Transitioning to Beta During Landing

by Rick Wheldon

Over the years, there has been much confusion over what is happening to the MU-2 engine and propeller as the airplane flares and slows during landing. Propeller "loads" increase, flight idle fuel flows, propeller governors, prop pitch controls and underspeed fuel governors interact, etc. etc. Frankly, it's confusing. Let's look at the complex interactions as you touch down and transition from the prop governing mode to Beta mode.

First, let's try to understand what a "load" on the propeller is. Load can be understood as the resistance to rotation of the propeller. Like drag to a wing, propeller load acts opposite to the direction of motion, except that, since the propeller blade is spinning, load is acting opposite to the direction of spin. Engine power works against load, and when the propeller speed is steady, the power and the load are equal and opposite. On a wing, angle of attack is measured in relation to flight path, and drag relates to the relationship of AOA and flight path. With a propeller, though, flight path of the blade section is a little more complicated. Primarily, the flight path of the blade through the air is the vector sum of the rotational velocity of the propeller and the forward velocity of the airplane (*Fig.1*).

To better understand load, let's look at an engine during start. Since the forward velocity is zero, to minimize load and make it easier to start the engine, the start blade angle is set near zero, producing no forward or reverse thrust (equivalent to zero angle of attack on a wing.) The only "load" on the propeller is caused by air friction resisting rotation of the propeller blades. The propeller just "slices" through the air as cleanly as possible (*Fig 2*). Any blade angle either higher or lower than zero would increase the load and the amount of work required to start the engine (*Fig. 3*). Imagine the huge work load if we attempted to start a feathered propeller with the blades positioned perpendicular to the direction of rotation. I would imagine that it is hard on the starter!

Now, let's look at an engine inflight, at flight idle. Remember, the intent at flight idle is to have zero thrust at landing. Regarding the flight path of the propeller blade, we still have a rotational component, but we also have a forward velocity component. Because of this forward velocity, then, we need some positive blade angle where the "bite" of the propeller again "slices" through the air as clean as possible, with minimum rotational resistance (*Fig.4*). The propulsion engineers, when they designed our airplanes, calculated that the flight idle blade angles at approach speeds would minimize the load (zero thrust from the propeller) at about 12 degrees. Any blade angles higher or lower than 12 degrees would increase the load (*Fig. 5*).

OK, what have we got? At zero airspeed, minimum load is at zero degrees blade angle. At approach speed, minimum load is at 12 degrees, so we've determined that the blade angle for zero thrust, minimum load varies with airspeed. But . . . what will the load be if we maintain a <u>constant</u> 12 degree blade angle while the airplane slows during the flare and touchdown? If you said that the load will increase, you got it right! That's exactly what the TPE-331 is designed to do.

Now, at flight idle in the flare, with an increasing load, but also with a constant flight idle blade angle controlled by the prop pitch control, what might we expect to see? As the load increases with constant fuel flow, the propeller rpm will decrease, similar to a fixed pitch propeller on roll out after touchdown. As the propeller rpm decreases, several more things occur. The propeller governor senses underspeed and increases pressure to the propeller dome. The Beta light illuminates. As the rpm drops, the underspeed governor assumes control of the fuel scheduling. You have just transitioned into Beta, and now, as you retard the power levers behind flight idle, you are controlling the blade angles hydraulically with the power lever through the prop pitch control. As the power lever is retarded below flight idle, load will increase further as reverse thrust is obtained, but fuel will only be scheduled high enough to maintain the underspeed governor setting.

How does this affect you, the pilot? If you want to make consistently good landings, it is important for both engines to make the transition from the propeller governing mode to the Beta mode evenly. Otherwise, when transitioning into Beta, one engine will provide reverse thrust earlier than the other, the aircraft will swerve, and, in your efforts to correct for the swerve with rudder and spoiler, you'll "wobble" on the runway. Although perfectly safe, the wobble is embarrassing, but maintenance can correct uneven reversing.

First, note that uneven reversing will be more pronounced at higher touchdown speeds. Use AFM published landing speeds, and remember that those speeds are based the 50 foot threshold crossing height, so touchdown should be at something less than the published landing speed.

If you find that your airplane wobbles on landing, ensure that you have the power levers together as you cross over the flight idle gate after touchdown. Looking forward, determine which way the nose swerves initially. Have a copilot note if the Beta lights illuminate together. Once you have determined the direction of the swerve, on subsequent landings try placing the opposite power lever slightly behind as you select ground idle.

You can check your flight idle flats (the area of power lever movement which maintains the flight idle blade angles and fuel flows constant near flight idle) on the ground by placing masking tape on the throttle quadrant. With the condition lever forward, advance the power lever for one engine very slowly from flight idle. Initially, the fuel flow will remain steady, but after a short distance of travel, the fuel flow will begin to rise. Mark that power lever position on the masking tape. Do this again with the other engine. Your marks should be even. If uneven, maintenance can adjust the relationship of the flats. They can also check and adjust flight idle blade angles, which obviously should be even and within specs.

Finally, uneven flight idle fuel flows could be a factor. Perform the flight idle check, paying particular attention to the flight idle readings. Five pounds difference in flight idle, while allowable within specifications, might still cause uneven reversing.

It's a complicated process shifting from flight to ground modes, but engines can be adjusted to work together at touchdown. Plan on several maintenance test flights to accomplish this. If you invest the time and effort in rigging and adjusting your engines properly, you'll find the experience of flying your MU-2 well can be one of the most rewarding in aviation. **AAOG**