The process industries developed in connection with the industrial revolution, when human muscle power was substituted for machines. The early processes were batch operation, typically scaled-up versions of previous manual practice. The advantages of continuous operation soon became apparent. This trend was reinforced because the production processes were based on flow of materials.

The process industries are convenient to automate because of this. The trend toward increased automation and continuous operation have often gone hand in hand.

The processes were originally controlled and supervised manually. Some control and supervising functions were gradually automated when equipment for measuring flows and quality were developed. Separate industries for manufacturing of control equipment developed starting from production of control valves, measuring equipment, and simple regulators.

The control systems were originally quite primitive. The control function was often integrated with sensor and actuator functions like in the centrifugal governors and direct-acting temperature controllers. On-off control was widely used in process industry by the mid-1920s. Although the idea of proportional control was known in the late eighteenth century, in connection with control of windmills and steam engines, it was not until the end of the 1920s that it started to be widely used in the process industries. See [6] and [26].

Design, installation, and tuning of regulators were originally made on a purely empirical basis. When regulators with proportional, integral, and derivative action became more common in the 1930s, there was a need to understand the tuning problem and to have proper tuning tools, which stimulated theoretical analyses of control loops by Mason, Ivanoff, Mittereff, and Callender et al. ([25], [22], [28], [10]). The first theoretical results were actually made earlier by Maxwell and others. Important results were obtained by Ziegler and Nichols [42], who developed a simple theory that led to tuning procedures, which are still widely used.
EMERGENCE OF AN AUTOMATION INDUSTRY

The technological innovations during the Second World War had a significant impact on process control. Application of electronic instruments for process control started in the beginning of the fifties. Standards for signal transmission, 3–15 psi in standard sized tubes for pneumatic signals and 4–20 mA for electric signals, were established. The control system was modularized in terms of sensors, transducers, regulators, actuators, and recorders. This simplified design, installation, operation, and maintenance. Because of the standards, it was easy to combine equipment from different manufacturers. Implementation of process control systems in terms of remote sensors and actuators and a central control room with PID regulators became the general solution to process automation. The standard control systems used set-point control. This means that each control loop attempts to keep the process variables close to a given value (set point), in spite of process disturbances. The set points were adjusted manually by the operators. Small production changes were made simply by changing the set points. For large-grade changes, the regulators were switched to manual mode, and processes were operated manually by the operators. Some plant operations like start-up and shut-down were sometimes automated by relay systems, which were separate from the control system. The relay systems included logic control as well as sequence control.

The control loops were designed intuitively. Regulators were introduced on one important process variable after each other without taking interactions into account. This led occasionally to difficulties because of the interactions among the process variables. The regulators were tuned using simple rules of the Ziegler-Nichols type.

The relay systems and the control systems were viewed as different units. They were designed and installed by different groups. It was not uncommon that the control and relay systems were opposing each other under some operating conditions.

The importance of process dynamics, i.e., the time behavior of changes in process variables in response to changes in disturbances or operating conditions, soon became apparent when process automation spread. The practice of determining dynamics by measuring responses to pulses, steps, and sinusoids started. There was also some awareness that process dynamics could be drastically influenced by plant design. These observations stimulated research into process dynamics, which resulted in books like Campbell [11], Eckman [16], and Buckley [9].

The automation technology turned out to be very useful. It gained rapid acceptance in the process industry. A particularly attractive feature was that the automation system could be built up from a few standard components, which could be manufactured in large series and adapted to a large variety of individual plants.

A system for process automation, which is composed of a collection of panel-mounted standard regulators and separated relay systems, is used to represent a system of the past in this paper. Such systems are still in operation in many processes.

REFERENCES


Precious Devastation

At the other end of the spectrum are vast, open-pit mines run by the world’s largest mining companies. Using armadas of supersize machines, these big-footprint mines produce three-quarters of the world’s gold. They can also bring jobs, technologies, and development to forgotten frontiers. Gold mining, however, generates more waste per ounce than any other metal, and the mines’ mind-bending disparities of scale show why: These gashes in the Earth are so massive they can be seen from space, yet the particles being mined in them are so microscopic that, in many cases, more than 200 could fit on the head of a pin. Even at showcase mines, such as Newmont Mining Corporation’s Batu Hijau operation in eastern Indonesia, where $600 million has been spent to mitigate the environmental impact, there is no avoiding the brutal calculus of gold mining. Extracting a single ounce of gold there—the amount in a typical wedding ring—requires the removal of more than 250 tons of rock and ore.