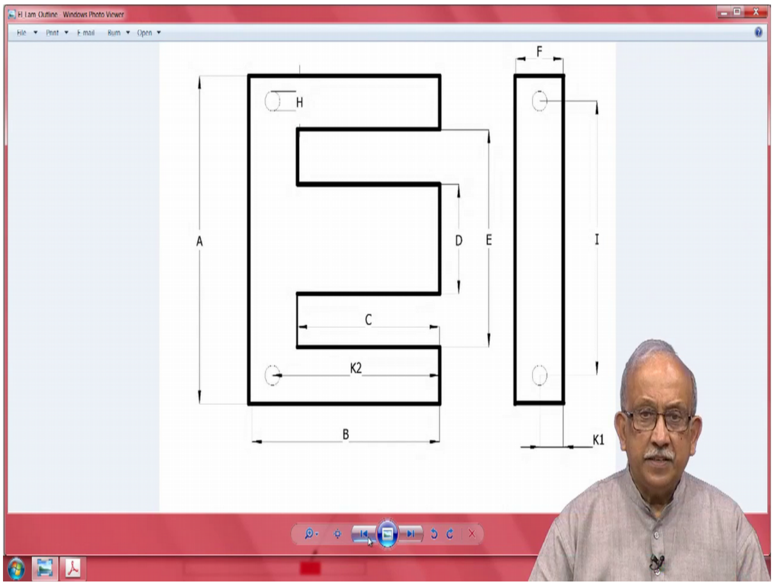

I will stop here now I will take you to a very familiar electronic object you are likely to see this one is called a EI lamination because; obviously, because of the shape. Typically the proportions have been. So, adjusted that if this is an E and then grains are in this direction. See you know they are flowing in our drawing you know left to right or from this and imagine this small thing what you call this I portion of it can be cut out off this portion then these also will be in the same line.

So, we if you were to make a transformer, a majority of the lines that they what you call magnetic lines of force will follow the grains and miraculously the total material wastage is small. So, generally it is expected that this total height you have here a and then if you take this C. If somehow you make A twice as much as C and then you have 2 Es facing each other in one stamping which is 2 times B and 1 times A and then it is a strip A times wide and then B times and their long strip.

So, possible for us to have a 0 waste lamination, so, 2 times B we will have 2 Es and then this I have told you if you can somehow make C has half of A, you will end up with a beautiful I portion of it also. This is how typically optimization is done in the tools such are used for this in this case it is probably made with a die a stamping die. So, you have a progressive blanking and die where this strip is mode continuously and then all the time the operations take place and in the end you have a beautiful stack of nice see laminations like this I have a beautiful stack.

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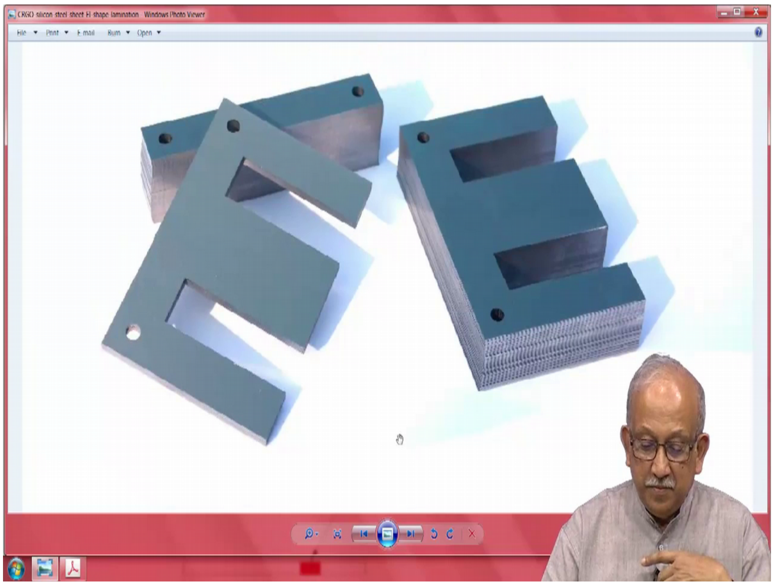

Now if you see here and then maybe if you observe carefully the proportions have been. So, adjusted that this E and I can probably be made from here or the I punched out here can be used in the next lower size of the lamination.

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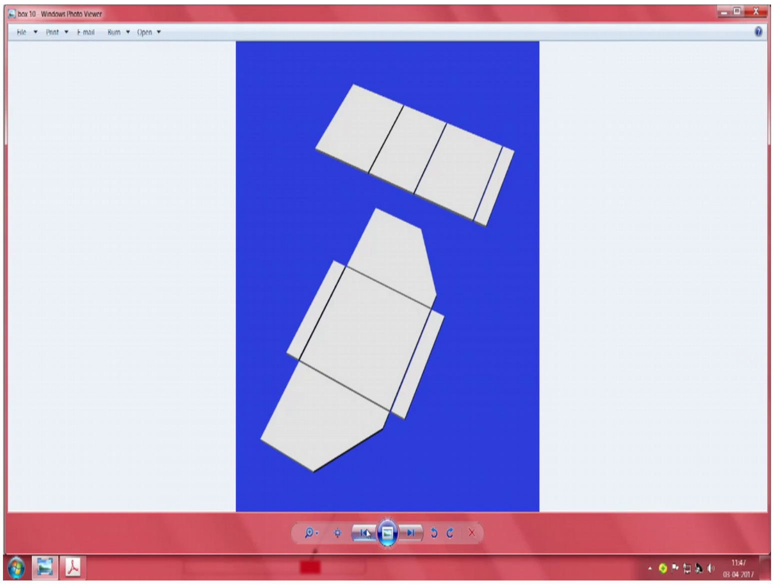

This lecturer is not about how to optimize the I laminations, more about how to make our own sheet metal work after you are aware of various operations and this. Now I would like to get back to one of my small box likes things which I started with.

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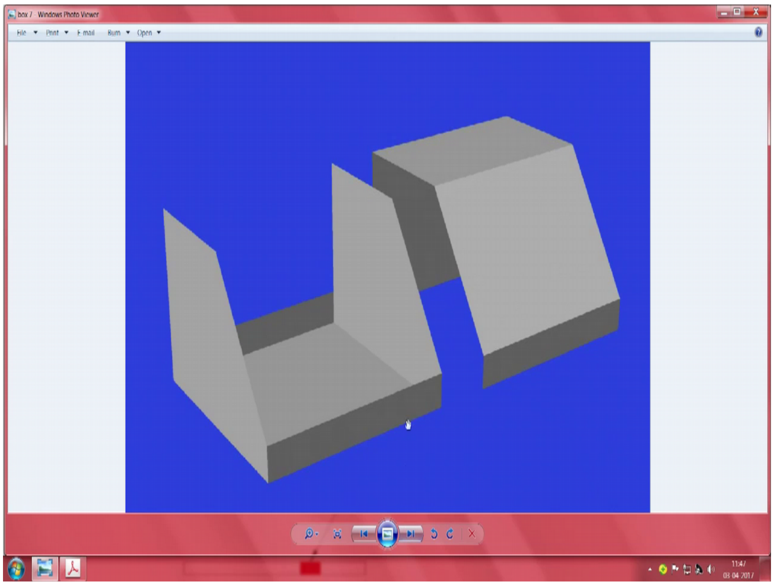

If you remember this is the picture I was trying to show you all the time can you see it now? You can see there is a bottom a chassis part of it then there is a top cover of it.

So, all the dimensions are known and then in one of the earlier drawings I have also showed you how to make sure that the top and bottom fits. However, this one the picture you see is the thickness they are all planes in space. Now in reality you cannot really have an object which has 0 spacing I am sorry 0 thickness and between the top cover and this if you take the outside dimensions of these 2 limbs, and then they have to coincide with the inside dimensions of this.

So, whatever thickness you have you still have a small prot of portion similarly if you go up now little close, up close this portion here in the corner very conveniently they are just sitting together occupying the same space 2 edges hum we have an edge here and then left side also we have an edge here. So, when these things occupy like these you end up with a real problem.

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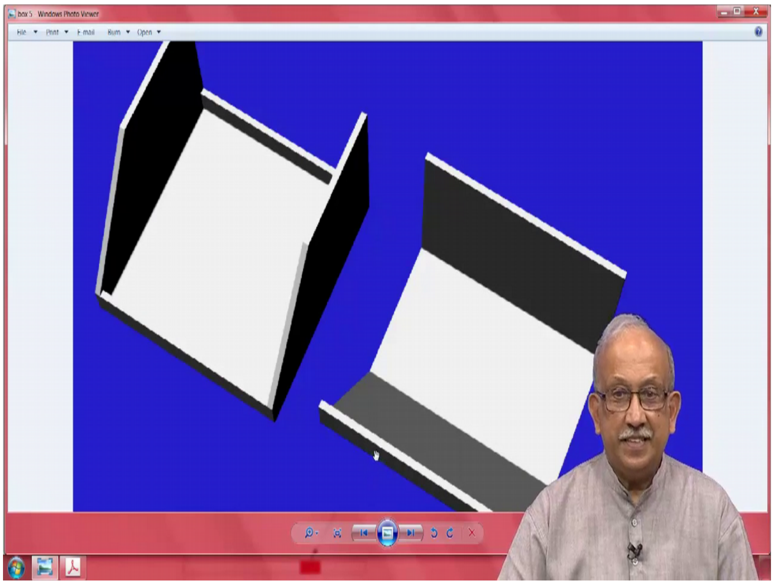

Now, imagine for clarification I would turned it over. So, that you can see how the bending take place and all that, but the real life object you know is likely to be thick there is a thickness associated with it now you see the moment that thickness comes if you have the assumptions we have made may not be very valid see here see this corner.

Similarly, if you go down you see this corner also, but this corner is a little more visible. So, I will take you to this corner. 2 or 3 small things have happened one of them is it possible to fabricate a piece like this where the internal dimension from here to here it should be exactly equivalent to the limb dimension here 2 issues are there one is if we take that this cover is overlapping. On the other I think the next picture shows you those things. See if it is overlapping like this you need very carefully calculate various dimensions here.

Now, already I have made a small jump here have a noticed while this one is a sheet metal enclosure with only a thickness, but in real life when you want to carry out bending as we have seen in the that demonstration down Sayers have you seen here a radius is there that involves 2 radiuses. One is an internal radius of that tool when we tried to do the bending on the bending press or the break and then the sheet thickness itself.

So, typically depending on the constraints and depending on the behaviour of the material, at least 0.5 millimeter internal radius is preferred unless the sheets are very thin in that case it can be proportionately smaller typically a rule can be what you call rule of them can be at least it should be one fourth of the thickness of the material.

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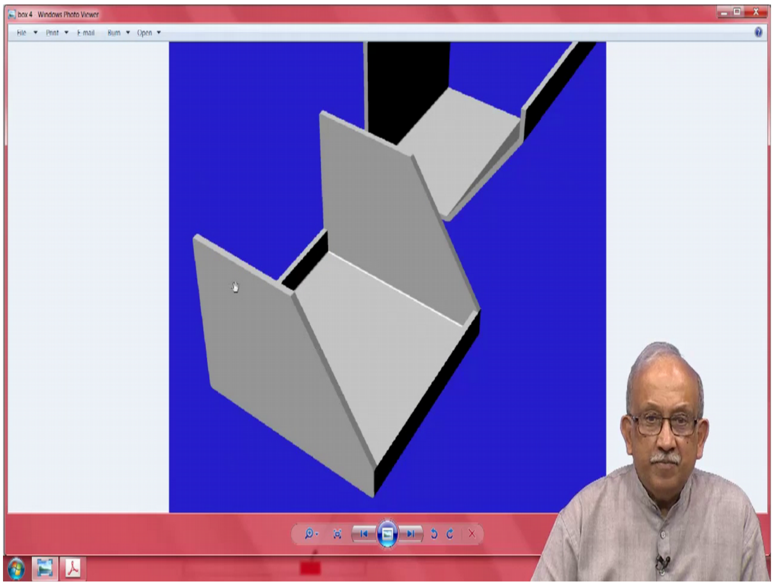

So, going by that if this is a 1.6 mm material this can be around 0.6 I am sorry 0.4 millimeter. So, then after that you have a outside bending. Now we will come to this corner of this have you seen here again; again there is a bending here which may or may not be required; however, this bend corresponds to this bend here of this top cover why this is required because after you finish you should fit neatly one over the other.

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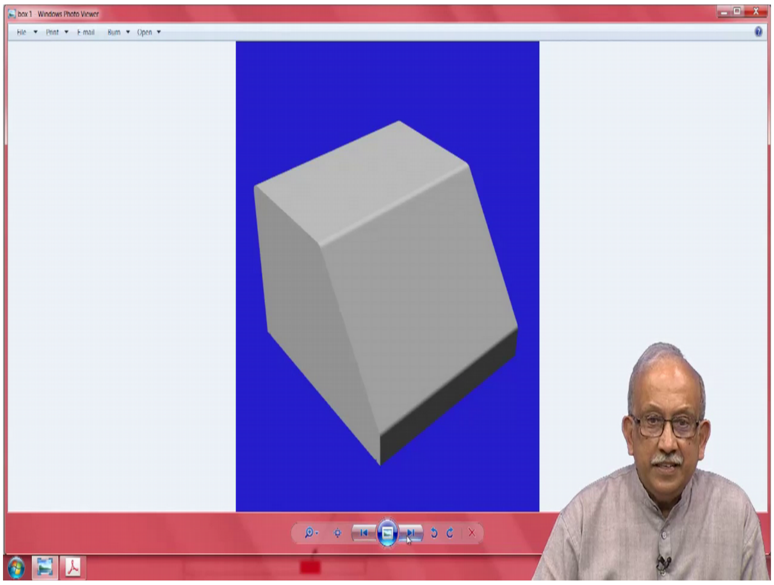

if you have a clarity of your concept now, you see they appear to fit quite close. So, you have in this corner I have an internal bending radius which is dependent on a little on the machinery we have in the tools we have, plus something which is related to the external bending the thickness of the whole thing.

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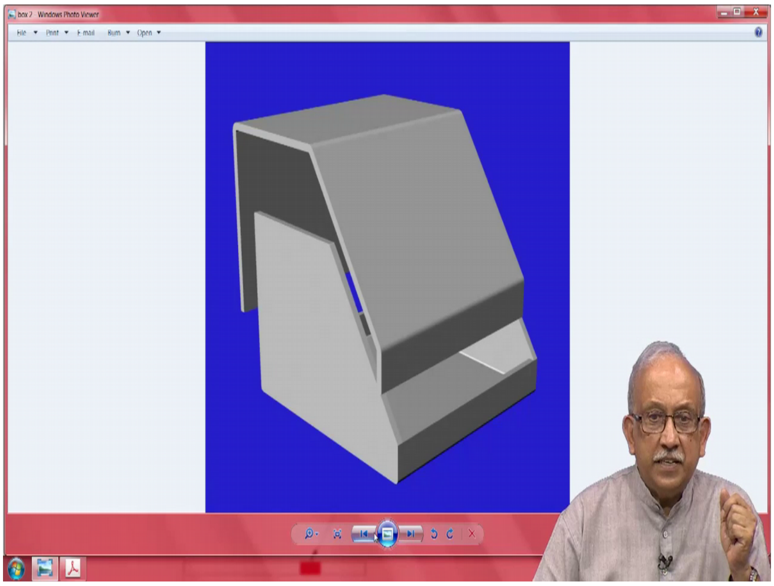

Now, together if you now place them they seem to fit nicely absolutely no issue about it at all have a beautiful box here, seen that it seems it fits and now coming back to the old demonstration again, it looks nice, but then anything you have any front panel you have here all these things must be done before the operation, that is in the flat condition.

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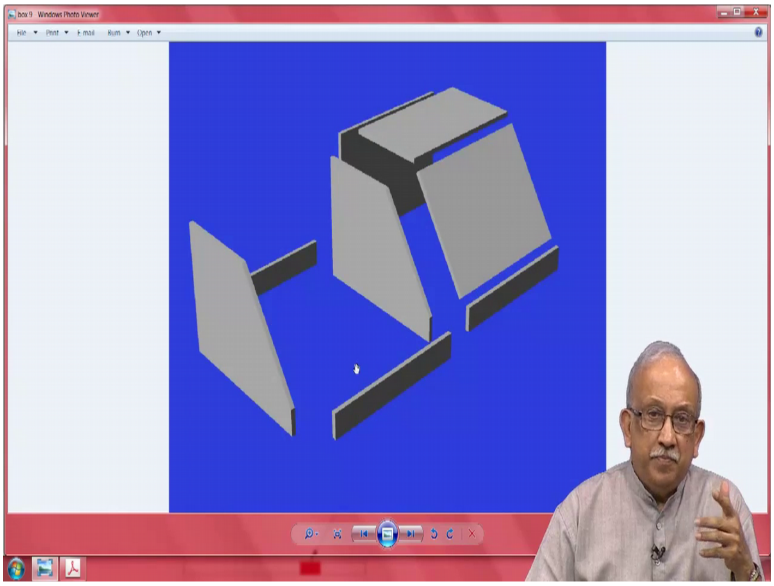

So, generally what is done here is, we try find out the actual panels of what fits where inside this is where all the thickness compensation and all will be there and then eventually try to lay them out flat. You see there is a small gap here can you see here in the corner there is a small gap this is not meeting here, this is not meeting here. So, here you know first time we end up with trying to work around or make proper blank or sheet metal calculations. Why this is important is you will notice that any errors or anything any decisions taken at the top are likely to effect the bottom. They were little familiar with it chances of their failing will be small; something again very much related to this is if you interact directly with your fabricator, he will explain these things for you and then you will notice is this probably you want to have some mounting holes you can have a standoff and then you required some holes for taking various nuts and bolts and all that. So, I have go out we finally, have a tolerable neatly done enclosure, but here again you notice here we talked about a spring back.

So, when you want that spring back this you needs to bend in a little. So, it can come out and in this corner you need a small gap here to ensure that we bend in take place without any problem understood you know. So, in the corner a small notch is required usually these are all details which are to be done by the fabricator, but then it is still useful for you if you can follow these things.

While it looks so good in a 3 D rendered drawing realities this. Reality is you see here what the thickness is started and then it does not close as well as you want especially if the materials are little thicker than what we are looking for.

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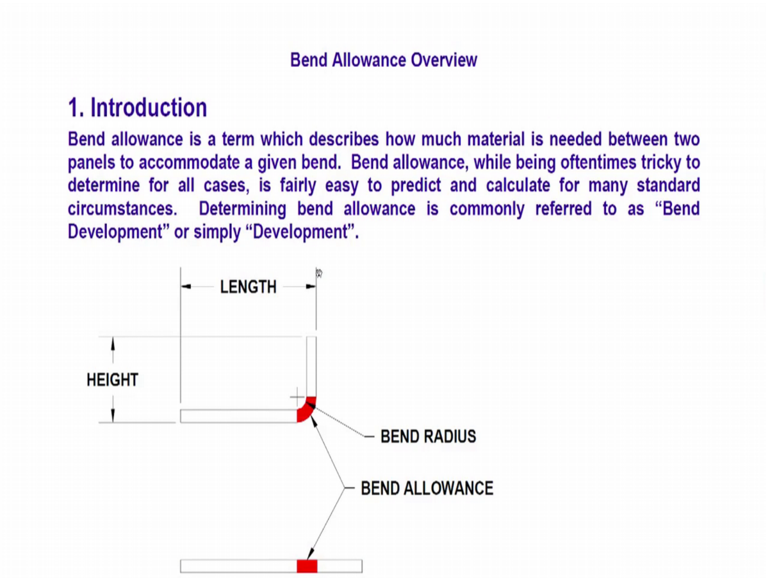

So, at this point I would like to draw your attention to what is called bending allowance and overview. I have 3 files here and one of these files the person who has uploaded he has given a open licence saying you are welcome to use it, but then in the original condition. So, at the end of it, it comes here and this is old; it is nothing new and then very very very important thing is it has to be tried out and its very specific to the conditions of the raw material, conditions of your operation and then conditions of the machinery they are using. And again related to all this is what are the type of errors that can happen and so on.

So, we will start with all those words which we are talking about. It is a term which describe how much material is needed between 2 panels to accommodate a given bend and notice here while being oftentimes a tricky to determine and easy to predict and calculate for many standard circumstances, determining bend allowance is commonly referred to as bend development or just simply developed sheet.

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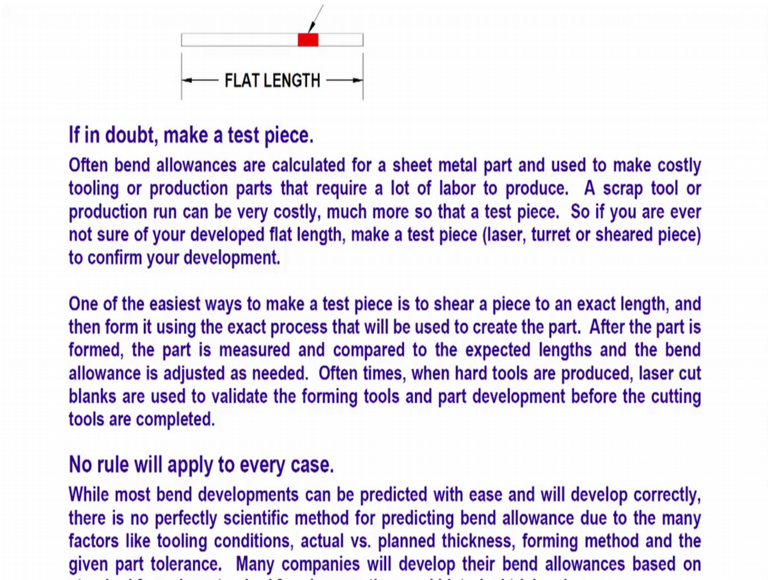

So, some of you have played with origami and typically if you have made a pinwheel take a square cut through the halfway through the diagonals bend over and you have a pinwheel ready. You will notice that it is a wonder it is how many it keeps you occupied and you will know what we are talking about when we talk about a bending allowance.

So, in this case we see carefully the 2 ways of determining that one is take the external dimension, this is what I was talking to you about there if it is a simple l shape external dimensions are easy to measure and if it is a you also we can make. But if it say z section you will need to find out what constitutes see external and what constitute see internal. This the bend radius say I have struck in l about the allowance is what we give extra there.

Now, we need to calculate this flat length if you can recollect what I had shown you at that time when we tried to make something which is 20 m, I mean 240 mms and total of 185 ended up with a little extra length then the nominal ends we have taken most important know read this it does not what you call bend allowance are calculated for a part and used to make costly tooling or production parts that require a lot of labour to produce a scrap tool or production run can be very costly much more. So, that a then a test piece. So, if you are ever not sure of your development length make a test piece to confirm your development that is what we have done there in that case I have asked my colleague to make a small strip which is 20 mm wide by the it total thing one of the easiest ways to make a test piece is to shear a piece of an exact length and then form it using the process that to be used outer the part is formed the part is measured and compared to the expected lengths, the bend allowance is adjusted as needed you have see this no critical of thing is adjustment.

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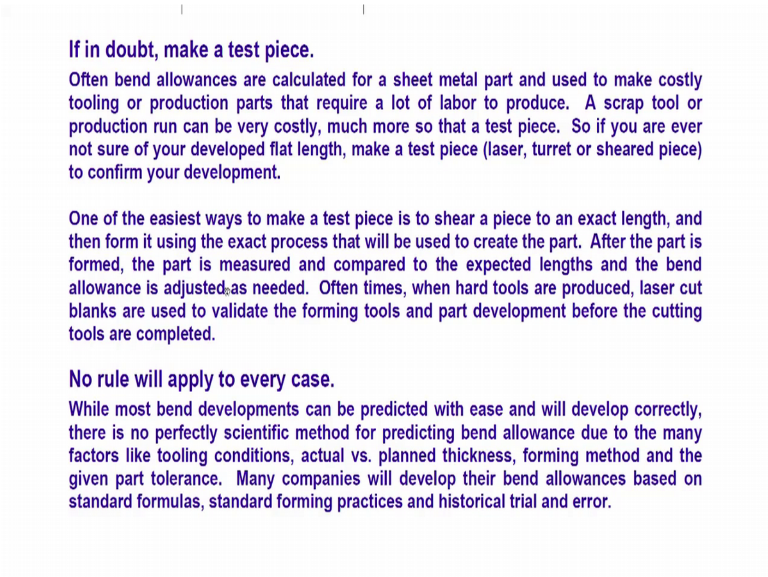

It is the physical process which leads to the equation and not the other way. And the equations in the given set of conditions ensure reproducibility and not the other way this can be taken to some other material, cannot be taken to some other way we have doing including rate phenomena. If you use impact they behave slightly different from if you use a gradual operation.

When hard tools are produced laser cut blanks are used to validate the forming tools and part development before the cutting tools are completed. And this is what I was telling you this is taken from this called sheet metal design dot com, towards end on page twelve the what you call legally is are releases printed there. Generally the release is yes it is released for a purpose of learning, but then not binding on us or it is not a mathematical exposition in which you know, you try to prove all the conditions and so on.

So, read along with me while most bend developments can be predicted with these and will develop correctly, there is no perfectly scientific method for predicting bend allowance due to the many factors actual versus planned thickness, forming method and the given part tolerance. Many companies will develop their bend allowances based on formulas forming practices historical what trial and error is given there again towards you know scientific and trial and error is it an oxymoron not necessarily, science is not predictive as we think it is a little analytical and then that analytical component if you use again we can come back to reproducibility.

So, in our traditional method the idea is anything which you give here is predictable, that last page a legal is your talking about they talk about do not take it as a rule in case there is any mistakes do not.

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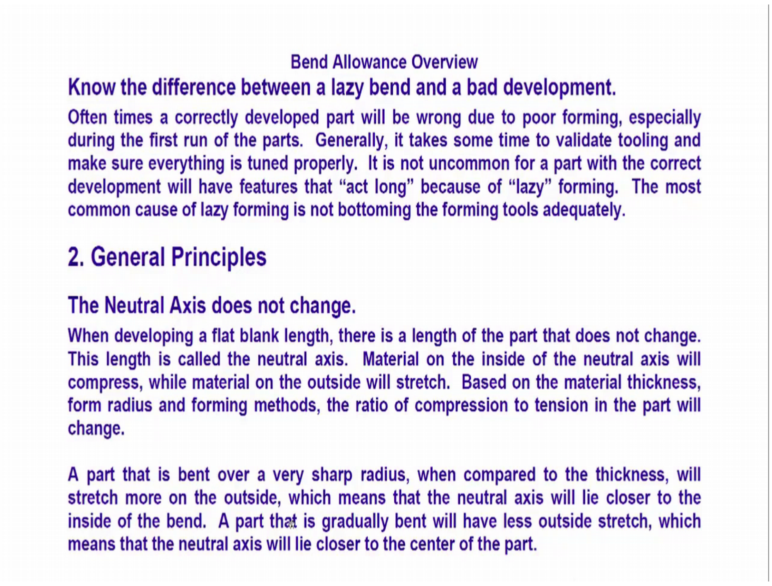

So, let me move on to difference between a lazy bend and a bad development. You have seen that know I think I leave you to read the first para yourself my voice I will avoid.

Sir let them read it put me the other thing take some time to validate tooling and make sure everything is tuned properly, not uncommon point of part with the correct development will have features that act long because of lazy forming the most common causes not bottom in the forming tools adequately. Eventually they will tell you about what is bottoming, what is coining, what is air bending 3 things.

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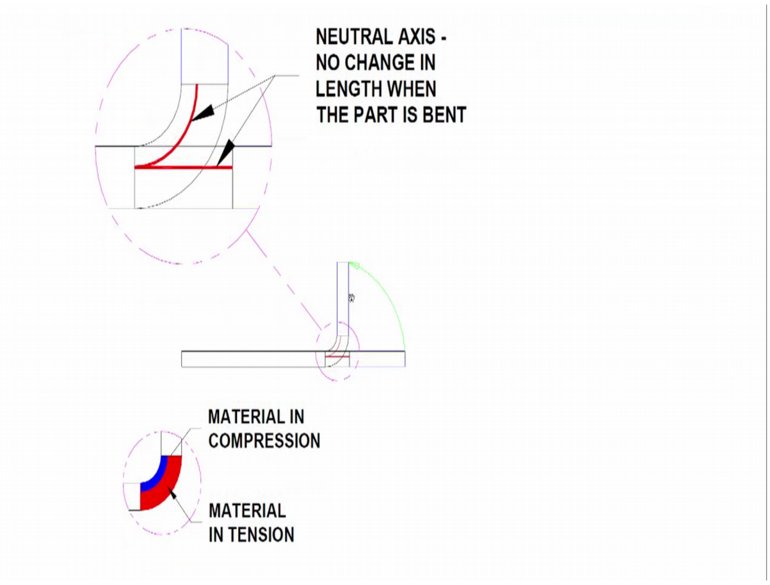

Most important again in this know if you read along with me first general principle you have seen that neural axis, that part of the length which does not change is the neutral axis. You does seen it when you bend anything in your hand typically a small flexible material and played out when you bend it you will notice that inside its compressed and the outside get stretched. And you see the neutral axis is not exactly in the centre you have seen that know you will not it is not a geometrical centre. A part that is bent over sharp radius when compare to the thickness will stretch more on the outside which one neutral axis will like closer to the inside of the bend the issue is about the location of the neutral axis. Based on the material thickness from radius form radius and method the ratio of compression to tension in the part will change.

So, it is not a simple this thing then it is also a rate phenomena if it done, gradually as in a hydraulic bending thing bending machine and time is given for it to accommodate the various things, bent will have less outside stretch neutral axis closer to the centre of the part is nearer the geometrical centre.

Now, if I go up same thing there is a material in tension point which I have talking to you about which is here. And then there is a material in compression you see here tension versus compression it also relates a lot to the direction of grains and the physical structure of the material. So, some materials have a tendency to open up here means there are while it is not a crack actually there are more gaps here than natural and the here all the gaps there is a physical limit after a small time everything is in compression as such you know not much of compression can take place and tension can be more.

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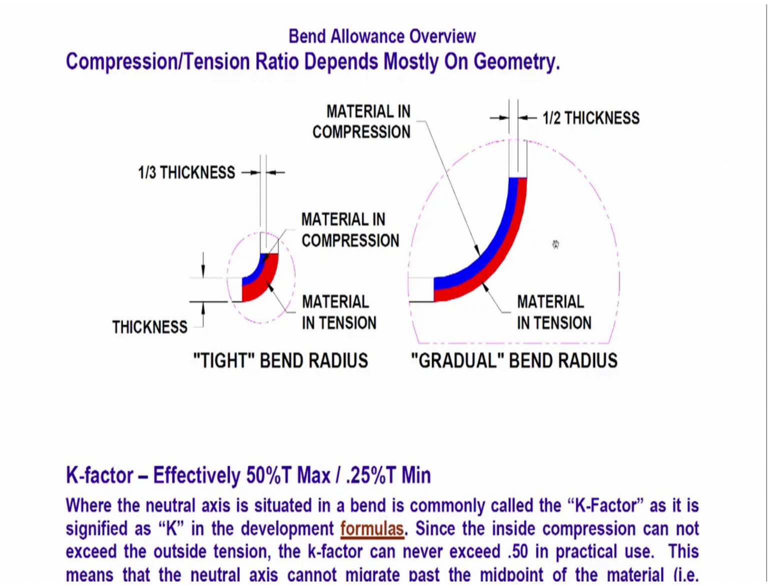

So, if you go up tension ratio depends mostly on geometry. When there is a smooth radius. So, in plumbing we call it a long elbow if see a pipe and then if it goes like this; this looks a little like the long elbow and this looks like a short this thing and then we really do not have square bending like this you know we really do not have something its absolutely square, though I mean we had like to call that something is absolutely square and there is nothing; such a thing does not occur in normal sheet metal going back to my this picture from a sheet metal dot com you have seen here if it is a tight bend radius the neutral axis seems to be about one third and then it is a large bend radius or a gradual bend radius its it exactly forms the geometric middle. Effectively we have this issue where the neutral axis situation in a band is commonly called the K factor and it is signified K in the development formulas, since the inside compression cannot exceed outside tension K factor can never a exceed 0.5 in use.

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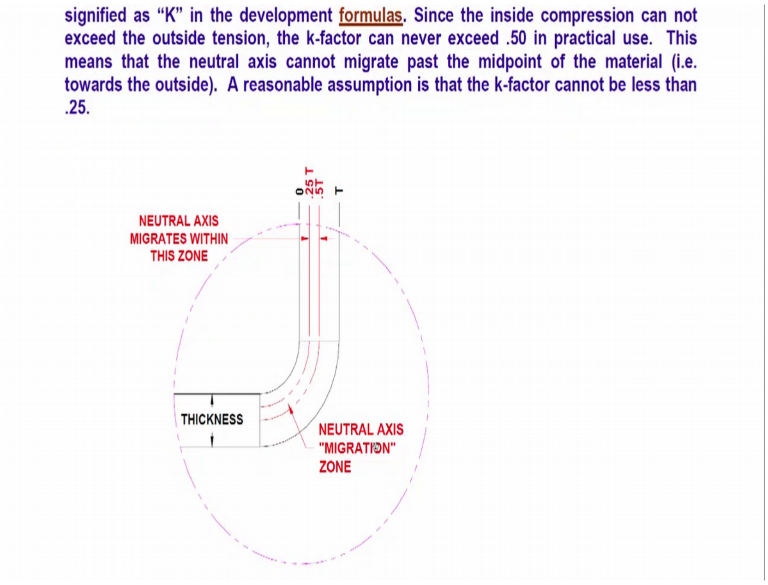

The new neutral axis cannot my grade past the midpoint of the material, a reasonable assumption is that the K factor cannot be less than 0.25, and migrate the again a assumption then I was explained earlier you know I mean I cannot give an answer it is all right what is then the K factor, subsequent lectures will explain to you about the things here.

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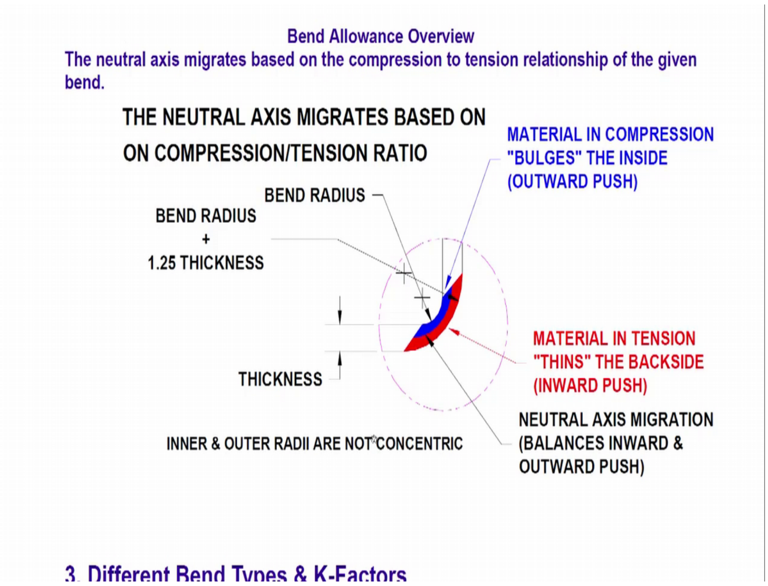

The neutral axis migrates based on the compression to tension relationship of the given bend we have this you know. So, we have you see here even the cross section does not seem to be constant it things out. So, if you take deep drawn parts like a can and all that sometimes they would have notice as if it the pieces are torn and thickness is not the same, inner and outer radii are not necessarily concentric material in commercial bungees inside outward push.

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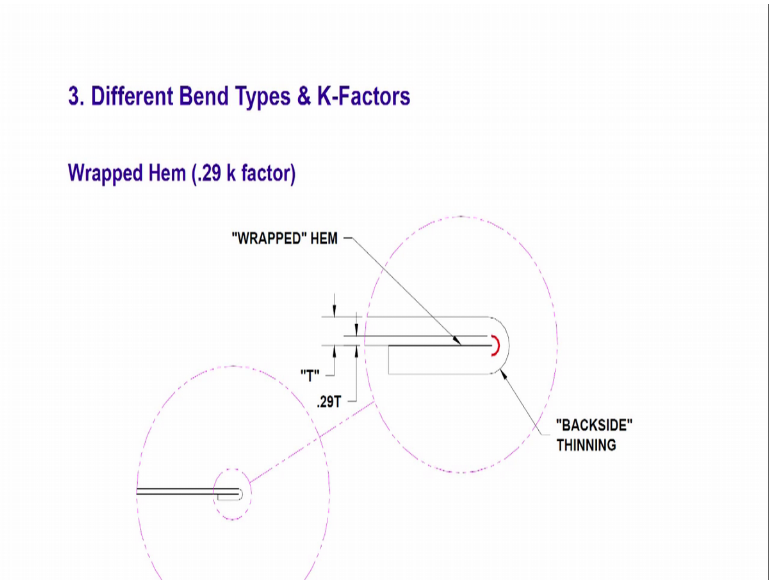

So, we see here a completely bent over 180 degree bend. So, can we actually make it flat some condition is depending on the softness of the material, the reality is that usually though it is not easily visible a small gap will be left there in this case you know it is given approximately one fourth of the thickness, a little over one fourth of the thickness.

When I showed you the a small cover for the power supply unit it is a small cover, and this is very thin to make the adjust stiff there have bend them over formed something like a little like a beard. Technically that is not the name, but; however, the whole thing you know what is here it completely made like this flat, you have a nice smooth edge important thing you know if there is a smoothness otherwise it will be like a shaving blade very very sharp and then because of the sharing operations or sharing operations are there, one part of it will give you a really harsh edges.

So, if you fold it over first thing we managed is we have got a very smooth radius and slight improvement in the rigidity of the material. So, if you can now just make something you know like this a small thing, you can increase the stiffness of the material as well as make the bending easier, but then all the thicknesses have a tendency to accumulate in your part.