Environmental Air Pollution

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Lecture 5
Measurement Units and Particulate Classification

So what did we do last time? [Conversation between Student and Professor – Not audible ((00:00:20 min))] Apart from that; that of course, you can do it at your ease.

What we will do today is some basic, simple things on units.

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It is very common to see the units in air pollution, something like this or let us say.... Here, you will find this unit (Refer Slide Time: 01:25 min); you will find parts per million; you may find micron per metre cube; you may also sometimes see something very specifically written like this (Refer Slide Time: 01:41 min). Sometimes you may also find something written as ppb, sometimes also written as ppt. We also encounter units in air pollution as this (Refer Slide Time: 02:27 min).

There is something very important that you need to recognise as, well of course, we can also express units in milligrams per litre also; no one stops you know, but generally in the air pollution, air concentration or something. If I ask you about ppm; you all know ppm – parts per million. Is ppm really a unit? In fact, it is not a unit; it is just a ratio. It is very frequently used. In air pollution when we talk about ppm, unless specified otherwise, we are referring to it volume by volume; ratio of volume of pollutant to the ratio of air, when air is taken as 1 million volume of the air to the volume of the pollutant that is in the air.

Let us talk about ppm in water. When you say ppm in water what ratio are we talking about? It is a ratio; we all agree that ppm is the ratio. What kind of ratio are we talking about? Is it a ratio. Is it a volume-to-volume ratio? Is it mass-to-mass ratio? So, remember that in water when we talk the ratio, it is generally called weight-wise. You also have in water - milligrams per litre will be equal to ppm. You all know that. Why? The density of water is 1000 kilogram per metre cube and because of that density is 1000 kilogram per metre cube; this relationship holds good. If I say something is similar, can I also say for the water or for the air the ppm will be equal to milligrams per litre? No.

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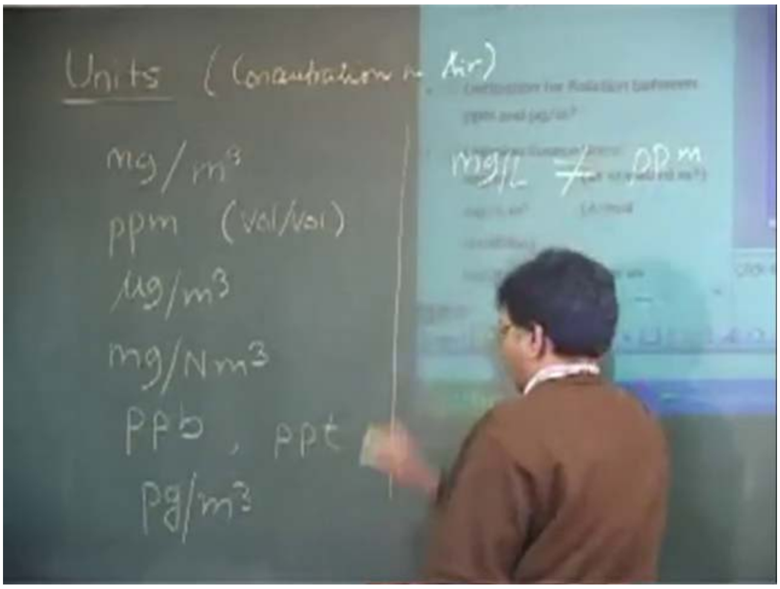

So here, this is not equal to ppm. Will it be true even for the sea water that ppm will be equal to milligrams per litre? It will not be; because, the density of the sea water is not 1000 kg per metre cube or 1 gram per cc. So milligram per litre is not equal to ppm. The other thing here, what you see is this metre cube. It can be very tricky. We do not want to say metre cube just because the metre cube in air and metre cube in water; there is a lot of difference. Meter cube of air and meter cube of water can be very different. Why? Well, look the volume is the same, but this volume where the 1 litre of water will always by and large be seen as 1 litre, but the metre cube of air that will change in the pressure and temperature, the volume will change.

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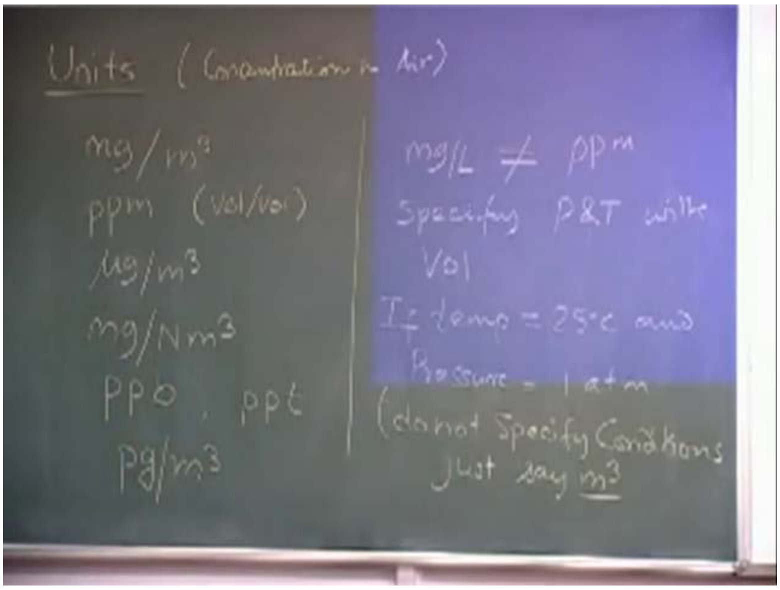

The other thing you need to remember really is specify pressure and temperature with volume. It is a matter of practice, it is a convention - just say metre cube; because, you know otherwise every time you have to write. Most of the time this standard things are translated to this conditions, the temperature; so that when you express something either you write the actual temperature and pressure at which the volume is measured or you convert that to the 25 degree Celsius and one atmospheric pressure and just simply say metre cube.

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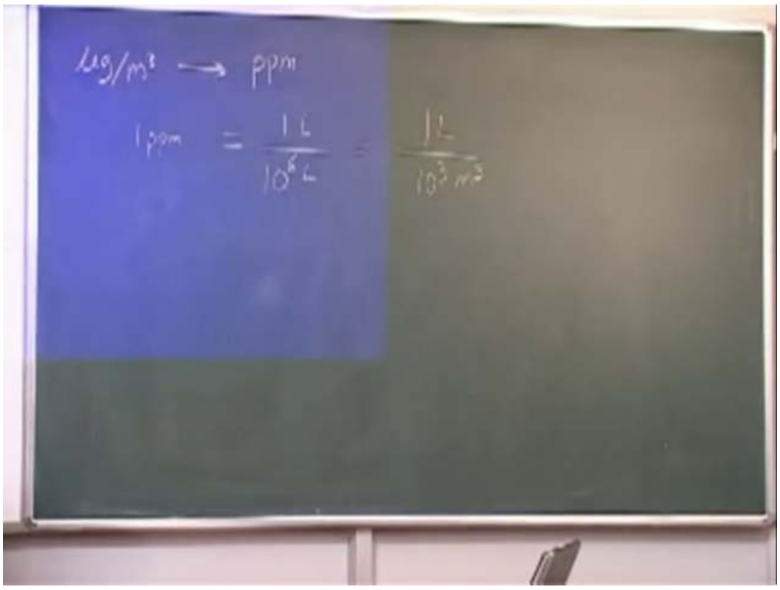

So we will go back to air. What we want to do in the process, derive a relation between this and ppm. A question for you: is the ppm, concentration in ppm, does it, when I am expressing the concentration ppm, do I need to specify the volume? Do I need to specify the temperature and pressure? Or do I not need to specify it? No, we do not have to specify it. So we have the advantage in the ppm, when we are expressing in ppm that we do not need to specify the pressure and temperature. This is simply the ratio; the same pressure and temperature are applicable for the pollutant, as well as for the air in which it is dispersed in. So that is the advantage ppm has, but the micron metre per metre cube, we are very familiar with it to understand the terminology mass per unit volume. We need to derive some expression which is in 1 ppm and I will try to do that.

Let us start here. In air we say ppm is volume-to-volume ratio. So I say 1 litre of the pollutant - some gas - divided by how much volume of air? I just want to say, 1 ppm is really in the true sense, what it is. 1 litre of pollutant, I am specifying the units as litre; so I have taken 1 litre of pollutant gas, which is dispersed in how much? 10 to the power 6. In fact, we take 10 to power 6 plus 1; that is the total volume that is expressed, but we will ignore that 1. Basic thing is we have just written what we know. Now just remember where I have to go - from ppm I have to go to microgram per metre cube. What do I need to change? I must change this litre somehow into mass units; because, from this litre I want to reach to microgram. How can I do that? Because this is already air, that is also air; so this I can also say this one if you like, this is one litre by that (Refer Slide Time: 11:13 min). Can I say that? Right.

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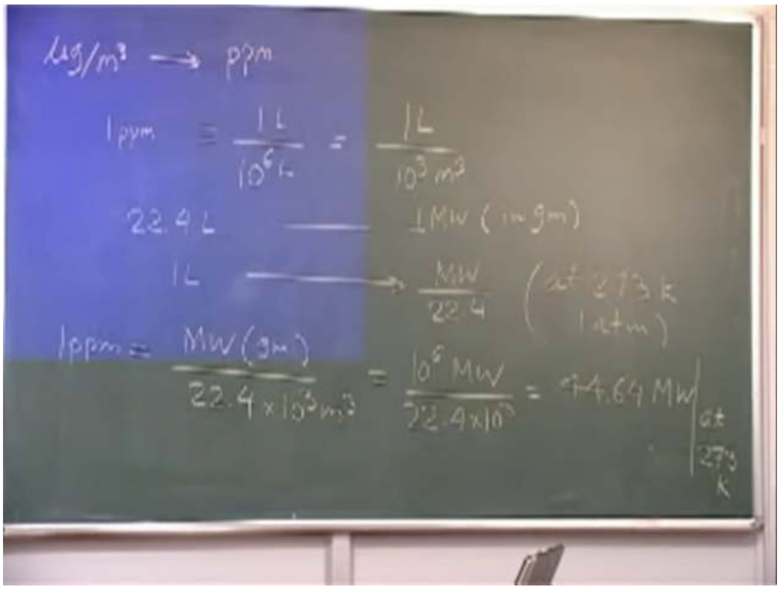

Now let us see about the pollutant. So more or less I got the metre cube down there, I must change the litre into mass units. If you recall, at normal temperature, pressure, the volume occupied by 1 mole of the gases will be how much? You recall Avogadro's Principle? I am doing some basic things. We know that 22.4 litre of gas will be equal to how much molecular weight of the gas? 1 mole of the gas. So that 1 mole will be nothing but 1 times molecular weight. What is the unit of this 1? What is the molecular weight here? Grams. We all know that but we will still write that as grams. Now this is done. So 1 litre of the gas or the pollutant that we are saying will be equal to how much molecular weight? Do not forget that it will be in grams by 22.4 litres; at what condition? Let us not forget at what temperature? Standard temperature - 273 Kelvin or 1 atmospheric pressure. Let us go and replace the same there. So 1 ppm equals to molecular weight, which is in grams, divided by 22.4 times this.

What do I want to get in micrograms? Let us change this to micrograms, so this is equal to the grams 10 to the power 6 grams to micrograms molecular weight divided by 44.64. Anything else? Nothing, I guess; that is all; you have taken care of everything. Do not forget that metre cube still at 0 degrees or 273 Kelvin and 1 atmospheric pressure. It is a good idea to express more at 25 degree Celsius or something, so we just simply change the volume.

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Pressure, I am assuming to be the same; pressure changes I am not incorporating, both are at an atmospheric pressure; so that goes off (Refer Slide Time: 15:17 min).

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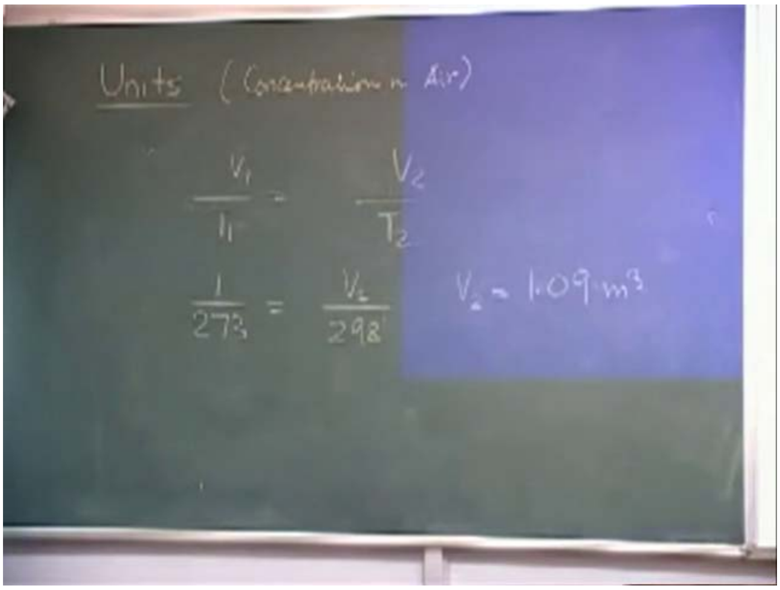

I want to find out the volume at this temperature. What is this volume right now, at these conditions, whatever? 1 metre cube by 1 metre cube; so, 1. What is the temperature here? 273. V_2, that I need to find out, divided by 298 at 25 degree Celsius. So please tell me the value of V_2; it is 1.09.

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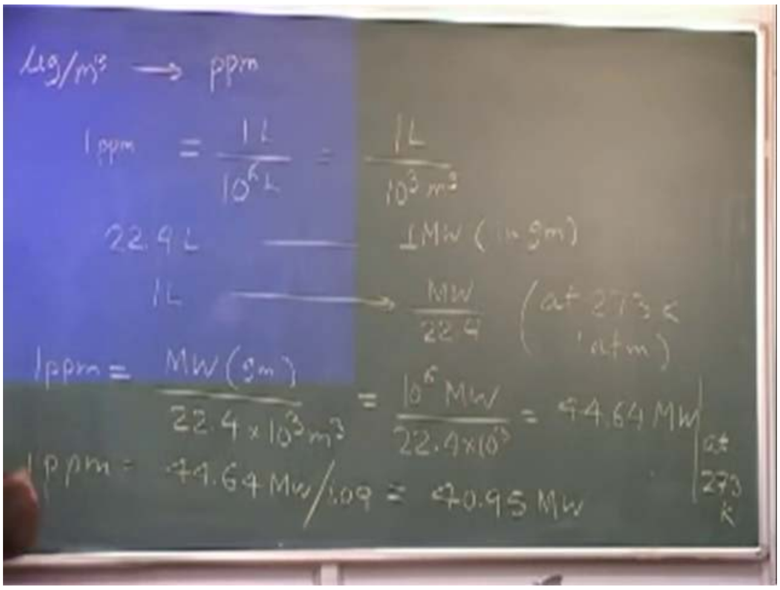

What do I do here to get the conditions at temperature like 298 Kelvin or 25 degree Celsius? What I need to do is 1 ppm equals to 44.64; that is the molecular weight divided by my new volume, it is not 1 but it is 1.09. Please give the number; 40.95 or 41; we will write 40.95. I do not have to specify the pressure temperature because we have said it is 25 degrees centigrade, we are not saying it.

What we have done in this 10 to 15 minutes is to form very basic principles (Refer Slide Time: 17:24 min). We have derived a relationship in the atmosphere for the gaseous pollutants when the concentration given in ppm. You can convert this into the microgram per metre cube and back and forth; we should not forget to write here; the box is complete (Refer Slide Time: 17:44 min). This is fine for the gaseous pollutants, but for the particulates or dust we do not have any such relationships. Why do not we have such relationships? We do not have such relationships because we do not know the density of the particles. It will be a mixture of the particles and when we do not know the density, we cannot change. So always remember in gases, whatever that gas may be or in the vapour form, we can always express in ppm or in microgram per metre cube for particulates or dust levels or always express in microgram per metre cube or milligram per metre cube or mass per unit volume; whereas, for the gases we can express in ppm or ppb or ppt and things like that.

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A little assignment: you need to try to get the same relationship from the universal gas law. I will not use this thing in deriving this thing, but you need to use this. The gas law that you all studied from class nine and ten, we need to get to the same thing. This you try and make sure that you are able to do this.

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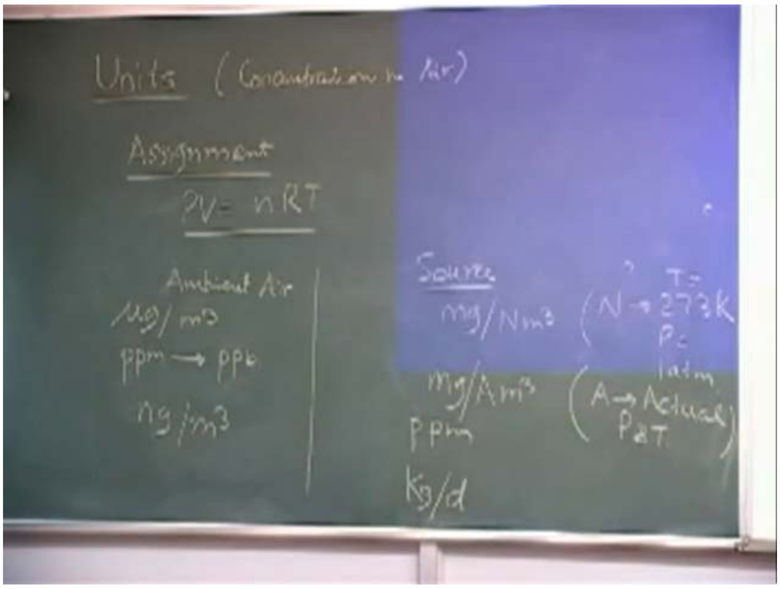

Is there anything else which I want to talk about? One more thing I can talk about is ambient air. Normally, we express units here something like milligram normal metre cube; here, this normally air is taken as N; N means.... (Refer Slide Time: 20:15 min) That is the temperature, pressure is 1 atmospheric, you may find sometimes also like this. A stands for actual. So whatever the actual pressure and temperature which might be specified somewhere in the description that might be the actual pressure and temperature. It is also not uncommon to define this in ppm at the source.

Sometimes people also like to express different system which is how different times that is an emission rate, emission quantity, so many kilograms per day. But here mostly in ambient air we write the units generally in micro metre cube; microgram per metre cube because the concentrations are low. It will not be a very good idea to write concentration in milligram per metre cube in the in ambient air as that number will look .00001. That sounds very funny. Similarly, here we use ppm, but many times we use ppb since the concentrations are low. Do not get surprised if things are interchanged at ambient air and things like that. Sometimes, when the pollution level is very low we also like to express in nanograms. Remember, if this is not at 25 degree Celsius, we will have to specify the pressure and temperature that we are talking about. These are very little fundamental things, but many people, at many levels make such mistakes.

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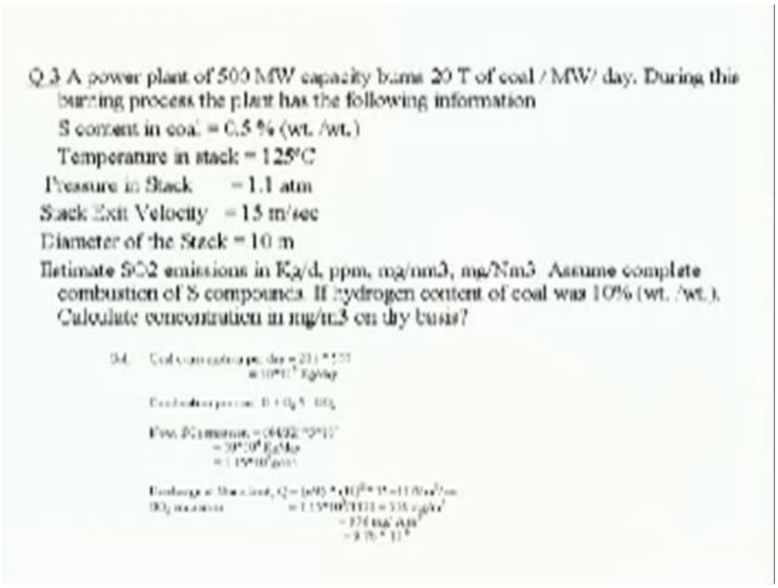

This is another assignment, number 3; read the question and you should do it. Let me see if everything is okay here. A power plant of 500 mega watt capacity burns 20 tonne of coal per mega watt per day. During the burning process the plant has the following information. The sulphur content in the coal is .5 percent. Then it is clearly specified weight-per-weight. The coal combustion it is normally given in weight-by-weight basis. Pressure in the stack will be slightly higher than the pressure that you encounter in the ambient air that is 1.1. The stack exit velocity were developed from through which the gases are coming out is one is 15 metres per second; the diameter of the stack, a very big stack, 10 metres, huge diameter, little a bit more than normally it is provided is about 10 metres. You have to estimate the SO_2 emission in kg per day in ppm, in milligrams per normal metre cube. Just read this. This is the same; there is no difference between this and this. Assume complete combustion of sulphur compounds. There is another additional thing which is given - the hydrogen content of the coal was 10 percent again weight-by-weight because the coal will have both carbon and hydrogen. Calculate the concentration milligram metre cube also on dry basis. So this we should try this one out. The question you might ask - why dry basis?

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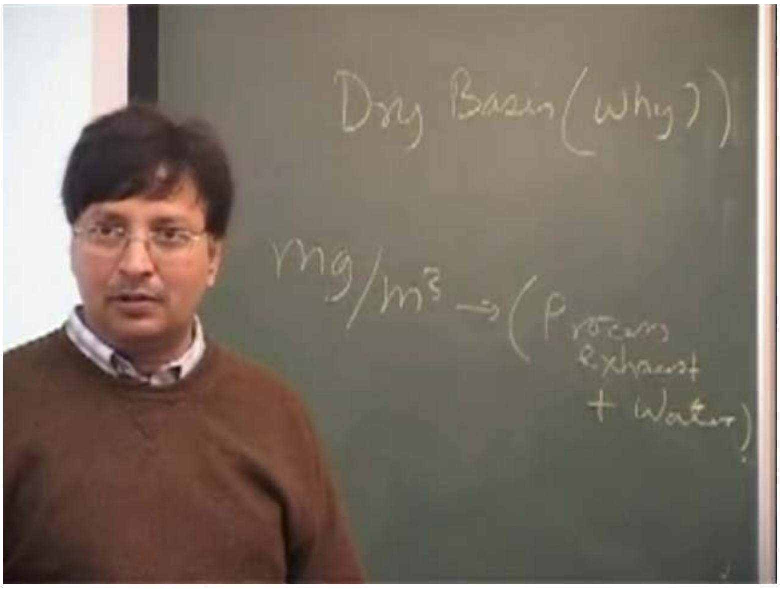

Generally it is preferred to do things on dry basis. The reason for the dry basis is that when we are really expressing the concentration, so you have the milligram per metre cube; this metre cube is from the exhaust or the process or combustion plus water or moisture. You see normally these things are fine, but this may really vary from coal to coal. Generally to standardise the things for comparison purposes we put it onto the dry basis. So, what you will do here when you under finding out this concentration? You will take the volume of the air that is going out; it will be the total volume that is going out minus the volume of the vapours that will go out. So that you have from the convention I have done here. I would like that you try it yourself.

You may make some mistake as well here, but then if I have 1 kilogram of sulphur, let us say, how much sulphur dioxide will be emitted. Suppose I have burnt a coal which has 1 kg of sulphur, how much will be the sulphur dioxide if all sulphur is converted to sulphur dioxide. [Conversation between Student and Professor – Not audible ((00:26:06 min))]

1 kilogram of sulphur is there that got burnt and how much? 2. What I want you to always remember, the sulphur to sulphur dioxide will always be doubled in quantity. Simple thing to remember and many times sulphur dioxide is many time talked about as this is such a common pollutant in air. We are all aware we have so much sulphur in our life. Then you quickly know how much is SO_2 we are talking about because the factor is very simple - just multiply by 2. That was the idea of just asking you to do this.

This one you do it yourself. [Conversation between Student and Professor – Not audible ((00:26:57 min))] You write down, may be I can have a look also onto this thing, but I really want you to try it out yourself, so that you already a bit practiced into the unit conversion and things like that. Though this is important in air pollution because many times people will mess up, you know like small things and can talk the big things, but you know we always wish that small things are not... we do not make mistake on small things. All numbers are typically true for about 500 mega watt plant. The numbers you will get will be very realistic as to what you will find really in the stacks and things like that.

Let us go further. Now we enter a new topic and that will be talking about particulate matter and briefly written as PM.

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Let us look at some definitions. The TSPM is or in fact many people just simply call it TSP. In the US literature, we will find it as TSP. TSP is the total suspended particulate matter. All particles smaller than 50 micron metre are called TSPM. As I gave you the feel how big is 50 micron – it is the size of the diameter of your hair. Another terminology is called PM 10. It is not actually quite the way it is written here, but this we write PM subscript 10; all particles of size less than 10 micron metre and they also call as inhalable particles; again related to the lung functions. Then we have the PM subscript 2.5, then the overall particles are less than or equal to 2.5 micron metre is called respirable particles or fine particles – two names. Most common is the fine particles. Particles PM subscript 0.1 or 0.1 less than or equal to diameter 0.1 we will call the ultrafine particles; they are really very fine particles. There is another terminology that is written as PM subscript 10 dash 2.5; that means, the particles of size less than 10 millimetres but bigger than 2.5 or bigger; these are called coarse particles.

The diameter is specified; this diameter is not the ordinary diameter. This is something the diameter, which all the time the word diameter you see in the slide and what I am talking about really is a diameter called - aerodynamic diameter; we will see what this is in a moment. I think it is better to call this coarse fraction (Refer Slide Time: 31:11 min). Now you want to discuss this. I use the word aerodynamic diameter.

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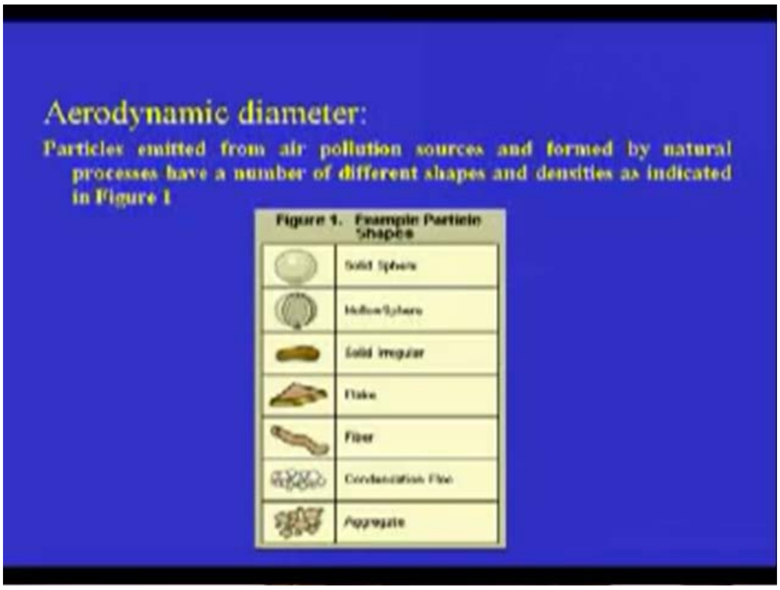

See the funny thing here is that particles emitted from air pollution sources and formed by the natural processes have a number of different shapes and densities as indicated in Figure 1. See here how do you define the diameter of these or this for that matter. If it is a hollow, this might behave very differently in the atmosphere as opposed to a flake or a fibre or the condensation flock or the aggregate, which you may not be able to see as fine as this one. So we must standardise the whole thing to a particular thing and that is what is the aerodynamic diameter is standardising the things so that they will behave in a certain fashion. If we can define the aerodynamic diameter, because depending on the aerodynamics.... It will be a little interesting for you here to note that some of the fibres, asbestos for example, since we are talking about the units, asbestos is not measured in terms of microgram per metre cube or ppm or this thing; asbestos is in the air is always measured in number of fibres per metre cube. That you may find very interesting.

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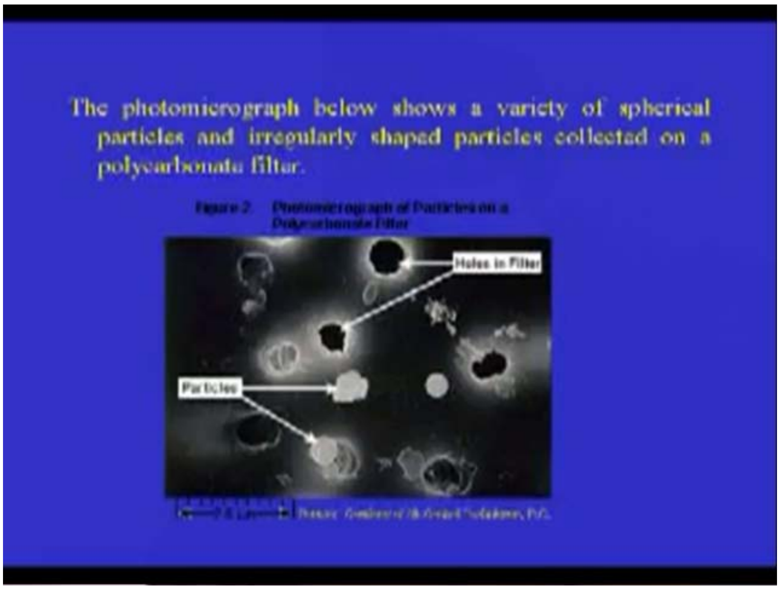

We want to define something very standard rather than going on a shape. Look at this; this is a real picture taken from a site. You see the particles, they can be holes in filter and there particles size can vary and things like that. So we need to list nothing very circular that kind of thing; so we need to define the aerodynamic diameter.

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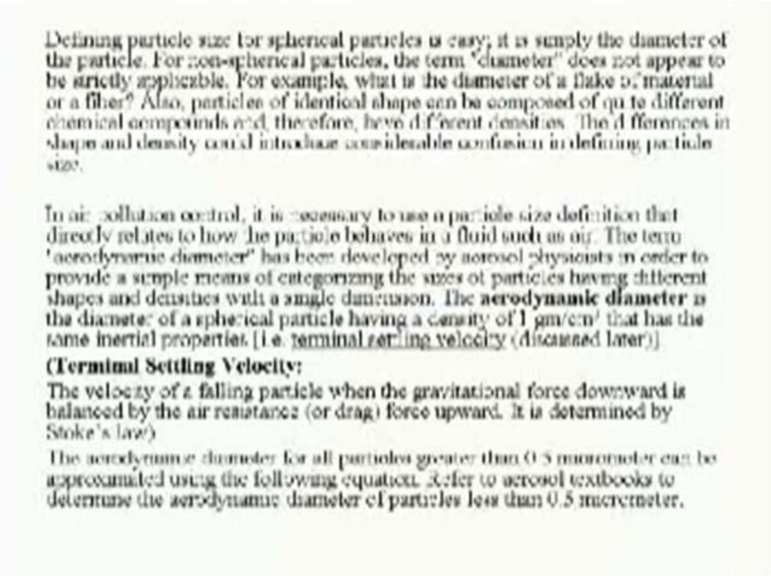
Defining particle size for spherical particles is easy; it is simply the diameter of the particle. For non-spherical particles, the term "diameter" does not appear to be strictly applicable. For example, what is the diameter of a flake of material or a fiber? Also, particles of identical shape can be composed of quite different chemical compounds and, therefore, have different densities. The differences in shape and density could introduce considerable confusion in defining particle size.

In air pollution control, it is necessary to use a particle size definition that directly relates to how the particle behaves in a fluid such as air. The term "aerodynamic diameter" has been developed by aerosol physicists in order to provide a simple means of categorizing the sizes of particles having different shapes and densities with a single dimension. The **aerodynamic diameter** is the diameter of a spherical particle having a density of 1 gm/cm^3 that has the same inertial properties [i.e. terminal settling velocity (discussed later)]

(Terminal Settling Velocity:

The velocity of a falling particle when the gravitational force downward is balanced by the air resistance (or drag) force upward. It is determined by Stoke's law)

The aerodynamic diameter for all particles greater than 0.5 micrometer can be approximated using the following equation. Refer to aerosol textbooks to determine the aerodynamic diameter of particles less than 0.5 micrometer.

This is a little description that you see here, but I think quickly let us go through this; this is a very meaningful thing. What is the purpose of defining the particle size? Defining particle size for spherical particles is easy; it is simply the diameter of the particles. For known spherical particles the term diameter does not appear to be strictly applicable; for example, what is the diameter of a flake or a material or a fibre? Also, particles of identical shapes can be composed of quite different chemical compounds and therefore have different densities.

The difference in the shape and density could introduce considerable confusion in defining the particle size because the behaviour of the particle will be different. We are defining the diameter more because of the behaviour of the particles.

In air pollution control, it is necessary to use a particle size definition that directly relates to how the particles behave in the fluid such as air. Basically what we are trying to do, we are trying to standardise and normalise a thing, so that there is no confusion as to the things. The term aerodynamic diameter has been developed by aerosol physicist in order to provide a simple means of categorising the sizes of the particles having different shapes and densities with a single dimension.

Just see what the aerodynamic diameter is. The aerodynamic diameter is the diameter of a spherical particle having a density 1 gram per centimetre cube that has the same inertial properties like the terminal settling velocity. If I have another particle and its density is 1 gram per metre cube and it is having the same velocity as my standard particle, then to have the aerodynamic diameter of whatever that the real spherical diameter. I will explain this little bit in a moment. The velocity of a falling particle when the gravitational force is downward is balanced by the air resistance or drag or force upward. It is determined by the Stokes law. You all remember the Stokes law from the same. You can also say that Stokes law is the balance of three forces: drag, buoyancy and gravity. That is the time when all three forces are balanced and particle will move with the constant; so actually that is called the terminal velocity.

The aerodynamic diameter of all particles greater than .5 micron can be approximated using the following equation. Refer to aerosol text books to determine the aerodynamic diameter of particles less than .5 micrometer. This is a little more complicated. I think I need to explain it quickly.

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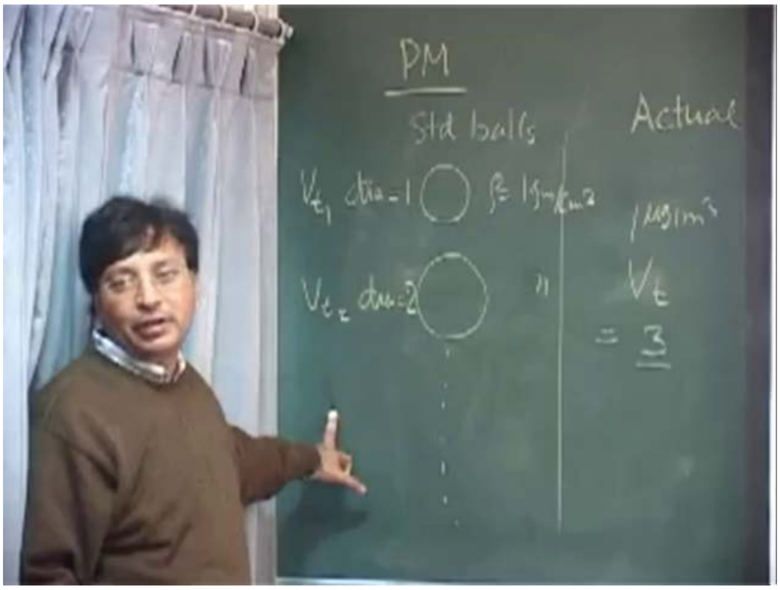

This is hypothetical, suppose I use standard balls. The balls I am referring to has density is 1 gram per centimetre cube and diameter, I am not giving you any units, but diameter is 1 whatever the unit may be. I may have this same property, same thing; I may have another ball with the same properties. It will have some terminal velocity in the air. Suppose that terminal velocity is Vt_1, here the density is the same, diameter is two and velocity is Vt_2 and so and so forth.

This is the standard thing which probably does not even exist, but I will take my actual particle and then I will see the particle if that particle had the density. Now, this is actual (Refer Slide Time: 38:07 min). Suppose I could see that how things will change for the particle; the density is 1 microgram per metre cube. It will give me some terminal velocity for this my actual particle. Then I can compare actual terminal velocities matching out of this one. So this diameter of actual particle may look like let us say 3. I am not giving the units, but I have to see what is its the terminal velocity and compare with this thing. Then that will be my actual aerodynamic diameter. So in fact, the diameter, which 3 micron metre, which you measure by some means, for that aerodynamic diameter may be more or less. The next sheet probably explains this a little bit more.

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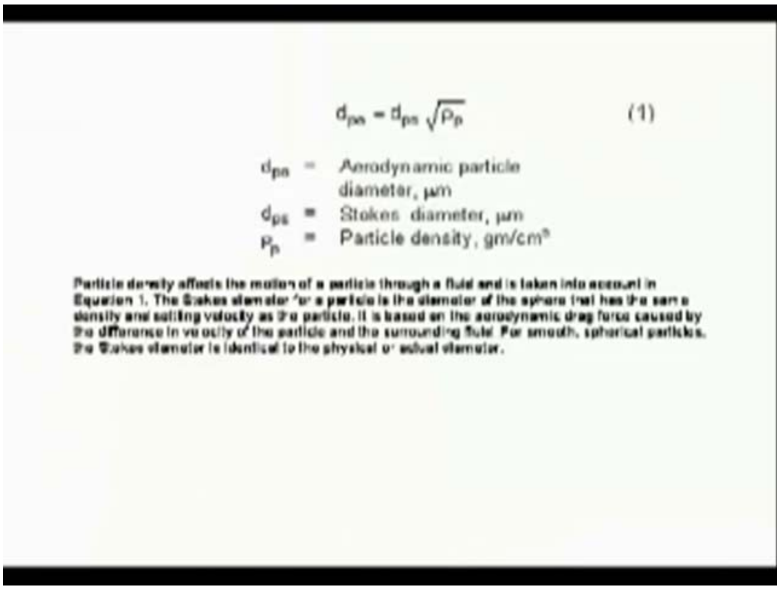

Normally people use this expression, but there are other methods also. To find out the aerodynamic particle diameter, you find out the Stokes diameter. How can you find out the Stoke's diameter? The particle density affects the motion of the particles through a fluid and is taken into the account in the equation of this. The Stokes diameter of the particle, listen carefully, is the diameter of the sphere that has the same density and settling velocity as the particle. Stokes diameter of a particle is the diameter of the sphere from the standard.

You are comparing with the standard, which has what, based on the aerodynamic diameter caused by the difference in the Stokes diameter of the particle of the diameter of this sphere that has the same density and the settling velocity as the particle. It is based on the aerodynamic drag force caused by the difference in velocity of the particle and surrounding fluid. For a smooth particle the Stokes diameter is identical to the physical or actual diameter.

You can find out the Stokes diameter and then you have the density of the particle; this one, obviously, you can see this is an empirical expression, this one, not that one. So if you know the Stokes diameter of the particle and the density of the particle, then you can find out. How do you find out Stokes diameter? Use that expression. [Conversation between Student and Professor – Not audible ((00:40:49 min))]. Now what we will do is that we know the terminal velocity of the particle, we are measuring the terminal velocity and for that one we are finding the diameter from the Stokes law. Normally we do the reverse thing. We assume the diameter of particle and find out the terminal velocity, but what you are measuring is terminal velocity and based on that expression of terminal velocity we are finding the diameter of the particle. In reverse direction that you are going on and that is the Stokes diameter that you can find out and the density of the particle is known. That is how you can find out the aerodynamic diameter of the particles. This is a little thing, as to how actual diameter, aerodynamic diameters, can vary.

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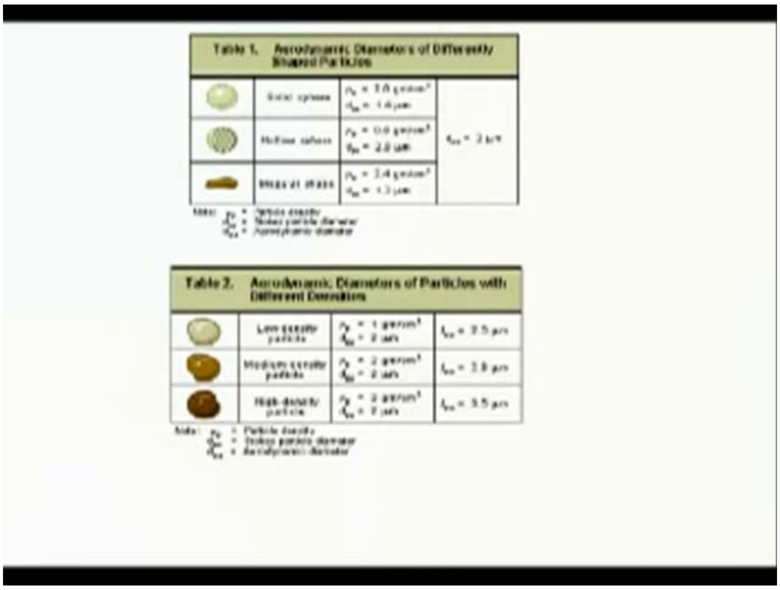

This is a solid sphere, all these things had the diameter as you will probably measure normally is 2 micron metre. What this slide is trying to tell you is that you have the particles different diameter, as you will see, 1.4, 2.8 and 1.3, but their densities are varying, but they are all equivalent to 2 micron metre in the aerodynamic sense. So that is what we are trying to say, while we can really, we have not, if you do not know the density then things like that you know like it is a ah these are not the real things that we want to use in air pollution engineering or air pollution control. With different densities you might get the equivalent aerodynamic diameter could be the same. All three look very different, but they will behave in the same way in the fluid air. Here, what you see is that you have the same size here and the density is varying and that equivalent aerodynamic diameter in this case, it is fine, because this is 2 here and this is 1 here, so you get 2 here; here because the density is different, the diameter is different. Although you will measure whatever ways and means you have as 2 micron metre, but we would prefer this to be called as 2.8 micron metre size of the particle. You might measure this as 2 micron metre and then you might say well this is little not quite correct, in the sense you want to use it and we might say that this is actually 3.5 micrometer. A little ordinary example for you to have a look after this one.

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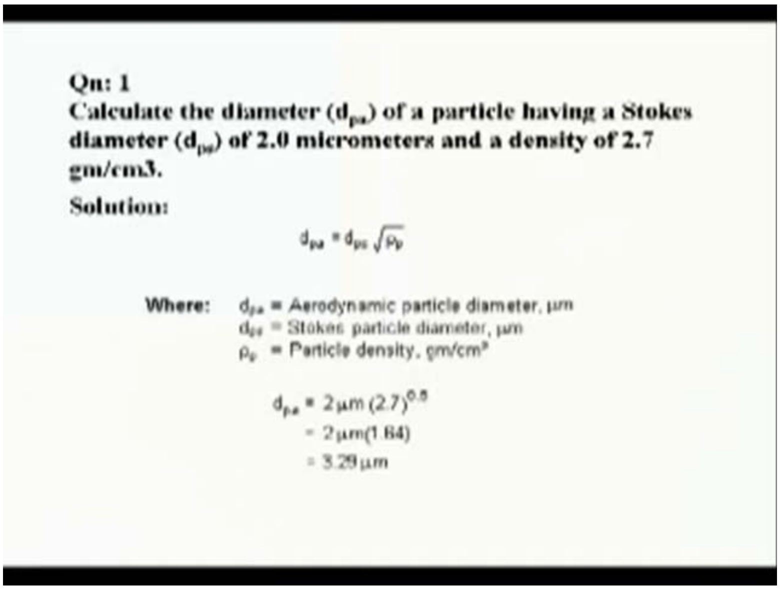

Suppose you are asked to calculate the aerodynamic diameter of the particle having a Stokes diameter or dps that you can find out is 2 micron metres and a density of 2.5 micron per centimetre cube, find out the aerodynamic diameter of the particle.

You see here what the density is, what is the density? The density is high; if the density is high the aerodynamic diameter will also be higher than its normal diameter as we see. Is that correct? Yes. You started with something like 2 micron metre and then you end up with the aerodynamic diameter of the 3.2 micron. Some more information on the particle size with respect to their sources and what they come out.

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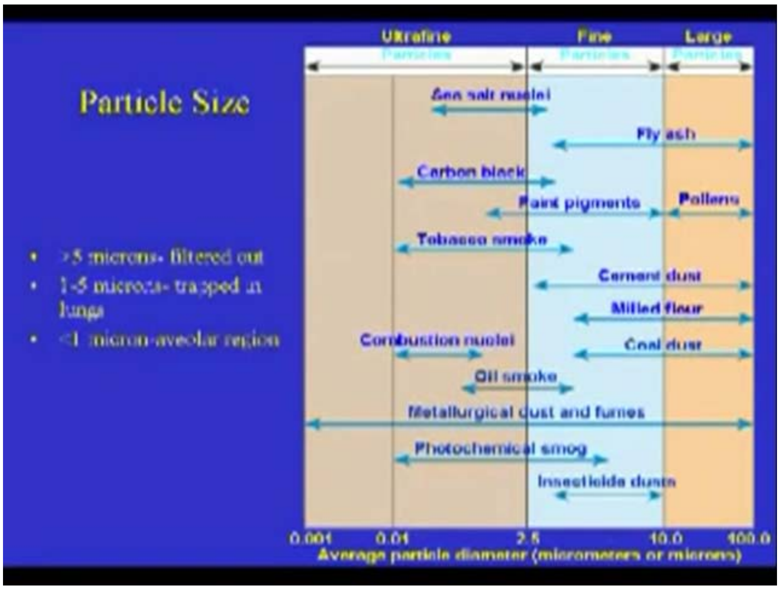

The interesting part is that we also call that ultrafine. Well, unfortunately, some definitions are little variable, but this 10 to 100 microns are really and they come in the large range people call it. You will see the fly ash because that you will encounter very many times. It is both, part of it will be in PM_{10} and part of this will be in the bigger than 10 micron here, as you see.

What do you think will be the size of the coal that you fire in a large power plant? You do not know, but then it can be anywhere from like 20 micron metre to 50 micron metre or so; that is so because it is pulverised. You see when the fly ash that comes out that is much finer than the things which you fire. So because, interesting thing is no mechanical processing can get you that below 10 micron metre. No matter how much you crush it, you cannot go below 20, 30 micron metre, but then once you fire it then it can the fly ash is in. Carbon black that you see from the exhaust coming out that can be of this size; paint pigments can be of this size. Pollens in the air because of that the plant thing which is flies off here and there this can be largely seen.

Tobacco smoke, cement dust, again some portion goes into this side but still it will be the largely this thing because cement is again not quite simply a mechanical process that is used to make cement. What happens in cement? You have the crushing of your limestone; first the mechanical crushing as much as you can do, then what we do? If you recall we do the calcinations, dry out the carbon dioxide component through that one; that is what the normal cement making is. So CO_2 is driven out and then as a result the size of the particles will become smaller. You start with large particles but some particles will become small. Milled flour, I really doubt that if they can go at 10; coal dust, again it does not go below 10; oil smoke is fully very fine particles, metallurgical dust and fumes well that can and the photochemical smoke what you see in the air that can be again defined.

Dust is more like insecticide dust, but dust is more like a normal terminology. Unfortunately there were more things to talk about, but before we end, I want to leave you some interesting thoughts or interesting points. Well I do not want to ask you this question but maybe I will just ask; tell me if you want to tell me; if you do not want to tell me, do not tell me. Who smokes? No one smokes? Very good. See this is something from the last class that I wanted to talk to you about.

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Cigarette comes with filter, except the Charminar cigarette; some people who are fans of Charminar, they do not mind if the filter is there or not. This is what it is, a little fire portion here. You will see a little trickle and this is little which is like fire on the tip. What it signifies in the sense that what we did in the last class; source, but formation of secondary pollutants. When you light up the cigarette, you will find there is nothing. There will always be a gap and the fumes you will see or the particles you will see will be at a little higher level. These which are in the vapour phase, they will convert into the particulates or the smoke that you see here and you will not see any smoke that is here. You will see the smoke here; so it started with the gaseous pollutants, it might condense, it might nucleate, it might agglomerate and then you see lot of smoke here. So this is basically going from primary to secondary and it is both the phase conversion as well as becoming from the particle the gaseous to the particle. You will not find anything here but you will find a lot of smoke here. This is what the conversion of this one is.

I was sitting in the airport waiting for my flight to come and then I could see at the runway; planes are landing and they take off. Every time like the big screen, I could see the planes were landing, as soon as they will hit the wheels or the tyres will hit to this thing, there used to be smoke, there used to be some dust; I always used to think that it is the dust that is coming out and I said well maybe the runway is dirty and things like that. There is some dust which is there on the road that comes and gets out, but that is not the dust. It is the heat. The tyres as they hit the ground and the brakes are applied, the tyres are at high temperature, the volatile components of this thing, that comes out and it goes little and then you see the smoke; you will not see the smoke on the runway, if you go little up there is a puff of smoke that is going out. So again that is some kind of secondary particles are formed and that is how the volatile components of the tyre slowly goes off from the air and it is because of the heat that it hits the ground.

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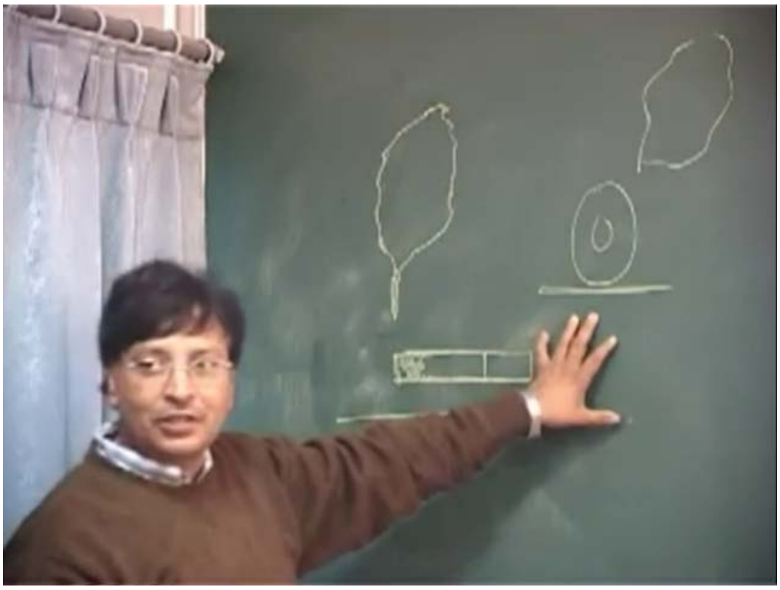

Suppose these are the tyres, as it hits to the runway and you will see the smoke, not here. The smoke, you know, like there is some gap which was very clearly that could be seen and then I remembered this example. It is not the dust on the runway that is causing the smoke and it is not very small, I must have been be somewhere like 400 metres, 300 metres away and I could clearly see that the smoke are coming out of it like this. This is the organics or the volatile compounds that are part of the tyre and that goes on this thing; this is still a matter of investigation; people do a lot of studies and then they are trying to see when this is the non-exhaust emissions. May be we will have the time to talk about that. This is a small thing, observe the cigarette, if you can observe you will see that this is what is happening and then you find a gap here.

We will stop here.