Cooling systems

Most model power boats require a cooling system of some sort to take away excess heat from their power units so that they can run under optimum conditions. The common media used for cooling are water and air.

Air

In some cases air flow is used to carry away heat from engines that are usually mounted in an exposed position or completely external to the hull, for example in specialist hydroplanes and air-boats. The engines most suited to this way of cooling usually have their design roots in model car or model aircraft applications.

More usually engines are mounted within the hull and their associated exhaust manifolds and tuned pipes (see later) are water cooled. Nevertheless, a flow of air through the hull not only provides air for the carburettor, but also helps minimise heat build up. Conventionally, for petrol-engined boats the air outlets are recommended to have an area in the range 1.5 to 2 times the area of the air inlets so that there is no significant pressure build up in the hull. However, for some applications such as off-shore racing boats minimum sizes of inlets and outlets should be used to reduce the possible ingress of water (especially sea water) into the hull. Extra precautions are often needed as well, such as introducing baffles in the air inlets to stop water spray getting to the carburettor. In general, the boat should behave in a similar way whether the canopy is on or off.

For electric boats, despite water cooling the air temperature increase within the hull might cause an increase in air pressure and even risk over-pressurising the hull. There may be a case for using an electric fan to distribute local heat sources to minimise the risk of over pressure, additionally a pressure release valve might be a worthwhile addition to avoid potential problems.

For petrol- or nitro-engined boats the actual shapes of air inlets and outlets are not that important especially if the canopy has to be modified to provide clearance for exhaust pipes, etc.. NACA ducts are often used as air inlets which are supposed to minimise drag and so are very effective as air inlets. It is important to remember such ducts only work where they are positioned in an undisturbed air flow.

Water

In the majority of boating applications water is the cooling medium of choice. Most petrol engines for marine applications have a water-cooled cylinder head and some even have a water-cooled crankcase. In petrol engines achieving high water-flow rates are usually important to ensure optimum power and reliability; the aim is to achieve a working temperature for the spark plug of about 80 °C.

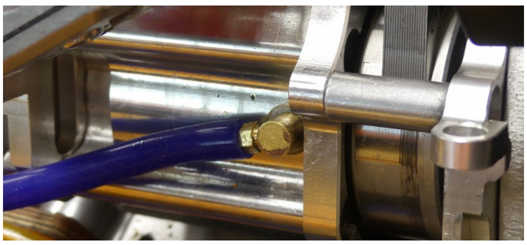

Photo illustrates the crankcase water inlet on a Zen 320; restricted access when using a quick release engine mount necessitates the use of a right angle adapter. © GNP

Some cooling system designs call for one water input and one output, but other variations are possible – see below. Generally, glow engines require much lower water flow rates and adjusting the flow rate can provide optimum power. It is a question of balancing the cooling influence of the nitromethane in the fuel against the heat generated within the engine to produce power.

Photo shows a 3-in 2-out water arrangement on a Zenoah 320. © GNP

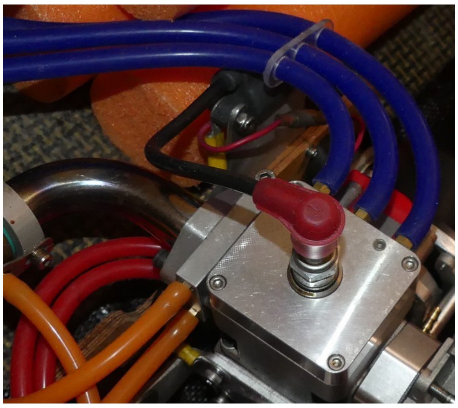

Photo shows a 2-in (red pipes) and 3-out arrangement (Quickdraw) unusually a water-cooled manifold (orange pipes) is also fitted. © GNP

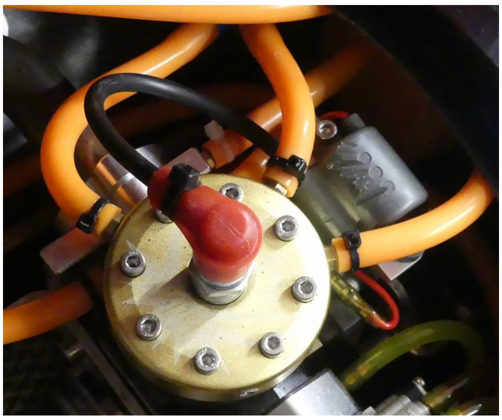

Photo shows a 2-in and 3-out arrangement (Tiger King 27 pro). The water outlets exit around the top of the cylinder head and the two inlets are partially hidden behind the water-cooled exhaust header. © GNP

Water-cooled exhaust manifolds are almost always used, except by Quickdraw and CMB which use a slightly different cooling system in the cylinder head from that used by Zenoah and Tiger King. Early designs of exhaust manifold coolers had o-ring seals that tended to leak after a while due to heat. More recently, so-called “no-leak” designs offer better reliability, see photos above. Some tuned pipes are water cooled (for example, several of the types supplied by Prestwich Model Boats), some pipes have no cooling at all (for example, the Quickdraw hot pipe), and some are partially cooled with water cooling in only the aft section of the pipe to quieten the exhaust noise (for example, JB). Achieving optimum temperature distribution along the tuned pipe to make sure that the engine develops the best performance is something of a black art.

Water pick ups

In the majority of cases, cooling water is collected by some means which is dependent upon the forward motion of the boat. Most commonly water is collected using water pick-ups: in the base of the rudder blade, on the underside of the hull, *via* a projecting water pick-up pipe mounted on the transom, or from pipes placed very near to the propeller. If a clutch is fitted to a petrol-engined boat, which would allow the boat to stop for a period of time, then normally a separate water pump is fitted. Such a water pump is powered by the pulse pressures developed by the engine.

Rudder

A rudder is probably the most often used way of picking up cooling water. The advantage of this set up is that the rudder blade is normally the lowest part of the boat and therefore is least likely to starve the engine of water. A water inlet on one side of the rudder is best; a water inlet that allows water to enter the water pick up from both sides of the rudder risks water flowing almost straight through the pick up at large rudder deflections. The only drawback of the rudder pick up is that they can pick up weed and block the water feed to the engine.

Photo shows an MHz rudder where the water can enter the rudder from both sides. © GNP

Under hull pick ups

Water inlets under the hull are very effective. Commercially-available single, dual, or even triple water pick-ups that can be let into the hull are easily obtainable. It is worth looking out for the larger versions of such pick-ups as their flow rates are so much better. However, the shape of these pick ups are rarely ideal as the water flow hits a complex junction at the rear of the pick up which forces the water through a nipple and thence to the pipe carrying the water up towards the engine. A carefully curved copper tube works much better.

Photo of a copper pipe based water pick up. © GNP

However, it is important to bond the pipe strongly into the hull and probably hard solder a plate onto the pipe to provide extra strength. It is easy to underestimate the forces that might be exerted on such fittings. A straight brass tube with an angled end can be used. However, it is more difficult to make a reliable connection to the water tubing as there is only limited clearance between the end of the pick up tube and the hull.

Transom pick ups

A pick up mounted on the transom is favoured by some off-shore racers. One advantage is that the pick up is deeper in the water than the hull mounted types. The pick up shown in the propeller mounted section below can also be used on the transom to pick up water.

Photo shows a water pick up designed to be bolted through the transom – water is collected via a hole in the base of the downward pointing shaped strut and a water connection is made from the nipple through the transom. © GNP

Propeller mounted pick ups

Using a tube close to the propeller is favoured when it is difficult to use an alternative, for example in an outboard motor, or sometimes in fast electric boats. The water flow from this type of pick up is not be as uniform as other methods, the problem is that both air and water are forced into the pick up pipe and this can lead to steam being generated in the cooling jacket of the engine. Local hot spots can be a source of premature failures.

Photo shows a typical submerged drive scale water pick up. There is relatively little cavitation associated with the water flow near the propeller so this is a relatively safe technique. © GNP

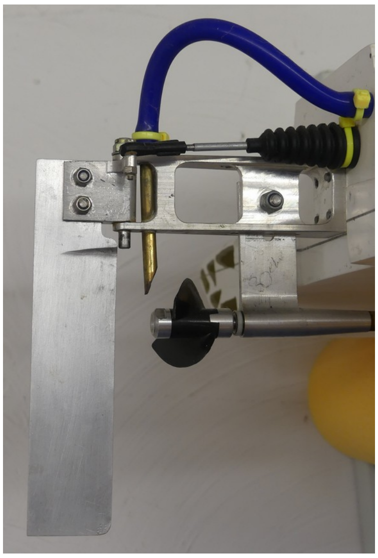

Photo shows a water pick up near the propeller of a model tunnel hull racer where the alternative location under the hull might be difficult as the hull is hardly in the water during a race. © GNP

Photo shows water pick ups in a scale outboard motor setting. Two pick up are used – one for the motor and one for the ESC in the hull. © GNP

Direct cooling

In certain cases it is possible to increase the cooling to certain components, such as an electronic speed controller (ESC), by mounting the cooling plate of the ESC in the hull flush with the outer surface. The use of bespoke heat pipes might have some applications, but usually more conventional approaches work sufficiently well.

Connections

Generally it is a good idea to maximize the flow from the pick up to component requiring cooling, even if it becomes necessary to reduce the flow rate later. For example, commercially-available bulkhead fittings look smart but do reduce flow. Right-angle connections should rarely if ever be used, however if essential it is worth either reworking the internal parts to improve flow or making bespoke fittings.

I find that using a short length of nylon tubing that matches the bore of the water pipe works well as a way of joining tubes together. Usually the silicon tube grips the nylon very strongly so additional clips are not needed, but for added security it is probably worth adding some additional fixings. A failure in any component in the water cooling system can fill a moving boat with water in a matter of seconds with expensive consequences. If large diameter tubing is used make sure that it is well matched to the size of the nipple even if this means introducing a short piece of tubing of slightly smaller bore at the nipple.

Pipework

For racing boats the long pipe runs from the water pick ups to near the engine are often made from soft-drawn copper pipe or carbon tube and frequently these pipes are built into the structure of the hull for added protection.

Silicon tube is most often used for water pipes. For petrol engines, 4 mm bore is probably most commonly used, although 5 mm bore is used if greater flow rates are required. It is worth ensuring that the pipes are not touching, or even near very hot components. Although silicon has very good heat resistant properties it is not worth risking a failure – this is particularly true with thin-walled tubing.

Outlets

It is a good idea to arrange the water outlets sufficiently far apart on the hull so that individual outlets can identified in case of problems.

Acknowledgements

I’m pleased to acknowledge suggestions from Club members.