How to (over)engineer a rudder assembly

This note is limited to describing a few refinements about installing the sort of rudder assemblies used in offshore and other surface drive racing boats. With the advent of powerful and extremely fast servos stresses and strains associated with the rudder system can be underestimated, which can lead to poor steering response.

The foundations

The rudder assembly is almost always bolted to the transom on some sort of angle bracket. Most transoms are usually strengthened with additional layers of carbon or carbon/Kevlar fabric, sometimes plywood is used as an alternative to add strength. Nevertheless, it is usually worth reinforcing the transom on the inside where the rudder assembly is mounted with a 3 mm or 4 mm thick carbon-fibre plate. Such a plate is particularly useful when plywood is used for transom reinforcement because the plywood tends to compress slightly under continued vibration and the rudder fixings can loosen. This loosening is less likely to occur with a plate in place.

Rudder arms often have a significant overhang from the transom to enable the rudder blade to operate in less turbulent water away from the propeller. As much as 150 mm overhang is often used, so there can be significant side forces on the arm under prolonged racing conditions. A cross brace with ball-jointed ends is useful in reducing any flexure problems, see fig. 1.

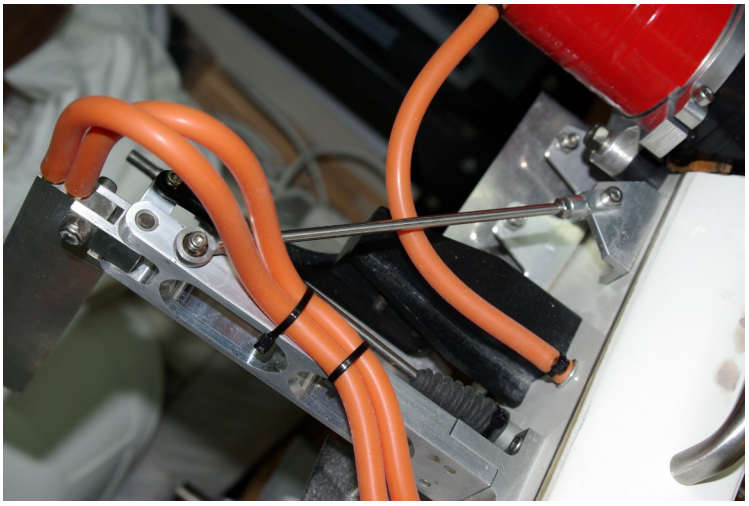

Fig.1 A strong point on the transom is used as one end of the brace to the end of the rudder arm.

Rudder blade mounting

Generally, the rudder blade is mounted in a machined metal block that also carries the rudder pivot shaft. It is not impossible for this shaft to work loose. To avoid this possibility, protective shaft retaining strips can be fitted above and below the rudder mount, see fig. 2.

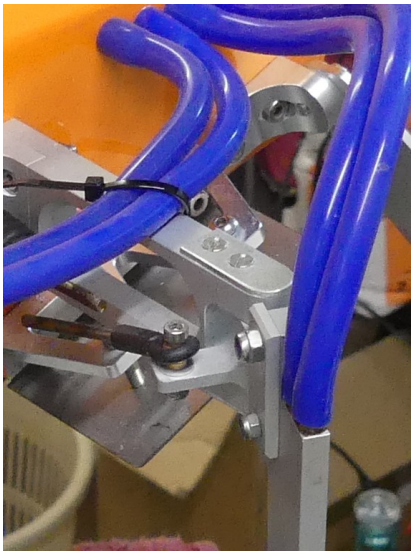

Fig.2 Small aluminium strips retain the rudder shaft on the top and bottom of the rudder arm.

Although most rudder pivot shafts are fitted with a plain bearing of reasonable quality, these can wear and precise directional control can be impaired. Changing the existing brass or phosphor-bronze bearing for a bespoke PEEK bearing can improve matters significantly. However, the precise fit is important in gaining any improvement to the bearing's characteristics.

The rudder blade is usually bolted to the rudder post at the top with a sacrificial pin below it to protect the rudder blade in case of a collision with an underwater object. Instead of this pin, some racers loosen the top retaining bolt and use a strong spring the function of which is to restrain the rudder in position but to return it to its original position if disturbed. This technique is more popular with the fast-electric racers, but it can be applied to petrol racing boats.

Push rods and servos

Especially for large and fast boats particular attention needs to be paid to the servo end of the rudder linkage. In my view, the ideal arrangement is: a perfectly straight control rod with a ball-ended joint at each end, and if the radio box is one which can be easily removed, the radio box should be mounted in a closely fitting "nest" to constrain movement, see fig 3.

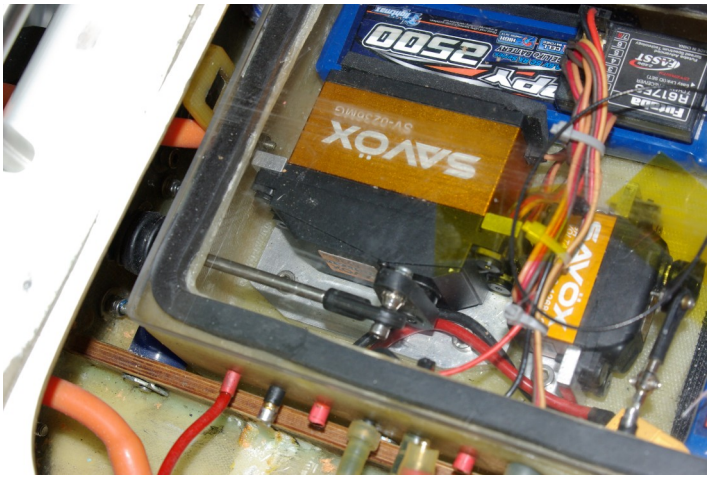

Fig.3 This is the servo end of a ball-jointed arrangement.

The set up above uses a 40 kg.cm servo fitted to a 3 mm thick aluminium angle plate mounted on a 3 mm thick fibreglass plate, the control rod is, in this case, 4 mm in diameter. However, this system can take a long time to set up accurately, but provided there is a hole in the transom large enough to enable the ball-ended joint to pass through it, the radio box can be removed easily and so maintain the rudder settings.

An alternative set up is to use a two-part control rod with two brass collars so that the rod can be quickly adjusted for length, see fig. 4.

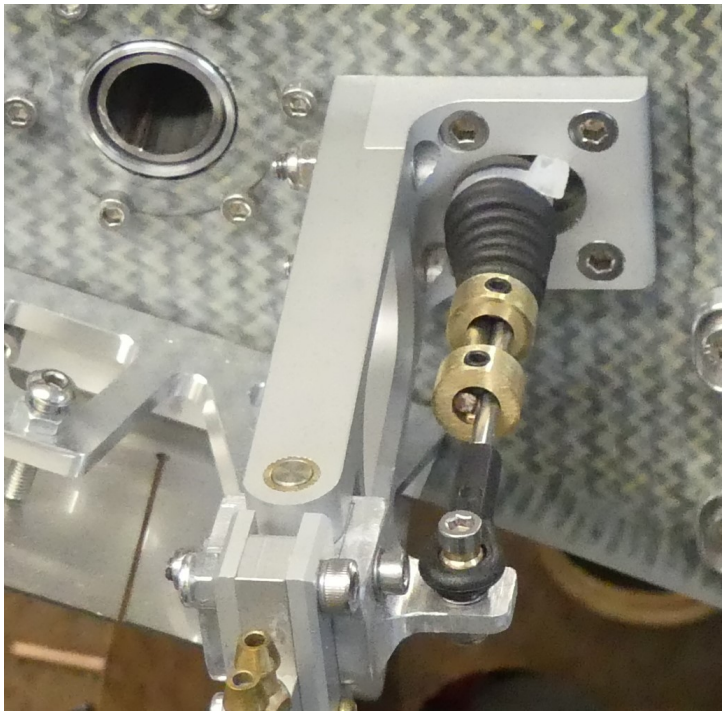

Fig.4 Two collars are used to clamp the rudder control rod so that when the collars are released the radio box can be easily removed.

Clevis pins are definitely not recommended (I know from first hand experience!) for either end of the rudder control rod as they can escape the servo arm very easily, even if they are used with additional constraints.

Acknowledgements

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