Introduction to Aircraft Engines

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Hello! My name is Dan Brauhn, I'm an Aviation Maintenance Navy Onyx instructor here at Indian Hills, and I'm going to be your video guide through your Engine Systems class. Want to start off with looking at the different types of engines that you might accustomed to and you might not be accustomed to in your pilot training. This is a standard opposed engine as they use an aviation. This is actually a Lycoming, an IO 360, as installed on a Cessna Cardinal.

So, in aviation there's a lot of different types of engines we've had all over history from 1903 to now. The F.A.A. is really more only concerned with two varieties and that is the horizontally opposed engine and the radial engine. And what makes this a horizontally opposed engine is that, unlike your automobile engine, the cylinders are on either side of the crankshaft. Now if you don't understand that right now we're going to take a look at what's inside the engine a little bit later. So that means the cylinders are opposing each other – you have cylinders over here you have cylinders over here. So, this is an IO and the letters in front of the number give us information on the engine itself. The I means that the engine is injected, it's got a fuel injected system. O means the engine is opposed. And the number after it which is 360, that's going to tell us the cubic inches of displacement in the engine.

So what engine is, hopefully you've done your homework, is a transducer. Just like your microphone how it changes your voice into electric signals and then the speaker changes electric signals into voice. An engine is a device that is transducing. It changes potential energy in fuel and air and heat and turns it into kinetic energy – energy of motion which is thrust in our four forces a flight.

So the 360 in this engine means that the cylinders, that's a unit of volume, will hold 360 cubic inches of air and fuel. So the bigger the engine, the more volume we have, the more energy we can make. So this engine right here will produce anywhere from 145 to about 200 horsepower if you want to think about it that way. But the larger the number, the bigger the engine. For example, the largest engines ever produced are 4360, that's 4,360 cubic inches of displacement which produce about 3,000 horsepower, so that's many, many times this engine right here. This is a very typical engine that's horizontally opposed. Very similar to what you're going to see in your flight training aircraft and most of your general aviation aircraft throughout the industry.

So this is another style of engine, this is actually a radial engine. So this is the other style that the F.A.A. kind of wants you to know about. Again there are many styles – there's V engines like the famous V12 Merlin that was installed at P-51 Mustang, there was an inverted Ranger engine with all cylinders are in line, again in aviation there's always so many different engineering ways to come up with the same solution but we're sticking on the two most common, which is the horizontally opposed engine and the radial. So the difference is that rather than the cylinders being laid out horizontally, the cylinders are laid out radially in a circle and so the crankshaft goes up and around. Now you notice the deep grooves on the cylinders. This engine is our 985, so as I said on the O360, the number on the back of the engine represents the displacement. So this engine displaces 985 cubic inches so this engine will produce around 300 horsepower give or take.

But the fins on the cylinders which makes it a little bit different in aviation engines then in automotive engines, automotive engines are cooled using liquid, using antifreeze. Radial engines and horizontally oppose engines aircraft engines, we have this big giant fan here and yes it's making thrust, we also use that air that it's moving to help cool the engines and that ends up saving weight because fluid is heavy and so are the resulting systems so unless you are in the Reno Air Races going for speed, an air cooled engine is the way to go in aircraft – it saves weight and saves complexity. So, this is a radial engine. Not used too much unless you're flying in Alaska or you're working on warbirds but it's still a viable engine and there were so many produced during the war years that there's actually brand new engines in containers ready to be opened, look brand new just as they did a day and they were manufactured in the 1940s and 1950s. They'll still be around for several years.

Besides reciprocating engines, the radial, and the opposed, the other variety of engine we use in aircraft are the turbo jet engines or the turbine engines. There are actually four different varieties of gas turbine engines that are used in aircraft. This is the earliest type, this is a turbo jet engine, and we'll the talk about the different types. The jet engine makes power or generates thrust in a slightly different method than the reciprocating engines and we'll discuss that on some later sections further in the course. But a turbo jet engine basically pulls air in the front and rather than having a piston inside a cylinder to smash the air, it actually has a series of rotating blades and the blades compress the air, we add fuel, we ignite it, and then blow it out the back, and due to Newton's third law, thrust out the back pushes forward, the engine is hopefully attached to the airplane, the airplane goes along with the engine, that's how it works. With the jet engines we can usually gain much more horsepower, but at the cost of massive amounts of fuel consumption. That's why jet engines will usually burn a cheaper kerosene or Jet A fuel, whereas the reciprocating engines will burn a higher refined aviation grade gasoline.

So this is a Westinghouse turbo jet. There's only really only two types of primarily jet engines that are used for thrust production on aircraft, and one is the turbo jet, the other is the turbofan. The difference between the turbo jet and the turbo fan is the turbojet is a pure action-reaction device. All the air that comes into the inlet of the engine is compressed and turned into thrust out the back, and the turbo fan engine we use some of the air that comes through the engine to make thrust and then we use some of the air to turn a rotating wheel called the turbine to turn a gigantic fan which is really a very advanced propeller, and we use that to make more thrust than we do action reaction. So this is a turbojet. We don't use too many turbojets in aviation much anymore – this was the very first jet type that was developed during World War II in the 1940s. This engine model here, this Westinghouse, was actually produced in 1953. This engine produces 3,000 pounds of thrust at 100% power and that equates to about 1,700 shaft horsepower.

So turbo fan engines are another subdivision of the jet engine variety and it's the trouble fan engine that are primarily used on airliners and aircraft today. The turbo fans are actually divided into three categories based on the amount of airflow that either goes through the engine to produce thrust or then around the engine through a fan to make thrust that way, and it's based on a ratio of the airflow, so you have a low bypass, a medium bypass, and a high bypass fan engine. The smaller the fan, the lower the bypass, the lower the ratio. Low bypass fans are usually used in aircraft in fighter engines – they give us more efficiency, but they also give us very high speeds. Medium bypass and high bypass fans are used more on commercial airliners and business jets. This is a medium bypass fan engine – this is a Pratt and Whitney JTD, and this engine actually came off of a Boeing 727. There were more of this type of engine on aircraft from the 1960s to the 1970s than almost any other type of engine produced. A JT8D produces about 15,000 pounds of thrust. So I showed you that 3,000 pound thrust Westinghouse J37, so this guy's five times that and most of the power difference comes from the use of energy in a fan and not just pure action-reaction. These engines were used on DC-9s DC-8s. They were used on 727s and all the early 737s, so there is so many of these engines out there and so many of these engines are still used today in actually modern varieties.

According to the F.A.A., the engine is referred to as the power plant and that's a really good way of thinking about it. The engine is almost truly the heart of the aircraft. Not only is it making thrust that provides the air speed for the wings to function, but it also provides shaft horsepower to turn things like our generator which makes electricity for our aircraft, our hydraulics comes from a pump which is run by the engine, we have oil and fuel pumps – all of these receive their power from the powerplant. Most of the time these accessories that they're called are driven by a gearbox, an accessory gearbox. In reciprocating engines, this gearbox is usually located on the back of the engine. On jet engines you have an open hole in the back of the engine so the accessory gearboxes are located usually down on the bottom where the technicians can gain access to these very important pieces of equipment, again maintaining the powerplant of the aircraft.

This is a high bypass fan engine, so this is a turbo fan a high bypass turbo fan, and you can see the size of the fan – this is a very large diameter. This engine produces about 56,000 pounds of thrust as opposed to the medium bypass engine I showed you produced 15,000 pounds of thrust. These are the engines that are used for the heavy airliners. This engine here was actually used on DC-10 aircraft, 747s, and they're different derivatives of large airliners.

So it is again, it is this fan, which is making thrust and compressing the air using a turbine principle, but we're using the turbine to actually spin this highly efficient propeller in the front, and that's what's giving us the most of the thrust. The engines here in current incarnations, this is a General Electric CF-6, the newest incarnation the CF-8, and the newer version the GE-90 which is on the Boeing 777 – those engines, that engine has a thrust rating of 150,000 pounds of thrust and is one of the most efficient engines ever made by man, and has a fuel consumption ratio that is lower and gives us more output than any other energy changing device we currently have for making propulsive force.

This is a turbo prop engine. This is also used on a lot of aircraft. Like our reciprocating engines what we're doing is the engine is making shaft horsepower, not to make thrust but to turn a propeller. The propeller would be attached here on this drive shaft. We're not using cylinders like we are in the reciprocating engine, we're using turbine theory so we're pulling air in, and we're smashing it with compressors, and adding fuel, but then we're using that energy to not create thrust but then we're going to use all of that to turn the propeller. This is a very cost effective way, again because the turbine theory of producing propulsion is a lot better than reciprocating concept and by turning the propeller you can get a lot higher speeds then a recip at much lower costs, and the problem is that your turbo prop can't go very high because again, what we're using is a propeller and we're limited by the aerodynamics of the propeller on how high we can go and how fast we can go. The turbo props live on a lot of aircraft, business aircraft, this is a Pratt and Whitney PT-6. This powers the Beechcraft King Air and there's lots of those out there. They also power your air tractors, your crop dusters – most of them are either powered by radio reciprocating engines or by these Pratt and Whitney turbo prop style engines. Now this is a Pratt and Whitney PT-6. It produces shaft horsepower, about 300 shaft horsepower. They make turbo prop engines that are incredibly large that will produce 3,000 shaft horsepower using very large propellers. Most of those aircraft aren't used anymore. They use them for heavy hauling air in the military transports. Most of the engines this size are used on either business type jets or commuter airliners where we see the propeller. So if you see a commuter airliner most of the time they're actually jet engines turning the propeller and not reciprocating engines.

So back here this is the accessory gearbox section of the engine. As I mentioned earlier, this is where we use some of the horsepower, the shaft horsepower from the engine to run other systems on the aircraft. For example, this is our hydraulic pump which is going to provide hydraulic power to the flight controls. Here's an oil pump which is going to provide oil flow to the engine – pretty important. This is our fuel pump and our fuel controller. The fuel pump is going to pull fuel from the engine using rotating veins that are driven by the engine's horsepower through the gearbox. What we're missing right here is actually the generator or the alternator, and this would plug in here, and this is where it would generate electricity for the aircraft – all comes from the powerplant accessory gearbox.

This is an Allison 250. This is a turbo shaft engine. This is the last but obviously not the least of our jet engine varieties. It doesn't make thrust nor does the turn a propeller. The purpose of this engine is to make shaft horsepower that we extract using drive shafts to do different things. This is actually a helicopter engine, so what this engine is used for, is again to make shaft horsepower to turn a drive shaft that comes out of the accessory gearbox that runs to the helicopter's transmission. The helicopter's transmission then steps down the speed of the engine to run the rotor blades and that's how it's done. The other place where we see a lot of turbo shaft engines are on larger aircraft that have what's known as an auxiliary power unit. An auxiliary power unit is a jet engine like this turbo shaft engine. It's not used to make thrust, but what we use it for is to make air, actually that we're used to cool and/or heat the passenger cabin when the main engines aren't on, and also we use it to turn a generator to provide electricity when the main engines aren't on.

So when you go to a commercial airliner and the main engines aren't running and you wonder why it has power you hear a loud screaming noise and there's probably one of these – a turbo shaft engine running in the back of the aircraft.

So this is a turbo shaft engine as installed on our Bell UH-1 Huey. This turbo shaft engine is actually made by Lycoming. Again, this engine does not make thrust even though it's got a neat little exhaust up in the back. It's just to send the hot exhaust gas out. The energy is produced to drive a drive shaft which runs into the transmission, and the transmission turns around rotor blades. This engine does not make any thrust. So most modern helicopters use a turbojet, turbo shaft engine, as their powerplant.

This concludes the introductory on engine types and varieties, We looked at reciprocating engines, we looked at horizontally opposed engines and radial engines, and we looked at the different types of jet engines or turbojet engines, turbo fan engines, turbo prop engines, and turbo shaft engines.

So in conclusion, the engine is the powerplant of the airframe. It's making the thrust, it's turning the systems that give us energy and power to the airframe. But if the engine is the heart of the powerplant, the pilot is the soul of the aircraft. Next time are going to look more into the internal workings of the different engine varieties starting with reciprocating engines and then switching to inside jet engine theory.
