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Understanding Paramotor Torque & Twist ad how to correct or minimize

Mar 18, 2013 | *Section IV Theory & Understanding* | *See other PPG Bible Additions*

See also Paramotor Torque Twist and Crash

Torque and its related minions have contributed to a number of crashes. The pilot starts twisting under the risers, usually to the left which pushes him left and decreases forward thrust. The wing goes right in an unwanted right turn. At this point, the pilot is confused—he's pointed left, the wing is right, he's slowing down and not climbing. The lack of climb makes him stay on the throttle—exactly the wrong reaction. In extreme cases, the pilot pulls so much left brake to stop the turn that he spins the wing. Ouch.

A well adjusted machine lets the pilot relax with minimal turn tendencies.

Why? There are two powerful forces and a bunch of nearly irrelevant ones. It's not terribly important to know what they are but it is important to 1) recognize when it's happening and react accordingly, and 2) set up your machine to minimize the effect.

We'll assume your prop spins counter-clockwise as viewed from the rear. Nearly all belt driven machines, which is nearly all of the large ones, spin this way.

Quick overview

Torque is what happens when you spin a prop in the air. The engine/pilot tries to spin opposite. Just like when drilling into a chunk of wood and your hand wants to twist opposite the drill bit. In this analogy, the wood is air, the drill bit is your prop and the drill is you.

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Note that the closer the ropes (risers) are together, the less force it takes to twist up in them.

Paramotor Torque Effect Explained (By http://www.scoutparamotor.com/paramotor-torque-effect-explained/#prettyPhoto)

The torque effect derives from the third Newton's law: for every action, there is equal opposite reaction.

If the engine acts with force on the propeller, the propeller will react with equivalent force. If the prop rotates to left (5), the torque effect will rotate the paramotor to he right (6). The whole paramotor will yaw to the right, mostly with the pilot as well. One side of the paralgider is more loaded a pulled down (9). **The paraglider will have the tendency to turn and is not capable of straight flight without pilot input.**

This effect is surprisingly strong and without proper compensation the paraglider would be poorly controllable

The PPG Bible covers this topic thoroughly but here's a summary. Torque acts in two planes, around the vertical axis (but only if the motor is tilted back) and around the propeller axis.

Lay a paramotor flat on its back, hanging by ropes attached to the carabiners, so the propeller plane is horizontal with the floor. Now throttle up. You'll spin like a twister. Angle the motor up a bit. You'll still spin, just not quite as much. Angle it up further, you'll still spin, just not quite as much. You get the idea. That's the effect of a motor hanging back and its called the **Horizontal Component of Torque (HCoT)**.

Now hang from bungee chords with the propeller plane vertical. Throttle up. It wants to tilt you right. That's the riser shift or **weight shift component of torque (WSCoT)**. HCoT is twisting your body left while WSCoT is *tilting* you right. Both are causing a right turn, though.

The real villain of twist is that thrust gets redirected, causing a bank and not propelling forward any more. Otherwise the wing wouldn't really care all that much.

What Matters

Here are the forces that matter in order of importance.

1. The most powerful twisting force for most pilots is the **Horizontal Component of Torque (HCoT)**. It's only present on machines that tilt back, though. It's easy to minimize by decreasing the tilt back. On low hook-in machines, move the hang points aft. On others, make whatever adjustments are necessary to get the prop plane more vertical.

2. **Offset thrust (OTh)** is where the thrust line pushes on one shoulder or another. This may be caused by torque if it twists the thrust line over to one shoulder. What matters is where the thrust line is relative to the center of the risers. That's why numerous manufacturers of low hook-in machines move one riser out using a metal piece on their right swing arm.

The significance of this force is that it matters less how much power you have. If the thrust line is too far off, you'll twist wildly. Solve it by making sure that, even at full power, your thrust line stays centered.

The above forces account for nearly all torque related accidents, usually in combination with a harness setup that doesn't resist the twist.

3. **Weight shift component of torque** (WSCoT) has limited effect based on how much riser shift happens. Go up and do a maximum weight shift without brake input. How much turn do you get? On everything I've flown its easy to counter with brakes.

4. **Gyroscopic Precession** is barely relevant, mostly because it's so fleeting. Gyroscopic action will make

you twist left as you tilt back. It only happens *during* the tilting. So as the wing lifts and tilts you back (if your motor is normally tilted back in flight), it will cause a brief twist to the left. But once you're leaned back, the effect goes *completely* away.

5. **P-Factor**, or Asymmetric Blade Thrust is essentially irrelevant. Not only is the force small for our craft, but it's actually trying to *counter* the other forces that cause problems.

P-Factor is where the descending blade enjoys greater relative wind which gives it more pull. The effect is made smaller by our slow speed. On airplanes with high horsepower, it's a big deal, for us, it's not. Imagine the prop disk angled not just 10 or 20° but 90°. Now the into-the-wind blade gets lots more lift. This is the same reason why helicopters want to bank more as they speed up without pilot input.

6. **Rotational Mass Acceleration** is present during throttle up only. It's the least relevant of all forces since it's only present during that brief time that the prop is accelerating.

Its the force touted by geared redrive users who claim that torque is countered by having the motor's rotating mass run opposite to the prop's—a partially true statement that's nonsense since the force is fleeting and small. Plus, the prop has far more rotational inertia than do the motor's spinning parts so the pilot still feels a twisting during prop acceleration.

Another Effect: Loaded Riser Twist

This one isn't related to torque directly but it powerfully contributes to most torque-related crashes. It is that, when the wing goes right, the motor wants to yaw left and vice versa. It aggravates the normal problems since, if during liftoff the motor yaws you left, thrust will then push you left relative to the wing which goes to the right. As the wing goes right, the left riser stays loaded while the right riser unloads and your body twists around the loaded left riser, causing even more left yaw.

You can see this clearly in Master PPG 2 (it's explained through both animation and live action). Here's another video where you can see these effects. In each case the wing goes one way, aggravating the pilot's twist the other way. This is why, on belt driven machines that you're not completely familiar with, you should:

1. Takeoff with partial power (as your situation allows) then *ease* into full power once up 25 feet),
2. Get the wing *slightly* left before lifting off (to the right for geared machines).
3. If you feel excessive twisting ease back on the power.
4. Once at a safe altitude, go to idle then ease into full power while looking up at the wing to see how much twist the machine has normally.

What to Do In All Torque Twists

First and foremost practice what to do if it starts: Reduce power, reduce brakes. It's better to land straight ahead or with minor turns than it is to crash on your side at full power. That's expensive at best. Don't just let off the gas completely, back off to about half of what you have now then adjust.

Second is to make sure your machine is adjusted to minimize all twisting effects. Find an instructor or experienced pilot *who understands these concepts* and implement the suggestions.

Good luck and fly straight. Well, mostly straight.

HOW to minimize or to correct with harness setup

Harness Adjusting: Hang Angle & Thrust Line

Section II Spreading Your Wings, Chapter 12: Setup & Maintenance
See also Hang Points: High or Low? | Suspension Systems | Harness Myths | Understanding Paramotor Torque

To fully understand the many harness permutations and terminology, check out Harness Systems.

Of many harness and motor adjustments, setting the proper motor hang angle affects far more than comfort. As covered in Chapter 12, correct setup can make or break launches and cause or prevent riser twist crashes.

The diagram at right shows how to adjust some popular styles of harness and how to set those with a hard point attachment.

Hanging back too far will increase the amount of torque effect which makes riser twist more likely. It also makes it more difficult to launch since, as the wing lifts, you get tilted backwards which makes your legs push against the thrust.

Attaching a carabiner incorrectly as shown in the diagram's upper right can (probably will) result in the motor sliding back and pointing nearly directly at the ground. If that happens, you'll end up looking nearly straight up and torquing violently. The only cure is to *immediately* get off the power, fly the wing, and prepare for impact. Fortunately, if this happens, it's usually right after liftoff or when getting into the seat. A good preflight is your best prevention here.

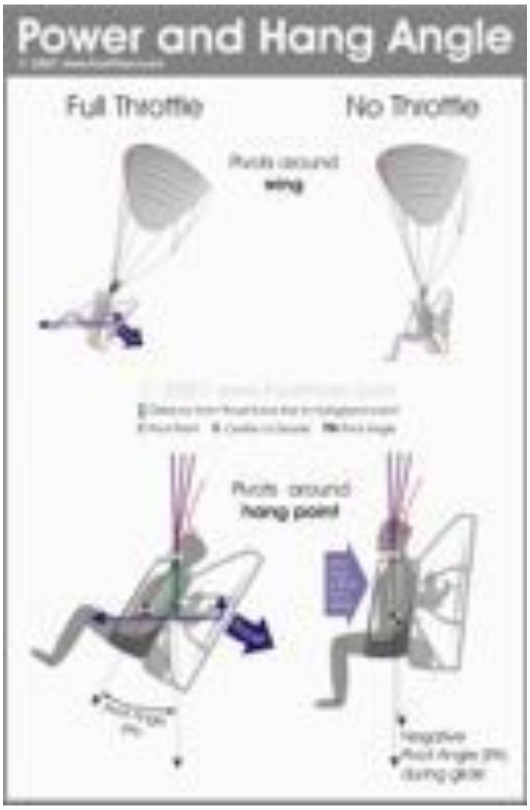
Thrust Line

When setting your hang angle be mindful of what effect thrust will have while flying.

High Hang Points

Machines with high hang points will normally have the thrust line well below the hang (pivot) point. Power will tend to push you forward and make you lean back at full power. That will also re-direct the thrust more downward which will slightly decrease your climb rate. The diagram at right shows this graphically.

This leaned-back condition will make it harder to launch and aggravate any torque effects. If launching is difficult, adjust the hang angle to be more upright. See Hang Angle Adjustments.



Low Hang Points

On machines with low hang points the thrust line is usually very near or even *above* the hang (pivot) point. If the thrust line is *above* the hang point than the motor will tend to make you lean forward. The top of the cage pushes toward the risers.

Be careful since the brakes may get dangerously close to the prop. If they can get through the netting they'll get caught up in the prop. At best the brake handle gets cut off. At worst the brake line wraps up in the prop—that only happens to a pilot once.