BALLS TO THE WALL

Let us have a look at the three levers (or two if you don't yet have a Manual Propeller Pitch Control endorsement) that lie between the control yokes. For the purpose of this exercise we will stick to a conventional Cessna or Piper aircraft and leave the older Beechcraft's with their crossed up throttles, pitches and mixture controls alone.

Starting from the right let's have a look at the mixture control which controls the ratio of fuel to air by **weight.** This seems to cause confusion with many people thinking mixture is adjusted by volume, but if you sit down and think about it, a 235 cubic inch displacement piston engine spinning at 2500rpm will move the same volume of fuel air mixture at 10,000 feet as it will at sea level, however we know that there will be fewer molecules of air in a given volume at 10,000 feet than at sea level and hence the air will weigh less. On the other hand the change in the weight of the fuel will be insignificant as we gain altitude.

Probably the most basic carburettor is the Marvel Schiebler MA3 as fitted to the Cessna 152 or Piper Tomahawk and other aircraft using the Lycoming O-235 and Continental O-200 engines. This carby is very simple with the throttle controlling the butterfly (air intake) only, there is no accelerator pump, and the mixture lever controls the flow of fuel to the main jet by means of sleeve valve in the bottom of the float chamber. The only other adjustment is the primary idle jet which cuts out and does nothing once the engine gets to around 1500 rpm. This is all very agricultural and simple, and without pulling the carby to pieces there are no adjustments that can be made externally that the pilot cannot control, apart from the primary idle jet. The critical adjustment on these carburettors is the float height as this will affect the amount of fuel going through the main jet due to the weight of air in the top of the float chamber and the relationship between fuel level in the float chamber and the position of the main jet. If we find an aeroplane over fuelling, particularly at low altitudes with the mixture rich, it will usually be caused by either the float being set too high or a faulty needle and seat on the float valve not shutting off the fuel entering the float chamber. Indications of over fuelling other than the obvious one of monitoring fuel usage, is a propensity to carburettor icing, fuel being a very effective evaporative cooling medium. What does it do when you spill it on your hand? Cools. So if you have an aeroplane with a history of carb icing then start looking at the fuel usage.

When do we lean? I have asked many experienced and senior pilots when they start leaning and I have had about as many different answers! And people refer to leaning properly!! What is properly???

We lean to maintain an efficient stoichiometric mixture, and most companies will have adopted a leaning policy after consulting flight manuals and considering power setting charts etc. Suffice to say that the engine will be running too rich at altitude if not leaned and if over leaned at high power settings there is a risk of detonation.

What is detonation? Explosive combustion. We normally have the magneto's timed to fire the spark plugs somewhere between 20 and 25 degrees before top dead centre so that we have the fire started and a flame front advancing to give us peak cylinder pressure about 16 degrees after top dead centre to obtain the maximum push on the piston and maximise the torque when this force is converted to rotary motion via the crankshaft. Ideally the flame front will advance from nothing up to a speed of approximately 90 knots depending on the engine design. If the engine detonates we don't have a controlled flame front but an explosive force which can have a speed of 1500 knots or more (faster than you can hit something with a hammer), hence the potential for damage.

Let us now have a look at why we get this explosive combustion. Fuels will explode due to pressure. The fuel in a diesel engine ignites due to pressure. Different fuels will spontaneously ignite at specific pressure. Back in the 1920's detonation was a problem in petrol engines and anyone who has taught a learner driver to drive a manual car will have heard the pinging noise when the learner tries to drive the car up a hill slowly in top gear. Detonation!

Standard gasoline comprises two main components, octane approximately 87%, and heptane 13%, both hydrocarbons. A molecule of octane has 8 carbon atoms (oct – 8), and heptane has 7 carbon atoms. Octane is stable and resists detonation, heptane on the other hand detonates readily. It was discovered in the late 1920's that the addition of tetra ethyl lead if added to the fuel would react with the gasoline releasing a carbon atom which would combine with the heptane molecule to create an 8 carbon chain molecule thus raising the octane level of the fuel. The other side benefits were that the by-product of this reaction, lead would coat the valves and valve seats forming a protective coating and reducing the tendency for the valves and seats to micro weld together which caused valve and seat erosion. Lead also burns to an off white colour which reflects heat and will form a coating on anything protruding into the combustion chamber like a filament of burnt carbon or a spark plug electrode etc and reduce the possibility of pre-ignition. Only one problem: lead kills people!

The pitch control controls the tension on the speeder spring in the governor which in turn controls the oil flow to the propeller hub of an aeroplane fitted with a constant speed unit now called variable propeller pitch control. This enables the propeller to maintain a set speed regardless of throttle setting. However we usually like to keep the prop speed up and reduce the power first. We don't like running a high power setting with low prop rpm. Why not?

Let's go back to our advancing flame front. If we have the spark plugs lighting the fire say at 22 degrees before top dead centre and the flame front advances at its normal speed, (which we have no control over), then at a lower RPM we will get peak cylinder pressure earlier than our ideal 16 degrees. As peak pressure moves back closer to top dead centre where the compression ratio is highest then the risk of spontaneous combustion due to high cylinder pressure increases. Detonation!

The last lever is the most used – the throttle, which basically controls the flow of air to the engine. It can also control the accelerator pump where it is fitted to the carburettor and the fuel control in fuel injected engines.

This discussion has considered only basic non-turbo charged training type aeroplanes and I welcome any discussion or debate on the subject.

Now for some threat and error management. You may have noticed that on our modern aeroplanes the mixture, pitch and throttles are colour coded, (red, blue and black), and you may have noticed that they are different shapes, the throttle being smooth, the mixture serrated and on the Pipers the pitch lever is tulip shaped. This is so you can readily identify the various controls easily. This was not always the case. If you have seen a cockpit picture of a World War 2 bomber you will notice that all the knobs on the levers are shaped the same – small round balls. On take-off the pilot lined up on the runway and pushed all those small round balls all the way forward to the firewall. Balls to the wall!