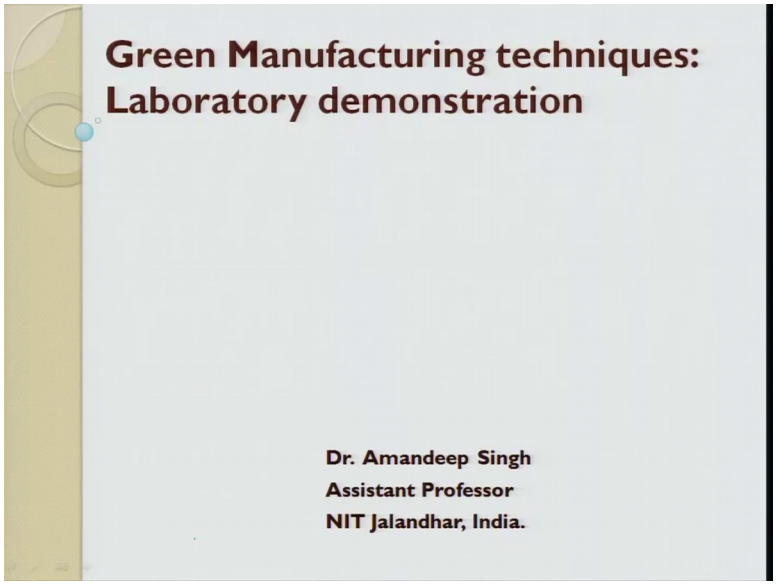
Sustainability Through Green Manufacturing Systems: An Applied Approach

Prof. Deepu Philip
Department of Industrial and Management Engineering
Indian Institute of Technology, Kanpur
Dr. Amandeep Singh Oberoi
National Institute of Technology, Jalandhar

Lecture – 25
Demonstration of Various Instruments Used for Green Machining

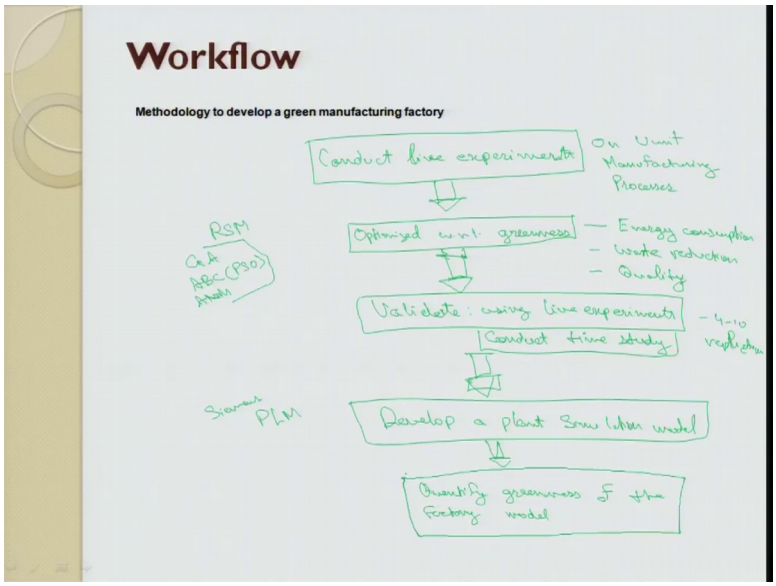
Good morning. Welcome back to the course Sustainability through Green Manufacturing: an applied approach.

(Refer Slide Time: 00:26)



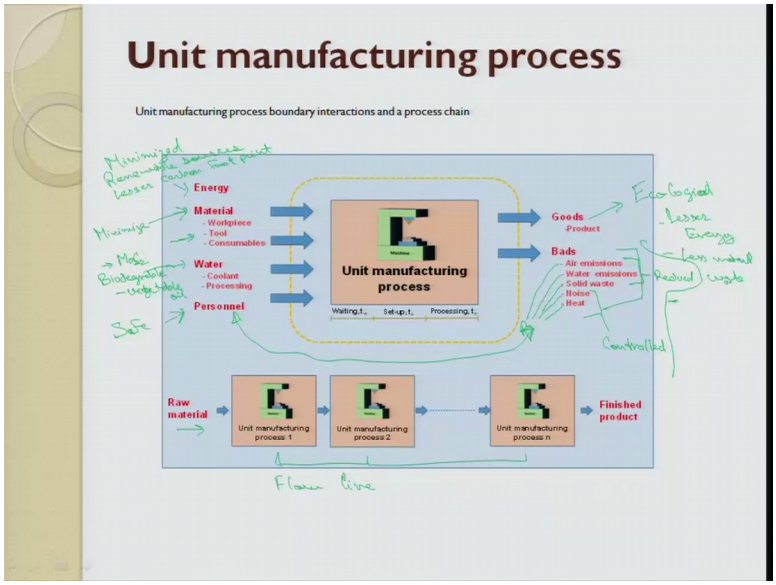
So, this is a lab demonstration session, after this session we will take you to the Manufacturing Science lab of IIT, Kanpur; where we will show you the live experiments, how do we do green manufacturing, how do we conduct experiments based on green techniques. This is initial session of that. In this session, we will tell you about the various instruments that we will use in the next session.

(Refer Slide Time: 00:55)



And we will use this work flow to convert the facility to green. What we will do? We will conduct live experiments on unit manufacturing processes.

(Refer Slide Time: 01:34)



Now what are unit manufacturing processes is? Just recalling; here we have a unit manufacturing process. A single unit or a single machine that might be milling machine, might be drilling machine, grinding machine some micro some modern machine may be turning, lathe, anything like this unit manufacturing. It has certain inputs and certain

outputs. Inputs are the resources that we use; outputs are that is the product or may be some waste.

Now, in this case, the input is energy, material, water and human resource; the personnel or the operator. A skilled operator has to be there to work on this one. And the outputs are goods and bads. I have put words bads here because air emissions, water emissions, solid waste, noise, heat all this are the bad things which we do not require, but, these cannot be eliminated; however, we can control this.

So, energy which we have here should be minimized. Maybe, some energy might be coming from renewable sources or may be lesser carbon foot print that is the cleaner source of energy, if not renewable. Then material used should also be minimized, this tool is quite expensive in manufacturing. Tool wear is a basic criteria in manufacturing. Tool wear rate is important to be considered while we do manufacturing specifically in conventional machining, now; in this case this should be minimized. Wastes are the consumables are there.

Then we have other resources like water. Water is used in coolant, processing; this coolant this might be in this case we use biodegradable coolant, then in the biodegradable we can use vegetable oil, we have already discussed ester oil or maybe some other. We can even add some additives to the mineral oil, like molybdenum disulfide to have better results.

Then personnel; regarding personnel it is important to keep them safe. Safety is the basic concern here. Now, we have goods here, now if the product that is produced is having lesser impact or may be equivalent impact then the regular product that is that may be called green product. Now, the product, if it uses lesser energy or less material waste.

Now, there are bads that are associated with manufacturing; air emissions, water emissions these should be reduced, then noise and heat we cannot eliminate these, but these can be controlled. This solid, water, this air emissions, water emissions, noise, heat and all these solid waste these also effect the personnel that are working. So these are connected. Besides the long term benefits, we have also the short term effects to the human operator get those are working on.

The noise, that is the sound that is being produced in manufacturing, in a machine chop; that is, there are 2 types of sound we have all discussed. Like it is average sound in the whole day during machining or might be the peak sound. These affect in the long run in work folks 5 years or may be some people who are working in machining factory they work for 35 or 40 years and in long term hearing impairment might be there or some cardiovascular or some other disease hyper tension is there. These type of bad effects might come. So, there are ill effects of these bads in short term and in a long term and also social impact is there.

Now, when these unit processes are connected together, we have a flow line. Now in this raw material is there, process 1, 2, so on, up to process n is done on it and a finished product is produced. These live experiments are conducted on number of product, number of processes here. Then each of these processes is separately optimized with respect to greenness. This optimization might be done based on energy consumption again, then waste reduction, then one quality parameter has to be there to maintain the quality along with minimizing the bad effects and this optimization might be done with certain tools like response surface methodology and we have multiple objective optimizations.

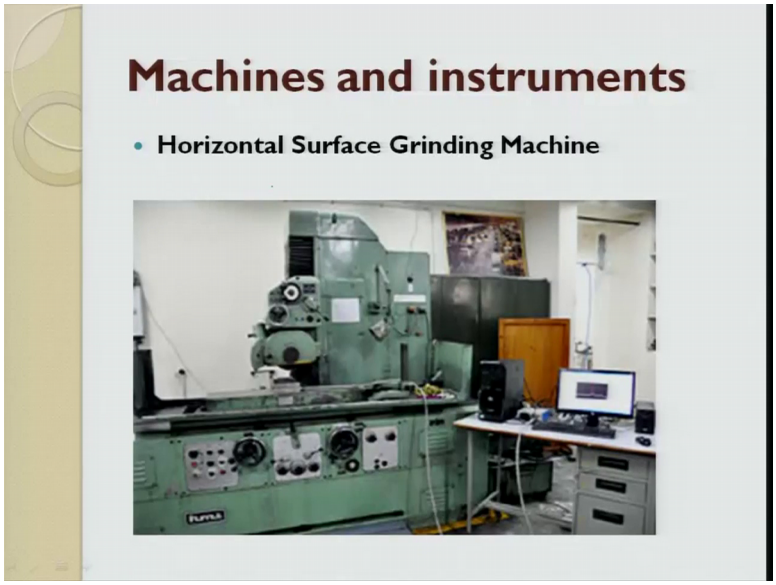
Then we can even use certain algorithm, genetic algorithm then we have ABC – artificial bee colony algorithm, then ANN number of numerous techniques available, anything we can use. Now, once we have obtained the optimum settings then we do we will have to; obviously, validate. This validation is done using live experiments, again. Validate or we also obtain the sensitivity. What is the sensitivity of the results that of the factor settings which we have obtained in the previous step.

This during this validations step we also conduct time study, because this time this processing time I will go back to this unit manufacturing process again we have 3 types of times here. Now we are talking about processing and setup time here. The setting which is done here is for processing time only. Here, we conduct time study and all these times waiting time, setup time and processing time are noted and we have number of replications here, maybe because this is sensitivity analysis only about may be 4 to 10 replications. Now, once we have processing time, then we develop a plant simulation model. In IIT Kanpur we have PLM software; PLM it is product lifecycle management software that is provided by Siemens, also there other tools like Arena and certain open

source open access sources are there like Modelica, those are available, but PLM is very good software in that. So, this is by Siemens.

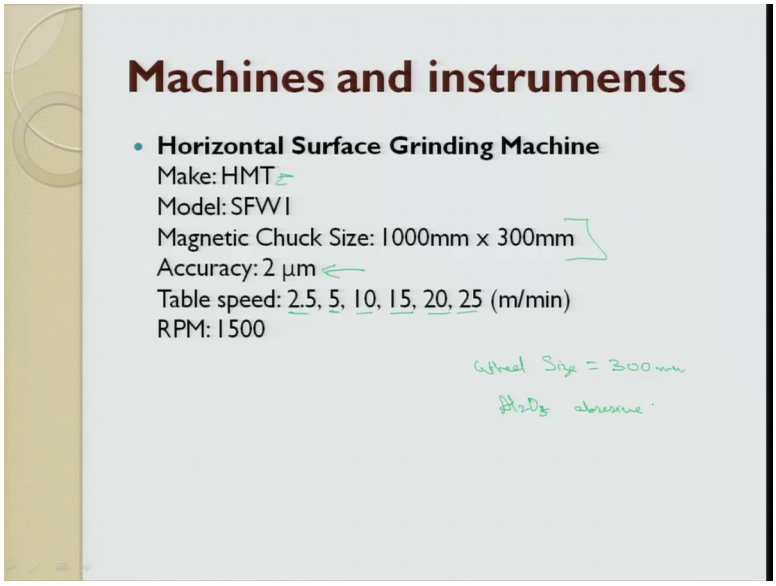
Then we quantify greenness of the factory model. So, I thought to introduce all this to you in this phase only because this is what we are going to do in our lab demonstrations.

(Refer Slide Time: 11:58)



Now, in conducting live experiments or unit manufacturing processes various unit processes were chosen like in this case I am showing you a horizontal grinding machine. In this case grinding machine is chosen. we will conduct experiments on this machine.

(Refer Slide Time: 12:05)

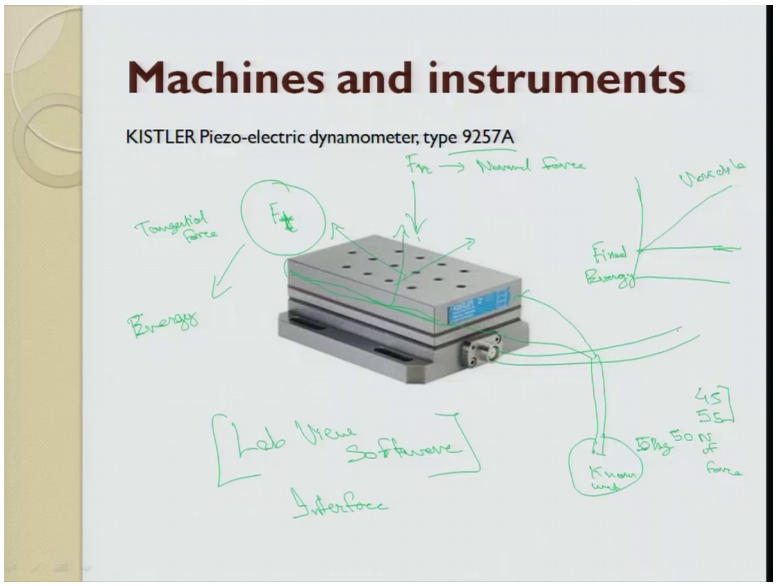


Regarding this machine it is a HMT make machine. The model number is here, the chuck size is here, the accuracy of the machine is 2 micro meter; that is the minimum depth of cut we can give here is 2 micro meter and table speed varies, these are discrete values 2.5, 5, 10, 15, 20 and 25 meter per minute. In RPM that is we also kept RPM same as 1500 RPM here and the wheel size here was 300 mm and it is aluminum abrasive wheel.

(Refer Slide Time: 12:59)

So, also we did milling and drilling differently, but machine that was used was this one this is EMCO Concept Mill 250. I will tell you about the machine when we come to the experiments of drilling and milling.

(Refer Slide Time: 13:31)



Now this is KISTLER make Piezo-electric dynamometer type 9257A. Now, it may have forces in 3 directions x, y and z. In this case, because this dynamometer is mounted horizontally, we have forces that are in this, I would say I would put this arrow like this; this is normal force, the force in this direction is we called as F n in case of grinding and in this direction this is F y or in this terms I will call it F t, this is tangential force and this is normal force and normal force is always greater than tangential force, this mechanical people know. I put it this is F t, please do not get confused here.

So, this dynamometer is calibrated before we do machining. Everything, machine, parameters or every instrument which you use has to be calibrated because these are experiments and it has to be in controlled environment. So, while doing calibration what we do, we put a belt over here and apply a known weight; this weight pushes this machine or I could say it pulls this machine.

For example: if this weight is 5 kg then we say 50 Newton of force, now, when we will go to lab I will tell you that 1 Newton is converted into 1 volt. This force is converted like translated into electrical signal and we have electrical output over here and in this case then we have some correction factor. For example: this 5 kg it had to be 50 Newton and if the signal is coming maybe 45 or 55 this much energy is never there; I will say, if I say it is like that 45 or 55 Newton we will put the correction factor in our LabVIEW

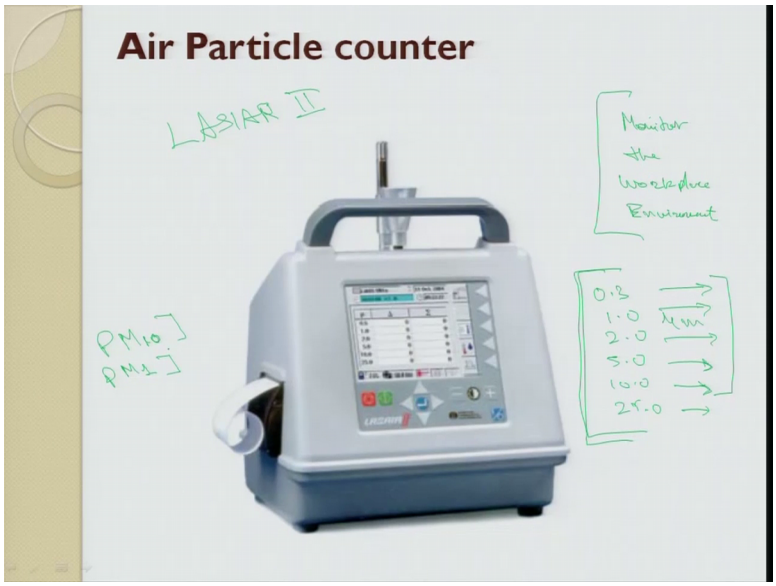
software. We use LabVIEW software as an interface. This software is an interface between this dynamometer and our computer.

So, we get F t and F n both, but this component is enough to tell us what is the force and this force in turns tell us the energy or we have chosen; this force as a factor that represent the energy that is required to do machining. It is to be noted here this is total energy. The total energy is like this, in machining this is fixed energy and this is variable energy and this is only the variable energy and this is I call it internal energy and from here we have cord that is a connected to our control panel.

(Refer Slide Time: 17:14)

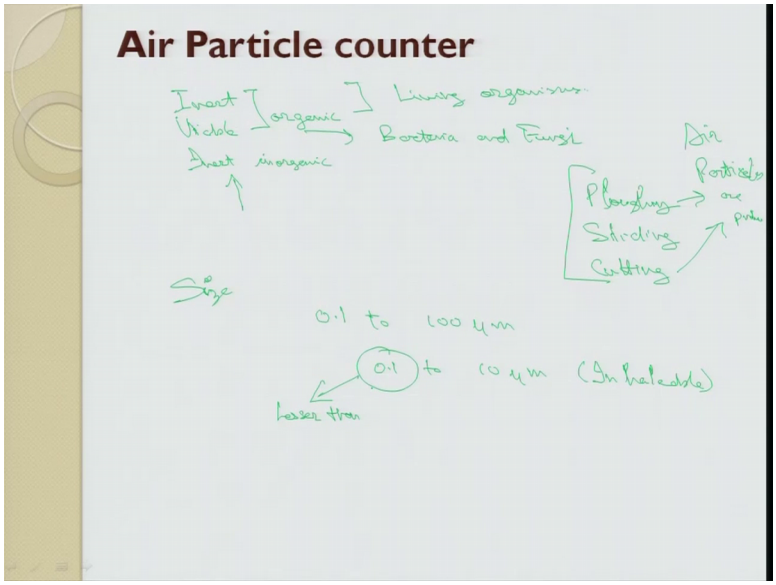
Now, this is a rotary dynamometer. This is another version of this KISTLER dynamometer and this is used for our drilling and milling experiments. It is 4 component dynamometer and it can may have 4 different computer F x, y, z and movement also F in x, F in y, F in z direction and also movement in z direction.

(Refer Slide Time: 17:50)



So, the next instrument is air particle counter. This is one of the instruments that we have chosen to monitor the work place environment. Out of the bads that are produced, air emissions are there, noise is there, heat is there; this will count the air particles. What is the size and what is the volume of particles that are present in our machine chop while doing machining.

(Refer Slide Time: 18:37)



Now, I will tell you something about air particles. There are generally 3 type of air particles; that is inert and viable, organic particles; then we have inert inorganic. Now,

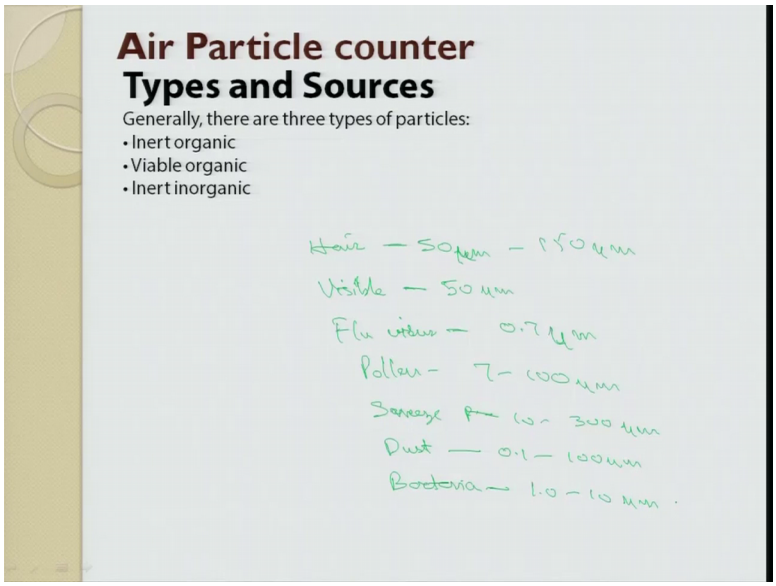
inert organic particles come from non reactive organic material which is material that is arrive from living organisms. This is come from living organisms and viable organic particles are capable of living, developing or germinating under favorable conditions like from bacteria and fungi are examples of this one.

Now, what is of our concern is inert inorganic particles here, because in our machine chop we have particles that are produced where rubbing of metals or rubbing of materials with each other. For example; like carpenter, when he does his work 2 materials that are non living are rubbing with each other. In machine chop also we are rubbing the material with each other; that cutting tool that is a hard material is rubbing with our soft material that is the work piece to do the machining.

So, we know that there are 3 mechanisms; ploughing, then sliding and then cutting in grinding. Ploughing is just where material is replaced, nothing happen. Sliding is our grid, the grinding grid that slides over the work piece and ploughing is just replacing material and doesn't remove it completely, cutting is when actual cutting happens. But, in ploughing also and in cutting the air particles are produced. So, these are inert inorganic particles. Now, humans shed many thousands of inert particles through continuous sloughing, example; dead skin, etcetera is also kind of inert particles here, but that is not of our concern here. So, we are talking about the particles that are in machine chop.

So, regarding size of the particles; the particle size might be from 0.1 to 100 micro meters. LASIAR II model and this has 6 channels of 0.3, 1.0, 2.0, 5.0, 10.0 and 25.0 micro meter. These different sizes are record in number of particles of all these sizes are recorded. And particles that are severe to human health are from may be 0.1 to 10 micro meter that are inhalable, like that can be inhaled while breathing.

(Refer Slide Time: 23:07)

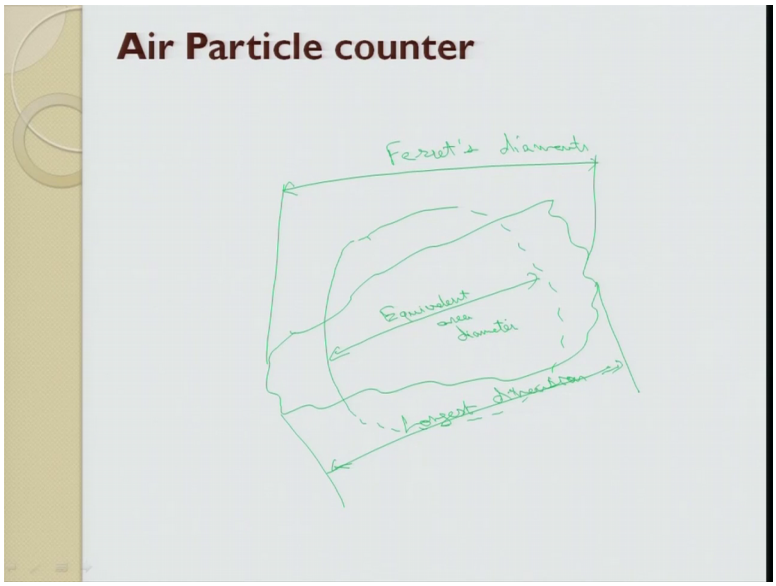


And even some reports are there if particle sizes are if it is even lesser than this one that even can penetrate lungs.

So, regarding the size of the particles I will tell you some examples regarding just to give you certain feel of; our hair is of 50 micro meter to 150 micro meter. Then the particles that are visible to us are, visible by naked eye are up to 50 micro meter. Then flu virus is also through the virus particles that are around us in air and its size is 0.5 micro meter. So, see I told you if it is less than 1 micro meter and it is bad for health here. Then pollen is from 7 to 100 micrometer; then sneeze particles may be they are from 10 to 300 micro meter; then general dust or the regular dust where that we have in our play grounds or may be in streets is from 0.1 to 100 micro meter. So, this is the size I put here, the general size. Then bacteria, in this case the particle size from 1 to 10 micro meter.

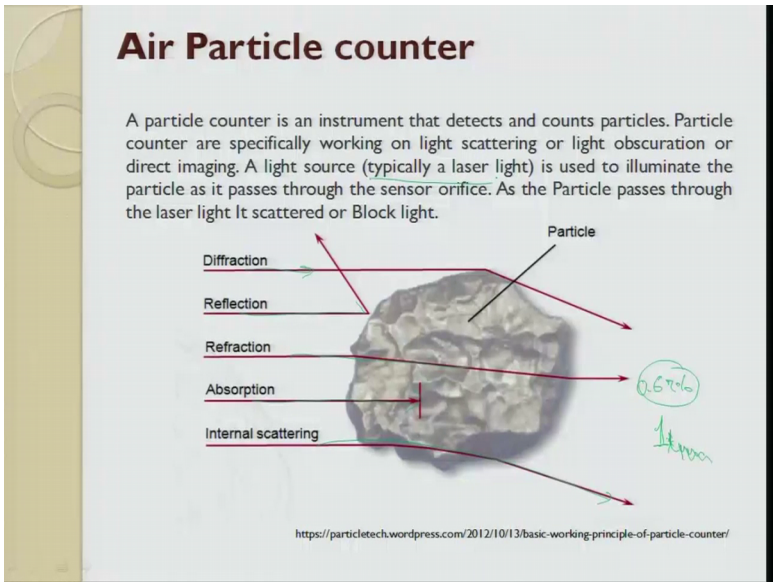
So, we have particle size counter here that has the 6 channels and it can count up to. So, what is important to us is, I will have 2 levels here PM 10 and PM 1. PM 10 is like weight of all the particles per cubic meter.

(Refer Slide Time: 25:33)



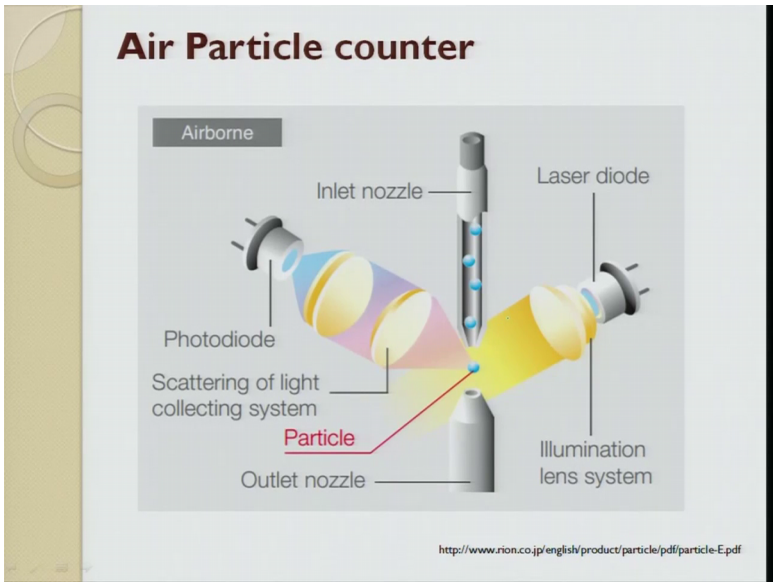
So, I will tell you criteria on which these air particle counter is working. We have particle for example, I take irregular size of particle here; for example, this is a particle and this case this is I will say longest dimension of the particle. This is our longest dimension. So, we have some dia that is, if it is the other view there is some dia that I call that is the average dia of the whole volume that is known as Ferret's dia. And based on this ferrets dia we have equivalent area, I will draw it dotted, it is equivalent area diameter and this diameter is there that is counted for our particular size here. So, it is giving us this dia that is if it is 1 micro meter it is this dia equivalent area diameter that is 1 micro meter and also because there are certain losses.

(Refer Slide Time: 26:55)



See the particle counter has certain limitations over it.

(Refer Slide Time: 27:06)



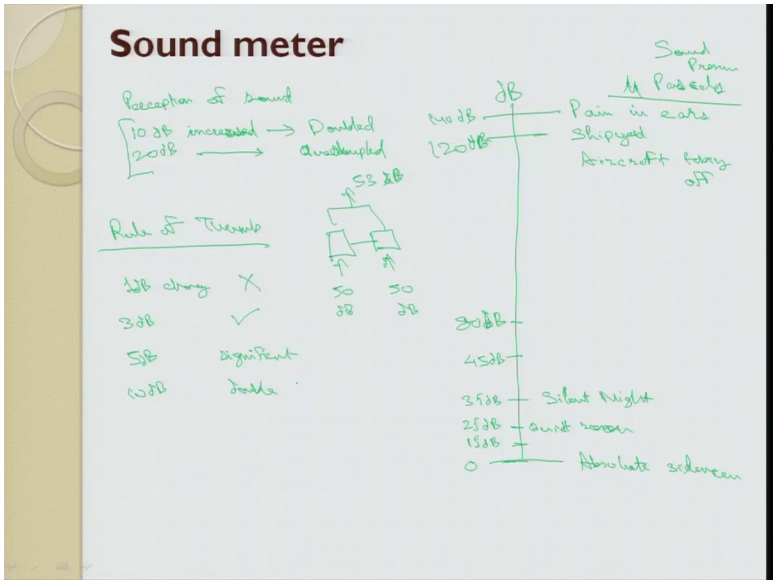
The principle on which this is working I will tell you. There is a light that is passing here, a photo diode is here, that is light is there scattered light is collected by the system and the particle, this scattered light produced a image here and this image is recorded on a diaphragm and that image is used to tell us the particle dia.

So, when the light is here it can either diffract or it can reflect back, the refraction might be there, only absorption is the criteria that is used here, internal scattering might be

there. So, in general the researchers told us that about 67 percent of the light is like used here like for actual calculation.

So, the particle size what we are having is might be like, for example, if we having particle size of 1 micro meter it is 65 percent of the actual size. It has to be calibrated accordingly. So, the principle here is, a light source typically a laser light is used to illuminate the particle and it passes through the sensor orifice. As the particle passes through the laser light, it scattered or block the light. A light, scattered light is used to tell us the particle size.

(Refer Slide Time: 29:15)



Now, next what we have here is, sound meter. 2 of the instruments here are portable like that you could bring to this recording room as well. Rest instrument we will show you in the lab demonstration I have a sound meter and our air atomizing nozzle with us. So this is our sound meter, I have a power button here. Now it switches on. So, before telling you how to use the sound meter, I will tell you something about what is sound and what are various characteristics of that.

Now, I will show you a scale, now the presently we know that the scale that is used for like calculating or telling this sound is decibel, earlier micro Pascal was used; that is actually those that was sound pressure, this was sound pressure. So, 0 decibel is absolute silence. So, even if you enter the silent rooms, you will find at least 15 decibel of sound over there as well. This is my observation.

So, about if we say very quiet room, if I say it is some there is some quite room, then it is about I would say 25 decibel; then a silent night this I am talking about the rural night not the urban traffic in that case it is 35 decibel. So, while I am speaking during this lecture, this sound recording is you see it is about 80 decibels and in a living room it is about 45 decibels.

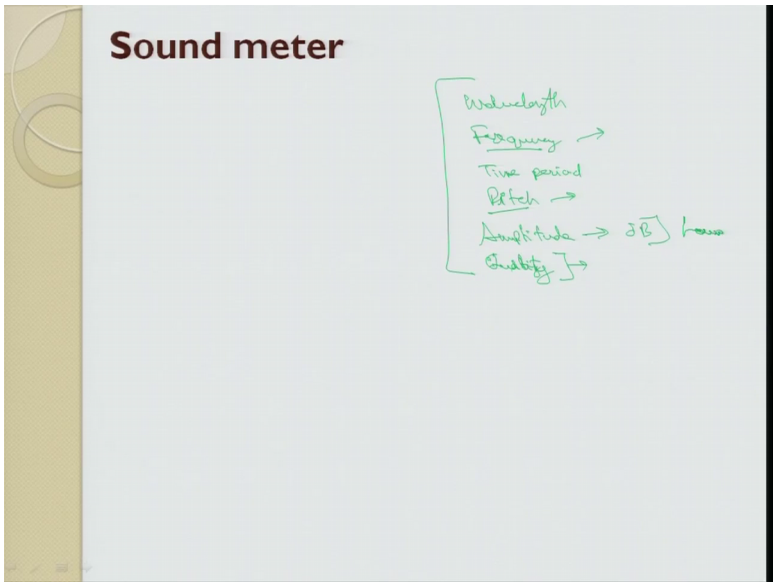
I'll take you to the higher sides. Now the 120 decibel is the sound of I will give an example of may be shipyard. When you are out on the deck, you will find high sound or when aircraft is or aircraft taking off and 140 decibel is something when you feel pain in your ears. Now, there are certain other things in between like busiest train would be about same order as 80 decibels or busy office like banks would be of same scale.

So, certain other things regarding sound, regarding running perception of sound, I will tell you something about the actual perception of sound. So, in this case if 10 decibel of sound is increased, what do you guess? What would a human feel? He will feel the sound is doubled and if it is 20 decibel, he will feel it is quadrupled. So, this is perception.

When we have 2 sound sources emitting equivalent sound for example, this is 50 and this is 50 decibels, total sound that is coming up is only 53 decibels, only 3 decibel increase. In a certain calculation behind this one, few are like to know, we can tell you that as well in the notes.

And the rough rule of thumb for the perception, 1 decibel change not noticeable, may be not at all. 3 decibel change is noticeable, 5 decibel change is little significant, 10 decibel is what, double.

(Refer Slide Time: 34:14)



There are certain parameters like wavelength, frequency, time period for which one is exposed to the sound, then I would write pitch here, amplitude, then may be the quality as well. The quality is only thing; quality is the parameter that decides the sound is good or bad. Like music is good otherwise it is noise. So, amplitude is the one that is calculated using our decibel, that is represented it in decibel. Now the frequency is the number of cycles per second and this pitch is the actually the brain interprets sound in terms of subjective quality, that is known as pitch and this amplitude is nothing, but decibels. Loudness is an attribute of sound that depends primarily on the pressure amplitude that is this tells us the loudness.

So, next I like to tell you something about the sound meter, which we have used to record the sound while doing machining. So, this we have here is Extech sound meter this is SDL 600. To switch it on I have to press the power button for 1.5 seconds and it switches on. In this case we have this wind, what you call, this is wind screen. So, because the wind blowing over like also could disturb; wind blowing across the microphone increases noise measurement.

So, the instrument is always calibrated before doing actual experiments. High temperature and humidity environments are not recommended for instrument to take along. This instrument could be used to work in both the frequency weighting scales, that is scale A or C.

For scale A is the scale that represents the human ear. So, this is even OSHA that is Occupational Safety and Health Administration, they also recommend scale A to be used to represent the human ear and scale C is something much flatter and we even have the options of fast and slow recording like the sound peaks that are recorded in fast mode and in slow mode it is recorded low. We have max and min modes and we can keep the backlight on and off and data hold can be done. I will tell you how the settings are here.

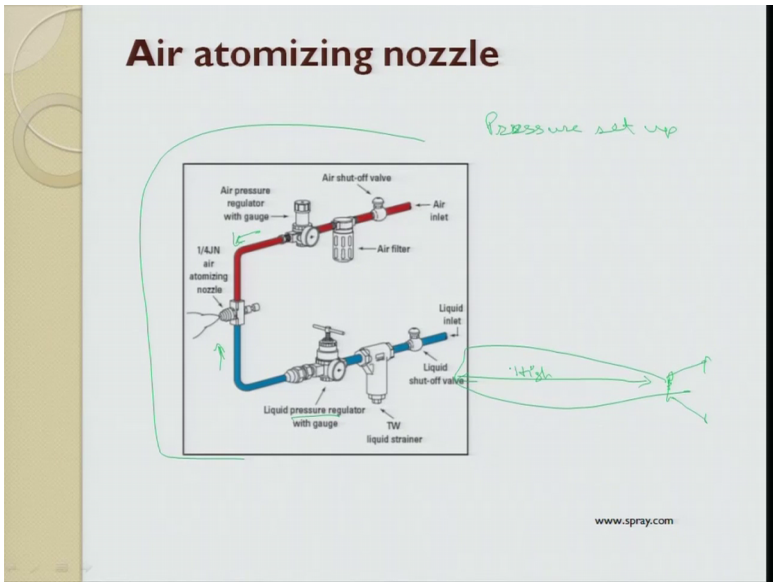
So, to have max and min, if I press it once it has started recording see record has come here, now, if I press it again it has shown the max value that has come since the recording has started. Now, if we press it again it is showing the minimum value. So, minimum value will remain same; if I increase my sound, hello, see the max value will change. Then to change the other settings, I have to go to set; this is for setting date, time and the data blogging may be power off and on and the scales which we need to do fast or slow.

In this case because we need to find, we need to obtain the data at every second, this data pulse is set to be 1 second and the recording scale the recording speed is kept to be fast and on A scale and it has, I switch it off to show you the card. This is data logger card that is recording the data. All the data is recorded in this one and I will show you the data in excel sheet. It give us the data in CSV format that is easily convertible to excel and also this can be connected to PC.

This can be connected to computer using this RS 232 port. This is RS 232 port, this is its charging point, also we have batteries in here and this is for calibrating and this may be AC out if required and in data log I will tell you the pulse rate that we can that can be put here is from 1 to 36000 seconds, after every 1 hour 1 pulse will be recorded.

This much length is required at some places for example, in some places this is used to monitor the noise for a longer period may be for 1 month. For example; traffic in a specific area or may be a sound in a specific park, in a specific domestic area at specific period of time, specific like for example, in evening right. What they do? The researchers, I have read it somewhere that researcher did research for 6 months to record the sound at 1 specific traffic point and differentiate and they compared between different weather conditions and at that point they set its value, the data sampling time, to be 36000 seconds. So, this was regarding our sound meter.

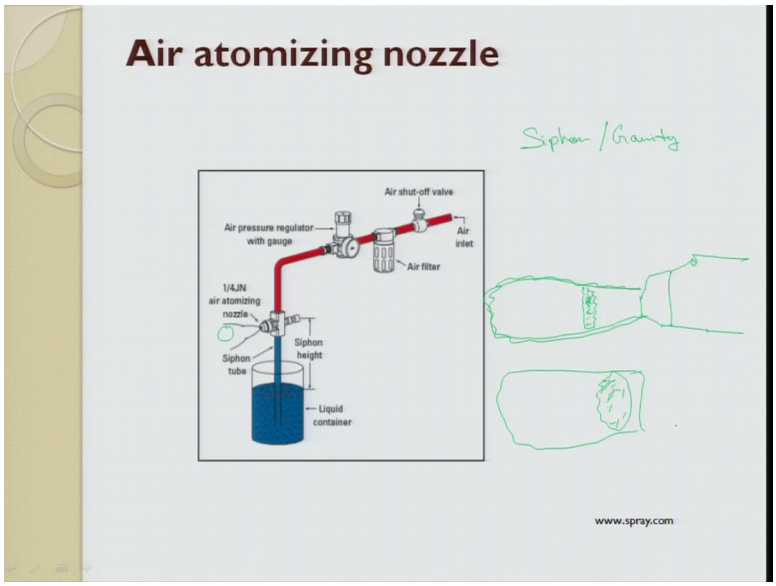
(Refer Slide Time: 41:37)



The next gadget I have in my hand is air atomizing nozzle. This is an air atomizing nozzle that also we call from US only. So, generally there are 2 types of setups for atomizing like for producing mist. So, this system that I am showing here is pressure setup. In this case, actually air pressure is there and obviously, liquid is there and liquid is also supplied through pressure.

In this case when high pressures are required and we need to have like more reach from the nozzle point, like this is our reach; when this length required is much high then this pressure systems are used.

(Refer Slide Time: 42:35)



Another system is siphon system; siphon or gravity system. In this case the air pressure is here and there is no pressure, but only through gravity, we have this mist coming up. Also, we have different types of patterns of flow.

Now, for example, this is my spray volume here, like reach of my spray. This might be flat or this might be round. This is generally, the flat type of pattern is used for painting etcetera and this we have used actually this front hole determines the kind of pressure the type of pattern we need to have. So, in this case we have this air cap, fluid cap and we have 4 holes and an orifice inside. So, this is an external mix, the air comes out here and from these holes air is coming in and from this point fluid is coming in and it mixes externally within this fluid cap, it mixes and we have mist out. We can control even the reach, like longest length that mist can reach using this screw as well.

So, with this I have covered the most instruments that we are going to use in the lab demonstration. So, next we will go to the lab and we will conduct experiments out there. Then I will tell you how to analyze the data, then further we will go to the next step, that is factory simulation.

Before factory simulation we will even do the optimization of the parameters and after that we will obtain a green factory. Green factory does not mean that it is all green. Green means that is we have moved a step advance; for example: if I categorize into colors from black, grey may be blue then green. If one has moved from grey to blue that

we can say we have turned a little thing to positive side. So, we will meet in the lab demonstration next.

Thank you.