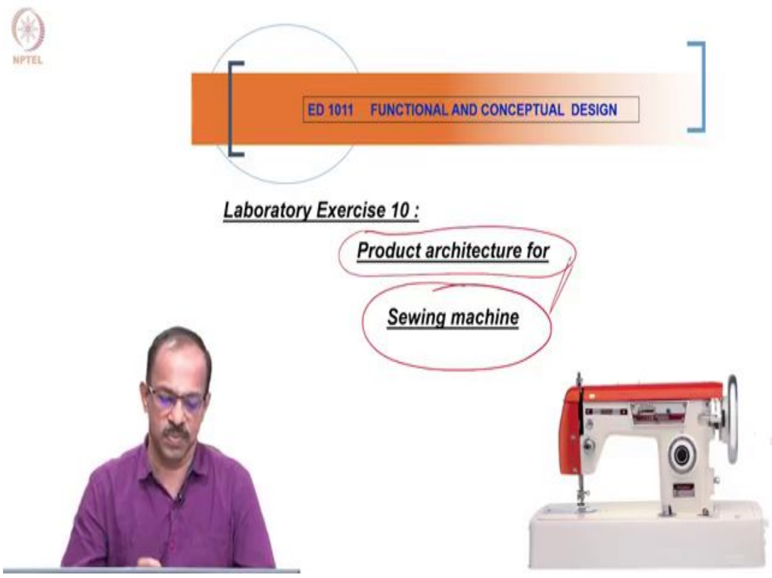
Functional and Conceptual Design
Professor T. Asokan
Department of Engineering Design
Indian Institute of Technology, Madras
Lecture - 36
Laboratory Exercise - 10

(Refer Slide Time: 00:13)



Hope you are enjoying the laboratory sessions. So today, we have a very interesting product for dissection and for experimentation. So this is a sewing machine. And I am sure all of you are familiar with this sewing machine. And there are different forms of sewing machine available in the market.

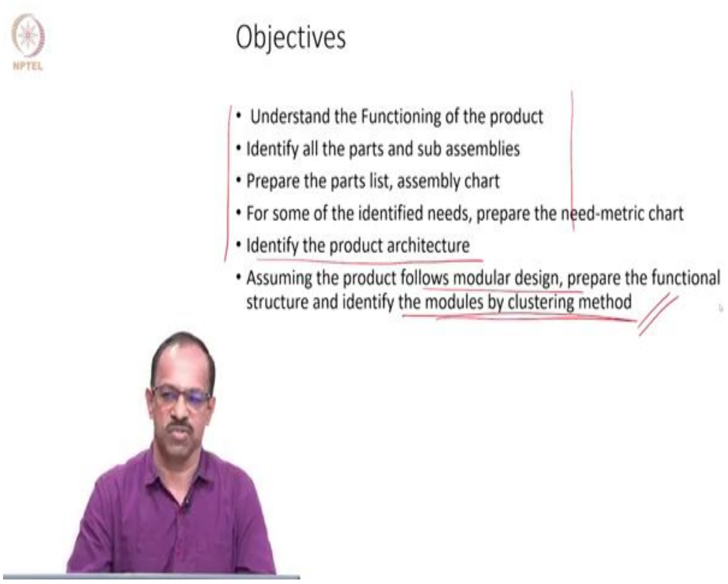
There are fully electronic and there are fully mechanical kind of sewing machines. And if you compare with the old machines, old machines were completely mechanical manual machines but then, slowly it moved to electrical powered machine with the number, a lot of electronics in it and with a lot of features which are coming, which was… which compared to the old machines, it is very much feature full in the current generation.

But whatever the design is, or whatever may be the model, sewing machine is a very complex mechanical system. If you look at the old sewing machines, you will see very interesting features. And again, the conversion of different motions, rotary motions to linear motions, and then very complex thread movement, needle movement, reciprocating motion.

It is a very interesting product for a designer to go through and understand the mechanisms, especially the mechanical components. And now, in the newer machines, and how the electronics and actually electronics have combined or use the features to get additional functionalities in the product. So we will look at one product, one such product; sewing machine. And then, try to understand how it functions, and what are the major mechanisms and controls in the sewing machine.

But we will be looking at from the product architecture point of view. So how is the product architecture developed here? So how the different modules are there, like you know, the thread module, and the transmission module, and things like that. You will be able to look at the product and then identify the different modules in the product and as a part of the product architecture analysis.

(Refer Slide Time: 02:32)



This product, as you know, the objective is basically to, the primary objectives are to know the product and the parts and its assembly. And then the second part is basically to identify the product architecture, and then see whether it is a modular design; if it is a modular design, what are the modules that you can actually think of, and then that you can do using that clustering method.

We have gone through many methods of product architecture development, that is, the clustering methods; using the functional decomposition, how can we use these functional blocks to identify the modules based on the dominant flow or transmission and things like that. So we use that one of the methods and then try to identify the modules in the product.

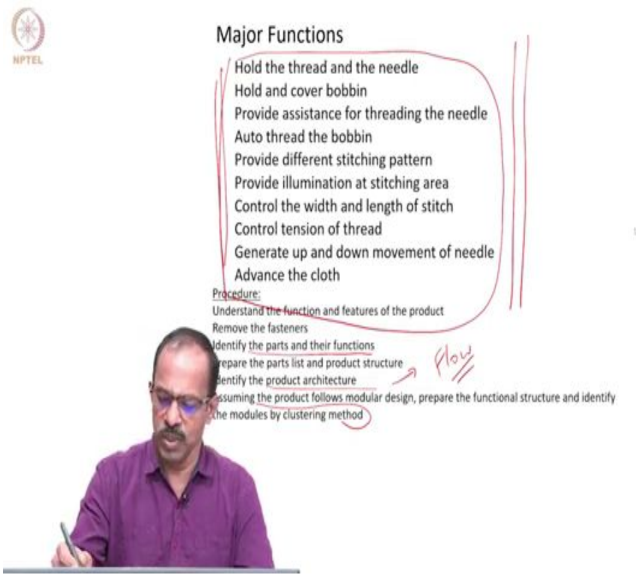
For that, you need to develop the decomposition chart and then identify the modules using the clustering method. So clustering method is a simplest form of identification module. So you develop the functional decomposition and then do the clustering method. So you can identify all the flow inputs and flow outputs. And then based on that, do the functional decomposition, and then cluster them to get the different modules. So this is what actually we will be doing in this exercise.

(Refer Slide Time: 03:57)

This is the sewing machine that you will be seeing in the exercise in the video, where the TA will be trying to explain to you the various parts and assemblies in the product. So it is again, a USHA make, and this is a Flora model.

As you can see here, there are different features for control and then I can see there are many knobs for controlling it. And then there is, inside there is a mechanisms for converting the motions, over two different kinds of motion. And there will be an electric motor which is attached to it which will be powering the whole system. And as the TA explains, you will be able to appreciate the complexity of various mechanisms used inside the sewing machine.

(Refer Slide Time: 04:51)



The major functions are given here. So though, you can say the single, if you want to say a single, so basically, to join clothes, that is basically we can say. We can join two pieces of cloth or any other material, suitable materials in order to develop a fabric or in order to develop a dress and other things.

But in order to achieve that, one, need to have many things. So you have to do many sub-functions like hold the thread and the needle, hold and cover the bobbin, provide assistance for threading the needle. So these are all the sub-functions needed within the product, just a few of them are listed here.

And then, we need to see how actually each part is contributing to providing these functions. So to understand that, what we will do, we will try to understand the all the parts inside and their function. If we look at each part and then see what function actually it is providing in the product. And then you prepare the architecture of the product.

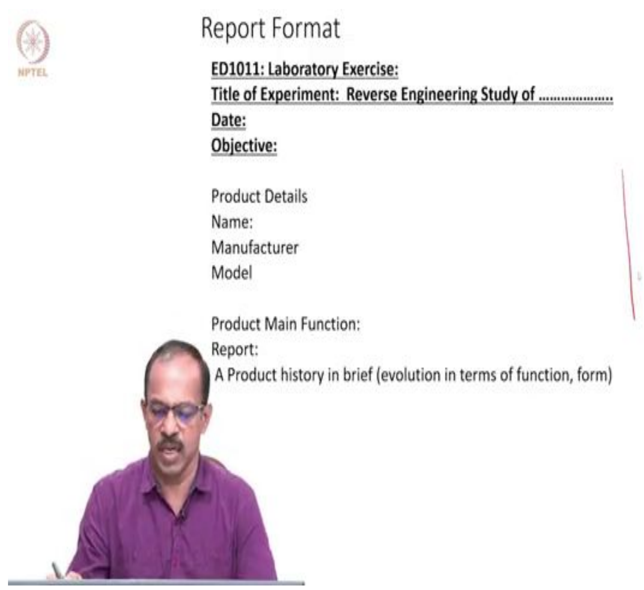
And once you do this, then you need to do, go for functional decomposition using the flow method and get the functional diagram or the structure, flow structure of the product. And using that, you try to identify the modules using the clustering method.

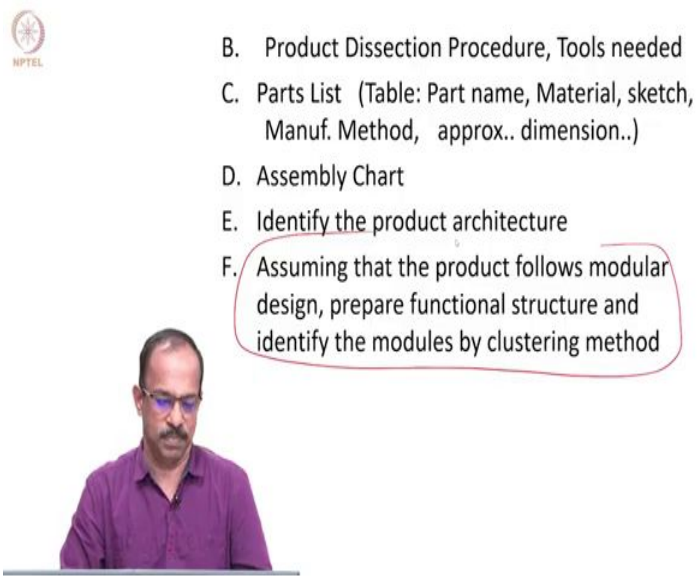
Go through the use of the clustering method and then identify the modules by clustering functions of similar nature or which actually share the common flow. So using that you try to cluster them and identify the module. So you would be able to identify different modules like a transmission module, or power supply module, or the thread management module, or thread control module. And that way you will be able to see different modules.

And then, if you want to have a different model, you can think of changing one of the modules to a different module, you will get a different kind of product. For example, you want to, there is a, say, thread to control module, which can actually use the… the distance between two nodes or the speed at which it is being done. So that actually is like thread control module.Now, if you want to change that into an electronic module, you will be able to make that in an electronic module and then replace this mechanical module with an electronic module. You will be getting a different product. So that is the way how we get different products by changing the modules. So that is where the modular architecture plays an important role.

The purpose here is to go through the different functions and then combine them into some groups and then put that as a module and the functions of that module will be clearly understood. And then, you can actually come up with a different concept for achieving that particular function in the module.

(Refer Slide Time: 07:45)





You have to go through this exercise and then do the module identification. So the report format is already given here, which is the same as almost the previous cases, except that you will be doing the product modular design; so identifying the modules in the product. That is what I actually expected in this exercise. So I hope you will enjoy this particular exercise because of the complexity of the product and its familiarity with most of you. Bye. All the best.

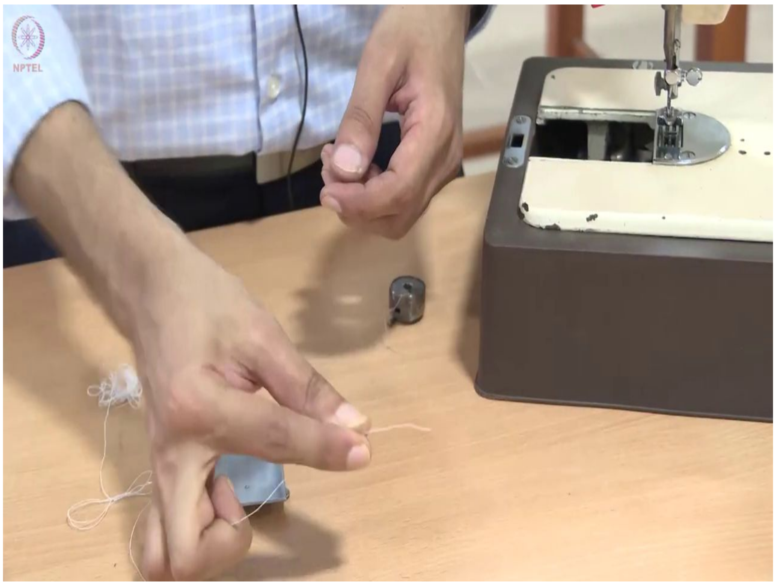
(Refer Slide Time: 08:20)

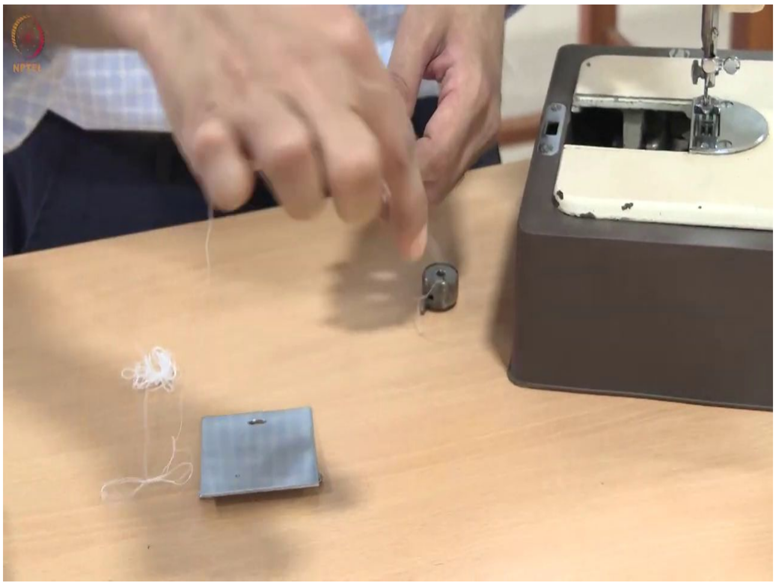
TA: Welcome, everyone. Today, we are going to look at very interesting machinery. So we will be looking at a sewing machine. Before I actually talk about the sewing machine, let me give you a very brief overview of the technology associated with it.

Sewing machine itself is actually a pretty old concept. So we do manual sewing. Right about in the year 1830, there was a Frenchman, a French tailor, who tried to automate the hand sewing. It was not an easy thing to do because to basically emulate the way in which we do stitching by our human hand to basically have a machine reproduce that movement has not been easy.

People in Europe, as well as in USA, have come up with various approaches to automate the sewing process in parts. So the very first sewing process, I mean, we can talk a, we can talk a lot about the types of stitches. One very old stitch is called a chain stitch, wherein you take a single piece of thread. Unfortunately, I do not have a needle to show you.

(Refer Slide Time: 09:36)





So you take a single piece of thread and then you keep looping it around with what we call as a bevelled needle. So we do that. That is called as a chain stitch. So that is one of the earliest forms of stitching.

(Refer Slide Time: 09:52)

Typically, if you look at a modern sewing machine, so this is, even though I call it modern, this is actually, this machine is about 25, 30 years old. So this machine uses what is called a lock stitch.

In case of a lock stitch, we basically need two spools. This one is actually placed at the bottom of the machine. And another one is at the top of the machine. Unfortunately, this is missing that. So imagine another bobbin here, at the top, another spool at the bottom. So basically, we have two threads that basically interleaf; like two sine waves crossing each other. So that is how stitches that you find in shirts and other clothing are made today. So to automate this process of sewing, we have multiple machinery. One of the most fundamental building blocks to realize such complicated machinery is a four-bar mechanism. So we have looked at the four-bar mechanism in the other session.

In the last session, where we looked at basically how we spoke about, a little bit about the path generation, a little bit about the function generation in case of a table fan. We looked at the oscillatory mechanism; basically it is a crank rocker mechanism. So similarly, we have a crank slider mechanism in this. So I will show you the details when we take apart the machine.

I encourage you to look at a term called coupler curve atlas. Please go to Google and look for a term called coupler curve atlas; coupler C O U P L E R C U R V E atlas. So when you look at it, basically I will add a link to this video. So you can go, basically, you can play around with the link links or the four-bar to get differently shaped curves.

This is very critical because such, because we call what is called a four-bar synthesis, we synthesize a mechanism for different path generation, different function generation, which is very critical for a machine such as this. So I will show you when we look at the individual sub-assemblies. So please look at coupler curve atlas, it is very important. So you can basically play around with the link links and then you can see how changing, for instance, the crank length changes the output of the curve; how do you address it.

Back in the day, people used to have a big book, a coupler curve atlas. So if you needed a specific path, you just go, look at a curve that you wanted, then once you identify the curve that you wanted, you can look at the L1, L2, L3, basically the link lengths. And then when you construct a mechanism, you will get that curve that you are looking for.

But modern days we have, today we have, C++ you can basically do, you can try to do loop closure equation, and then you can get any curve basically you want. So it is a slightly a little bit, I would not say involved, I mean you should know basically the procedure in getting that. So I encourage you to look at that.

So another building block is cam and follower. So the first building block that you have to keep in mind is for any sewing machine, it cannot be built without a four-bar mechanism, there are N number of four-bar mechanisms. And then there are cam and follower mechanisms. We will look at lobe cam, a single lobe cam; you can find it throughout this machine.

And then, of course, you have what is called as several gear trains. You have bevel gears, you have other kinds of gear trains, and I will take you around. And then, of course, you have different linkage assemblies that basically help in synchronizing the different movements of the machine.

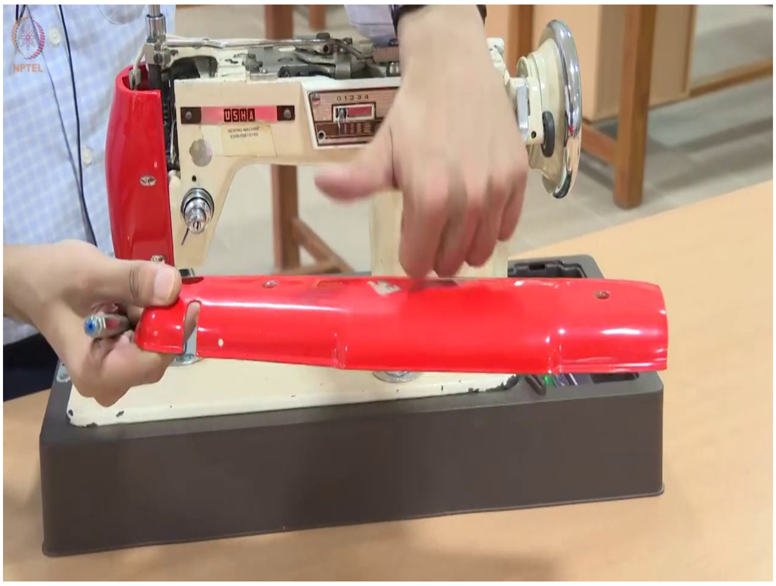
So one of the key things to keep in mind in a sewing machine is, all the mechanisms are driven from a single power source. So when you talk about the power source, olden days, people used to have what is called as a hand crank. So you have a crank that you have to rotate by hand, it was powered by hand. It was a little bit inconvenient because you have to feed the cloth with one hand and then coordinate the movement.

Then people went to what is called as a treadle, T R E A D L E; treadle. So basically, it is a foot-operated pedal that you might have seen tailors using it. So basically you have a foot-operated pedal. And then, you have another crank that basically converts this pedaling motion into rotary motion; basically the hand wheel.

Today, we have of course electric motors that basically power the machine. So there is no need for manually powering the machine. So you have a foot-operated, electronic foot-operated pedal; once you press that that powers the machinery.

Now, once I get, I mean I have a single power source, and then that power is split and then it powers various mechanisms. It feeds the thread feeding mechanism, it feeds what is called as the stitching mechanism, it feeds the cloth advancing mechanism, there are multiple mechanisms that are there that are all powered by a single power source. And they all have to work in synchrony; they have to work hand in hand. Even if there is a slight mismatch, the machine will start to malfunction. So it is a well-orchestrated mechanism. So we will go one by one.

(Refer Slide Time: 14:57)



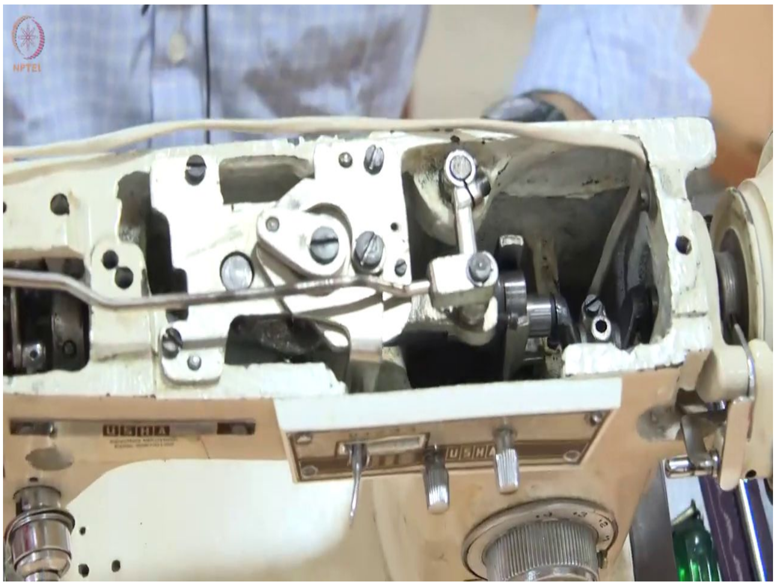
Let me start by dismantling the top cover. So let us first understand the machinery, overall machinery. So let us understand the overall machinery. So this is a very old model. You can see it is made of cast iron. It is pretty heavy, this machine weighs something like 10 kilograms, and it is pretty heavy to move around.

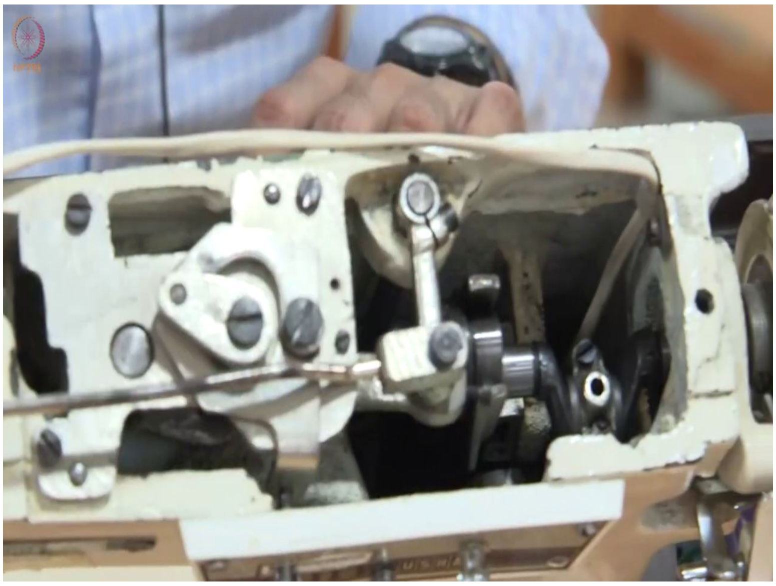
Modern machinery, you will have all the components that are typically injection molded. You can see this is sheet metal, so it is about, roughly about 1 mm thick sheet metal; pretty heavy by itself. This might weigh around 200, 300 grams; pretty heavy and it is again painted.

But the good thing about sheet metal is, even though it is heavy, it lasts your lifetime. Typically, injection-molded components typically have a life cycle of something like a decade and then you have to basically throw them away. So today, we live in a disposable society.

The advantage of an injection-molded system is it is very light, it is cheaper. But the problem is if you want it to last a lifetime, of course, it is not going to last a lifetime. These things, even though they are made of metal, they are heavy.

(Refer Slide Time: 16:03)



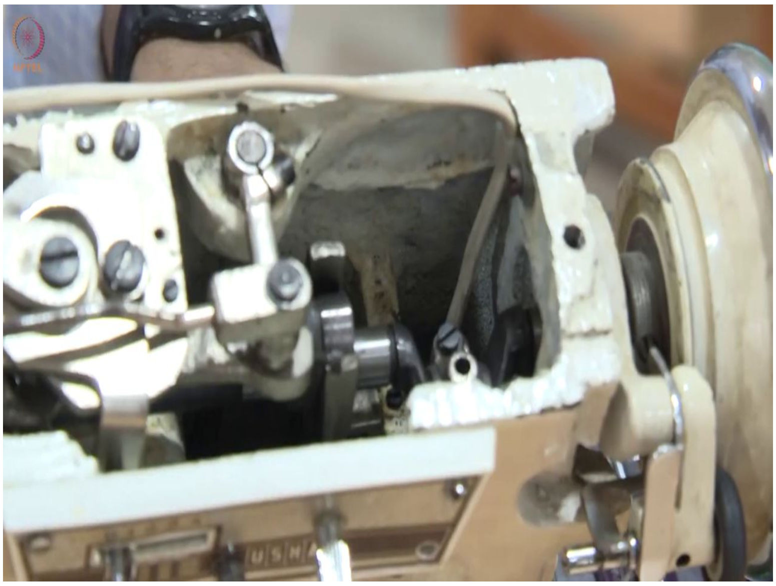


As you can see, the entire mechanism is robust because this has been dismantled something like 10, 15 times so far for our labs. But still, you can see it has most of its functionality intact. So that is the top cover to talk about it.

If you look inside, you can see basically, this is a cast component. The entire thing, it is a very thick-walled component. We call this the chassis, the entire thing, the entire body of the sewing machine, pretty heavy. Even though the outside is smooth, the inside surfaces are rough; if you pay attention to the inside surfaces.

The reason is when they cast it; they put in what is called as a core, sand core. So since functionally, this does not help to basically improve the surface finish, to keep cost low, typically what they do in manufacturing is they do not care about the internal surface finish, because the customer is not going to see this.

(Refer Slide Time: 17:04)



This machinery basically, it is going to be covered, so this is all the customer sees. The outside is well-finished, so it is, it looks good. But then once you take it apart, the insides may look basically not so good. You can see the surfaces are pretty rough but it does not matter. Functionally, it is not going to affect anything.

(Refer Slide Time: 17:27)

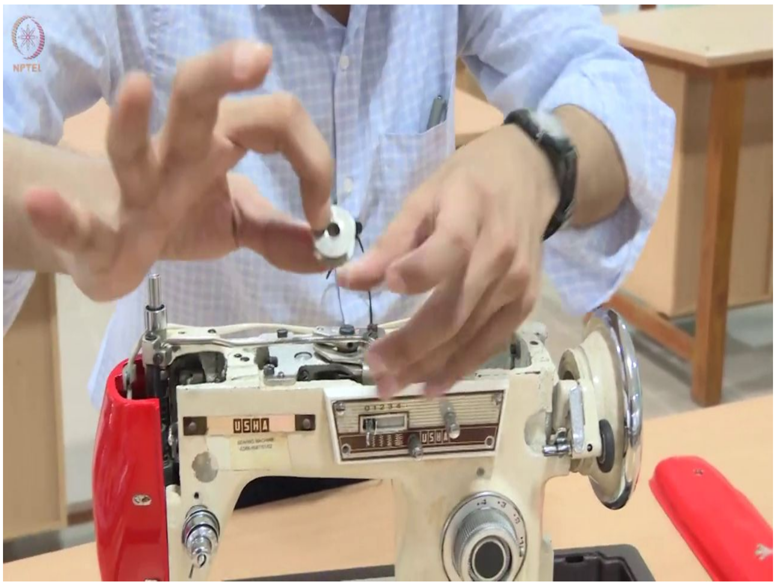
This machine is powered by an external motor. So this machine is powered by an external motor. You can see there is a groove here, so you will have typically another belt running. And then you will have, this machine basically will be bolted onto a table, and then you have an electric motor that is connected to this hand-wheel here. You have a pulley groove here. So you have a belt basically, that powers this mission. The motor is not an integral part of this machine. So since it is 30 years old, the motor is externally placed. Modern machines have them internally as part of their machinery. So once, now, I am rotating my hand, you can imagine there will be a separate motor that drives this through a belt.

(Refer Slide Time: 18:10)

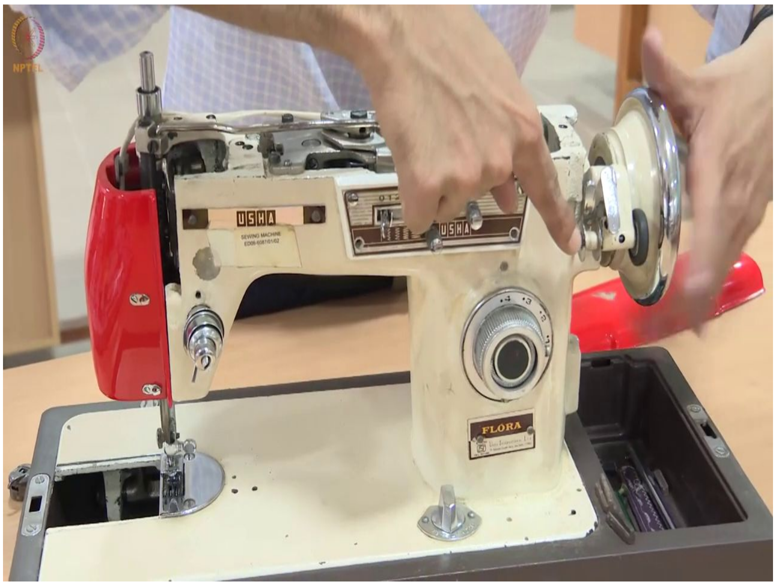
There is another mechanism here; this separate mechanism. So this basically helps, so this is one spool, so this spool goes to the inside part of the machinery. So this bobbin we call it, this bobbin goes inside. So this bobbin basically goes inside.

We have a threaded spool like this, there are two of these. Remember, sewing machine is going to be doing what is called as a lock stitch. So you need two such spools, one spool will be sitting on top; now, other spool is going to be at the bottom of the machine. So imagine threading this by hand. So I need to take a threaded bobbin and then have to manually spool it. So to speed it up what we do, we basically put it here, attach it here.

(Refer Slide Time: 19:01)


USHA
01234

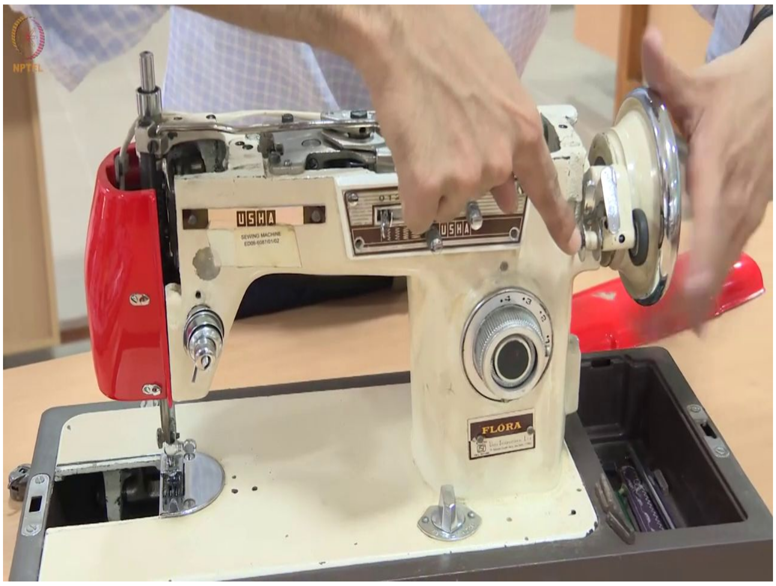

01234
USHA


USHA
USHA
FLORA

If you see here, if you look through, I do not know if it is clear on camera, there is a small spring-loaded Flexure inside. Sorry. So if you see here, so if you see here, there is a small spring here, I hope it is visible. So I am pointing it to, pointing into the camera. This can compress. So this can deflect inside because once you engage this, so once I rotate this, you can see this, this engages the rubber roller, and then it rotates this spindle. You can see it is it is rotating. So what we do is we take the spool, and then there is a notch in the spool if you see carefully.

You see here, there is a notch here. So when you load it, you have to make sure the notch and this aligns. You press it, and then now, this spool becomes an integral part of the spindle. So when I rotate it along with this, this rotates.

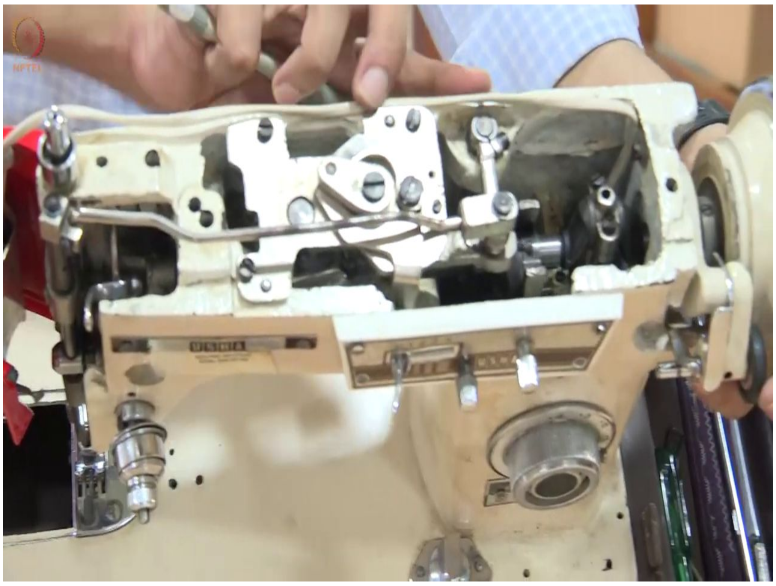
(Refer Slide Time: 20:12)



Imagine, on top, I have another thread supply; I have an external threaded bobbin. So I take it and then I feed it here. So what happens this starts once a power the machine. So basically, you can see it is rotating the spool, and it will start winding this spool.

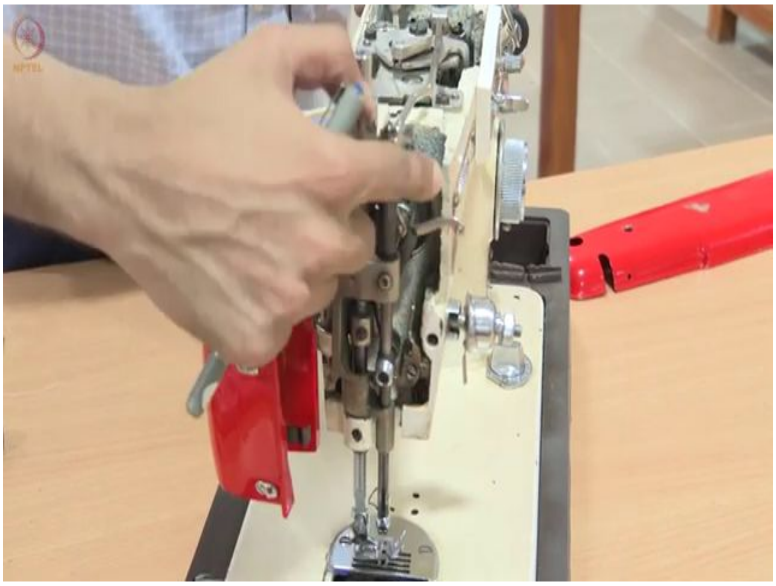
Now, we have a very fast way to load the spool. So this part of the machine helps us to quickly thread the spool. So once we do that, we have to do it for the top part of the spool and the bottom. So both spools have to be wound using this, this mechanism here.

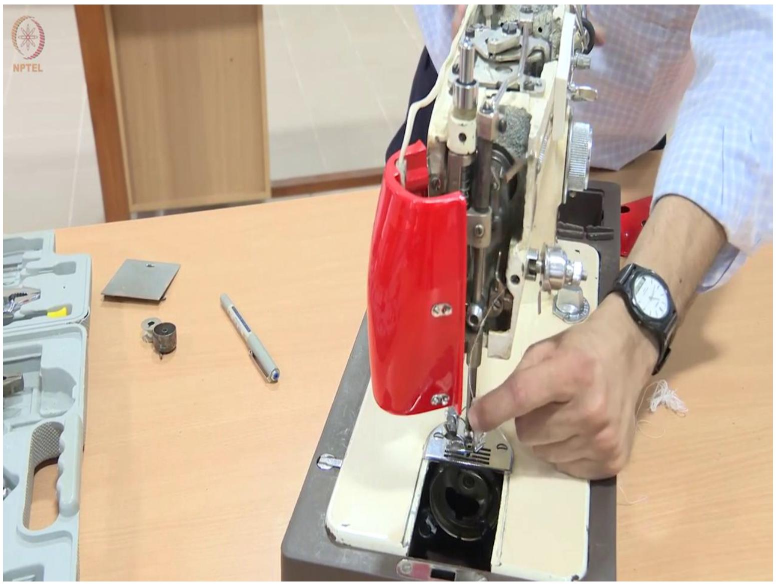
(Refer Slide Time: 20:52)



Now, let us proceed with the other parts of the machine, sewing machine. So we have other knobs here. There are various knobs that you see here. Different parts of the mechanism will be affected. For instance, this is where the needle will be placed. Just imagine a needle here. So you can see that this particular component goes up and down, basically. And it is connected to a series of linkages to the main spindle here. Let me just tilt it, so that you will get a better view. So your hand-wheel is powered by an electric motor; you have a common shaft that you see here, that powers various mechanisms. And the same mechanism basically, if you see here, also powers another crank that you see here that basically drives the needle up and down. And then you see there is another member here that does a very complicated motion.

(Refer Slide Time: 22:13)

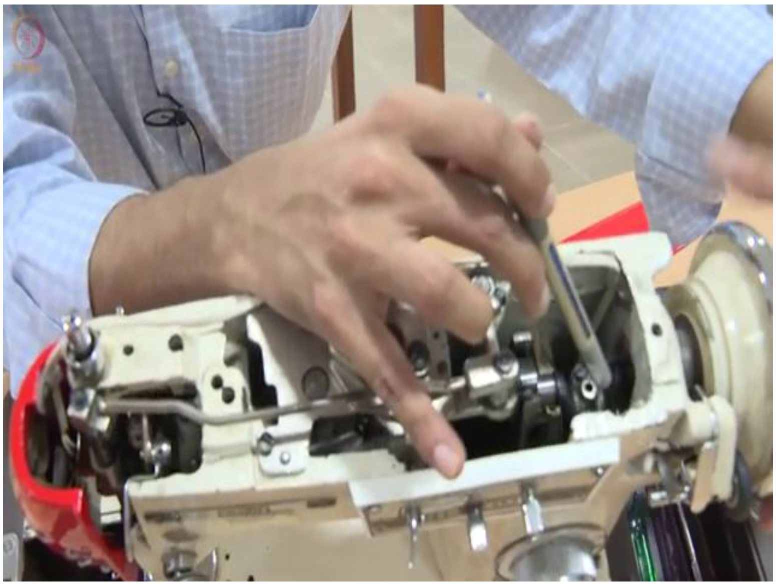


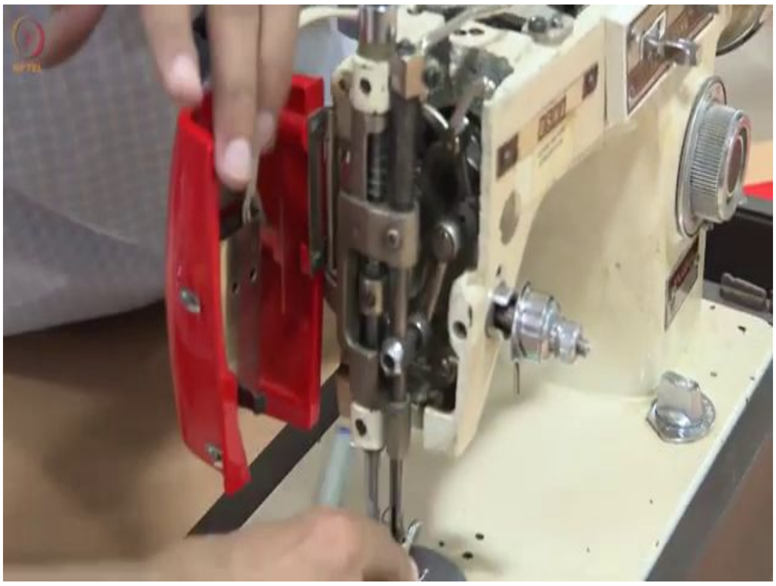


So basically what we will do is during threading, so it is called threading the machinery. So it is quite an elaborate procedure. If you have a sewing machine at home, I encourage you to please explore it on your own. So you thread it like this.

The reason why we have this lever here is that you can see. This is how it will be operating when we are stitching. There is a reason this lever plays a very critical role, I will explain in the latter part of the presentation.

(Refer Slide Time: 22:55)



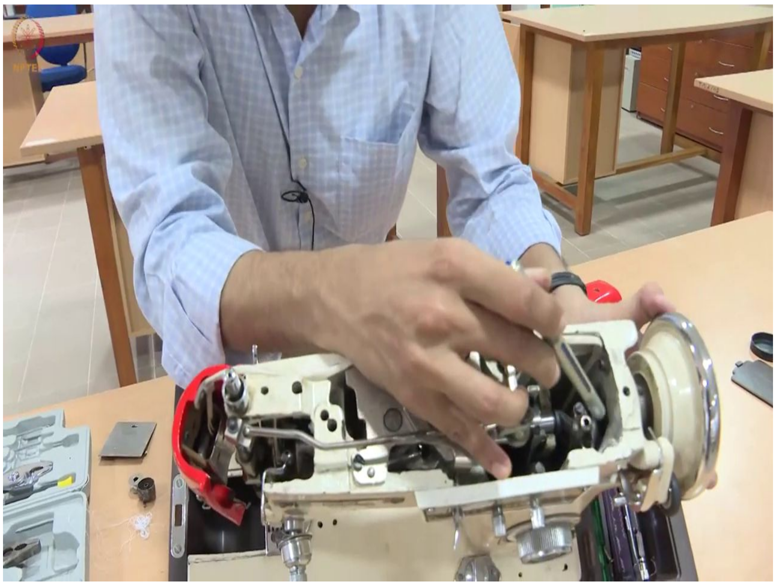


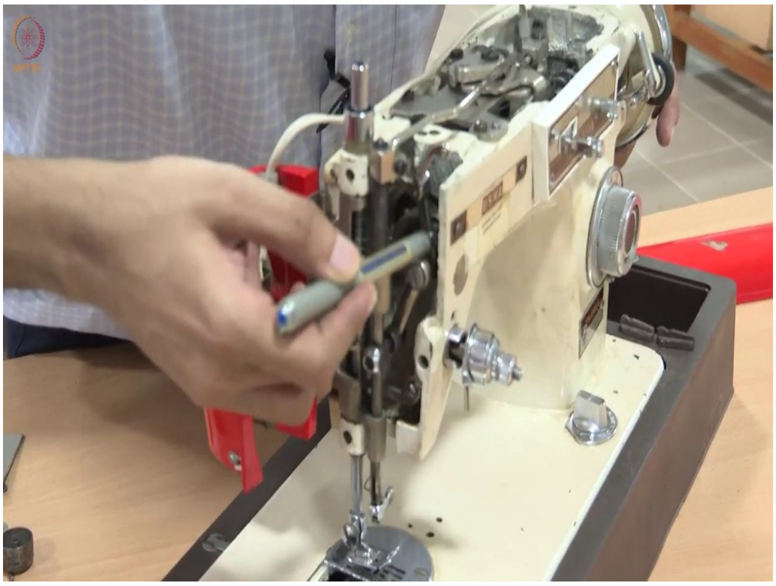
Now let us go one by one. We have what is called as a crankshaft. This is called as a crankshaft. You can see this is a common shaft and this is called as a crankshaft. If you look at any internal combustion engine, it has a four-bar mechanism; it has what is called as a crank slider. In this case, it is flipped.

In the case of an internal combustion engine, we have a piston that drives the crank. In the case of this machine, we have the crank that drives the sliding member. In other words, we have a crank slider mechanism. So you can have the slider as the input and crank as the output, or you can have the crank as the input and slider as the output. But there is a catch.

It is always preferable to have the crank as the input and have the slider as the output. The reason being we have what is called as a toggle point. I encourage you to explore what is called as a toggling point.

(Refer Slide Time: 24:08)





What is crank? Basically, you have a shaft. Imagine a cylindrical shaft like this. What do you call it, what is called as a crankshaft? Let us look at the English meaning, crank. We say, a cranky person; a person is not normal; something wrong with them mentally.

So a crankshaft is not a normal shaft, it is a little bit cranky; it is a little bit bent out of shape. If you look at this, this shaft is bent like this. It creates a rotary motion such that this part goes up and down. We call this the crank and then we have what is called as the connecting rod. So which is this part is called the connecting rod.

I will show you the bottom where the connecting rod connects to a slider. This helps in converting a rotary motion into a linear up and down motion. Similarly, you have another crank here. So this is another crank. There are actually two cranks in this case that are offset.

You have another crank and then you have the sliding mechanism. So you can see I can actually back-drive the mechanism. But then see, now, this is called the singularity. So I can comfortably drive the mechanism, that is, if I keep the crank as the input, I can keep driving this slider part easily.

Any time when they become all in line, I cannot basically give the input and get the output because the force that I apply and the crank, they are all aligned in a single straight line. So since I do not have any lever, that is any, what you say, I cannot produce a torque. Basically, the mechanism is said to be in a state of singularity or it is said to be in a state of toggle point.

Typically, in an internal combustion engine, how we overcome is we have a flywheel basically, that has what is called as a biasing. It has a certain amount of inertia basically, that helps to basically keep the crank running in a certain direction such that, when you go through the singularity, the momentum, the inertia of the system takes it through the singularity.

Whenever you have the crank part of the mechanism in a four-bar as the input, you have to have some sort of a massive flywheel that gives you a lot of inertia to the system, basically the momentum of the system as when it is running. So it takes it through the toggle point such that my input does not have to even when it is aligned, I need another source of torque to make it pass through the singularity point.

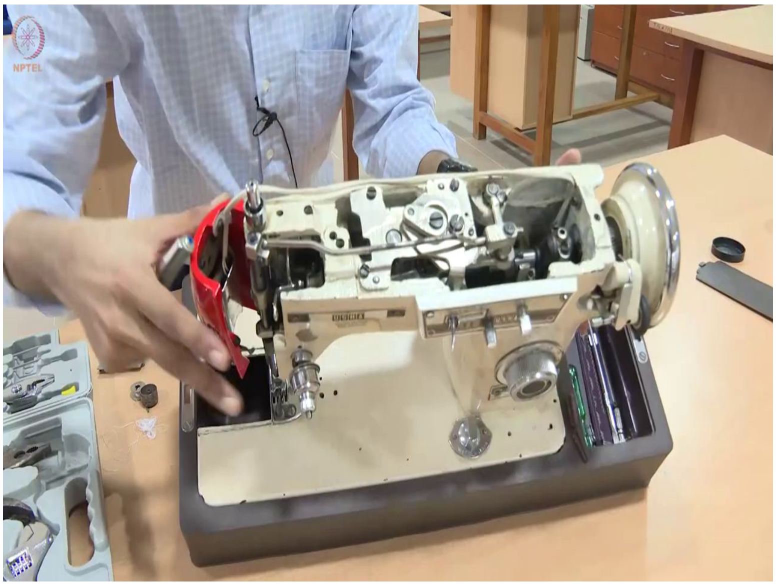
In the case of a sewing machine, we do not have that problem. Just as a heads up, I am just telling you. So when you look at machinery, how do you break it down? So we are looking at primitives. So this entire mechanism, when you look at it for the first time, it might look overwhelming. The way to approach any complicated machinery is to break them into what we call primitives.

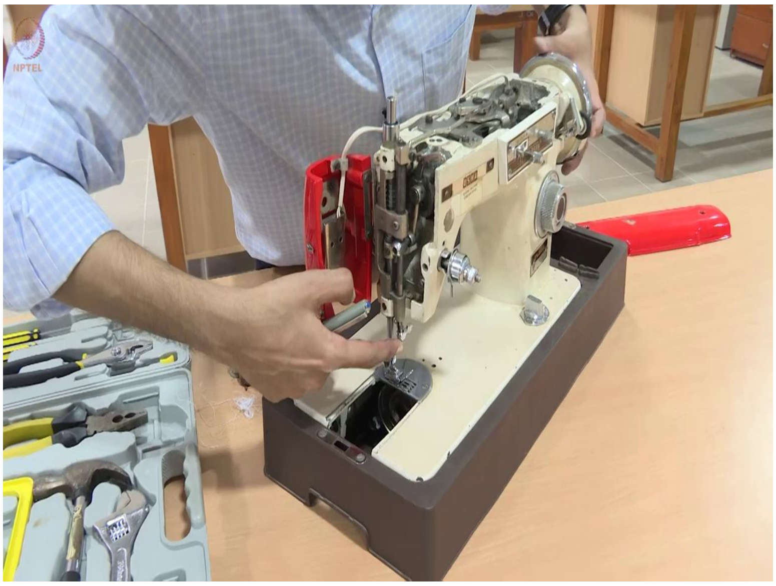
You look at them; look at it from the standpoint of a crank slider. Any mechanism because it is always going to be a rotary input. Typically, we will have back and forth motion, or we will have some other oscillatory motion, we will have a lever that basically rocks. You will have different kinds of motion. Typically, I can assure you any mechanism that uses a rotary input, it is going to have a crank somewhere in the mechanism.

Also, when you have, when you need complicated motion, such as in the case of a sewing machine, invariably, you will always have a cam-follower mechanism. So we will also look at the cam-follower mechanism. And you can, of course, there are going to be other, certain other kinds of a mechanism called as five-bar, six-bar, it is an extension of a four-bar.

But typically, any complicated mechanisms, if you really look into the, from a functional standpoint, look at it; you can break them into primitives, and then you can systematically study the mechanisms. So that is what we are doing here.

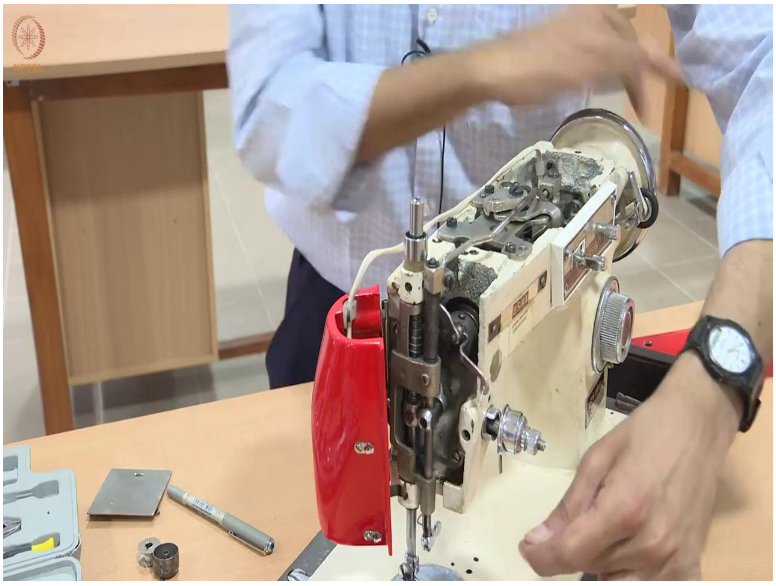
(Refer Slide Time: 28:28)





So far, what we have seen? Let us have a quick recap. So we have seen, we have a single hand-wheel that basically powers something. So I have not shown you what this is powering. The same shaft also powers another crank that drives the needle up and down. Let us now focus our attention to this lever that is going through a complicated motion. Why is this needed?

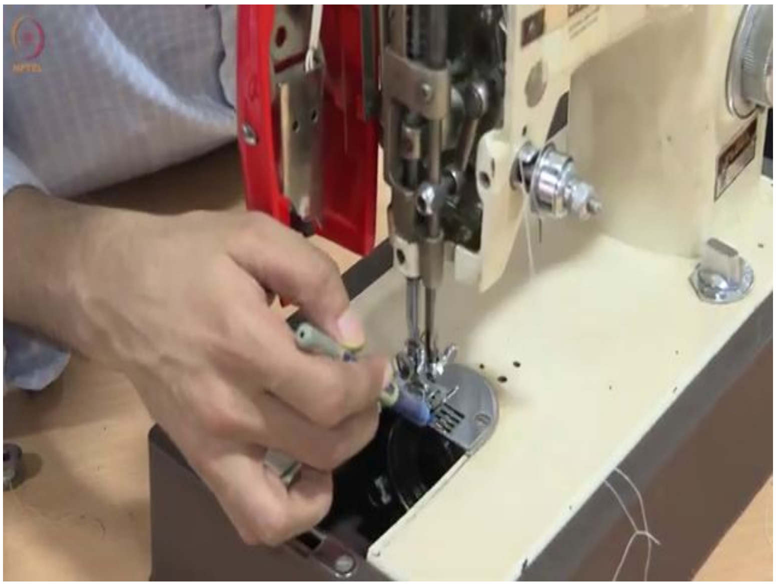
(Refer Slide Time: 28:56)



As I said, in the case of a lock stitch, you have two threads; so one thread is basically fed through this mechanism. So one thread is fed through this mechanism and another one sits at the bottom of the mechanism.

Like two sine waves that overlap, imagine two out-of-phase sine waves. One is going this way, the other one is going the other way; two out-of-phase sine wave. So those sine waves are, basically, you can look at these threads as two sine waves that are out-of-phase. So the top one is fed by all the mechanisms on the top, and the bottom one is fed by the spool that is at the bottom.

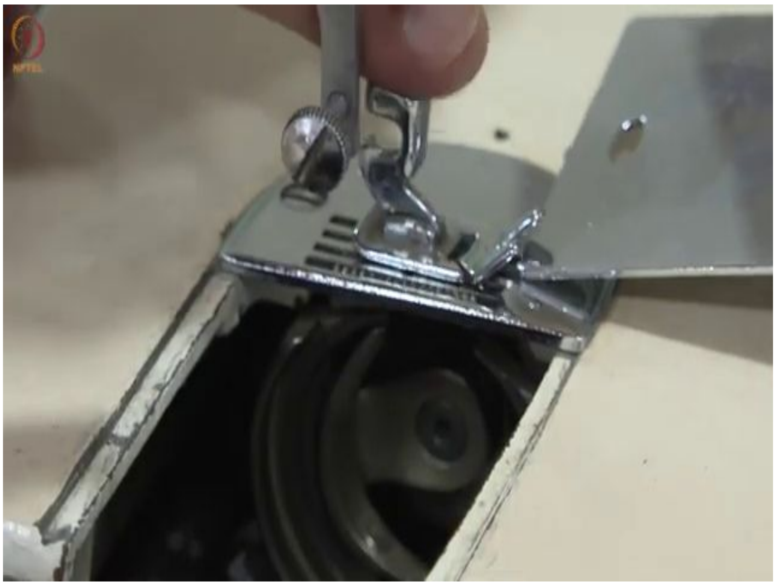
(Refer Slide Time: 29:50)

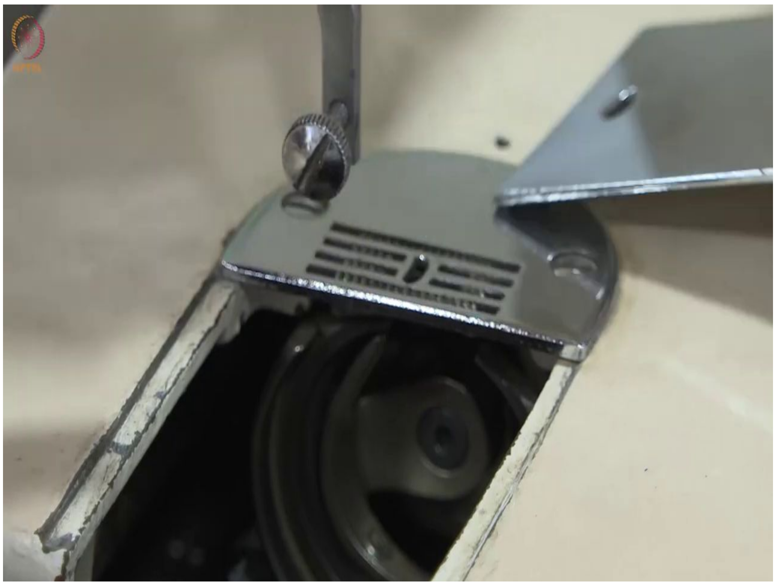


The reason that this lever exists is because this is what is called as the cloth feeding mechanisms. So if you look at this, this is what we call as a cloth feeding mechanism. So basically let me just, so if you look at this. Focus here.

If you look here you can see this serrated piece moves back and forth. This is powered through complicated linkages assembly so we will take a look at it. For now, pay attention only to the movement.

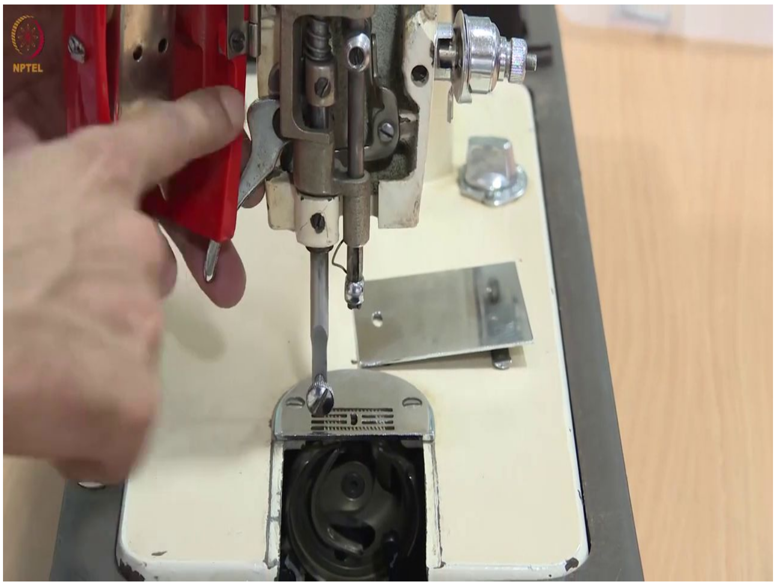
(Refer Slide Time: 30:52)

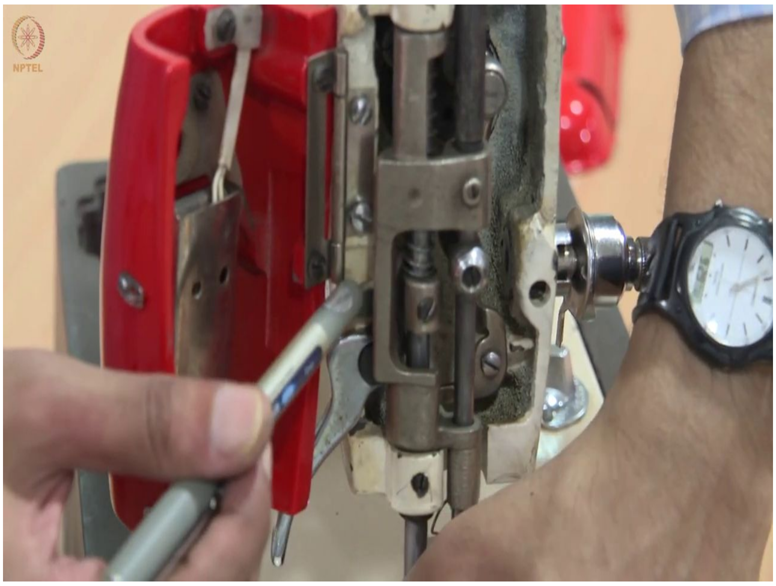


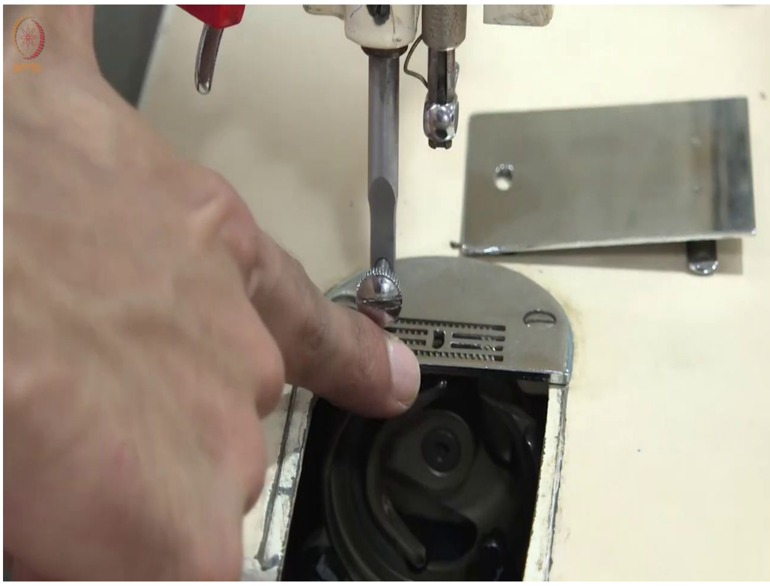


When you feed a cloth, this is how you will feed a cloth. So this is how you will feed a cloth. This puts a pressure so you have another lever here that moves this shoe basically that rests on top of the cloth and put some pressure. So this is another mechanism. If you look at it, I do not know if it is clearly visible on camera.

(Refer Slide Time: 31:31)







This is a cam. If you see here, this is a simple cam. So this moves, this entire thing is spring-loaded, as you can see. You can see this is the follower. So this is the follower. So this is the follower that you see. When you want to disengage it, all you do is you press this lever that moves, that moves this up and down. So this is a very simple mechanism that basically helps in, basically move the shoe; move the shoe up and down. So that puts pressure on the cloth.

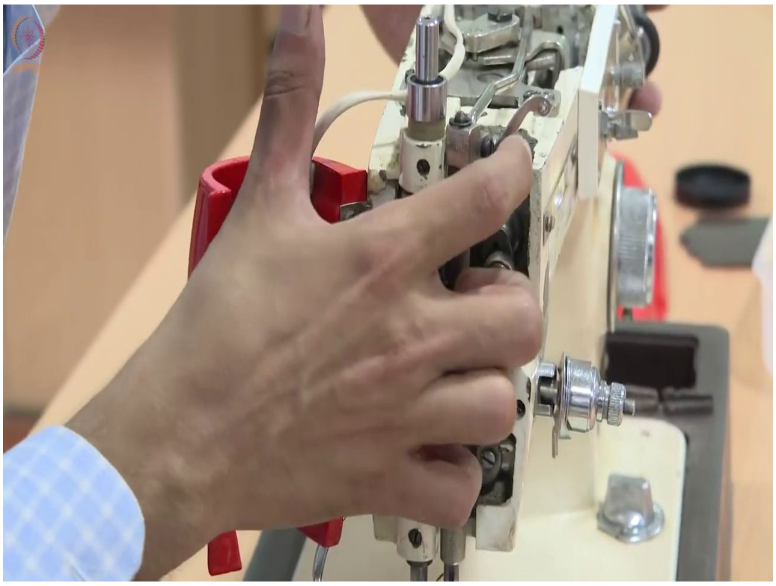
The reason why we have this mechanism is. The reason why we have this mechanism is when it is stitching; you need to advance the cloth at a specified rate. This is what we call as a pitch, the distance between two consecutive insertion points of the needle.

In other words, the nodes. If you look at a sine wave, it is the zero point; the nodes of the sine wave. So basically that advancing is done automatically because you do not have to feed in the cloth is pulled by the machine inside.

(Refer Slide Time: 33:15)

So if you pay attention, you have what are called the serrations. These are called serration, S E R R A T I O N; serration. These, what we call this saw tooth pattern, this zigzag pattern helps in, and it adds a layer of roughness to the component that you see here. These serrations basically help in latch on to the cloth and then pull it inward. So they help in advancing the cloth little by little. By using various knobs here, we can change their advancing length. In other words, we can change the pitch.

(Refer Slide Time: 34:30)



So far what we have seen is we have looked at the crank slider, we have looked at another crank slider that moves the needle up and down. We have another crank that basically drives this lever.

Now, I have not told you what the purpose of this lever is. The purpose of this lever basically is since you are advancing the cloth, this has to feed a certain specified amount of thread. If the thread is too taut, it will break, if it too much tension, if I simply put the thread on a spool, and if I feed it into the needle, it needs a little bit of tension in the string.

Something has to offer some amount of resistance, yet at the same time, the resistance should not be so much such that if it is too much pulling force is applied by the thread feeding mechanism, the thread will break.

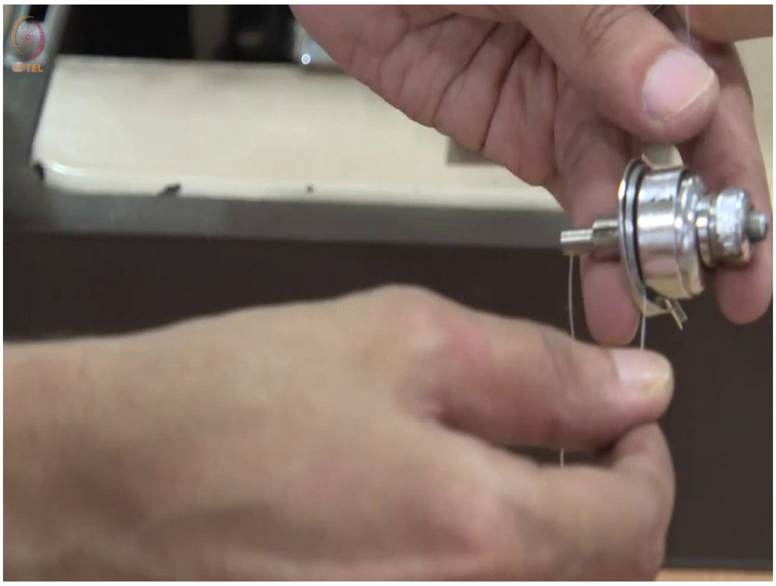
You can understand there is a fine, what to say, the system is calibrated such that the tension in the string is always maintained within a certain specified level. So which means you have to basically advance the thread at a specified rate, depending on the pitch that the user sets.

(Refer Slide Time: 35:42)

And the tension can be regulated by the screw here. So when I spool the, when I first thread it, I will put it through this and through the lever. So the thread will, so let me just show you quickly.

So now, we have the bobbin sitting at the top. Now, this will be fed through this, and then it will be fed through another lever here, it is missing here. So it will be fed to another lever here. So here and then it will go to the needle.

(Refer Slide Time: 36:20)



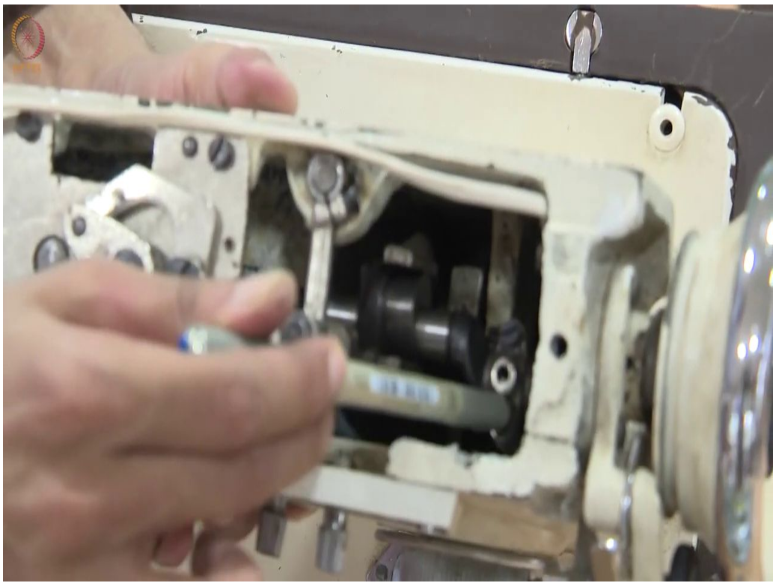
The reason why we have this is, so there will be spring here. So basically, when I tighten this, it puts, what is called as a clamping. So you can see here as a thread gets wedged between these two plates here. So this is how it is wedged. As the thread gets wedged, when I tighten this, it puts… it increases the clamping force, which means it will basically increase the tension on the thread.

If you put too much tightening force here, the thread basically will break. If it is too little, again, there will be slack, and the stitching will be too loose. So basically, there will be a small chart, depending on the thickness of the cloth you are stitching, and the type of thread that you are using. Basically, you will have to refer to that, and then you will have to set it.

So you have these graduations here you can see. Like a clock, it is labeled here; 0 1 2 3 4 up to 9. So at the top, you can see minus plus. So if I go this way, I reduce. I do not know if it is visible on the camera. So there is a minus symbol here and a plus symbol. So if we go clockwise, I am increasing the tension. If I go counter-clockwise, I am reducing the tension on the thread. So that covers the thread feeding part the top part of the mechanism.

Let us look at the bottom part of the mechanism. This is where all the much more interesting mechanisms lie. So you saw basically at the top we saw, remember the very first mechanism I showed you there is a crank there. So in this case, it is not a crank slider, it is a crank rocker.

(Refer Slide Time: 38:06)



So that connecting rod that you saw. It is this connecting rod. So this connects here. So this connecting rod here; so this connecting rod here, so this is the connecting rod that I am pointing out. So this is the connecting rod I am pointing out, this is the bottom part of it.

This is the bottom part of it, you can see this oscillates another shaft here. I will just briefly go through the mechanism without going in-depth because very elaborate treatment takes time.

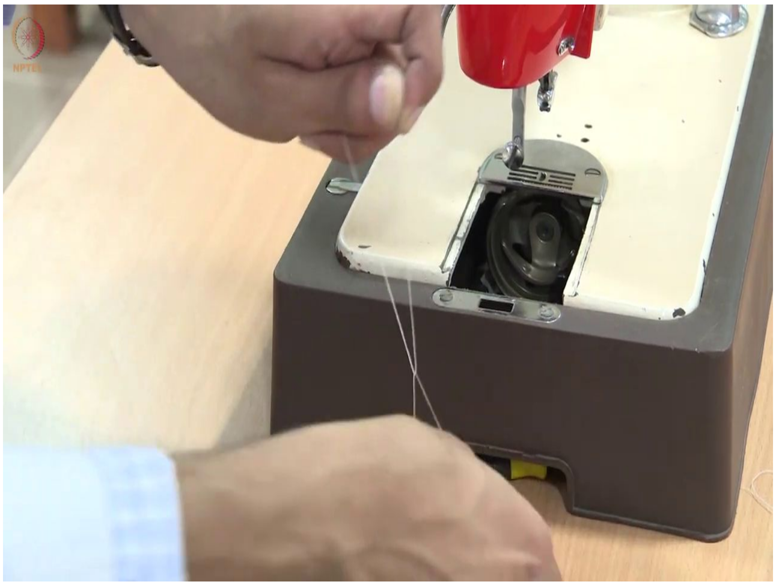
(Refer Slide Time: 38:49)

You can see this shaft, this bottom part basically oscillates. How does that get that oscillatory motion? So this is connected to a shaft here. And where does that shaft connects? It is connected to another crankshaft here. It is connected to another crankshaft here. So this shaft, it is connected to another crank.

(Refer Slide Time: 39:13)

You have a slotted lever, so this mechanism is called a slotted lever mechanism. So you can see, so basically we have turned a rotary motion. Using a crank, we have turned it into an oscillatory motion that drives basically another slotted lever. And there is a sliding block that is connected to another crank that gives you an oscillatory motion.

(Refer Slide Time: 39:40)



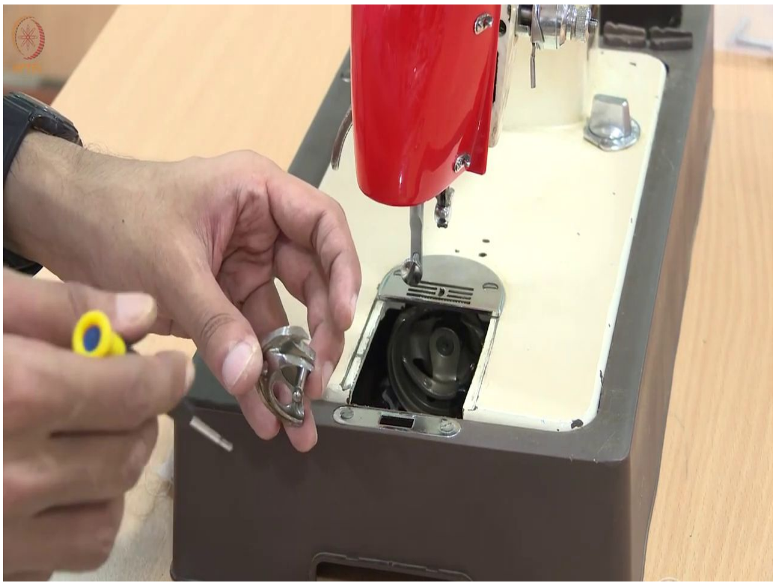
The reason why you have such complicated machinery is you have to basically, so this is the bottom part of the mechanism that basically synchronizes the movement. For instance, imagine this is the needle. So a needle is connected here to this lever. So when the mechanism goes up and down, it goes up sorry, when the mechanism rotates, it goes up and down.

So this goes and punctures the cloth. Remember, the needle has an eye-hole at the tip of the needle. So what happens? So you have the thread that goes through. So basically needle punctures, and then this goes through the cloth. Now, you have a loop. So basically, you have a loop.

So as the needle punctures, it makes a loop through the cloth. Now, you have another, you need another thread that goes through the loop. See, even doing it by hand, imagine how I mean, you can see how difficult this is, doing it by two hands basically. So now, we have a lock stitch. So this is what we call a lock stitch.

The thread that I am holding by the left hand is fed by the top part of the mechanism, the thread that I am holding at the right hand is fed by the bottom part of the mechanism. So you have two locking threads. So you can see how difficult it is to automate this process.

(Refer Slide Time: 41:04)

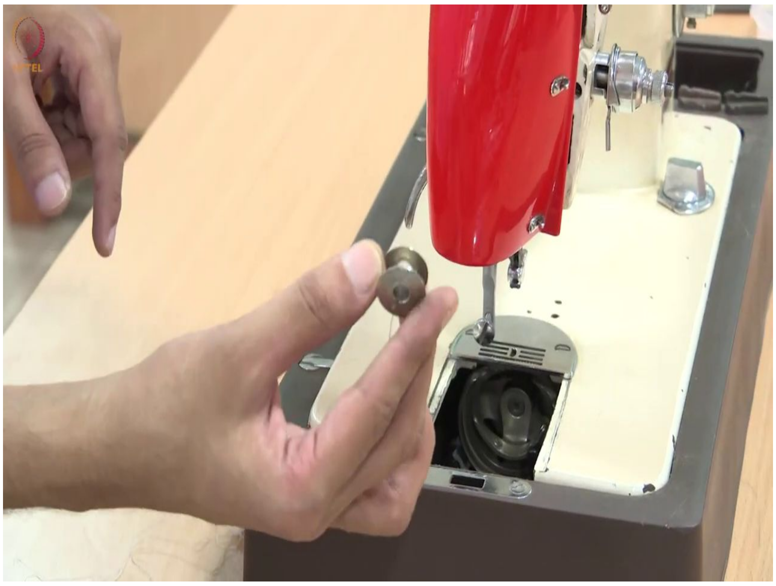


What happens is when this creates a loop, you can see it is quite sharp. And then you can see there is a slot here. So needle goes through this. So I will show you the, how to spool this spindle here. This basically takes the thread, it comes like this. So when it goes through this that entangles the thread.

I will put an animation of this as a reference to this video. So basically, that shows how the threading is done. So I encourage you to visit the link that I provided as a supplementary to this video. So please take a look at that because it is quite difficult for me to explain by words. You have to see the animation to fully appreciate it.

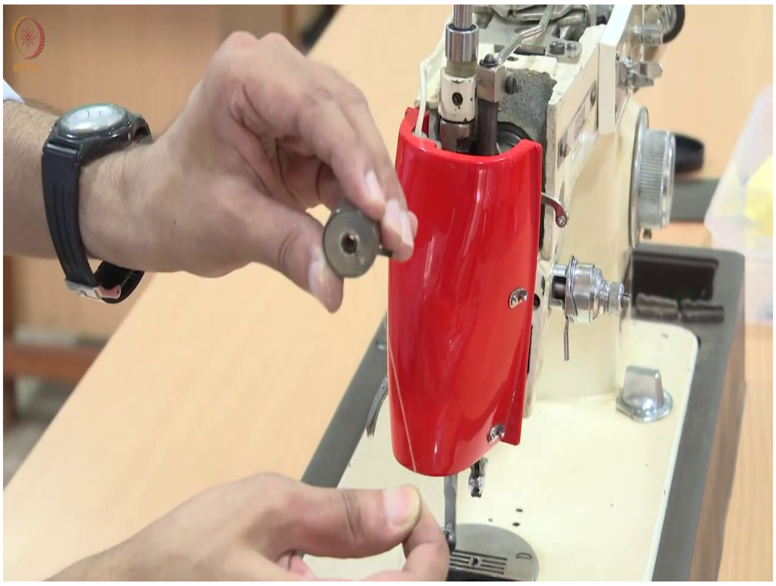
But keep in mind, just remember, the thread is basically taken by this oscillatory mechanism here that basically loops, the bottom part of the thread. And then once it looks it comes back then as the cloth advances, it continues doing that. You will only fully understand when you watch the whole animation, please watch it.

(Refer Slide Time: 41:20)



Now, how do we regulate tension at the bottom part of the spool? So remember, we basically spool this bobbin using this mechanism. Once it is spooled, we put it inside this housing here. Again, we have a tension regulatory mechanism. So if I simply put it, if I pull it, you can see there is no resistance, it is simply rolling off.

(Refer Slide Time: 42:45)

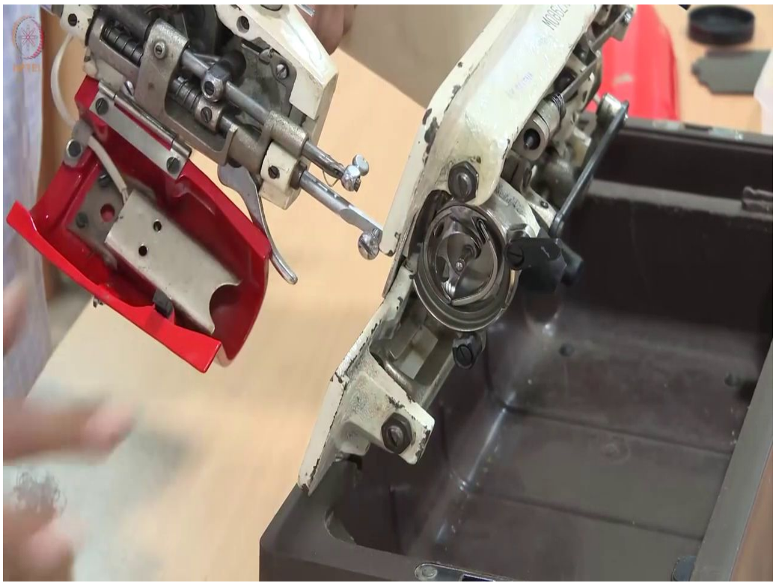


So how do we regulate tension? We have another spring here, a pre-loaded spring. So how you load it, I hope it is visible on the camera. So you take a certain free portion of the thread and then you pass it underneath this spring.

Once you do that, now you see I have some tension. Now, it just will note, even actually let it hang, it will not come out. Because this spring the same way how this puts a certain amount of pressure on the thread, there is a certain preset amount of tension that the spring has that exerts a force and that controls. Because remember, the top part of the thread basically pulls this thread.

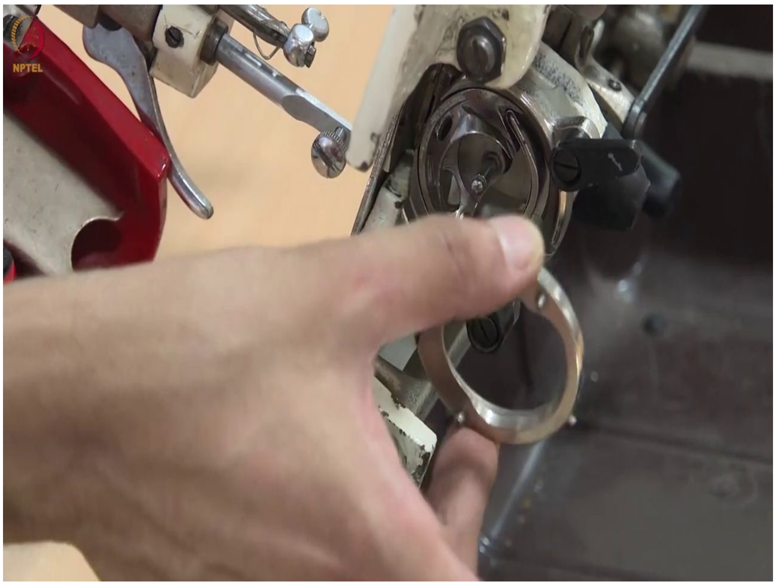
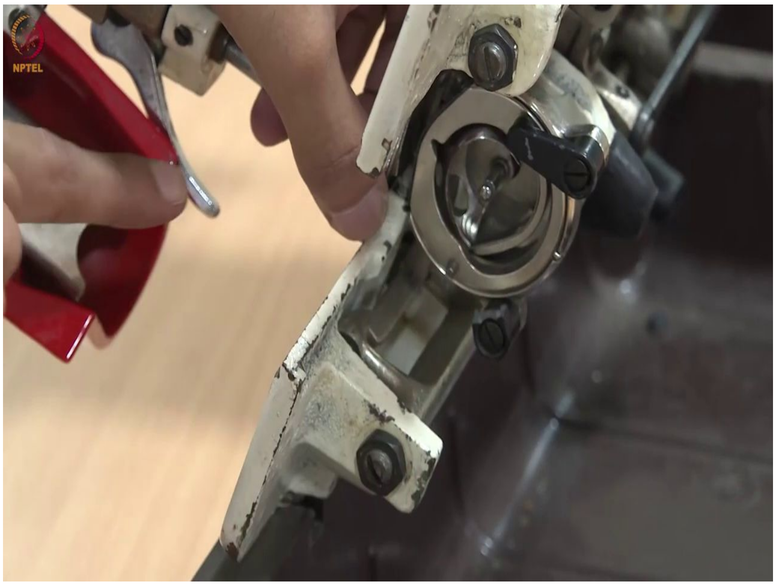
There has to be some resistance; there has to be just enough resistance such that all of the spool does not wind and unwind at once, but winds, unwinds just enough to feed a little bit of thread that is needed to perform that part of the stitching. So this puts this gives you a frictional torque. We call this frictional torque. Let me just show you how this is assembled at the bottom.

(Refer Slide Time: 44:02)



This goes inside like this. We remove this lever, one is broken. Now, in this construction, some machines will have it in this way, some machine, Singer, will have this entire bobbin facing this way, that is, 90 degrees; this entire mechanism will be rotated 90 degrees. So that depends on the manufacturer.

(Refer Slide Time: 44:25)

Once you load the spool, and then you load it as I said, you put it inside like so. So basically, you put this, and then you have another ring, this component, so pay attention to the orientation, it is direction since you cannot put it in any fashion.

In this mechanism, this projection basically has to go into this notch. And once you do that, you basically lock it in place. So it is difficult for me to do it all at once. So you lock it like that. There will be another lever that comes from the other way and locks it. So now you have this securely. So I will just show you once again the oscillatory mechanism, you can see this oscillates. We can see this needle basically it is synchronized.

And you can also see this mechanism; the cloth advancing mechanism is again powered by a separate oscillatory mechanism that helps in advancing the cloth forward as the machine is stitching. Another thing worth paying attention to is this. So let me just dismantle this for a second.

(Refer Slide Time: 46:15)

Once you put the spool, once you thread it in place. So this will be like this inside. And then all you have to do is put it and then press it. Now, this locks in place. How do you remove this? Basically how to pull this lever and then take this out.

How does this work? Pulling a lever, I hope it is visible in the camera. The hole should be seen. Is it seen? So please pay attention to the hole. So please pay attention to the hole. So once I pull this lever, you can see a slide that moves up and down. You can see a slide that goes up and down. You can see a slide that goes up and down.

This slide basically engages, if you see here, there is a groove on the shaft, there is a groove on the shaft. On the top part of the shaft is crowned, we call this crowning. So it is a smooth surface. So we have a shaft, there is a groove on the shaft, on the top of this shaft is crown. So when we assemble this, what happens is please pay attention to the lever.

(Refer Slide Time: 47:49)

I will do it slowly for you. So you will basically hear a click. I hope you heard the click. The reason why you hear this click sound is once this is when it is assembled. Pay attention to this part of the slide here. So I will do it as slowly as I can. So that basically moves up and then, when it comes down because it is spring-loaded, it hits the shaft and that is what creates the clicking noise.

You can hold the spool in place. And if you observe carefully, all the surfaces here are polished to a mirror finished. So we call this mirror finish. So the surface roughness is very, very low. The reason is, all these surfaces come in contact with thread. So if there are any rough surfaces like we saw in the casting before, that will basically catch the thread and it will break it. So you can see all the surfaces even though this is rusted, if you look at a new machine, you will have what is called as a mirror finish.

Anywhere that the thread comes in contact with, the surface is made mirror; sorry, anywhere that the thread comes in contact with, the surface is polished to a very fine degree such that the thread can gently slide over it without breaking. So please keep that in mind. So basically, that covers the bottom part of the mechanism.

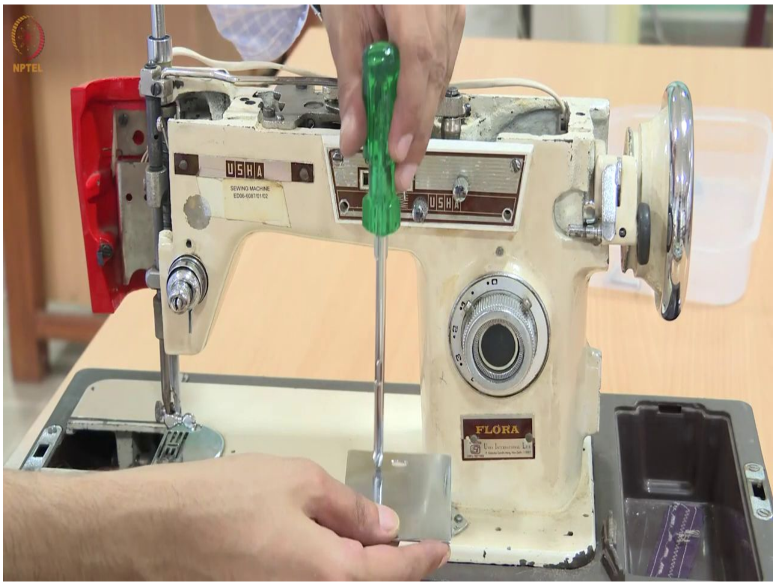
Now, let us explore the top part of the mechanism. So basically, this will conclude the entire machine. I will only remove the top part of the mechanism. So you get to see the cams and other interesting mechanisms inside. So let me quickly dismantle that.

(Refer Slide Time: 49:36)

Before that, let me quickly talk about these levers. You can see, please pay attention to the movement of the lever here. So it only goes up and down. So here we see. So this is a straight stitch, it is a straight linear stitch; it goes in a straight line.

Here we have a zigzag stitch of different width. So it starts with 0 width, 1, 2, 3, and 4. So if I keep it all the way at the right, all the way to my left basically, so you can, please pay attention to the needle holder here. So it will basically do a zigzag motion. So if you pay attention, you can see, so I will do it fast. I will keep the screwdriver at one of the extremities, so you can see. So you can see this is how much it has displaced. I will do it quickly for you. So you can see it is doing this. Keep in mind the cloth is fed forward at a constant rate and that pitch can again be set by other levers here. Turning this knob sets that pitch rate that is what is the pitch of the suture that is that stitching.

(Refer Slide Time: 51:10)



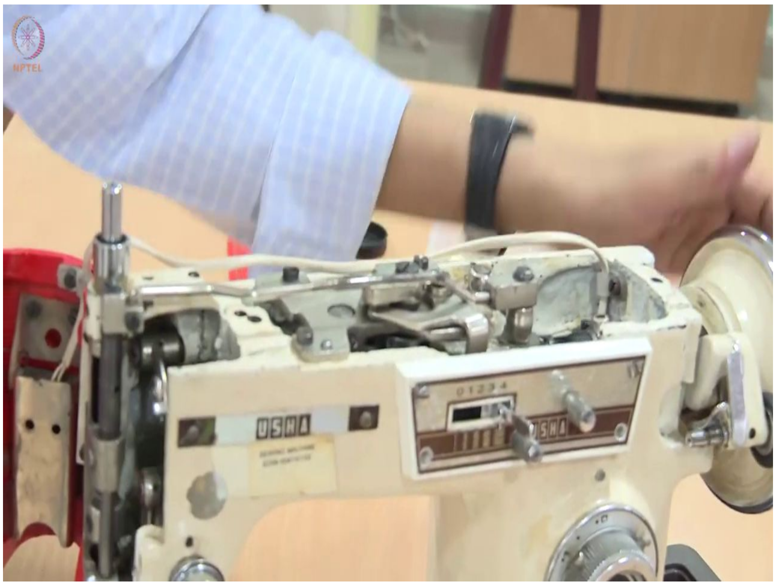
Now, in addition to that, if the needle had only travel up and down, it will be doing a linear stitch. Just think about relative motion, so it is just doing this. Now, as it is advancing, I am also giving a lateral motion to the needle. In addition to the up and down motion of the needle, there is also a superimposed lateral motion.

So we have a composite input. We are superimposing two waveforms one over the other. One is up and down. So you need another mechanism basically that moves this back and forth.

(Refer Slide Time: 51:36)

If you see here, this forms another revolute joint this entire spindle sorry the entire joint here basically about which this pivots, you can see this oscillate this way. Now, this will only be engaged, if I keep the stitch at the zigzag motion. If I go all the way to my right, you can see this is locked in place.

(Refer Slide Time: 52:00)



How does this motion come? You can see there is another lever mechanism here. So when I engage it, you can see at the top this lever that you see here basically gives you the oscillatory motion.

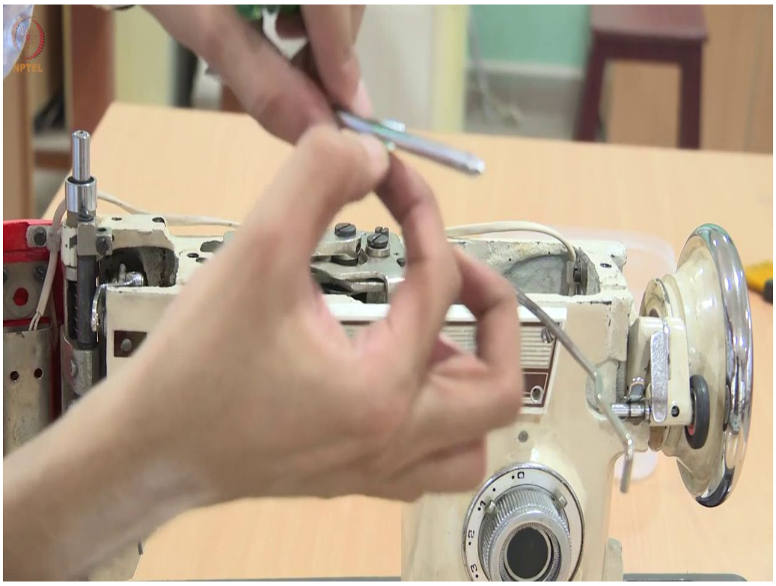
Let me quickly take it apart. So you can see a little bit more interesting, interesting parts of the mechanism. So now I have a disengaged the oscillatory part of the mechanism. So whatever I do, will have no effect on that. Now you see, so this can go up and down.

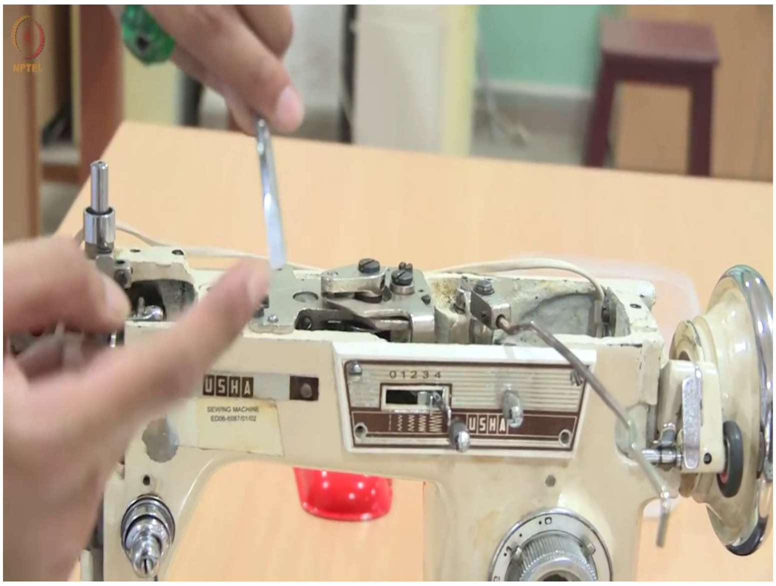
(Refer Slide Time: 52:45)

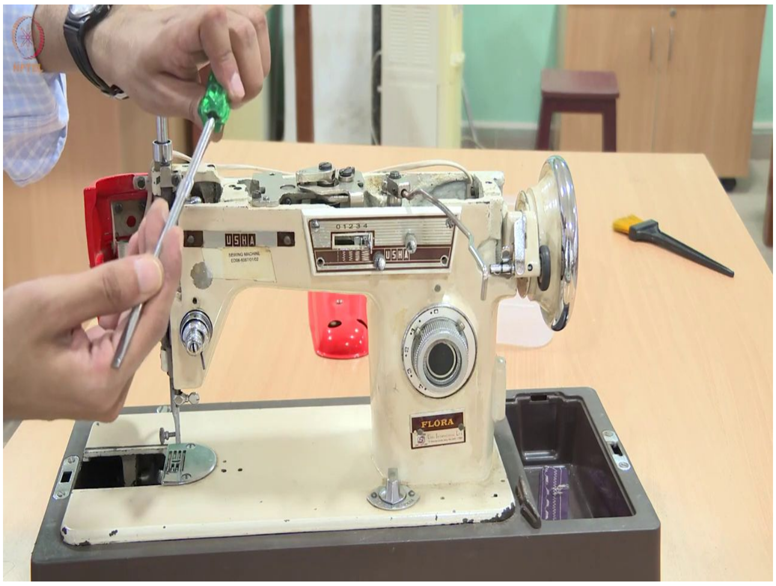
Now imagine me manually moving this. So this is what I spoke about, synchronizing different motions. So you have what is called as a positive linkage. You cannot have a belt drive here. Belt drives typically are used, I mean, you will find them in sewing machines.

Typically, these kinds of rigid rods are preferred because built will tend to elongate over time. And then you lose the different synchronization between different elements, different sub-assemblies of the machinery. So typically in older machines, if you see, all the linkages will be made of rigid links like this. Now, let us proceed to dismantle the top part of the mechanism, the interesting bits.

(Refer Slide Time: 53:42)




USHA
SEWING MACHINE
01234
USHA

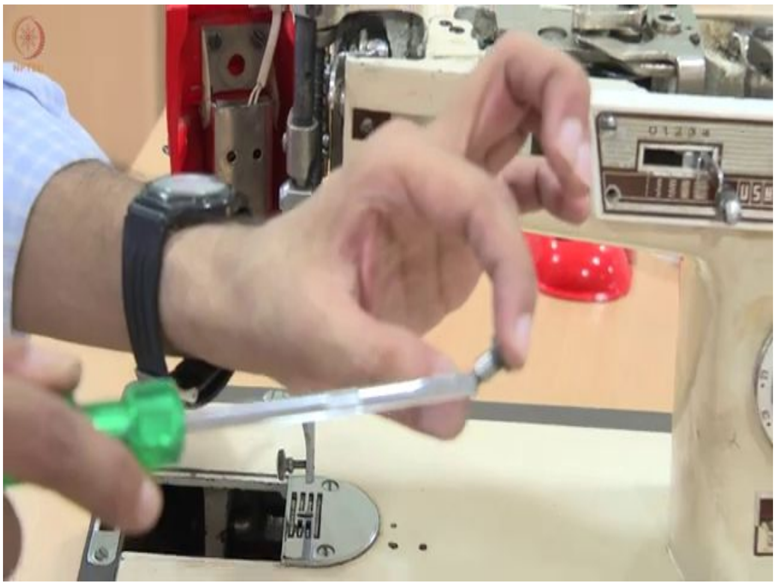

USHA
01234
USHA
FLORA

If you observe in a screwdriver, we have these flats here. So when you engage a screwdriver, so this is a multipurpose screwdriver. I have a flat bit here and I have a Phillips head here, depending on which one I want to use when I engage it, I just cannot put it like this because I am not constraining the rotary motion since I am applying a torque.

Imagine what we saw earlier how we lock basically with a spring load, keep that in mind. In this case, how we do it? So we have these two flat raised edges and then you have these recess, you have these slots here. So when you put the screwdriver, you have to make sure that it goes through it.

Now, the handle and the shaft of the screwdriver are one piece, they are integral. They have become two; these two components have now or positively locked. So now, there is no slip between the shaft and the screwdriver handle, it is worth remembering that. So let me proceed to dismantle it.

(Refer Slide Time: 55:20)



Keep in mind that these are special screws. This screw also functions as a bearing. You can see this is what we call as a shoulder screw. So it does not have to thread all the way through, there is a smooth part of the screw, and then you have the threaded part. This function is what is called as a bush bearing.

So this is a bush basically. So we call this a bush bearing. So to dismantle this, so basically, let me remove this screw. So I will keep it aside because that will take time for me to dismantle it, so let me keep it aside. So you can just see. So the screw basically goes through a bushing here.

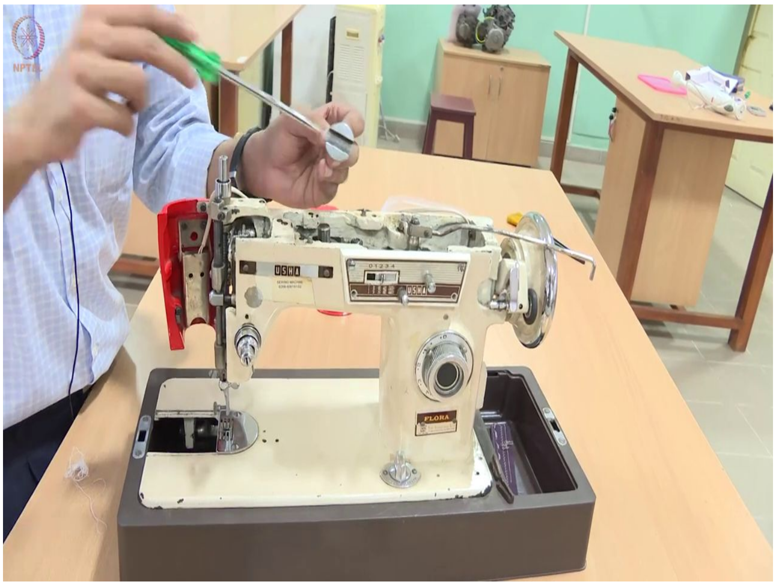
Now, this is very low friction you can see it is oscillating. So this is called as a bush bearing compared to what is called as a roller bearing or a ball bearing. So typically, when you are maintaining the machine, you have to make sure these points are well lubricated if you want the machine to last long.

(Refer Slide Time: 56:36)

Now, let me take the interesting part of the machine. So you can see this is a bushing. So this is called as an insert. So this is a metal insert because typically, you do not want to use the same material.

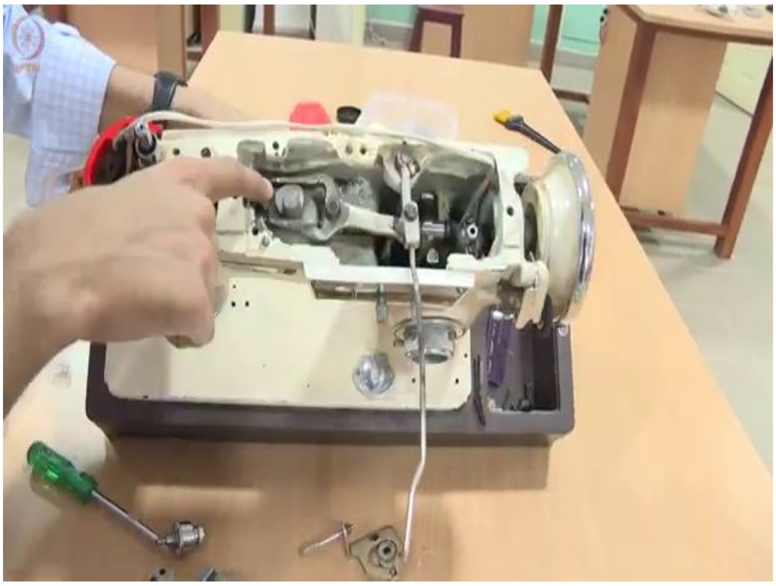
These are what is called, since I have since a bushing basically, this bushing is made of an alloy. It is a softer metal. You have materials like lead; you have different composition, a softer composition such that it provides lubrication also to the bearing.

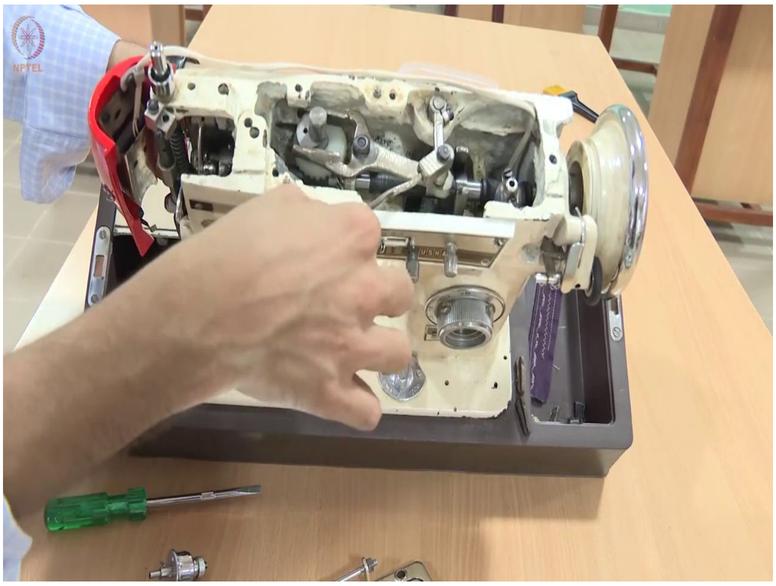
(Refer Slide Time: 57:16)



Now, let us look at the top part of the mechanism. If you see here, so again you see there is a slotted the slot here that basically rides one another. So this is kept in a place like this. So you have the slot moving like this. Let me just tilt the entire machine, so you can have a better look.

(Refer Slide Time: 57:40)





So here, you see. Now, this is called as a cam. So we have a lobed cam. So this is a double lobe cam. So you have two lobes here. Sometimes depending on the manufacturer, some people call it a tri-lobe cam. So you see the top part again as another bearing here.

So you have a cam here that converts the rotary motion into an oscillatory motion. Now, this oscillatory motion, you have another lever here, remember the zigzag stitch, this is how we get it. So do not worry about the complications of the mechanism; for now, what you have to remember is, you have a rotary input, you have a cam mechanism that basically converts the rotary input into an oscillatory mechanism.

So this is called as, what we call as path generation and that is also known as function generation mechanisms. This is actually a one-semester topic. So if you are interested in reading, please go read about path synthesis and function synthesis with four bars and, I mean other cams. So you can see. So if you see there is a bevel gear here, this is the bevel gear; this is a plastic bevel gear. So if you see, to reduce noise, one of the gears basically will be made of a softer material. So this is plastic, this is metal.

So basically, that shows you different aspects of the mechanism. I will add supplementary video to this video, please take a look at it. It goes in a much finer detail, better than what I have shown here. So please go through it and also remember primitives. So to recap what are all the mechanisms that we learned today, do not worry about the synthesis itself, it is a slightly advanced topic. For now, what you have to remember is, in a sewing machine, you have this is it does what is called lock stitching. So you have a thread feeding part of the top of the machine and a thread feeding part at the bottom or part of the machine; both interlock. When they interlock, you have this stitch. Now, what is the advantage of the stitch?

If I were to cut one part of the stitch, the entire stitch will not rip apart. In case of a chain stitch, for instance, if you see, please go check out rice bags; the stitching they have there is different. If I just, if you just cut at the right portion of the thread, you can basically rip apart the entire thread just by destroying one part of the stitch. So we do not want, in clothing, we do not want such a stitch. You do not want the clothing to fail. Even if part of the thread fails, you want the remaining part of the thread to remain intact. So a lock stitching is preferred here.

In rice bags, typically you want to quickly open it, so there the requirement is different. So that it is different. And there, you do not have two spools. It uses a single spool that is a chain stitch or that is a different stitch. There are different names for that; you can look up chain stitching. What are the other things we learned today? So we have, we learned about the tension regulation, importance of tension regulation, importance of synchronizing the movements of different mechanisms; the way to convert a rotary motion into a reciprocating or an oscillatory motion.

Rotary motion, how do you convert it into a reciprocating motion? A crank slider or a crank rocker, right; rotary to oscillatory, you use a crank rocker; rotary to reciprocating, you use a crank slider. Where all did we seeing a crank slider? We saw the crank slider mechanism basically that goes from the top part of the mechanism and powers the bottom spool to basically oscillate the bottom part of the machinery. And we saw cams that power this zigzag stitching of the mechanism.

And where else did we see crank slider? We saw a crank slider here that drives the needle up and down. And then we saw a cam mechanism that helps in giving you a zigzag stitch.

I hope that gave you a good overview of the entire machinery. Please look at the links that that is added to this as a supplementary to this video. That gives you much more in-depth details. Things that have not been covered, that may not be quite ambiguous; my explanation may not be crystal clear, once you look at and look at the animation, it will be much clearer. Thank you.