Your Engine and fixed Pitch Propeller

The effect the propeller has on engine operation and on aircraft performance is quite significant. Based on questions which have been asked by aircraft owners and from experience gained at the Textron Lycoming service hangar, there are several areas of propeller related information which may be of interest.

Aircraft equipped with a fixed pitch propeller will usually have static RPM (full throttle with aircraft standing still) limitations and full power in flight RPM limitations spelled out in the Pilot's Operating Handbook. If static RPM is below the minimum specified, the engine could be low in power. However, experience has shown that this is not always true. Faulty induction air systems and/or faulty exhaust systems have been shown to contribute to indications of low power. A propeller which is ever so slightly less than perfect may cause the static RPM to be outside the designated full throttle static RPM zone. In addition to these other factors, it is not unusual to find a tachometer which is inaccurate. If an incorrect static RPM reading is observed during the engine check, any one or all of these components could be at fault. The tachometer may be the easiest to check as there are hand-held devices that quickly give an RPM reading that will verify the accuracy of the standard aircraft instrument. Knowing the accuracy limits of the aircraft tachometer may eliminate the need for further examination of the engine and propeller, or it may confirm the need for further troubleshooting. In any case, consider each component of the system before blaming low static RPM reading on one of them.

Another aspect of operation with a fixed pitch propeller came in the form of a question from a Lycoming engine owner. He indicated that the propeller provided by the airframe manufacturer had been exchanged for a cruise propeller. (This exchange should only be done with FAA approval.) With the new cruise propeller is use, an increase in fuel usage was soon apparent. Operating costs increased and an explanation was requested.

It is well known that the amount of horsepower taken from an engine will have a direct relationship to the amount of fuel used. Therefore, it can be deduced that use of the cruise propeller increased the horsepower requirement. This deduction deserves some additional explanation.

As an example, the standard propeller supplied with an aircraft may allow the engine to develop 180 horsepower at 2700 RPM at full throttle, in flight at sea level, with a standard temperature. The Lycoming 0-360-A Series normally aspirated engine illustrates this example.

Next, let us assume that this same engine/propeller combination is operated at 75% power with a "best economy" fuel air mixture setting. Again, assume sea level and standard temperature to simplify and standardize the discussion. Seventy-five percent power will require about 2450 RPM with a brake specific fuel consumption of .435 pounds per brake horsepower hour. Also, 75% of the 180 rated horsepower is equal to 135 horsepower. Fuel usage at this power and mixture setting will be 58.7 pounds per hour or 9.8 gallons per hour. The mathematics to arrive at this fuel usage are simple:

180 HP X 75% of power = 135 HP

135 HP X .435 BSFC = 58.7 lbs. of fuel

58.7 lbs. of fuel / 6 lbs. per gal. = 9.8 gal. per hour

Having made some assessments about what can happen with a standard propeller, now we will try to see what happens when a cruise propeller is installed in place of the original. The first thing we must know about the cruise propeller is that it has more pitch than the standard propeller. This means it will take a bigger "bite" of air than the original propeller with each revolution. This bigger bite of air will have an effect on aircraft performance and on how the engine may be operated.

Taking a bigger bite of air increases the resistance to the turning propeller. Perhaps it may be easiest to imagine what happens by considering your hand when held in the air stream outside a moving automobile with the palm forward as compared to having the side of the hand forward. Because of this increased resistance, the static RPM will be lower than with the original propeller. The same thing will be true when full throttle, in flight RPM, is compared to that of the standard propeller at a similar altitude and temperature. This will reduce takeoff performance of any aircraft. Using the earlier example, the engine was rated at 180 horsepower at full throttle and 2700 RPM. Now, in spite of applying full throttle, the increased resistance reduces the maximum attainable RPM to something less than 2700. As a result of not developing the rated 2700 RPM, the engine also will not develop the power for which it was rated. Since maximum power is less than full rated, aircraft performance will suffer. This should be considered before a fixed pitch propeller is chosen or exchanged for a different model.

At this point we must return to the original question. Why does the engine require more fuel with the cruise propeller? It is an accepted fact that the cruise propeller is more efficient for cruise operation, so it would not be unusual to follow this line of thinking. Seventy-five percent of rated power, using the original propeller at sea level and standard temperature, required a throttle setting to achieve 2450 RPM. Therefore, without more thoughtful consideration, it seems logical that the cruise propeller might also be set for 2450 RPM when 75% power is desired. Of course there is an increase in performance, but this can be attributed to the more efficient cruise propeller. Next comes the realization that the improved cruise performance isn’t all efficiency. Instead of 9.8 gallons of fuel, the engine is now using a greater amount of fuel per hour. For purposes of this illustration, let us assume that the number is 11 GPH. By reversing the mathematics used earlier, it is possible to estimate the horsepower and percentage of power actually being used as a result of operating the cruise prop at 2450 RPM with a best economy fuel air mixture.

11 GPH X 6 lbs. per gallon = 66 pounds

66 pounds / .435 BSFC = 151.7 horsepower

151.7 HP / 180 rated HP = 84.3% of power

Assuming a fuel usage of 11 gallons per hour for this problem provides a reasonably realistic example of the change that a different fixed pitch propeller might create. It also illustrates the need for pilots to change their habits when a propeller is changed. In addition to the change of habits, the discussion shows a real need to reevaluate the takeoff, climb, and cruise performance of an aircraft if the fixed pitch propeller is changed for a different model.

Another very important point concerns leaning. Remember that Lycoming recommends leaning to best economy only at 75% of rated horsepower or less. It is very possible that leaning to roughness or to peak on the EGT gage could cause serious damage if the engine is actually producing more than 75% of rated horsepower as shown in this illustration.

With this information as background, it is easy to see that setting a desired power with a fixed pitch propeller can only be accomplished if the pilot has a chart that applies to the specific aircraft/engine/propeller combination. Although the power chart for a new aircraft may come from data obtained by test flying with a calibrated torque meter, a fairly accurate chart can be derived for any fixed pitch propeller and engine combination. Briefly, this is done by finding the maximum available RPM at any particular altitude and applying data from the propeller load curve.

To conclude, the purpose of this article is to make readers more aware of some operational aspects of the fixed pitch propeller. Usually it is only necessary to accept the material provided by the airframe manufacturer and to use the engine/propeller as directed. If a propeller change is made, or on those rare occasions when we question the power available to the propeller, the material presented here could prove to be helpful.