# Sealing an Anti-Air Warfare Destroyer

On the eve of the scheduled launch of the first of the Royal Navy's Type 45 Daring Class Anti-Air Warfare Destroyer, MER takes a detailed look at the composite bearing materials specified onboard

The Type 45 Anti-Air Warfare Destroyer will provide air defence cover for the Royal Navy and will replace the Type 42 destroyers in service.

The deep displacement is circa 7350t with a length of 152.4m and a beam of 21.2m.

The water Iubricated shaft bearings comprise the Main 'A' Bracket bearings and Intermediate bearings. Port and starboard shafts are of different lengths.

Because the shaft loading geometry has a large variance between the cold (static) condition and the warm (MCR) condition together with the length of the 'A' Bracket Barrel a computer program was developed to assess the bearing loading under both conditions.

The shaft bearings are required to operate at extremely low shaft revolutions and therefore cannot rely on the hydrodynamic lift induced by the shaft rotation; Orkot TXMM was selected as this material has low friction under boundary lubricated conditions.

The other requirements were that the bronze bearing housing should remain fitted in the bracket barrel under refit and that the bearings should be capable of being removed without dry-docking in an emergency.

**Three segments**

The bearings are in three segments with the bottom segment forming a 140deg arc, for good hydrodynamic performance. The bearing pressure was limited to around 5.5 bar but in reality this will vary due to the variable shaft angle from cold to MCR.

The segments are locked in position with a removable key assembly which is easily accessed with the front retaining ring removed. The key can be withdrawn as a self-contained assembly allowing each segment to be removed.

The bearing segments are machine-finished, which removes the need for any machining or work in the shipyard.

The Main 'A' bracket bottom segment is designed from the computer program to allow for elastic deformation. This eases bedding in by increasing the contact footprint and reducing the edge loading, because the shaft angle changes from positive to negative from static to MCR.

As the aft bracket barrel is longer than required for bearing requirements, and to reduce the effects of the shaft angle, the forward third of the bearing length is relieved as a safety bearing.

One requirement for the intermediate bearing is that the propulsion shaft has to be removed at an angle and therefore the bronze housing has two location diameters with the smaller diameter fitted into a removable bronze housing at the other end of the barrel. This allows the shaft to be tilted for removal within the length of the vessel.

Both the intermediate and aft bearings were fitted with thermocouples to monitor the bearing surface temperature during the basin trials. The reason is that for these trials the resistance to the propulsion motor is by brake blades fitted in place of the normal propeller blades. Since brake blades do not induce thrust there is no propeller lift to reduce the bearing pressure.

For any water lubricated bearing a period of running in is required to form the optimum running surface for hydrodynamic operation. As crude torque measurements are not sufficient to determine when the bearing is operating in this mode, thermocouples were fitted into the bearing to moiiltor bearing surface temperature.

**Coupling protection**

The shaft protection covers are designed to protect the hydraulic coupling which joins the propulsion shafts together from seawater corrosion.

Corrosion on the coupling nut and taper sleeve can prevent the normal disassembly of the coupling on refit and severe corrosion on the body of the coupling will reduce the hoop Stress induced by the taper sleeve.

Prior to this, aluminium cones and rubberised protective coverings were used. The effects of the shaft torque can cause cracking at the cone interfaces allowing seawater to penetrate into the coupling causing corrosion on the aluminium cones and coupling faces. The internal voids in the cones were filled with tallow.

Orkot Marine Bearings redesigned the complete covering system using their machinable composite material. This allows the coupling to be completely covered and sealed without the use of epoxy bandage, rubberised coatings and aluminium cones.

The Type 45 Coupling protection covers were purpose designed to suit the exacting requirements for this vessel. This was more difficult due to the proximity of the ropeguards (also manufactured from Orkot machinable composites). They comprise of a machined sleeve which covers the coupling to which cones are fitted and sealed with o-rings. The cones are located axially on the shaft with a split ring which is bonded to the bronze liner.

The other end of the sleeve is fitted with a short split cone. Both cones clamp onto the shaft and liner to prevent rotation. Trelleborg Orkot Composites use a specially developed biodegradable grease which is pumped into the internal voids of the coupling after assembly to further protect the coupling.

*Both the intermediate (pictured above) and aft bearings were fitted with thermocouples to monitor the bearing surface temperature during the basin trials*

*A typical ropeguard and coupling cover after docking, shown here on HMS Westminster (Courtesy UK MoD)*

**Rudder stresses**

The Type 45 vessel in common, with most Naval vessels, uses a spade type rudder. This type of rudder imparts higher compressive stresses to the bearing as the rudder is unsupported. This could subject the bearing to unequal bearing pressures if a stiff bearing was used, commonly known as edge loading.

Normally Naval rudder bearings are grease or oil lubricated. This is essential if they are manufactured from corrosion resistant steels or bronze materials as these would suffer from 'pick up' (contact transfer of bearing material to the shaft).

Unless these bearings are adequately sealed, oil or grease could leak into the seawater which would be unsuitable environmentally or for traceability.

It was decided to use seawater injection into the bearings as it was considered too large a step to operate totally dry.

Orkot TXMM was selected for its low friction under dry operation, low static to dynamic friction (stick slip) controlled elasticity under dynamic loading (hysterisis).

When the bearing is dynamically loaded under unequal loading (bending or misalignment) the material deforms elastically to give a larger contact area.

This reduces the unit bearing pressure. The recommended maximum static pressure will be between 80-100N/mm2, this being the elastic limit for this material. It is incorrect to consider the maximum compressive strength (>280n/mm2) as plastic deformation occurs above the elastic limit without full elastic recovery.

If a metal bearing is subjected to the same loading because the material is much stiffer, the loaded area is smaller (edge loading); this can cause damage between shaft and bearing i.e. metal transfer, hence the use of oils or greases to help reduce metal to metal contact.

The bearings as fitted to the Type 45 are retained using the bearing interference designed using the company's bespoke calculation program. This calculates the required bearing retention under all operating conditions, including the maximum turning force (torque) developed from the friction force between shaft and bearing, the operating temperature, and the machining temperature. If the bearing is overstressed i.e. from elastic to plastic deformation, it could loosen and turn in the housing blocking the water feed holes.

When Orkot TXMM operates dry, the bearing lubrication comes from the transfer of lubricant from bearing to shaft, further reducing friction and wear. Normally the higher the bearing pressure the lower the friction.

**Fin stabiliser bearings**

It was decided that due to Orkot TLMM's dry operational capability and lower wear, it should be used on the Type 45 Destroyer Fin stabiliser outer bearing. These are lubricated directly from the seawater via the axial grooves, and if any water blockage occurs the bearing will still operate. These bearings are subject to reciprocating operation with bearing pressures up to 25N/mm2. The bearings can be removed and replaced under water using purpose designed habitats – a well proven operation.

*Extract courtesy of MER (Marine Engineers Review) February 2006*