Power Trim and Tilt – What good is it?

Just about every outboard motor 50 HP or larger today comes with power trim and tilt as standard equipment, why? Power Trim and Tilt is a relatively recent invention in the 100 year evolution of outboard motors, but it’s now universally accepted for all larger motors.

First came just Power Tilt. About the time that the largest outboard motors had grown up to around 100 HP (late 1960’s) our increasingly “push button” life style was demanding easier ways to manage tasks like tilting the engine when entering shallow waters, or getting onto the trailer. Several attempts at using springs to counter balance the engine’s mass were only partially successful. The best solution that was eventually adopted by all the large outboard manufacturers, was an electro-hydraulic set-up – a reversible electric motor driving a small hydraulic pump supplying oil under pressure to a double acting cylinder. The hydraulic cylinder then replaced one of the two shock absorbers that most large outboards already had. At first it was only available as an accessory kit, see figure 1.

It was not long before some of the outboard boat racers thought a power tilt kit might have a future as a Power Trim kit – that is a device that can alter the engine’s tilt angle at any speed, even full throttle. Now normal power tilt kits could not do that, quite deliberately they had relief valves that allowed the motor to return to a vertical position if you opened the throttle much above idle. The leverage on the single tilt cylinder was too great for it survive at high throttle settings.

So the racers moved the cylinder from its usually almost vertical position to horizontal. That reduced the loadings, but at the cost of much reduced stroke or engine travel – OK for race applications where only a small effective range is required, but not for everyday fishing and recreational rigs. Still the success that race boats with power trim enjoyed ensured that it soon became a desirable accessory, so before long the Power Tilt and Trim kits appeared, see figure 2.

The main difference was spreading the load over two cylinders, and having two quite noticeable movement speeds. The motor would move quite slowly in the first 15 degrees or the “Trim Range”, because oil was being supplied to both cylinders. After the first 15 degrees, one piston stopped moving
and all oil went into the other cylinder, so the tilting speed increased markedly. From the end of the Trim Range all the way to full tilt up was the “Tilt Range” of about 50 degrees.

Special relief valves in both the cylinders and the pump housing ensured sufficient hydraulic pressure was available to overcome the engines full throttle thrust (about 1000 psi was needed), yet ensure if the throttle was opened much above idle while the motor was still the Tilt Range, the engine would gently come down to the end of the trim range. This was an important safety feature to prevent being able to move tilt the engine so far at planing speeds that the boat might become uncontrollable.

Power Trim and Tilt became standard equipment on larger outboards in the 1980’s, and it’s so well accepted now that most manufacturers quickly stopped making manually tilting models in the 50HP and larger sizes.

So why is it a good thing? Well planing hull boats, like airplanes, are actually quite trim sensitive. That is they are very responsive to small changes in the angle of attack to the water. Conventional planing hulls get their performance from their ability to move over the water, rather than in it. The ability to plane comes from their underwater shape. A shape that generates lift from speed. At low speeds, up to about 8 or 10 knots, all boats are displacement hulls, partially immersed in the water and pushing it aside to move forward. As planing speed is achieved, sufficient lift is generated to lift most of the boat’s hull above the water and its no small force being several hundred kilograms for your average family outboard boat.

So it stands to reason anything that improves the lift, or allows you to adjust it at will, will have a big effect on performance and economy.

Figure Three shows how Power Trim does this. The top sketch shows how most boats are when trimmed for most efficient operation in smooth water. The centre of pressure (C of press) is just slightly forward of the centre of gravity (C of G). The keel is at an angle to the water of approximately 3 to 5 degrees, which is the happy medium between minimum drag and maximum lift. Driving a boat at that trim setting feels free and easy. The boat is very responsive to steering input, and it provides the best speed, and economy, for a given throttle setting.

The middle sketch shows the effect of using a little too much trim out, the bow tries to lift too high, the C of Press moves aft of the C of G, then the boat pivots around the C of Press and the bow falls down. As soon as this happens the C of Press immediately moves forward and the bow starts to lift again.
Figure 3
A tendency to continue these up and down movements is known as “porpoising” and it’s very uncomfortable. It’s also a sure sign that the boat’s trim is not right. Very few boats can use lots of positive trim effectively. Some dedicated race and high performance boats go fast enough to generate some aerodynamic lift from the forward hull shape above the water. This extra lift from the air can allow the C of Press to be a little behind the C of G, without porpoising, for the absolute minimum of water drag, and therefore best possible speed. However it is a delicate balancing act and really only works on boats designed for high speeds, like 50 knots+.

The lower sketch shows the opposite effect, when the motor is trimmed in, forcing the bow down. This increases the area of the hull in contact with the water, increasing the drag and reducing the speed, and economy. But it also has a beneficial side as more waterline length in the water smooths out the bumps, so in really rough conditions trimming the motor in provides a more comfortable ride.

So how much trim-out or trim-in is enough, and how do you tell? Here again is where every boat, and application, can be different. The best trim out position in one direction (say into the wind) will not be the best in another direction. Also if the C of G position (where the load is positioned inside the hull) moves, so does the trim position that gives the best balance of lift to drag.

So, which way the wind blows and where your passengers are sitting do make a noticeable difference, that’s why being able to alter your trim angle at the touch of a button is popular. That’s also why the trim gauge that comes with your modern large outboard motor has a scale on it, but no “green zone” to aim for, or “red zone” to avoid. Where you put the needle on the gauge varies with wind and water conditions, and the load on board. So why have a gauge at all? It allows you to easily go back to the same setting quickly.

Figure 4 shows a modern Trim and Tilt system, the single ram design on a new Evinrude E-TEC 50 HP. Today’s more powerful motors and computerised manufacturing are shrinking the Trim and Tilt system, with small single cylinder types now used on engines up to around 140 HP. These modern trim units are capable of producing pressures around 10,000 kPa (1500 psi), while drawing less than 20 amps max.
There is one thing that modern power trim engines retain that looks out of place and often needs explanation. Figure 5 shows the transom brackets of two modern trim and tilt equipped outboards. The rows of holes look like the thrust rod position holes that motors without power trim use for adjusting motor angle. Why are they there on dedicated power trim engines designed as such from new?

They indicate the one area that is manually adjustable. By moving the thrust rod, or the lower trim unit pivot pin, the minimum trim position can be set, that is the angle the motor can come down to when the propeller is closest to the hull. This is a safety feature. If the driver trims the motor out too far at speed, the prop starts to come out of the water, the steering gets vague, the noise level goes up and the speed starts to drop. It’s quite obvious that’s not the way to go.

However, if you trim the motor in too far, and the boat’s hull has a steep transom angle, you can force the bow down until the boat will suddenly steer violently off to one side. That can be dangerous, so that’s where the manual adjustment comes in. Moving the thrust rod or lower pivot pin position limits the maximum trim in angle to avoid this problem. Just one more reason why every boat and motor combination must be water tested before delivery to the operator.