INDIAN INSTITUTE OF TECHNOLOGY KANPUR

NPTEL

NPTEL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

Course Title
Aircraft Maintenance (Engines)

Lecture - 11
Cooling Systems

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Our next system is the cooling the system, cooling system of a reciprocating engine, as we all are aware that combustion takes place in the engine, the fuel air mixture is ignited inside the engine cylinders. Due to this combustion lot of heat is generated, because of this heat all the parts in the engine are subjected to very high temperatures, so in order to have efficient functioning of these parts of the engine as a whole, cooling of the engine and these parts is required, so let us see what the cooling system of a reciprocating engine is all about.

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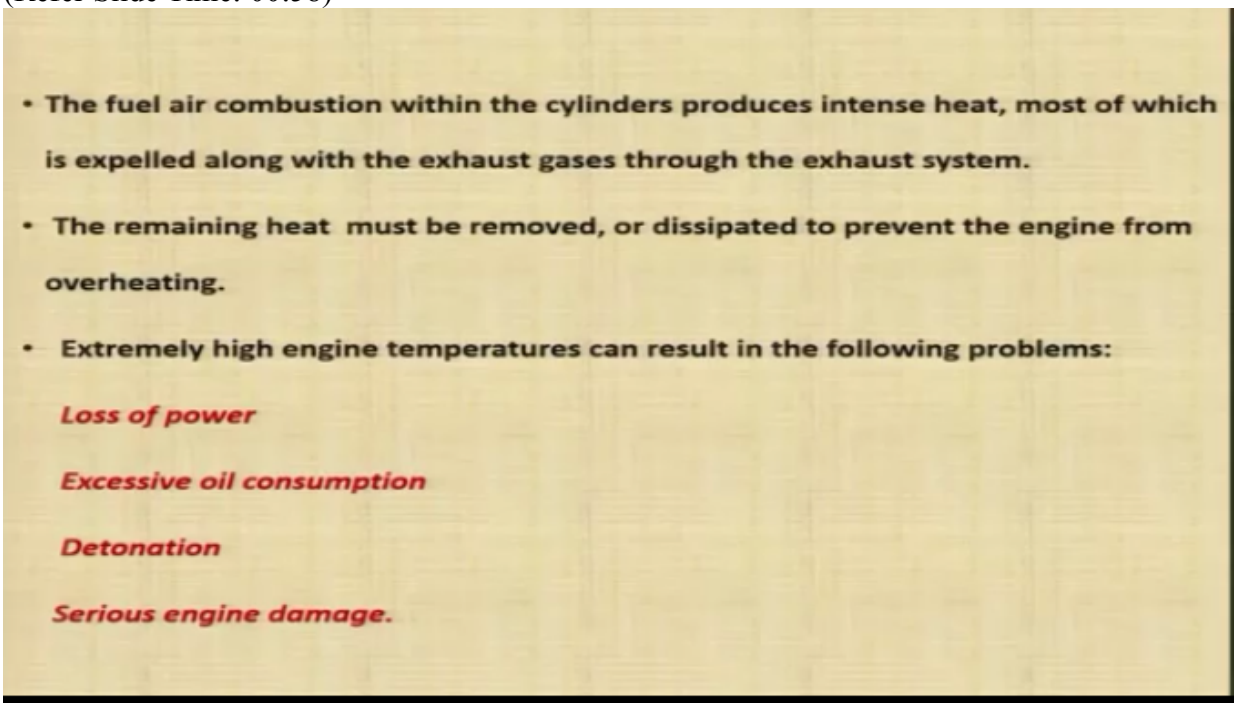

The fuel air combustion within the cylinders produces intense heat, most of which is expelled along with the exhaust gases through the exhaust system, so as just now I had said that due to combustion lot of heat is produced in the engine cylinders, this heat, most of this heat, most of

the heat produced is exhausted out of the system along with the exhaust gases, still some heat is left in the system that remaining heat must be removed or dissipated to prevent the engine from overheating, so this heat which is left has to be removed or it has to be dissipated so that the engine doesn't overheat.

Now there are problems associated with high temperatures, let us see what are the problems that we may encounter due to this high temperature, so extremely high engine temperatures can result in the following problems, loss of power, excessive oil consumption, detonation, and serious engine damage, so extremely high temperatures can result in loss of power, we may lose power during flight, there may be excessive oil consumption, your oil consumption may increase, detonation we will study about detonation in our further slides, and severe damage, so these are the problems which we may encounter due to very high temperatures.

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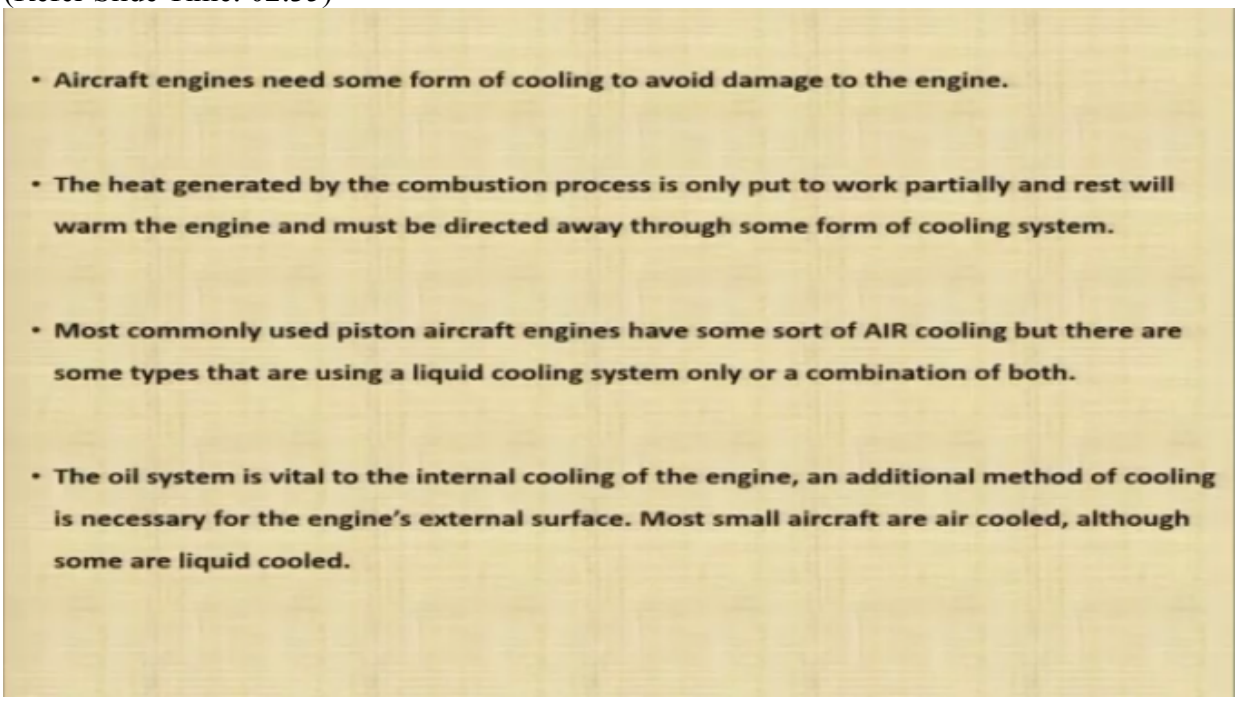

Aircraft engines need some form of cooling to avoid damage to the engine, so in order to avoid these problems some form of cooling is required to avoid damage to the engine.

The heat generated by the combustion process is only put to work partially and rest will warm the engine and must be directed away through some form of cooling system, so the heat generated due to combustion is converted to power, partially only and rest of the heat is warming the engine and it needs to be directed away from the engine through some form of cooling.

Most commonly used piston aircraft engines have some sort of air cooling, but there are some types that are using a liquid cooling system only or a combination of both, so some of the engines, some of the reciprocating engines are using air cooling, some are using liquid cooling and there are engines which are using a combination of both air cooling and liquid cooling.

The oil system is vital to the internal cooling of the engine, an additional method of cooling is necessary for the engines external surface, most small aircrafts are air cooled, although some are liquid cooled, so the oil system, the lubrication system it is very important for internal cooling of the engine, so the engine internal cooling is being done by the oil system by the lubricants, but an additional method of cooling is also required for cooling the external surface of the engine, so as we have seen above that some engines are using air cooling, some are using liquid cooling, and some are using the combination of both air and liquid cooling.

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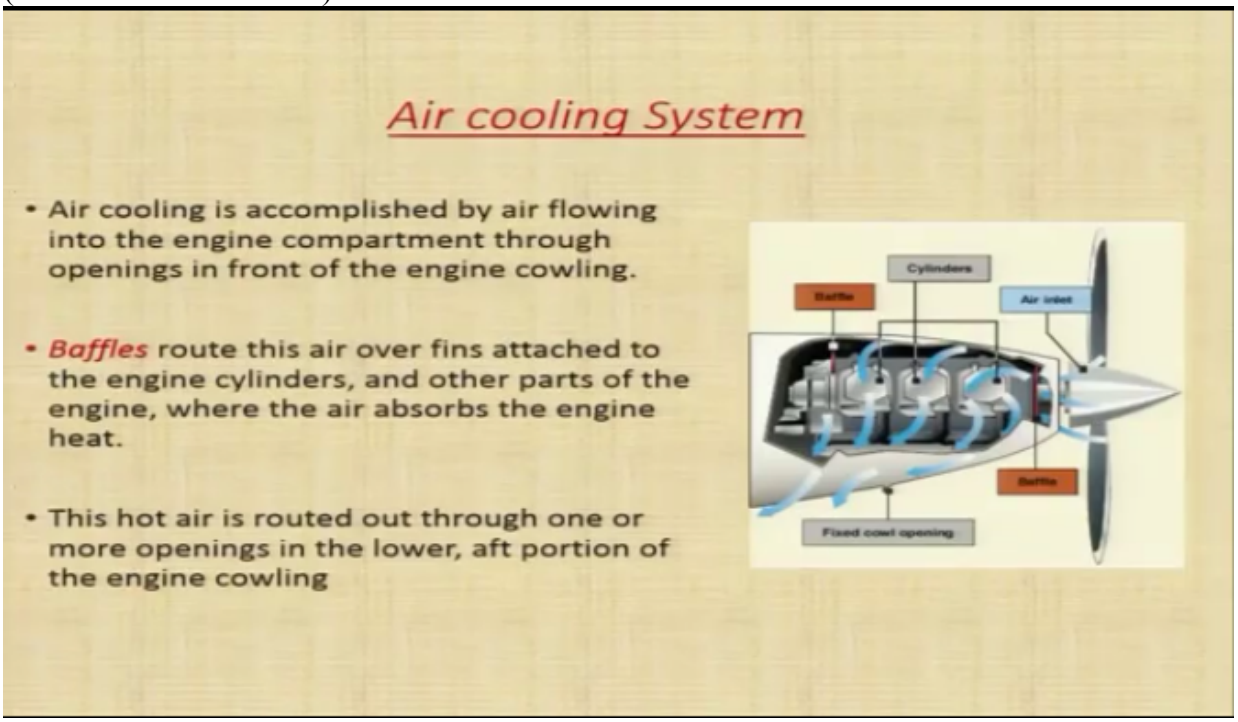

Now coming to air cooling system, what is an air cooling system? Air cooling is accomplished by air flowing into the engine compartment through openings in front of the engine cowling, so as you can see in the diagram, see the air, this air there is an opening in front of the cowling, this cowling is the cover which is surrounding the engine it is an aerodynamic shape and this cowling in front of the cowling there is an opening through which the air coming inside the engine, so air cooling is accomplished by air flowing into the engine compartment, so this air is flowing into the engine compartment through openings in front of the engine cowling, so this side there is an opening, the opening is also designed in such a way that you have an aerodynamic effect, you have a ram effect, and this is used for cooling the engine.

Baffles route this air over fins attached to the engine cylinders, and other parts of the engine where the air absorbs the engine heat, now inside the cowling, inside this engine around the engine you have baffles, and flexible seals, so these baffles are used to route the air, this air which is coming inside over fins attached to the engine cylinders, so we have seen that this engine cylinders have got fins over them, so this air is routed over the fins, and other parts of the engines, so that the air absorbs the engine heat.

This hot air is routed out through one or more openings in the lower, aft portion of the engine cowling, now we have seen there is an opening here, air is coming from this side, there are baffles inside and these baffles they direct by air over the fins of the cylinders, and now this air is routed out of the system through one or more openings which are there in the lower portion, lower aft portion of the cowling, so you will see in the diagram the air is coming this side, and it is cooling the entire engine, entire system and is being routed out through these openings at the aft bottom portion, of the engine cowling.

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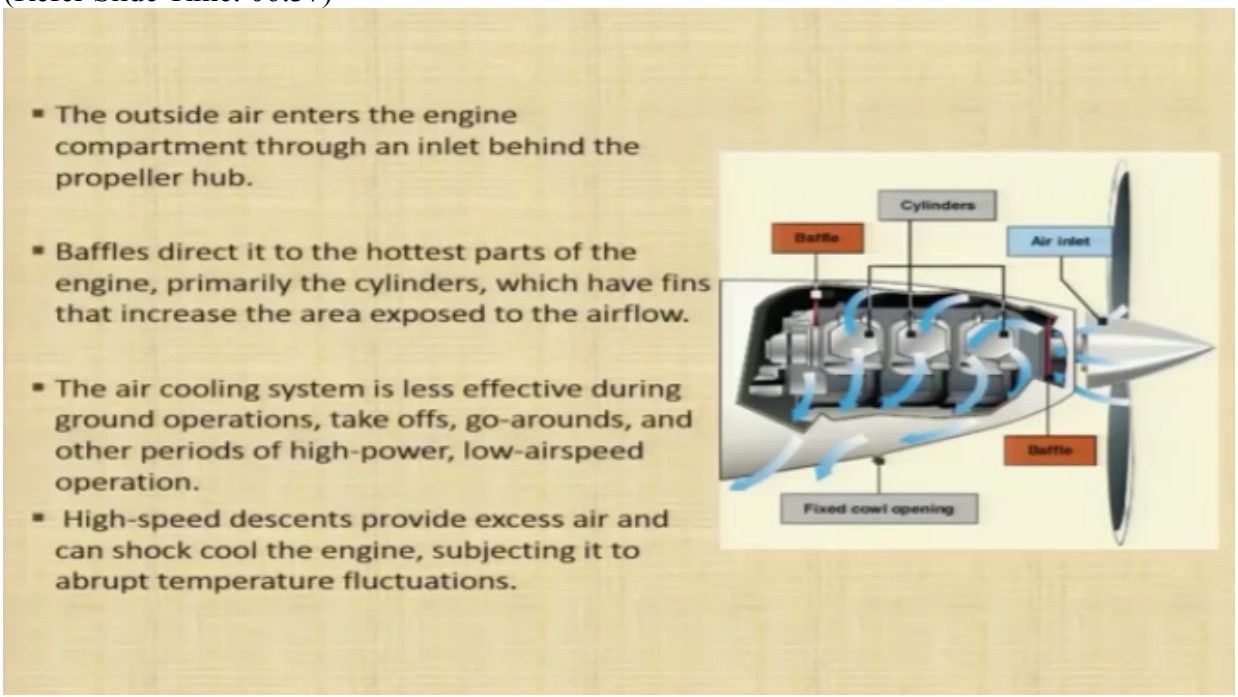

The outside air enters the engine compartment through an inlet behind the propeller hub, so this is your propeller hub, this behind the propeller hub there is an opening we have just discussed the air enters through this opening.

Baffles direct it to the hottest part of the engine, now there are baffles inside, these baffles will direct the air, the cooling air to the hottest part of the engine cylinders, primarily the cylinders, in fact the hottest part in the engine are the cylinders, so the air is being directed over the cylinders, and these cylinders have fins that increase the area exposed to the airflow, this cylinders they have fins which increase the area which is exposed to the air flow, and this aged in cooling the cylinders.

The air cooling system is less effective during ground operations, take offs, go-arounds, and other periods of high-power, low-airspeed operation, now this air cooling system this air cooling method is less effective during ground operations, during take offs, go-arounds, and other periods of high-power, low-airspeed operation, so this air cooling system has a disadvantage.

Further in case of high-speed descents they provide excess air and can shock cool the engine, this is another disadvantage that in case if you are descending in a high speed, this will provide

excess air and it can shock cool the engine, subjecting it to abrupt temperature fluctuations, so there might be abrupt temperature fluctuations due to shock cooling of the engine and that happens in case you are descending at a very high speed and the engine is having excess air.

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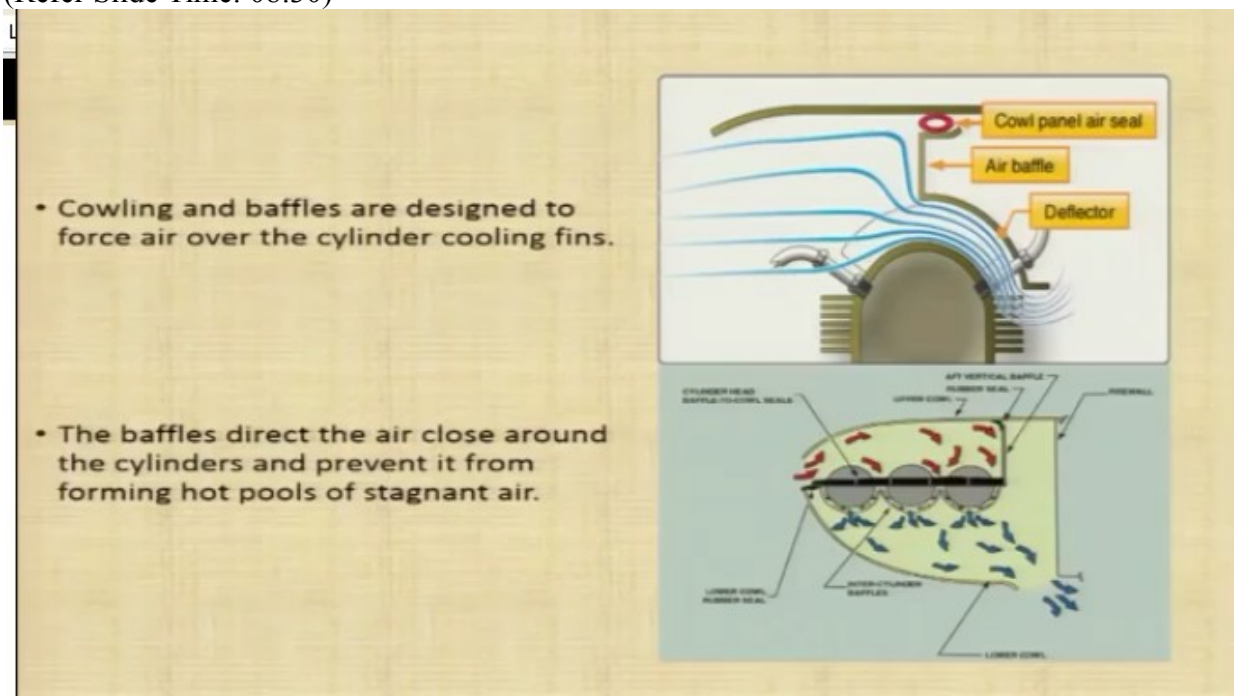

Here you can see in the diagram, this is one cylinder, you can see the fins here, and these are your baffles, you can see the baffles and on top of the baffles you have the flexible seals, so now the cowling and baffles are designed to force air over the cylinder cooling fins, we will see in opposes lines how this air is being directed, but here in this diagram you can see this air is being directed over the cylinder around the fins because of these baffles and deflectors and the seals.

Cowling and baffles they are designed to force air over the cylinder cooling fins. The baffles direct the air close around the cylinders and prevent it from forming hot pools of stagnant air, see in this diagram now this is your inlet, this is your upper cowling, this is your lower cowling and this is how the air is being directed over the cylinders.

The baffles direct the air close around the cylinders and prevent it from forming hot pools of stagnant air, so the air is routed and in such a way that hot stagnant air that is avoided, so that the air doesn't get stagnant here in this portion and it gets, it comes from this side and goes through the bottom portion outside the system.

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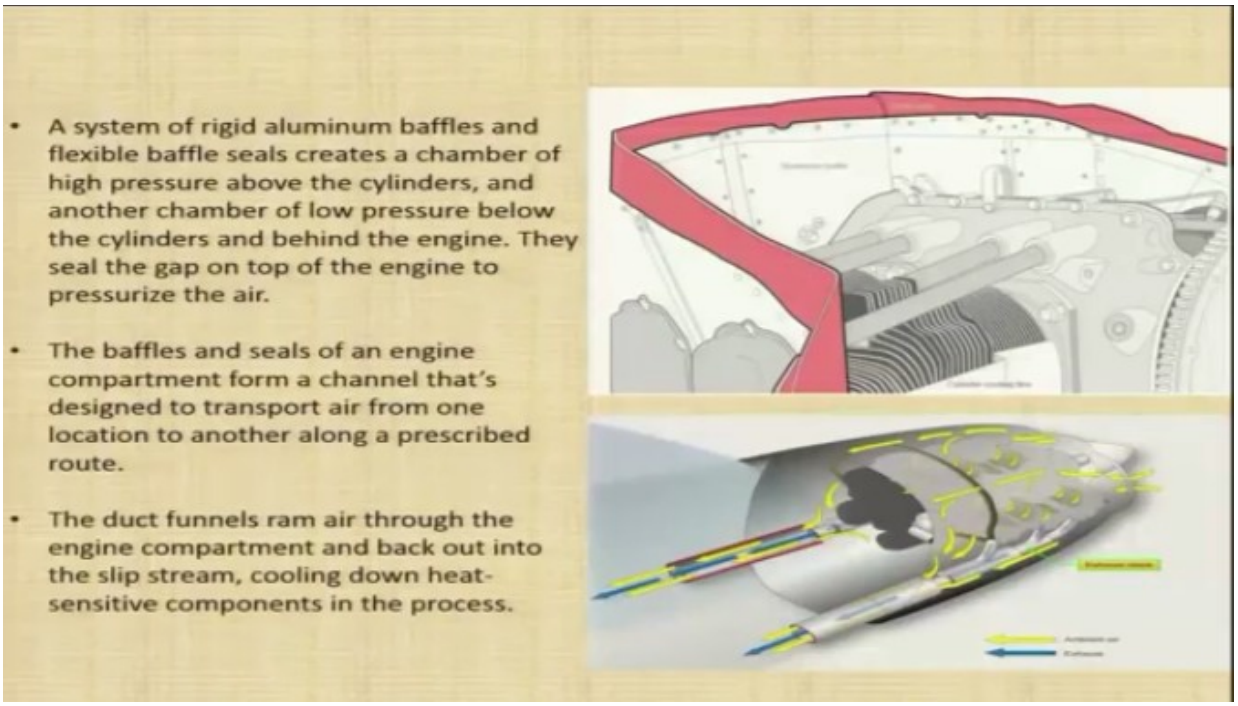

So in this diagram you can see these are your baffles, they are metallic structures, metallic sheets, aluminum sheets, and on top of that you can see this colored thing, this is your flexible seal, so you have the baffles and the seal, so our system of rigid aluminum baffles and flexible baffles seals creates a chamber of high pressure above the cylinders, so this system of metallic aluminum baffles and flexible seals over the aluminum they create a chamber of high pressure above the cylinders, so this system will create a chamber of high pressure above the cylinders and another chamber of low pressure below the cylinders and behind the engine, so there are two chambers formed one is high pressure over the cylinders, and one is low pressure below the cylinders and behind the engine.

They seal the gap on top of the engine to pressurize the air, so this baffle and the flexible seal along with the cowling the top portion of the cowling they seal the gap on top of the engine to pressurize the air, so that the air gets pressurized.

Now this flexible seal will seal the gap between the upper cowling and the engine, and thus the air will be pressurized over the cylinders.

The baffles and seals of an engine compartment form a channel that's designed to transport air from one location to another along a prescribed route, see in one of this diagram you can see how the air is ambient air, you can see these yellow arrow, this is ambient air coming from the front, how this is channelized and this air, this is extracting heat from the engine and then the warm engine exhaust air goes out of the system, the hot air goes out of the system, so the baffles and seals of an engine compartment they form a channel that is designed to transport air from one location to another along a prescribed route, so the air is following a prescribed route, a route is formed and the air is channelized so that it, the ambient air enters inside and extracts the heat from the engine system and is sent overboard outside.

The duct funnels ram air through the engine compartment and back out into the slip stream, cooling down heat sensitive components in the process, now this duct this will paddle the ram air inside, we have just now discussed that this ram air will come inside the engine compartment and will get back out of the slips, out into the slip stream and it in the process it will cool down all the heat sensitive components of the system.

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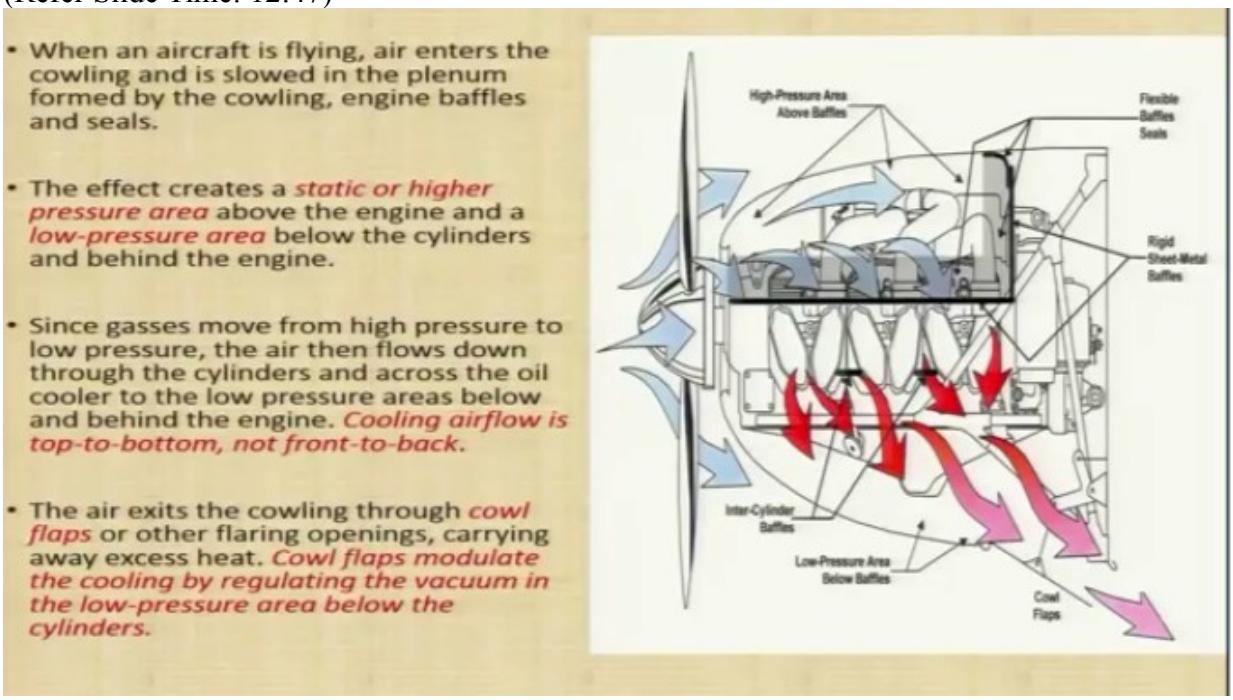

Now when an aircraft is flying, air enters the cowling and is slowed in the plenum formed by the cowling, engine baffles and seals, so here in this diagram you can see this is your air intake, air is coming inside the cowling, these are your rigid metal baffles you can see thick black lines this indicates your rigid heat metal baffles and on top of that you have the flexible baffle seals, these are your flexible baffles seals.

So when your aircraft is flying, air enters the cowling, the air is entering the cowling and is slowed in the plenum formed by the cowling, engine baffles and seals, so this is your cowling these baffles and the flexible seals they provide the seal in chamber.

The effect creates a static or high pressure area above the engine and low-pressure area below the cylinders and behind the engine, so this air is entering from the intake and is creating a high-pressure area over the cylinders, and a low pressure area below the cylinders and at the aft portion of the engine.

Since gasses move from high pressure to low pressure, we all know that the gasses will removing from high pressure to the low pressure, the air then flows down through the cylinders, so since you have high pressure over the cylinders and low pressure below the cylinders the gasses will be moving from high pressure area to low pressure through the cylinders and across the oil cooler to the low pressure areas below and behind the engine.

Cooling airflow is top to bottom and not front to back, so this cooling airflow is coming from top to bottom since we have the high pressure area on the top and low pressure area at the bottom, so the air is flowing from top to bottom, and not from front to back.

The air exists the cowling through cowl flaps, now you can see here you have the cowl flaps here, the air exits now this air since it is coming from top side to the bottom side, and this air is going out through the cowl flaps, or other flaring openings carrying away excess heat, so it is carrying away excess away.

Cowl flaps modulate the cooling by regulating the vacuum in the low pressure area below the cylinders, so these cowl flaps they modulate the cooling by regulating the vacuum in the low pressure area, so these cowl flaps when they open they are creating the vacuum, they are regulating the vacuum in the low pressure area below the cylinders.

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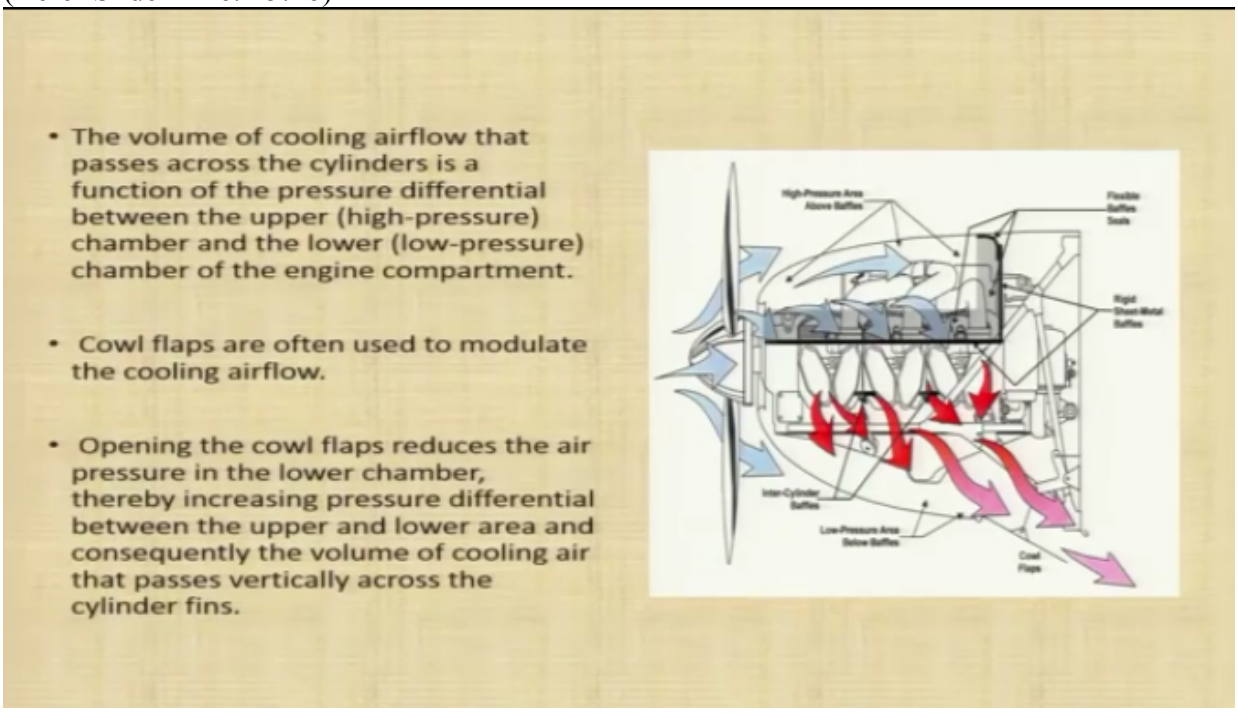

The volume of cooling airflow that passes across the cylinders is a function of the pressure differential between the upper high pressure chamber and the low pressure chamber of the engine compartment, now as we know that there is high pressure on top and low pressure at the bottom, on the lower side so a volume of airflow, the volume of airflow which is going through the engine is a function of the pressure differential, the pressure differential between the difference of pressure between the upper chamber and the lower chamber, so this special differential is responsible for the volume of cooling airflow coming inside the engine.

Cowl flaps are often used to modulate the cooling airflow, so we have just now seen that cowl flaps they will modulate the cooling airflow.

Opening the cowl flaps reduces the air pressure in the lower chamber, now when the cowl flaps are open this will further reduce the pressure in the lower chamber, thus the pressure differential between the upper and the lower area increases, and resulting in the volume of cooling air that passes vertically across the cylinder fins, so because when the cowl flaps open there is increased pressure differential and because of this increased pressure differential more volume of air will come inside the engine and it will more volume of air will cool the engine.

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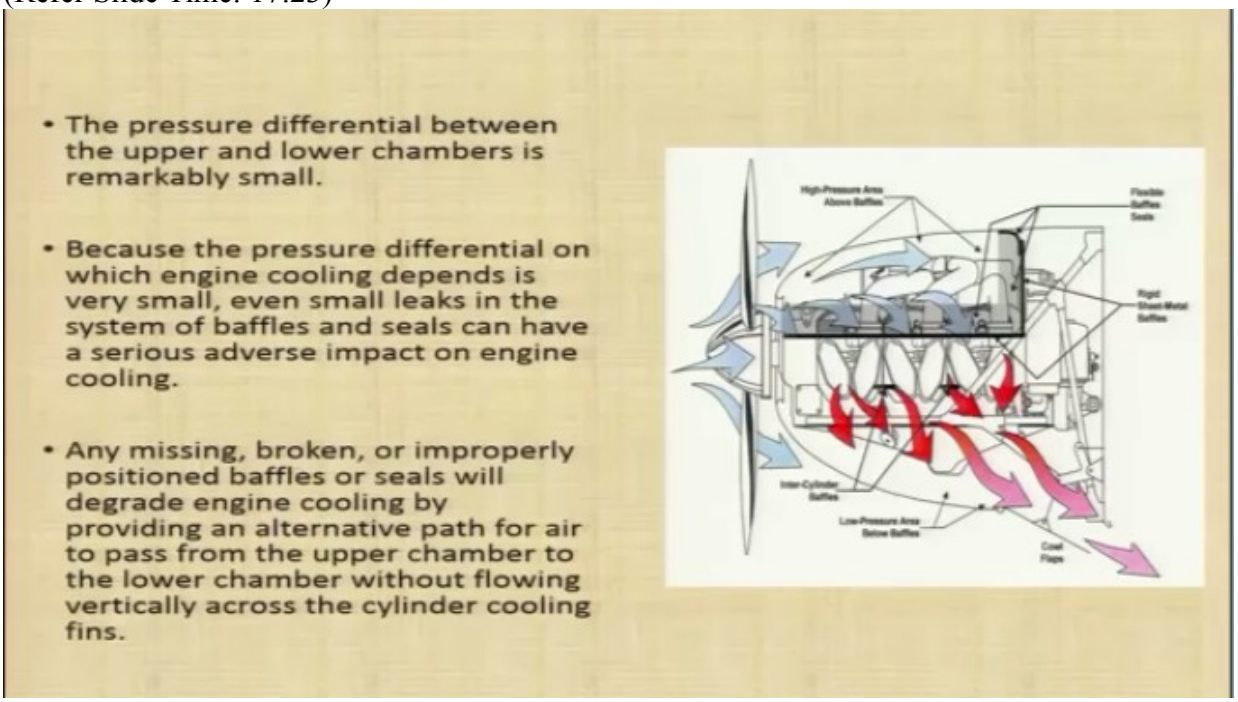

The pressure differential between the upper and lower chamber is remarkably small, although this pressure differential is very small between the upper and the lower chamber, but still this pressure differential is helpful in getting more volume of airflow in the, inside the cowling.

Because the pressure differential on which engine cooling depends is very small, even small leaks in the system of baffles and seals can have a serious adverse impact on the engine cooling.

Now since the pressure differential between the upper portion and the lower portion is very small, so any leak in the system of baffles or seals it can have a serious impact on the engine cooling, so any leak in these baffles are seals will leak the air which is coming inside and there will be insufficient cooling of the cylinders.

Any missing, broken, or improperly positioned baffles or seals will degrade engine cooling by providing an alternative path for air to pass from the upper chamber tot eh lower chamber without flowing vertically across the cylinder cooling fins, so any leak in the system, any broken part, any missing part or improperly positioned baffle or seal it will provide a part to the air to leak and thus the air will not go from top to bottom, it will not flow over the cylinders and it will not result in efficient cooling.

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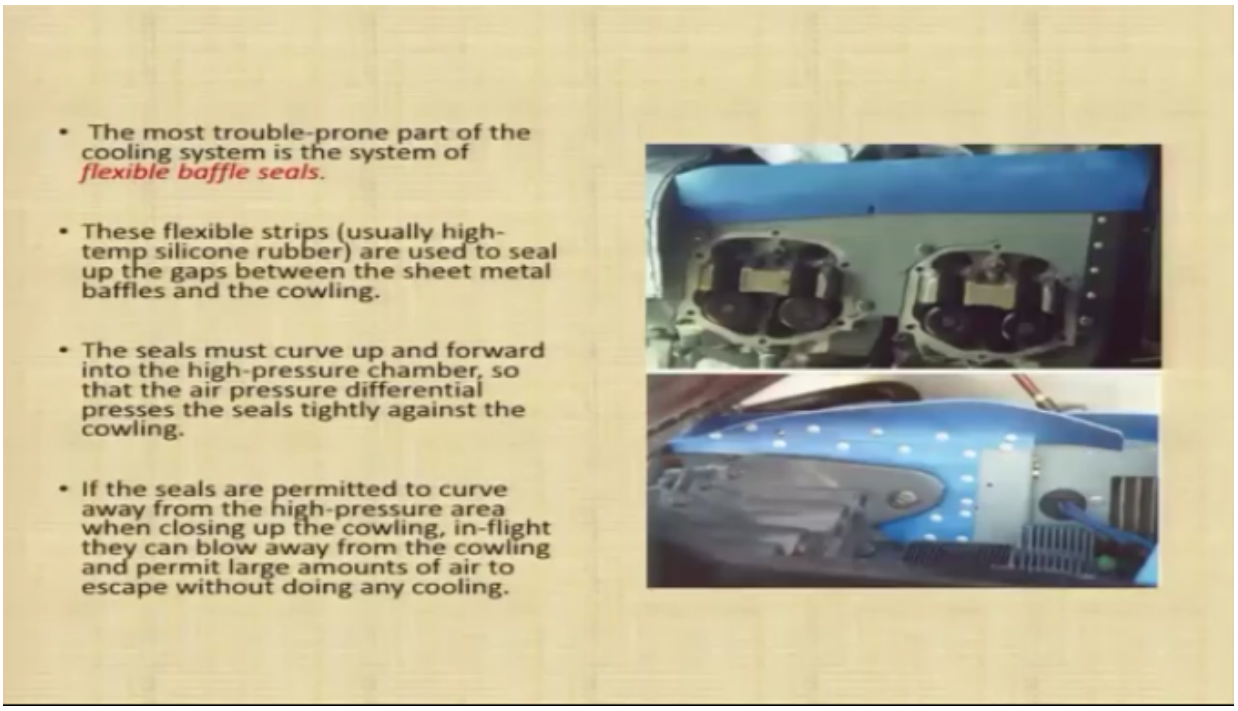

The most trouble-prone part of the cooling system is the system of flexible baffle seals, now here you can see in the diagram metallic fittings they are your baffles over the cylinder you can see and on top of these metallic baffles you have the flexible baffle seals.

Now we are talking about these flexible baffle seals, they are the most trouble-prone part of the cooling system.

These flexible strips they are usually high temperature silicone rubber, they are used to seal up to gaps between the sheet metal baffles and the cowling, so over this you have the cowling over this engine, so in order to seal the gap between these baffles and the cowling these flexible baffle seals are used and these flexible baffle seals are made of high temperature silicone rubber.

The seals must curve up and forward into the high pressure chamber, so that the air pressure differential presses the seals tightly against the cowling, so these seals they must curve up into the high pressure chamber so that the pressure differential presses the seals tightly against the cowling.

If the seals are permitted to curve away from the high-pressure area, when closing up the cowling, in flight they can blow away from the cowling and permit large amounts of air to escape without doing any cooling, so we see that apart from these rubber seals it is very important that these seals they curve up into the high pressure chamber, in case if they curve up away from the high pressure area then the air will blow away from the cowling and permit large amount of air to escape without doing any cooling.

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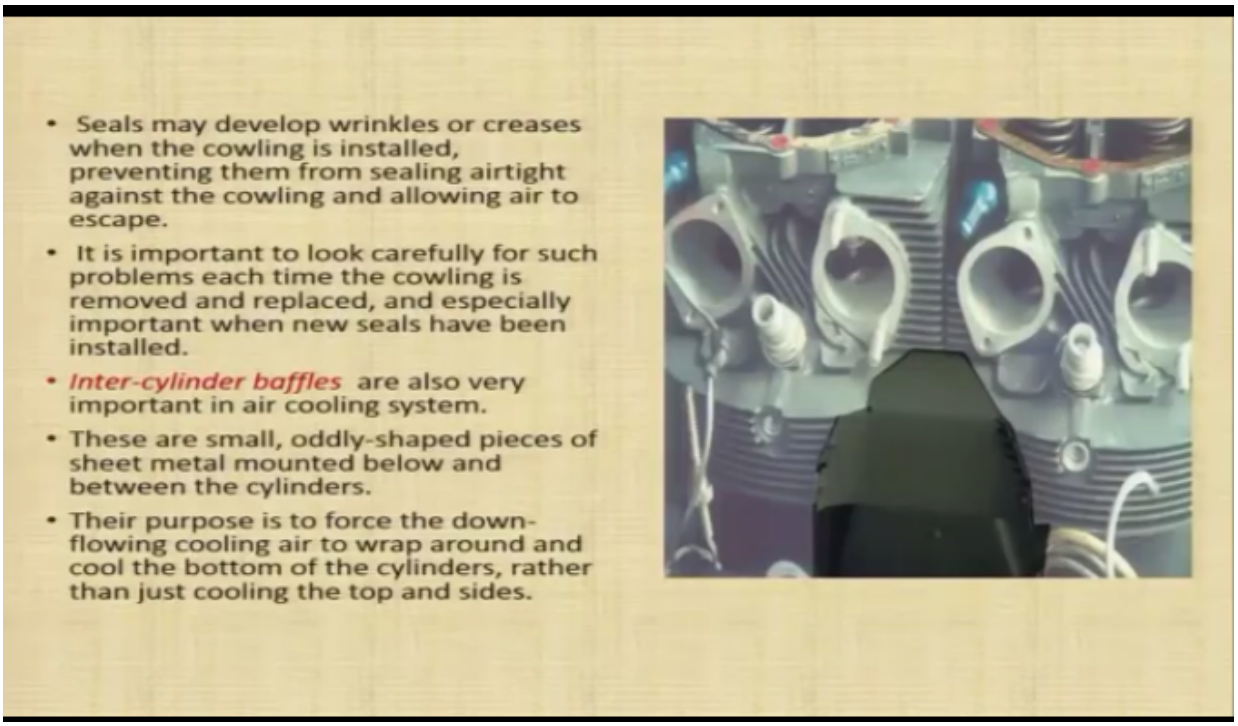

Seals may develop wrinkles or creases when the cowling is installed, preventing them from sealing airtight against the cowling and allowing air to escape, so these seals, this flexible seals they may have wrinkles, these flexible seals they may have wrinkles or creases when the cowling is installed and thus it will prevent them from sealing airtight against the cowling and will allow air to escape.

It is important to look carefully for such problems, each time the cowling is removed and replaced, and especially important when new seals have been installed, so it is a very important part of inspection to look for these flexible rubber seals that an the curve whether they are curved into the high pressure area.

Another thing inter-cylinder baffles, now the baffles between the two cylinders you can see in this diagram there are two cylinders adjacent to each other and in between them you have a baffle, so the inter-cylinder baffles are also very important in air-cooling system, so these inter-cylinder baffles they are also very important, these are small, oddly-shaped pieces of sheet metal mounted below and between the cylinders, so these are sheet metals mounted below and between the cylinders, so in between the two cylinders these are mounted.

Their purpose is to force the down flowing cooling air to wrap around and cool the bottom for the cylinders, rather than just cooling the top and sides.

So in order to ensure that the bottom of the cylinders is also cooled, so these inter-cylinder baffles they force the down flowing cooling air to wrap around and cool the bottom of the cylinders, rather than just cooling the top and sides, so this inter-cylinder baffle this is cooling the lower portion or the bottom portion of the cylinders also.

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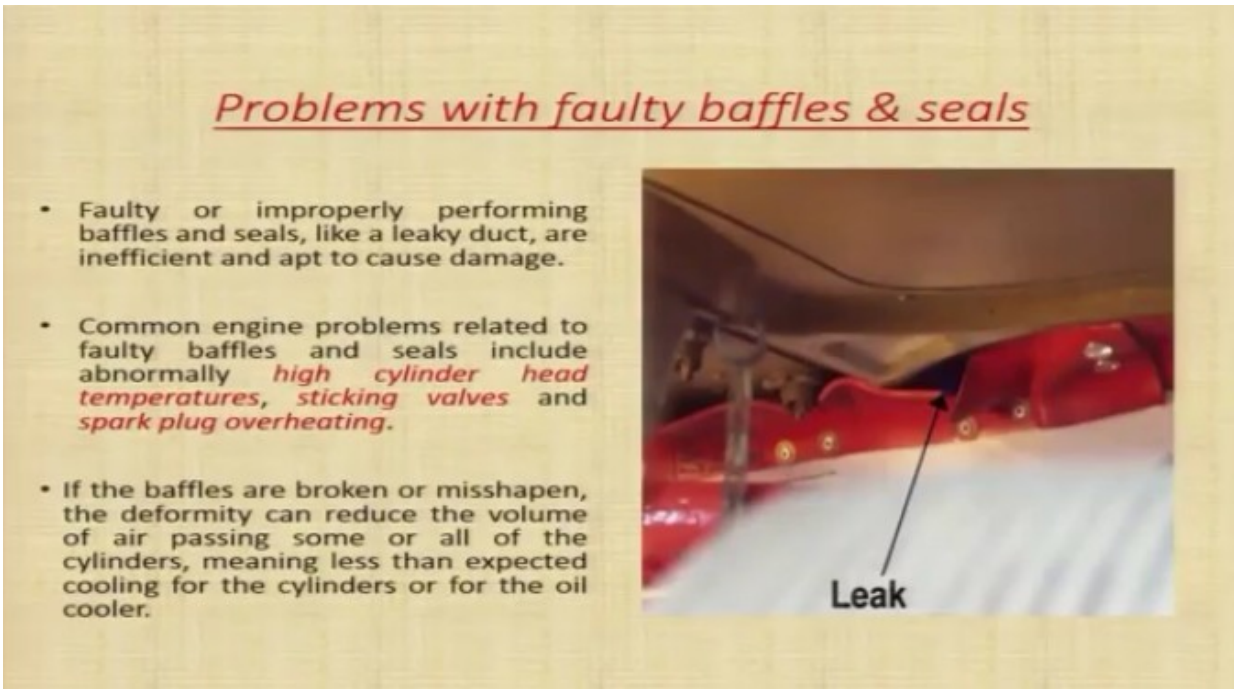

Now let us see what are the problems with faulty baffles and seals, faulty or improperly performing baffles and seals, like a leaky duct are inefficient and apt to cause damage, so you can see here in the diagram this is your aluminum metal plate which is the baffle, on top of the baffle you have the flexible rubber seal, and on top of that you can see this is your upper portion of the cowling, the engine cooling.

Now this slide you can see there is an opening here, so this provides the path for inner to leak, and you see that faulty or improperly performing baffles and seals they are like leaky duct and they provide inefficient cooling and can cause further damage.

Common engine problems related to faulty baffles and seals include abnormally high cylinder head temperatures, now when you are not having sufficient cooling the problems that may be encountered are high cylinder head temperatures, sticking valves and spark plug overheating, so some of the problems high cylinder head temperatures, sticking valves and spark plug overheating.

If the baffles are broken or misshapen, the deformity can reduce the volume of air passing some or all of the cylinders, now if these baffles they are broken or they are misshaped then your air, sufficient air will not flow over the cylinders and that means that less than expected cooling for the cylinders or for the oil cooler.

Now since sufficient cooling is not happening, air is leaking from this opening, so you will have less than expected cooling of the cylinders or the oil cooler.

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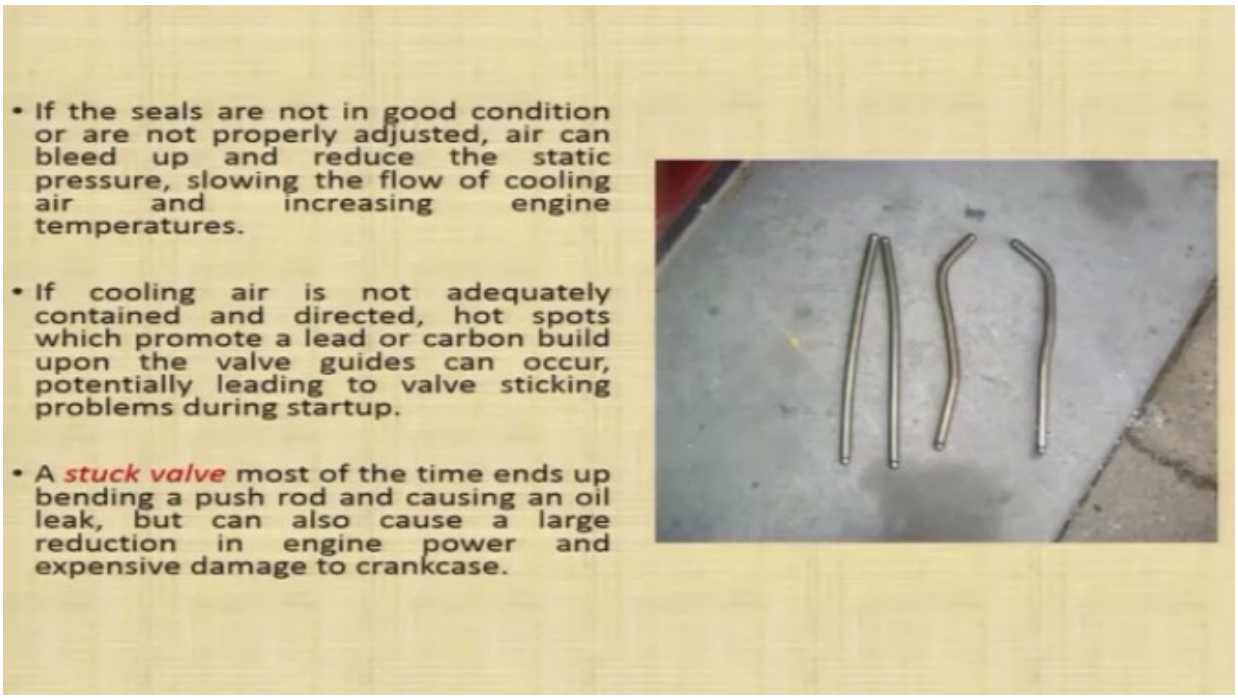

If the seals are not in good condition or are not properly adjusted, air can bleed up and reduce the static pressure, slowing the flow of cooling air and increasing engine temperatures, now if the seals are not in good condition, seals when we say that these flexible seals they are not in good condition and are not properly adjusted, now air can bleed up, air will bleed up through the leak, through the openings, and it will reduce the static pressure, it will reduce the static pressure, the high pressure above, which is formed over the cylinders it will reduce that pressure, slowing the flow of cooling air, because of that your flow of cooling air will be slowed and resulting an insufficient cooling and finally increasing the engine temperature. So we can see that just a small opening, just a small opening, small leak in the engine baffle can cause so much of problem.

If cooling air is not adequately contained and direct, hot spots which promote a lead or carbon build up upon the valve guides can occur, potentially leading to valve sticking problems during startup, now if the cooling air is not contained and directed then the hot spots maybe there on the cylinders, that they can lead to carbon build up on the valve guides and can lead to valve sticking during engine startup.

A stuck valve most of the time ends up bending a push rod, so in case if your valves are stuck they can finally result in bending of push rods, in the figure you can see some of the push rods that were bend, you can see some of the examples how badly they can be bend, and bending of these push rods will cause an oil leak, but can cause a large reduction in engine power and expensive damaged to crankcase.

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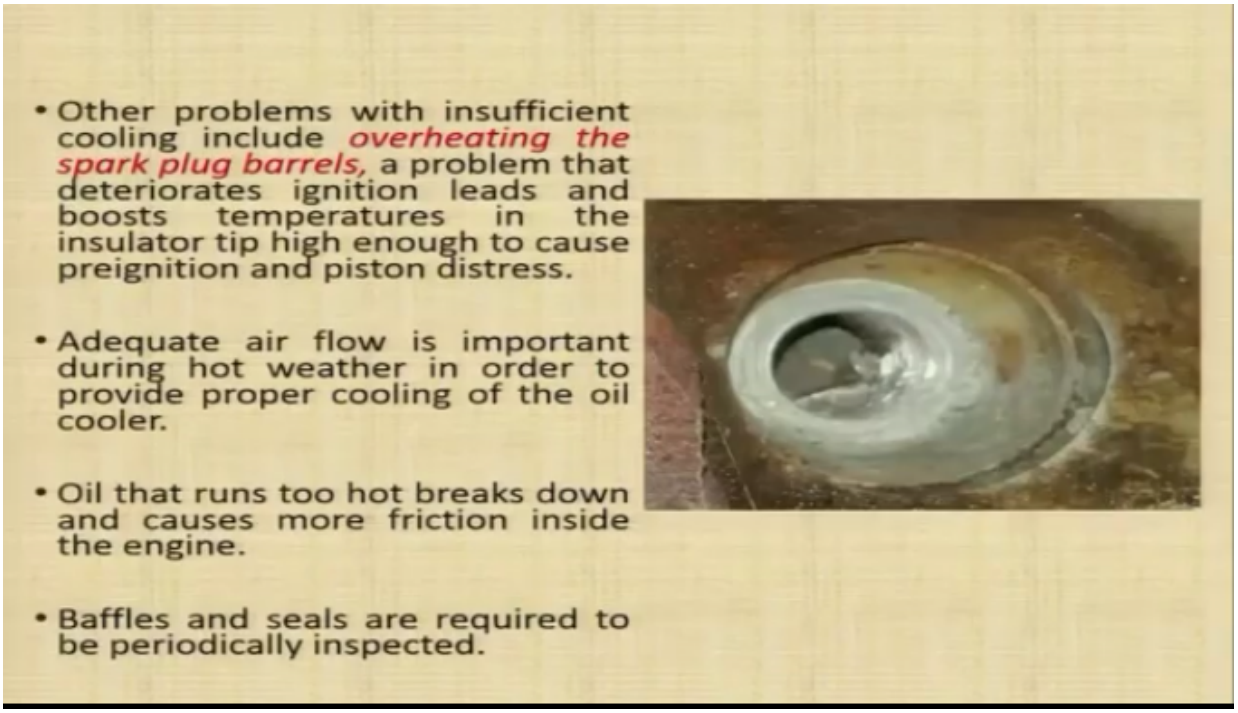

Other problems with insufficient cooling include overheating the spark plug barrels, now in sufficient cooling you can see this is your spark plug place where your spark plug is fitted, so insufficient cooling can overheat the spark plug barrel, a problem that will deteriorate your ignition leads and boost temperatures in the insulator tip high enough to cause pre-ignition and piston distress, so these overheating of spark plug barrels will deteriorate your ignition leads and it can increase the temperatures in the insulator tip which will be high enough to cause pre-ignition and piston distress.

Adequate air flow is important during hot weather in order to provide proper cooling of the oil cooler, so in case of hot weather operation we need sufficient air so that proper cooling of the oil cooler is done.

Oil that runs too hot breaks down and causes more friction inside the engine, now if we do not have sufficient air to flow through the oil cooler, then your oil will run hot and oil that runs too hot will break down and cause friction inside the engine, so for that reason baffles and seals they should be periodically inspected and we need to be very careful about them.

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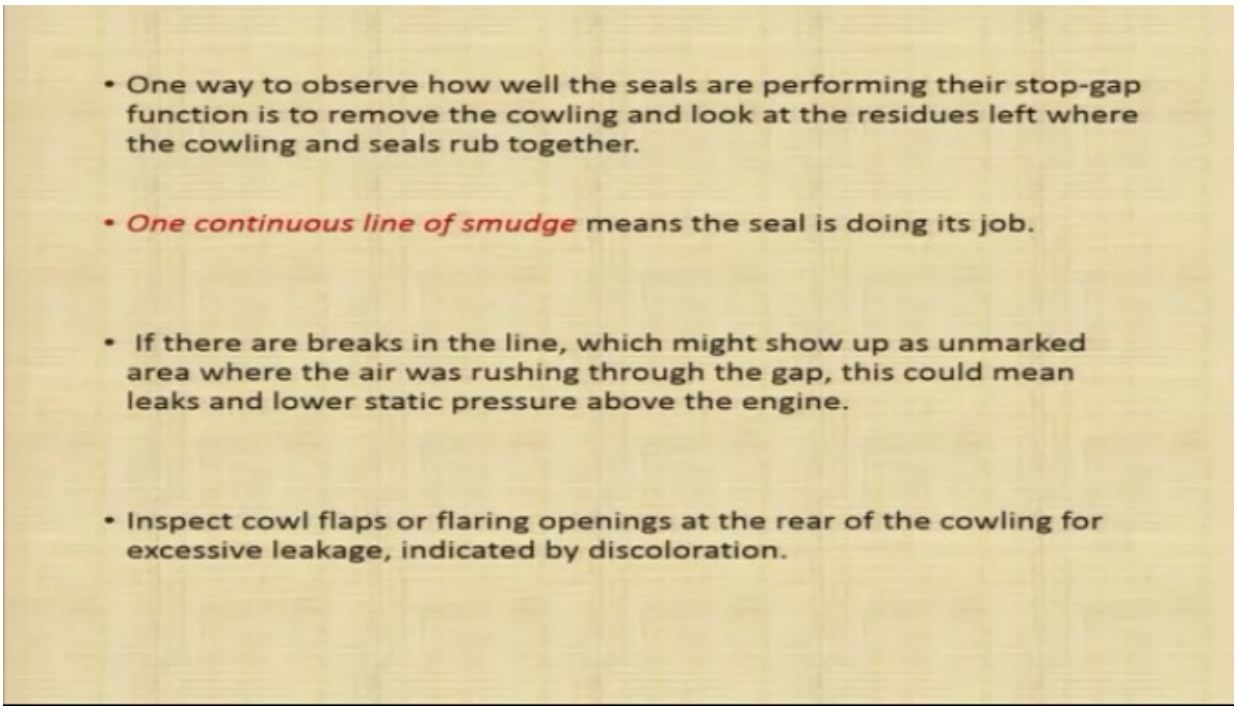

One way to observe how well the seals are performing their stop-gap function is to remove the cowling and look at the residues left where the cowling and seals rub together, so we need to ensure that the cooling system is working properly, the baffles and seals they are no leaks in the system, so one way is to see that the residues left where the cowling and seals rub together, we need to check the pattern of the residue left.

So one continuous line of smudge means the seal is doing its job, so now in case if on the cowling we are able to observe one continuous line that means your seal is doing its job.

If there are breaks in the line which might show up as unmarked area where the air was rushing through the gap, this could mean leaks and lower static pressure above the engine, now in case if you are not able to get the continuous line over the cowling that means your air is leaking, is rushing out through the gap and is not providing sufficient cooling.

Inspect cowl flaps or flaring openings at the rear of the cowling for excessive leakage, indicated by discoloration, so the cowl flaps they should also be inspected for excessive leakage and for any discoloration.

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Now coming to the engine cylinders, we have seen in our previous videos, we have seen the cylinders, we have seen the cooling fins of the cylinders, now the cooling fins they are of utmost importance with the cooling system, since they provide a means of transferring the cylinder heat to the air, now you can see this is the diagram of a cylinder and on top of the cylinder you can see the fins, these fins they provide a means of transferring the cylinder heat to the air, so now air is directed to flow over this cylinder.

That condition can mean the difference between adequate or inadequate cylinder cooling, so these fins, the condition of the fins this is very, very important and it can leak to adequate or inadequate cylinder cooling

The fins are inspected at each regular inspection, so this fins they are to inspected at regular inspections. Fin area is the total area for both sides of the fin, so both sides of the fin since air is flowing through the fins of both sides of the fin that is your total area which is exposed to the air.

During the inspection, the fins should be examined for cracks and breaks, so we need to be very particular during the inspection about the cracks and the breaks of the cylinder fins.

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Small cracks are not a reason for cylinder removal, so in case you have small cracks on the fins, they are still permissible if they are within the limits, and we need not remove the cylinder, these cracks can be filled or even sometimes stop-drilled to prevent any further cracking, so in case of any crack we can still address that problem, in case if it is within the limits, and we need not remove the cylinder.

But rough or sharp corners on fins can be smooth out by filling, and this action eliminates a possible source of new cracks, so any rough or sharp corner on the fin it can be smooth out by filling it and it will eliminate a possible source of new cracks, so in case if we don't do that, if we don't sharpen out or if we don't smooth out that filing, then rough or sharp corner then it can further result in some cracks, so once the corner or the rough or sharp corner is filled, is the smooth out then that crack can be avoided.

However before re-profiling cylinder cooling fins, consult the manufacturer's service or overhaul manual for the allowable limits, so as we have said that in case if the cracks are within the limits, then it is permissible, so these limits we need to check from the manufacturer's service manuals or overhaul manuals, we need to check what limits have been prescribed by the manufacturer and if the damage or if the rough or sharp corner or the crack is within that limit specified by the manufacturer that the cylinder can be used.

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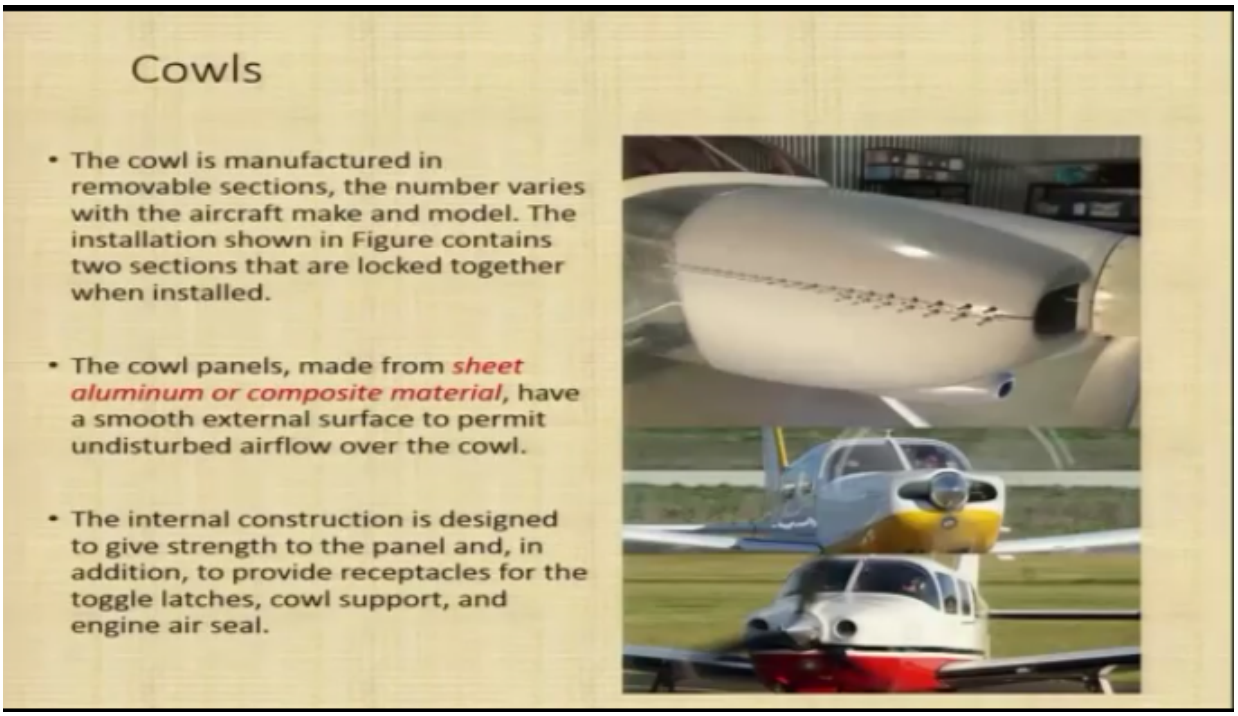

Now coming to cowlings, we can see in the figures these are your cowlings, this is your upper cowling and this is your lower cowling, this cowling this is used to cover the engine and it is provided in aerodynamic shape so that you have smooth airflow, and here you can see this is your opening that air goes inside the cowling to this opening to provide cooling of the engine.

The cowl is manufactured in removable sections, the number varies with the aircraft make and model, so different manufacturers they provide different types of cowling, but mostly they are provided in sections in the removable sections.

The installation shown in figure contains two sections that are locked together when installed, so this figure this is showing two sections, one is the top section, and one is the bottom section, and the two sections they are locked at this point, these are your fasteners which run the cowling the two sections together.

The cowl panels made from sheet aluminum or composite material have a smooth external surface to permit undisturbed airflow over the cowling, so these are made of heat aluminum or composite material and they are provided the smooth external surface to permit undisturbed airflow over the cowling.

The internal construction is designed to give strength to the panel and in addition to provide receptacles for the toggle latches, cowl support and engine air seal, so your internal construction is also designed to give strength to the panel and it further provides receptacles for the toggle latches, cowl support and engine air seal.

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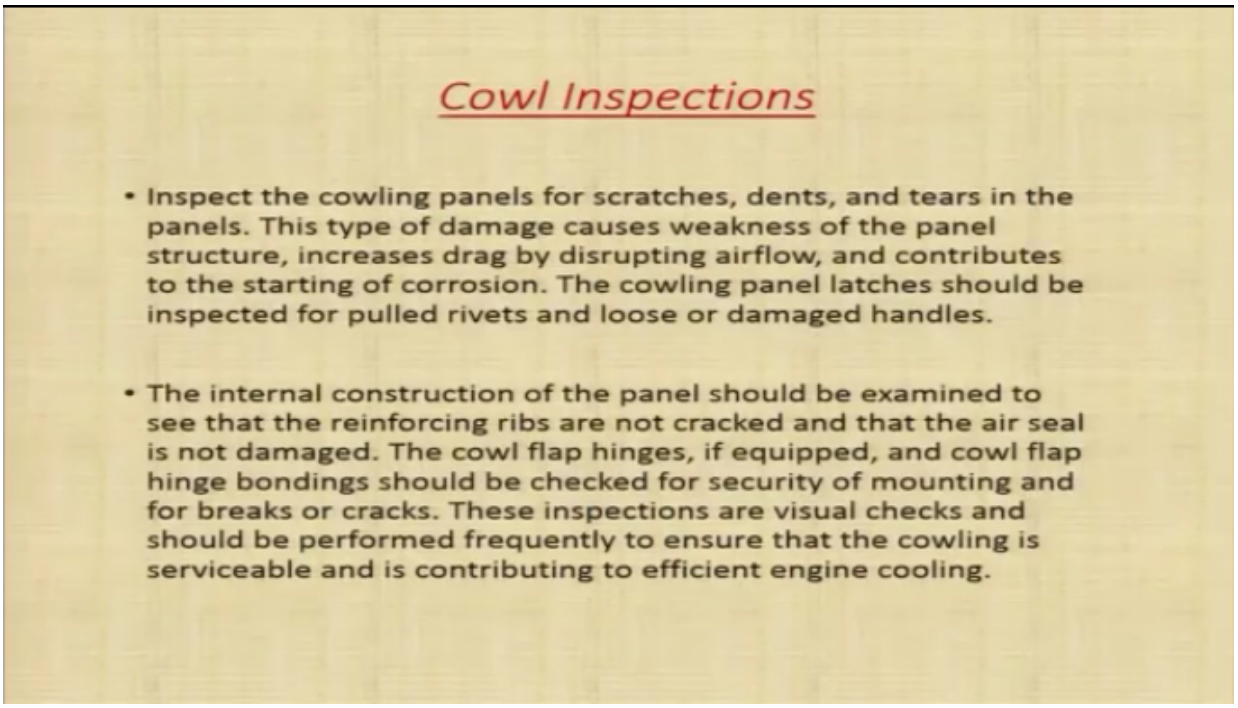

Cowl inspections, now what are the inspections to be done on these cowls? Inspect the cowling panels for scratches, dents, and tears in the panels, so we need to check, we need to inspect these cowlings for any scratch, any dent, or any tear or in the panel, this type of damage causes weakness of the panel structure, increases drag by disrupting airflow, and contributes to the starting of corrosion, now in case if there is any type of damage like in case if there is scratch, in case if there is dent, in case there is a tear in the panel, then this will cause the weakness of the panel structure, this will leaking your cowling structure, it will increase the drag by disrupting airflow, now airflow will not be that smooth, so it will increase that and it may further contribute to the starting of corrosion, so corrosion can also result.

The cowling panel latches should be inspected for pulled rivets and loose or damaged handles, now the panel latches they should also be inspected in case if there are rivets which are pulled out or they have loose or damaged handles.

The internal construction of the panel should be examined to see that the reinforcing ribs are not cracked and that the air seal is not damaged. Now this internal construction of the panel this is also to be inspected, to be examined at regular intervals to ensure that the reinforcing ribs they are not cracked and that your air seal is not damaged.

The cowl flap hinges, if equipped and cowl flap hinge bondings should be checked for security of mounting and for breaks or cracks of the cowl flap hinges, very important, they need to be checked for security of mounting and for any crack or break, these inspections are visual inspections and should be performed frequently, these are all visual inspections which are to be done, which are to be performed at regular intervals to ensure that the cowling is serviceable and is contributing to efficient engine cooling, and regular inspections will ensure that your cowling is serviceable and is contributing to efficient engine cooling.

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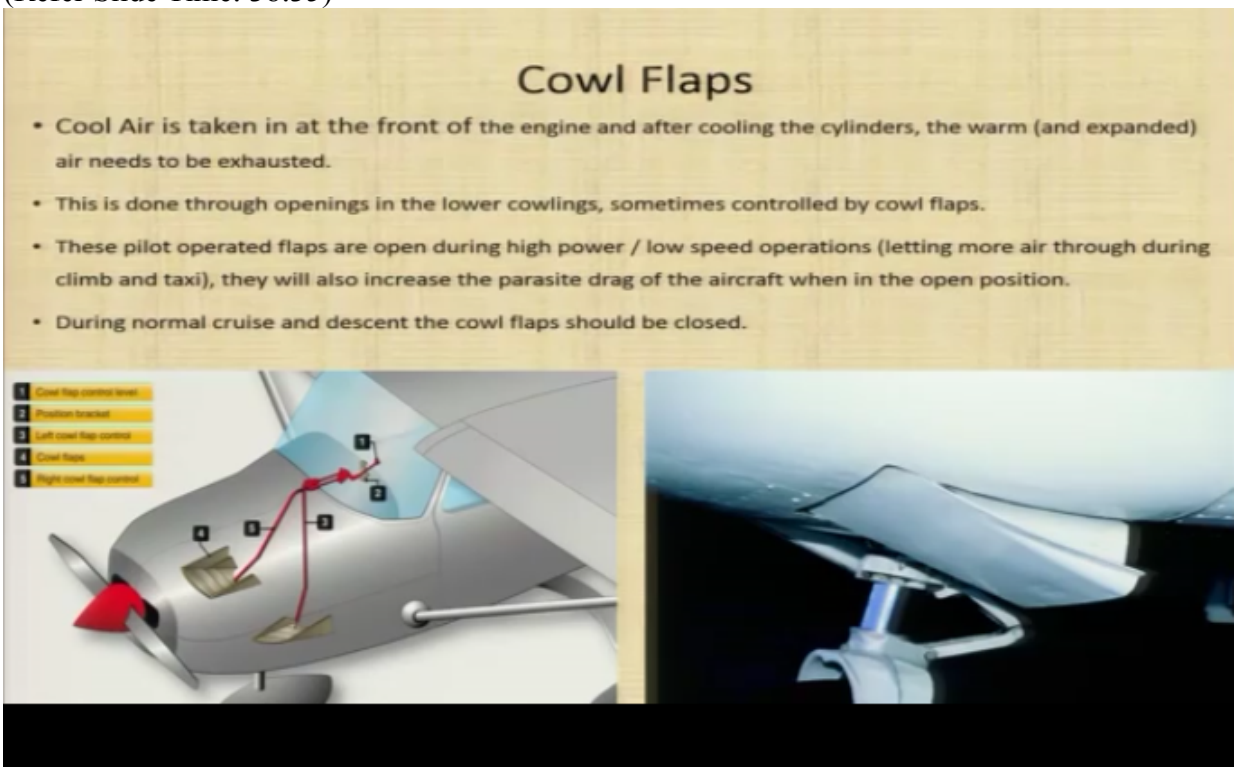

Next is your cowl flaps so this cooling air this is entering through the opening, cooling the complete engine and warm air is coming out, it is done through openings in the lower cowlings, this is done through openings in the lower cowlings and they are controlled, sometimes controlled by these cowl flaps.

These pilot operated flaps are open during high power or low speed operations, letting more air through climb and taxi, they will also increase the parasite drag of the aircraft when in the open position.

Now these cowl flaps they can be open by a control in the cockpit, and are generally used during high power or low speed operations which will allow more air to enter the engine, to enter the cowling, and it will further increase your cooling of the engine, but opening of these cowl flaps they will also increase the parasite drag, this structure is coming out, it is not flush with the cowling, it will act to that.

During normal cruise and descent the cowl flaps should be closed, so during normal operation, during normal cruse and descent the cowl flaps should be in a closed condition to avoid drag, but in case of high power or low speed operation, we can open these cowl flaps and further increase cooling.

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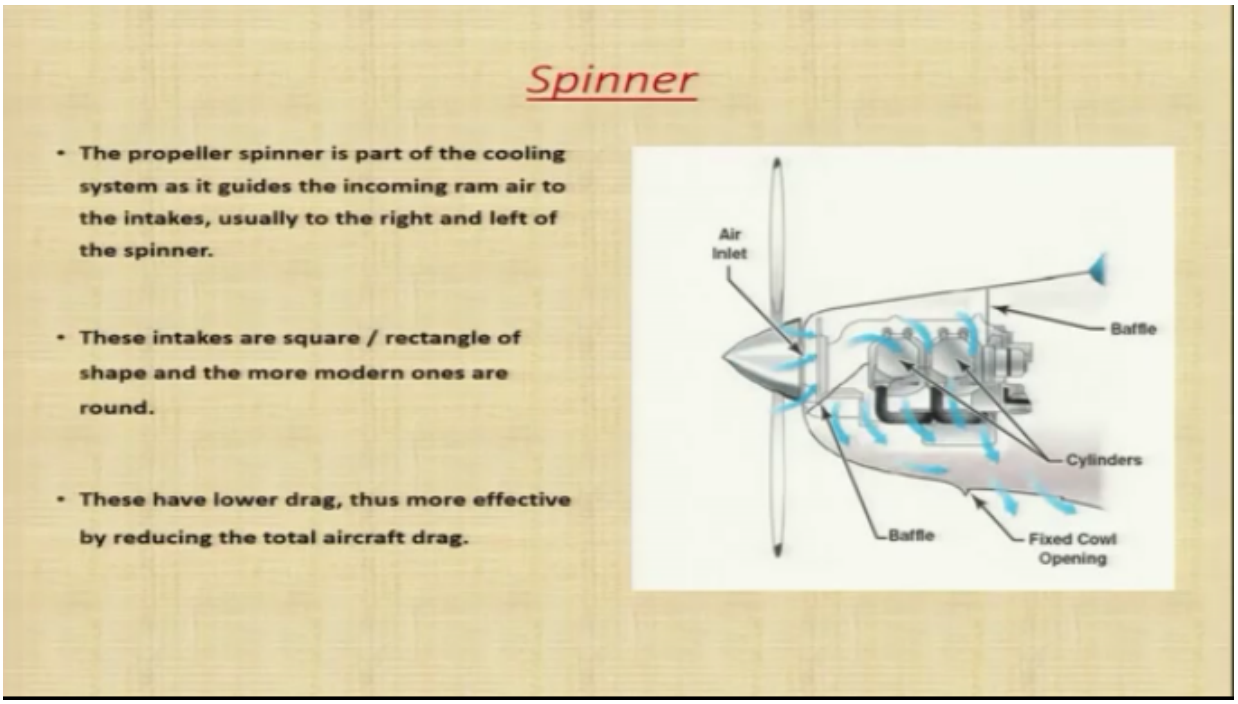

In the figure you can see there is a, this is your propeller and here this is your spinner, this is your spinner, this propeller spinner is also part of the cooling system as it guides the incoming ram air to the intakes, now this aerodynamic shape of the spinner this will guide the intake air, this will guide the intake ram air to the intake of the engine cowling, usually to the right and left of the spinner, so on the right and on the left of the spinner you have the openings, and this the aerodynamic shape of the spinner this will help in directing the air to the intake openings.

These intakes are square, rectangle in shape and the more modern ones are round, so the openings on the cowling these openings they maybe round, they maybe rectangular, but in most modern aircrafts you have round opening.

These have lower drag, thus more effective by reducing the total aircraft drag, so the aerodynamic shape of the spinner, the specially designed opening they reduce drag.

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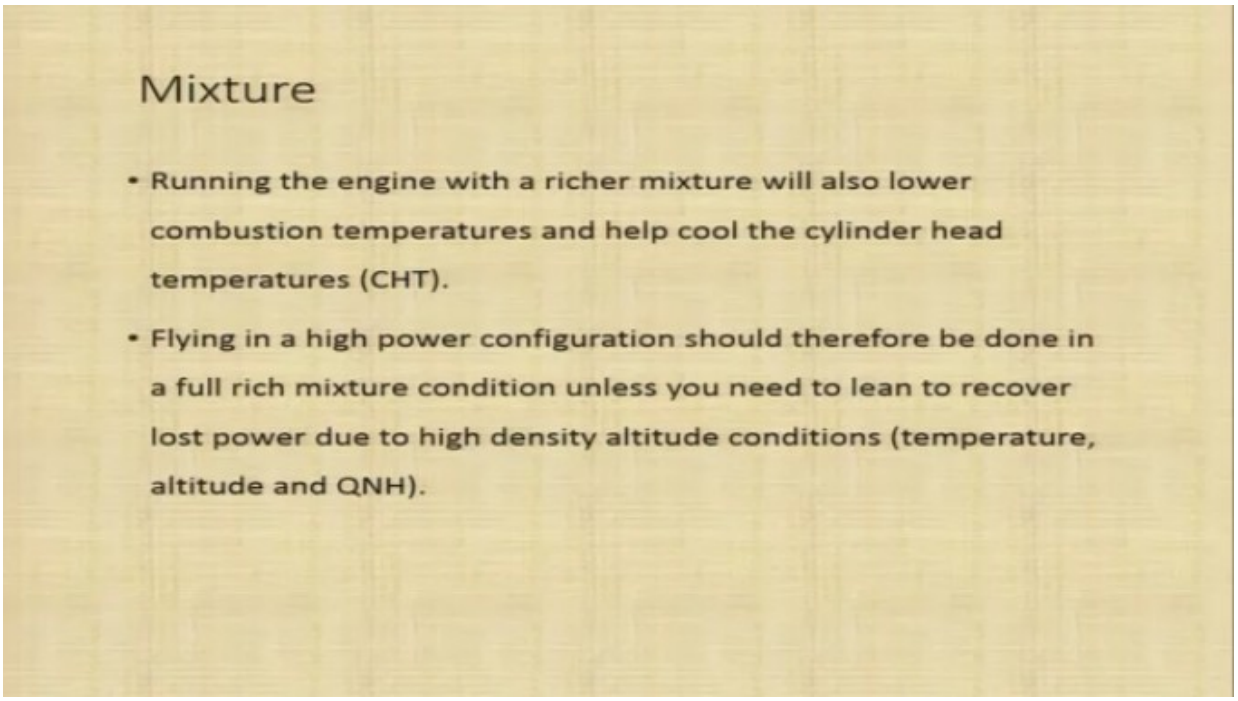

Now fuel air mixture, fuel air mixture this is also an important thing as far as cooling of engine is concerned, running the engine with a richer mixture will also lower the combustion temperatures and help cool the cylinder head temperatures, so in case if we are operating on a rich mixture this will help in cooling the cylinder head temperature.

Flying in a high power configuration should therefore be done in a full rich mixture condition, so in case if we are flying in a high power configuration, which we should be flying in a full rich mixture condition unless you need to lean to recover the lost power due to high density altitude conditions, so this is totally from the operation point of view, we will understand what is fuel air mixture all about in our fuel chapter, in a fuel system chapter, so this is just to mention here that your mixture also plays an important part in cooling of the engine.

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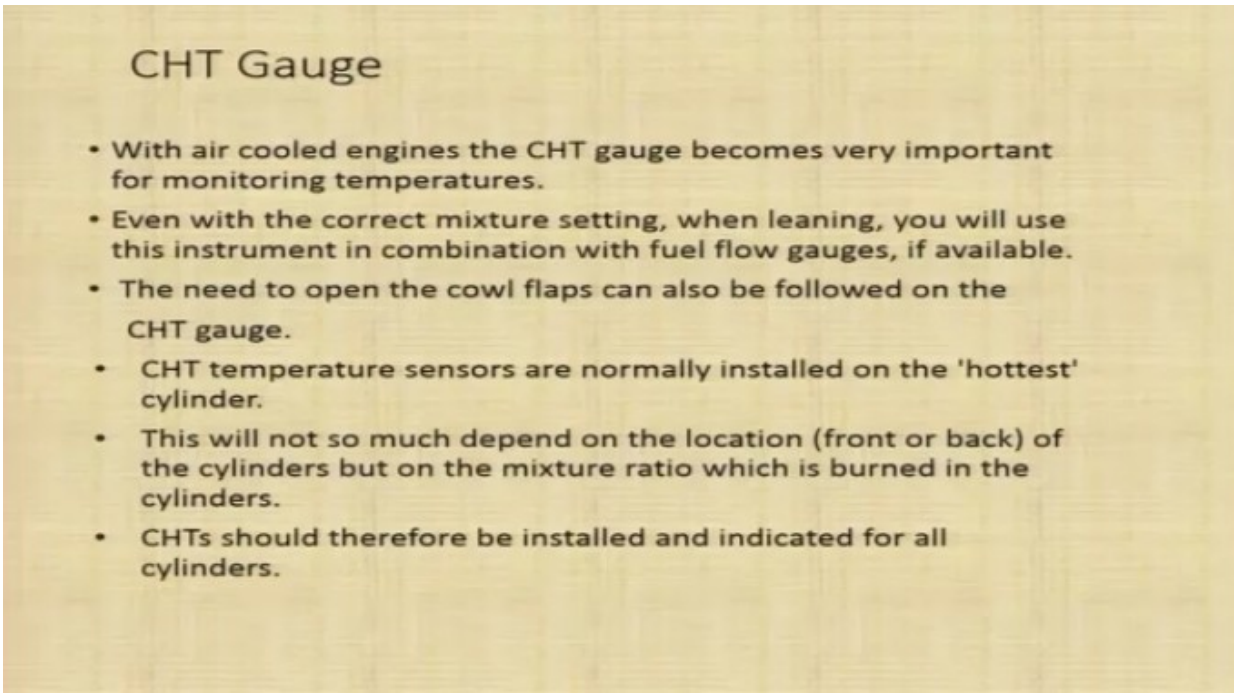

Another important gauge associated with the cooling system is your CHT gauge, with air cooled engines the CHT gauge becomes very important for monitoring temperatures, so in order to monitor the temperature the engine temperature, the cylinder temperatures we have a gauge which is called a CHT gauge or a cylinder head temperature gauge.

Even with the correct mixture setting, when leaning you will use this instrument in combination with fuel flow gauges if available, this is again from the operation point of view this gauge is a very important gauge as far as cooling is concerned, and it is used in combination with fuel flow gauges.

The need to open the cowl flaps can also be followed on the CHT gauge, now CHT temperature sensors are normally installed on the hottest cylinder, so the temperature cylinder head temperature sensor it is generally installed on the hottest cylinder, so however in most of the modern engines we have CHT sensors installed on all the cylinders and we get indication about the CHT temperature for all the cylinders which is a very important from the cooling point of view.

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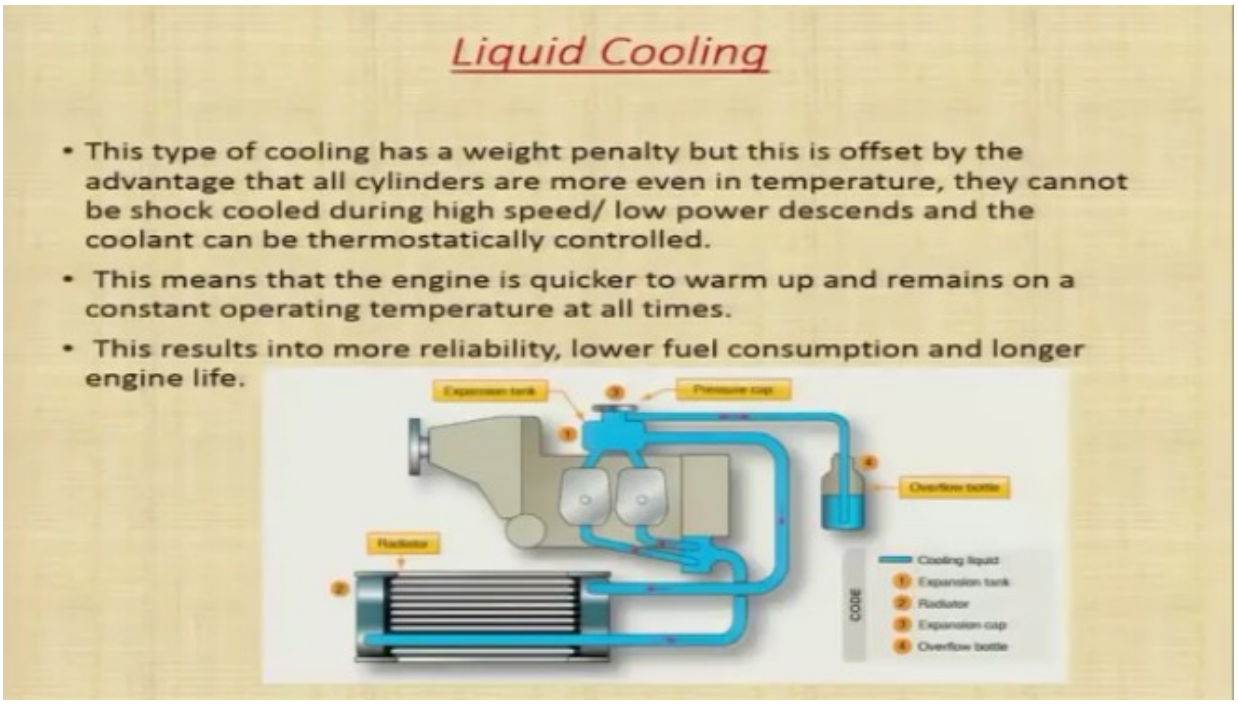

So far we have seen what was air cooling, in our previous slides we had seen that the piston engines, the aircraft piston engines are either air cooled or liquid cooled or we have a combination of air cooling and liquid cooling.

So now we have seen what is air cooling let us see what is liquid cooling and in some of the systems we have a combination of air cooling and liquid cooling, so let us see what is liquid cooling all about.

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
K. K. Mishra
Ashutosh Gairola
Puneet Kumar Bajpai
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
Santosh Nayak
Praduyman Singh Chauhan
Mahendra Singh Rawat
Tushar Srivastava
Uzair Siddiqui
Lalty Dutta
Murali Krishnan
Ganesh Rana
Ajay Kanaujia
Ashwani Srivastava
M.L. Benerjee

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