Effect of low temperature on the spray from a jet engine fuel nozzle

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SUBJECT EFFECT OF LOW TEMPERATURE ON THE SPRAY FROM A JET ENGINE FUEL NOZZLE

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ISSUED TO Internal

EFFECT OF LOW TEMPERATURE ON THE SPRAY FROM A JET ENGINE FUEL NOZZLE

INTRODUCTION

A question was raised by the R.C.A.F. about the effect of low temperature on the spray characteristics of jet engine fuel nozzles, with aircraft operating in the north of Canada. It was thought that the increased viscosity of fuel at low temperatures would tend to spoil the spray from the swirl-type pressure nozzles commonly used in many jet engines.

It was decided to make a test in the Engine Laboratory to investigate this effect.

TESTS

A "Simplex" swirl-type pressure nozzle was taken from a Derwent V engine and set up in the Laboratory with a fuel tank, pump, filter, pressure gauge and control valve.

The gear type pump sucked fuel from the open tank through a pipe with a filter in the line. The discharge was connected through a pipe to the spray nozzle, with a by-pass leading back to the tank. A valve in the by-pass line was used to control the pressure at the spray nozzle.

The nozzle was placed in the centre of an air stream issuing from the open end of a 5-inch pipe. The air was blown through the pipe by a centrifugal blower. The velocity of the air in the pipe was about 70 ft/sec. The spray from the nozzle was directed downstream, and the mixture of air and spray was exhausted through a 10-inch pipe to the outside of the Laboratory.

The fuel used was aviation kerosene to Specification D.Eng.R.D. 2482.

The method of study was to take random flash photographs of the spray, using a Leica camera with extension tubes, and the General Radio Company's "Microflash", which gives an exposure time of about 2 microseconds.

Such photographs were taken at various pressures, with the fuel at room temperature, (about +14 deg. C.), and also at -40 degrees C. The fuel was cooled to the low temperature by dry ice, which was dissolved in alcohol in a container placed inside the fuel tank.

The results at the two different temperatures, and two different pressures, 30 and 100 lb/in^2, are shown in Figure 1.

Higher pressures were not used because the spray motion could not be "stopped" by the flash equipment available.

The rate of flow through the nozzle was measured, approximately, by directing the spray into a graduated glass cylinder and timing the collection of a known volume of fuel. The results were as follows:

Pressure lb/in^2	Temperature $^\circ$C (tank)	Flow cc/min.
30	+14	750
30	-40	740
100	+14	1320
100	-40	1410

It could not be ascertained in this test whether the fuel temperature in the spray nozzle was exactly the same as in the tank. Some heating of the fuel could have occurred in the pump, piping and nozzle, since these were exposed to room temperature.

Repeating the test with all the equipment in a refrigerated chamber would have involved difficulties in the disposal of the spray, and therefore, to try and eliminate some of the doubts, the kerosene at -40 deg. C. was replaced by a mixture of kerosene and lubricating oil of the same viscosity at room temperature.

Since oil and kerosene have approximately the same density and surface tension, the mixture thus probably had, except for viscosity, approximately the same physical properties as kerosene.

The flash photographs of the spray obtained with this mixture are shown in Figure 2, and the rates of flow were as follows:

Pressure lb/in^2	Flow cc/min.
30	760
100	1400

CONCLUSION

Judging by the flash photographs of the spray and the rate of flow, the effect of lowering the fuel temperature from +14 deg. C. to -40 deg. C. was slight at pressures up to 100 lb/in^2. Pressures above 100 lb/in.^{2} were not investigated.

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