Introduction to Composites
Prof. Nachiketa Tiwari
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture – 22
Bag Molding Process

Hello welcome to Introduction to Composites course. Today is the fourth day of the ongoing week and what we will discuss today is another type of wet production process used for thermoset composite materials and composite structures. So, yesterday we discussed the hand layup process, today we are going to discuss a process which is known as bag molding.

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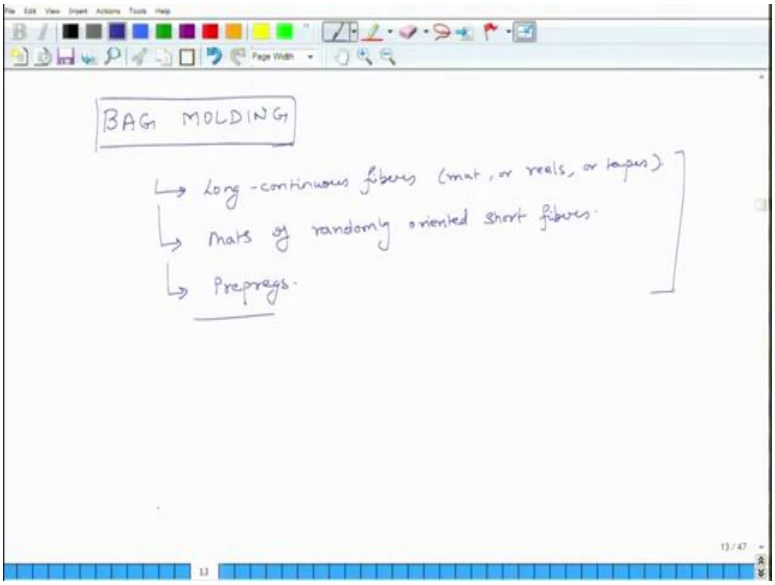

The reason this process is known as bag molding is because the entire process happens inside a bag, inside a bag and why is this bag used we will see it later.

Now, if you are an engineer and you are doing some research in composites and you want to make high quality composite plates with the right type of orientation or some curved panels and so on and so forth chances are that this particular method may be the most appropriate method to meet your needs. Also a lot of high end engineering applications which use thermoset composites materials they rely on some version of this particular bag molding process.

So, it is a very popular process. It is significantly more expensive than the hand layup process, it also requires one to be very careful while the process is being you know implemented, but then it produces parts which have consistent quality between different you know parts and you know these produce the same part and you follow the process it will have the same quality and the quality is high. And the time taken to produces parts is also less because this does not necessarily happen at room temperature, we often, not often more most of the cases we apply extra heat to accelerate the curing of the matrix material.

Now, this bag molding process can be used either if we use long continuous fibres, now these fibres can be inform of mat or reels or tapes, we can also use this process if we have mats of randomly oriented fibre. So, you can buy sheets, very thin sheets of randomly oriented fibre. So, they are sheets with randomly oriented fibres and these fibres are short in length. So, you can use bag molding process to make composites of using this materials also. So, bags of randomly oriented short fibres or you can also use prepregs. So, what are prepregs? They are mixtures of semi cured matrix and continuous fibres in a mat form and these are highly oriented fibres. So, you can use either of these and you can use the bag molding process to make high quality composite structures and materials from this.

So, what do we do in this? So, typically you put you have a mold and in the mold you put layer by layer these fibres and after you put each layer you still apply a coat of matrix and if it is a prepreg you do not have to worry about matrix because its already I am there and you put them in a specific sequence which you want and the entire thing is then put inside a bag and a part of the bag is connected to vacuum. So, what happens is that because of that all the air which is there in the system it gets sucked out and while the air is being sucked out the porosity of the system becomes less and while it is happening you can also apply heat and because the vacuum is there. So, there is also a pressure on the composite. So, it is also experiencing some pressure. So, because of this heat and pressure, because of heat the reaction of curing is faster, because of pressure because of attributable to vacuum you have higher density and more consistent materials.

So, this is what this bag molding process about and we will some see some pictures to understand this in a better way. So, actually probably the best thing is to see a picture to get an idea what this bag molding process is all about.

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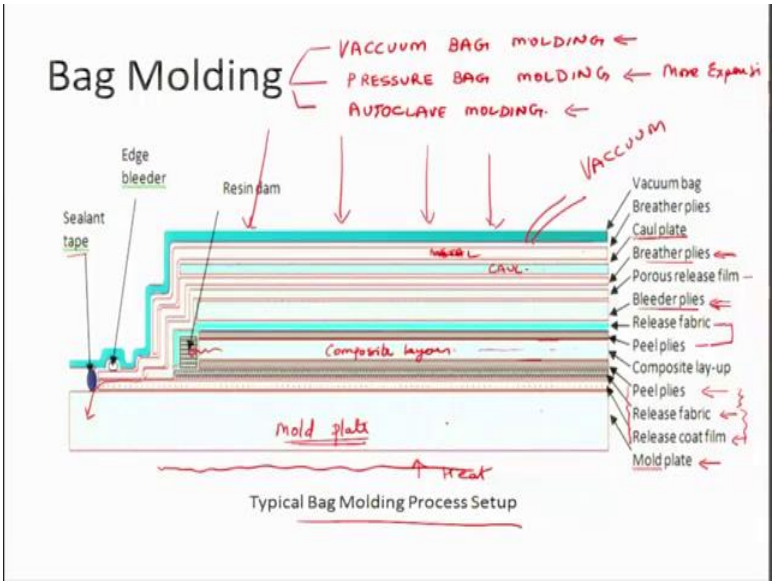

So, let us look at this picture and you will see a lot of terms. So, here what we are trying to do is we are trying to make a rectangular flat plate of composite material.

So, in that case we have a mold plate. So, this is my mold plate. So, it is made up of steel it is a rectangular plate because an a flat because I want to make a flat rectangular plate of composite and its thick because when I apply heat and pressure it should not bend. So, this is the mold plate on top of the mold plate I spray it with the release cost film. So, this is my dot dot dot this line is a release coat film. So, what does this ensure? It ensures that whatever composites is being fabricated its epoxy does not get bonded to the plate. Otherwise I make the next part it will the mold plate surfaces not good then it will get destroyed. So, I have to make another mold plate. So, that is a purpose of the mold plate.

Then it is not just a film I also put a release fabric. So, release fabric is again a non sticky surface and that also serves the same purpose and then I put some peel plies. So, what do these peel plies? So, all this peel plies, release fabric, release coat film all these 3 guys correctively they ensure that the mold plate is protected against the epoxy, collectively.

And the way all this happens is that once, one plate has been produced you remove the composite plate you peel of the plies that is why it call a peel plies you peel of the plies and you also remove the release fabric put a new peel plies put a new release fabric and then you again build up these entire sequence. So, that is why this type of process is

much more expensive because each time you make a plate you have to use a new peel plies and new release fabric and also probably spray some more release film.

So, once these 3 things are done then you have a composites layup. So, this is these are composites layers. Now, if these layers are made up of just fibers. So, you put them layer by layer and each time you put a layer you put some matrix material roll it make sure all the air is squeezed out put another layer and so on and so forth. If you are using prepreg layers you put first layer put the second layer on top of it, in the right orientation which you want again there also you roll the you put a roller to make sure that the between the layers there is no air. So, you keep on rolling removing the air.

Once all that is done then again you have peel plies release fabric on top of it again you have on top of it the same thing and once you have put this then you put something known as a bleeder plies bleeder plies. So, what does this do? So, ultimately what is happening is that you apply some sort of a pressure between the top plate and the bottom plate and here you have matrix and matrix material is fluid and even at higher temperatures there is flow of matrix materials even from the prepregs at higher temperature

So, all that flow happens and extra flow it has to be absorbed somewhere. So, that is why we put some bleeder plies. So, they absorb, it is like a layer of I will not call it cotton something it looks like cotton. So, it absorbs this extra flow it absorbs this extra flow and, but it goes through the peel plies and release fabric. So, these peel plies are having good finish. So, the top surface finishes also ensured on the bottom side also you have a peel plies. So, that also is assured because of peel plies and then on top of bleeder plies you have again a layer of release film bleeder plies. So, all these are. So, bleeder plies allows all this flow to go and it absorbs it and these bleeder plies are placed. So, that all the extra air can get out and then on top of it you have caul plate. So, this is again a metal thick metal plate and then you have some more bleeder plies. So, I am sorry this is the caul plate, caul. So, this is metal and then you again put some bleeder plies and the entire thing is captured in a bag, it is put in a vacuum bag. And what else do you have?

So, at this end you seal the bag using a sealant tape. So, as you see I mean it is a very complicated structures just to make one structure you have may be 10 12 different parts and all these parts get thrown off and then you put a new set of parts in each production

process. So, it is expensive, but it gives very high quality parts. So, the sealant tape ensures that air from outside does not come in and may be here you can connected to vacuum. So, all the air gets sucked out you also have a resin dam because as resin flows you want that this resin should not leak out, because otherwise resin can leak out and it can come again touch here. So, you have a dam of resin it is made up of some absorbent materials. So, it also absorbs this extra fluid which is flowing and you connect it to vacuum. So, this is the typical bag molding process setup. And you this entire in a plastic bag connected to vacuum and you remove all the air. So, this is the whole thing.

And then of course, from here you can heat it, so you can have some resistive element here and you can have current flowing through this so the entire thing gets heated and that ensures that the curing happens at a faster rate and if you keep the temperature pretty high may be 170, 200 plus degree centigrade may be the whole curing can happen in a couple of hours and then you slowly cool it or move it and take out a composites and cut it to the right dimensions and that is what your output is going to be. So, this is what bag molding process is all about.

Now, this bag molding process is of 3 different types. So, this bag molding process is of 3 different types the first one is known as vacuum bag molding, vacuum bag molding. So, what happens in this vacuum bag molding is that essentially we rely on vacuum to remove all the air and also when vacuum is apply what will happen if there is vacuum inside the bag you will have external atmospheric pressure press the whole thing right and that atmospheric pressure presses the whole thing and all that pressure gets transfer to caul plate and ultimately it gets absorbed by the mold plate.

So, the whole thing becomes dense and you have a good consistency high quality part also because this pressure is there air also whatever a small air bubbles are there they also get squeezed out and the surfaces becomes flat. So, this is what vacuum bag molding is about.

The other one is pressure bag molding. So, in this case we do not use vacuum pressure, so vacuum pressure can only give you one atmospheres of pressure, but rather we put some extra pressure, we do not rely on vacuum. So, that is why it is called pressure bag molding. So, you put some extra pressure using some source of high pressure and the

third one is auto clave molding and we will explain autoclave molding later, but let us look at this two pictures.

So, vacuum bag molding is very popular is very popular. So, it is autoclave molding. So, between these 3 vacuum, pressure and autoclave this is more expensive. And the reason it is more expensive is that you have to make specialized tools for each particular shape. So, you want to make a chair, not the chair a flat plate of some dimension you have to make tool off particular size, you want to make a curved plate you have to again make a different type of tool, but in vacuum bag molding and in autoclave molding these specialized tools are not required. So, as a consequence these are relatively less expensive. So, this is important to understand.

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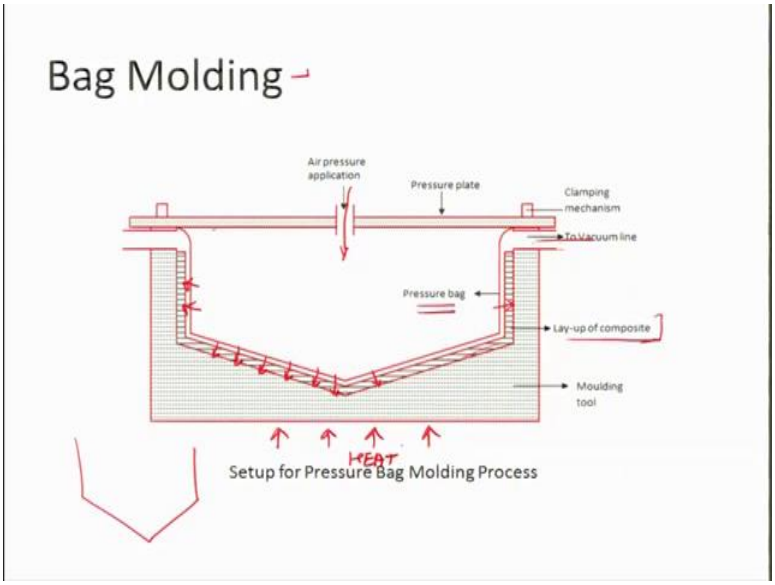

So, let us look at bag molding process a picture for bag molding process. So, what do you have here? This is your, remember this when I say layup it has all these layers all these layers are not shown in detail, but all these layer exist in this picture they should exit. So, you have molding tools. Suppose I want to make a tool like this right, like this, this is the part which I want to make. So, this is the lower side of the tool, this is the upper side of the tool and then I have pressure bag, so this is my pressure bag and what that means, is the bag should have the same shape as the inside surfaces of the part.

So, if I want to change the part I have to change this pressure bag and from here I apply extra pressure. So, I can put 20 30 atmosphere of pressure. And of course, here, when

this pressure is there this pressure uniformly the reason why I use the flexible pressure bag is because then it uniformly apply pressure on all the surfaces. If I use the metal part it will not dispute the thing uniformly. So, it applies pressure uniformly and then of course, I also have a vacuum line to set out all the extra air. So, this is the pressure bag molding process, this is the pressure bag molding process. The second process, so that is why because this tooling is specific to the shape it is more expensive.

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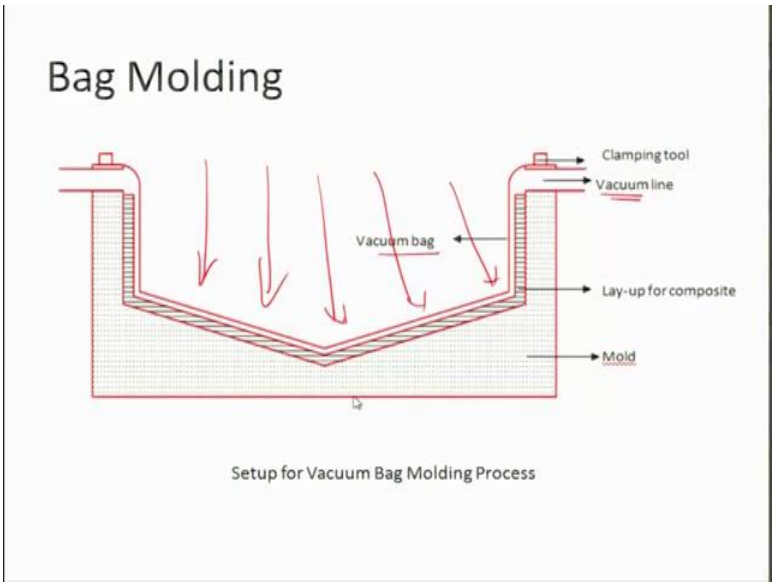

In this thing, this is the vacuum bag molding here I use a vacuum line and here see here I have to connect this pressure bag with this top surface I have to make a whole, all this is specific. So, here I do not need all that stuff. So, this vacuum bag is there and I just remove the air from inside and the moment air gets removed from inside atmospheric pressure starts acting automatically and it pressure the thing and that is why this is relatively less expensive.

And the third method is known as autoclave molding; autoclave molding and in that we apply both pressure as well as heat. So, in this case also heat is being applied from here heat is being applied from the lower side because you put heater, but in an. So, let us make it clear I do not want to rush this. So, heat comes from here. You have resistor heaters and heat comes from here. In vacuum bag molding again you have heat coming from the bottom side, but in autoclave it is a little different.

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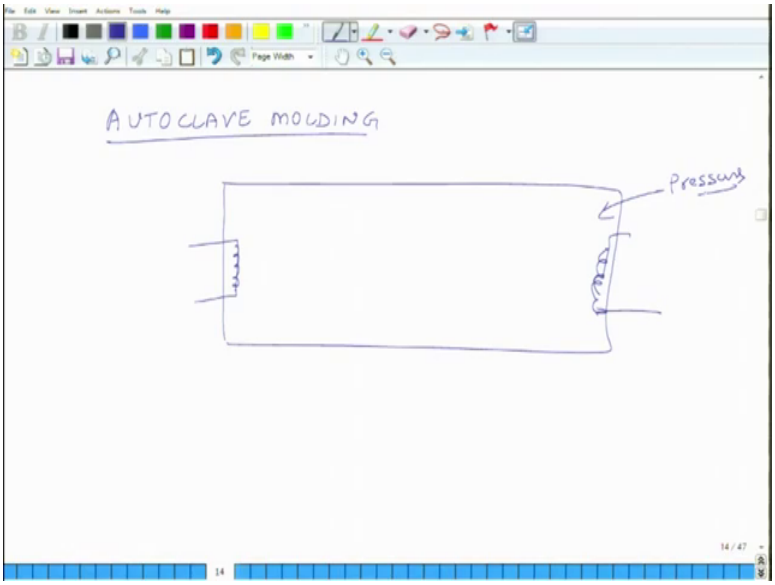

So, let us look at what happens in autoclave molding. So, to understand what happens in autoclave molding we have to know what an autoclave is. So, what is autoclave? Autoclave is a big empty cylinder and in this big empty cylinder you have some heater coils you know. So, through this heater coils you heat up the whole surfaces. So, it is not that heat is coming from one side the whole ensite chamber is heated up the whole ensite chamber is heated up and also you apply a pressure. So, the pressure inside the whole thing is also high.

So, it is a big chamber there could be autoclave which could be bigger than large rooms you know even with big rooms size autoclave are there or you can have small autoclaves. So, autoclaves inside an autoclave you have uniform high temperature and uniform pressure. So, that is what happens in an autoclave. So, what do people do when they want to use autoclaves to produce this part?

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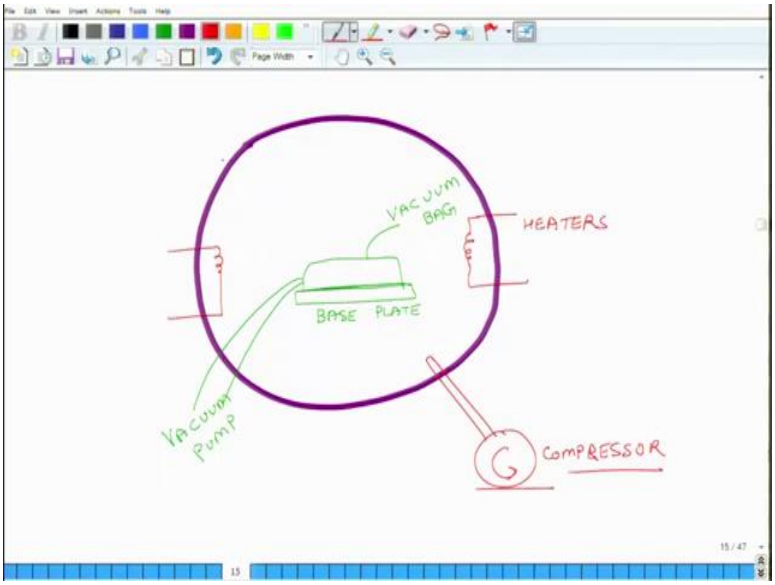

So, let say this is a big autoclave. So, this is a big autoclave it is like a cylindrical chamber, it could be of any shape we have electric heaters. So, these provide the heat and maintain the temperature inside the heater and then inside the chamber you can have a base plate suppose I want to make a rectangular panel of composites. So, I have a base plate and on top of this I have a vacuum bag, I can connect this vacuum bag to a vacuum pump, and to increase the pressure inside this what do I do? I have a pressure line.

So, this is a compressor and what this compressor does is, it maintains the pressure in the chamber at a high level you also have a vacuum bag which is connected to a vacuum pumps. So, inside this vacuum bag we have the entire layup of the product. So, this entire vacuum bag with the base plate is sitting in the autoclave, heat is coming from the heaters, pressure is coming because of compressors. So, the thing gets cured quickly and because of the presence of vacuum as well of this pressure all the air and porosity gets minimized. So, here again this is less expensive because you can use the same autoclave for all different types of parts as long as the part can fit in the autoclave. So, even if you have to make a big aircraft wing you can make a very large autoclave and you can put several aircraft wings in it and produce the same part continuously. So, this is what autoclave bag molding process is all about.

So, we have couple of more methods left for wet processes specifically resin transfer molding process and a particular flavour of it known as (Refer Time: 23:48). So, we will

discuss those processes tomorrow. So, till then have a great night and we will meet tomorrow.

Thank you.