MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

1 # A STUDY ON THE EFFECT OF SOME CLIMATIC FACTORS ON OIL
2 # CONSUMPTION RATES IN A RECIPROCATING DIESEL ENGINE.

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4 ABSTRACT

The paper reports the results of an experimental investigation on the effect of some climatic factors on oil consumption rates. Worn compression rings having a profile of super ellipse, high cooling temperatures and contaminated lubricants were considered in the study. The testing program was achieved on an EMSON AVI single cylinder diesel engine with a complete set of control and measuring devices. Different wear indices for the compression rings were investigated over the mechanicl and running conditions range of the tested engine. Three oils with different iron and dust contents were tested. Optimal oil consumption rates have been observed for worn ring shapes and which can be proposed for actual automotive engines. The interaction between oil contamination ratios and cooling temperature have been examined and reported.

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INTRODUCTION

The analysis and control of oil consumption in reciprocating type internal combustion engines are both challenging and interesting since adequate rates of oil flows provide optimal engine efficiencies and maintenance costs, [1]. Apart from any leakage the lubricating oil flows to the combustion chamber, where it is consumed, via two ways, [2]:

1. The piston cylinder assembly, where the oil flows through the hydrodynamic film between the ring face and the liner or due to the pumping action of the rings inside their grooves.

2. The valve stem-guide clearance where the oil flows as the result of the depression created during the suction strokes and the relative motion of the valve stems in their guides.

Oil consumption is not only related to various oil characteristics, design and different mechanical features of the engine but also on the running conditions and the environment in which it operates. Unefficient air and oil filterings are of the most important factors generating the interactive problems caused by the climatic conditions on the lubrication of the engine. Dusty intake air accelerates the abrasive wear rates and reshapes the geometry of the sliding rings. In addition, the contaminated circulating oil clogs the flow passages and alters the viscosity and the required chemical properties of a proper lubricant. Moreover, high operating temperatures, which are aggravated by a hot atmosphere with poor cooling, stimulate adhesive wear which is caused by the direct metal to metal contact that may occur when the resistant oil film cannot separate the surfaces due to oil viscosity decrease. Many investigators assumed specific ring shapes such as spherical, parabolic and barrel-faced to analyse the hydrodynamic lubrication features of the ring pack, Dowson and Economou, [3], Rhodes, [4], Furuhama and Hiruma [5]. Their interests involved the formulation of mathematical models, and comparative estimations of the minimum oil films generated and the pertinent coefficients of friction. Relatively little attention is given to actual comparative measurements of oil consumption rates with specific worn ring shapes. Due to the probabilistic type of ring motion inside its groove and the time variant tribological phenomena involved, testing programs carried out on specific engines with selected mechanical and running conditions are usually satisfactory, [6]. In the work presented in this paper, a representative ring face shape in the form of a super ellipse is experimentally tested. This configuration has been deduced by curve fitting typical profiles of collected used rings and which describes the wear process generated by contaminated oils, Fig.(1).

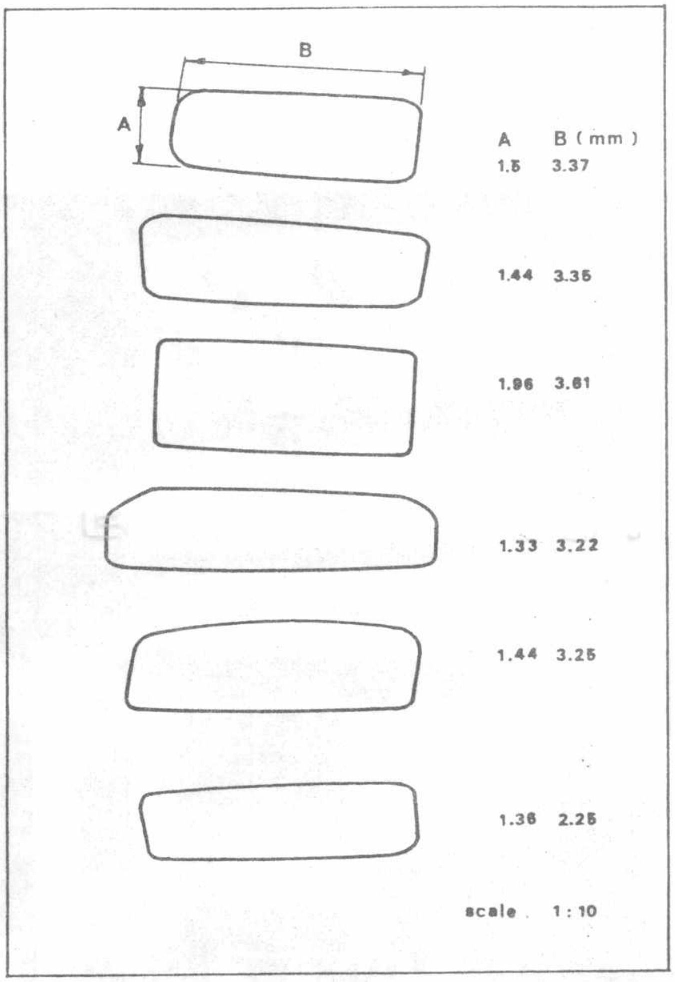

Fig. 1-a Typical Profiles of Collected used Rings Enlarged by Tool Room Projector and Micrometer (Measurement Labs-Faculty of Eng. Ain Shams University).

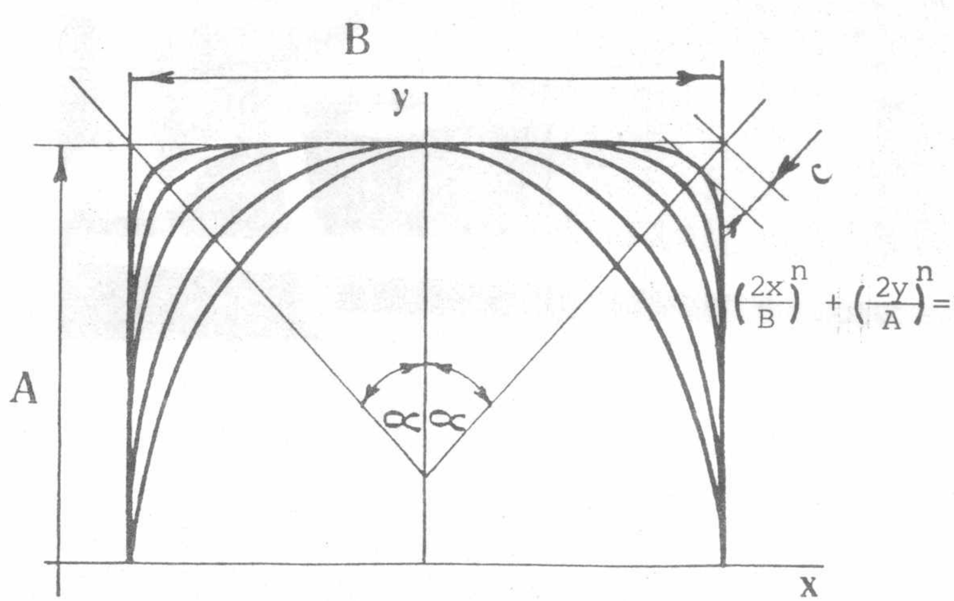

Fig. 1-b Geometry of Super Ellipse Ring Profile.

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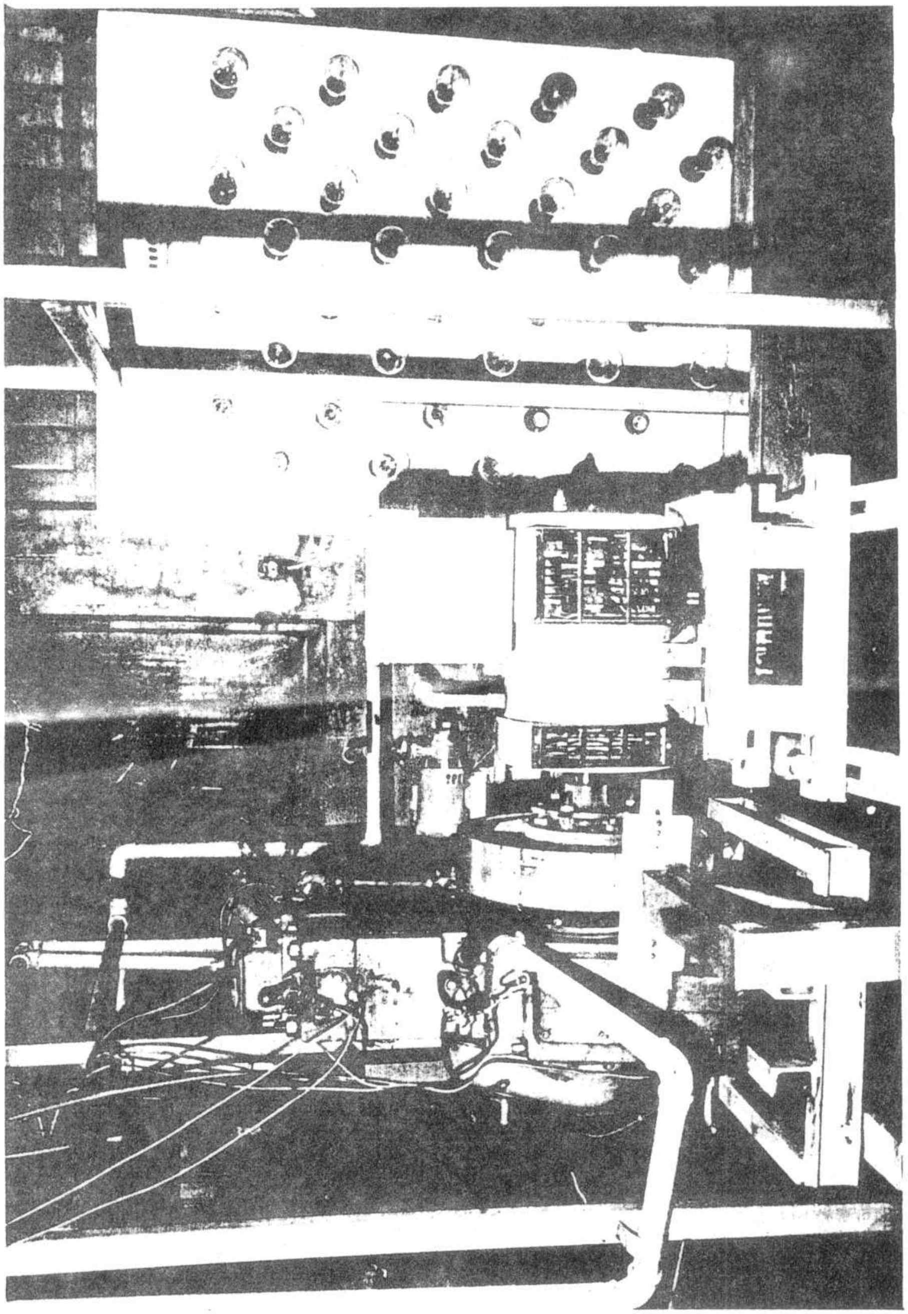

Fig. 2 Exploded View of the Test Rig (Automotive Labs in Helwan Univ. Mataria).

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Oil consumption rates are measured over selected actual ranges of operating temperatures, engine speeds and loads. Three polluted and used oils with different iron and copper contents are tested and evaluated and which represent actual climatic effects on a running engine.

EXPERIMENTAL WORK AND RESULTS

Fig. (2) shows an exploded view of the test rig used in this investigation. it consists of a 553 ml., 5HP EMSON AVI single cylinder, four strokes and water cooled Diesel engine. The loading of the test engine is achieved through an external electrical resistance fed by the current provided by an A.C. generator coupled to the engine. An open and closed cooling circuitries provide the adequate control of the operating temperatures up to 90°C.

For each test run, the engine is cleaned and degreased to remove all traces of used oil from a former test, especially the piston lands and ring grooves to assure free ring operation. A quantity of 3.5 liters of the tested oil is used in each run of 10 hours test duration with the selected mechanical and operating conditions being kept constants.

For specific side clearance values, the compression rings were grinded on a surface grinder to decrease the ring width. The shaping of the ring faces was carried out using a devised ring fixture and which consists of a truncated cylindrical block at an angle $\alpha = 42°$. With reference to Fig. (1-b) flat ring corner grinding has been achieved to a depth equivalent to that of a specific super ellipse exponent value (wear index). Smoothing of the side areas is then carried out. With this procedure, the technical difficulties involved in forming the supper ellipse profiles have been overcome with satisfactory approximation.

With reference to Figs (3) to (6) the results obtained for the average oil consumption rates for the different mechanical and operating conditions are reported. These include three rotational speeds (500, 1000 and 1500 rpm), three load levels (1.29, 1.72 and 2.58 KW) and four cooling temperature values(60, 70, 80 and 90°C). At the low temperature value (60°C) results show an almost constant oil consumption rate of 12 ml/hr for engine rotational speeds between 500 and 1000 rpm. At the high load level (2.58 KW) and aspeed of 1500 rpm oil consumption rates reach a value of 38 ml/hr. These rates increase to 70 ml/hr at the highest tested cooling temperature (90°C). Plots reported in Fig. (4) illustrate the increase of oil consumption rates with relatively high compression ring side clearance values. For three folds of the side clearances an average of 20% increase in oil consumption rate was observed.

The two plots reported in Fig. (5) are the results of an experimental evaluation of the ratio between the oil consumption via piston ring assembly and that from the overhead valve stem-guides. In order to differentiate between both actual quantities the discharge tube feeding the rocker chamber, which lubricate the valve-guide has been disconnected to eliminate the flooded lubrication in this area. Small drops of oil were provided at long time intervals during the test durations. For the 1000 rpm tests the ratio Q_{rings}/Q_{total} turns out to be around 58% while this ratio slightly increases to 62% at 1500 rpm. These ratios were almost the same for different loads. With reference to Fig. (6) where the oil consumption rates were actually measured for different wear index values for the operating compression rings the following observations were recorded. First, optimal oil consumption rates are most likely to occur for index value in the range between 2 and 3. Second, higher oil consumption rates were observed for flat and sharp ring profiles. In addition, rings with approximate index value of 2.25 showed the lowest oil consumption rates at the different operating conditions. Fig. (7) reports the effect of contaminant concentration in used oils. Three oil mixtures were tested. Oil C which possesses the highest contminant concentration shows the lowest oil consumption rates and which further decrease with the increase of the coolant temperature. This is a direct effect of possible groove glocking with an unefficient pumping action.

Oil	A	B	C	New oil
Base No.	8.8	5.2	8.5	9.7
Acid No.	2.58	1.84	2.4	2.08
Iron %	25	47	75	Nil
Copper %	Nil	Nil	8	Nil

CONCLUSIONS

The super ellipse profile for actual running compression rings is the most probable ring shape due to successive wear and which has been proposed from the study of collected used rings. A wear index between 2 and 3 provides optimal lubricating oil consumption rates over a wide range of engine operating conditions.

An increase of contaminant ratios in the lubricating oil leads to a decrease in oil consumption rates especially at high operating temperatures. Larger side clearance values between the rings and their grooves can provide optimal oil flows for an efficient tribological condition when oil and air filters are contaminated with polluants.

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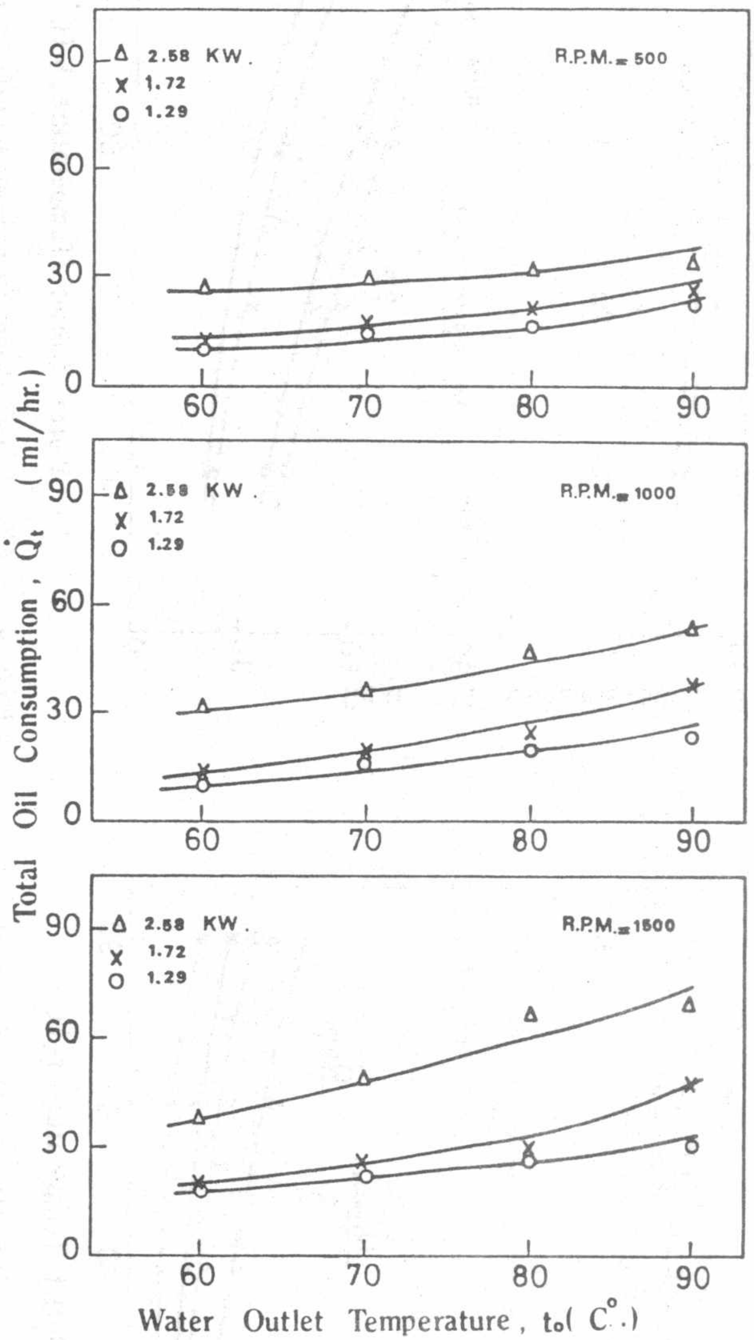

Fig. 3 Effect of Cooling Temperatures on Total Oil Consumption Rates at Different Loads and Speeds.

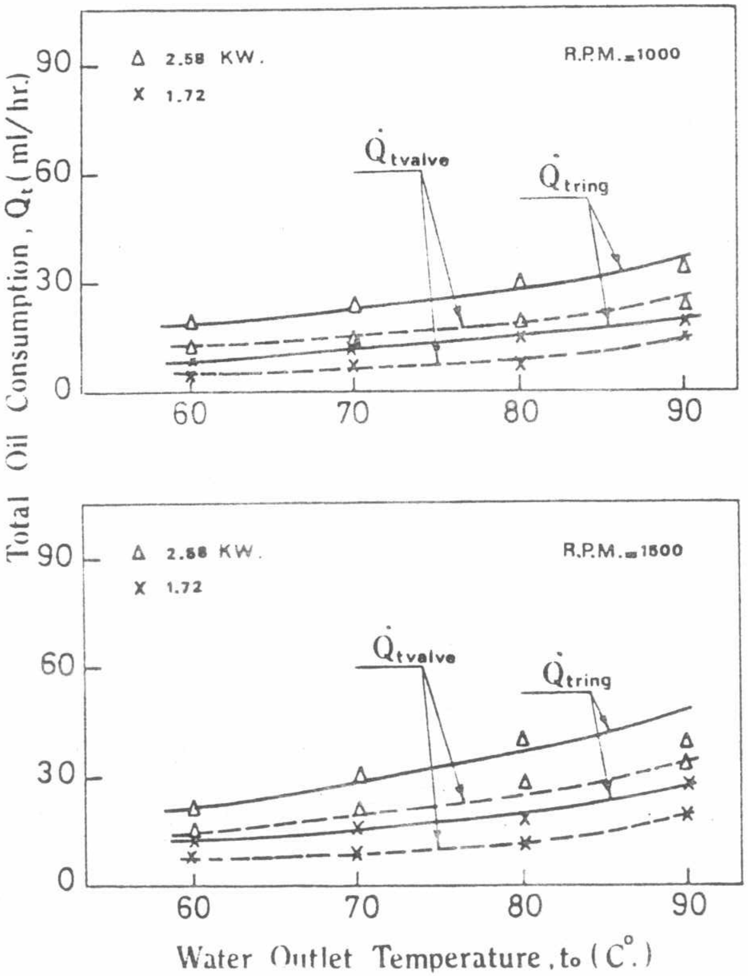

Fig. 5 Variation of Valve-Guide and Ring Film Oil Consumption Rates at Different Operating Conditions.

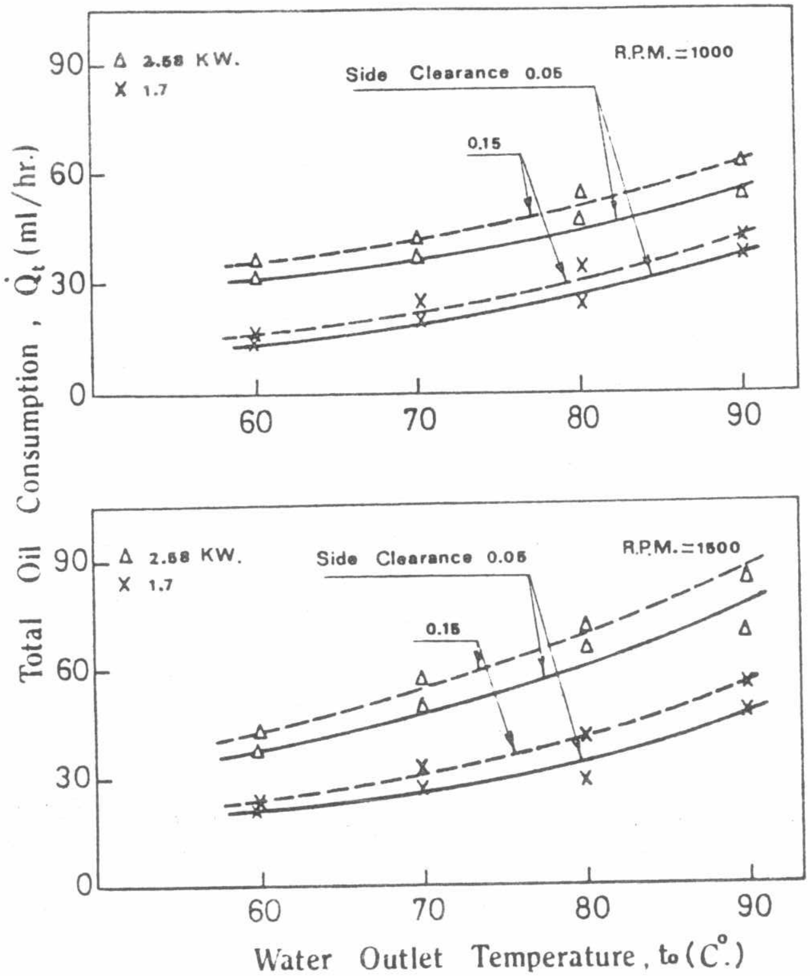

Fig.4 Effect of Compression Ring Side Clearance on Oil Consumption Rates.

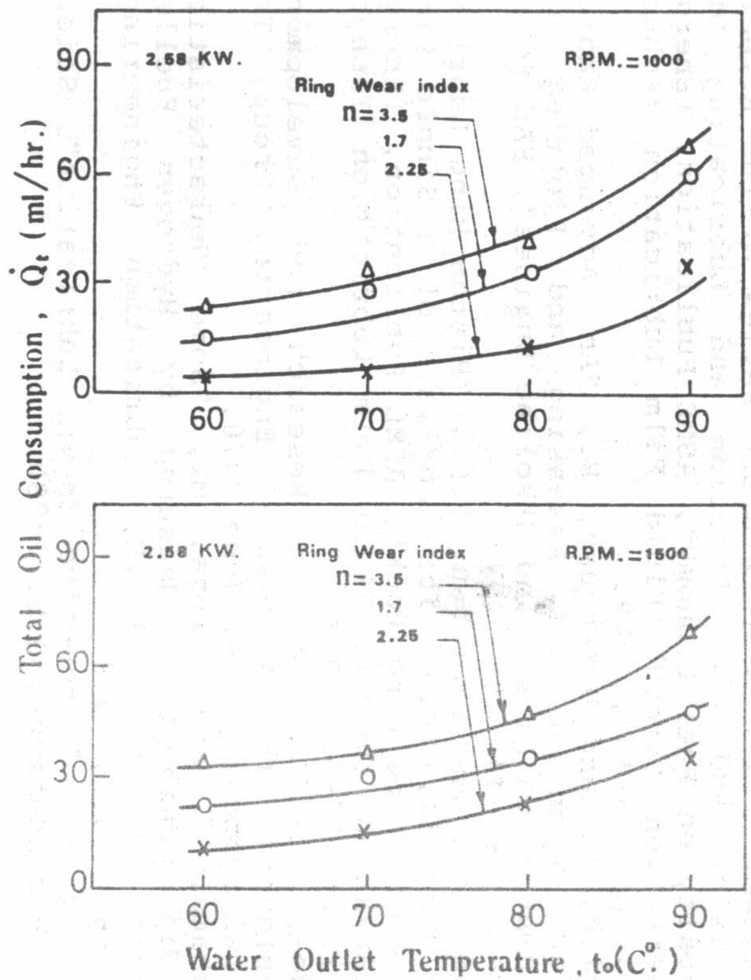

Fig. 6 Effect of Ring Shape On Engine Oil Consumption Rates.

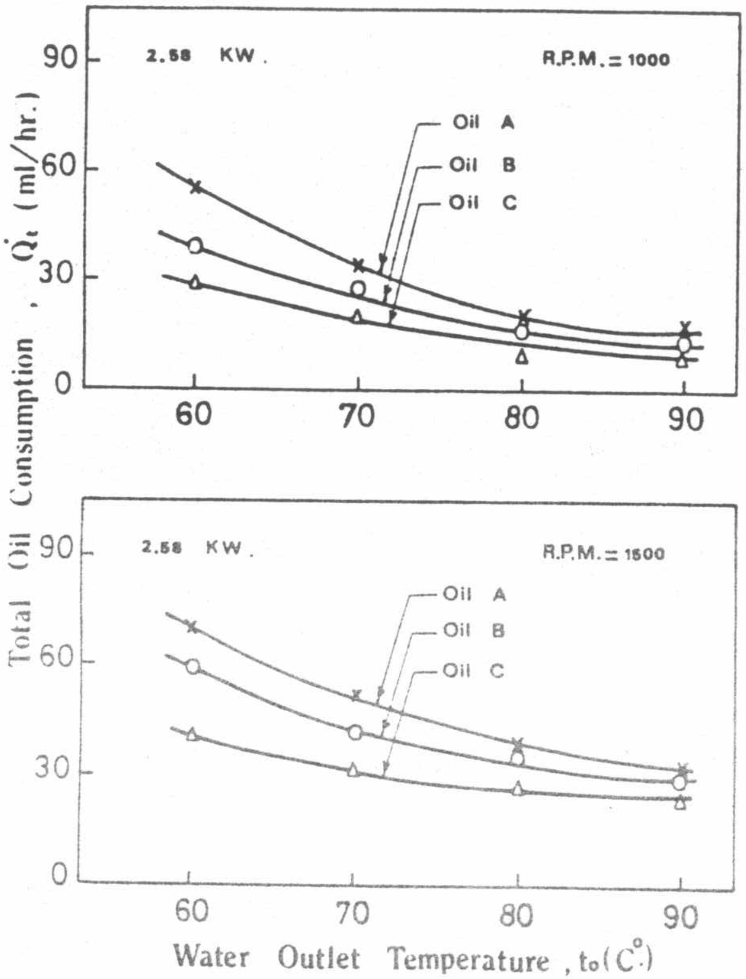

Fig. 7 Effect of Oil Quality on Oil Consumption Rates.

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