

Food Packaging Technology
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Week – 01
Lecture – 4
Paper as packaging material P2

Welcome again to the NPTEL course Food Packaging Technology. So, in the previous session we had discussed about the different types of pulping techniques. We had seen mechanical pulping, chemical pulping and semi-chemical pulping. We have also seen what is chemi mechanical pulping and after pulping the pulps are moved to the sheet processing section. Sheet processing; it is the production of paper of varying types and this depends upon the raw material. Type of paper that is required in the final stage and most of the paper and paper board productions include stock preparation, paper machine processing and finishing process. The stock preparation includes mechanical squeezing and pounding of cellulose fibers which penetrates the water to enter into the structure which causes swelling and also makes it flexible. Usually, mechanical action it separates the fibers, the small fibrils they are separated at microscopic level. This beating it reduces the rate of drainage from the fiber mat and producing a dense paper of which has high tensile strength, low porosity and stiffness and so this what it is done during stock preparation.

We prepare the fibers, pulping it releases the fiber but then these fibers they need to hold the water, so the flexibility can be improved and this is done using beating. Generally, we use Hollander beater for the beating purpose. A Hollander beater is an oval tank which contains a heavy roll which revolves against the bed plate and the roll is set accurately with respect to the bed plate. It is a progressive adjustment and beater can hold a stock of around 135 to 1350 kg and it has various dimensions. The common one is 7 meter long, 4-meter width and 1 meter diameter. There is a central partition in the center which helps in the continuous movement of the pulp or the stock.

So if you look at this picture here, this is a Hollander beater and you can see the central division here which partition which helps in the movement of the stock. Pulp is put into the beater and water is added to it which facilitates the circulation of mass into the Hollander beater. For this the roll also plays a very important role. It helps in circulating in the movement of the mass and as the beating proceeds the revolving roll is lowered and it rides on the fiber so fiber is placed between the roll and the bed plate and it runs completely over the fiber. This splits up the fibrils the fibers are split into small fibrils they are cut into a similar to hair and very thin fibrils. This helps in increasing the

absorption of water and when the water absorption increases, they become slimy in nature. So, the beaten fibers they are drained slowly by putting the pulp over the wire and the bond and beating also results in rubbing of fibers against each other which also produces friction and breakdown of the fibrils.

This is the general procedure what we have been discussing. Woods are collected and debarked. They are ground and chipped and after chipping these are screened and unwanted particles which are larger in size are removed. These are washed after screening and these are passed into the digester. Now you can see here the digester which has a conical V-shaped bottom and a dome shaped top inside the digester. The chemical digesting is done and these digested materials they are subjected to bleaching and then these are beaten and the pulp is used for developing the paper. Now this is schematic first paper machine which was developed by Lewis Rebert and this is a conical refiner machine which helps in improving the quality. During the beating process we can also add additives and other mixing agents like for sizing and for filling and dyes. These can also be added during the beating process and sometimes we use the perforated cylinders. So, these perforated cylinders they are partially immersed in the beating stock. These helps in removing the water and in modern mills we can go for continuous refiner also where we are using bail pulp. The pulp which has been stored as a sheet can also be used in the beater. Initially they are defibered using pulper. This bail pulp can also be used for developing paper sheets, but initially they need to be pulped ie they are subjected to pulping in pulper.

Pulpers are large open vessels with one or more blades rotating and these circulate the pulp water mixture and separate fibers and also blades. They transform the bails into a smooth mixture. So, it's a slimy appearance but these pulpers they do not have freeness and it also cause fibrillation of the fibers. The capacity of pulper is around 900 kg and the horsepower uses 150. So, we can go for higher pulpers also and the fiber content is around 6%. Then the papers are subjected to sizing that is the treatment of paper to prevent aqueous ink solutions to be soaked. Usually, the papers are used for printing and the ink should not be soaked into the paper it should be clear and legible so for this reasons sizing is done. For sizing we use rosin soap which is dispersed in stock that is 1 to 5% of fiber. According to the amount of fiber, 1 to 5% of rosin can be dispersed in the stock solution. We are also using aluminum sulfate or alum as a coupling agent so the acidity of alum, it precipitates the resin and rosin dispersion. The positively charged aluminum ions and aluminum hydroxides they flock together and to the negatively charged fiber surface. So, this helps in sizing the paper. And paper which are intended for writing purpose and printing they need to have brightness or they should also contain white pigments or fillers. That can also be added during the wetting process and when we add fillers or whitening pigment they improves the brightness of the paper opacity is also

increased and also it smoothens the surface so thereby the receptivity of the ink increases. The ink will not spread on the surface of the paper. So, generally we use clay titanium dioxide as an admixture, calcium carbonate is used as a filler which imparts brightness opacity and ink receptiveness. There are other fillers like zinc oxide, zinc sulfate, hydrated silica, calcium sulfate, hydrated aluminum talc, barium, barium sulfate etc. which can also be used as a filler. The filler composition is like 1 to 10% of the fiber. And colored papers these are dyed papers. They are dyed with colors and this can be used direct dyeing or basic dyeing. In dyeing, there is a natural affinity to the cellulose. We are using pure cellulose and the dye will have definitely towards the cellulose in basic dye generally ground wood pulps or unbeached pulps are used. The dye has affinity towards such kind of pulps and to increase the dry strength of paper, we can add starch, cationic starch or polyacrylamide resins gums like locust bean gum and guar gum can also be added to increase the dry strength of the paper whereas to increase the wet strength of the paper, organic resins can be added the resins. They change the paper to an insoluble form and which creates a resistance between the fiber thereby when it is wet it does not dissolve. So wet strength can be increased and generally the papers are held together by hydrogen bond and Van der Waals force.

Now after the pulp has been subjected to beating the other additives have been added. These need to be bleached and washed. So, initially in earlier times like before 19th century, for bleaching, calcium and sodium hypochlorite were used and it was single stage treatment. It was done using calcium hypochlorite or chlorinated lime and this had a low consistency. However, it was not practical for craft paper because craft paper it is difficult to be bleached. So multi-stage bleaching methods were developed and the bleaching was done at different stages it depends upon the type of pulp that is unbleached pulp and the requirement, how much it need to be bleached. So, depending upon that the multi-stage bleaching system can be used and presently we are using the multi-stage bleaching system. In this the first step is to treat the unbleached pulp with chlorine and this is done by 3 to 4 percent gaseous chlorine which is mixed with the pulp at a temperature of 21 to 27 degree centigrade and this increases the acidity of the pulp and the chlorine gets absorbed by non-carbohydrate components of the pulp and but it has no lightning effect it doesn't brighten the content. Usually, it is not dissolvable in lignin, solubility is less in lignin. In the second stage, it is alkaline extraction which is done using caustic soda. Dilute caustic soda, it dissolves the chlorinated compounds and then it is washed out and in the third stage it is treated with alkaline hypochlorite to neutralize the solution. So, we are using caustic soda in the second stage so this need to be neutralized and after this we are going for a final wash and small amount of chlorine dioxide it helps in achieving high degree of purification and brightness. But at the same time, it does not disintegrate the cell. So this is the multi-stage chlorination or multi-stage bleaching system and brightness of paper it is determined by special reflection meters

which contain photoelectric cells which measures the amount of light of selected wavelength that is reflected by the surface. Generally, the pure magnesium oxide is taken as the standard and on the brightness scale it is given a value of 100 and the other values they are compared with the value of pure magnesium oxide. So unbleached sulfide and ground wood it has a value of 50 to 62 in case of peroxide bleached ground wood it is 66 to 72 and single stage hypochlorite or single stage bleach sheet it has 80 to 85 multi-stage bleach pulp it has 85 to 88 and multi-stage with chlorine dioxide it has 90 to 94 so the bleaching improves the brightness of the paper. Now after the bleaching has been done it need to be converted to sheet and it is done in the paper machine the paper stock form to sheet of the desired weight by filtration pressing and consolidating the sheet with the removal of excess water so in the paper machine the pulp it is spread over the wire or over the spins and then it is pressed to remove the excess water the paper machines. They're generally 1.5 to 8 meters long and the operating speed will be 100 to 900 meters per minute. It produces around 1 to 300 tons per day and the paper weight it may vary from a light tissue paper like which has 10 grams per meter square and to boards which has the weight more than 500 grams per meter square. So, the paper weight can vary from 10 grams to more than 500 grams and all this can be done using one single machine. The paper machines there are two types that is Fourdrinier machine and cylinder machine. In Fourdrinier machine, the diluted suspension of the refined pulp, is deposited on the fine moving vibrating mesh belt. By a sequence of draining, vacuum filtration and pressing, the water is reduced to four to eight percent and then it is subjected to drying. From the belt, the network of fiber is collected and in the cylinder machine, we have six or more wire mesh cylinders which rotate partly immersed in the suspension of cellulose fiber. They pick the fibers during the movement and these fibers are deposited as layers on the moving belt and also water need to be removed from the layers of this fiber mat. In the model, Fourdrinier machine, we have different parts; head box - it helps in the continuous flow of wet stock at a continuous constant velocity. It is also called breast box or flow box. Then we have a stock distribution center, which distributes the stock to different to the table or it helps in moving the stock to further in the line. Then we have dryer table where the sheet is formed and drainage occurs. It supports the table rolls, breast roll, couch roll, suction boxes, wire roll and other parts. These parts, they help in removing the water from the mat and we also have dandy roll which helps in smoothing the surface so it flattens surface of the sheet also gives finished appearance the next section is press section where the moisture is removed. So, the wet sheets are received, they are pressed between the woolen pelt and it delivers the dried sheet. We don't go for other kinds of pelt in the press section. Specifically, woolen pelt is used and moisture need to be reduced and it need to be made compact. In the drying session, it is passed to a series of rotating steam heated cylinders which removes the remaining moisture content and then the sizing is done in the size press. It permits dampening the sheet surface with a solution of starch glue and other material which improves the surface and this also improves the

strength of the paper. Then it is stacked in calendar stack, where it is compressed and smoothed and then it is rolled over the wheels. So, this is a dryer machine and you can see the wheels. Over here, the paper will be rolled over the wheels, once it is finished. The last step in the production of paper is finishing. So, like the term suggests it is the converting stage, where the paper becomes useful for the consumers. It involves use of intricate and fastmoving machinery. Finishing is generally done by two methods that is wet conversion and dry conversion. In the wet conversion method, the paper in the roll form, it is coated, impregnated and laminated with materials to improve its properties. These papers are used for special purposes. In the dry conversion method, the papers they are converted to bags and gloves boxes and rolls and other sheets. So, there are different methods of finishing the papers. After these two methods, wet conversion and dry conversion method, finishing can be done and after coating on the surface of the sheet. It gives uniformity. It also helps in reproducing the images after years and visibility of eye is enhanced. It also enhances opacity smoothness glossiness. It is economical in weight. Therefore, coating is important and it can be done using titanium dioxide, calcium carbonate, satin white. Combinations of these can also be used to get the finishing. This can be done on machine coating or off machine coating or extrusion coating can also be done. On machine coating, the coating is applied between the drying process whereas off machine coating, the coating is done separately. In the extrusion coating, the polyethylene plastic coating is given to papers or paper board. This polyethylene, it helps in improving the properties, it gives a waterproof resistance to grease water vapor and gas barrier properties. It improves the flexibility during heat sealing and it also avoids the odor and toxicity from the paper. So, these are the different methods of coating.

With this we have come to the end of paper manufacturing process. In the previous sessions, we had seen how the pulp can be developed from the wood and what are the different types of wood. What are the different methods for pulping and once the pulp has been used. How the stock can be prepared and how the stock needs to be bleached. What are the different machineries that can be used at each step and before it reaches to the consumer. How it is finished or what are the different methods to finish the process that also we have seen so with this we'll wind up for today. Thank you!