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Consolidated Fuel Reprocessing Program

OPERATING EXPERIENCE WITH PULSED-COLUMN HOLDUP ESTIMATORS

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SYNOPSIS

Methods for estimating pulsed-column holdup are being investigated as part of the Safeguards Assessment task of the Consolidated Fuel Reprocessing Program (CFRP) at the Oak Ridge National Laboratory (ORNL) which is operated by the U.S. Department of Energy. The CFRP was a major sponsor of test runs at the Barnwell Nuclear Fuel Plant (BNFP) in 1980 and 1981. During these tests, considerable measurement data were collected for pulsed columns in the plutonium purification portion of the plant. These data have been used to evaluate and compare several available methods of holdup estimation.

The estimator method discussed in the International Atomic Energy Agency literature (STR-116 and STR-151) was applied to the data. This method is a result of Los Alamos National Laboratory-sponsored work by L. E. Burkhart and continued by A. L. Beyerlein et al.[1] The method proposes that column holdup calculations can be reduced to a simple linear function involving concentrations of feed and effluent streams. The constants in the linear equation are derived based on the specifics of the column design and typical operating conditions.

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A second method tried was developed by A. F. Cermak[2] at the Barnwell Nuclear Fuel Plant. His work suggested that holdup estimating techniques must consider actual mass flow rates. He proposed simplified estimator equations similar to those of the Burkhart method, but he added flow rate measurements to the factors considered. His proposed equations also required constants that were specific to column design and operating conditions.

A process-monitoring application to estimate holdup was also investigated. This method used process measurements of flows and concentration during the test operations to calculate the mass flows of feed and effluent streams to each of the columns in the Barnwell plutonium purification system. These mass flows were integrated over time to estimate holdup.

A very interesting study compares these three estimates during the startup of a column. The true measure of performance for an estimator is in its ability to track transients. Figure 1 shows the three estimates during startup of one of the Barnwell columns.

A final estimator method investigated uses the column weight recorder measurement. This measurement is simply a differential pressure measurement over the entire length of the column. This measurement can be related to column holdup, but still requires consideration of certain process specifics.

As part of the BNFP tests, column holdups were also measured directly by abruptly halting operations and draining the contents into measurable containers. The contents were then measured and compared to estimates by the various techniques.

This paper presents an evaluation of the various techniques using actual plant data. It explores the strengths and weaknesses of each method. As a final point, it proposes a mix of estimator methods that take advantage of the various techniques. It proposes a role of the process-monitoring effort in relation to inventory estimator techniques to enhance the safeguards system performance.

REFERENCES

1. D. D. Cobb, L. E. Burkhart, and A. L. Beyerlein, "In-Process Inventory Estimation for Pulsed-Column and Mixer-Settlers," pp. 145-151 in Proceedings 2nd Annual Symposium on Safeguards and Nuclear Material Management, Edinburgh, Scotland, March 26–28, 1980, European Safeguards Research and Development Association, 1980, ESARDA II, Joint Research Center, Ispra, Italy.

2. C. A. Ostenak and A. F. Cermak, "Comparison of Predicted and Measured Pulsed Column Profiles and Inventories," pp 236-247 in Proceedings of the Conference on Safeguards Technology, The Process Safeguards Interface, Hilton Head Island, South Carolina, November 28–December 2, 1983, CONF-831106, U.S. Department of Energy, Chicago Operations Office, New Brunswick Laboratory, Argonne, Illinois.

THIS IS A PLOT OF THE VARIOUS HOLDUP ESTIMATORS APPLIED TO THE 2A COLUMN
THE DATA ARE FROM MINI RUN NO.7
FROM NO. 40 AT 12:47 PM ON 19-Aug-81
TO NO. 105 AT 08:42 AM ON 20-Aug-81

THE INTEGRATED HOLDUP CALCULATION IS REPRESENTED BY A (H)
THE CERMAK ESTIMATOR IS REPRESENTED BY A (C)
AND THE BURKHART ESTIMATOR (LASL) BY A (B)

	INTEG HLDP KGS	BURKHART HDP KGS	CERMAK HDP KGS	(H-C) DIFF KGS
19-Aug-81				
40 12:47PM	-.3	3.1	-21.2	20.9
41 01:03PM	.1	2.9	6.5	-6.4
42 01:19PM	.8	3.1	-4.5	5.3
43 01:39PM	1.6	3.1	2.5	-.9
44 01:55PM	2.5	2.6	3.5	-1
45 02:11PM	3.4	3	8.6	-5.2
46 02:27PM	4.5	3.1	11.8	-7.3
47 02:51PM	6.4	3	14.5	-8.1
48 03:09PM	8	3.1	17.3	-9.3
49 03:23PM	9.1	3.3	15.7	-6.5
50 03:47PM	11.1	4.3	17	-5.8
51 04:02PM	12.3	5.2	16.7	-4.5
52 04:06PM	12.6	5.5	17.1	-4.5
53 04:22PM	13.7	6.4	15.3	-1.6
54 07:06PM	19.8	15.6	16.9	2.9
55 07:22PM	20	15.7	16	4
56 07:38PM	20.2	16.1	17.4	2.7
57 07:54PM	20.3	16.1	17.5	2.8
58 08:10PM	20.4	16.4	15.5	5
59 08:25PM	20.5	16.3	15.7	4.8
60 08:42PM	20.5	16.6	16.2	4.4
61 08:58PM	20.6	16.7	16	4.6
62 09:13PM	20.7	16.8	16.3	4.4
63 09:30PM	20.7	16.9	15.3	5.4
64 09:46PM	20.7	16.8	16.8	3.9
65 10:02PM	20.7	16.9	14.2	6.6
66 10:18PM	20.7	16.9	14.5	6.2
67 10:34PM	20.7	16.9	16.2	4.5
68 10:50PM	20.7	16.7	16.9	3.9
69 11:06PM	20.8	16.8	16.2	4.6
70 11:22PM	20.9	16.8	18.1	2.8
71 11:38PM	21	16.8	16	5
72 11:54PM	21	16.9	16.4	4.6
20-Aug-81				
73 12:10AM	21	16.9	16.8	4.2
74 12:26AM	21.1	17.3	18	3
75 12:42AM	21.1	17.4	16.7	4.4
76 12:58AM	21.1	17.4	16.7	4.4
77 01:14AM	21.2	17.3	18.2	3
78 01:30AM	21.3	17.3	15.5	5.7
79 01:46AM	21.3	17.2	16.3	5
80 02:02AM	21.3	17	15.9	5.4
81 02:18AM	21.3	17.2	16	5.3
82 02:34AM	21.3	17.5	16.3	5
83 02:50AM	21.3	17.4	16.9	4.3
84 03:06AM	21.3	17.2	17.7	3.6
85 03:22AM	21.4	17.3	17.6	3.7
86 03:38AM	21.4	17.2	17.2	4.2
87 03:54AM	21.5	17.4	18.2	3.3
88 04:10AM	21.5	17.2	16.7	4.9
89 04:25AM	21.6	17.4	17.7	3.9
90 04:42AM	21.7	17.5	17.6	4.1
91 04:58AM	21.7	17.6	16.8	4.8
92 05:14AM	21.7	17.6	17.6	4.1
93 05:30AM	21.7	17.5	17.2	4.5
94 05:46AM	21.7	17.6	14.9	6.8
95 06:02AM	21.6	17.4	15.2	6.4
96 06:18AM	21.5	17.4	14.5	7
97 06:34AM	21.5	17.6	15.8	5.7
98 06:50AM	21.4	17.7	15.9	5.5
99 07:06AM	21.3	17.7	16.2	5.2
100 07:22AM	21.3	17.6	15.6	5.7
101 07:38AM	21.2	17.6	14.8	6.4
102 07:54AM	21.1	17.7	14	7.1
103 08:11AM	21	17.7	14.5	6.5
104 08:27AM	20.8	17.4	12.4	8.4

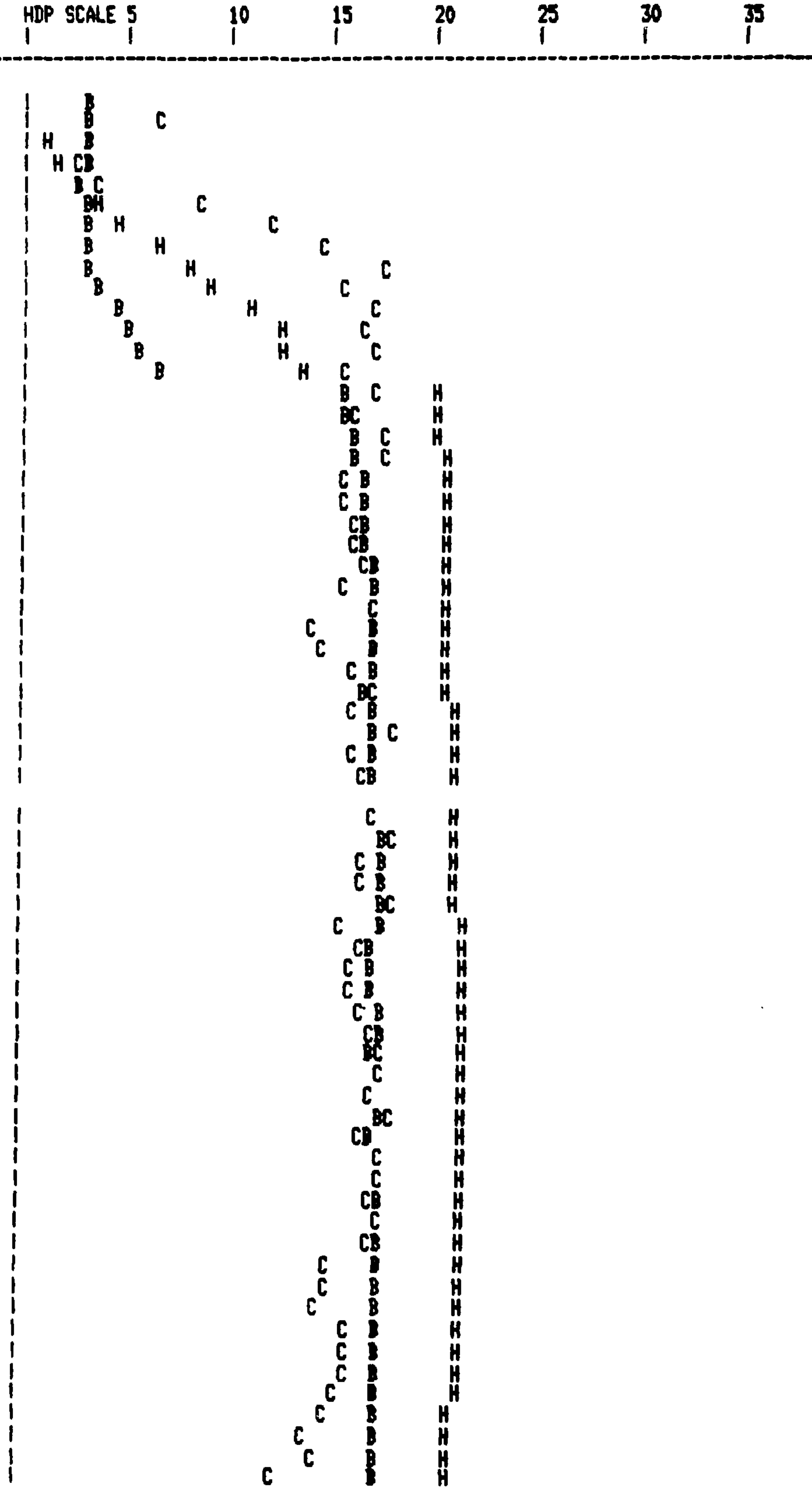

Fig. 1. Comparison of Methods