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# Part 2—What is advanced process control?

**Part 1** discussed what APC attempts to do and how it makes money. This part discusses modern APC.

**Structure of a modern APC application.** We now leave the philosophical concepts and go into the structure of a modern APC application (Fig. 1). At the heart of this application is a multi-variable predictive controller (MVPC), which reads all unit constraints and sets the manipulated variables. Two and three decades ago, we used to make a distinction between constraints and operating targets. Operating targets were typically product qualities, measured by analyzers, and those were to be kept ideally on targets. Constraints, on the other hand, were to be kept always below (or always above) targets. APC applications worked to satisfy operating targets while maximizing throughput against constraints. The control logic was configured on a host computer as a mixture of control block structure plus custom code.

When industry moved to standardize MVPCs, the distinction between targets versus constraints blurred, and they all became control variables with minimum and maximum limits. APC practitioners still tried to imitate the old approach by setting narrow ranges for variables with operating targets; however, MVPCs, especially large ones with many models, often became unstable with narrow ranges. While the better applications work with narrow ranges on target variables, the trend has been to widen the ranges.

The stability problems have to do with MVPCs' ability to predict future behavior of control variables. MVPCs' dynamic models are obtained experimentally by step-testing the unit in the presence of feed quality drifts, weather changes and other uncertainties, which often make it difficult to obtain good models. Secondly, MVPCs use linear models to predict behavior of nonlinear processes, and models obtained at certain operating conditions are liable to be wrong at other conditions. Thirdly, MVPCs do not support cascade structures, so the stabilizing influence of cascade configurations cannot be taken advantage of.

For example, a cascade of property inference to tray temperature to reboiler heat duty controller to flow controller, can be accomplished only if the tray temperature controller is a manipulated variable; whereas, the temperature controller to duty to flow cascade would be configured in the DCS. Many MVPC implementers would skip the temperature and heat duty controllers because of complexity and set the flow as a manipulated variable.

Academia should perhaps be called to task to explain why MVPC technology has changed so little in the past 30 years. Why is it not possible to include the temperature and heat duty of the example as intermediate variables? After all, the exclusion of cascade from MVPC technology is not because of a fundamental reason, but only because that is a specific problem with the MVPC structure in use today.

There seems to be a promising way to address model nonlinearity problems via the use of rigorous or semirigorous process models to predict MVPC model gains scientifically. The improved accuracy would be of great help because it would not only enhance stability but also permit a more precise level three constraint balancing. Ideally, we would compute those gains in real time as function of operating conditions, update the MVPC model and thus effectively linearize the MVPC model around the current conditions. Each process gain of the MVPC dynamic model is a partial derivative of the rigorous model. There are no iterations involved, nor convergence problems, just the creation of a Jacobian matrix of partial derivatives.

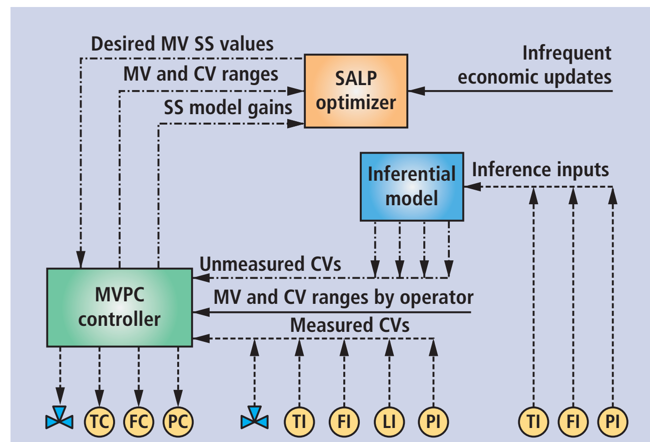


FIG. 1 Structure of a modern APC application.

Older MVPC software did not permit changes on the fly, but current MVPCs separate gains from dynamics and can accept at least gain changes. Honeywell has done some interesting initial work in continuous updating of model gains by rigorous simulation,[1] but later the Honeywell modeling group was sold to KBC. To my knowledge, this development has been discontinued. We would welcome a comment from Honeywell about this issue. HP

**Part 3** next month will discuss MVPC's small optimizer and the importance of inferential models.

### LITERATURE CITED

[1] Nath, N., Z. Alzein, R. Pouwer, M. Lesieur, "Online Dynamic Optimization of an Ethylene Plant Using Profit Optimizer," NPRA Computer Conference, November 1999.

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