Reciprocating Engines Construction and Operation

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Last learning unit we looked at the different types of injuries that were used in aircraft. Today we're going to look at specifically the reciprocating engine internal mechanisms and components and how we extract power to produce thrust for our aircraft. So we're going to look specifically at the parts and pieces in the reciprocating engine. So as I said last time, what an engine does is it's a device for transferring of power. So we're going to take fuel air mixture and we're going to compress it and then we're going to ignite it, and we're going to use that to move our crankshaft which then moves our propeller to make thrust for our aircraft. The power extraction is done primarily in the aircraft cylinder. This is an aircraft cylinder. It has a barrel and the head. The cylinder barrel is made out of steel, the cylinder head is made out of aluminum primarily to dissipate the heat during combustion.

Inside the cylinder is our piston. The piston rides inside the cylinder; it fits right in here. And it's connected to the crankshaft using a wrist pin and a drive and it'll attach to the crankshaft, like so. So the piston is moving internally inside the cylinder through, in an aircraft we use four cycle five events. In our five cycles we have induction, compression, ignition, power, and exhaust are five events of the four cycle engine. Most aircraft engines are four cycle there are some two cycle engines that we use in some light sport aircraft and in experimental aircraft; the most production type certified aircraft used four cycle engine. So we're pulling the fuel air mixture into the cylinder so you can compress it with the piston through an intake valve. The intake valve is located on top. The intake valve and the exhaust valve are moved in an intricate sequence of the five events. There are times through a rotating cam, this is a camshaft. The camshaft rotates with gearing to the crank shaft and we have what's known as the valve train. So we have a cam follower that rides on these cam lobes which look like little tear drops as the cam rotates to the top it pushes up against the pushrod against a rocker arm which then pushes the on the exhaust valve, opening it and closing it, opening the intake valve as well in the specific sequence to keep the correct five events in order for the four stroke, four cycle engine. So as the air is pulled into the cylinder we're going to use basic physics of the universal gas laws. So what we're going to do first with what the fuel air mixture is the piston is going to be all the way down at the bottom so we can get the most amount of air per given volume. Then as the piston moves from what's known as the bottom dead center, let's get my connecting rod in place here, so it moves from bottom dead center it's going to rotate to the top to top dead center as it goes down then it comes up. As it moves from the bottom to the top, the fuel air mixture is compressed. As the fuel air mixture is compressed the piston is going up inside the cylinder, the air has nowhere to go. As we enclose the volume by universal gas law, pressure must increase. As we increase the amount of pressure, we increase the potential energy that we can extract. We also create heat. So as the piston comes up and smashes the air once it gets to the maximum amount of compression and potential energy we ignite it using a spark created by a magneto that ignites the fuel air mixture. The piston is then slammed down by the explosion against our connecting rod and then basically throws the crank shaft into the next rotation.

As the piston goes down, we've exhausted the potential of the fuel air mixture inside here – it's now burnt, doesn't have an oxygen so the exhaust valve opens letting the exhausted air out as the piston starts to come up and we pull more air in, the cycle continues, and we repeat cycle. So the crankshaft, these are the throws on the crankshaft, and with the connecting rods and you can see they're off-centered in an interval. And that's so that not all pistons are going to be on the exact same portion of the cycle any given time. What we're really trying, the most important part of the cycle is the power stroke, and that's when it'll be compressed fully the piston and explode the fuel air mixture with the ignition and provides a downward kinetic energy into shaft horse power via the crank shaft. So we use, most of the crankshaft power goes out the front to turn the propeller. We still use some of that energy to turn a gearbox which then of course drives our accessories. It drives of course our camshaft to keep everything timed correctly, but then it also provides shaft horsepower for our generators, and our fuel pump, and our oil pump. Most of the shaft horse power or energy is transferred to the propeller.

This is a Lycoming 435 cutaway. So remember from the last learning unit that means this engine has a 435 cubic inches of displacement. Again what that's telling us is in the six cylinders, don't have all six here, but we have 435 cubic inches of displacement that is a volume that which we can put air into, then to compress with fuel air and extract power. On this engine most aircraft engines have updraft carburetors, not downdraft carburetors. So the airflow goes through here into a carburetor, but we'll talk about carburetor and fuel metering systems in the next learning unit. Here's where we mix the fuel to the appropriate air and then it goes up through a series of intake pipes and in this engine, it goes up inside, this is the oil galley. Intake pipe goes into the cylinder where it is then compressed through the process I explained earlier and then out the exhaust valve. So if we look a little bit closer at this cutaway of this piston; inside the cylinder we can kind of see more of a close up and how this acts within the four stroke, five events.

So as we're looking at this piston cylinder configuration, the piston in the cylinder is right now located at the bottom dead center, it's at the lowest point in the cylinder. So right now the exhaust valve is a little bit open; we're going to start pulling fuel air mixture in as the piston starts coming up and compresses the air flow. So as the piston comes up, the intake valve closes, now we're a sealed vessel, now we're smashing it, and when the piston gets about as far up as it can possibly get, that is top dead center. The air that now was in this volume is now down to this volume so now it's under extreme amounts of pressure and we've increased its temperature quite a bit. At that point is when the spark plugs will ignite and the kinetic energy will then extract as explosion occurs, and it's like hitting the top of the piston with a very large hammer – down it goes, throwing the crankshaft into a rotation. As it goes down, then the exhaust valve will open, the spent fuel air charge will then go out the exhaust valve as the piston comes back up, pushes it out like a syringe, goes back down. As it goes down, the intake valve opens and the cycle repeats.

So here we're looking at a cutaway in the engine case, and it shows our valve train, so we see the portion of the cam that I showed you before, and here's our follower or lifter, and as the cam rotates up to the high point on the teardrop, it will push up against the spring inside, and push rod hits the rocker arm and the rocker arm will then open and close the valves, intake and exhaust valve, (intake exhaust) in the correct sequence to keep the four stroke, five events in perfect order.

On the exterior of the cylinder we can see the spark plug. The spark plug threads right into the cylinder head and there's a specific gap and it's very close to what was a piston comes up, so it is on a timer as well, it is timed through the magneto which creates the spark for the spark plug. The magneto is a specific alternator that is creating electrical energy only for the use of the ignition, and it of course is turning at the correct ratio with the gearbox and the camshaft and the crankshaft to deliver the spark to the spark plugs at the correct time when the piston is that top dead center.

This is a fully assembled TSIO470 Continental engine. So here we can see everything as it would be all together almost as if it was installed in the aircraft. Very large cylinders – we have six cylinders in place here you can see our spark plugs. Our intake tubing comes right underneath here, and then this is our exhaust collector. Each exhaust riser is connected together in the collector tube, and with this engine we use the exhaust gas to turn the turbo which will talk about in some later units. This engine is a little bit different also than the engine we looked at earlier in that this is an injected engine as opposed to a carburetor engine, so it it's not connected to a carburetor we have fuel injecting lines that inject the fuel right into the cylinder. Right next to the sparkplug where we ignite it.

So now we're looking at the rear of the engine which is the engine gearbox. So again we're using the crank shaft rotational horsepower and we're going to use some of the energy to spin some gears to turn some other items. So here we have a couple of air pumps – one we use for instrument air for our air gyros and this one we actually use for anti-icing, or de-icing systems on the aircraft. We have our fuel pump right here. We have our oil pump down here. This is our aircraft generator to produce the electrical energy to charge a battery to run electrical systems, and this unit over here is actually our starter motor which we use to start the rotation and the ignition and start the engine with this motor right here. This unit right here is actually our tachometer, which is not a primary flight instrument but it's a primary engine instrument. The rpm of the engine is directly correlated to the rotational speed of the ,crankshaft which is then of course critically proportionate to the rotational speed of the propeller, which is going to determine the amount of thrust the propeller and thus the airspeed we're going to extract via horse power from the engine.

In review the aircraft engine is a very complicated component using a series of events to use a fuel air charge and extract that for power. So we have our piston, again moves inside our engine, inside the cylinder, moving up and down against the crank throws, in perfect timing with the intake of the air, the compression of the air with the piston in the cylinder, the ignition of the air, the extraction of the power, and then the exhaust of the air charge, and the cycle repeats.

Next time we're going to look at fuel air metering systems – how do we get the correct amount of fuel to produce the correct amount of rpm, and thus horse power in the engine.