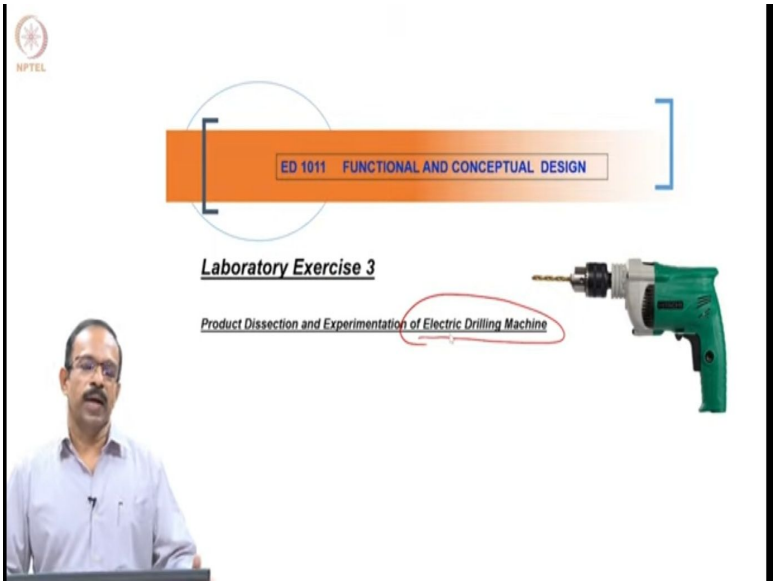
Functional and Conceptual Design
Dr T. Asokan
Department of Engineering Design
Indian Institute of Technology, Madras
Laboratory Exercise - 3

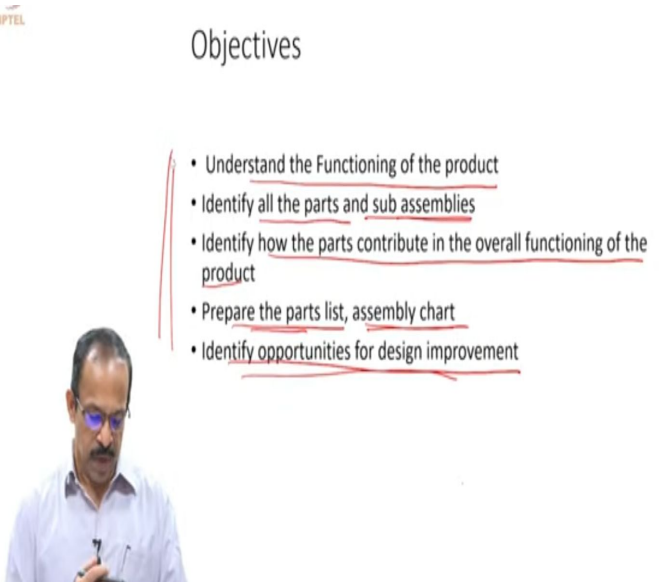
(Refer Slide Time: 00:13)



Hello everyone. Welcome back to the lab session. This is the third lab station we are having. In the last session, you had a product dissection experimentation for a printer and you saw how to do a formal or a systematic way of dissecting a product, identifying the parts and then looking at the assembly structure and then preparing a report on the product. So today we will repeat the same kind of an experiment for a different product.

So today we will look at the experimentation of an electric drilling machine, which is a handheld drilling machine and as you know a drilling machine has got the electrical elements and the mechanical parts, so it is actually a combination of both electrical, electronics and mechanical elements. So we will try to see how to do the systematic dissection of the product and then identify the product structure as well as look at the parts and its function in the product.

(Refer Slide Time: 01:20)



So the objectives as in the previous experiment, here also, you will try if you want to understand the function of the products. So what is the overall function of the products and then what are the parts and sub-assemblies are there in the product. So any product you will be able to see many parts and some sub-assemblies which actually provide a particular function in the product. So you want to identify all those parts and sub-assemblies in the product and then look at how the parts contribute to the overall functioning of the product.

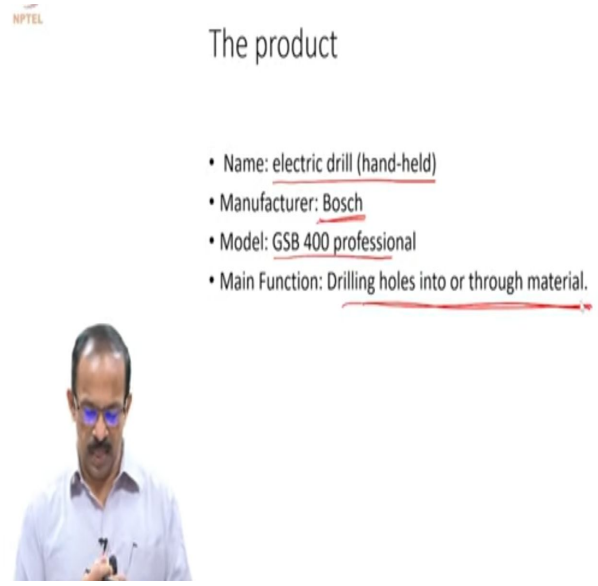
So whenever you take out a part from the product, you need to look at what actually it is doing in the product. What is its function in the product? So you do not need to worry about how you represent the function at this stage. At least you try to understand what actually it is doing in the product whether it is providing a power conversion or it is trying to transmit the power or it is providing some support.

So what actually it is doing in the product needs to be identified and then prepare the parts list and then prepare an assembly chart as the same format for what actually we did in the previous class and look at the opportunities for design improvement. So now after going through this you look at the product, as a designer and then see what you can do to make it a better product.

By the better product in terms of additional functions or existing functions or a pursued problem within the product and how do you actually modify it. That is what you actually

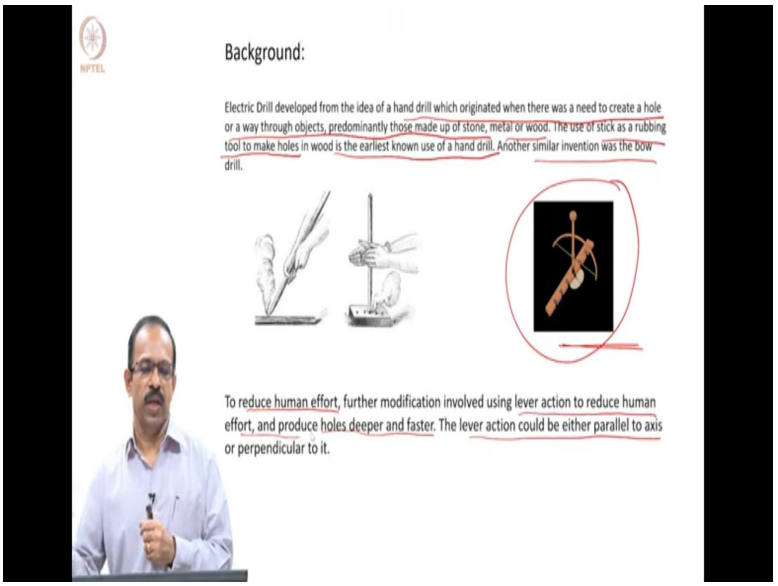
need to look at. So this will be a general objective in almost all of the experiments but only thing, the final report that you are making may be slightly different in each one of these experiments that is going to be the difference.

(Refer Slide Time: 03:05)



So this product is an electric drilling machine which is a handheld product, handheld machine and manufactured by the company Bosch and this is the model GSB 400 professional and the main function is drilling holes into or through material. So it can be either metal or it can be wood or any other material can be there where we can use it for drilling holes.

(Refer Slide Time: 03:32)



So just to give you a background, whenever you try to understand a product you need to have a bit of understanding of the history of the product, how it evolved over a period of time. So just to give you an idea. The electric drill developed from the idea of a hand drill which originated when there was a need to create a hole or a way through objects predominantly made up of stone, metal or wood.

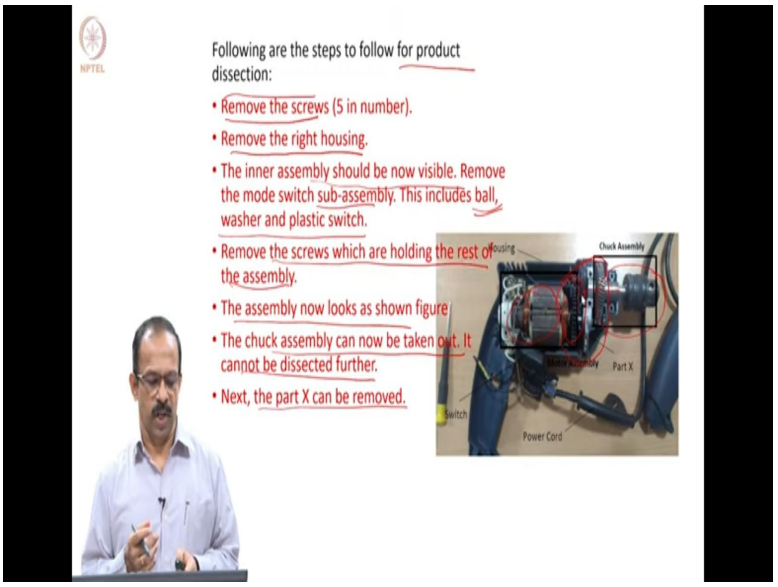
So that was the fundamental requirement. You want to make a hole in a material. It is wood, I mean, stone or metal so that was the requirement and people used to use sticks as a rubbing tool to make holes. So very old time, they used to have sticks and then it moved to stone, metal, etc and that was the earliest known use of a hand drill, using the sticks to make holes in a wood is the earliest product.

And another similar machine was the bow. So this kind of bow, you can actually use it for drilling holes. So you have a tool which is placed on the material on which the hole to be made and then you have a bow kind of arrangement and then move the bow to and fro motion which will be converted to a rotary motion and then you will be able to make holes.

So these things were actually very common in many places even in India. Maybe 30-40 years ago because most of the carpenters, there were no electricity in the villages and most of the carpenters were using a kind of mechanism like this to make holes and later on after the introduction of electricity only we started getting, instead of having a reciprocating motion convert to a rotary motion, we started getting electric motors which can actually have direct rotary motion and then that rotary motion can be connected to the tool and then we can have a drill to drill the holes.

So these are basically to reduce the human efforts and it uses lever action to reduce human effort and produce holes deeper and faster. The lever action could be either parallel to the axis or perpendicular to this also. There were different ways of doing it. So when you prepare the report you can just have a brief history of the drilling machine and then or the whole procedure is followed for making holes and then how it actually evolved to the current drilling machine. So this is the brief history.

(Refer Slide Time: 06:04)



Now, what are the steps to be followed for product dissection? So as I mentioned in the previous class also, remove the screws, so you will see in this case, there will be 5 screws that you will be able to see on the product. So remove the screws and give the number and then put them in a small bowl given to you so that you do not miss it and then remove the housing, the right housing and then the inner assembly should be visible. So when you remove the housing you will be able to see the inner assembly.

So remove the mode switch sub-assembly and then that includes the ball washer and plastic switch. So that is the 1 sub-assembly that you will be able to see and then remove the screws which are holding the rest of the assembly. So then you will see, once you remove that you will be able to see a few more screws. So remove those screws and again write down the procedure which one you are removing first.

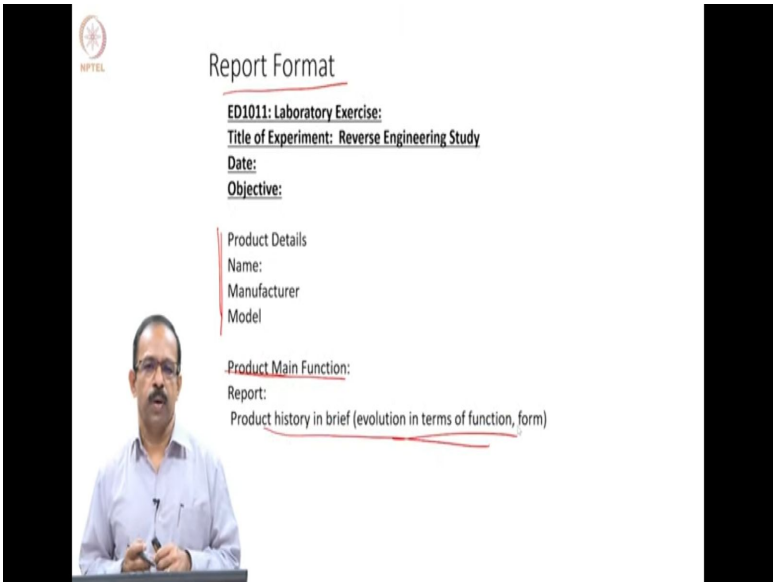
Number them and keep them separate one and then the assembly will look like this and then the chuck assembly can be taken out and you cannot really further dissect the chuck assembly. So just remove it as a chuck assembly and keep it. There are further parts in it. Of course, you do not need to go into that level of dissection at this stage because you know what the purpose of the chuck assembly is and how it is working.

And then the part X can be removed which is marked as here the part X that is basically the transmission part from where the motor is, motor this is the motor which actually provides

the torque and that is transmitted to the tool over here. So you will see an assembly here. This actually is the transmission so you will be able to see the gears and other things and then you will be able to get all the parts done.

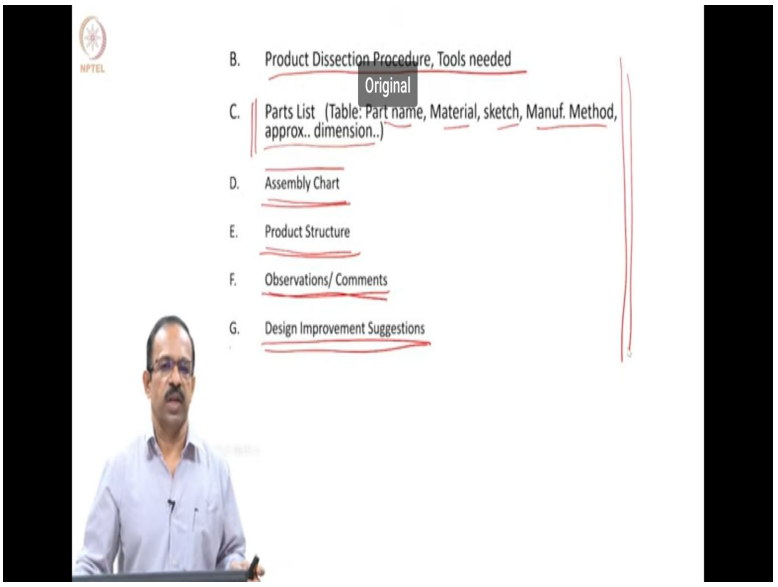
So now you have most of the parts taken out. So look at those parts and then try to identify them, ofcourse your TA will help you to identify the main function of these different parts and the assembly structure also. So after this you prepare an assembly chart for the product.

(Refer Slide Time: 08:10)



So the report format as in the previous case, we will be doing the same kind of a format in this lab session also. So you will write down the details of the product as I already mentioned and then write down the main function of the products and then write a brief history of the product evolution in terms of the function and form.

(Refer Slide Time: 08:33)



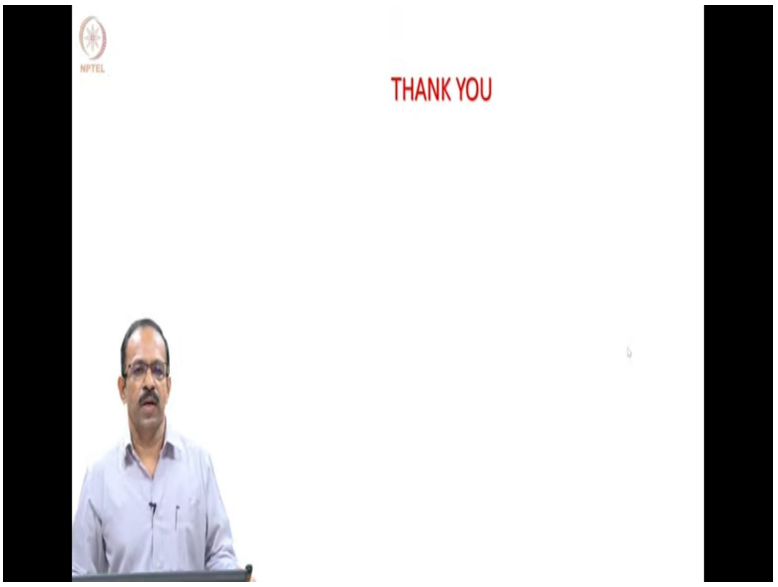
And then write down the procedure, what tools you used and how you did the dissection and then prepare a list of parts. The parts list which actually contains the part name, material, sketch, manufacturing methods and approximate dimensions. So whatever you can identify or whatever the methods you can identify in manufacturing. If you do not, we are not sure, you can discuss with the TA and then write down the manufacturing methods and then once you have the parts list, you look at the assembly chart.

So the parts, how different parts contribute to a sub-assembly and how sub-assemblies contribute to the main product can be identified. So all the parts you can assemble them or you can actually prepare a chart in terms of how the parts are assembled.

And that actually leads to a product structure where you show the assembly, subassemblies and the parts and the last part is basically to observe the product and then give your comments about the products and its functions and then see what suggestion you can make for improving the product.

So this is the way how you will be preparing the report for this product. I hope you understood this. Now you can actually go to the TA. TA will show you how to do the product dissection and then how to identify the parts and its function.

(Refer Slide Time: 10:05)



Okay. So, thank you, go ahead with your experiments.

(Refer Slide Time: 10:09)

Hi, I am Siddhanth. I will today be explaining about the drilling machine. So before you see the drilling machine, I just want you to guess what are the components that should be inside it?

(Refer Slide Time: 10:23)

I have some source of power and essentially I will be converting into some rotational motion. So I have some electrical energy. I am converting into a mechanical form of energy. So that is what is called a machine and what is a mechanism? So essentially there are 2 kinds of things. There is something called mechanism and there is something called machine. So in a machine, we have one input form of energy and we transform that into some kind of output form of energy.

So what is a mechanism? Do you have any idea about it, just a random guess? So when you hear the word mechanism, what is the first thing that crops up to your mind? Some steps one after another. That is what he is telling is some links connected to each other. So whenever I move the input link, there will be some form of motion to the output link. So that is what is called as a mechanism.

So you provide some input motion and that will be transformed into output motion and when I use such a mechanism into some kind of a product, that is called a machine, okay understood? Am I clear? So the thing is, right now I want you to guess that I am providing electrical energy and I am getting some form of rotational energy. So what should be the components that should be present inside our drilling machine?

So I will list it down. What I will do is I list it down and after we open it, we will be opening this drilling machine and then we will be seeing whether the components that you have told matches with it or not and what are the usefulness of each and every component.

(Refer Slide Time: 11:51)

So, essentially what it does is, if I provide you this drilling tool will you be able to drill something? I will provide you with this. So will you be able to drill something? You need the drill bit. So what it is doing is essentially a motor is providing that rotational motion, but that rotational motion needs to go into some tool which will provide the cutting action. So that is essentially called as a drill bit.

I will have some sort of a drill bit. Apart from that I have, right now I have 3 components. So let us go sequentially. I will have some sort of a power wire.

(Refer Slide Time: 12:30)

The power will go from the power wire. I will have an on-off switch which will be able to switch it on and off. So do I need to provide some sort of a safety procedure? Suppose there is a child playing around so in case he presses this. I do not want this to move. So I need to provide some child lock buttons, so this is yes. So this is what is called a lock button.

There is some sort of a transfer of electrical energy to that of a motor. So I have a motor then I will have gears. I have a drill bit. So what is missing? The power is transmitted from the motor. I have the drill bit, but I need something to hold the drill bit. Yeah socket. So essentially this is what is called as a Chuck. I will tell you what they are, this is a chuck and this is essentially a chuck key. So what it does is you can see. When I rotate this in one direction, the diameter of this chuck is increasing.

(Refer Slide Time: 13:38)

This is essentially a 3 fingered chuck. So one of the questions I want to ask is, why is it a 3 finger Chuck? Can I make it 2? It will slip. So essentially what is happening here is the contact between the drill bit and the chuck is maintained due to the force applied by the chuck. So I need to have some sort of a force closer that is the summation.

The algebraic sum of the forces should be zero. So this is what is called a universal chuck. You can note it down. So all of you can note down the components that you have told me, the first one was the motor. The second one is gear. The third one is the drill bit and the fourth one is the on-off switch. Till now we have guessed these components only.

And apart from that I have told you that there are some kinds, there are gears, and will talk about it separately. What are the gears and what are the different kinds of gears and all and I have been told about some sort of a chuck. So chuck is essentially used to hold something of radial symmetry. If I have a square will I be able to hold it?

(Refer Slide Time: 14:47)

No. So, I will be able to hold cylindrical objects here. In order to hold objects of different dimensions, I will have different kinds of chucks. Is the drilling machine seen now or was there any previous versions of drilling machines available? So drilling machines are what came 10 to 15 years ago. So before that in villages and all, have you seen any instances of drilling machines or something similar to that?

I am essentially trying to tell if we have a sharp pointed object and we have thread around it. Essentially we will roll the object and we will have some sort of a drilling machine. So, I think the most common example is in villages everybody used to see how we make lassi and all. So that is one form of a drilling machine. Essentially you have some sort of motion and you are transferring into another sort of motion.

What happened after that is, they tried to mechanise it by using v-belt pulleys. You know about pulleys and all. So I have a pulley here. I have made a v-belt around it and I am transferring power here, which is used to drill that work piece here. That is what you see in workshops. Huge workshops, they have a universal drilling machine.

After that, have you heard of the company called Decker? Black Decker. Yeah, so Decker is a company which patented this pistol gun technique. I have some sort of pistol shape. I press the trigger. I have some sort of a drilling machine. That is what we made a drilling machine

in some sort of a portable machine and what is this company? Bosch. What is Bosch known for? Mechanical tools.

Bosch came into existence by making automobile parts essentially. The first component that they made was, not the first component, I guess the most popular component that they made was the fuel injection. You have seen that in automobile cars and all. So in case you are not able to understand anything you can ask me.

After that they made several components and this is one of the products. I will just pass this product and just by looking at the product, I will ask you what you can notice about the product and all. You can read about the specs, you can read about the name and then I will ask you what the product is all about and then.

So, essentially when you see this product the first thing you will notice is GSB 400. So what is 400? GSB must be some kind of product manufacturing line and all. In case I have the first product line, second product line, so GSB is the code of the product essentially. But 400 is a number. It should mean something.

Can you make some guess what 400 should be? Dimension. So in case 400 is a dimension, it will not be 40 centimetre. It will not be 4 meters and it cannot be 4 mm because the 4 mm drill bit is very small. It cannot be dimensions. Apart from that? Power or it can be a variation of RPM are you telling? So essentially RPM.

So what it can be 400 RPM or it can be 400 Watts. I will tell you that if you are able to see when you make a small differential robot and you have 2 motors, they are essentially 100 RPM motors. 400 RPM is not a significant amount of number in order to drill materials. So 400 cannot be the RPM of the motor. Essentially it will be power. It is a 400 Watt.

Essentially what it means is, if you use this product for a time period of 1 hour, the 400 watts will be consumed, 1 second, 400 watts will be consumed. That is one of the formulas and by hand how do we get the torque of this? Essentially what I will do is, I will find the force. I will find the radius at which the force is acting and essentially I will find the torque of this machine. From the torque of the machine, I will find the power. So power is one of the units that is given.

(Refer Slide Time: 18:50)

It is given that it is operating at 220V. 220 Hz, so that is, it is operating on AC and the second thing is given is the RPM. So the drill bit that is provided with this you can see here. It's written at 8 ϕ. When you notice ϕ on any of the machining components it is essentially the diameter. an 8 mm drill bit is provided with this drilling machine and apart from that you can notice that it is 2800 RPM(min^{-1}).

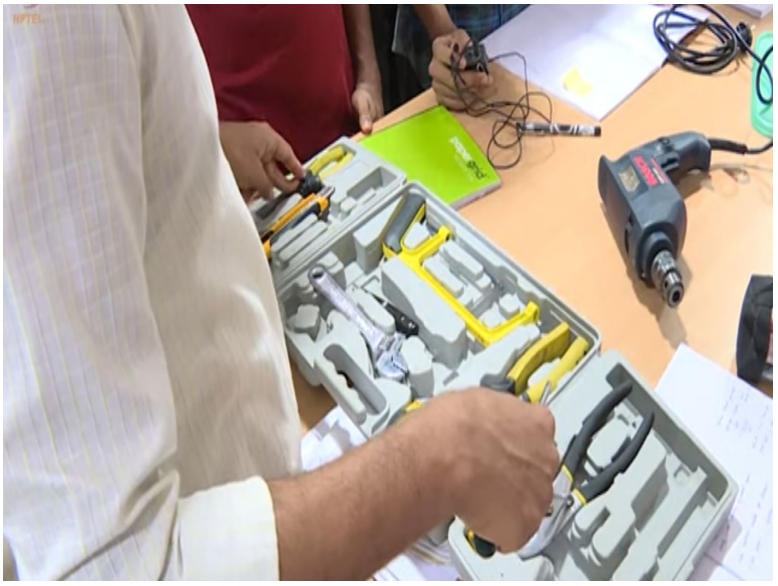
RPM is rotation per minute. So rotation is usually a number. So the unit will be 1 by time, so that is frequency. So we will have 2800 RPM and so on this side I can see that there are some dimensions that are noted that is for wood 20 mm, for steel it is 8 mm. So these are essentially the dimension of the drill bit that are provided.

In order in order to drill steel, you will essentially need that this is the general dimension that they are noting. So you need to use a drill bit of 8 mm or 20 mm and what is the speed of this. So you can see that on no load condition it's 2800 that was noted on this and on loaded condition the impact rate is 44800.

What is this impact rate? When I am drilling something do I have some sort of impact? I have some sort of impact and essentially does it come on every, if I am drilling this wood will I have some impact? So the common example that we have seen is that when I use a drilling machine on a road, they will have huge impacts but when I drill something like wood or steel it will be smoother.

When I drill something which is brittle and more concrete, I will have some sort of impact force and this is essentially the RPM that is provided at this impact. So right now we will try to open this and we will see all of the components.

(Refer Slide Time: 21:03)



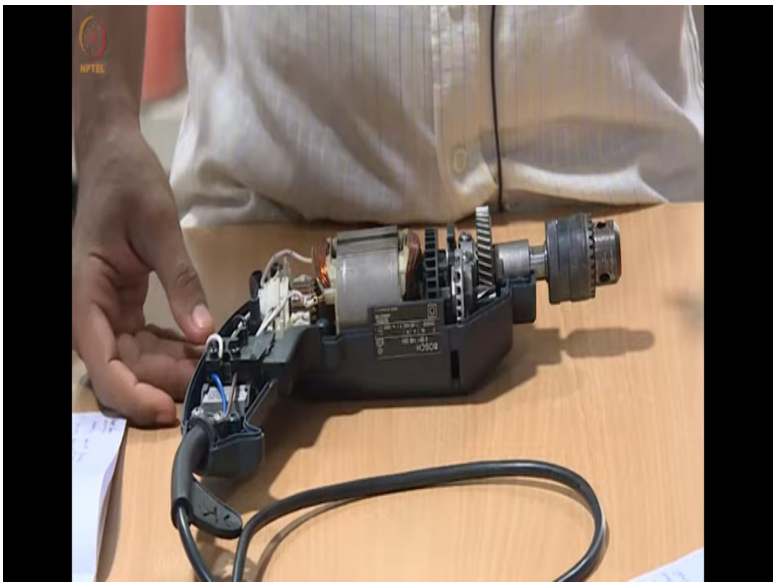
So what I want you to do is this is, this is also a plier and this is the cutting plane and we have this sort of 2 screwdrivers.

(Refer Slide Time: 21:12)

It will have some sort of thread. So essentially the entire screw will have 2 diameters. One is the diameter of the screw and one is the diameter of the inside component. I will define the overall that is the nominal diameter is a sub-function of the maximum as well as the diameter and the second thing that you can notice is the pitch.

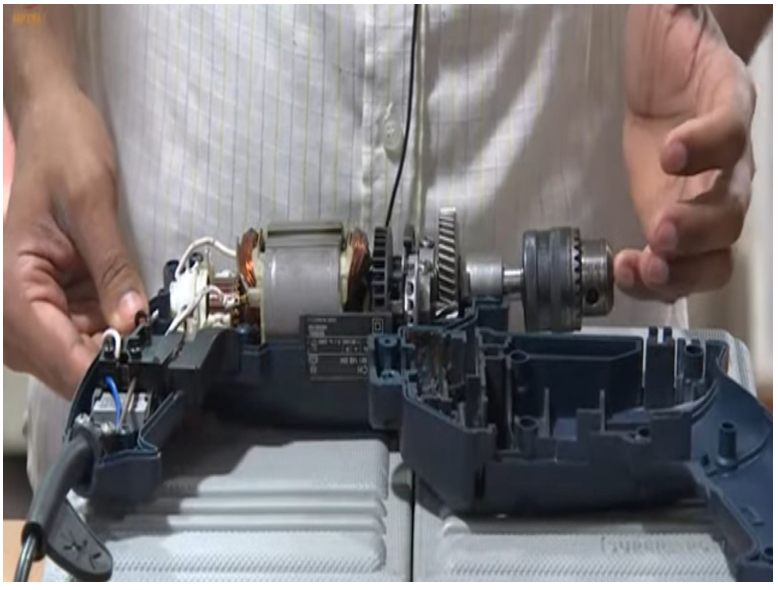
When we remove other screws you will notice that some pitch, the pitch of this screw is different from the pitch of the other screws and I tell you why it is. So the first thing is it is a cross headed screw, it has a pointed head and the pitch is not essentially a little bit less. So you need to rotate it more in order to go to a certain depth.

(Refer Slide Time: 22:39)



So the second component is removing the plastic casing. You can write it and paste it. Removing the screws. The second step was removing the plastic casing. So initially we noted down a few components. The one is the motor . We can find it here.

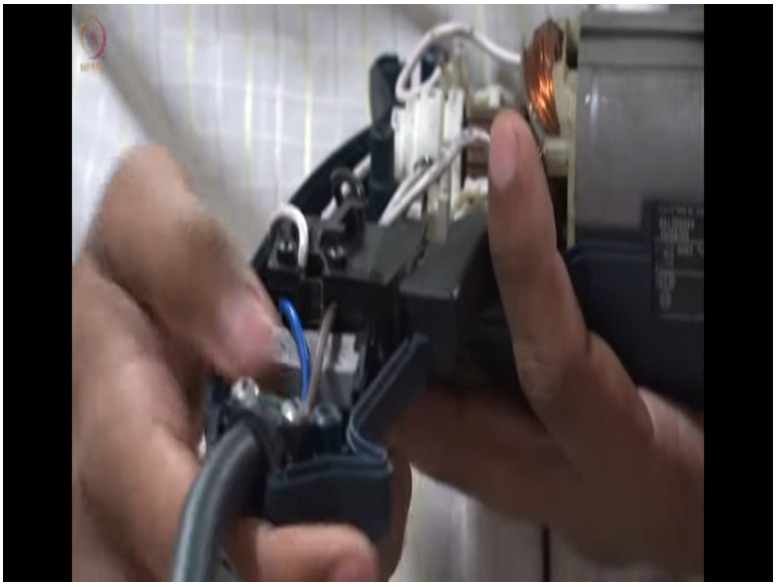
(Refer Slide Time: 22:56)



The second one is gears. So where are the gears? So these are the gears. We have found some sort of a gear and the third is a drill bit. So drill bit is some accessory that will be provided and all. On-off switch. We have an on-off switch, but what are the components that we are not able to guess? We noted that there are some vents on the product.

So in case in order to dissipate heat on this product, we need to have some sort of exhaust fan. So somebody was telling me about this. Essentially you are telling about that. So this is the cooling fan that we have. In case you want to notice it, you can see that the maximum number of vents is provided here because the fan is provided here. So this is the cooling fan. You can write it on a separate side that the components that we are not able to guess and the second thing is what is this small component?

(Refer Slide Time: 23:53)



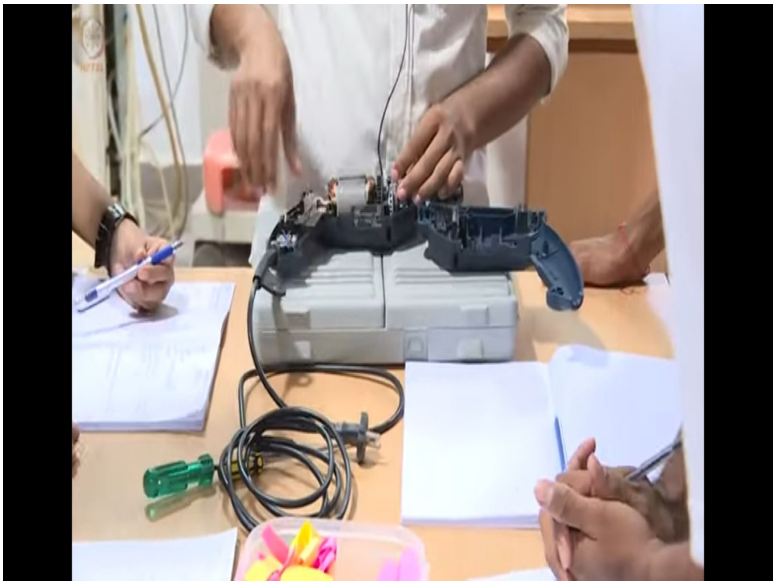
Adapter. Not essentially an adapter. Battery no, because we are providing it with some sort of power. Adapter. So essentially the adapter will convert, it will be a step down or a step up but this is not some sort of an adapter. So essentially I am doing some sort of conversion here. So I am providing an AC and there must be some sort of an electrical component that will be providing the initial torque and all.

So essentially when you see that in automobile engines, when you kick start a bike, there is something called as a spark plug. So a spark plug is used to initiate the piston action. Just a spark which will ignite the fire and keep the cycle going. In case of electrical components, the same function is provided by the capacitor. So you will have some sort of a, so you have a motor that is essentially the interaction between 2 magnetic fields.

So you will have some sort of a back EMF in the motor. In order to kick start that motion, the rotary motion will have some sort of a capacitor which will keep it charged at the end. So

providing I have some sort of a power. What will this do? It will have a jerky motion, but you do not want to provide that jerky motion. So when you switch it off, it will have some sort of a charge stored over here.

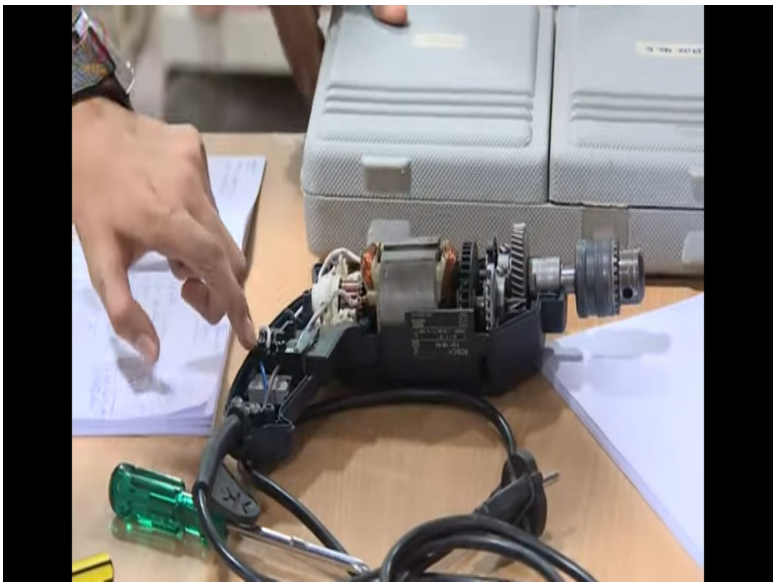
(Refer Slide Time: 25:07)



So when I start it, it will avoid that jerky motion of the drills and the second thing which we are able to notice. A drill machine can be made with the help of a motor but when you hold it, it is kind of a bit heavy. So why do we need to make it heavy? Is it a necessary characteristic or can we make it light?

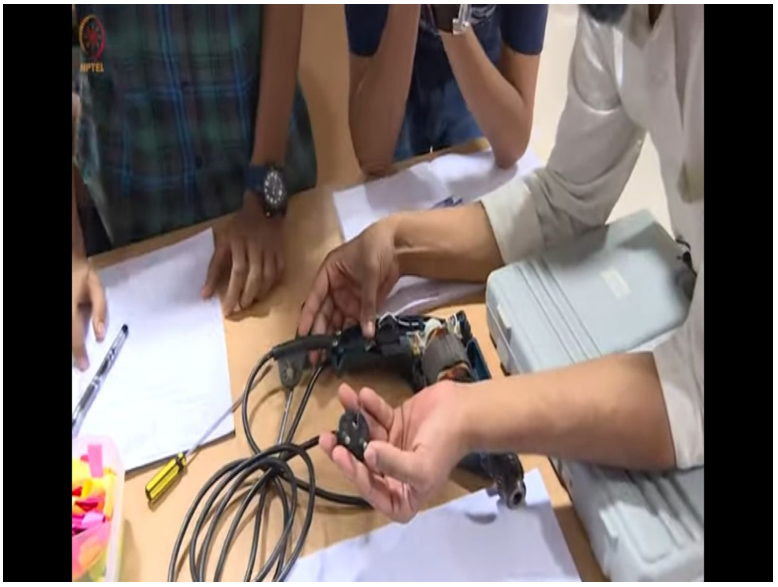
Heavier the thing is, the more inertia it will have, and with more, the more force you need to apply in order to move it. So when you need to drill something, you need to make sure that the drill that you are making is stable. It is perfectly aligned with the work piece. So for that in order to happen, you need to make it heavy. So the second thing is, we will remove the power casing.

(Refer Slide Time: 25:50)



We will remove these 2, these 3 screws. You can note the third step. Remove these small screws. I have provided an AC so I have 2 wires.

(Refer Slide Time: 26:05)



These 2 are the power cords that are going to the machine. So I have a capacitor here which will charge and discharge and it will just avoid it from having the jerky motion. So in case it will have some back EMF, it will be able to control that. So what is back EMF and how is the interaction happening inside the motor? I will explain to you when we will open the entire model.

So the third component is we will remove this one. Yeah remove this. So here you can see that I removed the power cord and I can also remove the capacitor.

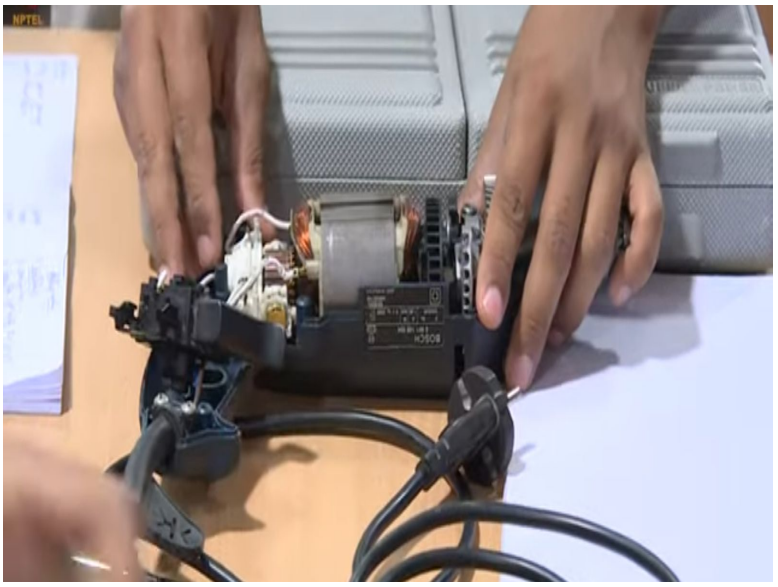
(Refer Slide Time: 26:38)

So this is a capacitor. So the capacitor will have some units in Farads. So it will have some units in Farad and it will be able to store some charge. So it is essentially 15 μF, you can see it here. So, have you seen a capacitor anywhere other than this? Have you heard electricians in your house telling us that we need to change the capacitor?

Fans, right, so in that case also, I need to have some sort of a rotational motion, and capacitor: what it does is, it will store the charge and it does tweak the motion smoothly. In case you switch on the fan, you will provide some amount of voltage to it. Essentially some, suppose I provide 20V, 30 V, 40 V in this case 220 V.

So, in case of 220 V, it will fast rotate, it will have jerky motion. Capacitor will first charge it up and during this charge period it will provide some amount of energy to it so that this motion is not at all jerky.

(Refer Slide Time: 27:40)

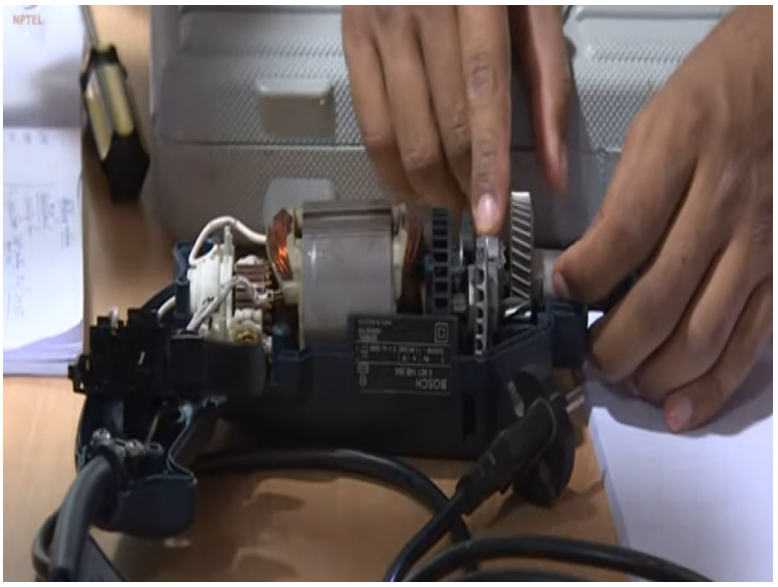


So now what I will do is, I will remove the chuck assembly from the drilling machine. So this is essentially called the chuck assembly because it is used to hold the chuck. So I will remove these 2 screws. The pitch, so you can see that here the pitch is not that uniform but in this case, it is a machine screw.

So a machine screw is something that you make in a lab machine. Have you seen the lab machine? So essentially there are, for in order to make these grooves, essentially this is a cylindrical rod and I make grooves on this, helical screws. So and in this case, I have to maintain a certain amount of pitch.

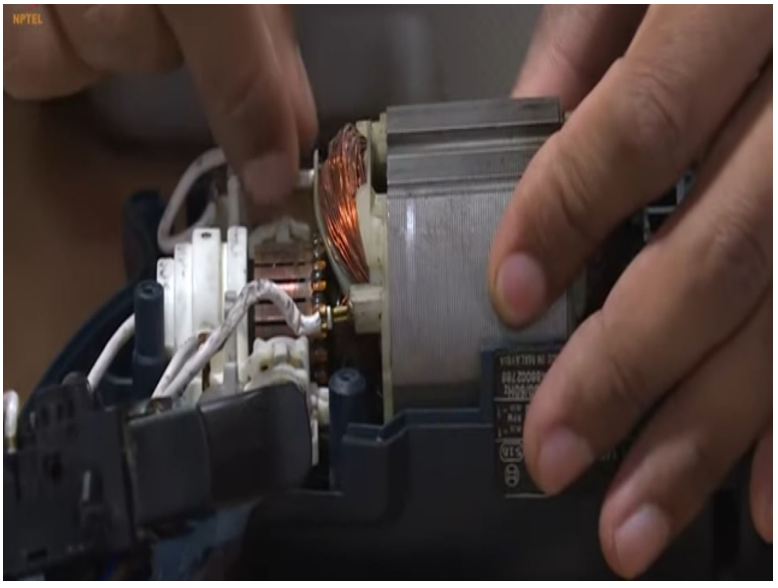
So in order to hold metallic components, I will use something called as a machine screw. In this case, the pitch will be much lesser so that it is able to hold the components more tightly and the second thing that you can notice is, it has a pointed head and this is not a pointed head. I can remove this but it is attached to this.

(Refer Slide Time: 28:52)



So I need to remove this too and what is this? When we remove this, we will notice what components are coming out of it and then I will explain to you what it is. Try removing this too and this is also cross headed and it is not a machine screw. So right now what I will do is, you can notice that this component takes power from the power switch and it is connected to the motor by these 2 things, these 2 wires.

(Refer Slide Time: 29:23)



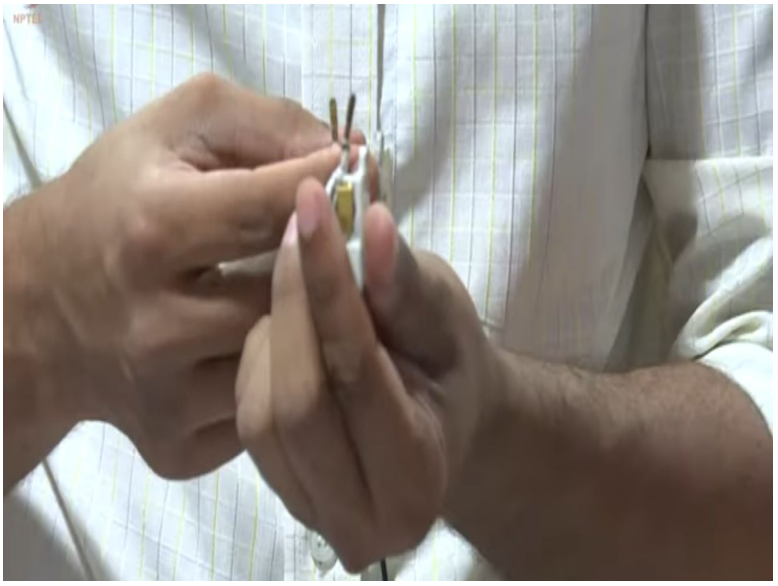
So I will remove these 2 wires and somebody try lifting this up. So when you pulled it, something came out of it. I just want 3 people this, 3 people take this and tell me what it is. Is

it a magnet? In case it is a magnet it will stick to the iron piece. So to give the power to this motor.

(Refer Slide Time: 29:47)

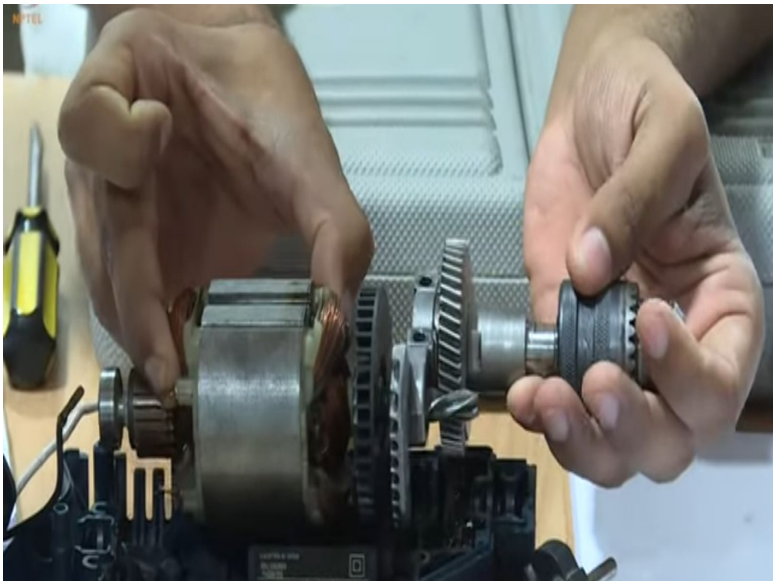
To give the power to this motor, I can use a wire. I can use any sort of component other than graphite, but why graphite. First thing, it is a conductor. Graphite is a conductor. Second thing is, it has the least amount of friction because of the carbon atoms between it is able to slide and it has the least amount of friction. So that is the reason we use it not the least but it has some amount of friction. The second thing that you want to notice here is.

(Refer Slide Time: 30:19)



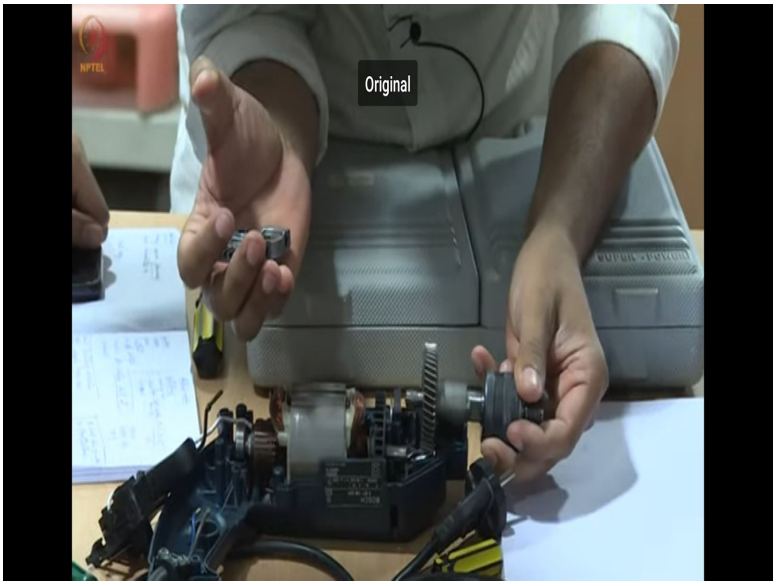
So these are spring loaded. Yes to hold it and the other thing that you can notice is due to successive rotation there is wear and tear in this carbon brush. So now I can remove this entire casing. Let me see if I am able to remove it.

(Refer Slide Time: 30:39)



Yes, so I am able to remove the entire casing. So, first I will remove this enter chuck assembly.

(Refer Slide Time: 30:47)



The first thing that you will notice is this is some sort of the gear and I told that gear was used for transforming motion. So what kind of gear is this? Helical bevel gear. So I will tell you

the different types of gear. The most common form of gear that you will see anywhere spur gears. So you know what a spur gear is, right? Essentially I will have a circle. I will have a circle, I will have some sort of teeth and this is helical gear. So in case of a helical gear the teeth will be in case of a spiral manner.

So what is the main advantage of a helical gear? So I will have some sort of spiral gear. I will have the corresponding sort of a spiral on the other teeth. So in case of the spur gear, you see that I have these teeth, I have the other teeth, I need to have a point contact between these 2 sets of teeth. When this contact is lost, I need to rely on the other teeth for transforming the motion but in case of a helical gear, I will have some sort of helix here.

I will have the corresponding helical here. So I will have entirely a line contact. So essentially the difference between these 2 are, in order to transmit more amount of force I need to have a larger contact area for this. In mechanisms, maybe you have read higher pairs and lower pairs or you will be reading about it. So the higher pair is essentially where you will have a line contact lying on a plane and the lower pair is where I will have a point. So what are the different kinds of gears?

One is spur gear, one is helical gear and we were told some sort of bevel gear. So what is the bevel gear? 90^{o} rotation. So can you tell me one example where I can use bevel gear. Sewing machine, okay apart from that, sewing machine is kind of, the first thing you think of bevel gears that should not be the first example that strikes your mind. The first should be I guess, any examples that you tell. Sewing machines are obviously one of the applications of bevel gear, but have you seen a car?

Car? So in the car, I have some sort of an engine. I have some sort of engine. So the power will be transmitted along the axis of the engine, but you need to transmit the power to the wheels. So the wheels are essentially 90^{o}. So you need some sort of a bevel gear in order to transmit your sources. So the entire assembly in the car, what it is done is, it is kind of a differential. So I can rotate it with different items also.

When you are making a turn essentially you are having a lower rpm in the inward wheel, having a greater rpm at the outward wheel. So we will have some sort of a differential there. So essentially the most intuitive of a bevel gear is, I can have 90^{o}, I can have 45^{o} as well. I can have 60^{o} as well. So this is called a bevel gear.

Apart from that, I can have warm gear also. I can have a rack and pinion also. So warm and rack and pinion both are similar kinds of gear transmission systems and essentially I will have some sort of a rotary motion and I want to transmit it into linear motion.

So essentially when you will be going to central workshop and seeing the lab machines and all, you will see they will be essentially rotating one of the work pieces and there will be translation motion along the understood what I am saying, essentially what it will be is, there will be one for sort of a circle which will have some teeth and there will be one sort of a plane which will have some teeth.

So when I will move this, the entire table will move forward or backward. So this is the entire mechanism of rack and pinion or warm. Warm is essentially, I will have some sort of a motion along the vertical axis. Yeah, so essentially you will rotate this one and I will have some sort of a vertical motion. Apart from that I have something called as a planetary gear as well.

So one of you mentioned that one of the possible things that we can do is we can increase or decrease the rpm of the machine. So in order to increase or decrease rpm of the machine, what do we use? In case of bikes what do we use? Bikes. So in case you are not so familiar with automobiles, all of you can ride bikes or cycles?

In case we need to change the speed of a cycle, we press a clutch and we change a gear that is the same case of bikes. In case of cycles, we have different gears, size ratio of the gears. So we change the rpm of the entire bicycle with it. In case of a drilling machine, the same can happen, but in case of a bike, I have a clutch set which will attach to different sizes of gears, but in case of drilling machines, the size is very compact.

You cannot have a clutch set for this drilling machine. So I have some sort of a planetary gear system. So this is essentially I will have 3 gears and this gear head will have different sorts of sizes. So if I need to rotate this one, I will have some sort of a transfer between this and this. If I need to rotate this one, I will have some sort of transfer between this and this.

It is used in a drilling machine. It is also used in some kinds of automobiles also so you can just search through the internet about planetary gear, you note the different kinds of gears. So what are the different kinds of gears that I told you about? I will hide this. Spur gear, helical

gear, bevel gear, rack and pinion, warm gear and planetary. So this is essentially, it is not a spur.

(Refer Slide Time: 36:41)

So spur will have the teeth horizontal. So in case it is helical, it will have some sort of a curve and so why is it used? If you are able to transmit a large amount of forces, we need something to have permanent contact. So line contact is better than a point contact that is intuitive, right. So we will have some sort of a helical gear between these 2 components. So this is the chuck assembly that I have removed.

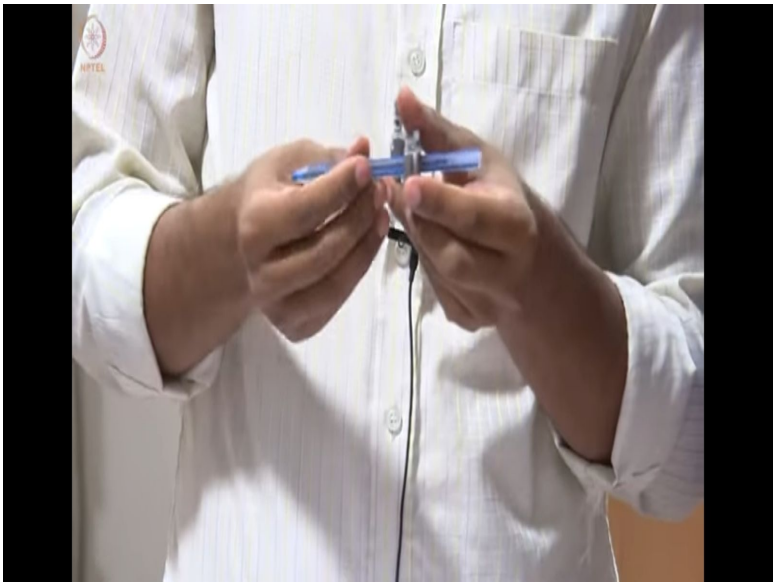
(Refer Slide Time: 37:13)

And we can notice here that this is the component which is supporting the motor or transforming the rotatory motion from the motor to the chuck assembly and in order to, so this is similar to something called something in the rim of your bicycles. So when you rotate a cycle, you have some sort of a rotatory component and you have to hold it with some sort of support. So what is the support that we use is cycles?

Essentially in cycles we will have some sort of outer casing where the entire wheel will go but in case this wheel is subjected to some kind of a, this wheel comes in front of a hump and all. So you will have some sort of forces acting in this direction. So I need to transmit rotary motion and I also need to withstand those forces that are coming with the wheel.

In case of a bicycle you will have some sort of a ball bearing. Have you noticed when they repair cycles they will come up with small balls. There are 16, 32 and all. So in this case can you see some of these? Essentially if I rotate this I am able to rotate a bearing.

(Refer Slide Time: 38:30)



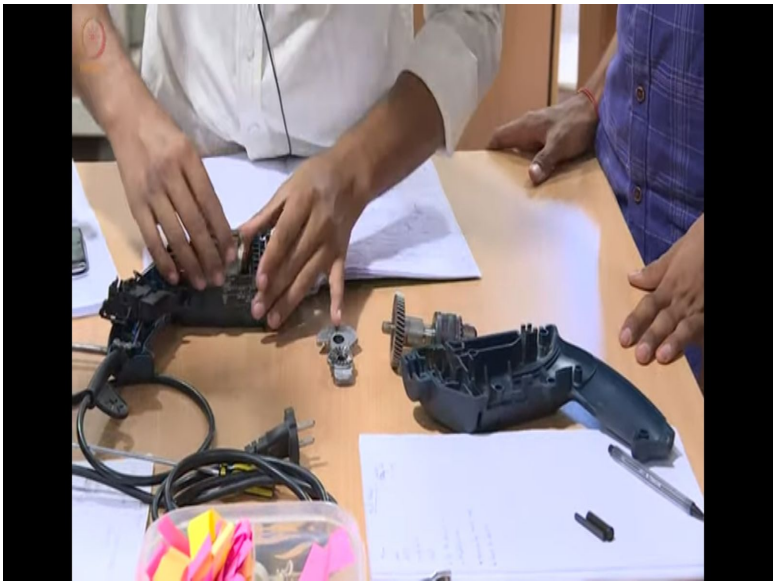
This is what we call as a bearing. It is able to transmit motion. It is essentially aluminium or mild steel. I guess it will be mild steel. You can use a spring, you can just mount a spring here and in case it is subjected to this force, the spring will compress and then make it restore its original shape.

So in our case radial bearing can be some sort of a ball bearing. It can be some sort of a roller bearing as well and essentially roller bearing is better than the ball bearing because it will have line contact, more area of contact so more force that it is able to sustain or less pressure.

And apart from this, when you in case you have the opportunity to visit any of the machine shops, who are kind of repairing the vehicles and all. You see that when they remove the wheel of a car, they will have some sort of taper roller bearing. So this is what I call a taper roller bearing. You have seen it. So these are the tapered rollers. So what is the advantage of this in comparison to this? Nothing complicated, just a simple concept.

So suppose. I have a taper roller bearing. What is the direction of force that I transmitted to this so I can reserve it into 2 directions, that is what I need? I need to support some sort of axial force, I need to support some sort of a radial force as well. So this is called taper roller bearings.

And the thing is, is this the entire set of bearings that they have in the automobile or machining industry nowadays? No, there are many different sorts of bearings but these are the things that you need to understand a drill machine. So I have removed this, this is the chuck assembly. (Refer Slide Time: 40:27)



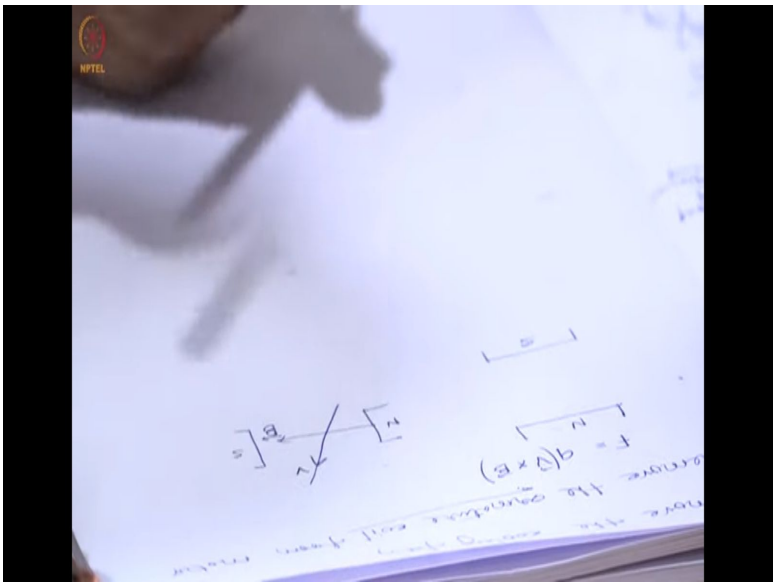
This is the component that is enclosing the motor as well as a chuck assembly. Now, what I will do is, I will remove the cooling fan.

(Refer Slide Time: 40:32)

So what is this? Armature coil. So forget about the armature coil. The thing is, on seeing this what can you see and they have some sort of a separation between them. So I am making some sort of copper coil. What can I have? I can have some sort of electric field. I can have some sort of a magnetic field and there is separation between them.

So I need to have a magnetic field or electric field or separate polarity, okay that is what is happening. So I have some sort of a step 9 to remove the armature field from the motor. So how does the motor work? Electromagnetic field, I will have some sort of an interaction between the electromagnetic field and how is the electromagnetic field generated? So the thing is, I have some sort of a force acting on a current carrying coil. So if I have a magnetic field, north and south.

(Refer Slide Time: 41:43)



I can have the magnetic field like this also, north and south and if I have a velocity in this direction that is a charge moving in this direction. What will be the direction of the force? So this is the direction of the magnetic field, this is the direction of the current and the V cross B will be the force acting on a current carrying substance.

So essentially, if this is the magnetic field and this is the current carrying coil, if I place it in this direction, there is a force which is acting on it in the downward direction, but I need to produce some sort of a rotary motion. In order to have some sort of a rotary motion I need to have some sort of torque or couple that is forced in the opposite direction. So, how can I have it?

I can have it in this direction. So I have a current in this direction which is coming back in this direction. So I have a positive polarity here, negative polarity here. So you told me that this is V, this is B. So, this is V cross B. V is the charge flowing through the V. So Q is the amount of charge.

If I guess 2 columns of, if I knew to increase the amount of force, I will just increase the amount of charge that it is carrying. So essentially think of it as an electron that is passing through a ball of fire. So if 2 electrons are passing greater the amount of force. So V is the direction essentially I can write is at QV sin θ.

So just remind me about sin θ in case I forget. Okay. So essentially I will have V in this direction. B is in this direction, V cross B will be the downward direction. I will have a force

in this direction and I will have a force in this direction. So essentially my field will rotate in this direction. So after having something like this.

Now it is in this direction. So V is in this, B is in this, V×B is in this direction and the opposite is in this direction. So is there any couple acting on the conductor now? No. So essentially at this point of time I will have no couple acting on the conductor.

So the entire rotary motion will be dependent on inertia. So it is moving in this direction and it will keep moving in that direction and the thing is, suppose till 90^o it is moving completely fine. After 90^o, it will depend on inertia and the thing is right now, I have the coil twisted.

So I have this kind of motion but the current direction is this and this direction and in this and this direction. The current direction is reversed. So you can see that the couple is also reversed. Initially it was in this direction so it was in this way, it was rotating like this. Right now, it is in this direction. So there are a couple in this direction. So I cannot have a continuous rotary motion.

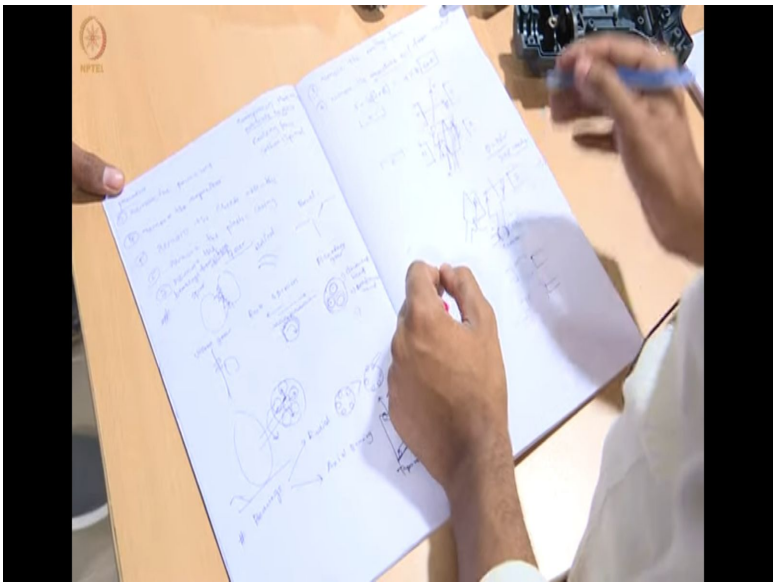
It will have some sort of a reciprocatory motion. Am I clear or should I make it understand again? Clear. I have 2 coils, it is moving in this direction. There is a torque. It is going like this at this point of time, force is in this direction, and force is in this direction. There is no torque. It is completely dependent on inertia. The moment it is turning like this, it is having torque in the opposite direction. So, how can I, essentially I want to avoid that problem.

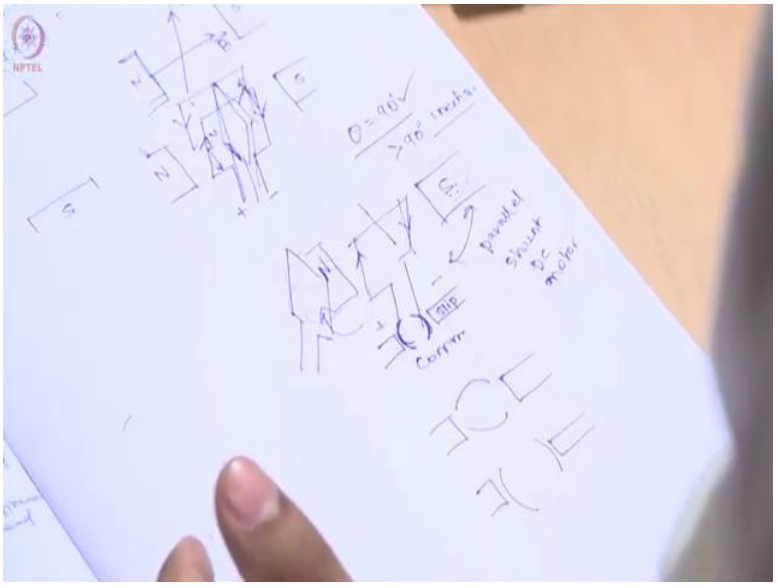
How do I avoid it? I am using DC current, we can use brushes but the thing is brushes are used to transmit just the current. Yeah, that is the essential reason. So what I want to do is when I mean theta that is perfectly fine, but when I am moving in the opposite direction, I need to change the polarity.

So right now what I will do is, I will make it exactly like this. So I need to have something in order to change the polarity of this current carrying coil when it is moving in theta greater than 90^o. So I will have some sort of coils like this. I will have spring rotate slip rings.

This is essentially what is called as do you know the name. Commutator. So this is essentially called a commutator. So when I am in 90^o it is essentially like this. When I am greater than 90^o it has rotated. So the polarity is also rotated.

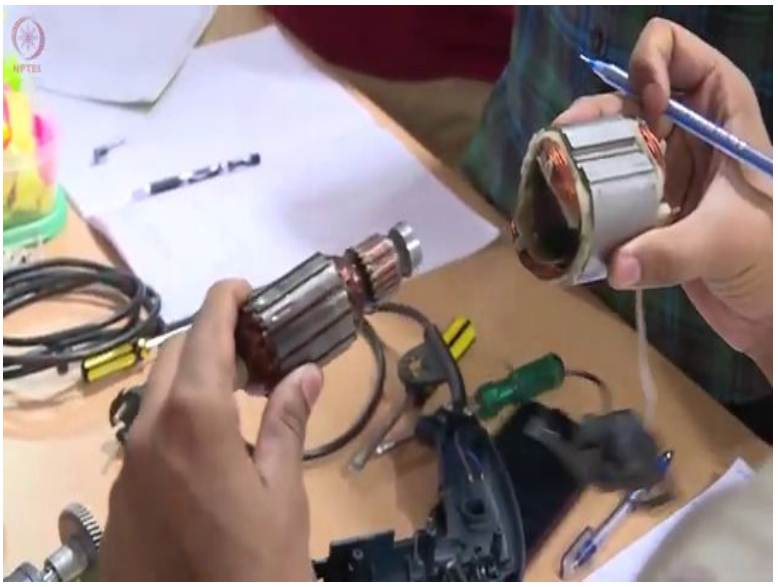
(Refer Slide Time: 46:38)





I also need to have some connections here in order to make it north and south. So the entire current that is passing from this positive and negative polarity is making this magnet a current carrying coil and also this is as a electromagnet and depending upon so I have this circuit, I have this circuit and if both of these circuits are connected in parallel, I will have some sort of a shunt DC motor. Shunt DC motor in the case of the connection of what is this?

(Refer Slide Time: 47:09)



Field magnetic and the connection of armature magnet are both connected in parallel and in case they are connected in series it will be series DC mall and the thing is, so right now I have, so you can see that essentially if I take a quarter of this coil I have 1, 2, 3, 4 so there will be 16 such armature coils passing around you. So essentially how can you visualize it?

(Refer Slide Time: 47:35)

It is one north, one south, one north, one south, one north, one south essentially a current carrying conductor. So every time there is a motion among this, there is a couple generated in

every coil and in case one of the coils is dependent on inertia. The other coils are driving it to move forward. So, I have one sort of a current carrying conductor going through here.

(Refer Slide Time: 47:56)

Suppose my current carrying conductor is now in this case panel. So the slip rings are no more in contact with the commutator. So there is no current supplied to this and there is no couple acting on this. So the entire coil is dependent on inertia in order to move but I want to avoid it. One thing that I can do is that I make the inertia of the coil more, that is make this more heavy.

But is this the only solution? No, I can have multiple armature fields so I have one current carrying conductor like this, I will have a second perpendicular to it.

(Refer Slide Time: 48:32)

So we can have a second current carrying conductor perpendicular to it. So in this amateur field how many holes are there? 16 and how do you count the number holes? Just take the quarter on the number of holes multiplied by 4. So what just in a nutshell any one of you can tell me what I told you about motors?

The thing is what is the current, what is the force applied on a current carrying coil when it is in a magnetic field? Torque is not applied. It will be on Lorentz Force. Some sort of Lorentz Forces is applied. So the Lorentz Force, when opposite the Lorentz Force, acts on each other. There will be a couple on it and how do I maintain continuous motion?

By changing the polarity and for changing the polarity I need to have some sort of a conductor. So if you use graphite because it has less friction because of the interstitial carbon atoms and I reverse the polarity. The thing is how do I avoid the problem of inertia? By having multiple, by secondary coils or multiple coils.

Secondary coils, the thing is there is nothing sort of a secondary coil, there are multiple armature fields rather than having a single carrying coil. I have multiple coils. So the thing is I told you that I am providing DC here but what is the power that we are providing it? AC. So how is it operating now? So that is the main thing that you have to find out.

So this motor is something called a universal DC motor. I will just give you a hint about it. I just want you to find it is. It is just 2 to 5 minutes of reading on the internet that is it. So there

are DC motors which run in DC polarity. There are AC motors which run in AC polarity. So what is the difference between AC and DC first of all?

So you can see that there is a change in phase between the current. So you can see that in DC I can have 2 wires but in AC I will have 3 wires. RYB. Red, yellow, blue or a red, yellow, brown something of that sort. So there are some motors for DC. There are some motors for AC and there are some motors which are called universal motors which work for DC as well as for AC.

So the thing is if I have some sort of an AC and I want to convert to some sort of a DC motor. How do I do it? I can have some sort of a rectifier motion. So for a rectifier I need a capacitor and the capacitor is well presented. So I just want you to study how AC is converted to DC or how DC is converted to AC and how a universal motor works. So that will be the last part of your report. You have to write it.

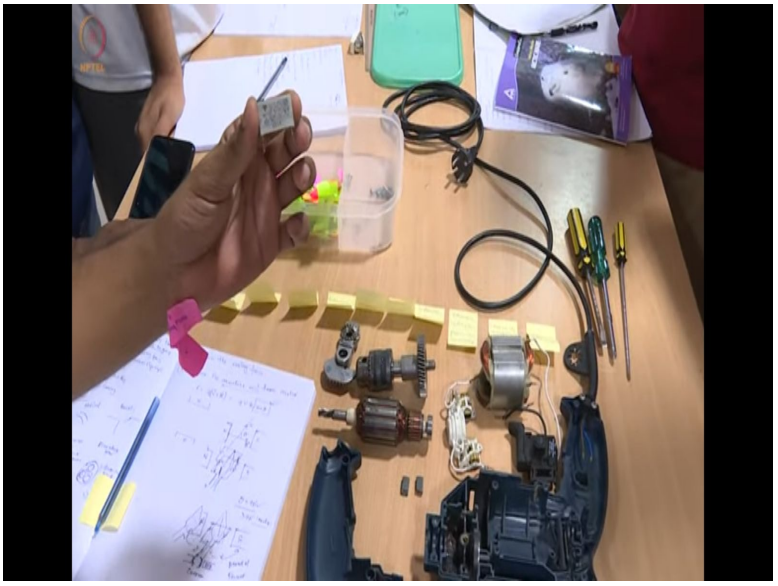
(Refer Slide Time: 51:36)

So these are all the separate parts. So what I want you to do is we will follow the reverse manner in order to do it. So I just want you to tell me, what are the steps we followed to disassemble the entire product? The first step was removing the plastic screws. So here we have all the screws that are present.

We saw that there are 2 kinds of screws, cross headed and flat headed, and for them we have 2 types of screwdrivers as well and this was the first step. The second step was to remove the

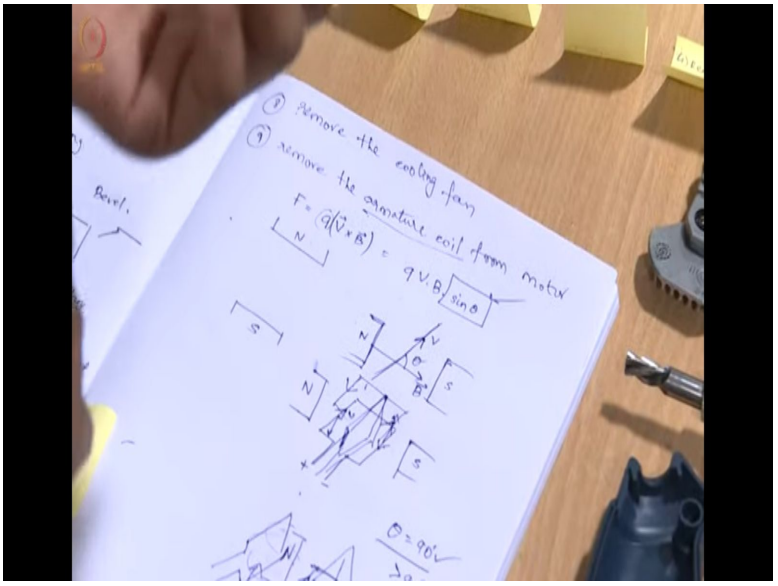
plastic casing. So there are 2 parts with the plastic casing. We remove them. The third step was removing the power cord. We removed the power cord and we saw that there was a capacitor.

(Refer Slide Time: 52:21)



So a capacitor can have essentially 2 functions. It can be used for the working of the universal motor as well and the second thing is for, it can store some sort of energy to prevent the jerky motion or to avoid back EMF. So we saw that, so what does back EMF mean? The thing is, I am moving so essentially told that this is a current carrying coil.

(Refer Slide Time: 52:48)



So this current carrying coil will also have a magnetic field attached to that and when you find the magnetic field of this, both of them will have some sort of opposite magnetic field. So they are opposing each other and you are trying to make the motion. So that is what is back EMF. In order to make the motion, we need to oppose the EMF that is the electromotive force. So because of that EMF also some amount of potential is present.

Third is, remove the power cord. We removed the power cord, we saw some sort of a capacitor. The fourth is to remove the capacitor. Fifth is removing the chuck assembly. So the Chuck assembly is used over something of radial symmetry.

(Refer Slide Time: 53:25)

This is a 3 fingered chuck assembly and 3 fingered is used to have force closer. The summation of all the forces should be 0. We thought that it was a plastic casing but on removing that we saw that there are 2 carbon brushes attached to it by means of spring and these were spring-loaded slip rings which are in connection to the commutator.

(Refer Slide Time: 53:48)

So this is the commutator. This is the armature coil and this is the field magnet. So due to the magnetic field interaction between the field magnet and the armature coil it leads to rotation of a motor and this is what kind of motor. This is universal and it is up to you to find out how this works. I have given you a hint. A rectifier circuit will be used.

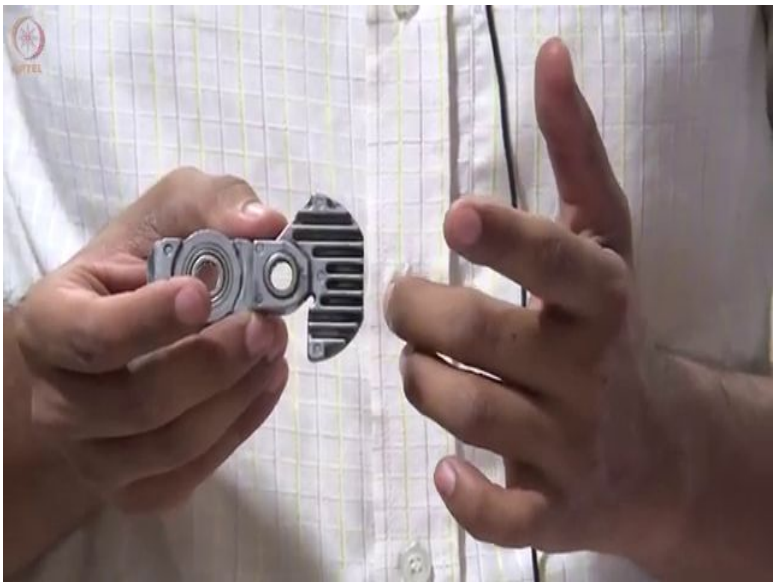
(Refer Slide Time: 54:20)

When I close this mode switch. There is a hammer here. There is some sort of a drilling machine here so in case of a hammering action, so when does a hammering action come into play? This will have some role to play. I will tell you about this and the other thing that I missed is this one. So what is this?

(Refer Slide Time: 54:34)

This is just in order to transmit the power. These are roller bearing here, roller bearing here. So I will have some sort of motion here which will be transmitted. What is this? Have you seen this kind of a structure anywhere?

(Refer Slide Time: 54:43)



You have seen this in engines. So the thing is I want to dissipate heat, I need to have some sort of a surface area which is so these are essentially called our fins and where can you see this? The corners of the engine will not be smooth. It will have some sort of a corrugated surface. So more the surface area is the amount of heat dissipated in it.

(Refer Slide Time: 55:07)

The other thing is, when you saw that the motor was fixed here, I was trying to move this, but I was not able to move it. So there must be some sort of interlocking structure that was

preventing it from moving. Have you noticed it? When I removed the outer casing, I thought I was trying to move but it was not moving.

(Refer Slide Time: 55:29)

This is the interlocking machine. So try to rotate it in this direction. Try to rotate in a clockwise direction. No-no hold this. You will not be able to move. The thing is if this joint is tight enough right now what is happening is, I am not able to hold it. This joint is tight enough so it will have rotation in one direction is possible but rotation in the other direction is not possible.

In this direction it is possible, in this direction it is not possible. So this is the interlocking mechanism. See this interlock with this. There are teeth here, there are teeth here. In this direction it can rotate, in this direction it will sit.

(Refer Slide Time: 56:16)

Can this gear be used for inversing the RPM? I have clockwise RPM. I want to rotate it anti-clockwise. Can this be used? No because of this interlocking mechanism and where can I use the application of rotating the RPM? So I have clockwise motion now, I want to have anti-clockwise motion. In case I have some sort of a mechanism, some sort of a gear motion in order to reverse the RPM. Where can I find the application of reversing the RPM of the motor?

Suppose you want to tighten the screws, you need progress motion. Remove a screw that needs the opposite RPM. So one of the modifications of this will be to reverse the RPM. Reverse the RPM so then we can tighten as well as remove the screws. So what I want you to do is one by one you try to move in the opposite manner. So remove the entire field magnet you will try to put it in and we will try to assemble the overall part. I will just try to help you out in case you are not able to do it.

(Refer Slide Time: 57:23)

The first 3 pins when I press it, it will have some sort of spring motion and in this case there was a ball bearing here. Somebody has removed it. There is a ball bearing. In this case there is a ball bearing so in order to have, if in case this will have, so if in case I am moving it in this manner the entire force will be acting on this point and if I have a hammer action this will be able to sustain the axial forces.

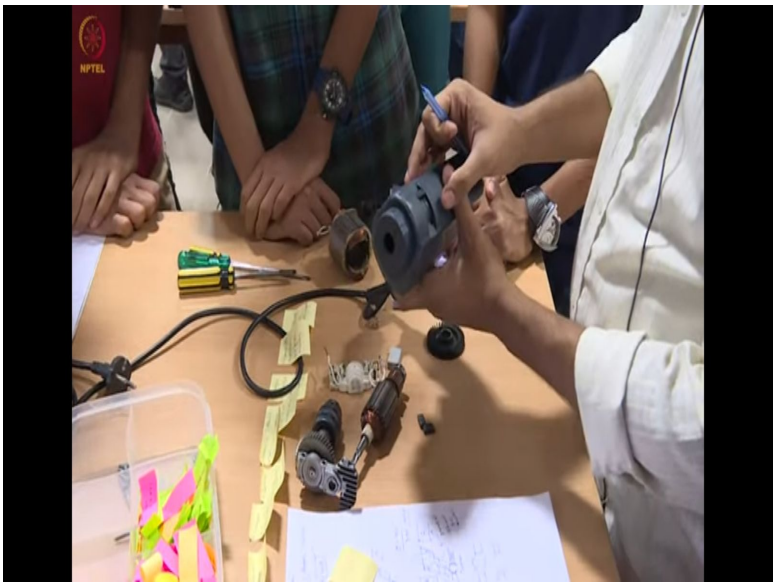
(Refer Slide Time: 58:03)

And in case I am drilling steel or any other structure where I need the drill bit to be entirely rigid. I do not need it to move. So I will have a ball bearing in this direction so that it will not allow any motion but I need to support the rotary motion. So ball bearing will essentially slide in this place.

(Refer Slide Time: 58:22)

This is the ball bearing. This is the entire drill bit. So I will rotate this. The ball bearing will roll but it will not allow any motion in the axial direction. Is this clear? So this is essentially a mode switch and I told you the mode switch was essentially used for drilling motion. In the case of drilling motion which will come into play the spring or the ball bearing.

(Refer Slide Time: 58:44)



The ball bearing or the spring? Ball bearing, right I do not want the drill bit to move. So I will have the ball bearing. In case there is a hammering action then the spring will come. Am I clear? So do the, yes sure, you can take that. This is just a component you can term is a connecting component or transmitting component. There is no sort of a new one.

The other thing is how do we manufacture them? So once you assemble them, we will note all the components and will talk about how we manufacture them. You can note this as a transmitting component or transmission component. So what is the 10^{th} step? Remove the entire field magnet. So I will try to put the field magnet in. From which direction is the field magnet going in? So this direction.

You can put it separately and then hold it, so right now step 10 is done. So what is the 9^{th} step? Fan, do not push it that is fine. So step 9 is done. What is the 8^{th} step? 8 is also done. What is the 7^{th} step? Removed bearing from chuck assembly. So you can put the bearing in this locking component, yes.

What you can do is, okay first assemble it here and then you can directly put it here. It should be in the opposite direction, right. Yes and both of these gears should mesh with each other. It is meshing with each other. Perfect. So now step 7 is done. So the next group can come. Now it is resting. I will just check if it is fixed properly.

Yes, now it is not moving, now this is also not moving. So step removing plastic casing. Yeah. Before removing the plastic casing what do we need to do? Slip Rings. Yes, you need to hold slip rings and also make sure that the wires are connected because after inserting it you will not be able to put the wires. So we move 2 of our wires, we will put those 2 wires in where did you remove it from? Yes, opposite.

Student: Field magnet

Professor: Yes it is okay. Now it will not go in that manner, no, there is just a slot here, slot on the top. Just be careful with it. So the thing is I just want you to ask a question. After assembling it how many of you think this will work? (Will this work) after assembling this will it work? Yes, No? How many are in favour of yes?

Where is the other member? (1, 2, 3, 4, 5 where is the other gone?) He has gone to the water dispenser. You need some water? You need a pen? What do you need? So the thing is, after connecting this how many of you think that this will work? People in favour of yes raise your hands. Only 3? 4 at least. Little optimism.

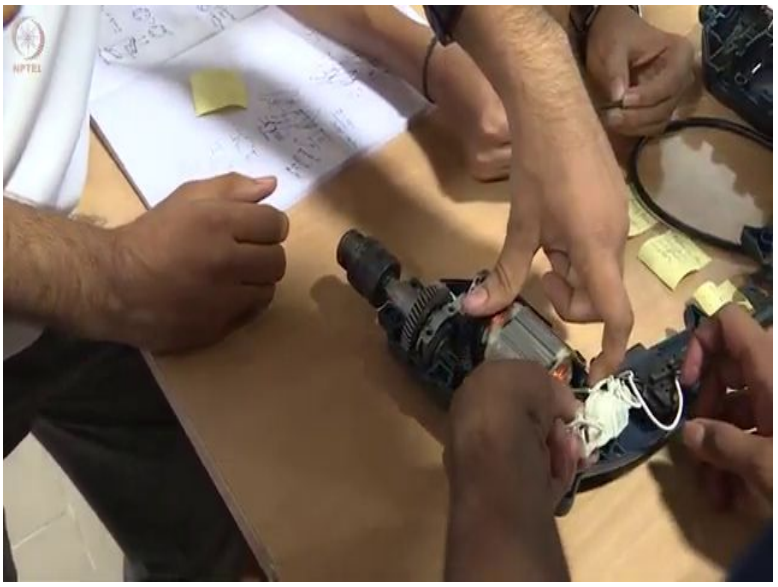
So the thing is yes. So there are 4 coils or there are only 2 wires. So I need to have coils from, 2 coils from here going in the same direction. You can see that there are 3 slots here as well as here. So I need to have 2 of these coils going here as well. So that has been purposely done in case somebody tries to press this.

There is one here, one here, one here and one in the other direction. So if I have 4 of these wires and I connect them, this will work. So which step were we in? Removing the plastic casing yes. Try to put the wires and will…

Student: slip rings.

Professor: No, the slip ring is not being put and will put the capacitor as well in case you are fixing this. You try putting the…no so it will go like this. So what you need to do is suppose I put this I need to have the slip rings also in place. So you need to press the slip rings and push it. So this is the hardest step. Let us see.

(Refer Slide Time: 65:37)

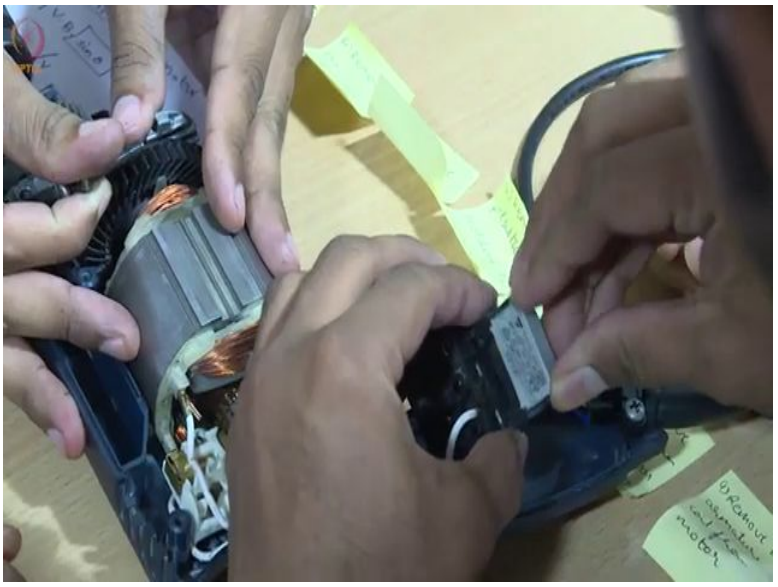


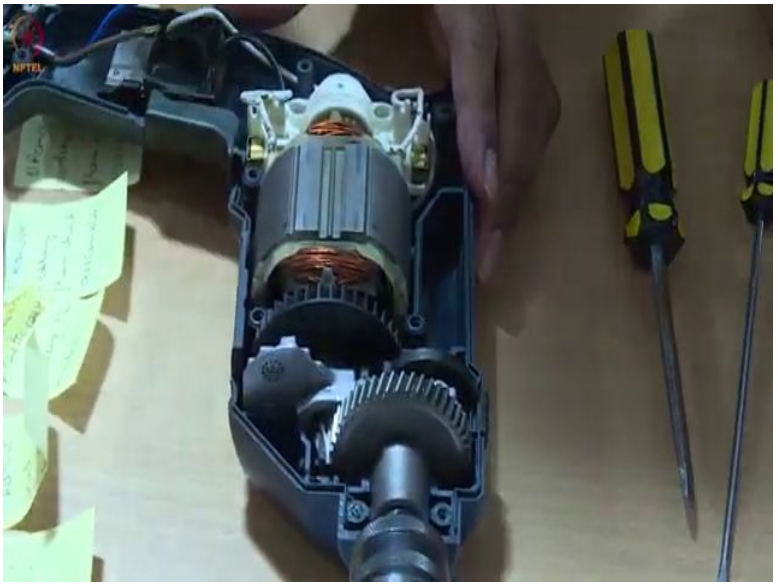
Make sure the wires are not in the way or if you are facing any trouble remove the wire. So what you need to do is you cannot do it this way so you essentially push it. Push both of them then put it in case. Try to push it in and then put it. The wear and tear component put it on the other side.

Yes done. So are the screws in place? It is in place. Hold that, now there are 3 of them. So we will have one here, one here. Try putting it here one of the wires, black, yes the black ones. It will be white-black, white-black. I guess the opposite side. Wait but we need to remove this. I am sorry. Yeah, so now you can put it, now there is I guess one left, oh form this you can put it here. It is in place. Put this, yes put this and this here.

Now this should work. I have 4 wires connecting the 4 phases. So till which step are we in? Remove the power cord, remove the capacitor, remove the plastic case, and remove the set. So the thing is what we need to do now? We need to, yeah capacitor we have not added, and we will add it.

(Refer Slide Time: 69:01)





We need to pull that out. Just provide some space. We have put the capacitor in place. Now we will try to seal the, what is this? Chuck assembly. Where is the flatted one? This is used to tighten and that is fine. So two of them there. Use the cross headed screw. This is done. We will connect the power assembly. I will just check if everything is right or not.

Student: This is not very tight.

Professor: Yes when I put the casing, yes it is fine. So how many screws do we need to put?

Student: 6

Professor: We have 6 but I guess there are many separate 1, 2, 3, 4, 5, 6. Yeah, so make sure the screws are symmetric. If you put in one direction put in the other direction as well

because some of the screws are missing, so front two, back two are most important. The thing is one of the groups what they did was they did not put the ball bearing. So we lost the ball bearing.

So what do you think that after assembling all of this what should be the final step? Check if all the components are there or not. I guess the most intuitive step would be just shaking the components. In case there is something missing or some screws are light there will be some sort of vibration. So there will be in case the ball bearing is inside and it is not fixed properly it will make a shaking sound.

So in case I get a chance I will just show you if this is working or not. Most probably this will not be working because the thing is the field magnet and the armature coil both of them will have the same polarity. Then only they will rotate so each of the groups will disassemble. The last batch had many people so they have replaced all the field magnets and armature with each other.

So everybody is clear with the report format that we have to write? So I will just sign them and what is this?

(Refer Slide Time: 74:52)

This is a bevel gear. So bevel gear is used for transmitting motion. In this case what is transmitting?

(Refer Slide Time: 75:12)

This is a gripper. So when I move one of the gears, there will be some sort of a linear component which is coming inside and it is pulling it outside or pushing it inside. So essentially here you have noticed that initially 8 mm drill bit was used. So 8 mm drill is the standard size that is provided with this.

But again use 8 to 18 mm in this kind of drill bit. So this is essentially used to hold that and one of the things that I want to mention is, what are the modifications that you want to tell? One person will tell one modification. However stupid it might be that is fine. Reverse the direction, 1. So I need 6 of them 1, 2, 3, 4, 5, 6. The reverse direction is first.

Second is yeah so making it wireless we can use lithium-ion batteries, we can use rechargeable batteries and make it wireless. That is a good recommendation. Third one, extra cooling fan. The extra cooling fan will just increase the size but it will be cool and the amount of RPM that we can get will be much more. The extra fan. This is the third one.

Yes, so I will increase the number of modes. That is what you are saying. So for different material, I will have different RPM. That is the fourth one. The thing is what I want you to understand is all the people that use this. You are an engineer so anyway you can understand

that RPM, the drill size and all. So all the people that they are using is they are carpenters and all.

If I have some sort of a slider for the material, if I have some sort of steel so I will directly put steel there will be some limit of RPM. There will be some limit of the drill bit size. So it will not allow a larger drill bit size in order to go. First thing, so that is what when you think from the customer perspective.

Yes, essentially user-friendly and the second thing is when a carpenter is holding this machine, he does not not know that this has to be efficient perpendicular or not. So the easiest modification then that you can make here is that just have a laser pointer. Laser pointer. So in case you are holding it a little bit tilted he will be able to see the tilt with the laser and he will be able to correct this. So 6 modifications are done I guess, 3 I only told. So you need to come up with 3 of your own. I will have them signed.