Marine Construction and Welding

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Lecture No. # 23

Plate and Section Forming – 2

Continuing with plate and section forming, we have seen how we go about bending frames talked about plate bending, and the we have seen that if it is a kind of a developable surface, that means, which is single curvature like cylinder or cone, some such example you saw is the bilge plate of a ship right, so there it could be done by passing the plates through rollers bending rollers right; free rollers machine depending on the upper roller diameter, you achieve the diameter of the cylinder what you are forming or the cylindrical bend ship you are going to achieve.

For other bending cases, that means, where you need to have a with the surface is a double curvature surface, means, where you need to provide for stretching of the plate, need to provide for some kind of strain in the plate, so they are also we have mechanism through bending it using a hydraulic Press, and another version one can think of is a kind of a universal press.

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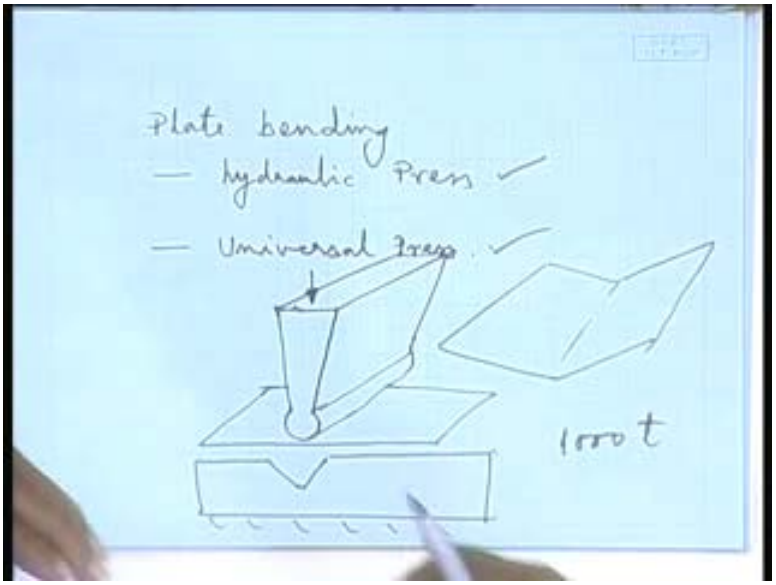

What is this hydraulic press hydraulic press is again nothing but…, you have a schematically we can see somewhat like this say a…, think some such fixture, this upper portion is the vertical ram which is hydraulically operated. So, if you put a plate here below this and apply force, the plate will bent in a v form right; when you apply a force the plate will form like this right, the whole plate somewhat will bend like this; so, again the same strategies you go on feeding the plate, go on turning the plate, and apply this force, this is of course it is a it is a it it has a certain length right some such thing.

So, these are very powerful phrases like power could be in front bending we talked about 500, 700 tons, here the power can go up to 1000 tons and even more, because here you may need to bend plate which are thick enough 30 35 millimeter thick plates right, so we need to…, again the same thing you need to achieve the achieve plasticity across the entire thickness of the plate, so that you get a permanent bend shape, you will have to exceed the ill point stress anyway; so, this is so what is a simple bending process using hydraulic press, where in again you can see suppose a typical a some bends shape is needed to be developed right.

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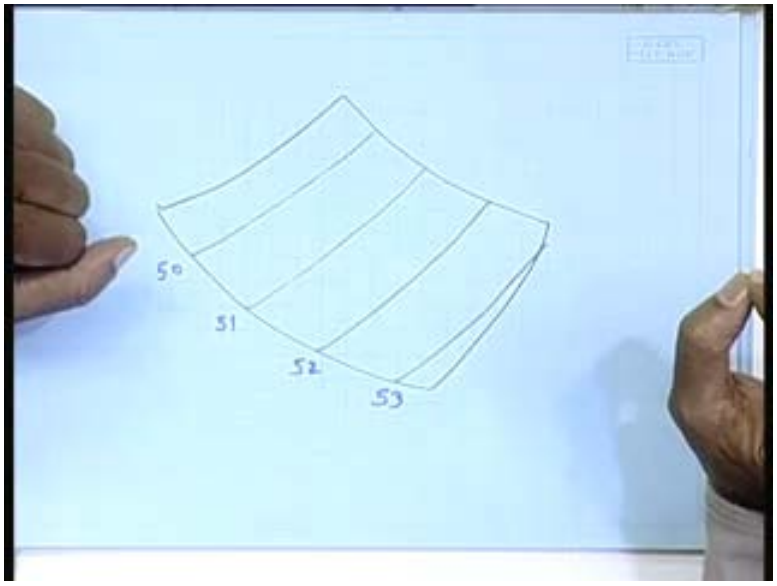

So, as we talked about from this patch we develop the blank, we have the cut plate and then you have to put it under this place, and again it purely a skilled job purely a skilled job, means, depending on the skill of the operator who has learn probably from his procedure right, that how to place the plate with it, because you see the plate is pressed in what orientation you have to press the plate and keep bending it in stages right, again whether the bend shape is coming to the requirement again that is checked by you will have to have those templates already are there for frame bending you have done and when you produce the blanks you mark the frame locations; the frame locations are already marked, that marking is also automatically done by in the flame cutting machine, because you see when you have got the definition of the blank, that means, the two-dimensional plate that has to be cut right, that cutting is done in a numerically controlled machine it may be using excessive flame or plasma that is a material.

But if you have an automatic working cutting station it will be numerical control machine, so it knows the boundary it cuts it and also you give the information about the frame positions see just marks it, so there you can have a different attachment which will mark the trim position, say, this is my frame number 50, 51, 52, and so on right, some I will tell I have showing; so, as you go on bending the plate you have the templates, put the template on frame 50 and see whether it is perfectly matching there is no other way, so there by the plates are bend to the required shape.

So, you can see this is again totally skill dependent person dependent process and a t d s time consuming process, so these are the areas where one can work and find out to give a solution, so that this process can be automated or can be improved the production efficiency can be improved right, that is on one way looking at it; other way looking would be you produce a design wherein you have minimum of curve plates minimize this operations, that means, a design wherein one can have a minimum, but well you will have to like, for example, I can have a section like this is also curved right or I can have a section like this is a difference.

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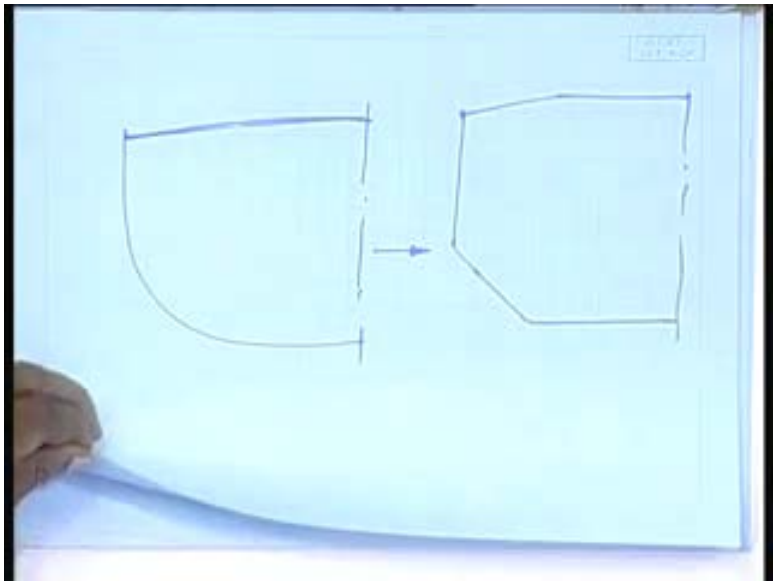

That means, I give a well-rounded bilge the moment I gave a well-rounded bilge the four part becomes double curved the up part also becomes double curved or I can give a chain double chain, so entire thing remains in the chain construction, so there is no bending of plates involves that deck I can give a nice parabolic ship to provide for the necessary camber or I give an inclined plate with the horizontal plate welded here.

So, all together that the bending or making curve plate is eliminated, but well these are one of the examples, but this may not be feasible always, because switching from here to here, this design I am sacrificing bit of hydro dynamic properties or I would say I am comprising on the hydro dynamics of it or in another words compromising in the powering requirement, these may have a higher resistance than this form right, but as far as smaller traps are concern the that difference is negligible or in other words that does

not that that does not take the predominant role, but you are making a 200 meter long big bulk carrier, it cannot make of chain construction, because there the resistance increase will be very significant, there you will have to go for curve plates and proper aerodynamic shapes. So, to say right there you cannot avoid, so the point is where we can avoid, let us avoid curve plates because making curve plates is a t d s job, that is what it is; so, that is how this using, so called hydraulic press schematically it is like this, the operation is operate bending as I have said.

So, now you see that it being a again the all that involvement is there, that means, you will have to have templates. So, if I make the frame bending in such a fashion I avoid temp plate, then again it is not done because for plate bending I need temp plates, so I improve upon the frame bending process by providing those camera technique and other things.

And if I do not produce templates, I mean, templates will not be needed for frame bending, but here we see it's needed for plate bending. So, what is the other way of avoiding those things, one possible way is making something called universal press, because here you see it is also a universal hydraulic press, I mean, a kind of…, but here I would not say it universal, I am just naming It hydraulic press, because its only capable of making free kind of bend shapes, only thing with my skill I make this v and turn it put a stroke here, so I bend this side up.

And so, and so, for that is how get a smooth curvature right, but I can have a setup which the best would have been if I could have had a concept of male female die like the once which are used in case of where you have a mass production of a certain shape in car automobile industry, there are lot of plate Bending is needed the entire curve body is very nicely aerodynamically designed how they do it its purely by a punch one single punch.

Entire roof is made the bonnet, it is made means you have specific male female die right; that means, the male female die and the male die it punches right, that means, match die plate bending there it is feasible, because those die, because you make a pair of die there will be expensive very expensive, and why expensive because they will be need to be made very strong and heavy and what not because so much of force will be applied.

In automobile industry its feasible why because you make one pair of die a mass production, so the cost of that die is very nicely divided in all the things, but in ship that is not feasible. Secondly, in car automobile I am bending what probably of a 1 millimeter thick plate or half a millimeter thick plates, here we need to bend may be 35 millimeter thick plate. So, imagine the capacity of the die should be, so technically also it becomes somewhat not very feasible and practically absolutely not feasible because the pair of you will need hundreds of such pairs of die for one single ship which will never we use probably in future, so you cannot do that.

So, what is the solution? Solution here is one of the solutions one can think off, the think off a universal die, there the match die is a one type, but I make a universal die, that means, that die can take the required shape right. That is what I have referred to as universal press imagine a situation like this, you have an say you have an array of such say hydraulic jacks right, and this all so as small squares what I am drawing there that top of a hydraulic jack, let us a square array where we have drawn of hydraulic jack right.

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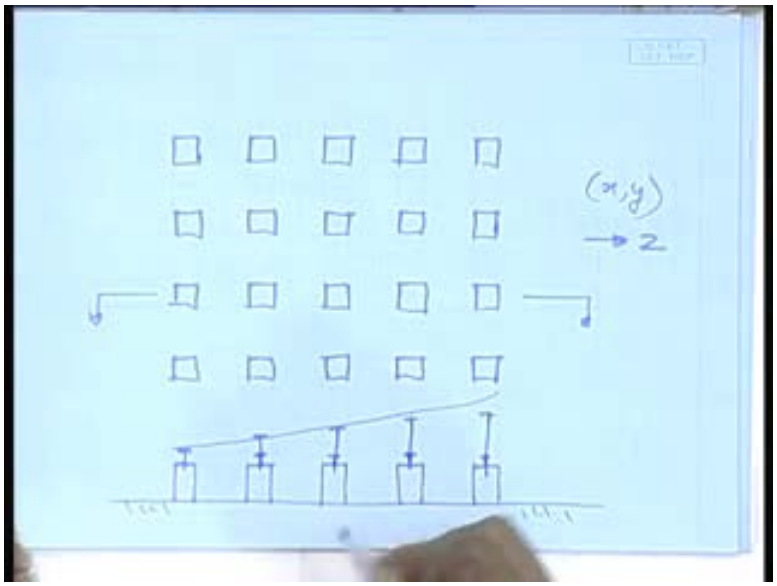

So, one cross section of jack if I see say this is my ground level, so what we have here is I am drawing it schematically, so imagine a situation that you have a…, I mean sufficiently sized arrays of such jacks, and now this jacks it as a stroke length right.

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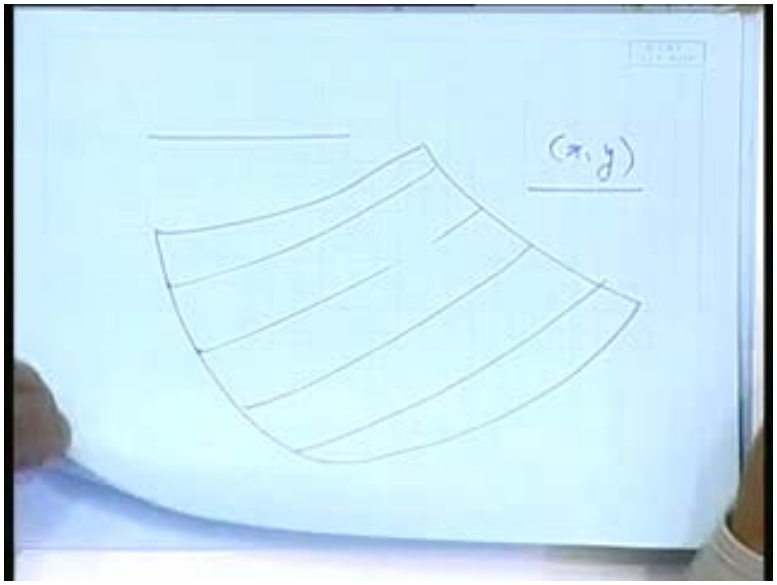

So, this can be thought of that if you have a plate say again that same plate I have to bend it like this, these are my frame lines all right, so I have for this given plate entire x and y coordinates right, here also it is fixed. So, I know x and y coordinate of each individual jack, so at those x and y coordinate values I can find out the z values isn't, it of the plate of the desired shape, all these jacks can be control through a computer right wherein the height operation of the jacks I can control through a computer. So, I fed in all the z data that means, the height for this x y coordinates, so once I achieve it, so it comes say for example, like this in this row other row in a different.

So, I get that particular frame line, so that way this flat horizontal surface.., from this I can generate any curve surface theoretically that is possible practically also possible not a very big issue right. Now similar set of things can be on top also hanging from a big frame work right, hanging from a big frame work.

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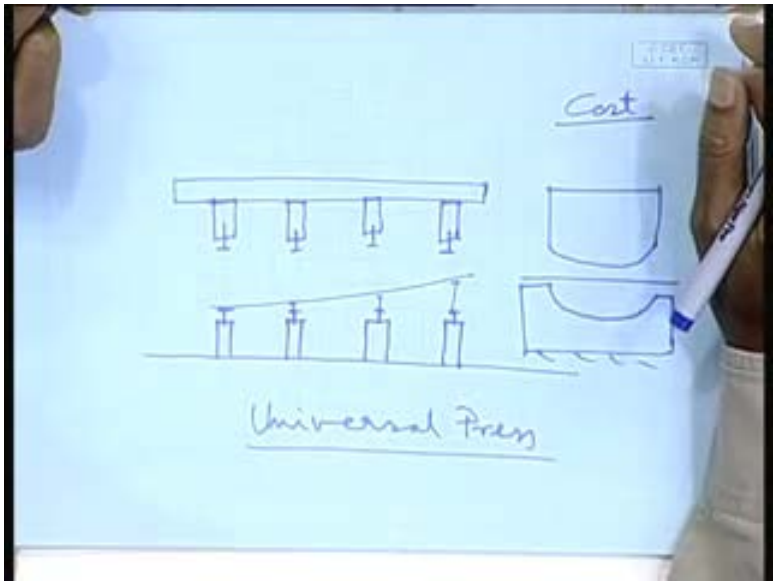

So, I can have a system wherein I have a set of this at the bottom and a similar set at the top, so what in the process we are getting? We are getting that same equivalence of a match die isn't it, this is connected to a say a frame work from which that entire array of this hydraulic jacks are sort of hanging. So, the bottom array I define the surface right, I generate the required surface required generate put the plate on top of this bring down the top array and press against each other.

It is equivalent to that of a match die concept in a match die what was it? It was somewhat like this, this is my fixed thing, and this was my female die fixed shape, so the plate was kept here and you give a punch you get that shape, but here this shape is I am generating. So, for all different shapes what it can be easily generated and bend it can have the necessary power, so that is what is the universal die or universal press.

So, theoretically and practically both was it happiest to be quite comfortable, quite convincing, quite simple, but unfortunately this is fruitfully it has not yet been used, why, what you think could be the… Well, one aspect is differently cost, but that is that can be invested cost is well cost is there, but well its feasible, it is one time investment you do, and the productivity you get out of it is definitely, it is worthwhile plate thickness is a different issue, because that talks on the cost.

So, well, if I am building say for example, a ship yard, he will look in to this that one ship yard it is not like that any thing comes in the way you built, you have your vision,

you have your plan, you know this is your product range. So, if your product range is some things say up to say 200 meter long vessel, so whatever you know what are the plate thicknesses you will be handling, what type etcetera one can think up where it is feasible, it is feasible. So, that is not…, what is the…, that means, that is also not the major factor which has not made this popular, that is extremely easy, not not not really what happens is the what is the problem.

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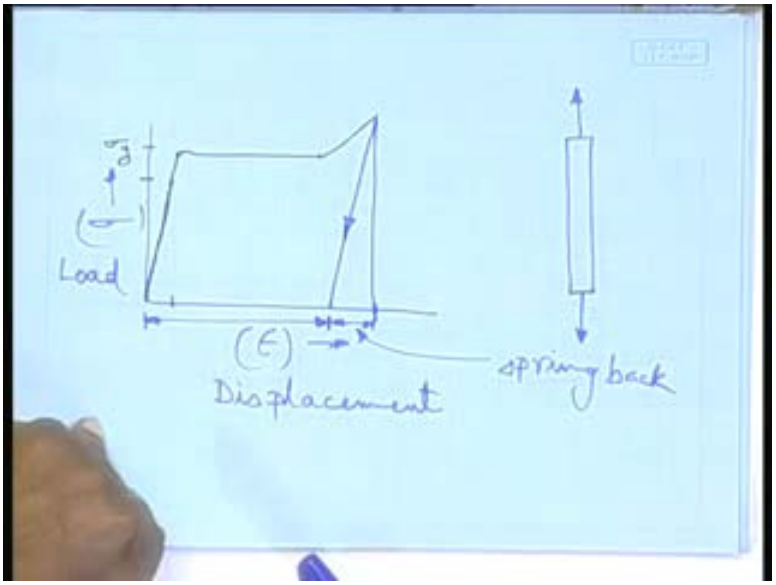

Yes, here you see what will have to do here is you know one aspect that whenever we subject a material to a force a tensile force, say, not work happening that what do you call elastic unloading, when I subjected to a tensile loading what happens, well, this stress strain I have written it can be load displacement load displacement by displacement here is elongation.

In this case it is essentially elongation, so how it will be elongate, let us see, if I go and applying the load It will the load will go on in the deflection will go on increasing in a very little fashion, I mean, not heavy deflection as the load increases, some deflection is there, how much? This much, at this load level this much of deflection is there, I release the load it comes back to 0, there is no deflection, no remaining deflection, but our plate bending I will have to be remaining deflection, that means, a permanent set as we call it, permanent deformation is needed, that means, I will have to exceed the yield point say

my ill point is here, and then what happens it goes somewhat like this, this is my yield point.

I need further displacement or more deformation then the work hardening starts like this, and I stop there, why I stop there because the strain needed is say this much; so, if I stop there and release the load what I will have, my actual bent shape will remain, that means, the available final strain will be this much residual strain will be this much, less by this much under load it was so much the deformation; that means, when it is under pressure from both the top and bottom array of hydraulic jacks it will perfectly conform to the plate shape required shape, but the moment I release the load it will straighten out, so called it will spring back right.

So, this is my extent of spring back which very easily can be seen in a simple experiment of this or even you take a small a steel bar you hold again hand you bend it and release it you will find it is straightening out little bit, because this elastic unloading will be always there this is my elastic unloading, that is what is called; that means, steel has this property of elastic unloading had it been led it does not have that elastic unloading, because it is fully plastic material sort of there is no elasticity in it, led is a soft metal it does not have any elasticity of bend it remains in that state, you give any shape, it is like plasticine the kids are playing right, but still is elastic material, so it will have this spring back effect. So, that is the main problem.

So, one can…., so what is the solution? Solution is one will have to access how much spring back may take place, so accordingly you bend it further such that after releasing of load it will come back to the…, it will spring back and come to the required shape desired shape that is theoretically feasible. Now, what are the practical difficulties doing that, no it is not that way because as it is a same plate if I bend in a normal hydraulic press I am bending it that is not the problem.

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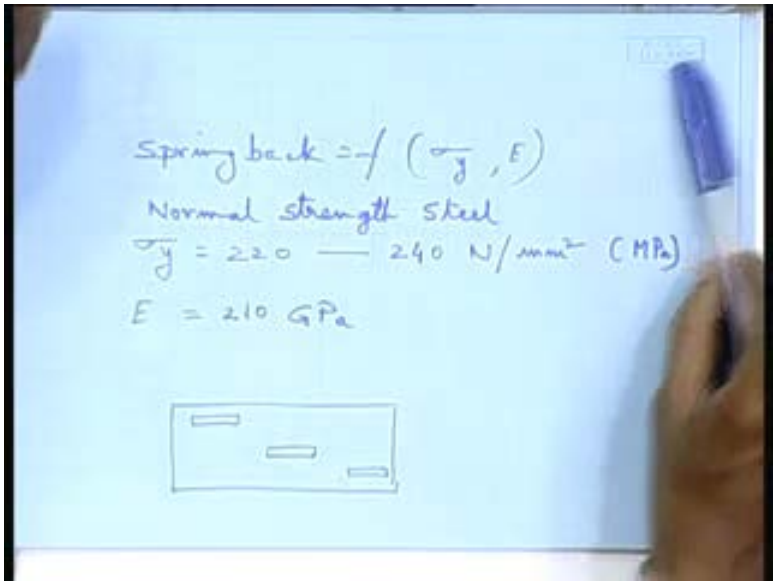

Problem is accessing of this how much spring back will take place that is the problem why because how much spring back action would be there that is a function of what, a function of all those mechanical properties essentially function of your well sigma y function of modulus right; primarily, these two at end than other things the dimension of the plate thickness etcetera, but material properties these two, primarily these two, it will depend on that.

Now, let us see what is the value of this sigma y as far as normal strengths steel is concern, what is the value for normal strength steel, that means, we are not talking about high tensile steels or high yielding steels say normal strength steel, because probably around 80 to 90 percent of the steel use is normal strength steel in ship building industry. The sigma y yield stress is of the order of…, it will vary within this zone 220 to around 240 newton's per millimeter square or I ,think so many mega Pascal's isn't it.

So, that is what similarly e is of the order of 210 gigapascal right, this is megapascal, that is gigapascal right of that order. Now, you see now which value to take 220 or 240 that is a problem which value to take it, we take average 230; well, so, any value you take a spring back will be different and that difference could be of the order of several millimeters and several millimeter difference I cannot tolerate because say my plate thickness is 8 millimeter I am making a frigate, side shell thickness a part of the shear strake at the 4 part is say 12 millimeter only and there this kind of variation gives me a

variation of 6 millimeter in the bend shape half the metal thickness I cannot weld the next component will not match the tolerance level is hardly plasma as 1 millimeter, so that goes grossly out right that is the problem; so, which value to take that creates a problem,

Also now you have the steel plate now if I want to find out the material property; suppose, I take a sample here I test it will give me some yield stress, say 228 gigapascal, I take a sample here it may be 239, I take something here it may be again something else, but all will fall within this range, so that is what it is; that means, the material property, this steel material is not a so called material of unique property, I mean it is not made of single crystal that anywhere only one single physical property will be there, no steels are qualified to a category of steel depending on whether it is falling within that prescribed zone.

This is the prescribed zone for normal strength steel right, but the zone is wide enough to get my spring back value also wide enough, so then becomes the problem; so, what is the solution to this, all problems should have a solution may be not feasible today but tomorrow; so, what is the solution? Solution is simple right like when we had been using that conventional hydraulic press what that skill operator was doing? He was bending it checking with a template, and you will find it has to be bent more, so he is again bending it at different location again checking with template, and at one point he may be find that it has been bent accessibly.

It is simply straightened reverse the plate he applies sufficient enough load to straighten it out; that means, by trial and error every stage he is checking and he is either bending it or straightening it getting the final shape. Same thing we can do here also, that means, will have to have a mechanism of monitoring the shape what we are getting like in case of frame bending we have talked about monitoring using a camera right and bending it and checking it with the prescribe bend form; so, same thing is also feasible here if you can have a mechanism of sort of monitoring the curve shape, this shape what it is generating; first I generate the surface as required with preliminary calculation of this spring back, because well some value it take probably take the mid average value with that spring back, I add that springing back allowance to the curved surface to the defined surface right and accordingly actuate my jacks press it down it bends release it.

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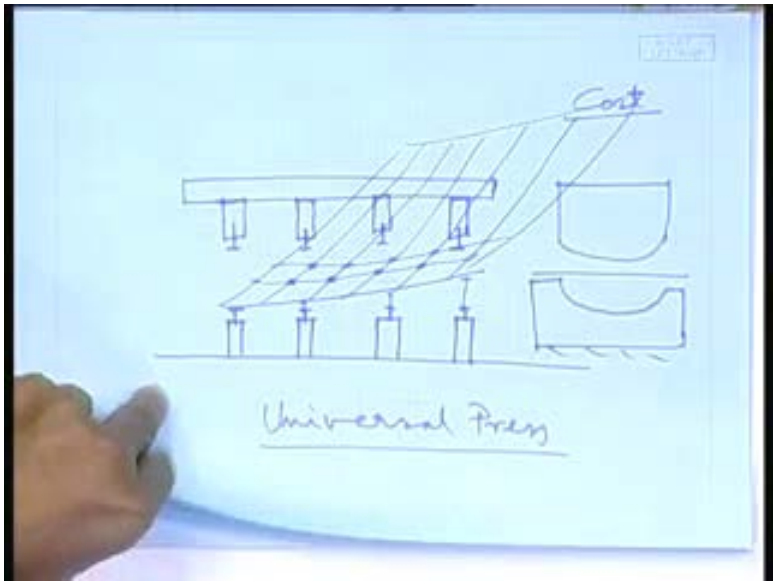

And then this surface has to be checked, checked for the coordinates whether it is come correct or not. So, again the same problem how do you check it; and now is a enter surface it is not only one line, in case of frame it was just that edge it was Much easier thing; now is the entire surface has to be check, that means, essentially how do You check a surface is will have to make a grid on the surface probably right, and that these coordinates are to be measure and checked with the my required surface those coordinates are there, so I have to check.

So, how do you do this? That means, here we need, it cannot be just take a camera image and do can be done, but that we tremendously computationally expensive and time consuming probably, because if you take a camera picture and eliminate all and extract this coordinate data could be difficult instead a laser beam scanning can be is possible. And in a preprogrammed way its scans and takes only the z coordinates at predefined points, because what you need is x y coordinates are well fixed only the variation is z coordinate I will measure; so, by means of laser scanning one can get this data, so that data with that data you generate the surface match with the required surface and find out whether it is to be in some place further bent or straighten accordingly generate the surface, accordingly actuate the jacks and give the second punch, third punch, fourth punch, and finally it comes out.

So, here the problem becomes that saying that laser will scan and will take the data, generate the surface match, and do possible, but still practically not that yet feasible most probably, there could be problem of computational requirement could be problem of cost involvement, could be problem of volume of work, all taken together it has not come out; means, people have tried full scale photo type, but has not been is not finally utilized commercially, because other aspect is also there the all these will have cost component weight; now, we will have to see also what is the volume required, because you can see when we are talking about like in some vessel by doing this I am eliminating this.

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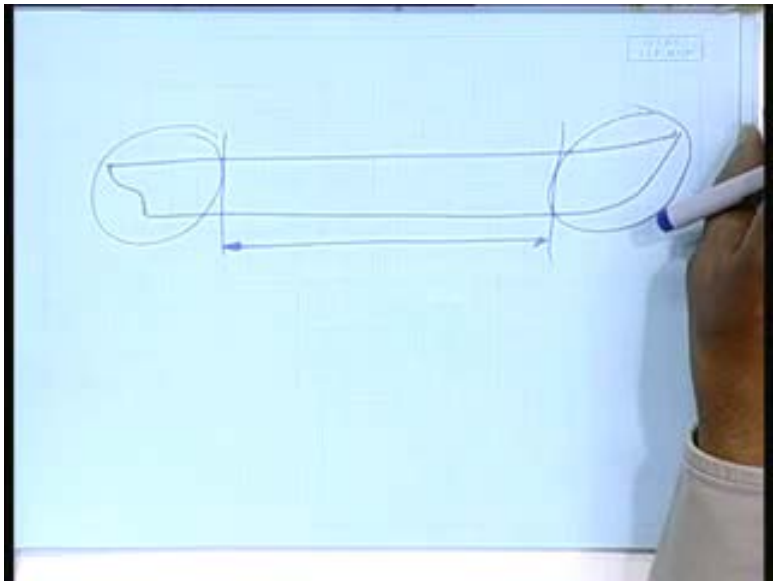

And when we are talking about…, there is a definite hydrodynamic requirement and where I cannot do away with your curved shapes; that means, big vessels, and bid vessels what we see only these two parts will have double curvature plates, what I have drawn is fairly proportional it. So, we can see probably two-third or more than two-third does not need curve plates, whatever it needs is in the bilge, for that you do not need such complicated thing; simple rolling machine will do it immediately, that is done very Fast right.

So, only little amount of curve plates in the ford and in the haft, so if it takes longer time for produce…, let it take you plan it accordingly when the work on this part is going on preparation of curved plates can start by the time work is over here, the curve plates are ready you get down with the forward Block and the up block, I mean all those planning

can be done, so for that you do not need a high productivity machine that is also there, so all these are to be seen, but the difficulty what remains is its not productivity, difficulty remains is on the availability of skilled worker that is becoming difficult to operate this machine that availability of skilled worker.

Because in ship yard will have few, so in one shift say two persons are coming who are doing this job, if we fall sick the work stops all together, is that kind of skilled right that is the problem. So, there are many aspects when you develop a technology developing a something, concept development is something from the prototype is something, else finally implementation is all together something else; there are many factors they coming which will dictate whether the technology to be developed if develop whether it can be implemented or not right, so that is what is the universal press.

So, here we see universal press is feasible, the whole press is of plate bending can be more or less automated, because all these operations will go automatically, laser will scan computer, will compute it will direct how much is to be actuated the jacks, feeding of the plates is through roller; so, one man will be operating the whole show, so it is fairly automated and efficient process could be…; but well these are the drawbacks, so what happens? Primary drawback is springing back action primary is because of the material is elastic and it has a when it is unloaded it will spring back.

To evaluate that exact how much it is springing back there comes the problem; that means, at one stroke you are not sure that you will achieve the required shape, so you will have to have a monitoring system, monitoring system becomes complicated issue that is all, so that is what all about the your mechanical means of bending.

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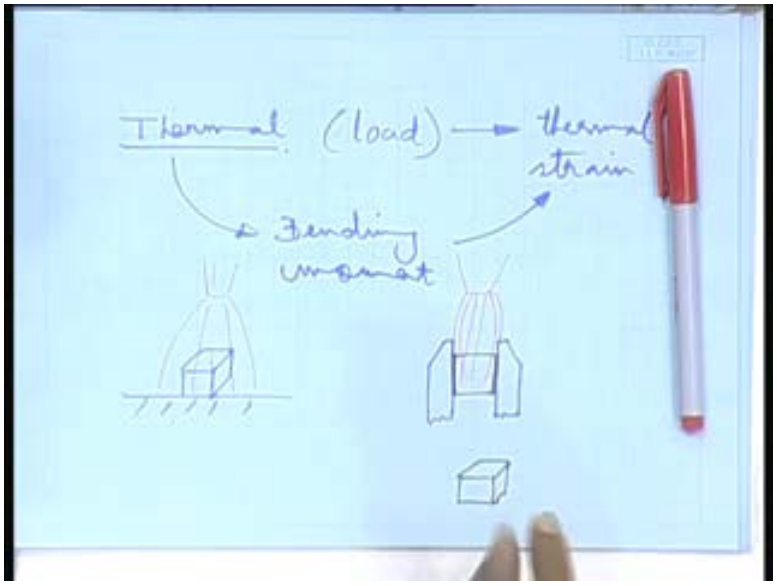

Now comes the thermal means, what is the difference, difference is in both the cases what we did is we applied a force generated a bending moment there by we exceeded the yield stress right, and depending on the orientation direction and all that of bending moment I got a bent shape both for plate as well as for frames. In case thermal it is essentially a thermal load, essentially a thermal load which leads to which leads to deformation; that means, formation of well I mean mention as thermal strain, where from I am getting thermal strength, that means, I am getting some bending moment is forming definitely which is giving rise to the strength, since the bending moment is from thermal load, so I am getting a thermal strength. Well, so, how it happens?

Let us first see how the thermal load comes in to plane, and then we will see how that can be applied. So, if we do a small experiment, because we know if we heat a metal piece it expands, because of some property call some something call coefficient of thermal expansion some property it has depending on that, depending on the extent of heating you are doing, you will have a expansion of the material and upon cooling it will come back to the original shape right.

So, there are two cases, say I have small say iron block a steel block on a table, and the same steel block I am putting on a against a wise, you know wise in work shop we have, so what I am doing in the wise is not actually pressing it hard, but just holding it by saying just holding it means I have tightened it enough, so, that some friction it is

holding it, it's not falling of…, I am not applying any great force as such little force, so as to have overcome the weight, the frictional force is enough to overcome the weight of the small cube.

So, these are the two cases, and this let us assume we heat at with a with some heat source, let that heat source be a say a gas flame right; same thing also I do it here, it is heated right, heated to a certain temperature and leave it, so what we will observe in these two cases. In this case, what will we would not observe anything as such in make I dies it will be heated up and left if I touch it I feel It is very hot; but in this case what will find is after I have left it will fall, it will fall down, it was lying there now it will just drop on the ground by that; that means, it will be lying on the ground basically, it will fall off.

Why it is falling off? Obviously, I am assuming the because of this heat, this heat, this clamps have not changed any of its physical property or anything, that means, something has got changed in this cube. Now, if you measure the cube this both this cubes which has undergone equivalent heating we will find that this cube retained its original shape, original size rather retained its original size, here I will find the size has changed, this has decreased.

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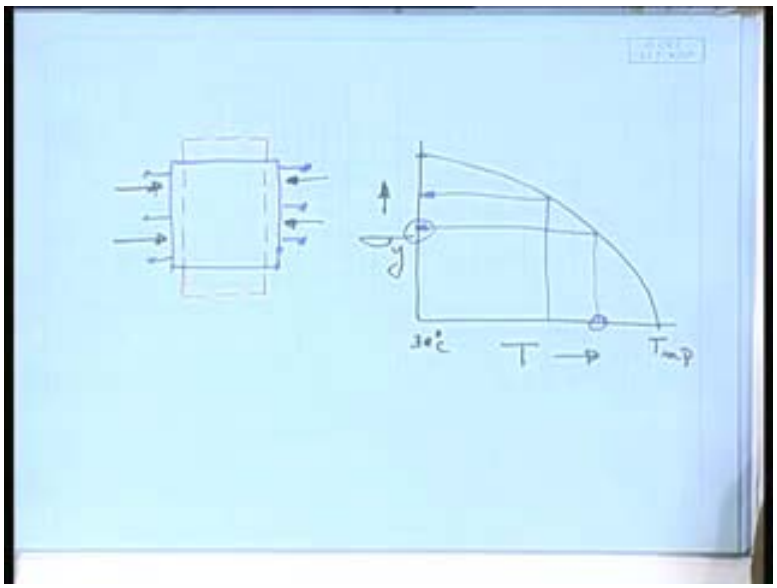

So, what has happen is, essentially say one cross section I am drawing only the front elevation which is seeing, it may have become or it has become like this, this dotted line is the change shape, obviously I am drawing little exhaugorated this, means in the in the

breadth as if it has shrunk; and now, there should be conservation of volume, so it has increased in this, that has happened whereas it has not happened here; so, that means, this vice has some role to play, what role it played when I heated it, it tried to expand isn't it, it tried to expand in this direction, but since the clamp was that it could not expand.

So, a reverse compressive force was generated, that means, a because of the clamp a compressive force was generated I can call it a compressive stress right that worked on the plate right; and then when I withdrew the heat the cooling started; so, in the phase of cooling what was happening the it tried to expand, it could not expand, but it was free to contract; so, it's started contracting, that contraction process was assisted by this compressive force stresses which formed, so it is freely contracting plus additional assistance from the thermal compressive stresses developed plus the temperature is high.

So, I know the stress temperature distribution yield stress is a function of temperature as the temperature is…, this is my hill stresses room temperature say this is my 30 degree centigrade, it drops like this, it becomes 0 where yield stress melting temperature when the metal is liquid, obviously, it cannot take any stress, it flows isn't it; here the material was flowing because of plasticity, the metal was flowing because of plasticity, but this value is very small if the metal is totally in liquid state it flows without any stress, it takes the shape of the wherever you kept.

So, in this case what is happening? The temperature is somewhat at the higher level, because I have heated it up when it is cooling down still from a high temperature it is coming down slowly. So, the temperature was here then my yield stress was less; gradually well cooling down, so temperature is coming down, yield stress is gradually increasing, but it is always less than the normal yield stress right.

So, the forces which are acting the compressive forces as well as natural contraction that taking place more comfortably I can say, because at now I need a lesser load to deform it, like a black smith what it does He heats up a metal piece and he just very casually he hammers not with full force and that thin takes shape, means what, he works at this somewhere at this stress level, he is working at this temperature level it is red hot 800 degree centigrade, say he is just small hitting means he does not need much low stress to be develop because the yield stress is has lowered, so that is what is happening. So, there

by it strings; so, this is the basically the mechanism of deformation. So, this how it works in a in actual plate bending or frame bending case that we will see. We still have some time sorry any way or maybe you have a class after this right; let us complete here today.