Optimising spray performance with pulse width modulated flow control

Improve accuracy and lower operating costs in precise coating and dosing applications

If you need to apply a uniform coating or dispense a precise amount of fluid, you know it is not easy – especially if you have to contend with variations in conveyor line speeds.

Whenever conveyor speed changes, flow rate must change by the same amount to provide consistent coating weight. Variations in line speed are common and can greatly affect product quality and/or production cost if accurate flow rate adjustments are not made. The most common problems are uneven coating (resulting in high scrap rates) and overspray (spraying too much material), which is both costly and messy.

The traditional method of accommodating line speed changes has been to adjust spray pressure. However, this method has inherent inefficiencies that have made it unsatisfactory for today's higher line speeds and quality standards.

Recent advances in spray technology have made accurate coating and precise dosing easier to achieve. Pulse Width Modulated (PWM) flow control has helped many manufacturers save cost significantly by decreasing quality problems and minimising the consumption of expensive coating solutions.

What is PWM flow control?

Pulse Width Modulation (PWM) is a common technique for controlling an electrically actuated device by turning the device on and off – or "pulsing" it – very quickly.

A simple analogy for PWM is riding a bicycle. You can maintain speed by pedalling and then coasting, allowing your momentum to carry you forward. As you slow down due to wind resistance or changes in terrain, you pedal to speed up and then coast again (see illustration).

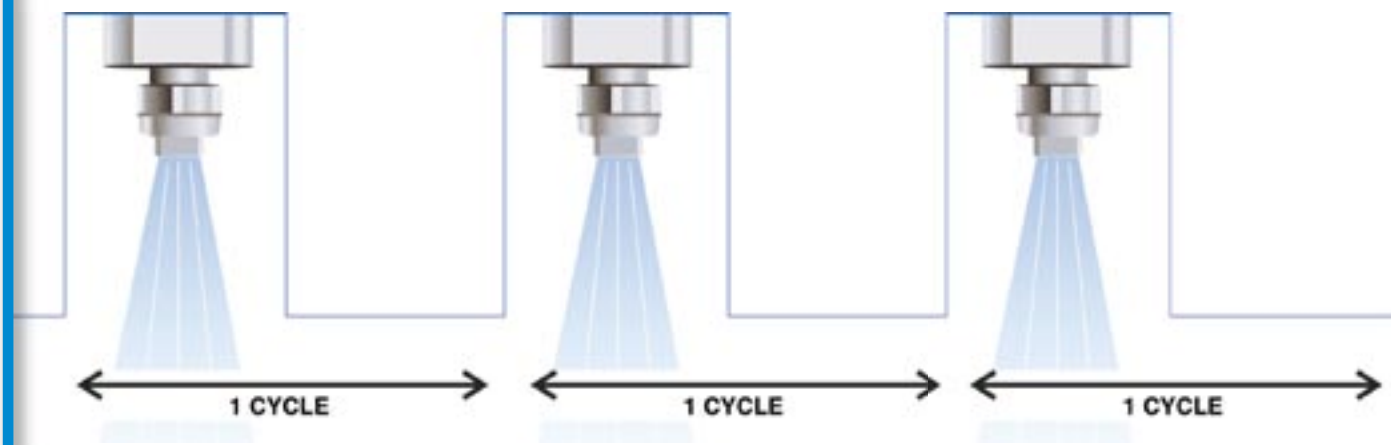
Applying Pulse Width Modulation (PWM) to flow control

- The speed at which the device is pulsed is called frequency.
- Frequency is expressed in cycles per second or hertz (Hz).
- The proportion of time during which the device is "on" during each full cycle is the duty cycle, which is expressed as a percentage.

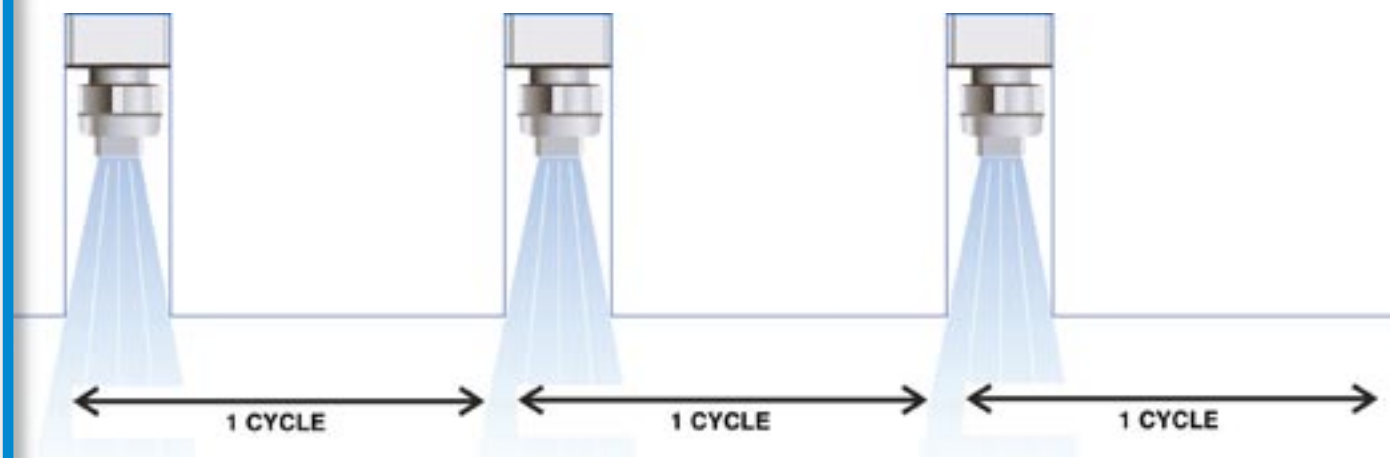
involves switching an electrically actuated spray nozzle on and off very quickly to control the flow rate of the nozzle.

• The cycling often takes place thousands of times per minute – so quickly that the flow appears to be constant. As a result, the coverage is uniform enough to meet stringent product quality requirements.

• Controlling flow rate by adjusting cycling speed and duty cycle of an electric nozzle allows pressure to remain constant. This offers several advantages over controlling flow rate by changing pressure. In PWM flow control, the nozzle's effective flow rate is controlled by changing how long the nozzle sprays during each cycle. This "spray time" is called the "duty cycle" and is expressed as a percentage of total time. For example: A duty cycle of 50% results in a nozzle that sprays half the time and is off half the time. A 50% duty cycle produces a flow rate that is half the maximum flow for the nozzle.



Higher line speeds require more flow and a higher duty cycle.



Lower line speeds require less flow and a lower duty cycle.

Ensuring even coverage by adjusting frequency

Even when spraying intermittently on a moving object, it is critical that the electrically-actuated nozzle is able to produce acceptably uniform coverage. This capability is provided by adjusting the cycle speed of the nozzle – also called the frequency. Frequencies of several thousand cycles per minute create coverage that is uniform enough for today's stringent quality standards.

To understand how this works, think about how motion pictures create a "smooth" appearance from a series of still pictures moving very rapidly. The more frames per second, the more uniform the movie appears. In the same way, an electrically-actuated spray nozzle operating at a very high frequency – thousands of cycles per minute – can produce uniform coverage on a moving object.

Why control flow rate so precisely?

Although there are many reasons to adjust flow from a single nozzle, the most common is to compensate for variations in line speeds. Adjusting the duty cycle controls the volume of liquid per unit of time. With duty cycles possible from 5% to 100%, PWM provides great flexibility for precise flow control. The subsequent pages point out the advantages and requirements of PWM flow control, and also highlight two application examples. FBA

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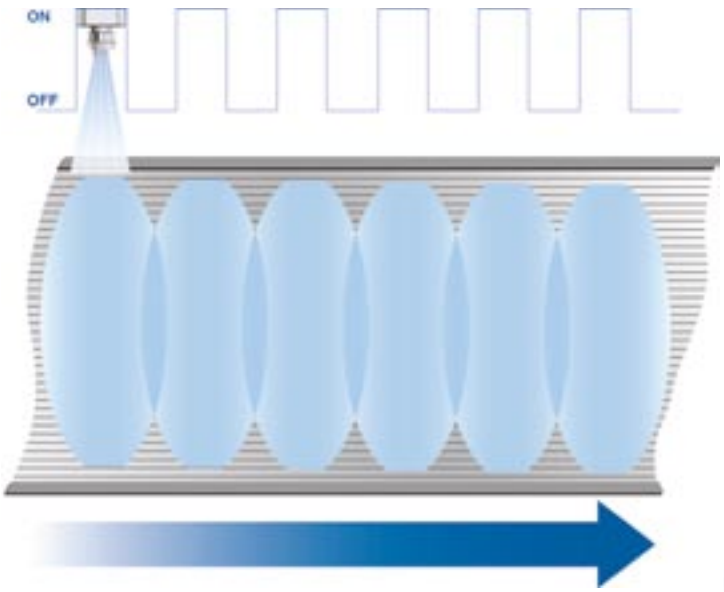

Spray patterns from a single automatic spray nozzle cycling at high frequency generate even coverage on a moving conveyor belt.

PulsaJet® automatic spray nozzles from Spraying Systems Co. are suitable for PWM flow control. PulsaJet nozzles operate at flow rates up to 59.8 L/min (15.8 gpm) and fluid pressures up to 24 bar (350 psi). Available with hydraulic or atomizing spray tips in a variety of spray patterns, PulsaJet nozzles can achieve cycle speeds up to 10,000 cycles per minute.

The PWM spray control panel (centre), from AutoJet® , provides manual PWM flow control regulation. For applications requiring automated operation, control panels using the Model 2250 AutoJet Spray Controller are a good choice.

Advantages of PWM flow control in coating and dosing operations

1. **Adjustable flow without changing pressure provides flexibility**
   When pressure is used to increase flow rate, spray angle and drop size can change dramatically causing changes in coverage. By using PWM flow control to vary flow rate, pressure, spray angle and drop size all remain constant – and coverage remains consistent.
2. **Effective flow rate can be changed almost instantaneously**
   Because PWM flow control requires the use of electrically actuated nozzles, response time is nearly immediate. This is a significant advantage over pneumatically actuated spray guns or standard hydraulic nozzles that actually change pressure.
3. **Reduced clogging improves reliability**
   PWM flow control can maintain low flows even with large spray orifices, reducing clogging.
4. **Reduced misting improves safety and transfer efficiency**
   Generating low flows using larger orifices at lower pressures reduces or eliminates the misting that often occurs at higher pressures. The risk of worker inhalation of chemicals is reduced and overspray is minimized or eliminated.
5. **Decreased fluid consumption saves money**
   Improving transfer efficiency and controlling flow rate more precisely can reduce costly chemical usage while maintaining or even improving product quality.
6. **Uniform coating improves quality**
   Because flow is controlled with duty cycle instead of pressure, drop size and spray angle remain constant. This results in more consistent coating over a wide range of flow rates.
7. **Eliminating atomizing air saves energy**
   Using PWM flow control, low flow rates that are normally only possible using air atomizing nozzles can often be achieved with hydraulic nozzles. The expense of compressed air can be eliminated along with the associated misting.
8. **Simple controls make implementation easy**
   Using PWM flow control to maintain consistent performance of low flow applications is much less complex than managing air atomizing systems.

PWM flow control requirements

What is needed for PWM flow control?

1. **A fast electrically actuated spray nozzle**
   Automatic nozzles that can achieve cycle speeds up to 10,000 cycles per minute are best. For maximum flexibility, use nozzles that are available with hydraulic or air atomizing spray tips and operate over a wide flow rate range at a variety of pressures.
2. **Spray knowledge**
   Designing an effective PWM flow control spray system requires a strong knowledge of how liquids flow and how spray nozzles work. The ability to turn an electrically actuated spray nozzle on and off very quickly is not enough.
3. **A spray controller plus software**
   A fast automatic spray nozzle does not provide PWM flow control on its own – it must be controlled. Using a dedicated spray controller instead of a PLC will provide faster cycling and more precise control. Dedicated spray controllers are available for manual or automated operation.

When to Use PWM Flow Control

PWM flow control can be used in many different spray applications. In general, PWM flow control may prove useful when a repeatable dose or consistent coating weight is required. Here are just a few examples of applications that are likely to experience significant operational improvements by using PWM flow control.

- Spraying food ingredients onto products or into trays.
- Spraying flavours or oils onto bread and pastries.
- Spraying ascorbic acid onto meat for food safety.
- Surface colouring with milk protein, egg or caramel.
- Spraying oil to improve mould release.
- Applying adhesive to tyre treads before re-treading.
- Spraying extremely small volumes of silicone on plastic blanks prior to a blow moulding process.
- Applying a uniform coating of silicone across a web of paper machine clothing.
- Spraying water on hamburger patties prior to freezing to maintain proper weight.
- Spraying water to act as a catalyst for glue in door manufacturing.
- Spraying water on a cellulose strip to reduce electrostatic charges while manufacturing incontinence pads.

Application examples:

Precise moisture application in industrial bakery

An industrial bakery needs to slightly moisten bread to make it sticky prior to sesame seed application. The conveyor belt speed is stable and cycles are repetitive and identical – suitable for manual PWM flow control. The frequency is preset to match the speed of the product and to be compatible with the desired duty cycle range. The PWM controller modulates the signal according to the turning of a potentiometer on the front of the panel or according to a 4- to 20-mA signal. This method is simple and efficient and ensures uniform coating consistency.

Flavouring additive application on product on variable speed conveyor

A food processor needs to apply flavouring uniformly to one of its products. A variable speed conveyor complicated the situation, but automated PWM flow control proves to be an efficient solution. With PWM flow control, a single nozzle operating at a single pressure accommodates the need by varying the duty cycle. Without PWM flow control, a spray nozzle with 1/3 the flow of the specified tip would be needed for the slower line speed. The pressure would need to increase by a factor of five to produce the required flow rate for the faster line speed.

PWM flow control can be used in a wide range of industries. Coating and dosing operations, in particular, experience many benefits from optimised flow control using PWM.