

**FISSION GAS RELEASE FROM FAILED FUEL PINS IN LMFBRs :
EJECTION CHARACTERISTICS
AND EFFECT OF GAS JET ON SURROUNDING PINS INTEGRITY**

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The purpose of this work is to give a realistic picture of the characteristics and consequences of fission gas release from failed fuel pins in a Liquid Metal Fast Breeder Reactor (LMFBR); focus is placed in analyzing whether or not failure propagates to the surrounding pins by the mechanism of gas jet impingement and pin blanketing. The incidents leading to cladding rupture and release of fission gas are summarized and the characteristics of gas ejection are quantitatively examined.

Pressure, velocity and mass flow-rate of the gas during the transient following the rupture are reported for a wide range of failure sizes and axial locations. A model is developed which, for the first time, considers both the sonic and subsonic discharge regimes, the effect of the gas compressibility and the effect of the resistance to the gas flow by the internal fuel pin configuration. A simplified empirical model which describes the fuel internal structure during the pin lifetime is reported. A code based on these models has been written in order to provide a tool for extensive investigation of this problem in LMFBR Safety Studies.

The analysis of the gas ejection characteristics has shown that gas at high temperature (in the order of 2000° F) is ejected with very high velocity (in the order of 1000 ft/sec) for a significant time (many seconds or, possibly, minutes). Thus, the gas jet has the possibility of impinging on the opposite pin with creation of a localized hot spot sustained for a long time.

The deflection of the jet by the sodium coolant stream in the subchannel and the location of its impingement point on the opposite pin is analyzed. It is found that only for very small areas of rupture (in the order of 10^{-6} in²) no direct impingement of the jet is possible. The cladding temperature increase due to hot gas blanketing on the outside is analyzed for different degrees of coverage; by means of a cladding stress-temperature relationship a failure temperature is determined, so that a critical combination of angular coverage and total blanketing time is found.

Examining the characteristics of spreading of the gas jet and the time of blanketing during the transient ejection, a critical range of area rupture (10^{-4} to 10^{-5} in²) was found for which a theoretical possibility of failure of the opposite fuel pin exists. However, the analysis indicates that extensive failure propagation throughout the subassembly is unlikely.

Finally the jet break-up is analyzed and the size of the gas bubbles is determined; this will help in assessing the thermal behavior of the subassembly and in the design of mechanisms to detect failed pins.