CONF-840614--29

DE84 006326

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CONF-840614--39

CAMEL II 37-PIN/7-PIN INTRA-PIN FUEL INJECTION TEST

by

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The CAMEL II 37-pin/7-pin intra-pin fuel injection test (C5 test) is the latest in the CAMEL and HUMP series examining fuel sweepout and related post-failure phenomena in the hypothetical TOP accident. Previous CAMEL, HUMP and HOTSHOT tests have investigated this sweepout and related phenomena under TREAT MARK-II loop hydraulics (HUMP tests and HOTSHOT I test)[1,2] and prototypical LMFBR loop hydraulics(CAMEL C-series) with 1-D (single pin)[3] and 2-D (7-pin)[4] effects. The CAMEL II 37-pin/7-pin IFIT was designed to investigate the "large-bundle" 2-D effects under prototypical LMFBR hydraulic conditions.

The CAMEL II loop is a newly designed and built, gas-driven, sodium loop capable of temperatures up to 540°C and mass flow rates of more than 5 Kg/s. Molten UO_2 generated by a thermite reaction (81% UO_2, 19% Mo at ~3470°K) was injected into the inner seven-pins of a 37-pin hexagonal array. These, initially evacuated, inner seven-pins contained predetermined local wall faults and internal plugs in order to facilitate the fuel injection process. The molten fuel was driven into these pins until they reached the plug region at which point the combined effect of heating and driving pressure caused the pins to fail at the predetermined fault locations, injecting the molten fuel into the coolant channel. Instrumentation used for analysis included piezeo-electric pressure transducers, permanent magnet flow meters and direct current voltage tops for void detection.

The initial test conditions for the sodium system and for the thermite injector are given in Table I. Overall, 10 $\pm$ 1 g of thermite products were injected into the sodium channel. The initial fuel entering the coolant channel caused a channel pressurization of 0.85 MPa (see Fig. 1) with a pulse width at half of maximum pressure of 38 ms. This type of pressurization is indicative of slow vapor generation coupled with the injection of the argon driving gas. This mild pressurization reduced the inlet flow to a minimum of 2.0 Kg/s, or approximately 41% of initial flow as shown in Fig. 2. The exit flow was accelerated to a maximum of 15.0 Kg/s at 156 ms into the event.

TABLE I. TEST CONDITIONS FOR CAMEL II C5 TEST

1. <u>Sodium System</u>	
Temperature	500°C
Coolant Mass Flow Rate	4.85 Kg/s
Pin Bundle Velocity	7.00 m/s
Total Flow ΔP	0.78 MPa
Flow ΔP Below Injection Point	0.577 MPa
Flow ΔP Above Injection Point	0.203 MPa
Pressure at Injector	0.30 MPa
Inlet Inertial Length	2.56 m
Exit Inertial Length	1.91 m
Distance to Sodium-free Surface Above Injection	2.75 m
2. <u>Thermite Injector</u>	
Initial Thermite Load	687 g
Fill gas	Argon
Fill Gas Initial Pressure	0.15 MPa
Injection-tube Pressure	Evacuated
Peak Injector Pressure	2.35 MPa
Mass of Fuel Injected	10 g

The inlet flow was reestablished to 99% of initial flow in approximately 300 ms. Void measurements indicated some voiding as far as 12 cm upstream even though there was no inlet flow reversal. Voiding in the injection region was estimated to be as much as 62%, while the maximum voiding 40 cm downstream was ~48%. Posttest examination revealed frozen fuel around the center pin of the 37-pin bundle with a cross-sectional areal blockage of ~8% over a 5-8 cm length. Of the approximately 10 g injected into the coolant channel, 0.25 g or 2.5% was swept out and recovered from the downstream particle trap.

It is concluded that the 2-D effects of this test allowed the coolant to bypass the injected fuel, prohibiting any significant intermixing of the fuel and sodium to take place. This lack of intermixing resulted in a benign pressurization event and significantly reduced the fuel sweepout over previous CAMEL tests. The resulting fuel blockage is predicted to be in a coolable state when analyzed with PLUGCO[5,6], a numerical computer code for analysis of post-transient blockage coolability.

References

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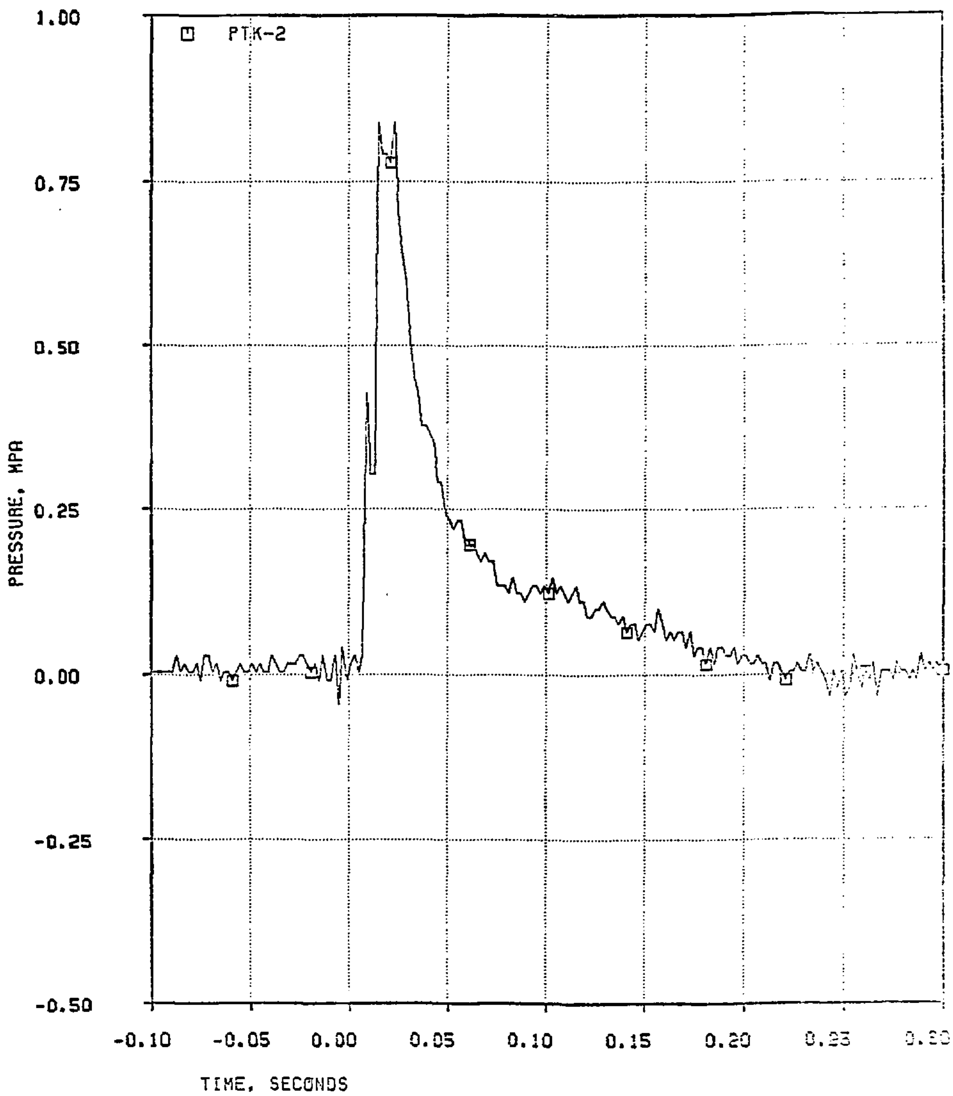

Fig. 1. Coolant Channel Pressure, 2.5 cm Upstream from Injection Point.

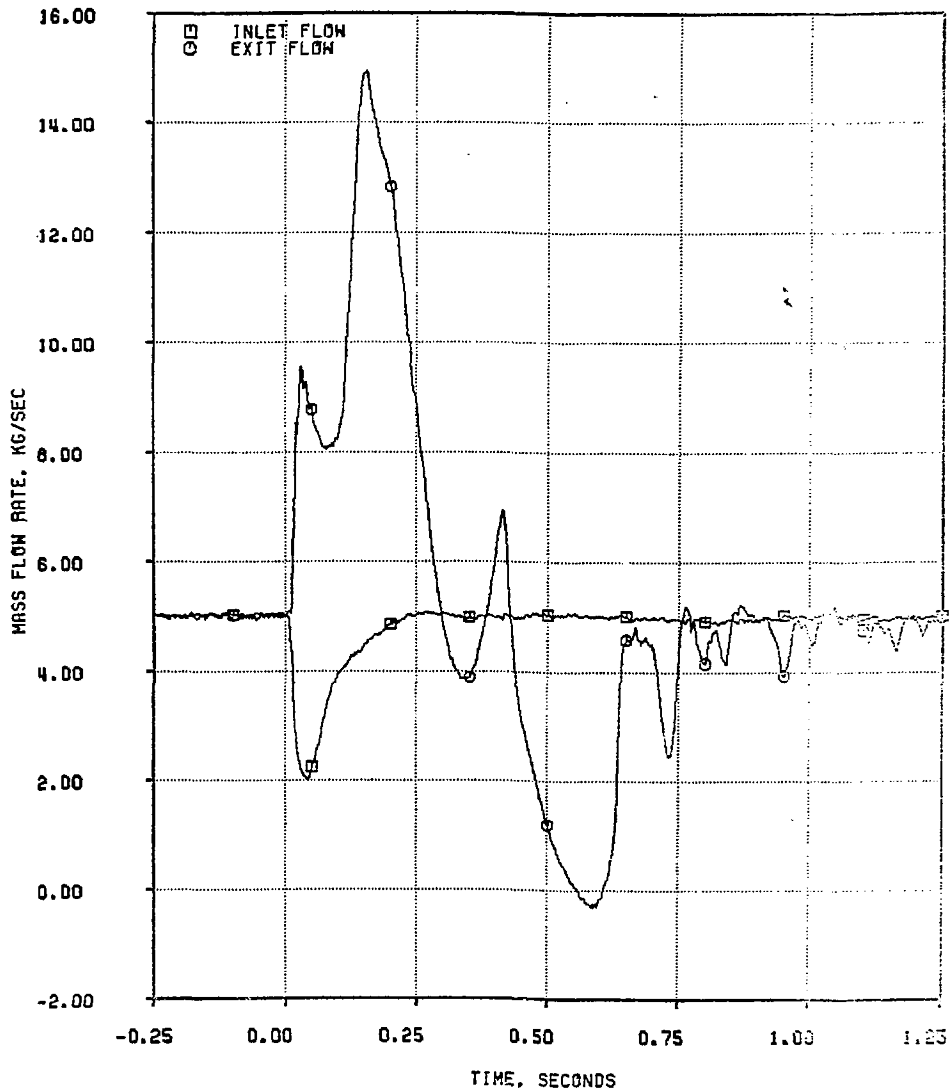

Fig. 2. Inlet and Exit Flow Response to Fuel Injection.