Automating the production line

Henry Ford began it all when he designed the first car assembly line in 1914

In the industry that first conceived and implemented the "automated factory," signs of automation may begin far from the automobile production lines. For example:

• New-car orders, received from sales districts over a data-communications network, are keyed into a teletypewriter system that uses computer-stored data to identify accessories, optional equipment, and other distinguishing features that are to be built into each car. When assembled cars leave shipping bays, a controlling and monitoring computer keeps track of their movements.

• Stockpiles of components and materials to be used in production are inventoried on a regular basis by a computer that may be linked directly to other computers at major suppliers' facilities. Once each week, the auto maker's computer "talks" to suppliers' computers and, based in part on their reports of current production requirements and capabilities, transmits or updates orders and delivery schedules.

• Intermediate steps from prototype design to production have been shortened considerably, at least in the case of body panels. By use of a special contour scanner, the surface coordinates of a prototype panel fabricated in plastic or other material can be recorded on punched tape. The tape, in turn, may then be used to numerically control a production milling machine to duplicate the surface that was scanned.

Numerous other examples of automated control exist in production areas, where it may take one of several forms ranging from virtually complete control of a mass-produced part to extensive off-line testing of systems and components, as well as the finished, assembled automobile.

The manufacture of the standard eight-cylinder engine block exemplifies one of the most automated processes. In production, the cylinder block is conveyed automatically along a transfer line, where various operations such as drilling, tapping, boring, and milling are performed in sequence at different stations. In automotive factories throughout the world, areas devoted to engine manufacture possibly come as close to being "unmanned factories" as can be found; only skeletal crews are required for maintenance or for handling of unworked and finished parts.

In comparison with component and some system manufacturing, automation techniques have made little headway in assembly operations—though welding robots are among the notable exceptions. The reason most often heard is that there are simply too many different features among individual cars for auto makers to automate assembly lines completely. Out of a sample of several tens of thousands of cars, up to 80 percent may have unique specifications due to customer-selected options and different regional requirements, among other factors.

Nevertheless, the automotive industry—the world's largest manufacturing industry—is also one of the largest users of computer and automation techniques. In addition to component and material storage and distribution and to component and system testing, the techniques are applied in continuous processes, such as the production of various materials; in discrete processes, in which the sequences of tool operations are directed; and in various forms of numerical control of point-to-point tool movements. Furthermore, many production records are accumulated on an hour-by-hour basis and stored in a computer.

Trade secrets

Many of these and similar achievements have taken a decade or more to develop fully, and so reports have filtered into the common knowledge of the engineering community. Obtaining information from the automotive industry on more recent developments, however, is something like attempting to learn details on next year's models before they are announced. Knowledgeable executives at General Motors, Chrysler, and Ford are likely to refer a reporter to public relations personnel, who, in turn, may discourse on how *little* is the extent of automation.

To be sure, there may be a number of developments that are proprietary in nature, and that provide one car maker a competitive edge over another. Thus, an auto company must guard against external disclosures. Yet often the vendor who supplies an auto maker with equipment that provides the competitive edge is also negotiating with other car companies on the same or similar equipment—if those other companies have not, in fact, already achieved the same results through in-house development. In this sense, there exists industry-wide awareness, and possibly discussions on the relative merits, of new approaches.

The sheer number of cars and parts manufactured tends to encourage relatively rapid implementation of new cost-cutting production techniques. The U.S. automotive industry produces 13 million cars annually, and each car may have up to 15 000 individual parts. Moreover, automobile manufacturers generally make at least some changes in their models each year, and thus usually have an annual opportunity to retool and apply new production methods.

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Sparks fly as teams of robots on this automobile assembly line in Yokosuka, Japan, busily engage in auto-body spot welding. (Nissan Motor Co., Ltd.)

For further reading

Additional information on some of the points raised in this article may be obtained from the following sources.

Cook, Nathan H., "Computer-managed parts manufacture," *Scientific American*, p. 22, Feb. 1975.

Shapiro, Sydney F., "A look at computer control and automation in automotive manufacturing," *Computer Design*, p. 48, Oct. 1973.

"On-line emission system testing," *Automotive Engineering*, p. 50, Oct. 1976.

"Making production pay off," multipart special report, *Automotive Industries*, Aug. 1, 1977.

Pond, James B., "The road to CAD/CAM," *Iron Age*, p. 32, May 30, 1977.

However, changes on the production line must be accomplished within a few months (to meet shipment and other schedules). Innovative processes and equipment must meet rather specific production requirements, and they must be sufficiently compatible with existing techniques to allow fairly rapid integration into production lines. The net result is that industry-wide acceptance of innovative manufacturing techniques tends to evolve over a number of years.

Emissions testing

Nonetheless, when the need exists to augment existing methods, owing to market requirements, Federal regulations, and other constraints, the industry can move quickly. End-of-line emissions testing is a case in point. Automobile manufacturers installed automated emissions-test equipment at the end of their assembly lines in the early 1970s. The equipment has been improved steadily to meet ever more stringent requirements.

A typical system, designed to automate most phases of emissions testing, can handle more than 15 cars per hour. An operator need only drive an automobile onto a test station for the system's minicomputer to proceed to run through the test series. In those tests that require human intervention, the computer displays appropriate messages to guide the operator.

One phase of emissions testing that does not require operator intervention is gas analysis. Among other functions, the computer controls solenoid-valve openings and closings, and coordinates the flow of exhaust gases through an analyzer.

A carburetor test system exemplifies other automated equipment that may be employed on or near an assembly line. Initially, an operator must connect the carburetor to a test fixture, but after that, the computer takes over, even to perform carburetor idle screw adjustments, and completes the test series by indicating either acceptable or unacceptable test results. A single minicomputer can control up to eight carburetor test stands and feed the results to a central computer for production-data storage.

Still other examples of automation on the assembly line tend, in general, also to be achieved off line. For instance, tires are automatically assembled to wheels, inflated, and then balanced. Completed units are stockpiled next to the assembly line, and a computer may be employed to feed them to the line as needed. In the assembly of the wheels to the automobile, however, multiple drivers automatically fasten nuts onto the studs holding the wheels. Some fasteners employ numerical control to provide the proper torque.

Robots on line

Industrial robotry is a form of on-line automation that has found major applications both in component manufacturing and on the assembly line. These mechanical arms, often controlled by sophisticated electronics, find use as functional interfaces between other automated equipment. Tasks assigned to robots in component manufacturing range from simple material handling to machining gears. On the assembly line, their leading application has been in welding entire car bodies (see opening illustration). Common to most present and proposed robot applications (painting operations are an example of the latter) is their use at a point in the manufacturing process where value-added content of a part or product is high.

Operating in a cylindrical-coordinate reference system, the robot moves in three basic axes—vertical, horizontal, and swing. For increased flexibility, the robot's end-of-the-arm "wrist" may also be able to rotate, sweep, and yaw. In some cases, the robot may be mountable on a track to yield a traverse axis, for a total capability of seven axes. Advanced robots are likely to incorporate microprocessors and relatively large memory capacities. And they may allow program changes through external commands, as well as interfacing with other computer-based systems in factory-wide operations controlled by a host computer.

Planning for the future

The U.S. automobile industry has embarked on an ambitious plan to overhaul its products and most of its equipment and facilities. Over the next five years, the industry expects to spend nearly $30 billion, an amount, say auto makers, that is mandated largely by Government regulations. From 40 to 60 percent of these funds will go into new tooling, which translates, according to industry observers, into growth for automotive industrial electronics by at least a factor of four.

Though auto makers are hardly willing to discuss specifically how these funds will be spent, the expenditure of such amounts should advance the already discernible trend toward virtually complete computer control of the entire manufacturing process, from design stage to assembly and distribution. In this envisioned system, computers would not only participate in each step, but all computers would be coordinated into an overall system. And that system could conceivably link and control unmanned factories.

Already, various components, or subsets, of such a futuristic system have emerged. Suitable automated equipment for batch production is the weak link, however, and one that is frequently conceded to have the longest road to travel to full development. Batch production accounts for over half of all parts-manufacturing costs in all industries, and refers to parts manufactured in lots of less than about 50, with annual volumes possibly reaching 100 000. In such relatively small quantities, costs for special-purpose automated equipment cannot be justified as they can with mass-produced parts. To date, the major technical barriers to achieving automated equipment for batch production are those associated with development of computer hardware and software that could be applied readily to a wide variety of parts. ◆