INDIAN INSTITUTE OF TECHNOLOGY KANPUR

NPTEL

NPTEL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

Course Title
Aircraft Maintenance (Engines)

Lecture - 16
Engine Fuel and Fuel Metering Systems (Lab Session)

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Hello friends, we are again in front of Cessna-206 aircraft. Today we are going to look at the fuel system, the engine fuel system, we have already seen the airframe fuel system, we are again going to revise about the air field, airframe fuel system. The fuel used in this aircraft is aviation gasoline 100LL, the fuel is filled in the fuel tanks, the tanks are here in the links, there are two tanks, one in the left wing one in the right wing. The tanks, the capacity of the tanks is 46 US gallons, each tank has the capacity of 46 US gallons.

And the tank spaces, the tank air spaces are interconnected for balancing the air pressure, the tanks are also vented you can see the tank vent here in the tank, these are the vents, vents are provided on both the tanks, then from the tanks the fuel is coming by gravity to the fuel selector valve, I'll show you the fuel selector valve in the aircraft, the fuel selector valve is here, this is your fuel selector valve, you can see the fuel selector valve, the fuel selector valve has different positions, left, right and both, left means the fuel is been supplied from the left tank, right means the fuel is been supplied from the right tank and you have the both position, you can see this is your both position, that means fuel is being simultaneously supplied from both the tanks.

So the fuel is coming by gravity from the tanks to the selector valve, in the selector valve in the bottom you have a collector tank, from their the fuel goes to the auxiliary pump which is electrically driven, I can show you I have a spare pump, this is your electrically driven auxiliary fuel pump, this auxiliary fuel pump will pump the fuel to the strainer,
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which is the filter used for filtering the fuel, so this strainer the strainer after filtering the fuel passes the fuel to the engine driven pump, engine driven fuel pump.

Now the airframe fuel system ends at this point, at the engine fuel system will start from the engine driven fuel pump, so I will show you on the engine the engine driven fuel pump here (Refer Slide Time: 02:59)

you see this is your engine driven fuel pump, the engine driven fuel pump you can see here, this is your engine driven fuel pump, this engine driven fuel pump will now pump the fuel, the fuel metering unit, this engine which is Lycoming IO-540 engine, the fuel from the engine driven fuel pump is coming to the fuel air metering unit,

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this is the fuel air metering unit you can see here, this has fuel injector, we will study about the injectors in our further classes, this fuel injector meters the fuel in proportion to the airflow, it has got various controls you can see here this is your mixture control, here is your idle speed control, here you have your throttle control, so this fuel air metering unit after metering the fuel sends the fuel to the fuel manifold, this is your fuel manifold here you can see, the fuel after coming from the fuel air metering unit from the fuel injector is coming to the fuel manifold, this is your fuel manifold and from that fuel manifold it has being evenly distributed to all the cylinders.

The fuel from the fuel manifold is transferred through these stainless steel lines whereas lines these are called fuel lines and the fuel lines are connected to the nozzles, the injector nozzles they are air bleed nozzles we will study in detail about these nozzles and the fuel is transferred through these lines, through the air bleed nozzles to the intake of the cylinder, this fuel is coming through these lines and the air, this is your air intake manifold we have seen in our earlier classes how the air is coming to the intake port of the cylinder, so the air is coming through this manifold, the fuel is coming through this fuel line and the air bleed nozzle.

Now the fuel and air mixture is available at the intake port of the cylinder, now as we have told that this is your injector, fuel injector, the fuel air metering unit you have controls on this injector, this is your throttle, this is your throttle linkage, then here you can see a spring loaded screw, this spring loaded screw this is your idle speed adjustment, then this, this lever and the wheel this is your mixture adjustment, this is connected through this control and this is your

mixture control, so you can see the mixture control being operated, it will touch at the two stops in the extreme positions.

Now we will show you the throttle movement also, so this is your throttle movement, see how the throttle is being moved, this is the throttle movement, now in order to adjust the mixture, the mixture can be adjusted through these wheels, this flywheel you can adjust the mixture through this wheel, this position, this side is your rich side and this side is your lean side, so turning the wheel you can correct your mixture, you can set your mixture in the rich condition or in the lean condition as it is required, now idle speed can be adjusted through this screw we can adjust the idle speed.

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This is Rotax-912 engine on one of our machines, we are showing you this engine because this engine has carburetor, the earlier aircrafts Cessna-206 had pressure injector, now here we have carburetors as far as the engine fuel system is concerned, the engine fuel systems starts at the engine driven fuel pump, this is the engine driven fuel pump in this engine, the pump will forward the fuel through these lines, these are the fuel lines you can see here through these lines the fuel comes to the manifold, this is the fuel manifold here rather this manifold directs the fuel to individual cylinders, so the fuel is being directed to the individual cylinders through this point, here you can see this is your carburetor, there are two carburetors this engine, this is one carburetor and the other carburetor is this, so the two carburetors the fuel from the engine driven fuel pump through the manifold is coming to the carburetor, this carburetor has controls as we had seen the controls in a fuel injector, this carburetor also has controls here you can see, this is your throttle, the throttle is being operated now, see this is your throttle control it touches at the two extremes, this is one extreme, now we will show you the other extreme see it is touching at this point and this screw is your idle speed adjustment, through this screw we are able to adjust the idle speed and this is your throttle touching at the two extremes. This is one extreme, and this is another extreme.

Then this carburetor also has a choke assembly we call it a choke assembly it can be compared with the primer, so you can see here we will operate the choke, see the choke being operated and this will also touch at the two extremes,
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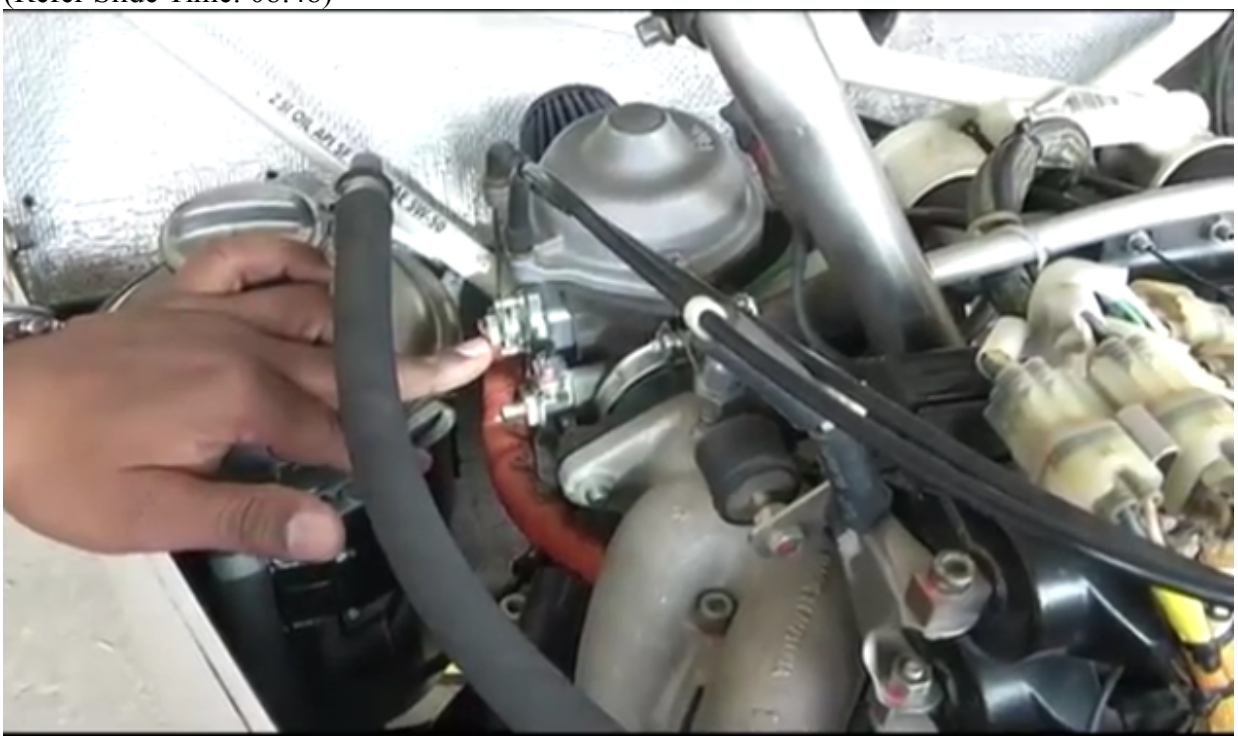

the choke is being operated and this is another extreme, so you've seen an injector, you have seen a carburetor installed on the engine, we will now see how a dismantled carburetor looks like, we will see different types of carburetors and how do they look like, what are the different parts of the carburetors.

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Here we have a carburetor, it's a very old carburetor marvel schebler carburetor, we have dismantled it you can see here

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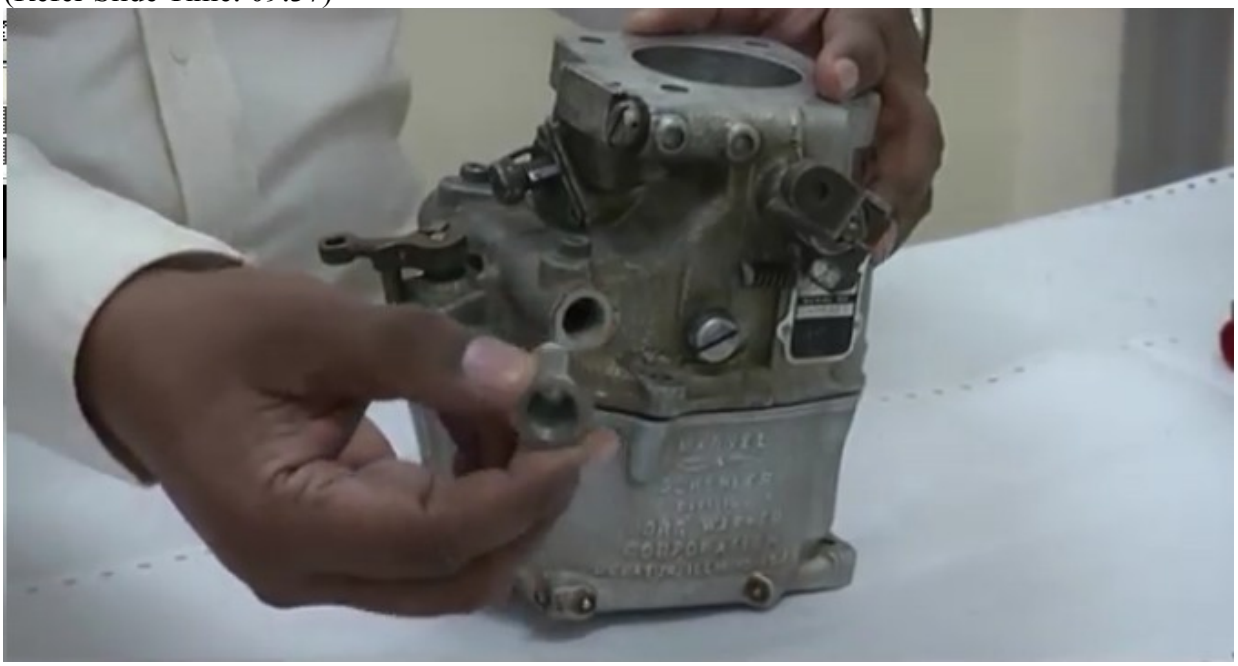

this is the inlet from where the fuel supply comes in from the engine driven fuel pump, the fuel supply comes in through this inlet, this is the inlet point of the fuel in the carburetor, so fuel coming in through this point, now this inlet also has a strainer,

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you can see here this is your strainer which will filter the fuel coming inside the carburetor, so inlet, fuel inlet and a strainer, inlet fuel coming from the engine driven fuel pump getting filtered here.

Now since this is the float type carburetor, it has got floats inside plus this linkage you can see here, this is your throttle linkage,
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this is your throttle this is connected to the throttle control in the cockpit, so when the control in the cockpit, when the throttle control in the cockpit does moved this linkage via the mechanical linkage this moves, when this moves you can see here in the front there is a butterfly valve here

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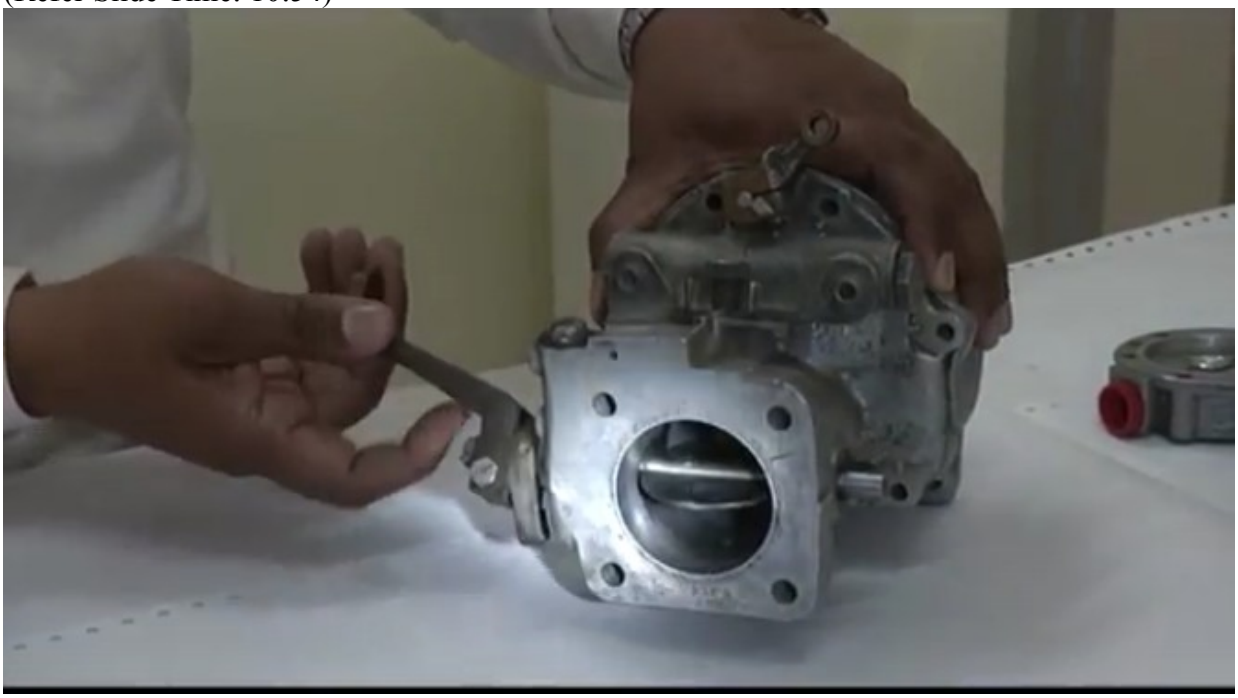

this is your throttle, this is the disk type valve a butterfly type valve you can see the valve moving, so with the throttle movement with this movement this is your idle condition, this is your idle speed condition we call it as idle speed condition you can also say that this is the minimum speed condition, this is the minimum speed condition and you can see here this opening, this is your full throttle condition where the throttle is fully open in this condition the engine will generate maximum power, so maximum air flow, this will be maximum flow of air through this opening and the fuel will be metered proportionately according to the air being flown through this passage, so this throttle the more throttle you give the more power is generated, and this is your idle speed condition, so you have seen the idle speed condition and the full throttle condition.

We have dismantled this you can see lot of hardware here, we have dismantled the complete carburetor just to show you here you can see this is your mixture control,
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this lever this is your mixture control, this is your rich side R is here, and this is your lean side you can see L written here, so this is your mixture control, this control is also moved with the control in the cockpit, so when you move the mixture control from the cockpit this is mechanically connected to that control and this will move and they will move to the rich or the lean condition as per the selection of the control.

Here you can see one screw, a spring loaded screw, this is meant to control the idle speed, from here you can change your idle speed, you can correct your idle speed with the help of this screw,
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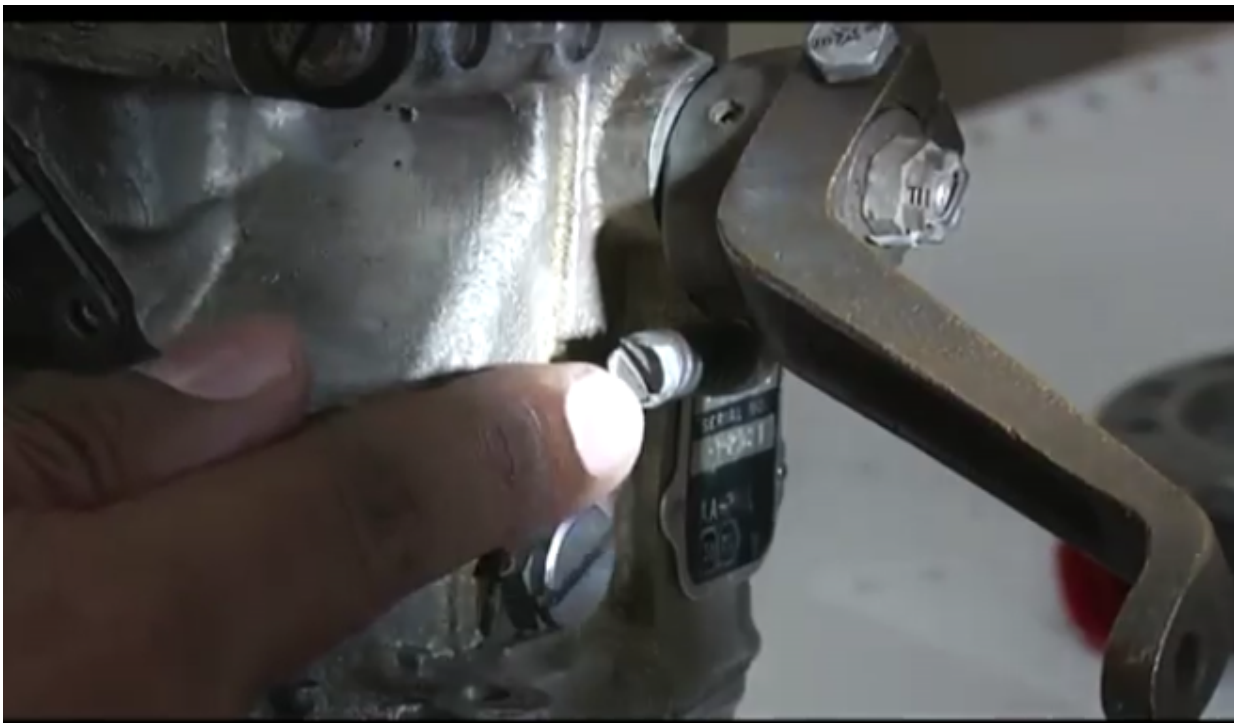

so this is your idle speed adjustment, screw and for idle speed also you need to have your proper mixture, proper mixture of fuel and air so that idle mixture adjustment is done from this condition, this is the needle type valve we have removed it, you can see the valve here,

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this is the needle type valve and this valve is meant to correct your idle fuel air mixture, this is also written rich you can see here rich and lean, the help of this screw this needle valve you can select your, you can adjust your idle fuel air mixture.

Now we have seen the controls from outside, this is your throttle control, this is your idle speed adjustment, this is your idle mixture adjustment and this is your mixture adjustment, fuel has entered from this side it got filtered here and you have seen the butterfly valve, the disk valve, on the top you have seen the idle speed and the maximum throttle positions, now I'll remove this from the top you can see this has been removed from the top and I keep it in the inverted condition, here you can see these are your floats,
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these are your floats we call this as the float type carburetor, this is the float carburetor you can see the floats.

Now what is the purpose of floats? Here you see this is the chamber, this is your float chamber here, the floats they rest in these two housings, and this housing the floats are resting, this is your chamber, basically float chamber is a reservoir where the fuel is stored for the carburetor, so the fuel gets stored in this chamber, this is the float chamber and these floats they float on the fuel, so once this chamber is empty the floats you can see here they are operated with the help of this float arm you can see here this is your float arm and I can remove this pin and we have removed this float arm, you can see the float arm has been removed and with the float arm you have a needle seat and a needle type valve, you can see this, this is your needle valve and a needle seat.

Basically needle seat this is made of bronze, and needle tip is of a harden material which rest on this seat, so once this needle valve and the seat this is basically controlling the float,
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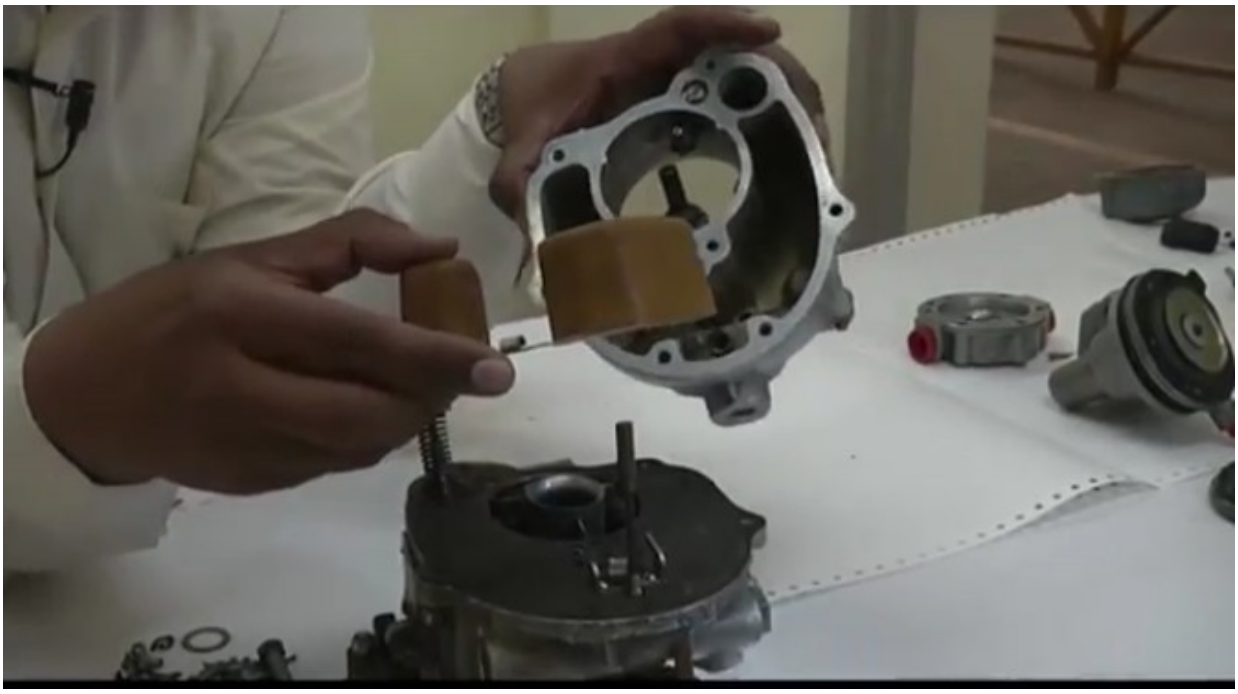

now when the float chamber is empty when there is no fuel in the float chamber these floats they move down, when they move down this will pull the needle valve up, when the needle valve moves up the passage, the fuel passage for the float chamber it opens and the fuel fills in this float chamber.

As the fuel fills in the float chamber the floats they rise, the float level rises as the float level rises the needle valve moves towards exceeded position and once the fuel level has come to a predetermined level the needle valve seats, needle valve moves to it seat and the passage to the float chamber is closed, so with complete fuel in the float chamber the passage is closed with the help of this needle valve.

Now during the time when this carburetor is functioning, when the engine is running and the fuel is burning, there is a constant supply of fuel from the float chamber to the carburetor, to the main discharge nozzle we will show you where the discharge nozzle is, that is a constant flow of fuel from the float chamber to the discharge nozzle, during that constant flow the fuel is burning, then in that condition this needle valve this will assume and intermediate position and there will be a slight opening of the fuel passage and fuel will continuously fill in this float chamber, so the fuel is been complete, is being continuously replenish in the chamber and the fuel is also continuously being delivered to the fuel discharge nozzle, so this is about the float chamber.

Now the float chamber is also vented to that atmospheric pressure, we have the vents here you can see here the vents, the float chamber is also vented to the atmospheric pressure so that there is positive supply of fuel to the discharge nozzle, so this is about the fuel discharge nozzle.

Now let us see where is, we have already seen where is the throttle valve, now we will see where is the discharge nozzle, now after seeing the float chamber we will see the main discharge nozzle, this is your main discharge nozzle here and between the float chamber and the

main discharge nozzle you have the main metering jet inside, we have the main metering jet inside this between the float chamber and the main discharge nozzle,
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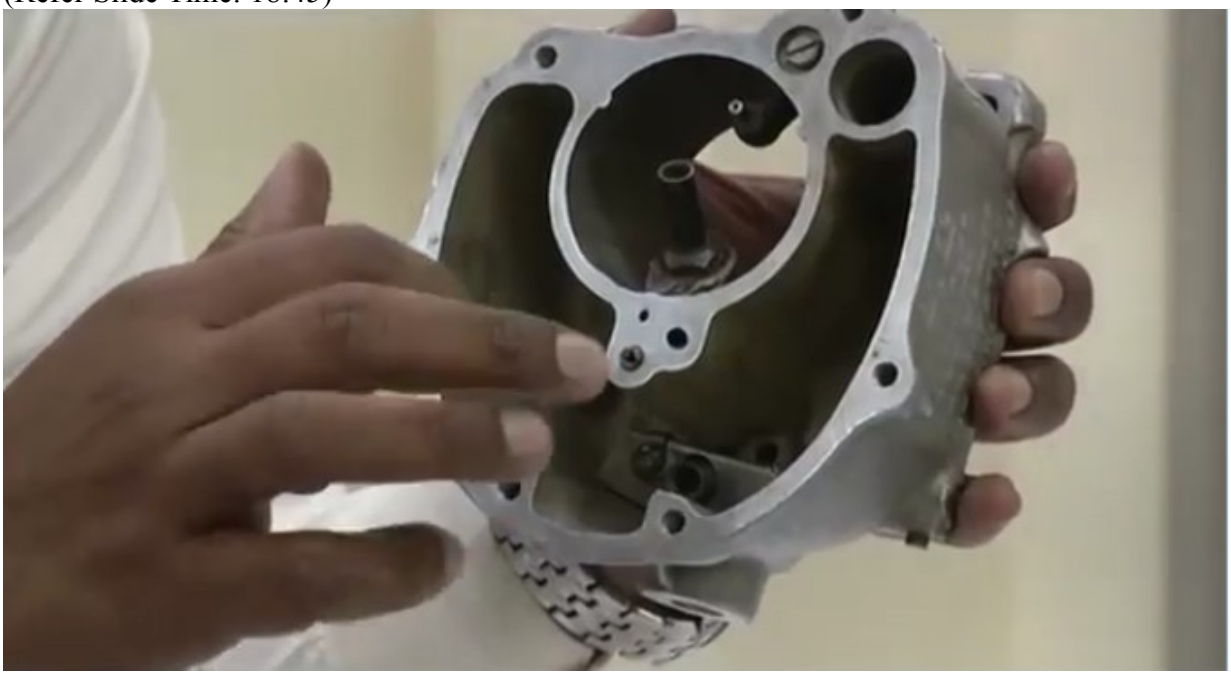

now this main discharge nozzle this protrudes between the venturi throat, this is your venturi throat where the low pressure is acting, so now when the air is flowing through this passage, when the air is flowing through this passage, when this throttle is moving due to the movement of the throttle your air is flowing when you move this throttle this allows air to flow, when this air flows it flows through this opening.

Now when the air flows through the venturi throat it's velocity increases and the pressure drops, so when the air is flowing through this, there is a drop in pressure, this discharge nozzle is in the area of the pressure drop, since it is like this, this discharge nozzle is in this area.

Now as we know that the float chamber is vented to the atmospheric pressure, there is an atmospheric pressure acting on the float chamber and the fuel discharge nozzle is at the low pressure area, so because of this there is a pressure differential, because of this pressure differential there is a force which is called the fuel metering force.

Now this fuel metering force will allow the fuel to come out of the discharge nozzle, the more throttle we give the more throttle is given, the more air is make to flow through this opening, the more air flows there is more pressure drop, more pressure drop means more metering force, and more metering force means more fuel coming out of the discharge nozzle, more fuel coming out of the discharge nozzle means more combustion, and that means more power is being generated, so this is how a basic carburetor is functioning, in the carburetor we know that there are various systems, you have the idle speed adjustment, you have the mixture adjustment, so we have seen the float chamber, we have seen the main discharge nozzle, here you can see from inside this is your mixture adjustment, you can see here this is your mixture adjustment when the mixture control is being moved,

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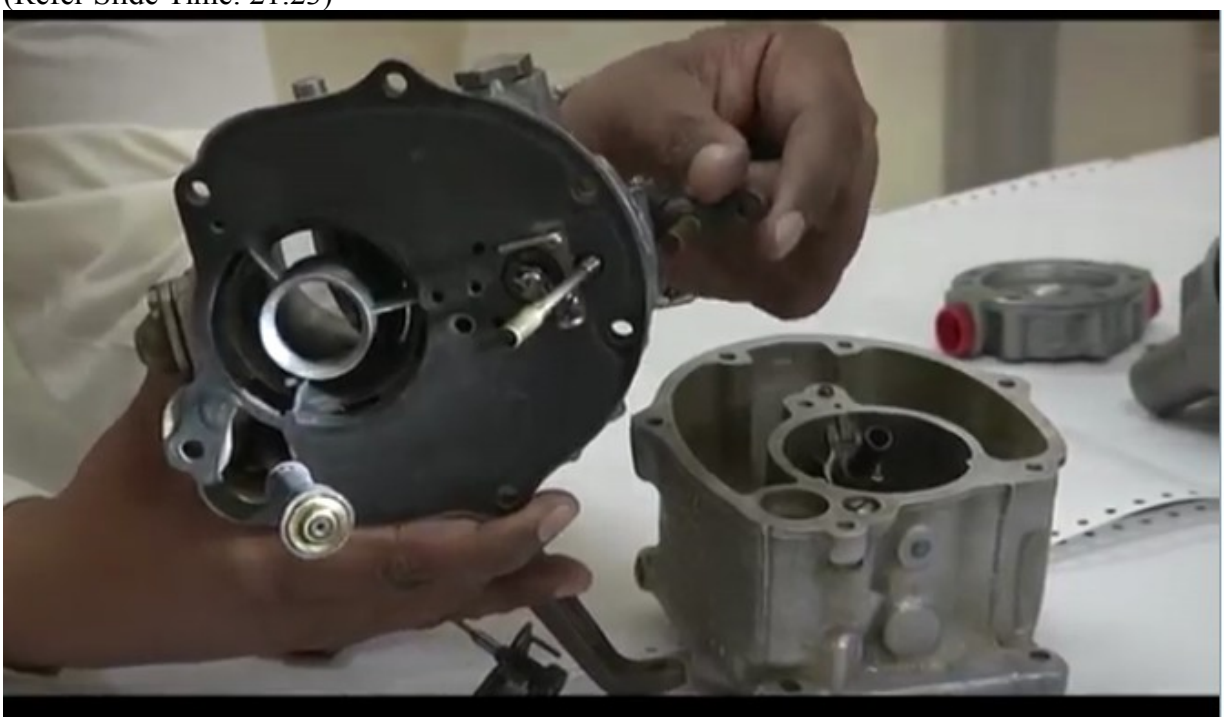

when the mixture control is moved you can see this valve, the movement in this valve.

Now looking at the idle condition again you see this is your idle position, the throttle is at the idle, now you can see the throttle is almost closed,
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now when the throttle is in the almost closed condition the velocity of air or rather we can say the pressure differential or the fuel metering force is not sufficient to bring fuel for combustion in the idle condition, in that case the fuel is supplied through these holes you can see there is a hole here, you can see small holes on one side of the valve,
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the fuel is discharged through these holes in the idle condition, this fuel is being blood from the main discharge line, from the float chamber and it is coming out through this hole, we also have a idle mixture adjustment, we have a idle mixture adjustment at this point, this idle mixture adjustment you can lean the mixture or rich the mixture in the idle condition, so you can see here there are further more holes you can see inside, and when in the idle condition one hole is partially closed and one hole is completely open, so depending on the your idle mixture adjustment the fuel can be made lean or rich through these holes.

Now this is another carburetor which we had seen on one of our aircraft Rotax-912 engine, you can see here this carburetor, this is your throttle control you can see the movement of the disk throttle, this is your throttle control we had seen it on the aircraft also the movement of throttle control,
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now here you can see the movement of the disk, this condition this is your full throttle condition where your disk is completely open, you can see here the disk, the throttle disk is completely open.

Now when I do it like this, this is your closed condition, the throttle is closed, so this is your throttle condition, this is your idle speed adjustment screw we had seen it on the aircraft also, this is your idle speed adjustment, this is where now since this is your throttle, this is your closed condition, and you can see here when the throttle is in this position, this throttle disk valve, this is closed and with the adjustment of this screw you can adjust this movement of the disk in the idle condition and you can adjust the idle speed, so this is throttle, this is idle speed, then we had seen that there is a primer, this is your choke, this is the choke assembly we will study in detail about this choke assembly and about this carburetor in our next class, but this is just to show you the different types of carburetor and this is your choke assembly, so we have removed the choke assembly, now at the bottom you can see this is your float chamber, here this is your float chamber I have removed the float chamber
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you can see the float chamber here, see the float chamber of this carburetor and these are the floats, you can see the floats.

So the purpose of the float is to monitor the fuel level in the float chamber, so as the level of the fuel increases the floats level also increase and they close the fuel passage to the float chamber, you have seen the floats in the float chamber, now this float chamber, this is your arm, this is your pin through which your float chamber was connected,

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this is the arm this moves like this, there is a needle seat, I'll remove this, see this is removed and this arm is removed, and you can see here this is your float arm and this is your needle seat

in this carburetor the needle tip is of a rubberize material, you can see the needle tip this is of a rubberize material and this is your needle seat where it seats here, now when this seat goes in when the float level rises this closes the fuel passage to the float chamber and when it comes up the fuel passage to the float chamber opens, so this is how the fuel in the float chamber is the fuel level in the float chamber is maintained, so this was about the float chamber for this carburetor, now this is your main discharge nozzle here and this is your main metering jet, here you can see this is your main metering jet, this is the special kind of an orifice, you can see here the opening, the special orifice.

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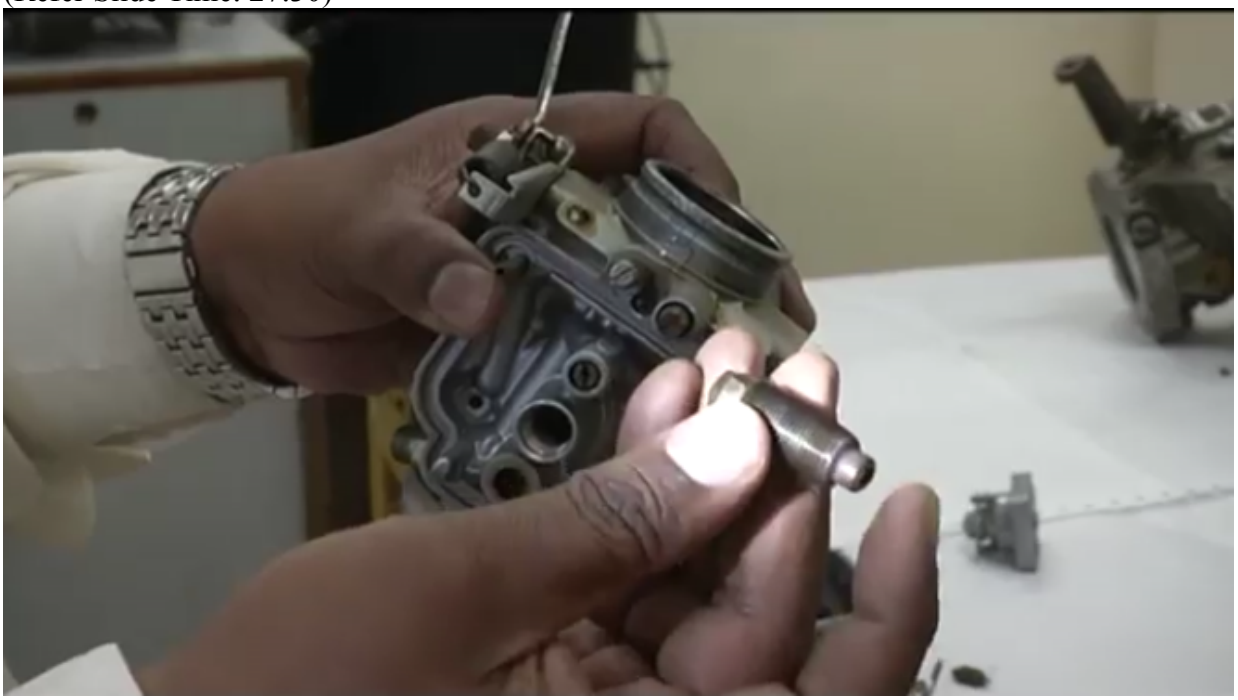

Now the main or metering jet this is between the float chamber and the discharge nozzle, so you have seen the main metering jet which goes in like this, we will study in detail about this carburetor in our next class, so this was just to show you the basic system about this carburetor, you have seen the throttle control, you have seen the float chamber, you have seen the choke, you have seen the main metering jet, this is your fuel injector, we had seen this unit on Cessna-206 aircraft, this is the fuel injector

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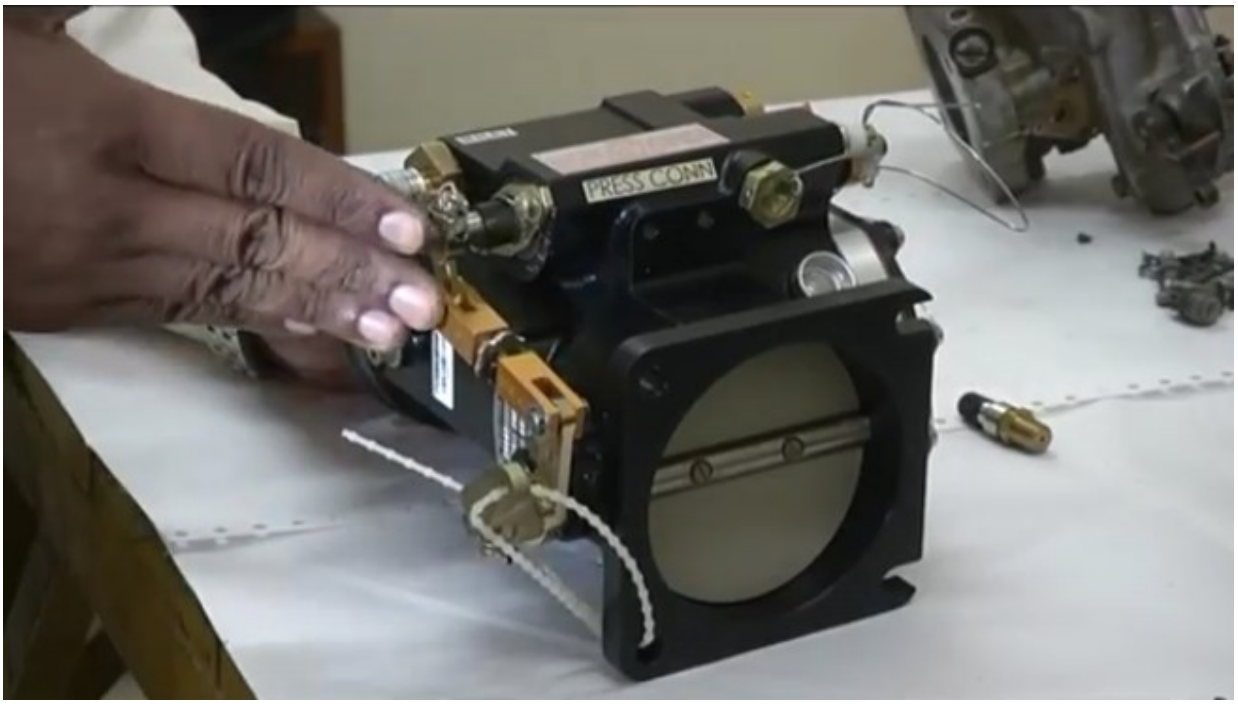

we will study in detail about the injector, we have seen some carburetors this is a pressure injection system, fuel injector, the various controls on the fuel injector, this is your throttle, this is your throttle control, this is your idle speed adjustment you can see a spring loaded screw, this is your idle speed adjustment, this is your mixture adjustment you adjust the fuel air mixture from this, this wheel is there, by moving this wheel you can adjust the fuel air mixture and this control, you can see here this is your mixture control, the cockpit mixture control is connected through this linkage, so this is your mixture control level, this is your mixture adjustment, this is your throttle adjustment, throttle control and this is your idle speed adjustment, so we have seen the different controls on the injector and this is, this point is the fuel inlet point you can see here, this is the fuel inlet point from the engine driven fuel pump the fuel enters through this inlet and this side we have the finger strainer which is used to filter the fuel coming inside the injector, so this is the fuel injector we will study in detail about this injector in our next class.

Apart from this injector in the fuel injection system we have the fuel manifold from the fuel injector the fuel is metered according to the airflow, the metered fuel is transferred to the fuel manifold we have seen it on the aircraft, the fuel manifold, the fuel manifold will distribute the fuel evenly to all the cylinders and the fuel is transferred through the stainless steel lines to the bleed nozzle, this is the air bleed nozzle which will transfer the fuel, which will atomize the fuel to the intake port of the engine cylinder.

Acknowledgement
Ministry of Human Resource & Development

Prof. Satyaki Roy
Co-coordinator, IIT Kanpur

NPTEL Team

Sanjay Pal
Bharat Lal
Ashish Singh
Badal Pradhan
Tapobrata Das
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Bhadro Rao
Shikha Gupta
Aradhana Singh Rajawat
Sweta
Nipa Sikdar
Anupam Mishra
Ram Chandra
Manoj Shrivastava
Dilip Tripathi
Padam Shukla
Sharwan K Verma
Sanjay Mishra
Shubham Rawat
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Praduyman Singh Chauhan
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