Textile Finishing
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Lecture-31
Waste Heat Recovery

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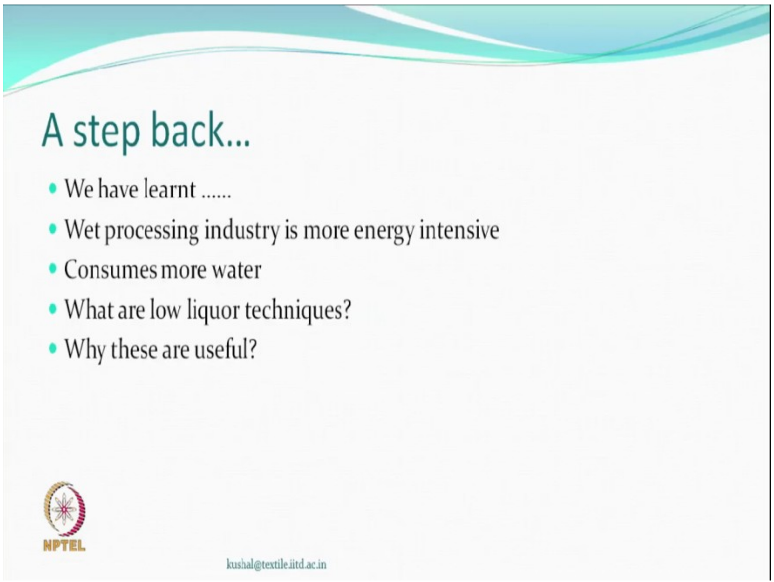

Welcome back to this class on textile finishing. What did we do last time? We learned that wet processing industry is an energy intensive industry. It consumes more water and therefore, more liquor is required, and more liquor has to be dried and so you have to spend more energy, so, less consumption of water will always be a good idea. So, we did learn about low liquor techniques or which sometimes we are known as minimum application techniques.

They were useful, is not it? They were useful because you less use less water. If you have less water, you evaporate less evaporate less energy is consumed. So, in some way, you are helping the environment and of course, saving some money also. So, this energy management.

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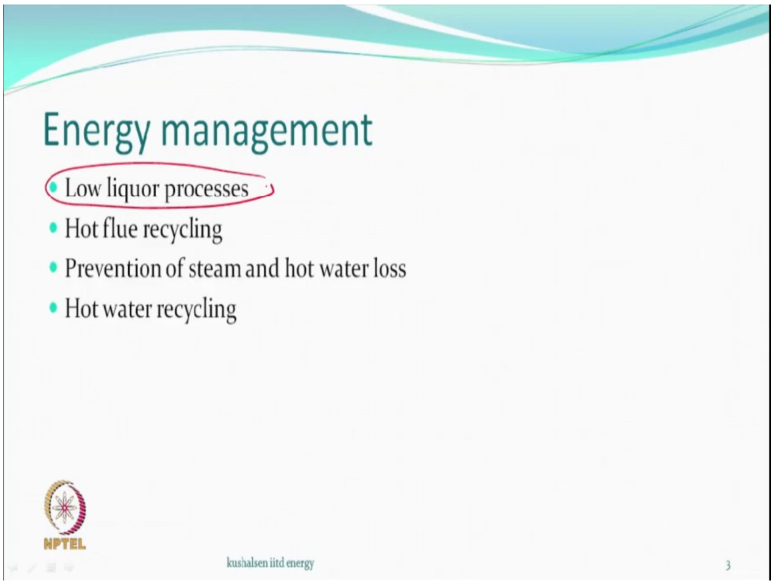

We talked about low liquor techniques. We did talk about the low liquor techniques. Now, what else can be done? So, one is hot flue recycling. So, there is hot flue that means some gases exhaust or otherwise, can we do recycling of that? If it is possible, of course, common sense prevention of steam and hot water losses and hot water recycling all of them are methods with which you can use the energy which is already there for the new process, a new process cycle.

So, that way you can recover. So, all this will be in some sense known as the heat recovery processes. So, where the heat is wasted are likely to be wasted more all right driers when you have a drier then you have to supply hot a fresh air which has to be heated fine then the moisture comes out of the fabric in the chamber you know it becomes more and more moist than the rate of drying will obviously be affected. So, you want to remove part of the hot air, so that fresh air can be brought in.

So, that moisture level within the chamber is controlled, optimized, stenters which do drying as well as curing you require hot flues are going to be coming the exhaust will be hot dyeing machines where the hot liquor is going to be coming out preparatory machines there is something hot liquor may be coming out. And so many processes will be there as a unit operation in the word processing industry where either the hot water or the hot gas is going to be coming out of the waste.

While it is good that you could use the water, reuse the water after purification before purification, if possible, whichever way the processes are designed, but what about the heat with they are carrying.

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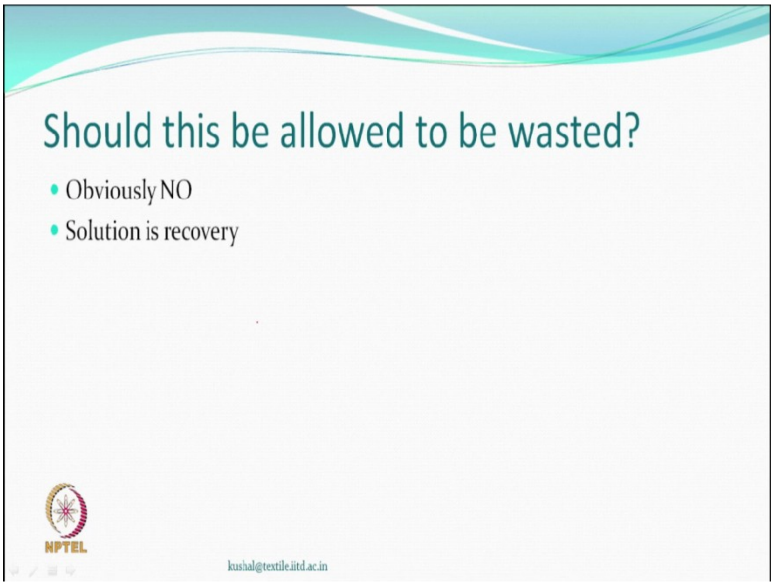

What you do that should this be allowed to be wasted? The heat talking about the heat obviously no, right. So, what is the solution? Solution therefore is recovering the heat whenever it is possible. So, very small short discussion we are doing in this session just to tell in which way you can utilize this heat which is going out of the system.

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So, this in short is called the waste heat recovery. Waste heat recovery, so what we required? We require, things like called heat exchangers. You must have seen, let us say a motorcycle for example you are riding the heat is going out of the engine through fins, you know, so you exchange the heat. So, the engine is cool, that right? So, heat exchangers are the ones which take the heat away and take it somewhere else. That is how you make the systems cool.

That is one radiator, you understand it keeps the engine cool, but how? By an exchange process where the water gets heated in a way, so that the engine becomes cool, right. So that is the heat exchanges. So, we know in our daily lives, we do use heat exchangers to transfer the heat from one to another portion right. So, what is to be done you know.

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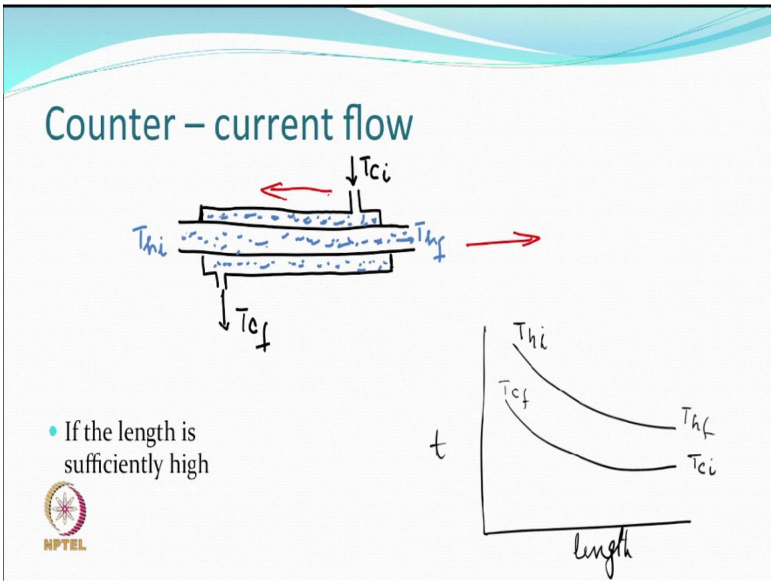

So, they waste heat will go from one direction the fresh air may come from the other direction for example, in a drier or stentered as we said the humidity levels inside the chamber have to maintain. So, if you throw out something because more humidity has generated fresh air will come the fresh air is at room temperature right. So, you may like the fresh air which is at room temperature should first somehow come in contact with the waste air exhaust air which is going out So, that they can exchange heat. If that happens, life will be easy.

So, how do we do the 2 ways people sometime have been doing it, one is co current flow that is the gases which are going out or the liquid which is going out and the liquid or gas which is coming in are actually flowing in the same direction that is called the co current flow. For example, this is a temperature of the let us say outgoing liquor outgoing I will consider a fluid which is coming from the process alright.

So, this is going in this direction. So, there is a temperature of the high-end temperature the final temperature of this liquor cannot become room temperature it may be slightly higher than room temperature when it comes out because you depend on how much efficient the exchange that has been and the other colder flue also is passing in the same direction. So, this is called the co current flow. So, the temperature will come down of the input liquor will increase the final temperature will be high of the hot flow which is going out it will reduce.

So, at some stage you will have this temperature will be higher than obviously this temporary. So, you would have exchanged some heat, and this will be the input to the next process for example, then it is a good idea right. So, based on the length of the contact the hot flue, the temperature will keep coming down along the length up to let us say, initial temperature of the hot flue, final temperatures the hot flue, initial temperature of the cold flue and in final temperatures of the cold flue.

So, they there was a difference which was large difference with key becoming smaller and smaller as they are going together in the same direction alright. So what happens is, in the beginning the rate of heat transfer will be high, but at the end, the rate of transfer heat will keep on reducing as the length becomes more and more length of this transfer system becomes more and more the rate of transfer will keep on reducing further and further because the difference between the 2 will keep coming down right.

But if it is infinite hopefully, the temperature of both the outgoing and the waste as well as the useful flue will be the same, but you may not like to go to those kinds of lengths, it may be uneconomical because as you increase the length, it is not just the length, which increasing some pressure also will be built, you know, you had to force the liquor in one direction so, that resistance also we have to do because there is a viscosity element which comes into. The other method people use is counter current.

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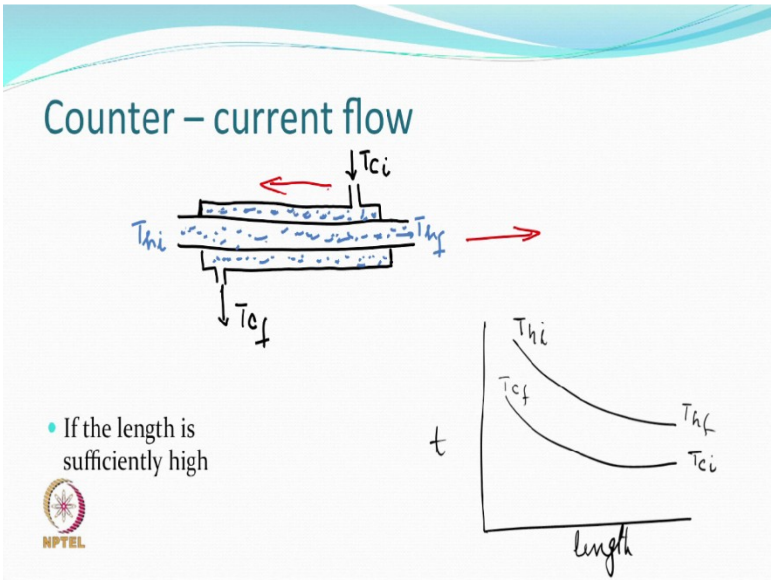

So, the hot flue which is going out goes in one direction let us say in this direction is going while the incoming flue or the liquid is moving in this direction right. So, they are counter current. People sometime prefer this method; the rate of heat transfer almost remains constant here almost remains constant. For example, the counter current will be something like this, the length and the temperature of the hot flue will go like this.

So, which will say T hot initial and T hot final the cold stream will have will also be like this. So, T cold initial and T cold final and therefore, they move in the same direction and the difference between them remains more or less constant the heat rate transfer rate remains more or less same, but even if you go for a very long length, this approximately remains constant. So, you know when to stop.

So, we there can be advantages and disadvantages of both the co current and the counter current processes. But both the things can be used based on the requirements what is the temperature difference and how much can you afford the length. So, one type of systems which can have is called the shell.

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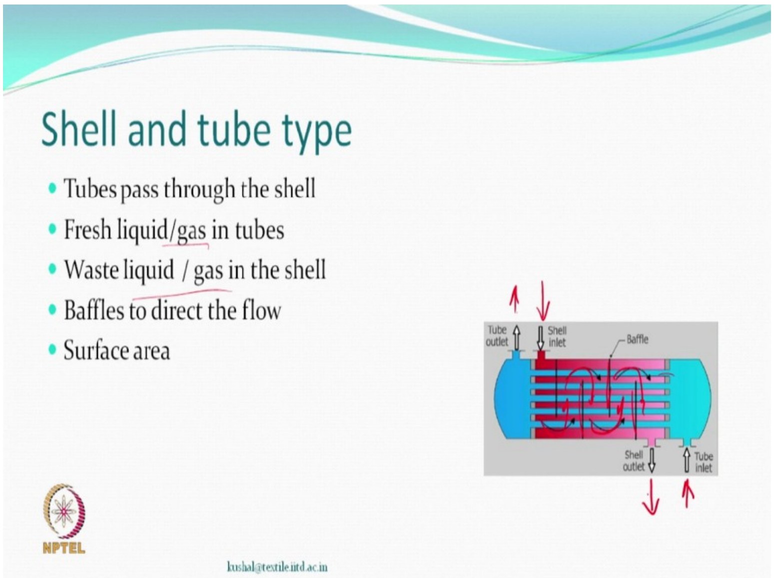

And tube type heat exchangers. Now, this so-called red area you see is a shell through which the blue type of things are tubes moving. So, you can have the hot things coming, the waste coming from this direction from in the shell and going out in this direction and the cold things, for example, entering in this way we are looking at counter current. So, this cold one is going and go this is out right. So, they can flow in the counter current direction the temperature exchange will take place and the one would be able to utilize the heat.

Now, this can be used this kind of system can be used for liquid liquor, it can be used for liquid gas, it can also be used for gas and gas also can be used. So, depends on what you are doing? But if it is the liquid gas is more efficient in some sense, because what you require large surface area. So, the tubes pass through the shells, which are the tubes, these are the tubes passing through the shells. The fresh liquid is in the tube.

The waste liquid is in the shell that is the normal arrangement. It could be liquid or a gas in the shell. There may be baffles, like these black things that you see these baffles these are the baffle plates. So, the liquid will have to go in this way go in this direction and then go in this direction and then like this and like this and come out, if it is these baffles are not there, then the liquid can just pass in one way, but now it has to go like this. So, that is the way it will travel in the shell itself.

So, that there is more chance of coming in contact with the tubes which are carrying let us say the cold fresh liquid or a gas, which has to be which will be heated up which will get the exchange of heat. So, surface area is important, so, how many tubes did you have? So, that would make sure how many tubes what is the pressure differential that will be created if you have so many tubes.

So instead of having one long tube going like this, you may have a bundle of tubes through which the liquid is moving from one to the other side good idea more thing, but the volume required will be also more, material require will also be more, but you have to create more surface area for heat transfer. Let the tube number of tubes, all of them will become design parameter for any such heat exchanger. There is some similar type thing which are called the recuperators.

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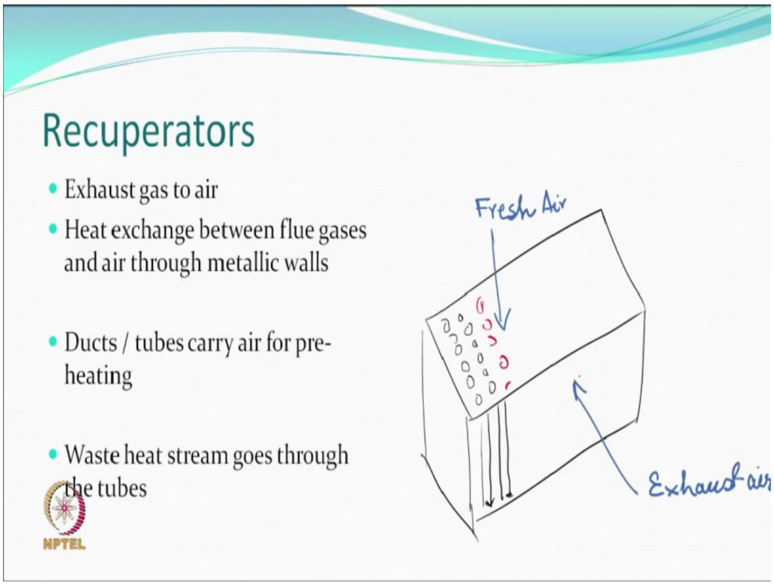

It is for gas to gas kind of thing. So, you have a chamber let us say we have got a lot of tubes for example, these are tubes all over this plate, there can be tubes, which are going from one side to the other bottom. The fresh air is forced into this or sucked whichever way you call it, the goes through the tube, the exhaust air is allowed to go perpendicular to the tubes. And so, heat exchange takes place and number of tubes, number of the total volume of this unit will decide as to how much efficient will be the exhaust.

So, you can definitely have so, gas to air or gas to gas. So, between the flue gases and air through metallic walls, so metals hoping that they are obviously conducting thermally conducting. So, hopefully they will exchange the air to create more surface area as much as you can the ducts carry the air for preheating. So, this air which is a fresh air will be created before going to be process. So, waste heat goes perpendicular across the tubes, not in the tubes, right. Interesting, simple but it works.

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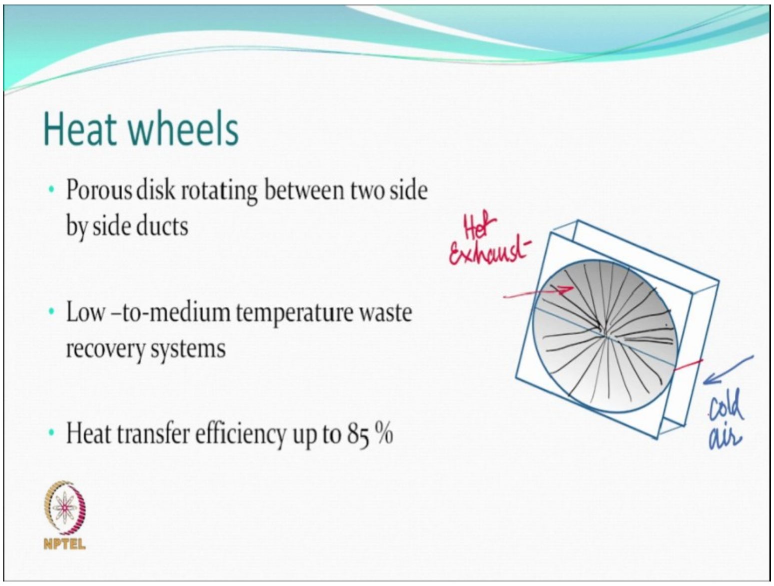

Other type of things which we also see called the heat wheels. So, these wheels are actually rotating. Let us say you create a separation you have ducts for example, you will have ducts on one way, the heat hot exhaust can go only in one half top half for example, the cold air will come from the bottom half. You make design in such a way that the cold air that is coming from the bottom half the hot is going from that in and this wheel is rotating.

It is a perforated type of a wheel or there can be fins which rotate, so there are metallic, so immediately they get heated and there it is rotating, so it goes to the cold area the heat get exchange. So, it is rotating wheels, while the hot air goes on one side the cold air goes on the other side and the heat exchange takes place. So low to medium temperature waste recovery systems sufficiently efficient, but not very high, but not too bad either.

You can look at about people claim that about 85% efficiency can be seen. So, it is all depends on how many fins what is the perforation level, how much contact area actually you can large number of fins. So, this wheel keeps on rotating. So, hot portion of the wheel goes to the cold portion, the hot air mixes this top portion. For example, here as a hot continuously and this continuously gets cool.

Because the cool air is coming from the other side continuously of course, there can be some contamination because they are fine perforated or fins you had to clean time to time, but it will be interesting way of heat exchange. Then other interesting heat exchanger.

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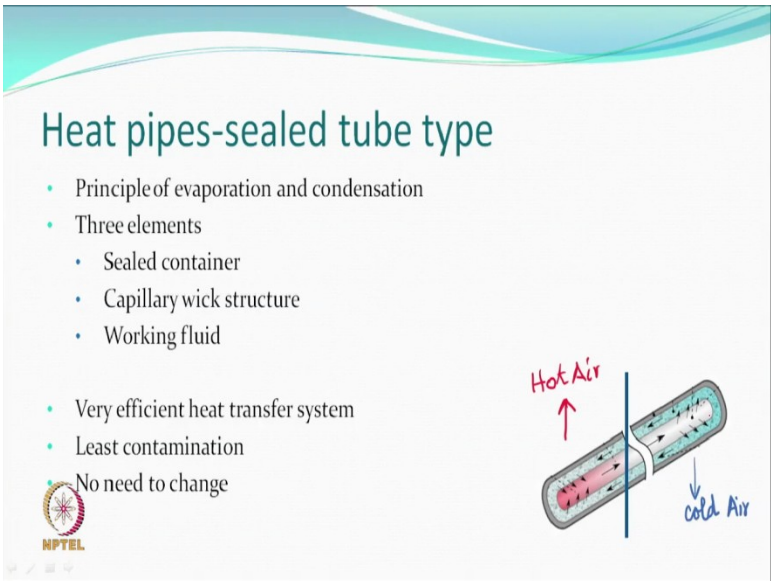

Which is a sealed tube type Where the, there is a liquor which is let us say low boiling point liquor, right low boiling point liquor, the moment the hot air comes, it evaporates and evaporates and goes to the other side. Let us say it starts moving on the top right the vapors there it meets cold air and it meets cold air for example, this is the cold air area, this is the hot area. So, whenever it contacts the hot area, the liquid evaporates it goes as a vapor, the cold air comes in contact, it immediately condenses.

So, this condensation evaporation is use of latent heat right. So, it is using both ways evaporation more heat is taken because of the latent heat and more heat is given out because of condensing. Very interesting nothing goes out of this system only surface is being touched the liquor is going up and down. You have capillary wicking systems here the liquor can wick down by gravity or otherwise by capillary action and this working fluid as we said is low boiling point.

So, this can be decided on what temperature are we talking about very efficient heat transfer system and contamination does not take place. Because there are hardly any moving parts also, just the gas is being sucked in or forced out. And therefore, you do not need to change because the sealed system nothing comes out of the sealed system, no contamination generally very nice beautiful systems.

There are other systems also which can be used, but one thing is clear we must recover waste heat. Okay. So, I am just leaving you with an exercise you can do it whenever you have time.

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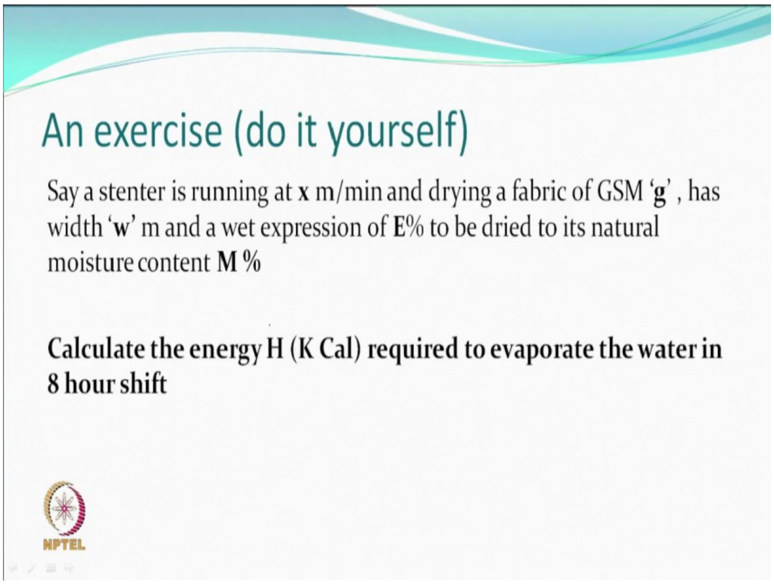

So, because the heat energy and everything is there. So, there is let us say stenter, which is running at some speed called the x meters per minute, a drying a fabric which has got some GSM. Let us say g has got some width which is w and got some expression. Now we know the expression can be this or that let us say some expression which is E% to be dried to let us say it is natural moisture content, which is M% complex, right?

Every parameter is here. And what do you want to find out? If you want to find out the energy required, let us say in kilo calories to evaporate the water, let us say in an eight-hour shift, control the machine is running for 8 hours, and then you want to find out how much energy is going to be consumed. In evaporating this water something some more data, helpful data I am just pushing it.

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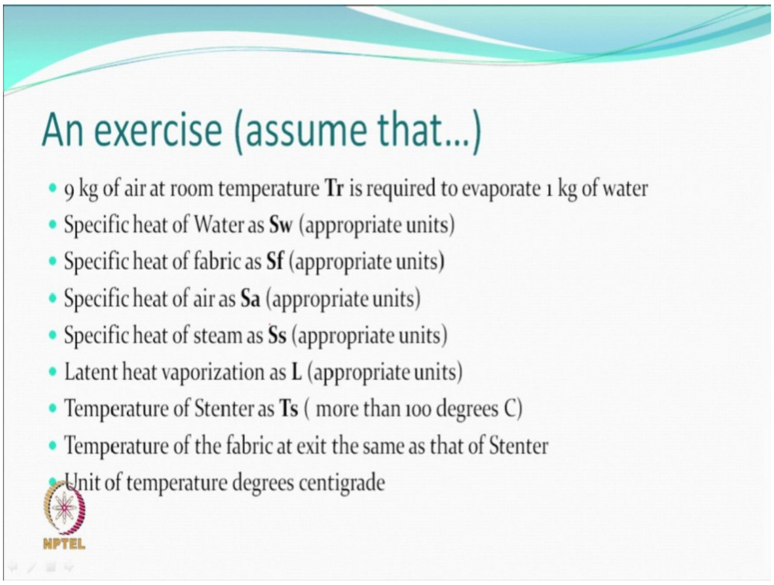

So, you can remember while you are solving approximately 9 kg of air would be required fresh air would be required to evaporate let us say 1 kg of water you can assume this. Then the specific heat of water will be required, specifically to fabric will be required, specific heat of air will be required, the specific heat of steam will be required depending on what are you doing what temperature the fabric is coming out, what is the temperature of the stenter, which may be more than 100 degrees centigrade.

The latent heat of vaporization the temperature of the stenter can be more than thing so 100 degrees centigrade. So, you have temperature stenter temperature of the fabric is the same as that stenter that is Ts and temperature let us say is measured degrees centigrade. So, if this is the data with you can you fill up any kind of values and keep calculating the amount of energy required to evaporate water through a stenter okay. We can call this any drying machine for that matter, right. So, what have we learnt? That there are many processes in finishing

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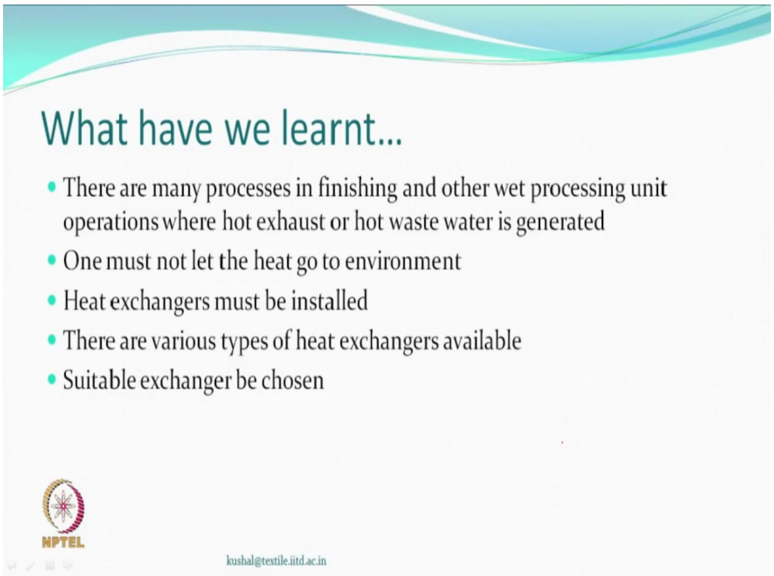

And other wet processing unit operations where hot exhaust or hot waste water is generated right. One must not let the heat go to the environment which is very unwise, heat exchangers can be involved installed in the process systems, various types of heat exchangers available. One some of us, some of you have discussed. So, you can always choose a suitable exchanger for your own processes but must use.

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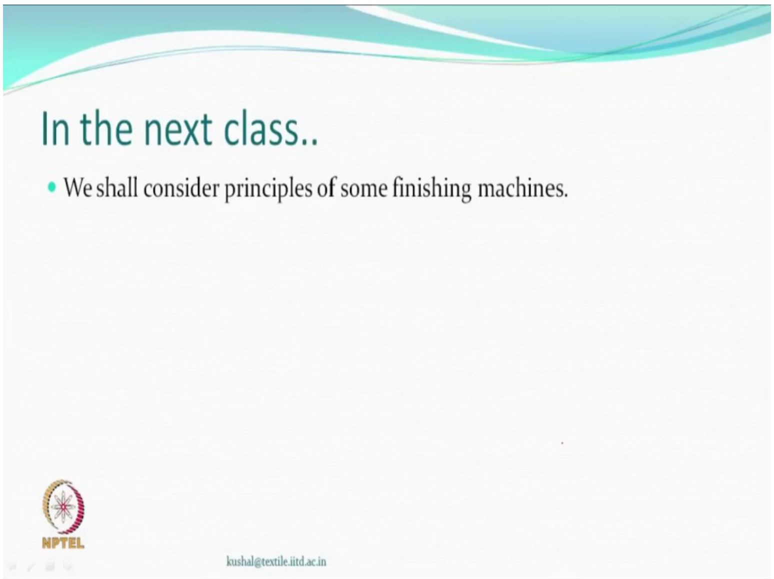

The next class we shall consider principles of some of the finishing machines, you know. This course is on finishing but not on finishing or impressing machines, but just to get a glimpse as to what type of machine some of you already know. We just discussed a little bit in the next class, till that time. All the best. See you.