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PIPE FLOW TESTS WITH NORMAL AND ANTI-MISTING (FM4) AVTUR FUEL

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SUMMARY

Flow tests have been made with AVTUR and AMK (anti-misting kerosene), type FM4, in a 12.7mm smooth pipe over a temperature range 24°C to -40°C. In the laminar regime the FM4 fuel has been shown to be a power law model fluid with a flow index of 0.9 and an effective viscosity of 5×10^{-3} N s/m^2 at ambient temperature: the flow resistance (pressure drop per unit length at any velocity) is approximately twice that of AVTUR and this factor is maintained down to -40°C. Below -20°C the fluid changes reversibly from a pseudoplastic (index <1.0) to a dilatant (index >1.0) fluid. In the turbulent regime, at room temperature, the flow resistance of FM4 is less than that of AVTUR; for example at a fluid velocity of 3 m/s, corresponding to Re = 20000 for AVTUR, the factor is about 2.5.

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1 INTRODUCTION

The anti-misting and fire suppressing properties of aviation kerosene can be increased by the addition of small amounts of high molecular weight polymers[1]. Such fuels are known as AMK (anti-misting kerosene). An investigation of the flow characteristics of one such fuel, FM4, has been made by ICI[2] using a straight 15mm bore glass tube. The tests now to be described extend this work to low temperatures, using 12.7mm bore straight Perspex tubes.

Three batches of FM4 were investigated using two test rigs. In one (A), adopted from the ICI rig, only room temperature tests could be made and all three batches were tested. In the other (B), the supply reservoir was jacketed and a refrigerant could be circulated; tests were made on one batch only, down to $-40^{o}C$. Prior to using FM4, tests with AVTUR were made on both rigs to establish techniques and for comparison purposes. The experimental procedure is described in section 2 and the results are given in sections 4 and 5. Table I summarises the test programme.

The results have shown that in the laminar regime FM4 can be treated as a power law fluid (shear stress = K(shear strain)^n where K is the consistency index). The background theory for the flow of non-Newtonian fluids is reproduced in the Appendix and summarised in section 3. Table II gives the values of the power law index, n, consistency index, K and effective viscosity, K' (wall shear stress = K' nominal wall shear rate). It should be noted that although AMK type fuels are classified as viscoelastic, in these experiments the viscous element is of much greater significance than the elastic component.

It is concluded that in the laminar regime the flow resistance (i.e. pressure drop per unit length at any velocity) of FM4 is approximately double that of unmodified AVTUR over the temperature range $24^{o}C$ to $-40^{o}C$. In the turbulent regime, at room temperature, the flow resistance of FM4 is less. For example at a fluid velocity of 3 m/s (corresponding to Re = 20000 for AVTUR) there is a factor of 2.5. This factor increased up to the limit of the experiment (Re_g = 40000). No low temperature tests in the turbulent regime were made.

Further investigations of the behaviour of AMK in the fuel system components awaits an adequate supply of consistent material.

2 EXPERIMENTAL PROCEDURE

2.1 Test rig A (ambient temperature)

The rig, which is shown in Fig.1, consisted of a cylindrical tank of nominal $0.14m^3$ capacity and $300kN/m^2$ working pressure. The vessel had a