Evolving Automation in the Asphalt Paving Industry

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The evolvement of processes and equipment has made the asphalt industry a fertile area for automation in construction. The asphalt pavement construction industry, spurred by competition and the desire to improve quality, has responded by adopting automation concepts and contributing to the development of rugged, dependable automation components. Although other areas of construction have struggled to fund automation costs, the paving industry has developed incentives and quality control processes that encourage investment.

Asphalt Plants

Over the years asphalt plant designs have changed significantly. These changes have been driven by a desire to improve working conditions, lessen environmental impact, increase production, respond to changes in pavement material technology, and reduce initial and maintenance costs of plants.

The traditional picture of an asphalt plant belching dust and smoke, with the plant operator standing on a platform in the midst of it all, pulling levers to proportion aggregate and asphalt, is in contrast to modern automated asphalt plants (Figure 1). Transition from that historical vision has been incremental. The plant calibration process has changed. Early methods involved weighing aggregate and binder samples with platform scales. Today's plant can be calibrated much faster because of aggregate belt scales and binder flow rate sensors that are integrated into the plant controls. With such facility the proportions of one or more mixtures can be set and stored, and later produced on demand.

A significant change has taken place in mixture temperature control. In early plants mixture temperature was determined with a thermometer and any necessary modifications were made by manually adjusting the burner. Subsequently a temperature probe was installed to obtain a continuous, remote readout or a permanent graph of mixture temperature versus time at the plant control panel. Recent refinements have resulted in the automation of temperature control.

Automation has progressively improved working conditions in asphalt plants, particularly for the plant operator. Lever pulls have been replaced by standoff pulls with cables from a control room. Further development has allowed an increasing number of plant processes to be controlled electronically. The modern asphalt plant control room is airtight, air conditioned, and equipped with a control panel comparable to any automated manufacturing process.

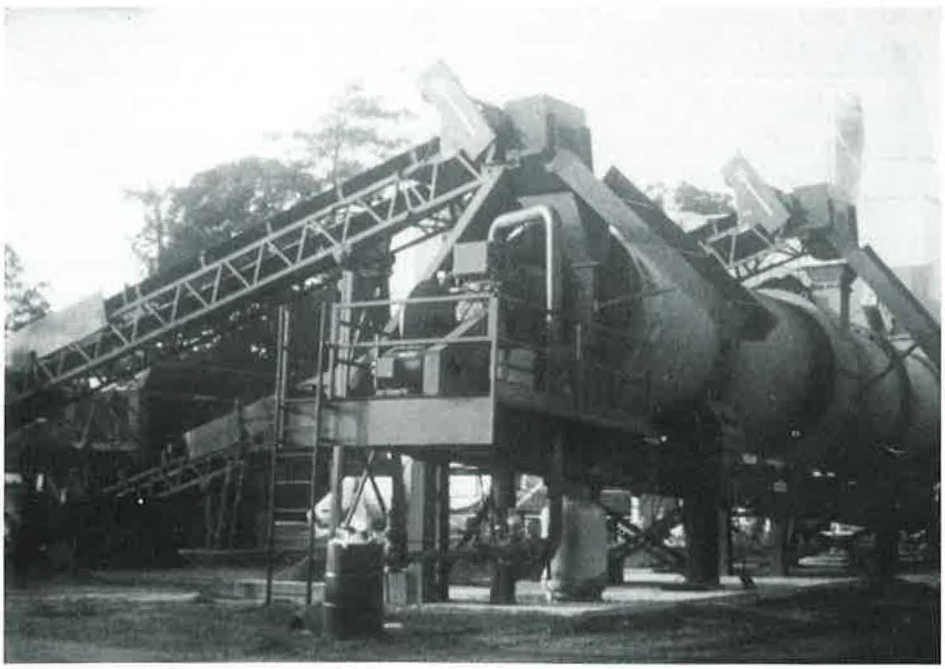

FIGURE 1 Drum mix plant.

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New features and designs have been developed for asphalt plants. The most notable is the baghouse, which collects dust from aggregate drying and other points of processing and feeds it back into the mixture, thereby minimizing the environmental impact. Effective baghouse operation depends on automatic controls. Asphalt plants have been modified or built to allow incorporation of more components into asphalt mixtures. For instance drum mix plants feature a port for the mid-drum addition of a mixture component such as recycled asphalt pavement. Multiple in-drum pipes provide injection points for asphalt additives or modifiers. These additional components are automatically proportioned to achieve the desired properties and to maintain mixture quality.

FIGURE 2 Twin windrow pickup.

Material Delivery

Asphalt pavement quality depends on uniformity of the material streams during the paving operation (*1*), including delivery of the asphalt mixture to the paver. Ancillary equipment is being developed to enhance the uniform flow of the paving mixture. The asphalt mixture can be delivered to a windrow on the pavement in front of the paver. Subsequently a windrow pickup device loads the mixture into the paver. As a result, surge capacity is provided ahead of the paver, which allows the paver to run at a constant speed. This process minimizes variation in the material passing through the paver and the head in front of the screed.

By integrating the pickup device into the paver, larger surge capacities are possible (18 tons on rubber-tired machines and 25 tons on track machines). These larger capacities can even out variations in the cross section of the windrow and allow the paver to operate at a constant rate of production. Augers on the outside of the pickup device allow for pickup of twin windrows or for windrows placed inaccurately (Figure 2).

An integrated paver with a truck dump allows trucks to be unloaded into the machine at a very high rate [(1100–1400 metric tons per hour) (1,200–1,500 tons per hour)]. With a 23-metric ton (25-ton) surge capacity, trucks can be quickly unloaded without running the paver at high rates of speed, resulting in continuous operation.

A material transfer vehicle can unload a truck at the rate of 1100 metric tph (1,200 tph) and convey the mix into its 32-metric ton (35-ton) storage hopper. Use of a material transfer vehicle has contributed to smoother pavements, reduced segregation, and uniform high density.

Paving Machines

Paving machines are used to build smooth pavements and were designed to mechanically provide this function, thereby introducing an early degree of automation in the asphalt paving field. Many of the settings on the early pavers were made manually, but through the years these were also automated. Automation was incorporated to improve productivity while maintaining or improving pavement quality.

The basic automatic feature of an asphalt paving machine is the floating screed. This feature was part of the early paving machines (Figure 3). As the paver moves forward, the screed, on the basis of its weight, support from the paving material, material resistance, and pulling force, seeks an equilibrium condition that provides an automatic smoothing function as long as the screed is moving. Modern paving machines (Figure 4) include the original floating screed plus automation to maintain longitudinal and transverse grades. Options for longitudinal grade control include individual sensors, extended multipoint reference sensors, single stringlines, and dual stringlines. A multipoint reference beam and a single stringline reference system are shown in Figures 4 and 5, respectively. More recently, broadcast lasers have been considered.

FIGURE 3 Early paving machine.

FIGURE 4 Modern paving machine.

Potential Technology

The dispersed nature of pavement construction lends itself to applications of global positioning systems (GPSs). For example, asphalt plant production and paving operations depend on transportation efficiency. Transmitters in each truck and on the paver and other equipment could provide real-time management of construction processes and operations. With the sensor technology available, material characteristics, such as asphalt mixture temperature, and equipment functions, such as fuel consumption, could be monitored. In the former, temperature could be immediately adjusted at the asphalt plant. In the latter, a fuel truck could be dispatched and the best route planned using GPS and an associated geographic information system. Simple two-way radios or telephones could be replaced with computer terminals.

Additional automation features may be possible for asphalt plants. As sensor technology and analysis continues to develop, points in the mixture production process can be monitored for gradation, asphalt content, and uniformity. This may be possible with image analysis or infrared monitoring. The plant can also become self-monitoring by using image analysis, infrared, and sonic techniques.

Further automation of the paving process is being explored. Nakamura et al. (2) reported on a three-dimensional positioning, automatically controlled asphalt paver, which includes a closed-loop system of guidance and control. The three-dimensional plan is transmitted to the paver, where sensors provide data for position and attitude of the paving machine. Error adjustments are calculated and implemented.

Control during paving may be enhanced with on-board sensors (sonic or laser) that could scan the pavement surface. Micro-screed adjustments would be possible for the profile and cross section. The problem of rutted pavements could be addressed with a segmented screed that would leave additional mixture over a rutted area. The mixture would contribute to higher density and reduced compaction by traffic.

Summary

A barrier to construction automation that is frequently discussed is cost recovery. In paving, continued enhancements to automation contribute to smoother pavements. Longer performance life and lower maintenance costs result. Consequently, from a life-cycle analysis, highway agencies can afford to invest additional money in building smoother pavements.

References

1. Brock, J. D. *Pavement Smoothness*. Technical Bulletin T-123, ASTEC Industries, Chattanooga, Tenn., June 1992.
2. Nakamura, T., T. Kirlyama, M. Fukuda, T. Maeda, M. Fukukawa, S. Nagasaki, Y. Fujiwara, K. Sugano, F. Goto, T. Namekawa, K. Denda, and Y. Ageishi. Development of Three-Dimensional Positioning Automatic Control Asphalt Paver. *Automation and Robotics in Construction*, XI, Elsevier B.V., The Netherlands, 1994, pp. 47–54.

FIGURE 5 Stringline reference.