This is one of a series of advertisements dealing with basic facts about process control. Reprints of all the advertisements in this series are available.

Basic Cascade-Control Systems

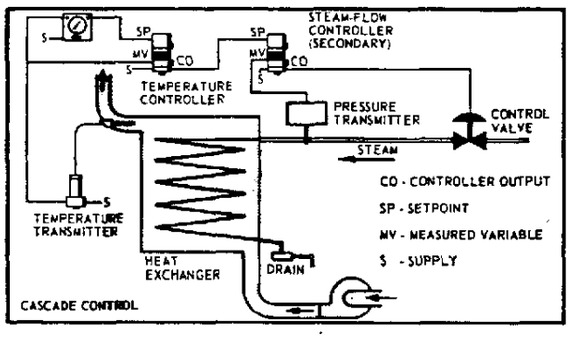
Disturbances to a manipulated variable such as steam flow or steam pressure make it very difficult to maintain close control of long time-constant processes. In such situations, a simple single-loop control system proves inadequate—because the controller cannot act until after an error has developed in the primary process variable. (i.e. until a disturbance to the manipulated variable has upset the entire process.)

To insure close control of such processes, cascade control circuits are generally employed to compensate *immediately* for disturbances to the manipulated variable.

Eliminating Process Upsets

In a cascade system, two controllers are connected in series—with the first (or primary) controller sensing and being ultimately responsible for the control of the primary process variable. The output of the primary controller is the setpoint "command" signal to the secondary controller.

The secondary controller, in turn, senses and regulates the manipulated variable by modulating the control valve. Thus, if there are any disturbances which would tend to upset the manipulated variable, such disturbances will be sensed immediately—and appropriate corrections will be made by the secondary controller before a disturbance can affect the primary process variable.



The basic advantage of cascade control can be illustrated with a heat exchanger. In this case, the primary controller measures the outlet temperature (primary variable) and provides a setpoint signal to the secondary controller. The secondary controller measures and controls steam pressure (the manipulated variable). Thus, if the steam pressure changes, as it commonly will with variation in demand on the steam-supply line, the effect on steam pressure to the heat exchanger will be sensed instantly, and corrected for by the secondary controller. Consequently, there will be no effect on outlet temperature.

Other Cascade Applications

Frequent applications for cascaded multiloop systems include: Fractionating-column temperature control, with a temperature controller setting either a steam-pressure or a steam-flow controller; batch-reactor temperature control, with a batch-temperature controller setting a jacket-temperature controller; fired-heater temperature control, with an outlet-temperature controller setting a fuel-rate controller.

Moore engineers will be pleased to help you with any problem related to process control. Feel free to call for their services; their time is yours—without obligation.

If you are planning a cascade control loop, you should contact the nearest office of Moore Products Co. for information about single-station cascade control. Or mark reader inquiry card for Bulletins 5019 and 5022—each contains information about "cascade control in a single station."

MOORE

MOORE PRODUCTS CO., Spring House, Pa.
In Canada: Moore Instrument Co., Ltd., Rexdale, Ont.

URL 17979

to produce a pound of vinyl chloride by a typical Process I or Process III. Values for Process III were found in the literature,[5, 8, 10] and those for Process I were estimated from available information. Cost of reactants were assumed to be 8¢/lb. for acetylene, 4¢/lb. for ethylene, and 2.5¢/lb. for chlorine. Using these values, the total cost of reactants for Processes I and III were calculated, and are shown in Table I. Total cost of reactants for Process I is decidedly higher because of the relatively high price for acetylene. Operating costs, other than those for reactants, are probably not significantly different for the two processes. As a rule, total production costs per pound of vinyl chloride are less for Process III. Unless the cost of acetylene relative to that of ethylene is significantly reduced, Process I will likely be of lesser importance in the future.

Companies that have cheap supplies of both ethylene and hydrogen chloride may find it advantageous to use a simplified Process III. They would use a combination of oxychlorination of ethylene plus pyrolysis of dichloroethane.

Process II is claimed to produce cheaper vinyl chloride than can be produced by Process I.[3, 4, 15, 32] Costs of acetylene and ethylene are cheaper than in Process I. Capital costs for a Process II plant are significantly greater because a naphtha pyrolysis unit must be installed and because dilute hydrocarbon streams complicate to some extent the separation and reaction phases of the process. A Kureha plant to produce 66 million lb./yr. of vinyl chloride had a total investment cost of $4,150,000.[15] It is estimated that a plant if scaled up to 200 million lb./yr. would cost about $9 million.

Although detailed and comparable cost data for Processes II and III are not available, both processes seem to offer significant advantages in terms of production costs for most American companies as compared to previous vinyl chloride processes. Many factors, including cost and availability of reactants, would have to be thoroughly considered before a final decision could be made as to the preferred process.

Process IV will be seriously considered by many companies in the future because of its apparently increased simplicity and high yields of products. Considerable industrial research is known to be occurring in this area. Up to now, the Kellogg process is the only one in which a significant amount of design data have been reported. A plant based on this process would likely be relatively simple and cheaper than one based on Process III. Process IV also has the advantage of increased flexibility of operation. Variations in availabilities of chlorine and hydrogen chloride, or changes in relative demands for vinyl chloride and 1,2-dichloroethane, can be more easily handled than in Process III.

Because of the complexity of the plant, a balanced process requires excellent instrumentation for control purposes. An upset in any portion of the plant tends to upset the remainder of it. Methods of starting up the unit, and maintaining the desired optimum conditions as the catalyst ages and as flows and yields vary, require careful planning. Kureha has described in considerable detail its methods of handling this problem.[15]

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Key Concepts for This Article

Active (8) Passive (9)	Input/Feedstock (1)	Output/Product (2)
Reviewing Processes*	Acetylene*	Vinyl chloride*
Analyzing Chemistry*	Ethylene*	Ethylene dichloride*
Vinyl chloride*	Chlorine*	
Hydrochlorination*	Hydrogen chloride, anhydrous*	**Special Agent (4)**
Chlorination*	Air*	Copper chloride*
Pyrolysis*	Oxygen*	Carbon*
Reactors*		

(Words in bold are role indicators; numbers correspond to EJC-AIChE system except for Role 8 modification. Asterisks mark key concepts suggested for indexing. Others are added to improve reading as an abstract. Indexing is described in *Chem. Eng.*, Oct. 11, 1965, p. 187; or you may order Key Concept Reprint, 50¢, using Reader Service Postcard.)