SYNTHETIC LUBRICATING OIL IN PROPULSION DIESELS

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ABSTRACT

The R.A.F. has suffered for a long time with lacquering of internal combustion engine components in their vessels causing failures before reaching their expected life. This article discusses ways of overcoming this by the use of a synthetic oil.

Background

The R.A.F. operates six Rescue Target Towing Launches (RTTLs) currently being run on behalf of the R.A.F. by James Fisher Ltd. These craft (FIG. 1) are used for towing water-borne targets for naval gunnery and for aircraft, and also for practising survival drills for air crews. Vessels are based at Plymouth, Great Yarmouth and Invergordon. Also two are based at Gibraltar and are run by the Navy.

Brief details of the craft are:

Type: Paxman Ventura 8YJCM

No. of cyclinders: 8

Configuration: 60°V, water-cooled

Bore and stroke: 7·75 in × 8·5 in

Combustion system: Diesel 4 stroke, turbocharged and intercooled

Rating: 1000 BHP at 1500 rev/min

Gearbox type: ZF marine reversing gearbox type BW800H20.

Electrical power is supplied by two Perkins 4·236 diesel generators for H.M.A.F.V. *Spitfire* and 2 Perkins 4·107 for H.M.A.F.V. *Halifax*.

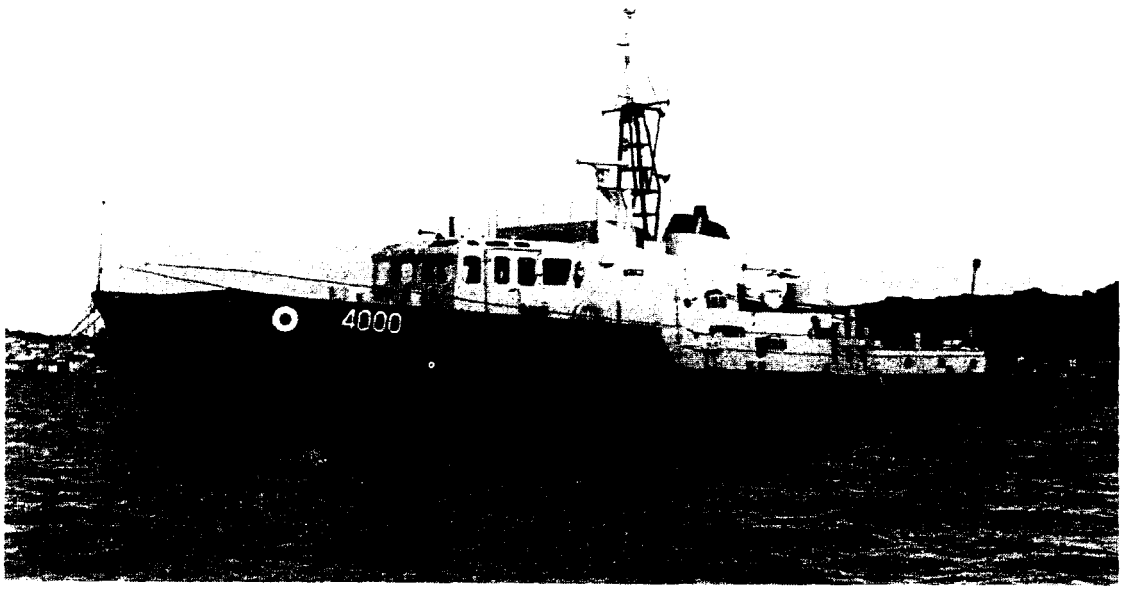

FIG. 1—H.M.A.F.V. 'SPITFIRE', A R.A.F. RESCUE TARGET TOWING LAUNCH

Introduction

For a considerable time the R.A.F. has been experiencing buildup of lacquer in the combustion area of the propulsion engines fitted in H.M.A.F.V. *Spitfire* and *Halifax* based at R.A.F. Mount Batten, Plymouth. Lacquering generally occurs in cold weather when the engine has been idled or run at low load. Where poorly atomized fuel droplets injected into the cylinder hit the cold walls inside, they are quenched and are only partly burnt during the combustion cycle. The residual hydrocarbon/carbon mixtures coats the piston crown, valves, etc., and, unless subsequent firing cycles give a significant rise in combustion chamber temperature, the residue builds up. This gives a shiny black appearance (FIG. 2). Lacquering causes the sticking of cylinder head valves and piston rings which results in bent valves and ring/piston failures, and engines are therefore being changed before they reach their overhaul life of 6000 hours.

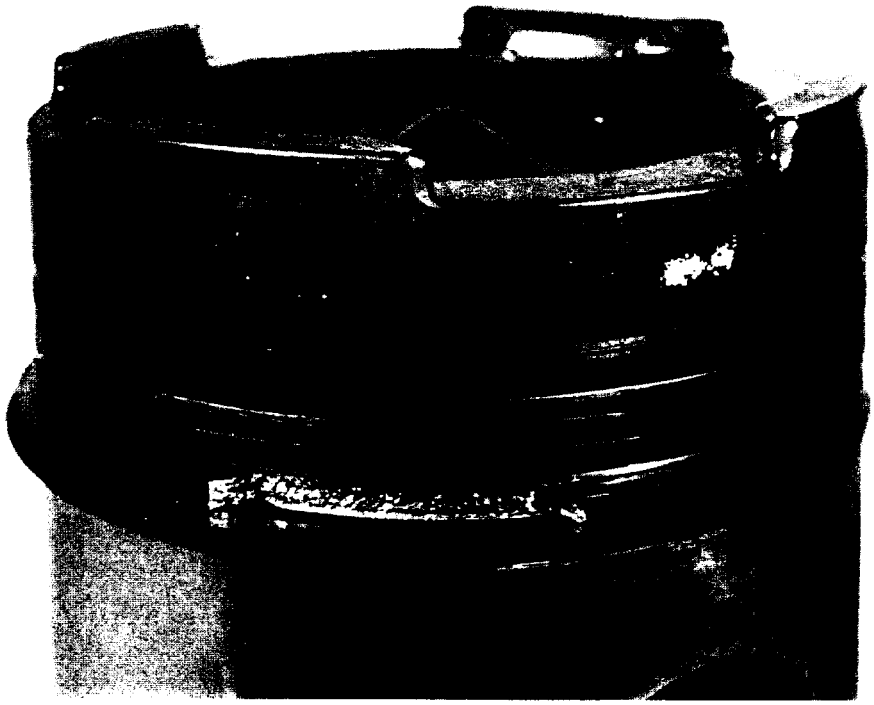

FIG. 2—LACQUERED PISTON REMOVED FROM H.M.A.F.V. 'HALIFAX'

Lacquering has been more pronounced since the running of the vessels was taken over by James Fisher and Son, as these craft were rotated around the country when they were operated by the R.A.F., but are now permanently based at the same establishment.

In 1985 a decision was taken to try overcoming internal lacquering on the propulsion engines by using Mobilguard SHC 120 synthetic lubricating oil in H.M.A.F.V. *Spitfire* under a minor trial arrangement. This oil was chosen due to its compatibility with OMD-113; it was designed for low temperature applications, and no special Health and Safety precautions are necessary when handling the oil. At the same time it was also decided to use the same Mobilguard synthetic oil in the ZF gearbox and Perkins generators, for logistic purposes as well as to give further assessment of the synthetic oil. Before the minor trial commenced both propulsion engines were given an extended top overhaul (at 3900 hours for port engine and 2700 hours for starboard engine). This involved the extra requirement of removing the pistons and cleaning off any lacquer that was present.

Composition of Synthetic Oil

The base stock in the process of manufacturing Mobilguard SHC 120 is ethylene gas which is polymerized to form liquid alphaolefins. Then a second stage of polymerization forms polyalphaolefins which are saturated with hydrogen to form very stable molecules.

The resulting fluid consequently consists of mixtures of a few types of very similar molecules with well defined physical and chemical properties, in contrast to the complex mixture of hydrocarbon structures found in mineral oils such as OMD-113.

TABLE I—*Comparison between Mobilguard SHC 120 and OMD-113*

Oil	*OMD-113 Esso*	*SHC 120 Mobil typical figs.*	*SHC 120 as supplied to H.M.A.F.V. Spitfire*
Appearance	Brown, clear and bright	Clear and bright	Dark brown, clear and bright
Density at 15°C (kg/l)	0·892	0·876	0·878
Flash Point (0°C)			
Open	—	227	—
Pensky Marken Closed	203	—	194
Kinematic Viscosity at 40°C (cSt)	117·5	93	95·3
at 100°C (cSt)	12·53	13·00	13·33
Viscosity Index	98	145	139
SAE Viscosity Grade	40	40	40
Total Base No. (mgKOH/g) IP 177*	9·1	—	9·6
IP 276*	—	12	—
Rubber Swell Test			
7 days at 100°C (change in volume)		—	
Natural	+124		+83
Synthetic	−0·1		−2·9
Butadiene-Acrylonitrile 'O' Rings	−3·7		−1·0

*Note: Method IP 276 always gives higher result than IP 177

In-service Experience Using Synthetic Oil

H.M.A.F.V. *Spitfire* was converted to using Mobilguard SHC 120 in November 1985; by May 1986 60 running hours had been completed on the propulsion engines. At this point the vessel started to report that they were experiencing numerous leaks from the oil seals. Mobil Oil Company, Ltd, was contacted and were surprised at the number of leaks; this apparently had not been a problem where Mobilguard had been used in commercial engines.

The offending seals were changed and it was agreed that rather than waste the effort put into the trial so far, it would continue. But this would not answer the question of whether the oil leaks were the result of using Mobilguard. In order to resolve this problem an additional craft, H.M.A.F.V. *Halifax* which is also based at Plymouth, would be converted to Mobilguard to see if the same problems occurred again. *Halifax* was converted during June 1986 and to date no major oil leaks have developed. Therefore, as *Spitfire* has not experienced the same problem again, this must have been an isolated occurrence. Nevertheless it was later ascertained by RAE Cobham that during tests natural rubber does not swell so much when in contact with Mobilguard as with OMD-113 (see TABLE 1).

By June 1987 575 hours had been run on *Spitfire*'s port propulsion engine with no further oil leaks reported. At this point it was decided to carry out an internal inspection, which consisted of removing three cylinder heads and one articulation of pistons, i.e. two pistons (FIGS. 3 and 4).

Examination internally revealed the engine to be very clean and with no sign of sludge or condensation build-up in the rocker covers. The piston condition was excellent with no evidence of lacquer on the crown or skirt. Carbon deposit was minimal on the crown and none on the ring belt or skirt. From FIG. 3 it can be seen that the original marks where the lacquer was removed before the trial are still clearly visible, confirming that no build-up of lacquer had occurred since changing to Mobilguard.

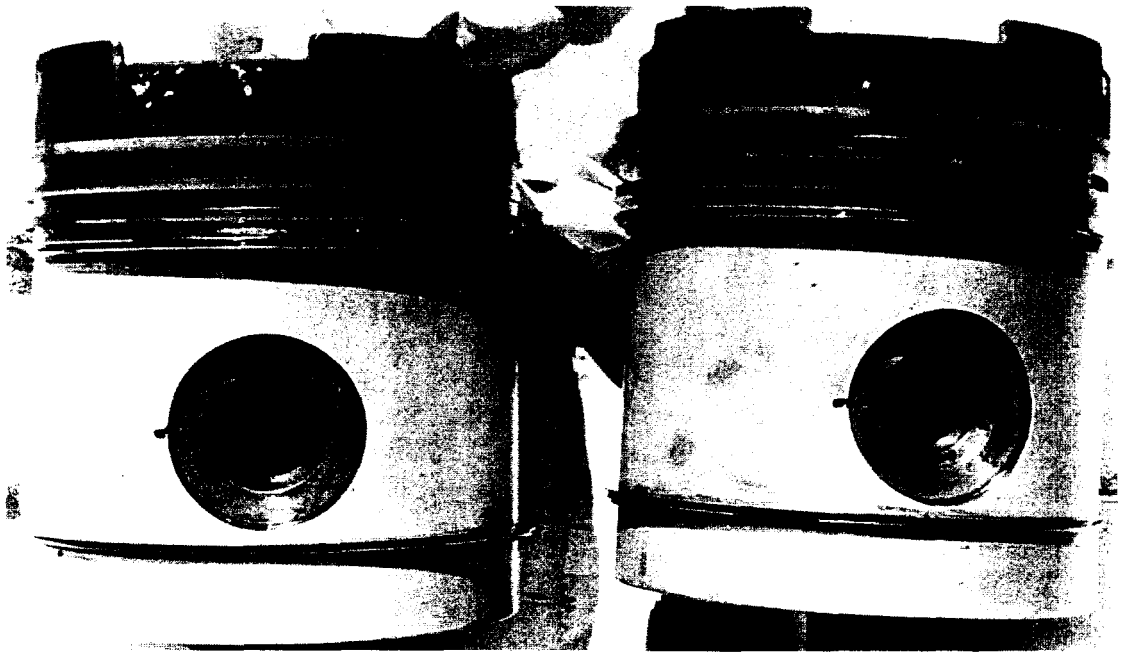

FIG. 3—PISTONS REMOVED FROM H.M.A.F.V. 'SPITFIRE' PORT ENGINE AFTER 575 HOURS RUNNING ON MOBILGUARD SHC 120 OIL, SHOWING ABSENCE OF LACQUERING

Cylinder head condition was good with only a light carbon deposit on the combustion face (FIG. 4) Valve seats and valves were in excellent condition with no signs of lacquer and only slight carbon deposition on the lower stem of the exhaust valves—rather less than that seen on engines running on OMD-113.

This inspection increased confidence in the synthetic oil, until October 1987 when (after 800 hours) flash fires occurred within the 'vee' of the engines in *Spitfire*, where the exhaust system connects to the turbocharger and excessive oil/mist was coming from the turbocharger vents. At the same time *Halifax* was beginning to experience the same symptoms.

It was determined that the problem was occurring after a period of light load running followed by a period of full speed running when the rise in exhaust temperature ignited the oil. Initially it was thought that this was a seal failure within the turbocharger allowing oil to pass into both the air manifolds and from the turbine end into the engine exhaust manifolds.

At this point it was decided to change the turbochargers on *Spitfire* and return them to the manufacturer for technical investigation, and to revert back to OMD-113 in *Halifax* (which was later found to have been an unwise decision). Also at this stage oil samples were taken and sent to RAE Cobham for analysis (TABLE 1).

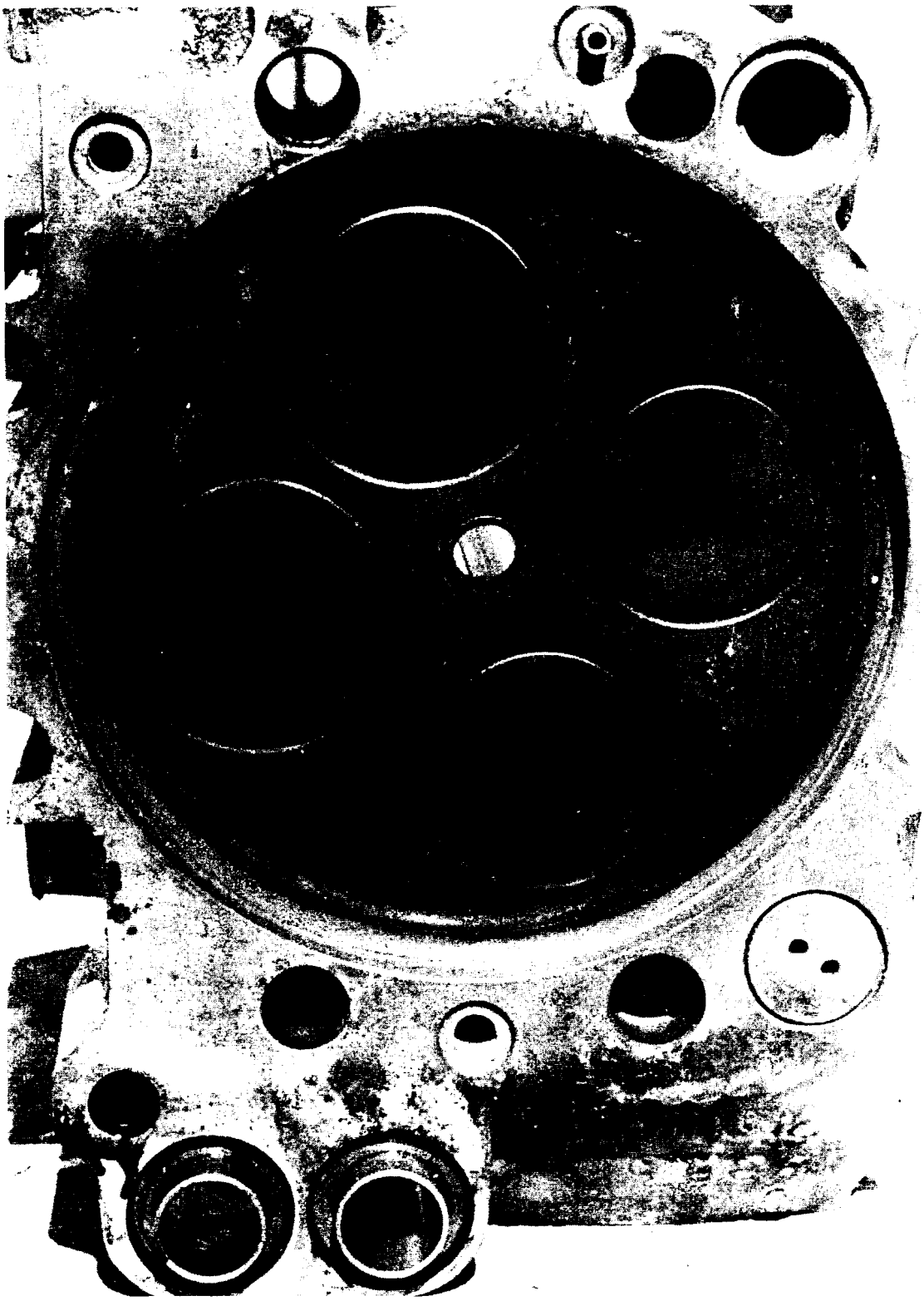

FIG. 4—CYLINDER HEAD REMOVED FROM H.M.A.F.V. 'SPITFIRE' AFTER 575 HOURS RUNNING ON MOBILGUARD SHC 120 OIL

Examination of the turbochargers at Napiers Turbochargers, Ltd, revealed that the emission of oil from the breathers was not caused by a seal failure, but by high oil level in the turbocharger sumps. This was caused by the synthetic oil retaining its viscosity at higher temperatures (TABLE 1) and not being able to drain away fast enough. Lacquering on the turbine inlet bends (exhaust side) and nozzle ring was also clearly visible.

Due to the evidence of lacquering in the turbocharger it was decided to carry out further investigations on *Spitfire*'s port main engine. Endoscope examination of cylinders revealed a clean combustion face after a period of sustained running whilst on exercise. The following day when the engine was completely cold it was started and run for a period of three minutes then stopped. Further examination by endoscope showed a small pool of oil and fuel on top of each piston crown, together with a wet surface finish across the whole surface area (FIG. 5).

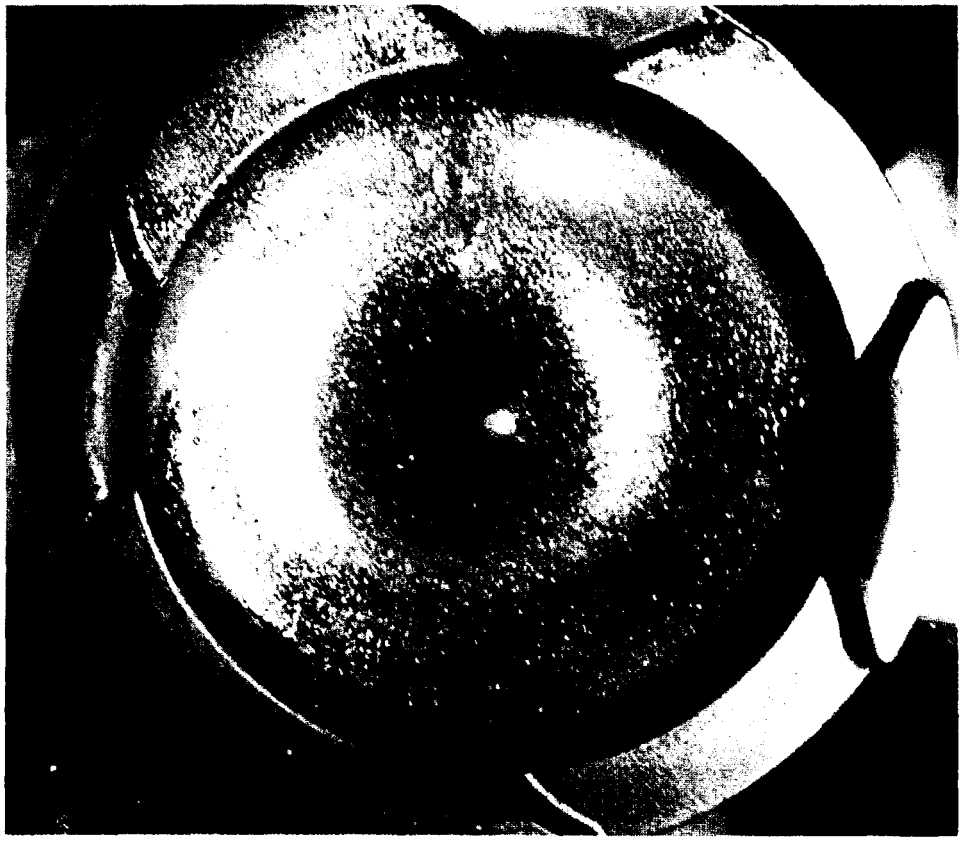

FIG. 5—PISTON REMOVED FROM H.M.A.F.V. 'SPITFIRE' AFTER 800 HOURS RUNNING ON MOBILGUARD SHC 120 OIL. THE SURFACE IS WET

The engine was then run for a further 35 minutes at 600 r.p.m. and stopped; one cylinder head was then removed. Both the combustion face of the cylinder head and the piston crown were coated in a satin black lacquer. This lacquer also extended into the exhaust manifolds and explains the presence of lacquer in the turbo-chargers examined at Napiers. The piston was removed and it was seen that the lacquer had not reached the ring pack, ring grooves or the skirt of the piston.

Meanwhile, after only three hours running on OMD-113 *Halifax* suffered sticking valves and high crankcase pressure. Investigation revealed that all the top four piston rings had broken in numerous places together with ring land break-up caused by lacquering on several pistons. After repair *Halifax* was converted back to Mobilguard SHC 120 oil.

It would appear that synthetic lubricating oil is still passing the piston ring pack to mix with unburnt fuel to form a lacquer although not to the extent of OMD-113 in cold low-load running conditions. However the synthetic oil does not encroach into the piston ring grooves, but follows the gas path, i.e. it forms deposits on the exhaust ports and exhaust turbine in the turbocharger.

There also seems to be a contradiction in events as, whilst oil is not draining fast enough from the turbochargers due to the greater viscosity when hot, it does appear to be pumped or pushed into the exhaust system resulting in collection in the turbocharger bellows at prolonged low-speed running when the engine is hot. This oil is then forced out of the bellows when full power is next used, causing oil droplets to fall on the hot exhaust manifolds and ignite.

Conclusions

To minimize the critical period when lacquering occurs the following actions are being introduced or are still under investigation:

(*a*) The cooling water supply to the intercooler is to be shut off until the manifold temperature reaches 60°C and then be maintained at or near this temperature by minimal opening of this valve. (It was found during one visit that these valves were left open all the time.) This will enable the engine to be brought up to operating temperature more quickly.

(*b*) Operating the vessel from port to station and return on one engine. This has the advantage of operating the engine at a higher temperature/load.

(*c*) Introducing a larger lubricating oil drain from the turbochargers to enable the oil to flow away from the turbocharger sumps more quickly.

(*d*) The pre-heating of the lub oil and water overnight before the craft are used and the use of ambient air heating. At present all these craft have lubricating oil and water heaters fitted and they are used on all the vessels except those at R.A.F., Mount Batten. This is because the craft there have to be moored at a buoy with no electrical power available.

The results so far are encouraging, but only about 2000 running hours have yet been achieved on the four engines. Therefore it is difficult at present to ascertain if this synthetic oil is the way ahead for the future. The trial is to continue in order to gain more experience, and then the possibility of a trial on a generator engine will be considered.

References

1. Rayner, R.: Examination of components from Paxman 8YJCM in HMAFV Spitfire after 575 hours running on Mobilguard SHC 120 lubricating oil; Paxman Diesels Ltd. Post Design Report PDS/FR87/35 dated 8 Oct. 1987.
2. Perkins, T.: 8YJCM engine lubricating oil problems; Paxman Diesels Ltd Visit Report dated 8 Dec. 1987.
3. Mobil Oil Company: *Marine diesel engine . . . synthetic lubricants and their marine applications*; [1985].