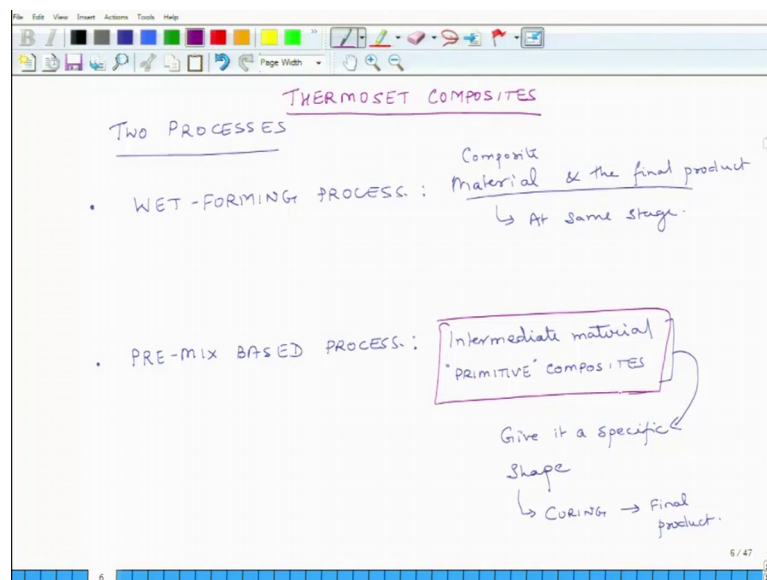


Introduction to Composites
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Lecture – 20
Fabrication of Thermoset Composites

Hello, welcome to introduction to composites, today is the second day of the ongoing week. Today, we will start discussing how are composites made from thermoset plastics made. Now, broadly speaking, thermoset composites or composites which use matrix materials based on thermoset plastics they are made using 2 categories of processes.

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So, there are 2 different processes which may be used, the first process is known as the wet forming process and the second process is known as premix based process. Now, what happens in broadly speaking in wet farming processes? That you take fiber, which is dry you arrange it in some way whichever way you want, these fibers could be either short fiber composites or they could be short fibers or they could be continuous fibers.

So, you arrange them in whatever you way you want and then on top of these fibers you somehow you immerse them in a matrix material which is not cured, it is thermoset material it is not cured and you immerse them and because it is not cured it is liquid. So, you are immersing the fibers in a sea of; wet sea of matrix and because this sea of matrix

is wet, that is why it is known as wet forming process and then in that state you somehow cure the overall composite.

So, you put fibers in a particular orientation in some shape and then you immerse these fibers in a sea of wet matrix, do the curing and you get the final product. So, in this process if you think about it the composite material and the shape or the final product are produced at the same stage, they are produced at the same stage and it is known as wet forming process because the physical state of the matrix, when the process happens is wet, it is not dry. This is not the case with pre mixed raised process.

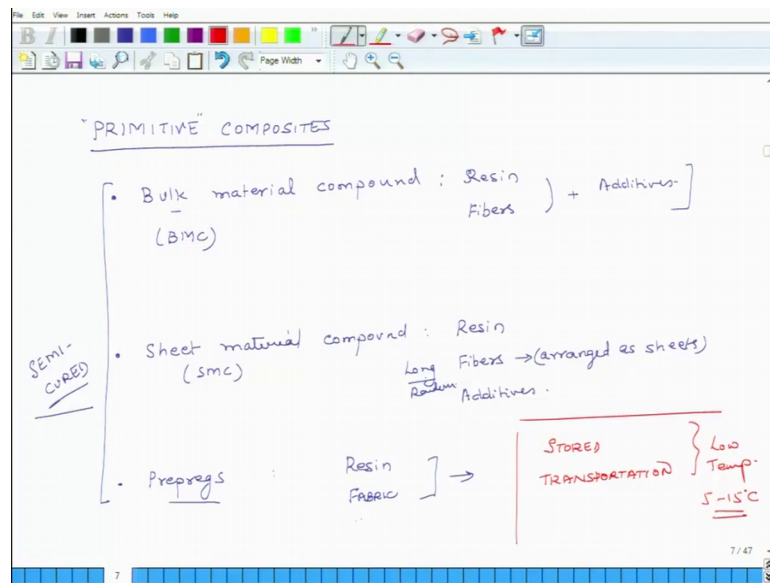
So, in this you have you start with an intermediate material, sometimes these intermediate materials are called primitive composites, these are called primitive composites it is an intermediate material, it is not the final material and in last class we have discussed that these could be of 3 types, bulk material compounds, sheet metal material compounds and prepregs. So, it is an intermediate material and the nature of this material is not wet, it may be somewhat tacky, sticky, but it is not exactly wet.

This material if you place on a flat table it will not flow by itself, but it is deformable it is like dough. So, this intermediate material you give it a certain shape; give it a specific shape and then apply heat and pressure, so that the curing starts. So, you give it a specific shape and then after application of heat and pressure curing starts and you get the final product.

So, this intermediate material is a mixture of fibers and matrix, but the matrix in this intermediate material is not fluid it is gooey dough like, so this is the final product. So, in the pre mixed based process it is not a wet process, it is not I will also not call it dry because it is still sticky, but it is certainly not wet process . So, this is, these are broadly speaking 2 categories of production processes used for producing thermoset composite materials or thermoset composite structures.

So, these are for remember, these are for thermosets; thermoset composites. There are different types of production process for thermoplastic composites, for metal matrix composites, for ceramic material composites, for thermo set these are 2 broad categories they are not themselves by processes, but within each of these there are several processes. So, let us discuss a little bit more about these primitives. So, we will look at a little bit more about primitives.

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So, we said that there may be 3 categories. So, the first 1 is bulk material compound, what is bulk material compound? It is a mixture of resin, so this resin could be a polyester resin or an epoxy resin or all the types of pre cell thermoset resins, which we had discussed.

So, it has resin, it has fibers and so by fibers I mean fibers not sheets, not mats, it is having fibers and then it can have plus additives and these additives could be of all sorts of types and this mixture is then semi cured, it is semi cured. So, you also add to it a reaction initiator or a trigger or a hardener all these terms which we have discussed earlier and you slightly heat it. So, the things starts curing and let us say once it is semi cured, it is not fully cured, so it is not of solid in shape at that time you take it away and this is called a bulk material compound or BMC.

The second one is SMC or sheet material compound . So, this bulk material compound it comes as dough in form of dough, it does not have a definite shape, but it has the consistent, it has the shape of dough and it also has the consistency of dough you can change it is shape in whatever way you want.

Now, here you have resin and you also have fibers, but the difference between SMC, which is sheet material compound and BMC, which is bulk material compound is that here fibers are arranged as sheets. So, you have a sheet of fibers and these could be

continuous long fibers and then you take it and you mix it with resin and you get this thing sheet material compound and then of course, you have other additives also.

So, in sheet material compounds you have basically long fibers and you have sheets and the third one are known as prepregs. Now here, what you have is resin, then you have fabric. So, fabric means what? It is having, it is also in sheet form, but the fibers are in both the directions, fabric has fibers in both the directions and then yeah, and typically you do not have a lot of additives, not a lot of additives in prepregs.

So, you can have long fibers in sheet material compounds or you can also have randomly oriented fibers in sheet material compounds and prepregs fibers are highly oriented, you will know how many fibers per square meter are in the long 1 direction and other 90 degrees direction, you have that knowledge, so this is there. So, these can be long fibers or randomly oriented. So, you have this is the third class and all these guys are semi cured.

So, if you take this material. So, in case of bulk material compounds you have the overall raw material is in shape of dough. So, if you want to make a part like this you have to give it a shape like this and then you somehow cure it and you will get a part like this. In sheet material compound basically you get sheets and you can put 1 sheet over top of each other and then you can press it in any form or shape you want and then you can heat it and press it and then it will get fully cured and something similar happens in prepregs, but the distinction is that here the orientation of fibers is highly oriented and you have in both the directions and you do not have a lot of additives, so that is there.

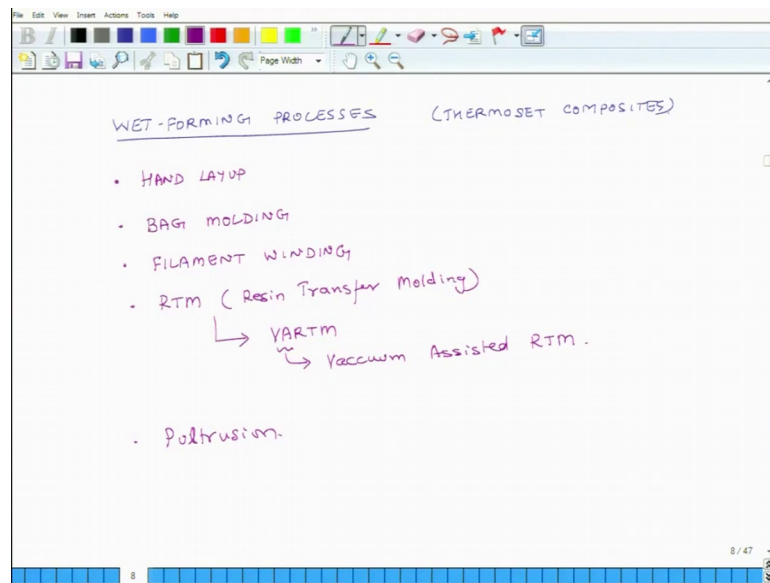
Now, I have said that here the primitive composites are semi cured, what that means is that, if I take a piece of some primitive composite material and put leave it at room temperature maybe after 24 hours or 48 hours it will be finally cooked, because of; because the racks reaction keeps on going all the time continuously. So, these materials are typically they are stored and even during transportation or during storage they are exposed to maintained at low temperatures; they maintained at low temperatures, this could be as low as 5 degrees to 15 degrees centigrade or sometimes even lesser.

So, when you want to make these composites from these materials, you take them out of a cold place where you store this and then you put them in the right shape, apply heat, apply material, apply pressure and at elevated heat and pressure it the reaction into it

becomes accelerated and it gets cooked and it freezes into the final shape. So, these are this is what I wanted to talk about bulk material, SMC's and preregs.

So, we will come back to primitive composites and these materials later, but now, we will go back to the first category which is wet forming process. So, I had explained that these materials are belong to the category of wet forming because the composite material is when we are fabricating the matrix is in wet state and this is what we want to process.

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So, we will start discussing wet forming process in detail. So, they are broadly speaking 5 or 6 types of important wet forming processes and once again these processes are applicable for this type of composites, thermoset composites.

So, let us discuss or let us first list all the different processes which we will discuss in detail. So, the first 1 is called hand layup and the hand layup is itself of 2 categories, we will discuss that later; the second 1 is bag molding, the third 1 is filament winding, the fourth 1 is RTM and RTM is a short form of resin transfer molding and there is a special category of RTM known as VARTM, VARTM and what does that mean? VA stands for vacuum assisted resin transfer molding and the last category we will discuss is pultrusion.

So, these are 5 important categories of wet forming processes, starting tomorrow we will start discussing hand layup and will discuss all these processes and then we will move to

fabrication of thermo plastic composites, metal matrix composites and ceramic based composites. So, that concludes our discussion for today, I look forward to seeing you tomorrow for this course.

Thank you very much, bye.