troducing the concept of process interactions. The students are then expected to design and implement a decoupled controller using lead-lag compensators. This experiment normally takes six to nine hours to complete.

5. ***Adaptive control.*** *An adaptive single loop controller adjusts the steam valve to control the exit temperature. This experiment, used in a fourth-year elective control course, makes use of the ACS system and would normally involve fifteen hours of laboratory time.*

POSTGRADUATE PROCESS CONTROL RESEARCH

Current research utilizing the rig is on a predictive control design technique described by Maurath, *et al.* [2]. The basic predictive control algorithm uses a model to predict the output for a number of future moves due to the previous inputs. An error is formed by subtracting the prediction of the output from the setpoint. This error vector is then used to calculate a change in the manipulated variables. The design technique being tested is to use a singular value decomposition to condition the Dynamic Matrix [2] of step responses. Results from this study are reported elsewhere [3].

Future work on the rig will include fuzzy identification and control. A model-based controller designed around a fuzzy model of the process will be used to control the rig. Fuzzy identification techniques will be used off-line to derive an initial model, and on-line to provide continuous updating of the model. The on-line use of fuzzy identification turns the model-based controller into a fuzzy adaptive controller [4, 5, 6].

A reactor heat recovery system is a possible extension to the current rig. This is achievable by using an exponential function on the exit temperature of the double pipe exchanger to move the steam valve. This allows for simulation of variable heats of reaction without the danger and cost of reactants. In this mode only one manipulated variable is possible, i.e., the water valve (V2).

CONCLUSIONS AND SIGNIFICANCE

The pilot-scale heat recovery system is a valuable teaching and research tool. It is sufficiently flexible to demonstrate basic principles and yet sufficiently complex to demonstrate common process control problems such as nonlinearities and interactions between variables.

The process control system equipment allows students to obtain experience in real time computing, at several process control functional levels.

TABLE 2
Relative Gain Array

	TT2	TT3
V1	0.22	0.78
V2	0.78	0.22

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ChE letters

UPDATED REFERENCES

Dear Editor:

In a recent paper, "A Course in Mass Transfer with Chemical Reaction," *Chem. Eng. Ed.*, **21**, No. 4, 164 (Fall 1987), W. J. Decoursey refers to *Gas Liquid Reactions* by P. V. Danckwerts as a source in English for the seminal papers by S. Hatta which were published in Japanese [*Technol. Repts. Tokoku University,* **8**, 1 (1929); **10**, 613,630 (1931); and **11**, 365, (1932)]. Complete translations of the latter articles have been published in *International Chemical Engineering,* **18**, 443-475 (1978). The readers of this article may also be interested to know that a translation of the closely related pioneering paper by G. Damkohler, "The Influence of Diffusion, Fluid Flow and Heat Transport on the Yield in Chemical Reactors," *Der Chemie-Ingenieur,* **3**, Part I (1937), has recently been published in *International Chemical Engineering,* **28**, 132-198 (1988).

Stuart W. Churchill
University of Pennsylvania