APPI PPG LECTURE 7: EFFECTS OF THE MOTOR ON THE WING

Introduction:

The following lecture describes the effects of a Paramotor on the glider's handling and behaviour in flight. There are three main forces: Thrust, Torque and the Gyroscopic Effect. As Paramotorists we need to have a good understanding of these forces and the effects they have on the wing.

Thrust = Pitch (Use a Whiteboard or a Diagram)

- When paragliding, the wing relies upon forward movement in order to give it the required airspeed to become airborne. This is normally achieved by the pilot running down a slope.
- With a Paramotor the wing now has a force propelling it forward. This enables the wing to maintain or increase altitude.
- However, unlike most aircraft the thrust line is not aligned with the wing's centre of pressure, instead it is far below the aerofoil. By accelerating and decelerating you directly affect the Pitch of the wing.
- The first danger one needs to be aware of is the pendulum effect. If you rapidly apply full power in flight the wing will enter into a steep climb and assume a high angle of attack, if the pilot applied the brakes at this stage they could potentially stall the wing. If you rapidly release the power whilst the wing has a high angle of attack it will dive forward and loose height quite dramatically.
- If you continue to do apply full power and then rapidly release it you stand the chance of having a frontal collapse. If this is done at low level you will potentially pendulum swing in to the ground very fast.
- In order to avoid the pendulum effect your acceleration must be smooth and progressive. When close to the ground and climbing with a high angle of attack never drop the power completely; instead you should gently release the power to prevent the wing diving. If you ever do cause the wing to pitch backwards and then forwards, always brake the dive!
- The pendulum effect is most dangerous when taking off, flying low and landing. It must therefore be avoided. Be smooth and progressive on the power and brakes so you do not experience this problem.

Torque = Roll (Use a Whiteboard or a Diagram)

- When looking at a Paramotor from behind, the propellers are turning either clockwise or anti-clockwise at high speed.
- For every action there is a reaction and the Paramotor therefore wants to counteract this force and attempts to spin in the opposite direction. This creates either a right or left hand force, depending upon the way the propellers spin, causing the wing to Roll to the right or left when under power. Roll is when one wing tip is up and the other wing tip is down.
- A good example of the torque effect is if one imagines holding the blades still, thus restricting their rotation, the engine would spin in the opposite direction.
- The more power one applies the more exaggerated the torque effect becomes. Generally the more powerful the Paramotor the more exaggerated the torque effect.
- The amount of torque depends upon prop mass, prop diameter, revolutions per minute but more importantly, power.
- There are certain ways to deal with the torque effect; certain low hang point Paramotors have offset hang point systems which help cancel out a certain amount of torque however this can have the opposite effect when you kill the engine. Torque can affect hang point Paramotors a lot more as they tend to lack a proper anti torque system.
- The simplest way to counteract the torque effect is to weight shift and apply a little bit of brake on the opposite side to the way the wing is rolling. Be aware that applying too much brake to counteract torque is very dangerous because of the possibility of spinning the wing.
- The simplest and safest way of overcoming the torque effect is to reduce the power and then gradually apply it back on.
- If the Paramotor is very powerful and has a lot of torque, be sure to allow plenty of room on take off to allow the wing to turn with the torque. Do not over react on the opposite brake, particularly on take off because you have a lot of Induced drag and are flying slowly, which increases the risk of spinning the wing.
- If the pilot is not smooth on the controls you can cause the wing to Roll from one side to the other. To counteract the Roll one should gently decelerate and raise the toggles up to the neutral position, before applying both brakes to their ears and settling the wing down.

The Gyroscopic Effect = Yaw (Use a Bicycle Wheel)

- A spinning propeller acts as a gyroscope and initially tends to resist any forces attempting to change its axis of rotation. A good example of this is when one holds a spinning bicycle wheel and attempts to tilt it forward; the result is a deflection 90° away for the tilt, known as the Gyroscopic Effect.
- In flight, particularly during take off, the Gyroscopic Effect can cause the pilot to twist and thus cause the wing to turn on it Yaw Axis. Yaw is when one wing tip is ahead of the other.
- The Gyroscopic Effect is caused by the sudden change in the tilt of the propellers as they spin at a high speed, normally by the pilot leaning forwards or backwards. This causes the pilot to twist under the wing and point in a different direction, with one wing tip ahead of the other.
- This is potentially very dangerous because the thrust line is no longer pointing in the same direction as the wing and can result in the pilot becoming twisted under the wing.
- Certain Paramotors exaggerate the Gyroscopic Effect; for example a very powerful Paramotor with large propellers and a high hang point harness with a light pilot will create a strong gyroscopic reaction.
- With high hang point harnesses the pilot is further away from the wing and the risers are closer together, making it easier for the pilot to twist underneath the win. A low hang point harness is not as affected by the Gyroscopic Effect because the pilot is closer to the wing and risers are further apart, meaning the pilot has a better centre of gravity.
- The Gyroscopic Effect will also occur if the pilot is not secured tightly in the harness.
- Unfortunately Gyroscopic Progression is most likely to occur on take off. In order to avoid this make sure that you are correctly secured in the harness, that you gently increase the power and stand up as straight as possible on take off. If you tilt back and forth during the take off run then as you become airborne gyroscopic progression could occur.
- In the event of gyroscopic progression during a climb out you should not apply any brake; instead you should gently back off the power and allow the wing to settle onto a steady course without loosing height before reapplying the power.

Further Information

- When forward launching under power the Paramotor may spray hot oil or grease from the crack case or exhaust onto the wing. If you have a constantly leaking Paramotor simply do not do forward launches under power.
- The reason one can maintain height and climb when under power is because the Paramotor changes the wing's angle of attack. The pilot is effectively being pushed ahead of the wing when under full power. You should all now be aware that the Paramotor does not increase one's speed whilst under power. However, in the event of an engine failure the added 25-35kg of the Paramotor causes the wing to fly faster than if it was simply being used for Paragliding. The Glide ratio remains the same however the landing is faster.
- Finally, always remember to kill the engine at height to allow the wing to pitch forward and regain level flight before coming in to land. If you kill too low the wing will pitch forward and pendulum swing into the ground.

Conclusion

- As a general rule of thumb, the three main forces, Thrust, Torque and the Gyroscopic Effect, and the influence they have on the wing, can all be counteracted by simply reducing power and putting your hands up to neutral.

ANY QUESTIONS?

END OF LECTURE 7