Electrical Measurement and Electronic Instruments
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Lecture - 04
Features of PMMC & Electrodynamic Instrument

Hello and welcome. In last two videos we have studied about PMMC Instrument and Electrodynamic Instrument. In this video we shall talk about some very important properties and comparison between these two instruments which we all should know.

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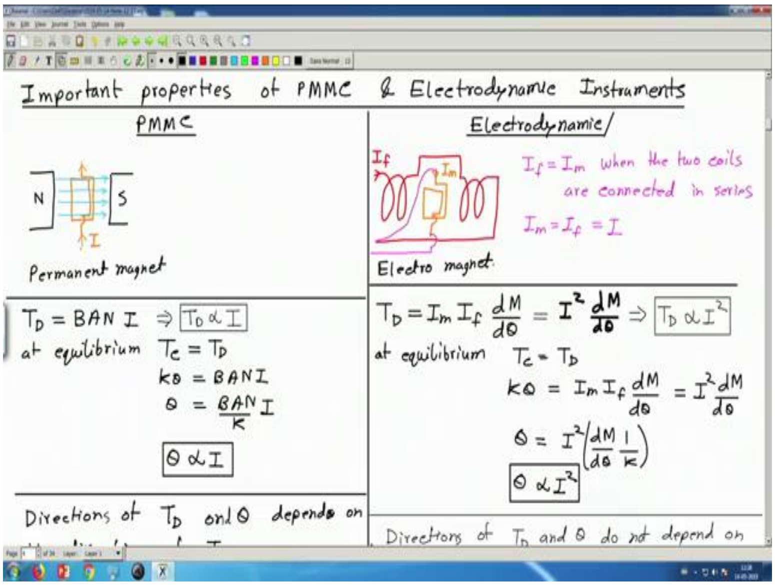

So, important properties of PMMC and Electrodynamic instruments; so, let me do it side by side. I will do PMMC here an electrodynamic instrument here. This is also called dynamometer type instrument just for your knowledge. Now, a quick recap, we have seen that PMMC instrument is made up of a permanent magnet and inside that, we have a coil which carries the current to be measured. In case of electrodynamic instrument, this permanent magnet is replaced by a pair of electromagnets.

So, this is the coil carrying a current which generates the magnetic field, call it I_f, because these coils are called fixed coils and we have a moving coil inside which carries another current called this I_m. So, here we have permanent magnet and here electromagnet. Now, we have seen that the deflecting torque

$$\mathrm{TD} = \mathrm{B\ A\ N\ I}$$

$$T_c = T_D$$

$$K\,\theta = B\ A\ N\ I$$

$$\theta = \frac{B\ A\ N}{K}\ I$$

where B is the flux density A is the area of this coil, N is the number of turns and I is the current through this coil. And, then at equilibrium we have the controlling torque or spring torque.

$$T_D = I_m I_f \frac{dM}{d\theta} = I^2 \frac{dM}{d\theta}$$

M is the mutual inductance between the fixed and the moving coil, θ is the angular position of the moving coil.

$$T_c = T_D$$

$$K\theta = I_f I_m \frac{dM}{d\theta} = I^2 \frac{dM}{d\theta}$$

And, we also have said that normally we can connect these two coils in series, maybe like this. So, if we connect them in series,

$$\theta = I^2 \frac{dM}{d\theta} \frac{1}{K}$$

So, important property is that, for electromagnet for PMMC instrument we have,

$$\theta\ \alpha\ I^2$$

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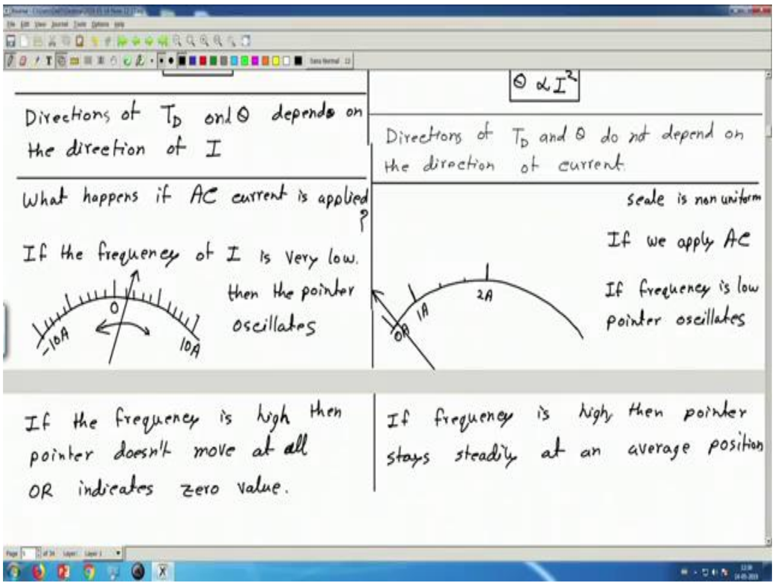

So therefore, we can now write for this instrument that the direction of the torque T_D or the angle of deflection θ, depends on the direction of the current I. So, for that let us look at this schematic here. We have north and south pole like this, flux lines are all from left to right. And if the current is flowing like this, then it will have some direction of force or some direction of torque, which you can find out using Fleming's left-hand rule which we did yesterday in our last class.

And, if I now change the direction of the current then we will immediately see that the direction of torque and force will get reversed. So, in this case the direction of the torque and force depends on the direction of the current. Also, this expression θ proportional to I and the fact that T_D is also proportional to I this implies that if I have negative current, if I becomes negative with respect to some reference, then T_D will be negative, or its direction will be negative, θ will be negative; that means, the pointer will move in the opposite direction.

So, the direction of T_D and θ so, both depend on the direction of the current I. Here the direction of T_D and theta do not depend on the direction of current. Why, because one observation you can make here is that theta is proportional to I square. So, if I take minus I, I square will still be positive. So, the direction of theta or sign of theta will not change. So, once again the direction of T_D or the sign of T_D will not depend on the sign or direction of the current and from the physical consideration, what can we say. Suppose if I if the current is flowing in this direction, which may possibly create flux, say from left to right. And, then the current is flowing in some direction, it will generate a torque it will generate some force and torque. Now, if I change the direction of the current, then both the direction of the current as well as the direction of flux will change.

So, if I change the direction of the current like this, then the flux will also get reversed. Then the flux lines will become in the opposite direction. Now, if you apply Fleming's left-hand rule, the flux lines are reversed the current is reversed. So, the force will remain in the same direction and therefore, the torque will remain in the same direction. It is like 2 minus signs cancelling each other.

So, the direction of T_D and theta do not depend on the direction of the current. Now, the next question is what will happen if I apply AC current. The answer is like this, say if the frequency of I is very low, say like 0.1 hertz or even lower. So; that means, one oscillation in every 10 seconds. So, every 10 second the direction of the current is reversed. So, what will happen?

So, let me draw the scale of the instrument and I have a pointer. So, every 10 second the direction of the current is reversed. So, I would like to go to the overhead camera. Now, what will happen the pointer will change it is direction every 10 seconds like first positive current so, the pointer goes towards the positive value, then it comes back to 0 and again to the negative side comes back again to 0 and to positive side and so on.

So, this way it will oscillate between positive and negative value. So, the conclusion is that if the frequency is very low, then the pointer oscillates. Now, let us increase the frequency slowly, if the frequency is high, maybe as high as power frequency 50 Hz.

So, 50 oscillations per second what will happen. So, let us see what happens if we increase the frequency. So, for low frequency the pointer moves like this positive 0, negative 0, positive 0 now I increase the frequency. Positive 0, negative 0, positive 0, negative 0, positive 0, negative 0 like that, but at the same time the amount of oscillation or the amplitude of oscillation will be reduced, because due to inertia, in a smaller time it cannot go far too much. So, if the frequency is increased, it is getting smaller time less time to move. So, the amplitude will be decreased.

So, this will work like this, for low frequency plus 0 minus 0 for higher frequency, plus 0 minus 0 plus 0 minus so, with small oscillation. And, at very high frequency plus 0 minus 0 plus 0 minus 0 plus 0 minus 0, only a small vibration we can see. And, if the frequency is even higher the vibration will be invisible, unobservable. Then, the pointer will stay at some average position and the average position for pure AC current is 0. So, the pointer will stay at 0 position, it will not move at all.

So, once again for low frequency it will oscillate plus 0 like that and at high frequency as frequency increases plus minus plus minus plus minus very fast plus minus plus minus plus minus only a vibration and then no movement at all. So, the conclusion is if the frequency is high, then pointer does not move at all. So, it stays at 0 value or indicates 0 value.

Now, same thing what will happen for electrodynamic instrument. For electrodynamic instrument, we know that the direction of pointer movement does not depend on the direction of the current. In this case, if this is my 0 position then one side may indicate plus current may be say 10 ampere another side will indicate minus 10 amperes. For electrodynamic instrument the pointer can move only in one direction, because for both positive and negative value of I, theta is always positive.

So, in this instrument we will always have 0 value on 1 extreme, like this is 0 ampere and then this side will be a higher value. And, we also know that theta is proportional to I square. Therefore, if this angle denotes 1 ampere, then for 2 ampere current theta will be 4 types. So, theta will be 4 types. So, if this is 1 ampere then 2 3 4 so, this will be 2 amperes and so on. So, the scale is non-uniform.

So, in this case scale is non-uniform. So, and what will happen to the pointer if we apply AC, if frequency is low then of course, the pointer will once again move from 0 to positive, and then comes back to 0, then current becomes negative, but the pointer will go towards the positive so, current minus pointer towards the right side. So, the motion will be like 0 plus 0 minus 0 plus 0 minus and if frequency increases then the amplitude will be reduced, because it will not have enough time to move very far.

So, as frequency increases it will be like 0 sorry 0 plus 0 minus, 0 plus 0 minus, 0 plus 0 minus like that. And, the amplitude will decrease slowly, at very high frequency it will only oscillate, or it will only vibrate at. Even further even higher frequency the vibration will be invisible, and the pointer will stay at some average position. So, the conclusion will be if frequency is low pointer oscillates and if frequency is high, then pointer stays steadily at an average position. So, what do I mean by average position precisely? I mean this.

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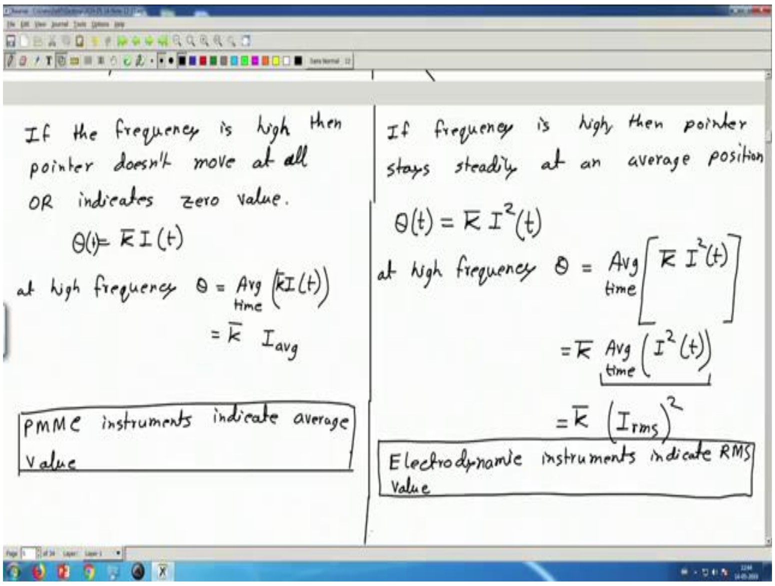

$$\theta(t) = \bar{K}\, I^2(t)$$

$$\theta = Avg\ Time\left[\bar{k} I^2(t)\right]$$

$$\theta = \bar{k} \times Avg\ Time[I^2(t)]$$

Now, what is this quantity? You must have studied this earlier. This is nothing but the square of the rms value of the current.

$$\theta = \left(\bar{k}\, I_{rms}\right)^2$$

So, therefore, this meter indicates rms value. So, one observation very important electrodynamic instruments indicate rms value. So, this is very important to note. On this side, we can write PMMC instrument indicate average value. Why? We can give a similar argument that we know, in this case theta is some constant times I where this constant. So, this case different from the spring constant K, this is not the spring constant. This is a different constant. So, if you if you want, let me put a different symbol here say $\bar{k}$ everywhere, some constant.

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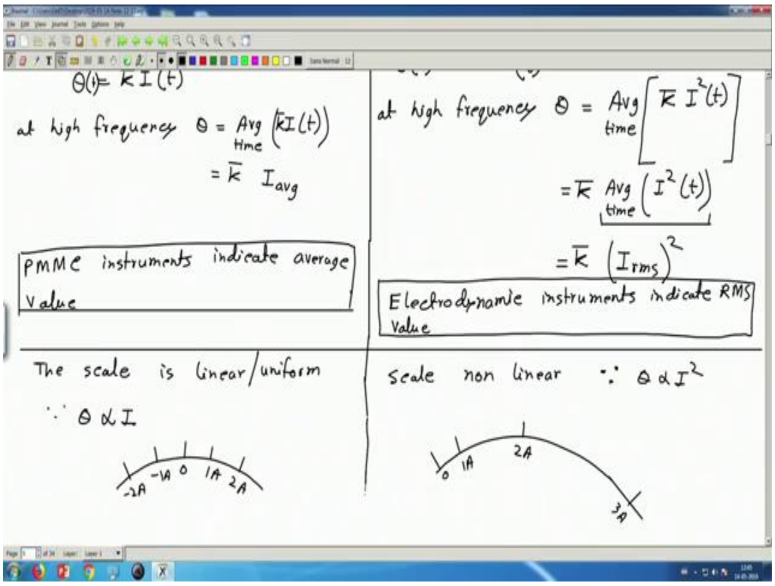

So, this is another important point to note. And, the final point that I will talk about is which I already have mentioned, but I will write it down. For PMMC instrument the scale is linear or uniform, because theta is proportional to I.

So, the scale is uniform like if this is 0 this is 1 ampere, this is 2 ampere, then this is minus 1 ampere, this is minus 2 ampere, all these gaps are equal. In this case, the scale is non-uniform or non-linear or quadratic, since theta is proportional to I square. So, we already have mentioned, if this is 0 ampere this is 1 ampere, 2 ampere will be further here, 3 ampere will be quite far somewhere here and so on.

Thank you for watching, we will continue in the next video.