

**Clean Coal Technology**  
**Prof. Barun Kumar Nandi**  
**Department of Fuel, Minerals and Metallurgical Engineering**  
**IIT ISM Dhanbad**  
**Week-07**  
**Lecture-33**

Hi, I am Professor Barun Kumar Nandi, welcoming you to the NPTEL online certification course on clean coal technology. We are in module 7, discussing various strategies or methods to reduce emissions from different combustion utilities. In this lecture 3, we will continue with pollution control from coal combustion utilities, focusing on bag filters or fabric filters. Bag filters or fabric filters are used in air purification by filtering air. These filters are made of fabrics or cloths that are used to directly filter or purify the air, similar to how we purify water.

In this system or process, a particular type of cloth or similar material with pores is used. The requirement is that we need durable clothes or similar materials suitable for industrial applications, which have pores, porosity, or pore openings to separate dust particles. Whatever dust particles are present in the air will be trapped or captured by this material cloth, and the air will pass through the pores and openings. As a result, we can separate the dust particles from the air. This can only be used with low-temperature flue gas since we are using clothes or similar materials, which may be made of plastics, polymers, or similar substances. These materials have temperature sensitivity, meaning they can withstand temperatures around 100, 150, or 200 degrees Celsius. Beyond that, these clothes may ignite and burn in the presence of hot air. Therefore, fabric filters or bag filters are useful only in low-temperature or near-atmospheric conditions. If the flue gas temperature is high, beyond 200 degrees Celsius, they cannot be used for such purposes. These bag filters are mostly used in other coal-based industries where coal or ash particles need to be separated at lower temperatures, not at very high temperatures. Typically, in thermal power plants, where flue gas temperatures are higher, they are generally not used. However, if there is a heat recovery unit that can reduce the flue gas temperature before it enters the bag filter, they can be used. Bag filters are common in cement plants and similar locations where strong heat recovery units ensure the flue gas temperature entering the fabric or bag filter is low enough for fire hazard dust particles get separated by the filter clothes depending on the pore size. So, whatever the dust particles are there they will be filtered by the filter clothes. So depending on the pore size of the filter clothes we can reduce or we can increase the cut-off size for the dust particles, so that we can if we

want a bigger size dust particles to be separated we can use big pore size clothes which will effectively reduce the pressure drop and very high air flow rate can be handled but if we want that only very smaller size particles to be separated by this filter clothes of very small openings are to be used in such case velocity of air will get reduced So, for this purpose, what we have to know is that we have to know the particle size distribution of the dust particles. If these dust particles are in smaller size or there is a 50% or 60% size is in the very lower range, we have to use lower opening filter clothes.

Similarly, if it is to be an only bigger size as particles are to be separated, we can use bigger size filter clothes. clothes with having higher pore size. So, they can be designed based on the requirement of any size of fly ash material as the final treatment unit. Like in this picture, if we see, these are the dust clothes material, which has some cottons or some threads are there. So, these threads have some pores and opening through which this dust particle can pass.

So, if we see, whenever this dusty air goes there, whatever the smaller particle, they may not be able to trap there but the bigger particle will always get trapped over this filter clothes. So, what will happen after a certain time a dust layer or cake layer will form over this filter clothes. So, after this time any particle even the smaller size particle can also get trapped. So maybe at the initial stage of this operation only the bigger size particles will get trapped and smaller size particles may pass but after certain time when some amount of this dust layer or cake layer has been formed. So, in this case all the particles will get trapped over this and there will have significant amount of pressure drop because air has to pass through this layer. So, there will be significant amount of pressure drop through this, so if this pressure drop is increased to certain values so that That means that signifies that this filter clothes needs to be cleaned or dust particle has to be removed. Otherwise, it will create problems in the regular plant operation.

So, this is the in general how this bag filter or fabric filters are used. So, we have to find suitable filter clothes. This is most important. Like if we want to separate or filter very fine size dust particle, maybe 1 micrometer or 2 micrometers, we can use any material made of cotton or nylon or any polymer which has the pore openings of 1 micron. If we want to separate 0.5-micron particles, we can use a filter close having 0.5-micron openings.

So, depending on the particles which has to be separated their particle size distribution whether there are some bigger particles is there or smaller particles is there what is their 50 percent particles in what size range. So, depending all those distributions we can get or we can use some of the filter clothes similarly if there are some issues with the cotton material, we can use

some polymeric material or plastics material nylon type material. So that it can be used even at little bit higher temperature maybe 150 degree or 200 degree centigrade So this entire bag filter design is depends on the hot temperature to be used and which material has to be used if this dust particle has very much affinity and they get stucked to this cotton or this filter close very tightly that means if cleaning is very difficult or cleaning is very easy depending on all this condition we can use suitable type of clothes materials filter closed materials to decide what type of separation we can what type of filter closed material what design we should use typically this flue gas is forced to pass through this filter that means these bad filters and these dust particles are collected at the surface to the permeable fabric. So, fabric will be permeable so that this will only allow the air to pass through this fabric and any of the dust particles present in this fabric they will be separated and they will be collected on the surface of this fabric. So, these systems have very high collection efficiency. like depending on the requirement, we can use suitable type of filter clothes. So, it is not like the design of cyclone separator that cyclone separator velocity and others are the major parameter here only is that we have to identify suitable type of filter clothes and accordingly we can separate the dust particle. So, if we need micron size or if we see nano range size filter clothes we can also use it so effectively it can separate Theoretically, you can say 100%, but if we say in actual value, we may call it like 99.9% or 99.5%, like this type of efficiency we can easily get.

So, we can get very high separation efficiency. for all the size, for both bigger size as well as for the fine particles. So, they can effectively separate even up to 0.01 micron to 100-micron size materials. And this fabric needs to be replaced that as this fabric; it is getting continuously clogged by the dust particles and it needs regular cleaning and maintenance and it is also exposed to some of the chemicals that can be present in the dust particles as well as the different type of corrosive gases in the dust particles.

This fabric needs to be replaced frequently, maybe in the gap of two-year, three-year, four year and hot gases, whatever is there, they must be cooled. Otherwise, it can create fire hazard for the plant. So, whatever the hot gases are there they must be cooled to below the temperature of 150 or 100 degree centigrade as per the temperature required for the fabric filter or we can say as per the safety guidelines of the fabric filter. System generally operates in the range of 120 to 180 degree centigrade in most of the cases this fabric filter or bag filter can be used even up to 180 degrees centigrade if we use very strong thermal resistance or heat resistance materials like nylons and others. So, depending on the material of cloth material or filter material we can go even up to 180 degrees centigrade with getting almost full efficiency of hundred percent. So,

whatever the size we have to separate we can use this fabric filter for their applications. This is the typical image for the fabric filter how it operates typically this type of from this side or one side dust particles enters there and this dust particle enters this goes through this filter.

These go through these individual bags. So as a result, whatever the dust particles are there, they will deposit either inside layer or outside layer depending on the side where we are sending the dust particles. Like these are bags like in this way. So, either we can send the dust particle through this so in such case dust particle will be deposited over this layer and if we send it in the opposite way like this if we send the dust particle through this in such case dust particle will be deposited inside this layer. So, depending on the side where we are sending or feeding this dusty air accordingly dust particle will be getting deposited either inside inner layer or the outside layer depending on the design or type of the bag filter.

So, after this from the opposite side like if in this case dust particle will deposit over this side and from this side we can get the clean air like this. Similarly in this case dust air will go through this so we can get clean air from this surface. So accordingly, this fabric filter system works and after certain times this dust particle will fall or we have to mechanically remove it using some arrangement. So that we can collect the dust particle from the bottom of this chamber and we can get this clean air from this. So basically, it will be like a normal cloth filtration. through which we separate the dust particles and this is only an industrial type of units where dusty air will pass through this filter or bags as why we called it like a bag if we see it is like its actual design is like a bag through which air passes. So as it is visually seen like a bag it is well known as the bag filter and some of the cases that is made of different type of fabrics it is also known as the fabric filter, so both the terminology is used in the industrial applications and accordingly this particular location where all these bags are kept, they are used first to treat the dusty air this location is known as the bag house that means different type of or all the bags are placed in that house where air purification takes place so that particular section of that plant is called as the bag house Like this is the different type of bags which is used. We can see this is the bag what is used. Inside it, these filter clothes are placed and in between a strong layer or support material made of iron or other suitable material is there.

So effectively some type of frame or a structure is created at the circular shape or maybe in the rectangular shape using the iron rods. So, over these iron rods, these filter clothes are kept. which will create these lichen bags so if we pass the air through this so we can get clean air from this surface like if we send this air through this we will get air through this clean surface.

So, in such case all the bags will act or all the bags will purify air in parallel to get the desirable separation efficiency. So, if we see like this, all these bags individually are placed here.

These are individual units which are like these bags. So, these bags, this unit is effectively you can say this is the bag which is used in the purification. that's why they are mentioned these are the different type of different bags. Typically to maintain or to get the desirable flow rate of air or to allow a significant higher value of air to be purified or cleaned from the dust particle. Many numbers of bags are operated in parallel.

It is not like that only one bag is used there. There can have 32, 46, 48 or 64. This type of many numbers of bags are operated in parallel. So that overall, whatever the air velocity is there we can handle large amount of air flow rate with very less amount of pressure drop. So many numbers of bags are used in such plants So if we see the in general things about this fabric filter or bag filter, there is some operating cost.

This operating cost involves typically for the cleaning of bags. Typically, after operation or utilization for sometimes maybe one hour, two hours, depending on the amount of dust particles getting deposited over these bags, these bags need to be cleaned. so, there are multiple bags or bag unit operates, so when one unit is under cleaning purpose second unit will be under operation similarly second and third unit is under operation first unit is under cleaning after some time one two will be in operation third can be in cleaning. So, in this sequential manner different type all the bags are cleaned and for cleaning of these bags' removal of dust particle. As this dust particle if their thickness is on the higher side in general they can fall by their own as increase in the mass but if the clothes are clogged completely and if depending as these particles can enter almost in the pore size of the blacks sometimes removal of this dust particle can be very much difficult So in such case they will not be getting removed easily.

So, in a similar case, either a mechanical scraper or mechanical system had to be arranged, which will remove the dust particles from the surface of these clothes. Or in many cases, it can be done using some vibrating equipment or some vibrators are used so that they will efficiently remove the dust particles from the surface. So, like if this is the back surface, any dust particle gets deposited here. If their weight is extremely high, they will fall due to their gravitational force. But if they stick to this wall very tightly, so that they are not getting removed very easily. So, in such a case, the pressure difference like  $P_1$  and  $P_2$ , that value will be significantly high. That means this  $P_1$  minus  $P_2$  should be on the lower side, as low as possible, so that whatever the combusted flue gases there can easily go out of this combustor. But if the pressure drop is

increased, then in such a case, the P1 value goes beyond a certain limit. In such a case, the combustion utilities for the combustion unit performance will get affected. So, to avoid that, we always measure this pressure difference. What is the pressure difference? If the pressure difference goes beyond a certain value or design value, that means this filter unit needs to be cleaned or dust particles need to be removed. Otherwise, it is not operating properly. So, in such a case, either a mechanical or some mechanical arrangement is done, which will easily remove these dust particles using some scraping, like if we use some iron rods or some things which will cut or remove this manually through some equipment.

It can be used through some mechanical arrangement to create scraping or vibration. If we vibrate it in such cases, these dust particles also get removed. Alternatively, we can create a pulse jet. By changing the velocity of air very frequently, all these dust particles will be removed by the action of the pulse jet. These types of arrangements are placed inside the bag filter or bag house so that all dust particles can be removed during maintenance, repair, or cleaning. In some cases, if a bag filter needs to be used at higher temperatures, such as 400-500 degrees centigrade. When replacing bags, we can use different types of ceramic or metallic filters. These ceramic or metallic filters are recently being used in many plants or applications. Ceramic filters have a long lifespan and are highly resistant to temperature rise. If ceramic filters are used, they can operate even up to 1000 degrees centigrade. Similarly, using powdered metal, different types of metallic filters are now produced with high porosity or porous surfaces. These metallic filters can also be used if required. If designed properly, this filter or design can be used even at higher temperatures. In some modern designs, different types of ceramic and metallic filter-based bag houses are used. Though generally called a bag house, it effectively contains ceramic or metallic filters.

Typically, this bag filter cannot operate at higher temperatures if using bags made of cotton, plastic, or polymeric materials. These materials cannot withstand very high temperatures, making this unit a potential fire hazard in the plant. In the plant, if there is a heat recovery unit, it may recover most of the heat, so the entry temperature into the bag filter is around 200 or 150 degrees centigrade. However, in some cases, even for a few seconds, if there is a problem in the heat recovery unit. The heat recovery unit may fail to remove heat from the flue gas. In such cases, even 500-degree centigrade hot air may enter the bag.

So, all these bags will catch fire. and all the entire bag house will be under fire. So as a result, this is always an extremely fire hazard units for the plant that is the main reason in many of the

thermal power plant where always the flue gas temperature is on the higher side they try to avoid using this bag filter but other units where temperature is on lower side they use this bag filter for separation. So, bag filtration or this fabric filter-based units are only used in those type of coal units, coal combustion units where temperature is confirmed or well known that the temperature entering in the bag filter will never go Exceeding the design temperature for the bags like if the coal combustion is happening maybe at 600 or 700 degrees centigrade and there are very strong heat recovery units. So only in those cases this fabric filter can be used. Otherwise, it is an extremely fire hazard units in the plant. and any sudden rise or any accidental rise in flue gas temperature may cause fire in the system and this should be used after the cyclone separator and recovery of the waste heat typically These fabric filters are used after cyclone separator in the circuit.

Like the bigger size particles, whatever is there, those should be removed initially by the cyclone separator so that overall particle matter load is reduced. If this overall number of dust particle or quantity of dust particle is less, then this bag filter can remove the very fine particles efficiently. Otherwise, if it has to remove the bigger size particles, then very frequently or very within a very few seconds or very few moment it will create a very thick cake layer of dust particles and it will lose its effect ability and it very frequently it has to go for cleaning so to avoid that at least what about the particles which can be separated easily by the cyclone separator Like if cyclone separator can remove most of the particle of above 10 microns.

So those particles corresponding to maybe 30 to 40% of the entire particle size distribution. Like if we see this is the particle size distribution of the dust particle. So, if this is the bigger size particles which are separated by the cyclone. So, remaining smaller size particles can be separated by the bag filter. So, in such case overall particle load on the bag filter will be less and cyclone separator will effectively pre-clean the dust particles. So that overall operating cost of this plant is less otherwise if this bag filter is used for all types of dust particle then very frequently it has to go for cleaning and there has to be many number of bag filters to be ready or to be kept for filtration of the dust air but if we use cyclone separator before this unit they will remove some of the particle matter so overall load on this bag filter may be reduced to 30 to 40 percent so that this bag filter can be used for longer time and second is that There is always need a heat recovery unit as these bag filters are sensitive to temperature. Some type of heat recovery unit must be there in bag filter. And they need regular cleaning by inbuilt shaking mechanism. There has to be inbuilt shaking mechanism to remove the dust particles or maybe using some vibration or maybe using some pulse jet or maybe using some mechanical scraper,

etc. There has to be some regular cleaning. cleaning mechanism should be there so that all the dust particle whatever is get deposited that they can be efficiently removed from this surface within this short span of time so that less number of bag filters are used this is one of the image or system how it is used in the bag filter like if there is some incoming gases are there can have three units they are operating in parallel Like this one, two, three. Both these three units are maybe operating in parallel. So, dust particles are entering there after filtering.

You are getting the clean air. But after some time, that will go to the exhaust fan. But after some time, these units should go for the maintenance or cleaning purpose. So, these units should go for shaking. And during shaking, we have to ensure that no dust particle goes to the air stream. They will be collected through a separate system. pipes or separate systems that they don't go back to the air. So, this unit will be under shaking and in such case these two units will be doing the required filtration. So, this type of arrangement has to be there like one unit will be under maintenance and units 2 and 3 will be under operation.

So, whatever the volumetric flow rate of this air is there, those can be handled by these two filters. So, this type of capacity has to be built so that this entire flow rate or entire velocity of this air can be managed by these two units. So, after some time, if this unit cleaning is complete, this one unit can be under filtration and this unit, be used for the cleaning or shaking so this unit now this unit will be used for shaking where this valve is closed to remove the dust particles so this unit under maintenance and 1 and 3 will be under operation to doing the filtration job similarly after certain times this 1 and 2 will be operation Three in third unit will be under cleaning.

So, in this way, in this sequential manner, depending on the requirement or depending on the velocity of air, flow rate of air, multiple bag filters are used. And if one unit is under maintenance or cleaning, other units will be under operation. So accordingly, depending on the air velocity, the many numbers of bags are placed inside the bag filter. So, there can have 30, 40 or 100 bag filter used. Maybe some of 30% or 40% is under operation and others are during the cleaning or separation of dust particle.

So, in this way typically bag filters are used in many of the industries where dust particle has to be there. So, these are the different type of design parameters or operating parameters we have to see if it is matching like what is the amount of pressure drop. If pressure drop is significantly on the higher side it will create problems in the combustion units or in the back it will create back pressure in the flow gas pipeline. So, pressure drop has to be on the lower side

or effectively without any pressure drop air should be allowed to pass through this filter. There should be how much air and how much close surface area is required. Like to separate some volumetric chloride whether we need 2-meter square of surface area or 10-meter square of surface area. That ratio we have to see how much surface area is required to operate or to remove some particular barometric fluoride, what will be their collection efficiency like how much particles they can trap what will be their minimum cut size that it will be able to separate dust particles up to 1 micron or 0.5 micron whatever, what is the type of fabric to be used it should be made of cotton jute polymer or synthetic any other material what we should use how we should clean it frequently how at what duration it can be operated how we can control the temperature because if temperature is excessively high it can catch fire what will be the required spacing of the individual bags whether these bags should be spaced very tightly or it can have some distance that efficient cleaning is there and air whatever the air is passing they can go without creating any of the pressure drop how much space it is required and how much cost it will be there. So, these are the different parameters. which is typically considered during design and operation of this bag filter.

So effectively, if we see this bag filter and compare it with the cyclone separator, the cyclone separator always has some limitations in terms of particular metal cut diameter. It cannot operate or separate dust particles of very fine size. But if we see the bag filter, if we use a suitable type of filter, like if we use a filter or cloth with very small size, having 0.5-micron openings or 5-micron openings or 10-micron openings. So, depending on the requirement of dust particles, we can use a suitable type of fabric so that it can always give efficiency close to 100%.

So, if we see in terms of particulate matter removal efficiency or dust particle capturing efficiency, it can achieve 100 percent, or more specifically, or if you say for safety purposes, 99.99%. So effectively, it can remove all the dust particles, but it has the major drawback of having some pressure drop and temperature issues. These are the two major parameters. These are the major drawbacks for this bag filter, as it always has some higher pressure drop, as the air as well as dust particles face some barrier during their path. So, there will always be some pressure drop. The second is temperature loss.

If the temperature of this filter or the air medium is on the higher side, this fabric may catch fire, and this entire unit can catch fire. So, these are the two major drawbacks. Otherwise, this bag filter is very efficient and can be designed as per the requirement, with the only operating

cost involving some cleaning. But there is no other major operating cost. The only operating cost is whatever the cost for cleaning or making arrangements for cleaning is required.

So that is the only operating cost. The second cost is that as some of the units will always go for cleaning or dust particle removal, we have to keep like 150%, 200%, or double the number of bags we have to use so that we can always have some of the bags under operation and some under cleaning. Since this number of bags always goes to cleaning, we have to use more bags to meet the desired capacity or filtration capacity. of the flue gas. So, in most cases, these bag filters are used in cement plants and similar other plants where temperature is not a major issue, but in thermal power plants, it is generally not used. However, if it is a low-temperature operation, this can be used.

Thank you.