Human Factors Engineering

Prof. V. K. Tiwari
Prof. P. K. Ray
Department of Agriculture and Food Engineering
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Lecture - 45
Ergonomic design of auditory environment in different workplaces

Welcome friends, students, participants and other practitioners who are attending the course on Human Factors Engineering. The sound level or the noise level, which is of more important in whatever sector that we are talking of- whether it is a service sector, if you are talking of even classrooms, or examination halls so on and so forth.

Whenever situation is there and how do we analyze that, what sort of parameters are to be taken, what is the intensity of those parameters, how do we manage such high levels, what are the nomenclature for those sound levels? We talked of the octave band, we talked of the one third octave band, we talked of the various noises or the sounds which is coming out from the different locations like we talked of the tractors, mufflers or the noise available from engine.

We can say stationary engines, we can think of the noise levels coming out of various types of equipment in the workshop like lathe, lathe machine. We are talking of the rolling machine, we are talking of even the sewing machine, and cutting machine; several such machines which are there in a big workshop.

There could be noise coming out from various locations and people working over there. How to evaluate that noise, how to measure that noise and what is the collective effort of those noise levels on the human being? The human being is the is the central theme of this human factors engineering that we are talking of.

We are talking of the factors which need to be engineered while we are talking of the machines and the human beings; this is what we are trying to engineer. Therefore, since human being which is a biological system, which is its own capabilities and limitations of various kinds.

They can understand certain things, they can perceive certain information, they can see at to a certain distance, they can see to a certain size of a particular item. Various biological limitations within that we have to perform best in the system and we have seen lot of accidents taking place, where ultimately it comes out that everything being alright.

It was human error and therefore, this has the greater importance. In the series of a second lecture, we will talk of design of auditory environment at different work places.

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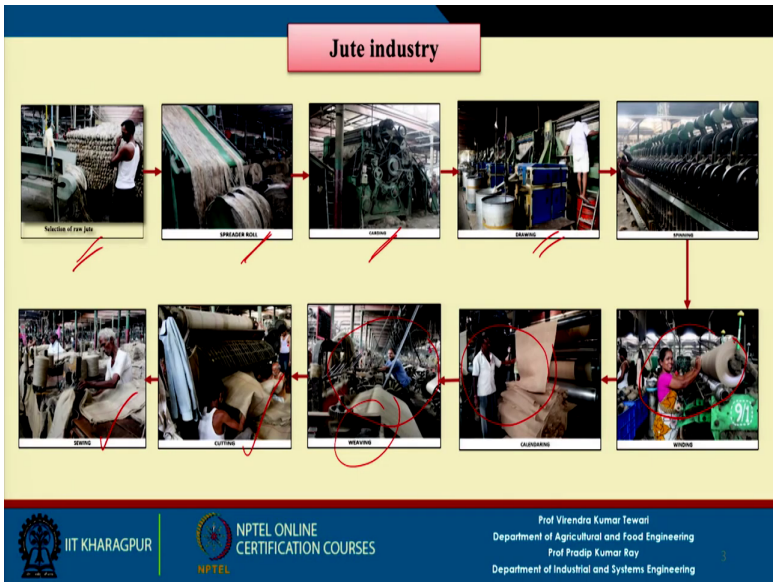

Here I have given example of a jute industry. We had visited a jute industry in Bengal and we have seen the condition of the workers, who are there in the various sections of the jute industry, when the jute comes from the farm and then, how it is kept in water for some time and after that and jute is to be extracted at various situations, various positions.

You can see here the selection of the raw jute, which comes over here; then it takes the spreading of the rolls, you talk of carding of these, then you talk a drawing of the material. Then it comes to spinning, it comes to the spinner, you can see what is the condition. Then it comes to calendaring. Now, put it in fashion like this is a process, which is set. Then the weaving section and see the noise. The noise we have heard is another important factor in a jute industry.

You can see sewing, there is the cutting; lot of activities. While we are talking of the dust and the sound or the noise; the people are affected, because of the dust more than the noise. Although both are affecting the health of the persons and after questioning or interviewing with some of the workers, it was found that this condition is very pathetic.

Sometimes these mill workers continue for long duration of time. Although they do have mask and ear plugs, but even then, many of them get into some sort of trouble always. That means, these are arduous task and industries. Efforts are on to see that as good as possible environment is created for such people.

Now, if it is possible, you should see jute industries functioning and then, you will be able to appreciate why we are talking of human factors in engineering and when we are talking of a thermal environment, where we are talking of a noisy environment, where we are talking of a dusty environment and so on and so forth. If the illumination level is not enough, you are going to create problem. You will not be able to see things properly you will not be able to take actions properly.

So, each and every parameter of the environment, which is there, has to be taken into consideration with perfection as much as possible to get the backs out of that human machine system, which is in question of analysis. So, I have just shown you a jute industry all the activities which are taking place.

I have not given the values of the noise which happens over there. It is tremendous, much higher than the one which is expected of human being and the dusty environment. There are arrangements made to see that the dust is not in the air and it always remains moist so that it does not get into the ear or the throat.

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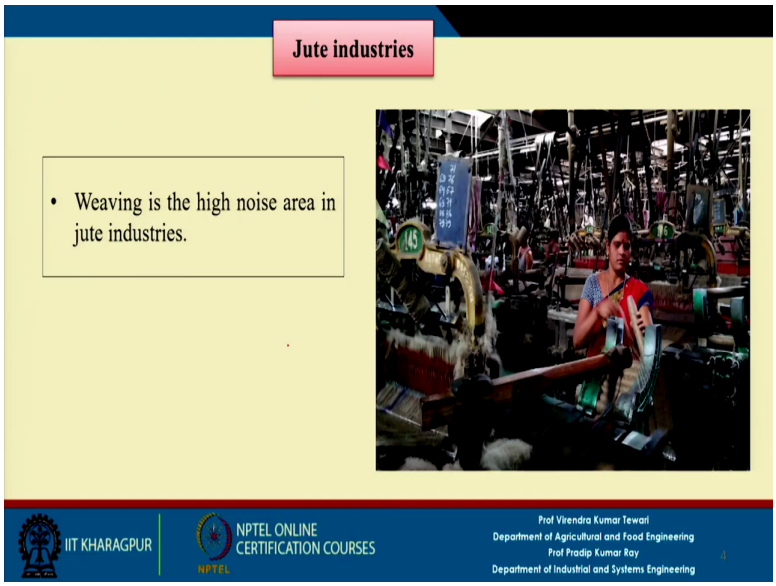

Now, we will go to some other examples.

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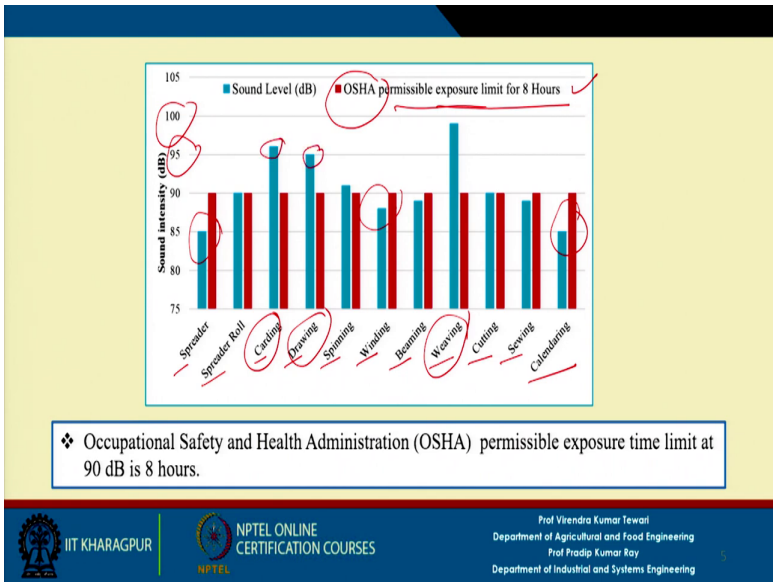

The levels you can see here, we have given certain levels; when there is an exposure limit of 8-hour duration. The occupational safety and health administration of USA has permissible exposure limits for 8 hour day. The red ones are the ones which are permissible levels and the sound pressure levels which are heard in the various six sections as the spreader roll, the carding, drawing, spinning, winding, beaming, weaving, cutting, sewing and calendaring.

You can see each for one of them the permissible limit is given in red; the limits are here. Whereas, these limits which are sound pressure levels are either this or more in most of the cases. Then some cases sound pressure level is lower than the OSHA limit which is good.

Only few of these are within the OSHA limit. But all other are going beyond the limit ch and the occupational safety and health administration adheres to such nomenclature and such regulations very particularly.

Now, if there is a check, the mill owners will be in trouble, because these are the requirements; you can see here that this is going in 95 dB; beyond that is closer to 100 dB, in case of weaving. When the weaving is taking place, that is the sound level, when carding is taking place, when drawing is taking place, you can see that it is above 95.

The people are given certain limits for exposure limit; but they are much higher and if they work for months together, years together from every 8 hours, you can understand the condition of these people.

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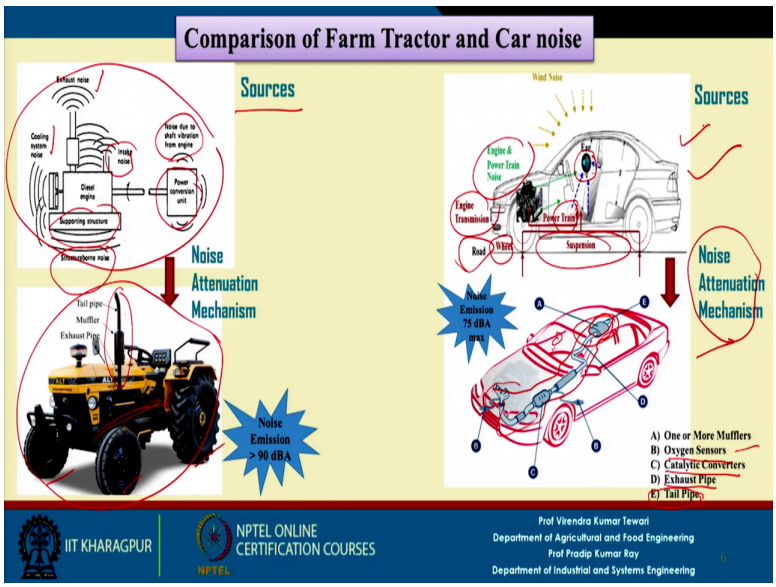

Now, there are certain other examples, which I have picked up just to let you know about the various gadgets, various devices, various locations.

For example, when you talk of a car, when you talk of the relevant locations from where the noise intuition takes place, we will talk of this. When we are talking of the tractor,

this is the exhaust. If we talk of a tractor, then this is the actual tractor and then the attenuation mechanism. What are the attenuation mechanisms, which have been taken care of in the modern tractor which we have over here.

These are the sources; we have taken up the various sources. You can see the noise. Cooling system gives another noise, then this engine gives another noise, where we are talking of exhaust noise is here. Then intake curve noise is here then supporting structure gives noise, then the structure borne noise. Then power conversion unit; it is giving noise due shaft vibration from engine.

Now, these are the different sources of noise. How do noise attenuation mechanism work? This is the exhaust pipe, which has been designed; which is called tail pipe here, muffler is this portion. Now, we see here that how best we can transmit this sound level from here to the other portion and out.

Now, you can see here that the various structure bornes and, these tires will talk of and the type of structure which is here will take care of the attenuation level or try to minimize that the noise level. Here also you can see in a car, we have the engine and power train, you can see the ear of the person here. Then engine and power train is the source.

Power train here, which is creating noise, the suspension is creating noise. The wheels will create noise, engine transmission is conduit. The road as well. You can see here the one or more mufflers. Now, you can see here A, such muffler is put here. This the dB, which is noise emission is 75 dB-maximum here.

You can see that this person is hearing much less noise inside when he is seated over here. A is one or more muffler, then B is oxygen sensors. Now, by oxygen sensors here there could be some noise coming out of this catalytic converter. Some catalytic converter will help you in reducing the noise. The exhaust pipe –you can have a look at the exhaust pipe such a long one here.

Then the tail piece is given over here. When you have such an elaborate exhaust pipe or the muffler or the arrangement which has been made. These will help you to attenuate the noise mechanism in case of a car. If you have opened a car, you will be in a position to see that and appreciate.

Similarly, as I talked about the tractor; the current tractor noise which is there in one of the modern tractors. Of course, the operator will hear, even in the ac cabins which are employed many a location; where temperature is very high or very low that helps them. Therefore, lot of attenuation of this noise has been attained. Overall exposure is 95 dB and beyond. The more you reduce from 90 and below say 80, 85, it will be better for the human operator.

This will result into longer duration of work done and hence, more work output. A comparison of farm tractor and car noises. Power tailor is a power source which is there on the farm; you can check in that the car motorcycles are there, you can think of that noise which you get into that.

There are various types of noises which come out You can think of how much is the noise when you are driving a small scooty, when you what is the noise when you are driving a motor cycle?

How long one can sustain, maybe the helmets which we wear helps us in protecting the head, as well as it also protects us to some extent about the noise as well.

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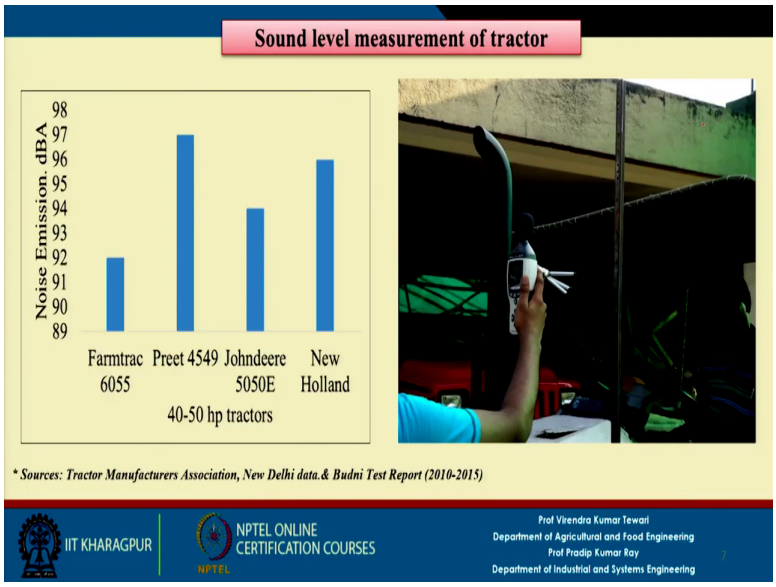

Now, we have made a small experiment just to indicate to you how best one can evaluate the value, how best he can think of certain modifications in the design of the attenuator,

which has been utilized in the system. What type how such attenuators are made? What is the significance of those things? What is the method of doing that?

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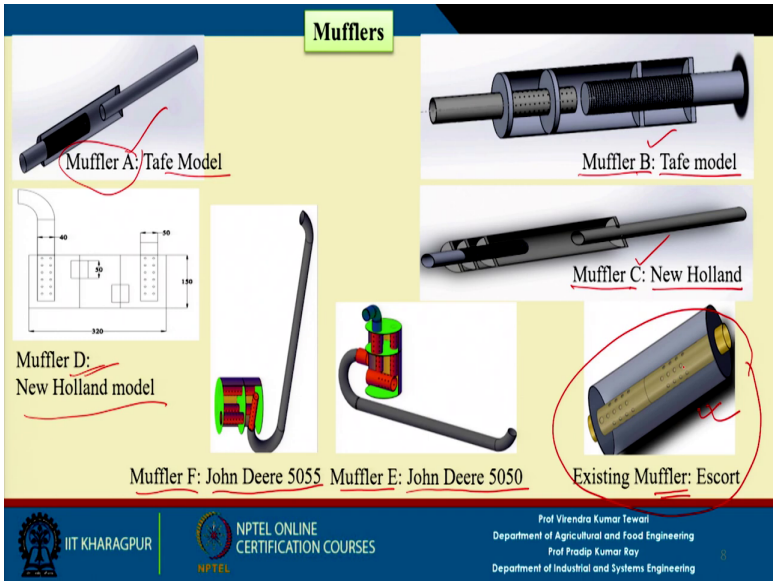

There are various types of mufflers. When I talked of the muffler of in case of a tractor or even a stationary power you know tailor or a power engine or a power source which is available, you get the maximum noise at the pipe.

When you pick up those, how you are going to utilize that noise and design the system in such may such that noise is as low as possible. You can see here that the muffler F which is John Deere 5055, then muffler E is a John Deere 5050, then we have muffler C of a New Holland tractor, the model is not given.

The muffler B is of a Tafe model tractor. We have at present muffler B, muffler C, and then muffler F. Muffler D is a New Holland model. There is a New Holland model of tractor, where muffler D is designated. So, we have B, C, D. If another model of tafe is taken and farm equipment limited, then muffler A which has a different model is designated as muffler A.

So, we have taken muffler A, muffler B, muffler C, muffler D, and muffler E, and F. With this escorts tractor existing muffler is this. We wanted to understand and study the various types of these mufflers, which have been employed in the various models and see as to what is the construction in the design? Why we are hearing different types of

different levels of sound depending upon the course, depending on the horse power of the engine?

It is true that the horsepower of all these tractors is not same. This could be one of the flaw in the study that you are talking of, because had it been of the same sound level which you are same horsepower of the tractor.

If some horse power of the tractor you see, 50 horse power, all of them and then you take the different designs, then there is a possibility that the design is affecting. But since we have taken of varying and it is not possible to get exact one particular horsepower of all the different tractors.

Because, they have different brands, they have different l/d ratio and other parameters of design of the engine which are taken. Therefore, it is not possible to pick up of the same horsepower and hence, a range has been taken. So, in a given range of horsepower what are the types and how the size and design vary.

We have picked up those mufflers from various locations the genuineness of that data is retained, and kept secret with the experimenter and he has tried to understand the various designs.

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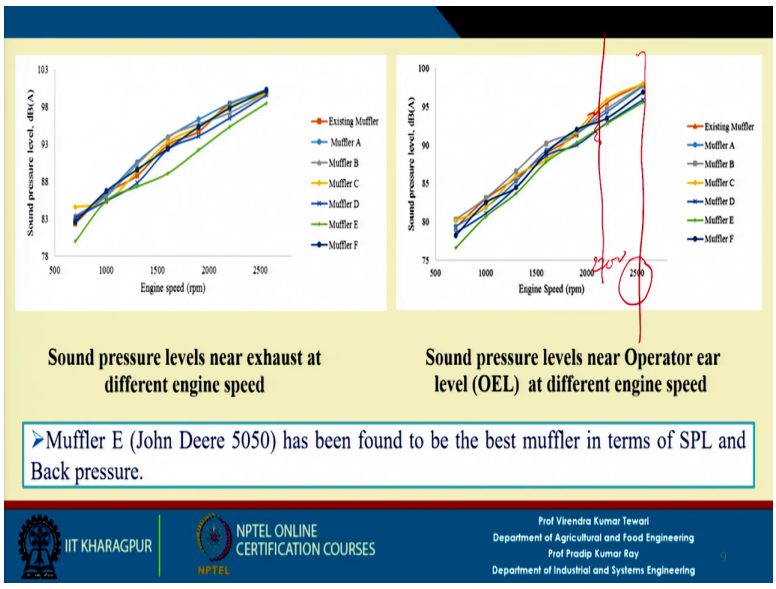

The sound pressure level near ears operation or operator, ear at different engine speeds are also given. Then sound pressure level near exhaust at different engine speed, and

near operator's ear level and then sound pressure level near exhaust. At two different locations, they are talking of the values of sound.

There even the engine speed is varying. If you say 2500, maybe you will get a value which is somewhere there. If you get 2000 rpm then somewhere there.

You need to know what are these values which we get and the sound pressure level at that speed. The power is a combination of the speed and the torque. Therefore, when we talk of these comparisons, they need to be subjectively put and objectively monitor the values of those parameters and then only you can compare. While we have taken A, B, C, D, E, and F with the existing muffler.

If I want to redesign a better muffler for a particular engine, then this becomes my existing design of that engine and then, we will pick up different data of the various others engines which are available in a given horsepower range.

And then we try to see that what changes could be made, and then how does it compare with the existing muffler whether the sound level has decreased or attenuated or magnified. Depending upon the condition, depending upon the exhaust gas which is coming out, depending upon the speed at which the engine is running, this needs to be understood.

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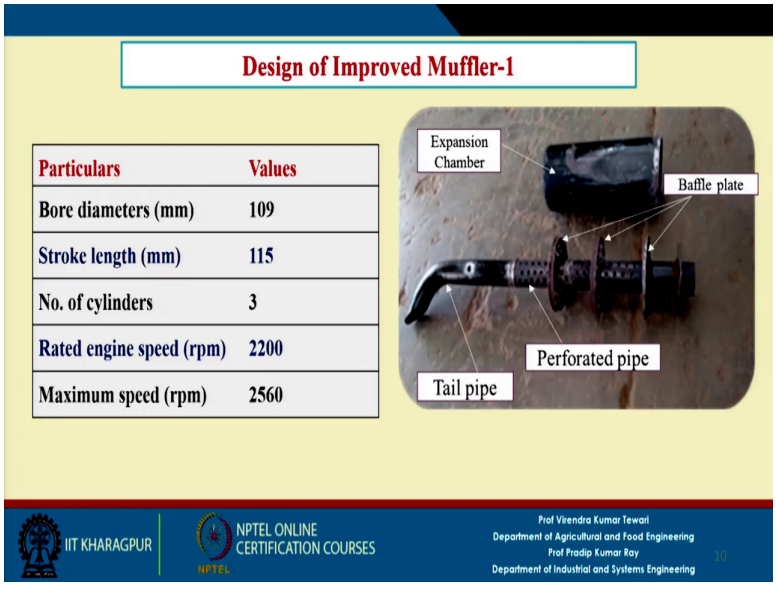

Certain information the experimenter has held it, because it is his confidential work of the higher degree. Therefore, he would not like to detail all the details. The various designs have been studied with regard to various parameters.

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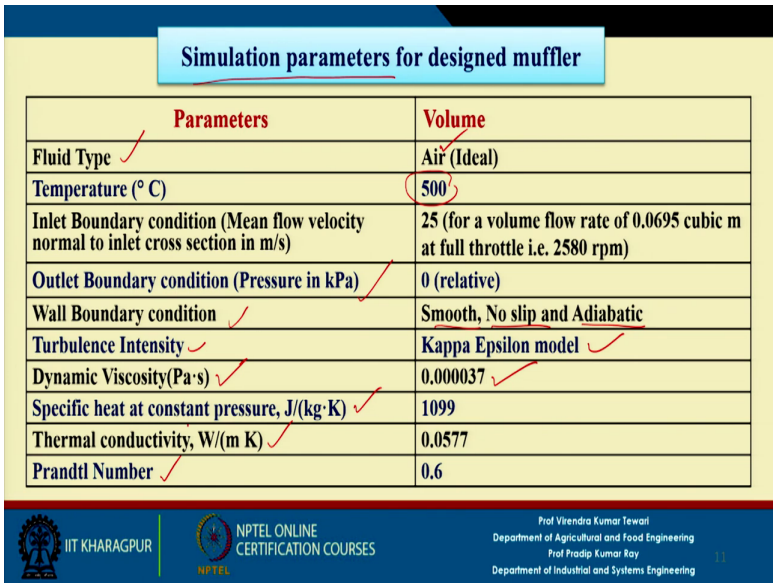

Those parameters could be anything. What is the movement of the air inside? What is the flow of exhaust gases which are taking place? What is the temperature there? What are the types of viscosity of the gas which is coming through? And the thermal environment inside and outside.

They one way is to physically see; the other way is to analytically understand by varying the computer using certain software. Simulation parameters for design muffler, we wanted to design a muffler to study these and the one which is existing in a given tractor. If you want to tractor a power tailor whatever power source that the experimenter has taken; he wanted to have a different design.

The noise level he which he measured at with the existing one were definitely higher than he wanted or whatever with the value he wanted to further reduce that. So, in order to do that he studied several other designs to see what are the best in each of the designs; what sort of permutation combination?

In order to study each and every value each and every muffler which is given, he took the route of simulation of the parameters so that you can know how best we can simulate

and get that. This is the circulation of the air or the gas which will take place; this will be the variation in the temperature and this will be the variation in the heat content resulting from the temperature.

You can see here that parameters. Fluid type, then the it is air. The temperature which has been kept as this much exhaust temperature, inlet boundary conditions that is the mean flow velocity normal to inlet cross sections and sound outlet boundary conditions pressures in kPa.

The wall boundary conditions, where it is smooth or adiabatic and no slip, depending upon the type which is given; turbulence intensity, level of intensity of the turbulence which is given. The kappa epsilon model. The dynamic viscosity. The specific heat at constant pressure, the thermal conductivity and prandtl number. Some of these simulation parameters have been picked up for design of the new muffler in the context of what the experimenter has taken up for.

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Some of the new design mufflers are there which equals DM1 and set of 1. This is the CAD view of DM1, this is the meshing of DM1 which has a cut view. Here the boundary conditions applied to inlet and outlet of DM.

Now, you can visualize what changes he has made and how he is trying to do more and more once you understand these aspects of computer aid design view. Particularly, the

simulation part which he has used through a given software and studied the flow of air into those perforations, which he has seen at different locations. What he has made, certain variations in that which are helpful for giving him a proper design, which will have a reduced level of noise.

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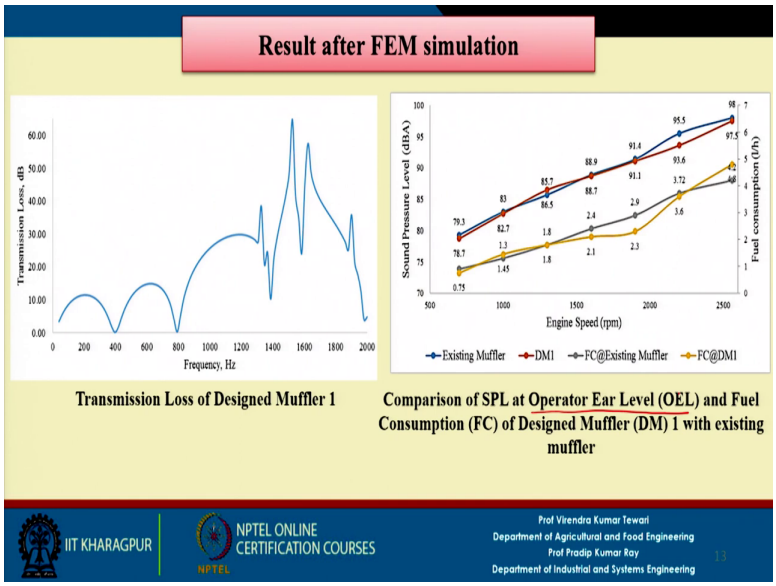

After the finite element method simulation, you can see here that the transmission loss of design muffler 1 and the sound pressure level heard at the ear level at different value at different locations. We do not find any conclusive thing in this particular study, but what is important is- it has been found that the sound pressure level which is emanating from various locations at the operated ear level and fuel consumption and the fuel consumption level and the one which is heard at the operator's ear level.

This is one parameter which has been understood and try to be argued upon, because some people say that how does it affect the performance of the engine or the overall cost involved in the system? It has been found that if the sound pressure level which is heard at the operator's level is also very high and the sound pressure level is affecting actually the amount of fuel consumes.

Although you have talk of lot of back pressure and then, it will result into the higher consumption of fuel. Then you will have to have a tradeoff between what sort of back pressure we need to maintain and at the same time we need to maintain a golden value between the fuel consumption as well.

It is not possible to the zero point of view- there will be certain back pressure. How best this back pressure should be maintained that it does not affect the fuel consumption to a great extent and you and the experimenter has to forego about this because these are the costly inputs which are coming into the engine vis a vis the total output that we are getting.

Therefore, the experimenter has it studied on the finite element method of simulation and try to see that what does he hear at the operator ear level when the different designs of the mufflers were taken care of well.

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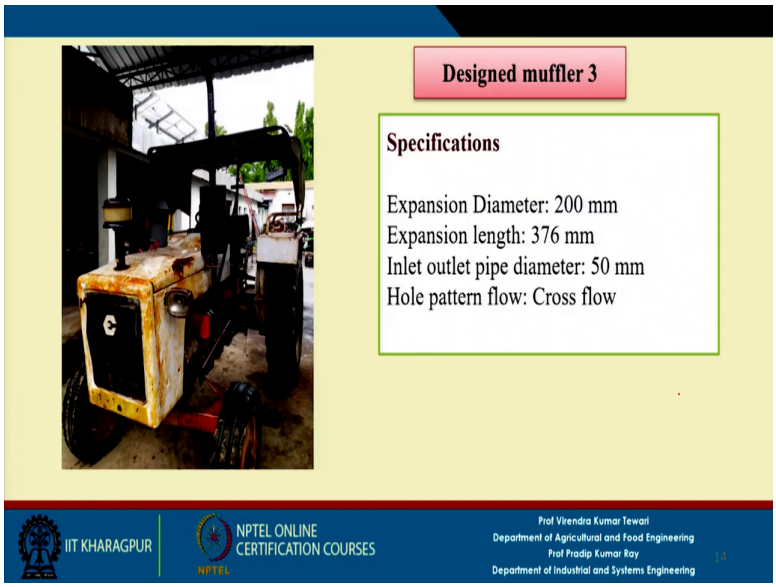

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Some of the designs details are given here.

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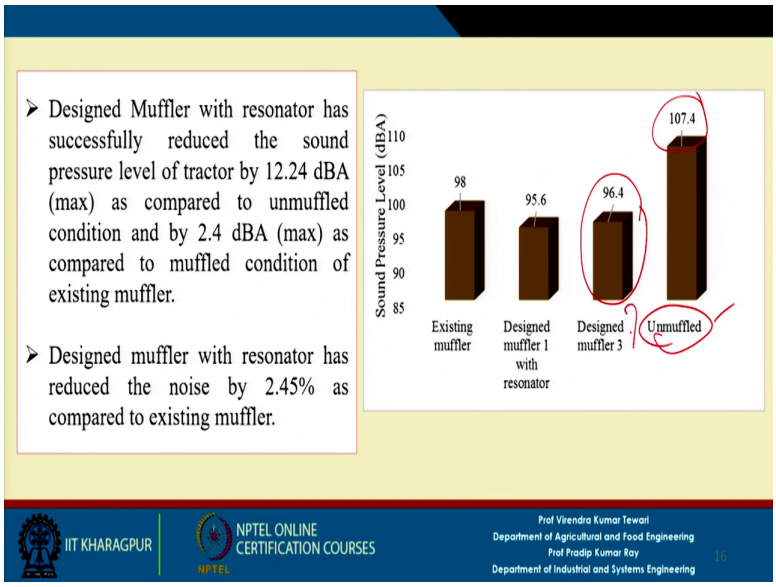

You can see here these values, there is no muffler at that time. What is the value you hear and their mufflers. What is the minimum value that you hear and how does it happen as compared to the one which is there?

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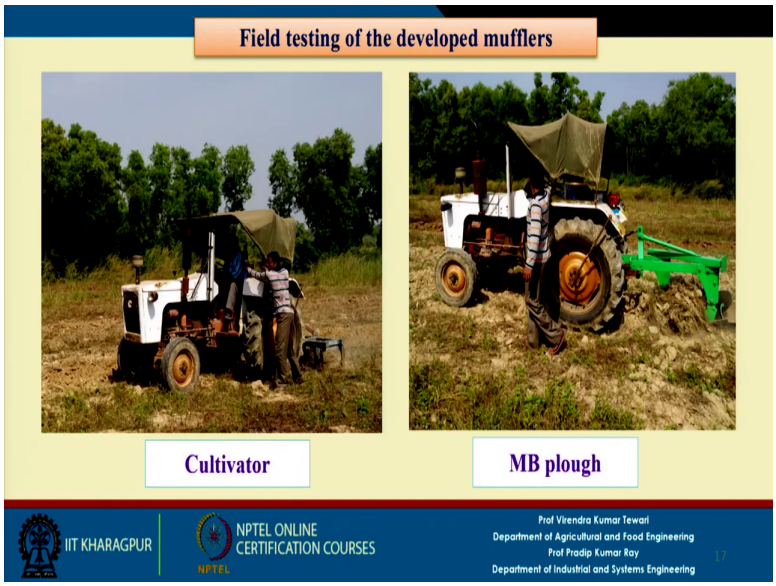

Similarly, we have done field testing of with different types of equipment- you see that equipment which are kept here.

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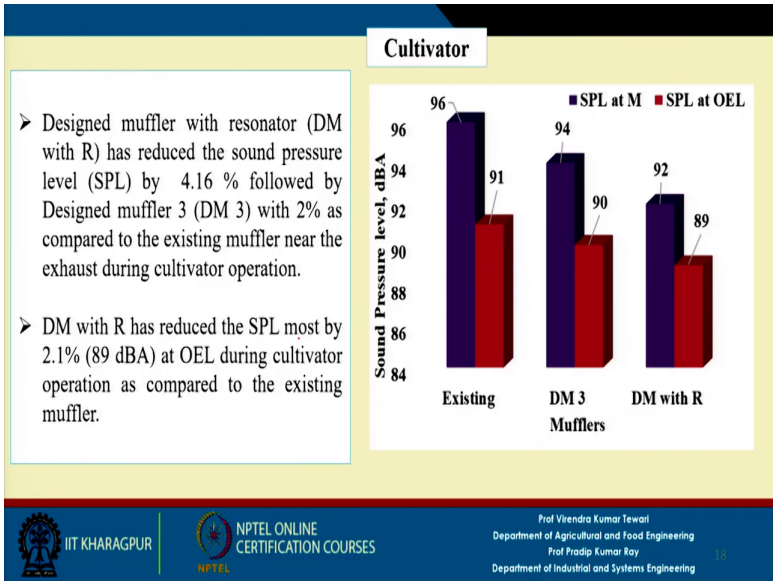

When the equipment comes in contact with the soil while being drawn behind the tractor what happens to that and, during that period, what is the load on the tractor and then what happens to the noise which we heard at the operators the ear level emanating from the exhaust of the engine? The cultivator (Refer Time: 30:59).

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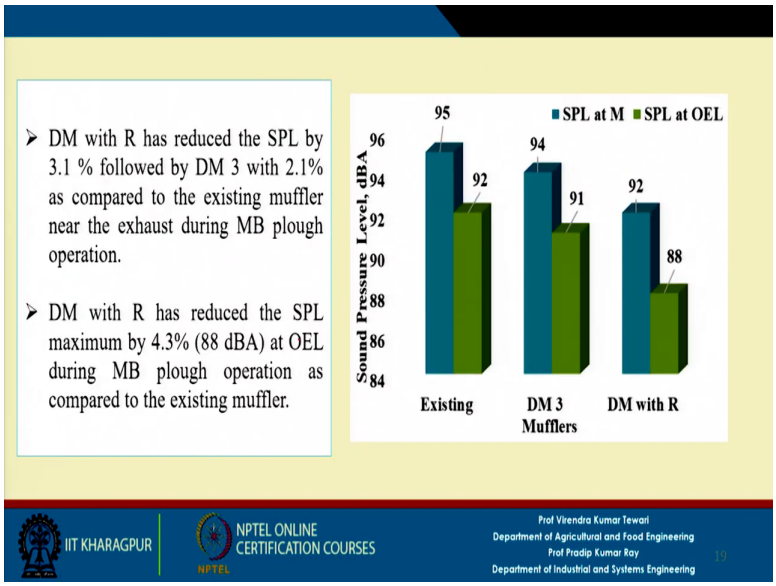

and then various other aspects have been considered.

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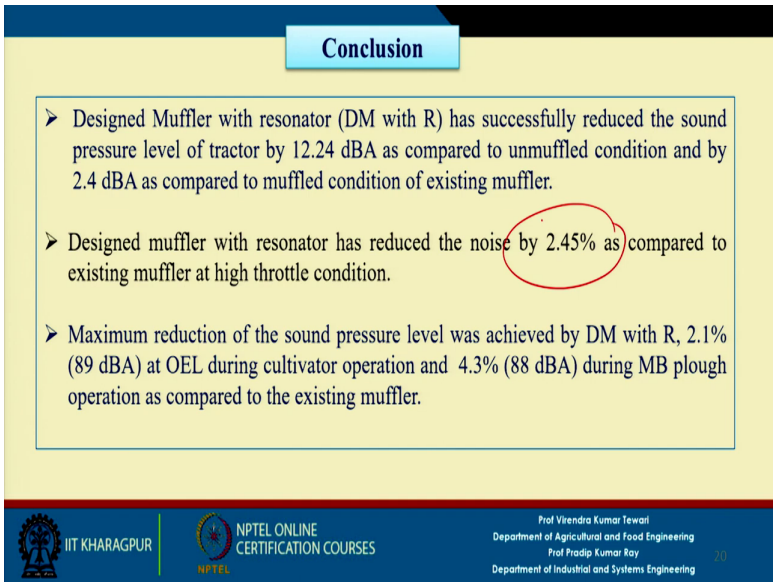

The design muffler- some success has been achieved, but it needs to be more realistic in those values. More tests are to be conducted and also some thought has to be done on the material construction of those mufflers as well as the thickness of the material and the other parameters which have been taken care of.

There is need to relook at a large number of permutation combination and simulations that have to be done to bring the level to somewhere around 84-85 dB from a very high

level of 85 dB and 95 dB. With this short example I wanted to explain to various examples of the sound pressure level, what is effect on the fuel consumption, which is concern of the operator or the consumer and how does it affect the overall health of the tractor, as well as the operator and when it goes into the atmosphere, there also we are very concerned and we would like to reduce the value.