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Evidence of Fast Non-linear Feedback in EBR-II Rod-drop Measurements*

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Feedback reactivities determine the time dependence of a reactor during and after a transient initiating event. Recent analysis of control-rod drops in the Experimental Breeder Reactor II (EBR-II) Reactor has indicated that some relatively fast feedback may exist which cannot be accounted for by the linear feedback mechanisms.

The linear and deduced non-linear feedback reactivities from a control-rod drop in EBR-II run 93A using detailed temperature coefficients of reactivity (1) in the EROS kinetics code (2) have been reported(3). It was noted that the time constants inferred from the deduced non-linear feedback are similar to the time constants of the radial steel reflector. Subsequent comparison of the amount of this non-linear reactivity with the non-linear reactivity component (4) deduced from static power-reactivity-decrement (PRD) measurements indicate that the former is about 2-3 times greater. (The PRD measurements indicated that 4 cents of positive non-linear reactivity is built-in in going from zero power to full power.) The transient analyses have now been examined in more detail for times close to the drop to ascertain if additional positive reactivity is being built-in early in the drop which could be gradually released later in the drop.

The total feedback (derived via inverse kinetics of the measured system power), the calculated linear feedback reactivity and the deduced non-linear feedback reactivity for this run is shown in Fig. 1 for times close to the drop. A 7 cent positive peak in the non-linear reactivity at short times (0.2-0.3 s) is seen. This could reconcile the difference between the static and kinetic results.

To eliminate the possibility that this peak might be caused by calculational and/or measurement errors, various possible sources of errors were examined. For example, errors in the relative timing of power and rod-motion,

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uncertainties in rod-worth shape, and relative neutron and gamma sensitivities of the detectors were examined. It was concluded that the possible effects of these error sources were not sufficient to substantially alter the results.

Since this observation could not be explained by any obvious calculational or experimental errors, feedback reactivities from several other rod-drop measurements were examined for times close to the drop. Shown in Fig. 2 are the total feedback, the estimated linear feedback and the deduced non-linear feedback for Run 130A. A peak in the non-linear feedback (also in total feedback) is observed in the same time range as in the Run 93A results. The magnitude of the peak is smaller, however the amount of reactivity inserted by the rod was also smaller. (In run 93A the rod inserted 36 cents worth of negative reactivity whereas in Run 130A, 20 cents of negative reactivity was inserted.) In Fig. 3, a peak is not evident in the total feedback reactivity of the analogous results for Run 143A. When the estimated total linear reactivity is subtracted, it is unclear if a positive insertion is deduced in the 0.2-0.4 s range.

Thus there is evidence that fast positive reactivity insertions have occurred during some control-rod drop measurements in EBR-II. The magnitude of the positive insertion appears dependent upon the amount of inserted reactivity and the run configuration. This phenomenon may be caused by a small, but rapid, change in core dimensions.

References :

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Fig. 1. Total Feedback Reactivity, Linear Feedback Reactivity and Deduced Non-linear Feedback Reactivity for a ∿ 36 Cent Control Rod Drop in Run 93A.

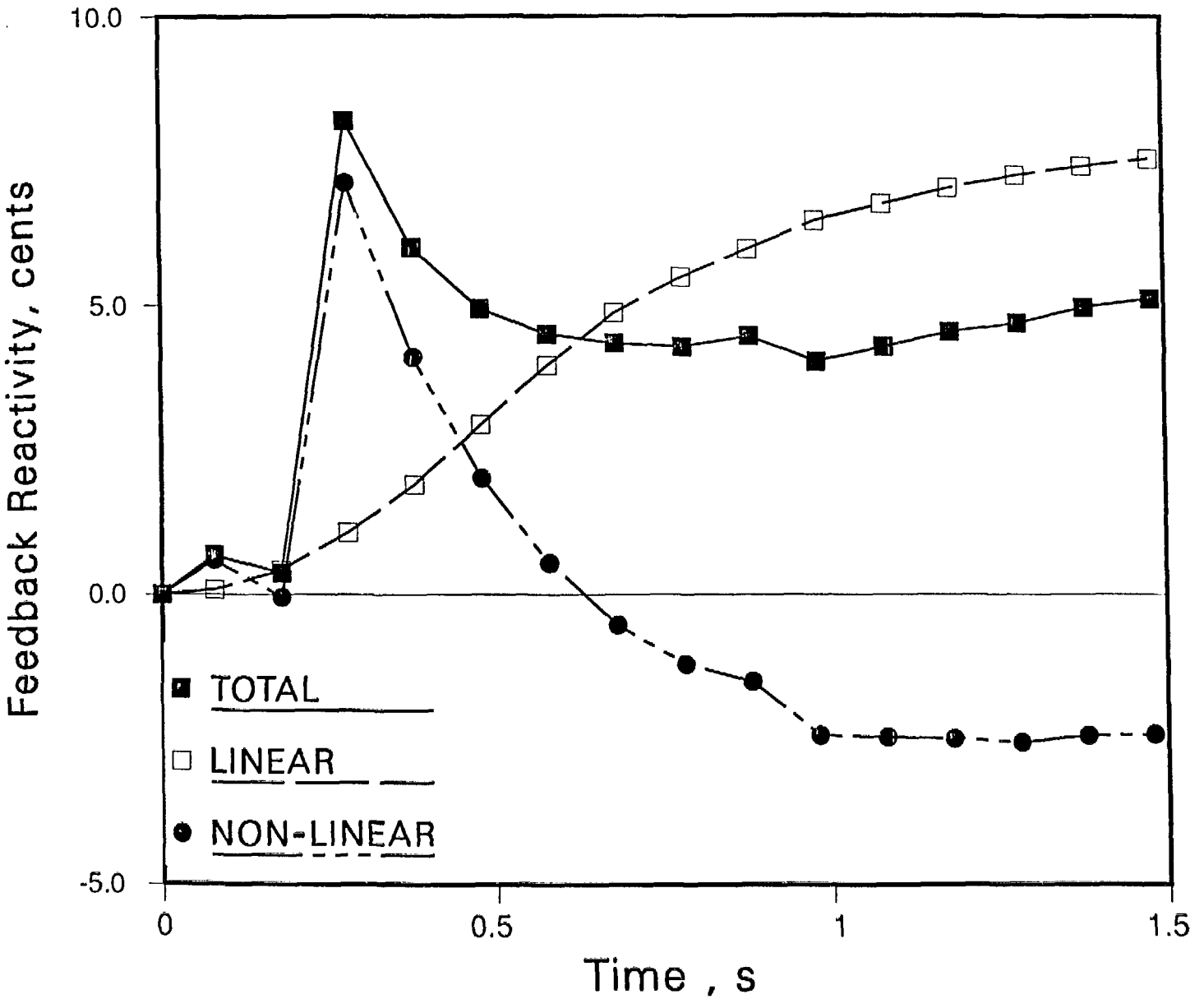

Fig. 2. Total Feedback Reactivity, Estimated Linear Feedback Reactivity and Deduced Non-linear Feedback Reactivity for a ∿ 21 Cent Control Rod Drop in Run 130A.

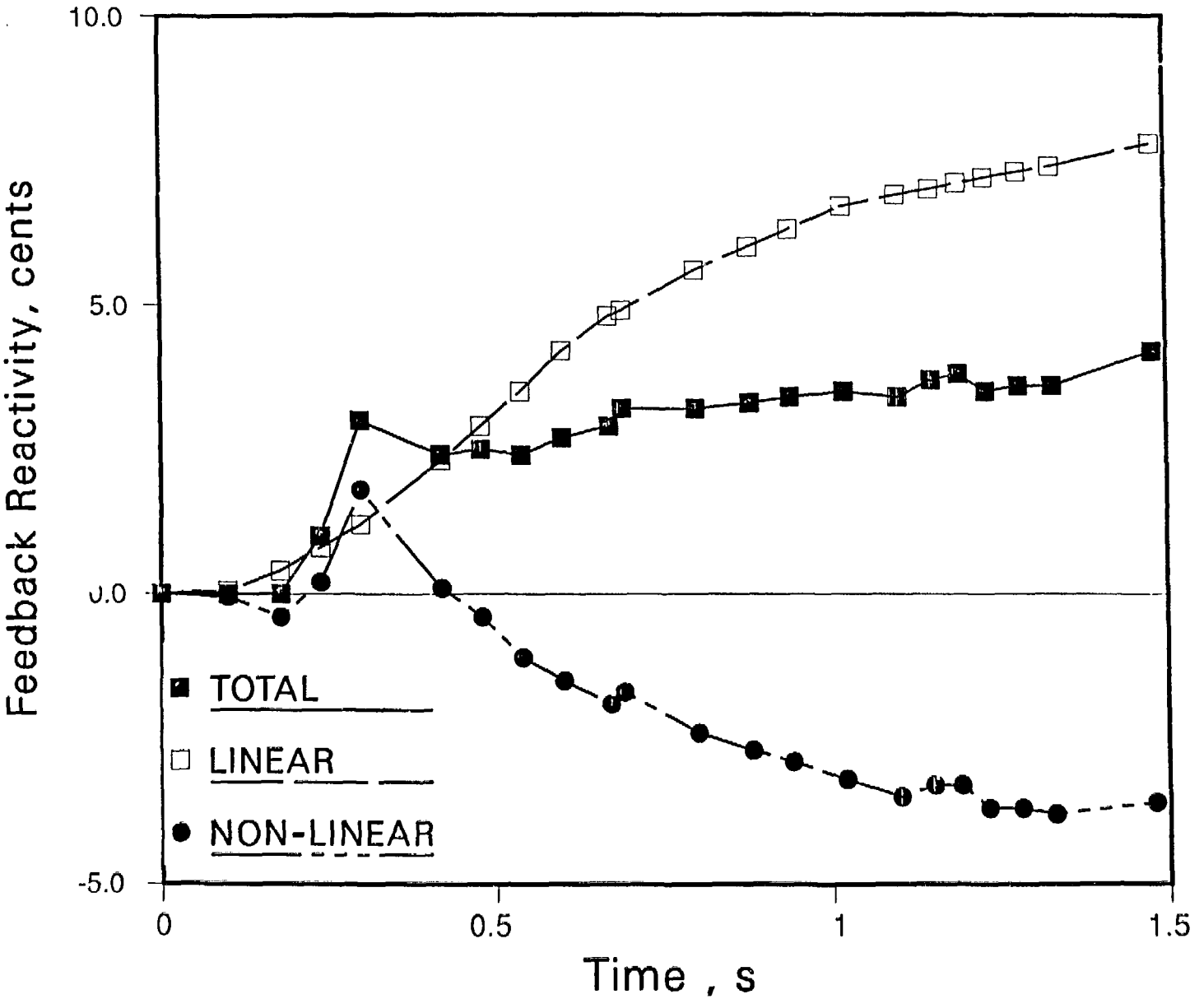

Fig. 3. Total Feedback Reactivity, Estimated Linear Feedback Reactivity and Deduced Non-linear Feedback Reactivity for a ∿ 21 Cent Control Rod Drop in Run 143A.