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Title: Partial Control of Complex Processing Systems

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Final Report

This grant was the third finishing a research program dealing with the design and control of advanced chemical process systems with emphasis on the type of large continuous processes that are typical of refineries synthetic fuel plants such as coal and gas conversion plants to clean liquid fuels and large petrochemical plants. The research focused on developing a systematic approach and framework for the design and control of such plants, which are very complex and often highly nonlinear. Special emphasis was given to two critical issues.

- A. How integrating control considerations into the initial design and development of the process can lead to better design and control, or in other words, to develop a theoretical framework for cocurrent design.
- B. To develop a methodology based on this type of cocurrent design that will ensure safe scaleup and minimize the need for expensive large pilot plants.

The program has been successful in reaching both goals. The methodology has been presented in eight papers (ref. 1-8), three of which (6, 7, 8) deal with research supported by this grant. A paper summarizing the work is now being submitted for publication in Industrial Engineering Chemistry.

The approach can be summarized as follows:

Conventional design methods for control are not only linear but also require a detailed quantitative steady state and dynamic model for the process and the proposed design. Such detailed model information essential in aerospace is very seldom available in complex chemical processes even for existing plants. Experience has shown that an experienced designer can successfully build complex plants with very limited model information. In fact the first fluidized catalytic cracker probably the most important refinery process today was successfully built without any pilot plant with a few laboratory experiments compensating for the lack of information by over design and by choosing a design, which has the capability by proper control to compensate for the large model uncertainty. The incremental cost of such a more expensive design was much less than the cost of obtaining the required model information. Our methodology allows a designer to do so for a large range of new processes. It clearly formulates the minimum information required, and how to obtain it by laboratory experiments. It is based on the fact that most complex processes have a few dominant process variables, either state variables or internal flow, that have a strong impact on all the outputs. Furthermore, by choosing designs that minimize or bound the uncertainties of the scaleup one can provide safe scaleup without pilot plants. The paper DOE Patent Clearance Granted the required information in the laboratory.

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The work has already had a large impact on industry in the way new designs are developed.

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