SECTION 4

PROTECTION AND MARINISATION

4.1 THE HOVERCRAFT ENVIRONMENT
4.2 PROTECTION MODIFICATIONS REQUIRED
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4.1 THE HOVERCRAFT ENVIRONMENT

Hovercraft may be expected to operate over water and beaches and to throw up appreciable quantities of spray, sand or dust. Mechanical components therefore need protection against the adverse environment in which the craft operate, the degree of protection depending on the proposed utilisation of the craft.

The main hostile conditions are sand and salt water, attacking engines internally and externally.

The attack by sand and dust, not only desert type dry sand but also spray-carried as in river or estuary operations, can be very vicious and wear can be very rapid indeed. The protection commonly used, however, is an external measure, by fitting efficient filters on the engine intakes and adopting procedures against residual dust, such as making certain that the filling of oil and fuel tanks is carried out so that the sand or dust does not enter.

Generally speaking, the Wankel rotary engine in its present form – and probably for some time to come – as a commercial unit is very similar in its external features to an equivalent piston engine. It has carburettors, (or injection equipment), distributors, pumps, cooling fans, sparking plugs and coils or transistorised units, which are virtually identical to current ancillaries. Therefore, there is the existing range of knowledge about marinisation to draw upon, which is easily applied to the rotary engine.

The two main water-created problems are surface water which, if it is fresh, causes relatively unimportant rusting and affects the electrical and ignition circuits of an installation; more serious is corrosion and galvanic action by sea water, especially for those engines which are unprotected by craft structure, e.g. the propulsion engines on HD.1.

Surface water and its effects are relatively easy to overcome. For simple rust prevention, fairly rudimentary protections, e.g. plating and painting, are adequate. However, in operation over salt water, corrosion on unprotected parts can be severe. Varying degrees of marinisation can be applied, depending on the application. These will vary from the relatively simple procedures normally adopted on conventional automotive units when used to drive motor boats, to the more extensive and costly modifications that may be needed when operating in a particularly severe environment, (e.g. tropical, exceptionally salt-laden atmosphere, etc.), and in remote regions.

Generally, normal marinisation techniques and protective treatments would be applicable and adequate.

4.1.1 Cooling System

Normal marine practice, applicable to sidewall craft, is to pass the engine cooling wa through a heat exchanger where it is cooled by sea water circulated by a separate pump. Devices should be fitted to prevent blockage of the sea water system and to prevent damage to the engine should this occur. Suitable materials should be used for the sea water system as in marine practice, but since the engine cooling system is in contact with fresh water it does not need special protection. If direct sea water cooling is used, as in outboard engines, the engine cooling passages and pump should be suitably protected (see 4.1.8).

4.1.2 Electrics

The main components should be, if possible, waterproof types (see also 4.2), or cov should be made and fitted. Cables would have connections sleeved and, in very adverse conditions, sealed with mastic. Some electrical items, for example, batteries, coils, fuel pu can be installed in protected compartments.

Good, non-permanent protection is provided by the copious use of aerosol water inhibitors and sealers such as 'WD.40' and 'Dampstart'. An example of these techniques in practice is the Hover-air 'Hoverhawk' which with completely exposed Velocette 'Viceroy' propulsion engines would operate over open water untouched for tens of running hours spread over several weeks without any electrical trouble. In cold weather trials, a craft left outside in snow and sleet for several days started immediately, again with no waterproofing troubles on the electrics. This is particularly important for hovercraft which might be operating in the field and when maintenance is essentially a 'do-it-yourself' exercise.

4.1.3 Carburation

The carburettors are normally die castings in zinc alloy and particularly prone to corrosion. These can be replaced by brass or gunmetal equivalents, or alternatively protecte by a stove enamel or oil resistant marine varnish. Internal corrosion by salt atmosphere is not a problem as the parts are enclosed and subject to a cleaning action by the fuel, and th choke tube by air scour.

4.1.4 Engine, Main Castings (rotor housings, spacers, covers)

These are among the least vulnerable components of liquid cooled engines. Even severe rusting, or corrosion where the castings are in aluminium, is likely to have little effec on the life of an average high performance engine, particularly if one considers a major over haul period of at most, say, two years. The usual external treatment is painting with a corrosion resisting enamel or a heat and sea water resistant varnish, as on the B.M.W. motor boat conversion engines. Aluminium may be anodised.

4.1.5 Transmission and Auxiliary Drives

On the engines under consideration, the NSU KKM 612, Toyo Kogyo 10A and Mercedes M 950, the various shafts are fully shrouded from the environment and possibly further protected by an oil film due to slight leakage through seals and bearings. This avoids the need to take the more drastic measures that would otherwise be necessary, e.g. replacing components by new parts in stainless steel or plating them, to avoid corrosion, causing pitting which would act as stress raisers on highly stressed parts. The front fan belt pulley drives and any other low power drives can be protected with bellows or gaiters.

4.1.6 Air Cleaners

Normal precautions must, of course, be taken to prevent the ingestion of spray. Wankel engines in general seem more sensitive to the ingress of dust into the engine than reciprocating piston engines. Since some hovercraft may operate at times over dry ground, and are thus liable to be enveloped in clouds of dust, it is imperative to incorporate generously proportioned air cleaners and pay close attention to the provision of clean induction air throughout the design and manufacturing stages. In practice, this means slightly larger air cleaners, oil bath types if possible, preceded by efficient centrifugal (cyclone), type separators, similar to those fitted to vehicles prepared for desert duties.

Where engines are accommodated in special compartments, nominal pressurisation may prevent the entry of a great deal of dust into the compartment. Air should be admitted to the engine compartment only by way of some form of air cleaner, such as centrifugal type separators. The engine will draw its air from the compartment and ordinary automotive oil bath type air cleaners should prove quite satisfactory under these circumstances.

Virtual sealing of the engine compartment has the additional benefit of reducing the noise levels, especially if it is designed with noise suppression in mind. Sealed engine compartments also facilitate the incorporation of automatic fire suppression devices, which are most important if petrol engines are used.

Adequate air cleaners for free standing power-pods, usually associated with aircraft type propeller propulsion, present a slightly greater problem, the solution of which may entail a modest power loss. Depending on the size and shape of available oil bath type air cleaners, it may be necessary to locate them elsewhere on the craft and extend the induction system to suit. A great deal of experience and information was accumulated at M.V.E.E. (then F.V.R.D.E.), during the 1939–45 war period in connection with the desert campaigns.

4.1.7 Control System

This is usually relatively unprotected on automotive engines, so fairly intensive treatment could be required. Simple shafts, push-pull rods, etc., should be replaced by stainless steel or plated parts. Links, nuts, bolts and other small parts, should be well plated.

It is advisable not to use cadmium plating on control systems for two reasons. Und conditions of high humidity it does not necessarily give complete protection and secondly, more important, if cadmium plating is used as a bearing surface there is a possibility of 'pic up' and preventing movement. (Drastically brought to light as the result of an air crash so years ago.)

The prevalent use of nylon bearings does obviate one potential trouble spot without modification.

4.1.8 Galvanic Action

In the choice of protections for marinisation one has to consider the cause of the corrosion, for example galvanic action, where two dissimilar metals create an electrical potential when moisture is present acting as an electrolyte. This can occur not only with standing surface water but also in regions of high humidity, as may well exist in the variou compartments of a hovercraft. This potential exists not only between components of dissimilar metals but also between parent metal and plating, so care must be taken to avoid discontinuities in the plating either at the manufacturing stage or during engine fitting operations. If a high degree of safety is required, adjacent components of dissimilar metals should be plated or coated with a material (if possible) compatible to both.

It will be seen, therefore, that when considering a marinisation programme for an engine, to provide complete protection, each part must be examined materially to ensure t any incompatible materials are not allowed contact. This is especially important bearing in mind that for hovercraft use, lightweight engines are chosen and often a high proportion of aluminium, and occasionally magnesium, is used in their construction. If shafts and transmissions are of a corrosion resisting nature, high potentials can be created between them an adjacent light alloy parts if suitable barriers are not interposed.

4.2 PROTECTION MODIFICATIONS REQUIRED

Since these must ultimately vary with specific engines and only generalisations ca be made, as in Section 4.1, an examination is made of the two engines being considered fo installation into the Hovermarine HM2 and the Cushioncraft CC-7, namely the NSU KKM and the Daimler-Benz M 950/4. Details ascertainable for the Toyo Kogyo 10A engine are shown since this could be used, if available, as an alternative to the NSU engine in those a of the world covered by Toyo Kogyo under their licensing arrangements (but see 3.1.2). Tables 4.1 to 4.4 show the main components, their material and suggested treatment, but should only be considered a guide as, particularly with the M 950, development is a contin ous process with materials being constantly changed and improved. It will be seen that wi the exception of the magnesium oil pump on the M 950, intensive protection is not requir

Although the rotor and end housing casting material (very similar on all engines, including the Fichtel & Sachs range), is inherently corrosion resistant, all manufacturers – and Daimler-Benz particularly – advise that for salt environment operation some protection to the exposed surface is required.

4.3 ECONOMICS OF PROTECTION

It will be seen that two major factors arise:

(i) the cost of protecting an engine,

(ii) the life that might be expected from a particular component, taking its working environment and frequency and standard of maintenance into account.

4.3.1 Cost of Protecting an Engine

To marinise an engine completely can be a costly exercise. Generally, manufacturers are not prepared to interrupt production lines to produce a few parts in non-standard materials, therefore most marinisation is done by specialist firms who rebuild the engine, making individual parts as required. This is reflected in the cost with tooling, new casting patterns, etc., being amortised over an anticipated run of engines. In the sort of run which might be expected for hovercraft, these costs would be spread over relatively very few engines and the resultant price per engine could be very high and might even exceed the first cost. Even a high standard of surface protection can be expensive compared to a new part; for example, good chromium plating costs come to some 24/- (£1.20) per component pound weight. As an example, a stub shaft priced new at say 50/- (£2.50) and weighing 2 lb would cost nearly the same to plate.

A rough estimation of costs would show an increase of perhaps 40% to 50% in the new cost of an engine for a reasonable degree of external protection, i.e. plated or metal sprayed ferrous parts, varnished or enamelled main castings, anodised aluminium parts and waterproofed electrics. This would give a life compatible with the expected life of the engine. Alternatively, one could use rudimentary surface treatments, e.g., degreasing followed by polyurethane or epoxy varnishing on metal parts, some waterproof electrical components and use of waterproof sprays at 2% to 3% over the engine cost, plus retouching as necessary.

The decision must rest with the user, bearing in mind the first cost of the complete craft, the proposed use of the craft, proficiency of maintenance staff and relevant labour charges and expected life of the engine or craft.

In practice, it could take several weeks to obtain components to replace vulnerable parts and to design alternative fittings, etc., though the actual work of marinisation of one particular engine could probably be carried out in two to three weeks. Consequently, some three to four months should be allowed for marinisation.

TABLE 4.1

Engine Component Protection
NSU KKM 612 Engine

Component	Material and Specification	Hoverprojects' suggestion for treatment
Rotor housing	GAlSi 12 MgFe	Anodise after machining, otherwise enamel engine assembly.
Front cover	GAlSi 10 Mg	Anodise after machining, otherwise enamel engine assembly.
Fan (if used on hovercraft)	Plastic	Nil
Water pump	Aluminium	Chromate and varnish.
Controls (Due to type of twin carburettors these are quite complex)	Steel	Replace by stainless steel, or nickel and/or chromium plated.
Carburettors	Zinc alloy	Replace with marine gunmetal type, or marine, oil resisting varnish existing unit externally.
Clutch assembly	Various	Ensure fully protected by new required bell housing or gearbox.

TABLE 4.2

Engine Component Protection
Daimler-Benz M 950 Engine

Component	Material and Specification	Hoverprojects' suggestion for treatment
Rotor housing	Aluminium alloy Si 9-9.5% Mg 0.3-0.5% other 1.4% Al *GAlSi 10 Mg.wa	Anodise after machining, otherwise enamel after assembly.
Rotor sandwich plates	Cast iron	Zinc rich paint and enamel.
Front casing	As rotor housing	
Rear casing	As rotor housing	
Oil pump	Magnesium	Preferably replace. Alternatively chromate treat and varnish.
Fan (if used on hovercraft)	Plastic	Nil.
Controls	Steel	Replace by stainless steel, or nickel and/or chromium plate.
Fan belt pulley unit		Fit plastic bellows between pulley and end cover. Replace standard nut by plated cap nut.
Clutch Assembly.	Various	Ensure fully protected by new required bell housing or gearbox.

* Daimler-Benz specification.

TABLE 4.3

Engine Component Protection
Toyo Kogyo Mazda 10A Engine

Component	Material and Specification	Hoverprojects' suggestion for treatment
Rotor housing	Aluminium alloy*	Anodise after machining, otherwise enamel after assembly.
Rotor sandwich plates	Cast iron	Zinc rich paint and enamel.
Front cover	As rotor sandwich plates	
Rear cover	As rotor sandwich plates	
Carburettor	Zinc alloy	Marine oil resisting varnish externally.
Water pump	Aluminium alloy	Anodise after machining, otherwise enamel after assembly.
Oil pumps	Aluminium alloy	Anodise after machining, otherwise enamel after assembly.
Clutch assembly	Various	Ensure fully protected by new required bell housing or gearbox.
Fan unit (if used on hovercraft)	Steel and Aluminium	Zinc rich paint. Anodise or enamel.

* Specification not known but probably similar to NSU and Daimler-Benz engines.

TABLE 4.4

Engine Component Protection
Typical for Fichtel & Sachs Engine Range

Component	Material and Specification	Hoverprojects' suggestion for treatment
Rotor housing	Silumin gamma aluminium alloy GAlSiMgwa type	Anodise after machining, otherwise enamel after assembly.
Front cover	Hyper eutectic aluminium silicon alloy	Anodise after machining, otherwise enamel after assembly.
Rear cover	Hyper eutectic aluminium silicon alloy	Anodise after machining, otherwise enamel after assembly.
Carburettor	Zinc alloy	Replace by marine gun-metal type or varnish.
Air guide housings and covers	Aluminium alloy	Chromate and enamel.