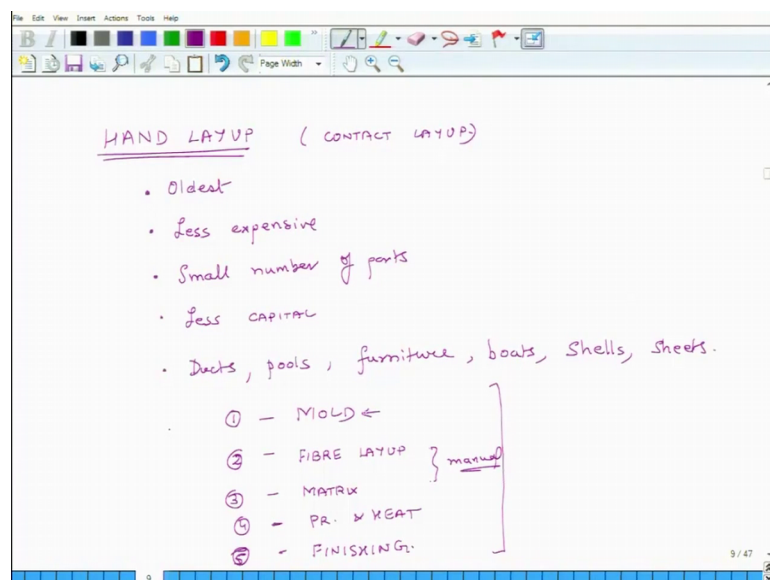


**Introduction to Composites**  
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**Lecture - 21**  
**Hand Lay-Up Process**

Hello welcome to introduction to composites today is the 3rd day of this particular week. And starting today we will start discussing a specific type of wet process, which is known as hand layup.

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Now as I mentioned earlier wet processes are very popular for producing thermoset composites. And the first process we are going to discuss is known as hand layup. And as the name suggests there is a lot of manual labor involved in the process. And the reason it is known as hand layup is because all the placement of fibers is done manually. And you lay these fibers either layer by layer or in you know bundle using manual processes.

This process is also known as contact layup, this contact layup. This hand layup process is probably the oldest process used to produce composites. It is also a relatively inexpensive. So, when I say relatively it is in context of other processes used for producing composites, it is the least expensive. So, it is less expensive and when you use it you use this process, when you have to make small number of parts.

So, for instance if you have to produce 5 particular shapes, 5 shapes of the same type 5 parts of the same shape you may use this process, but if you have to produce 50 000 parts of the same shape then this can become very expensive. So, if the number of parts or the number of if the volume is less than this is appropriate, also it is appropriate when you do not have a lot of money to make expensive tools. Because it requires less capital it requires less capital what does capital mean?

It is money used to produce tools at least in crosses in context of production to produce. So, it requires less amount of tools, it requires less amount of complicated expensive machinery and things like that because a lot of it is manually driven. What do we produce from this type of process?

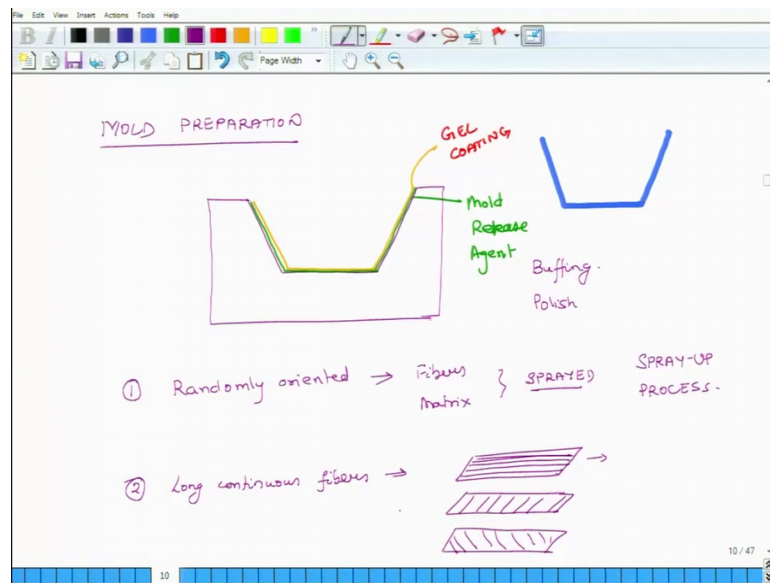
So, we will give some examples we produce ducts we produce swimming pools. So, you want to make a swimming pool in some home you dig out stuff, you know and where exactly, you want to make the swimming pool, you use this process and you construct a swimming pool which is integrated with the ground there.

So, swimming pools furniture again not in large volumes if the number of volume is if the volume is small. Boats, shells, sheets, but again the caveat here is the volume of production is not large and. So, what is what do we do in this process well typically what we do is suppose? I want to make a specific shape. So, what I do is first I make a mold then I put inside the mold fibers in a particular in the desired orientation. And this process is called fiber layup fiber layup. And then I put some matrix material I apply pressure and heat and I also make sure that all the air in the process gets removed and when the curing happens I do some finishing operation.

So, this is the overall process fiber layup. So, this fiber layup putting matrix all this is manual it is not automated. So, we will discuss this further, but before that I wanted to give put some important comments about mold making. So, this is the first step this is second step matrix placement is third application of pressure and heat and we are finally, finishing.

So, we will discuss maybe for a couple of minutes some more detail about mold making.

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Mold preparation this is a very important stage in hand layup process. So, suppose I want to make a shape suppose this is the shape I want. So, what do I do? I make a mold which will be which will have a shape similar to it. So, this is the first step. I make a mold. And this could be made up of something inexpensive.

Now if suppose you want to make a swimming pool you do not want to make the whole mold of metal machining and all that will be very expensive. So, you quickly figure out how to make it make an inexpensive mold, maybe from wood or even from cement and concrete in that and then what, so that is the first step more in the preparation you make the shape. And then if you really are interested in having a good finish.

Then you do several finishing operations. So, buffing is done as the first step, then you polish the surface, you polish the surface and then on top of this mold you apply a mold release agent. Because what you want is that once the composite materials are placed on top of this you should be able to separate it out from the mold, they should not stick to the mold permanently. So, this thing is mold release agent. And then so, this is for mold release agent and to ensure a good finish you also apply a gel coating on top of it.

So, you have a mold release agent and then a gel coating. So, these are thin layers now in the picture they look thick, but in reality they are pretty thin layers. So, this is gel coating and this gives this makes sure that the overall surface has no roughness and it is pretty smooth.

So, this is how you broadly do the preparation of the mold and then you start putting fibers. Now in context of fibers I wanted to say 2 things you can put fibers in 2 ways first ways is. So, it depends on the requirement.

So, there could be a reason why you are interested putting some randomly oriented fibers. So, the fibers in that case so, if they are fibers are randomly oriented if they are randomly oriented. Then what you do is you have small you know lengths of fibers and through some nozzle, you spray them and because you are spraying them they fall in all sorts of orientations. And you keep on spraying it on top of the mold and while you are spraying it on top of the mold through, another nozzle you also spray matrix in fluid states simultaneously.

So, this is. So, here fibers and matrix are sprayed and the application of matrix and the application of fiber is simultaneously and because they are sprayed this is this type of hand layup process is called spray up process it is called spray up process. So, you have 2 nozzles from non-one nozzle you get fibers from another and these are short fibers. They are not continuously long, because they are long then they will not get randomly oriented the short fibers.

A lot of boards chairs all this stuff they are made from short fiber composite, but you can also use this process to make materials which have long continuous fibers. So, this is how you apply the matrix and fibers. The second one is where you have long continuous fibers. So, what do you do in this case? So, in this case it could be that the top layer let us say this is this is the bottom most layer and you want in the bottom. So, here the fibers are deposited in layers they are deposited in layers.

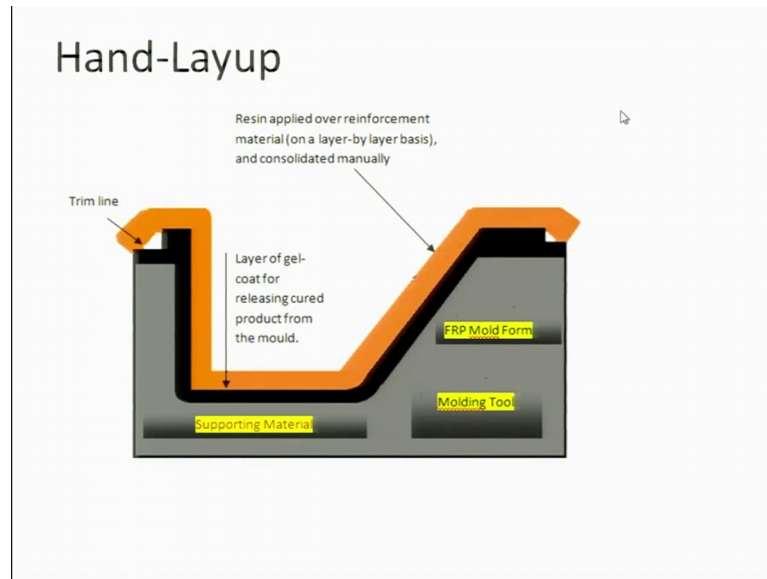
So, it could be that the bottom most layer is having fibers in this orientation. Then the next layer could have fibers it all depends on what your engineering calculation state it could be in this direction. Then the next layer could have fibers at an angle and so on and so forth.

So, what do you do here? You put the first layer of fibers in the required orientation and that is done by hand, because that is done by hand. And then once you have deposited the first layer of fibers then you spray matrix material. And then once you have placed the matrix material you roll the entire surface with some rollers. So, that extra matrix material gets squished off and also the air bubbles get squished off then you place the

second layer of fibers. And then again you put matrix again you roll it. So, that wetting is proper air is removed and layer by layer you build up the whole thing ok.

So, this is the second thing the second way of doing this let us look at 2 pictures, which explain this process further.

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So, this picture is about the hand layer process. So, what do we see here? So, here we have a mold and you see that the mold is. So, suppose you want to make the material which is indicated in.

Student: Black Portion.

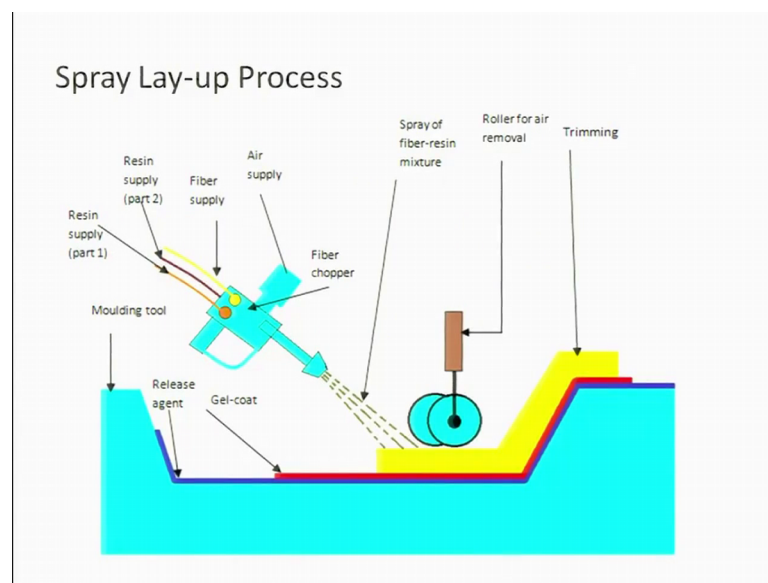
Dark black dark black this is the shape we want to produce. So, first what we do is we make a mold. So, we have a supporting material we have some other mold form and we have basically a mold, on top of that this black portion is a gel coat. To ensure that it gets released from the once you are putting fibers and matrix, it will try to stick to the mold because it is sticky. So, you want you put this gel coat for releasing and also for giving a good finish. And then or in this this orange zone is basically several layers of fibers several layers of fibers.

So, you put first layer of fiber then you apply resin squeeze of the extra material second layer of fibers and so on and so forth then you slowly build it up. So, once you have built up the whole thing and the resin when you are applying it, already has the hardener in it

already has hardener mixed into it, but you do it at a temperature that the curing rate is very small it is not high enough. And then once the whole thing is done then you either apply some heat or you let it remain in that portion and slowly the thing becomes hard, once the whole thing has hardened then you take out this orange portion and that is your final product.

So, this is the hand layup process and most of it is this work is done by it is consolidation is done manually.

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This is the picture which is a schematic for spray layup process. So, this blue thing is your moulding tool on top of the moulding tool as we had discussed is the release agent which ensures removal of the part from the mold, to provide finish you have this red layer which is a gel coat. And then through this tool which has 2 nozzles or in this case at least there are everything is coming from the same hole.

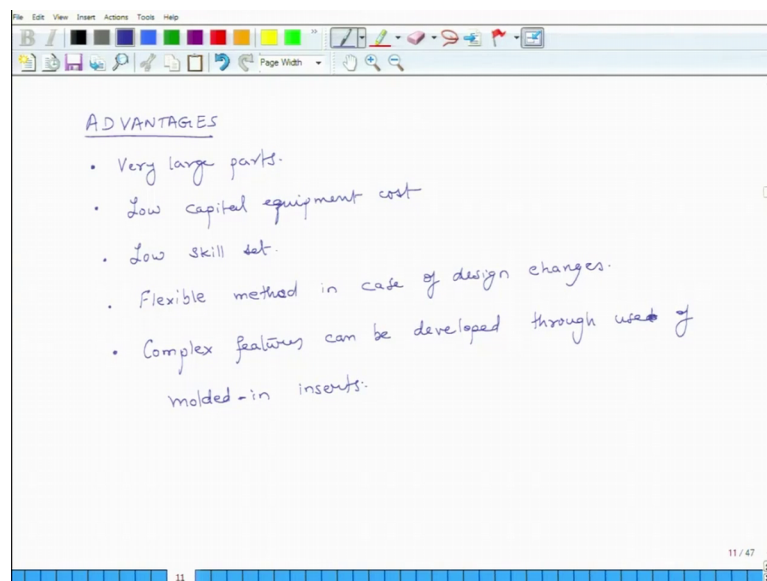
So, you have a supply. So, here you have 3 supplies you have a supply of fiber and this fiber is continuous fiber, but remember in spray layup process we use for randomly orientation. So, inside this blue tool there is a chopper which cuts the fiber into small pieces. So, it cuts it and then it ejects it through this nozzle and as it passes through the nozzle it also gets mixed with resin and the resin has 2 parts a hardener and a part one which is the most of the material.

So, when they mix curing starts. So, all that mixture is deposited in this yellow zone and then to remove air you keep on rolling it continuously using some rollers. And once the whole thing is done, then you let it cure either through heat or at just at room temperature it takes some time. And once you are done you can remove it and then you can trim it at its edges. So, that it has the final shape.

So, the good quality surface in both these processes will be at the interface of the red and the yellow. So, that is the surface which gets exposed to people. So, if you are both the inside of the boat you want it to look shiny or it depends which side of the boat you want to look shiny and smooth that is the side you place at the interface of the red and the yellow zone. So, that is something important to understand.

So, that is about the spray layup process next we will look at we close this discussion on a spray layup process by talking about its advantages and limitations.

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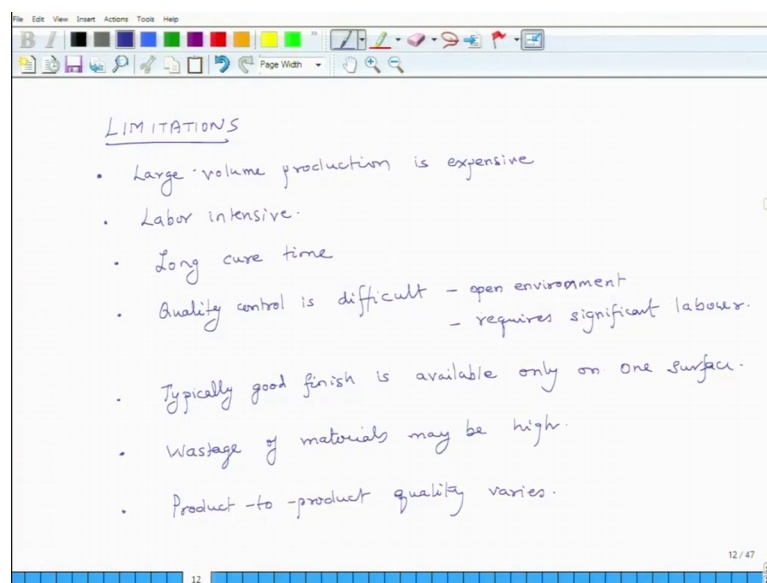
So, let us look at its advantages and limitations. So, the first one is that you can use this process to make very large parts, you do not really need fancy molds and fancy tools to make complex large contour surfaces you know as we talked about swimming pools and boats and things like that.

I have already mentioned that it requires low capital equipment cost; you do not need highly skilled and trained people. So, low skill set because the concept is simple and

once person does this couple of times he or she learns it very fast. So, the charge or the expense associated labor is also not significant.

And it is flexible method in case of design changes because is the design of your part changes, you can very quickly change the tool, which is the molding thing and you can again do it in some other methods change of the tool is becomes very expensive, but here it is not the same thing. And we can make complex features can be developed through use of molded in inserts let us look at it is limitations.

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So, this process is slow and if you want to make 20 000 pools very quickly then this is not the right way to do it. So, large volume production is expensive you can make 1 2 5 10 pieces, but if you want to make 50, 000 cheers quickly then this is not the right way to do it.

Labor intensive and this is again which makes it expensive especially for large production. Typically suppose you are making a large part you cannot put that whole mold in a big oven and heat it very easily. So, what; that means, is that you leave it at room temperature and let it cure slowly and what that implies is that the cure time long cure time. And if it is longer time again you cannot produce very large number of parts in short period.



Quality control is difficult, because it is happening in open environment. So, you do not know at what is the operating temperature from time to time it will change humidity in the air changes all these things change. So, it is difficult because of open environment and also because it requires significant labor.

So, one person does this layup in 3 hours, another person does this layup in 5 hours the quality of the product will be different, because in 3 hours the whole thing is done and it is curing process will be different in another case it will be different. So, 12 varies a typically good finish is available only on one surface, because the other side is open you do not ensure the control quality of the other side ok.

Wastage of materials may be high and finally, product to product quality varies. So, consistency of the product quality is not assured. So, this is what was intended to be discussed in context of hand layup. And we have said we discussed that a specific type of hand layup is the spray layup process and this concludes our discussion on hand layup. Tomorrow we will discuss some other types of wet processes things like bag molding RTM and so on and so forth. So, with this we conclude our discussion and I hope ah we meet together and we continue this discussion further.

Thank you, bye.