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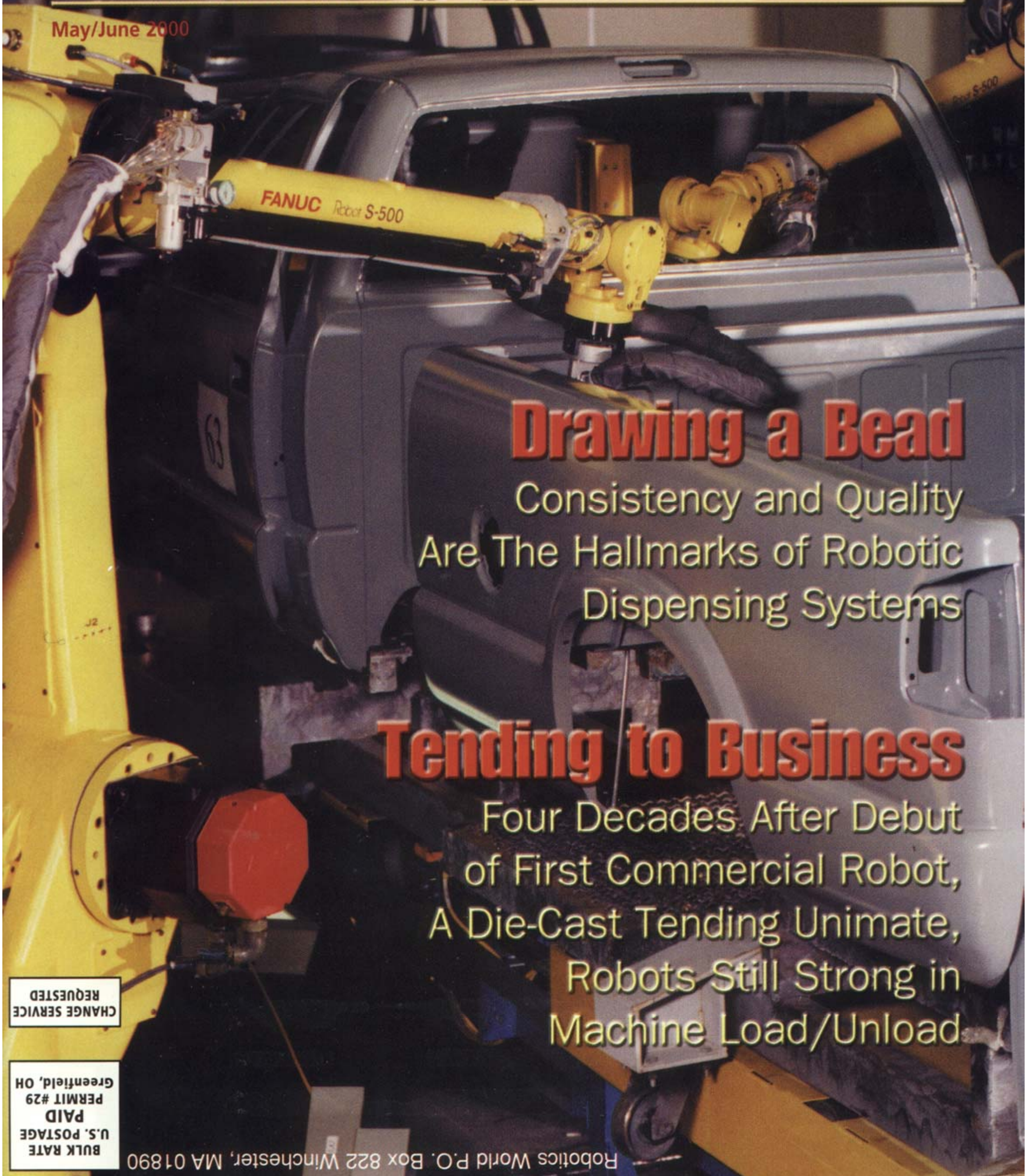
THE END USER'S MAGAZINE OF FLEXIBLE AUTOMATION

May/June 2000



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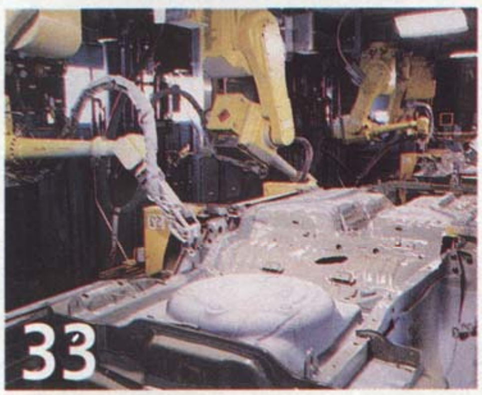
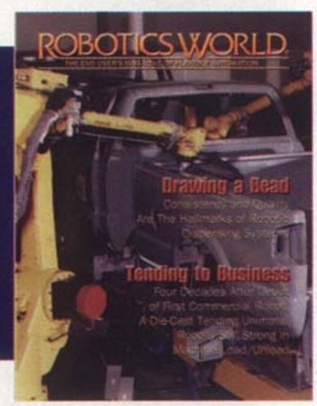


FEATURES

DEPARTMENTS

On the Cover:

FANUC Robotics' S-500 robots perform seam sealing on truck bodies in an automotive manufacturing plant.



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Not Too Hot, Not Too Cold

Importance of Temperature Control in Robotic Dispensing Applications Cannot Be Overstated

By Michael Bonner, St. Clair Systems Inc.

There are few industries where the use of robotically dispensed materials has grown as fast, or been elevated to such an art, as in the automotive industry. Sealants and adhesives are now used to replace welds, reinforce body panels, seal and smooth seams and joints, diminish noise and vibration, prevent chips and dents, reduce rust and corrosion, and more. For these materials to be successful, problems associated with deposition thickness, volume dispensed, overspray, surface finish and others all had to be addressed.

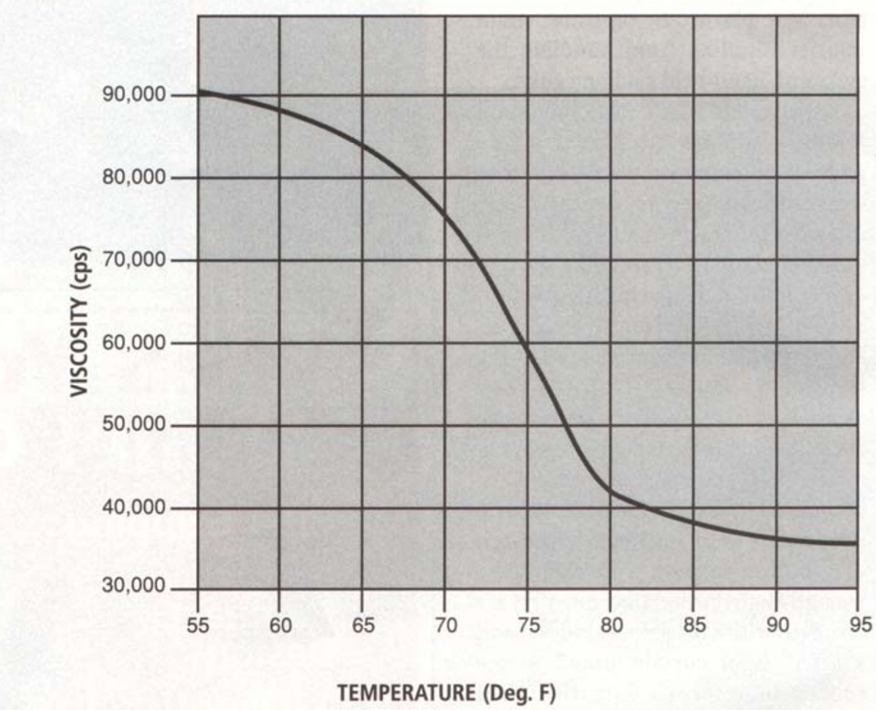
In the early days, sealants and adhesives were applied in the auto plants manually, with a spray gun, caulking gun or brush. These methods were inconsistent at best. This became an issue as the materials and applications began to be used to replace structural fasteners. For instance, when a 2 mm bead of heat-curing epoxy was applied around the perimeter of a hood, replacing all welds, gaps in the application could not be tolerated. To ensure the integrity of the auto body, methods of application had to be developed that would guarantee consistent position and quantity of the material on every part. Enter the industrial robot.

A robot could move an applicator through the same motions time-after-time, maintaining the same path, speed, distance and angle with respect to the surface. The ultimate solution appeared to be simply coupling an industrial robot with a pump and flow gun, fixturing the part and teaching the right path.

A whole new set of issues arose, however. It became apparent that while a robot could provide the basis of a consistent application in terms of path, there were other variables that needed to be controlled to get a consistent result: orifice size, pressure and viscosity. For the purposes of this discussion, a fixed-orifice system (the most common type) is assumed.

In a fixed-orifice system, variations in pressure and viscosity affect flow, changing the pattern of the material being dispensed. Pressure was easily regulated and shot-meters could ensure that the right amount of material was dispensed; however, neither of these solutions resulted in a consistent pattern of material being applied. While a human oper-

Figure 1



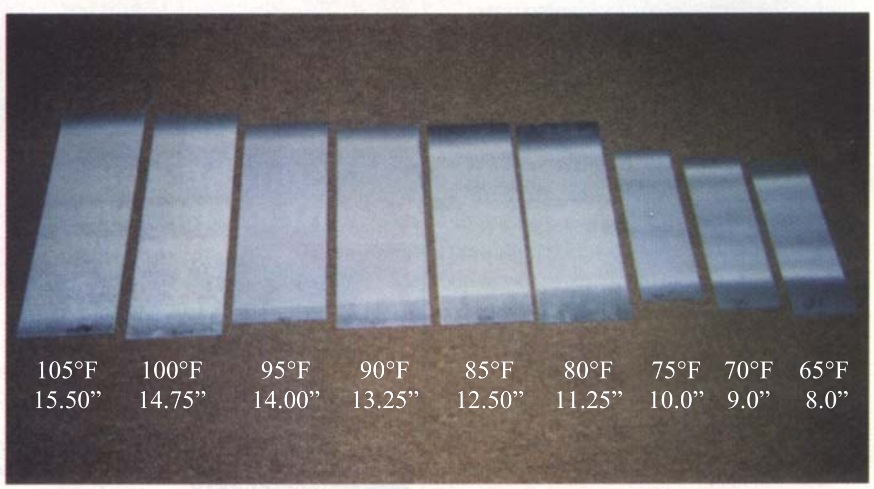


Figure 2: Effect of temperature on spray pattern

ator could adjust for variations through eye-hand coordination or by reapplying over an area that was undercoated or missed completely, a robot had no means of judging or adjusting for these variations. Early attempts at automation still had workers brushing out seams and recoating areas that had been missed.

Similar issues had been dealt with in the paint shop, where exacting standards are the norm. It was known that warm paint is thinner, so it flows faster, increasing problems like sags, runs and drips, and cold paint is thicker, resulting in uneven coverage. For these reasons, virtually all automated paint systems included some form of material temperature control. If the same principles held true for these higher-viscosity materials, temperature control would solve the problems with sealants and adhesives. They did. Once temperature control was installed, the systems started performing as intended. The reason is the effect of temperature on viscosity.

The effect of temperature is well-known among sealant and adhesive suppliers. Supporting evidence can be found right on the specification sheet where viscosity is given at a specific temperature (often 70 degrees F). This is even more obvious if a viscosity vs. temperature curve is provided. Typically, these curves exhibit a very sharp change in viscosity over a fairly small temperature range, often falling directly over the normal ambient range (See Figure 1).

Temperature of the material in the process is the issue and just controlling ambient will not address it. Viscous materials require a great deal of energy to pump from one place to another. Some of this energy ends up in the material as increased temperature. Moreover, when viscous, thixotropic materials shear, the temperatures at the shear interface increase and the viscosity decreases. Standard process-control components, such as pumps, regulators, meters and filters, all contribute to this phenomenon by adding shear and friction to the material path.

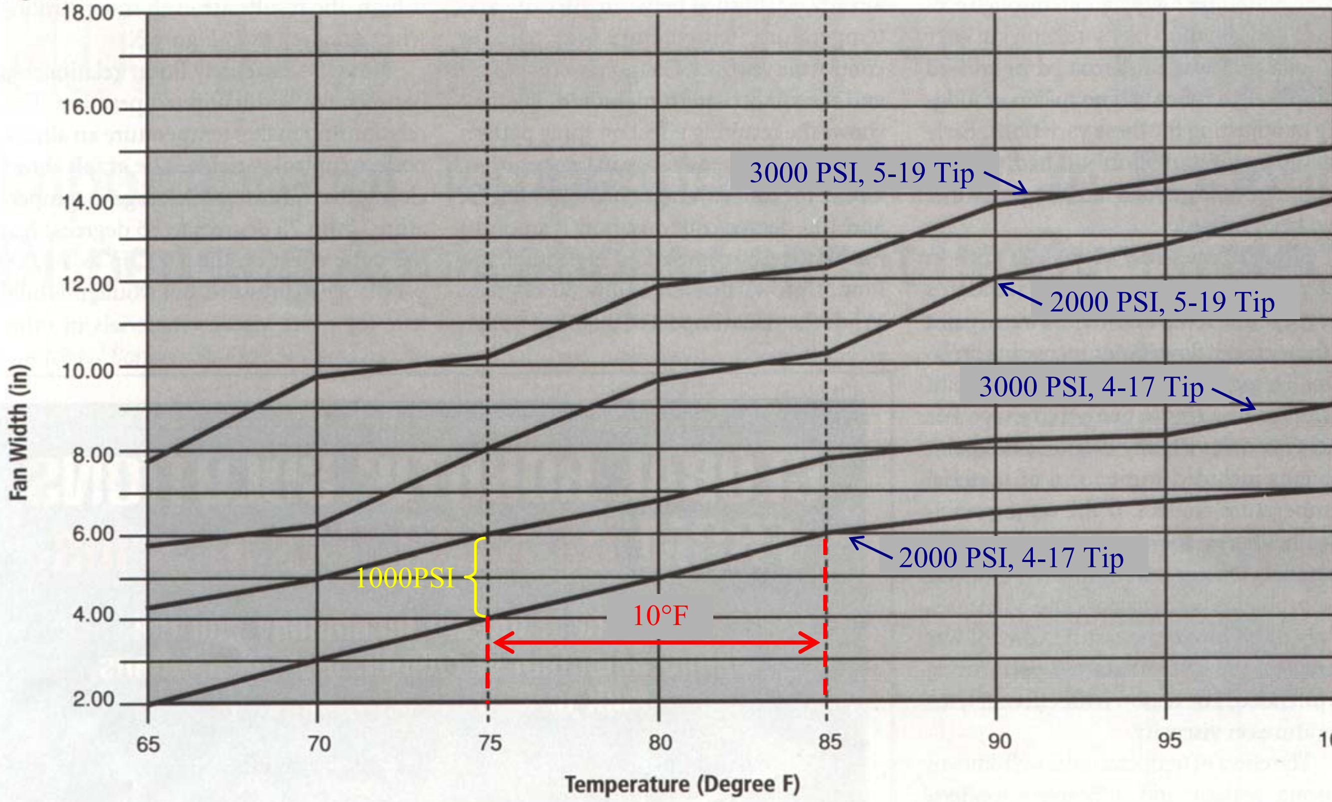
The effect of temperature on the robotic dispensing process can be readily demonstrated. When all other factors (pressure, flow, path, speed, distance, angle, etc.) are held constant and temperature is varied, the pattern dispensed changes dramatically.

For this example, orifice, pressure, distance, and angle to the surface were held constant while a PVC body side material was sprayed. Due to the direct relationship already established between viscosity and temperature, temperature was used to control the viscosity. Coupons were sprayed and the spray pattern measured. Figure 2 shows the resulting effect on spray pattern across a 40-degree change in temperature. Notice the thin coverage on the 100-degree and 105-degree coupons; how it smooths out between 80 degrees and 95 degrees; and how it grows uneven below 80 degrees. While the visual impact of this photograph is high, the results are even more striking when graphed as in Figure 3.

Note the extremely linear relationship between fan width and temperature. This relationship makes temperature an almost perfect control variable. The graph shows clearly that a 10-degree change in temperature (from 75 degrees to 85 degrees) had the same effect on the 4-17 tip as a 1,000 psi change in pressure. But would this hold true for more viscous materials in other

See advertiser index on page 56 and 57

Figure 3



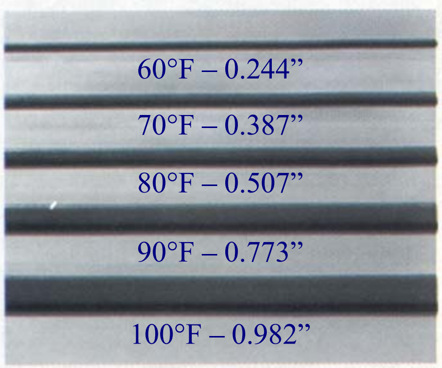
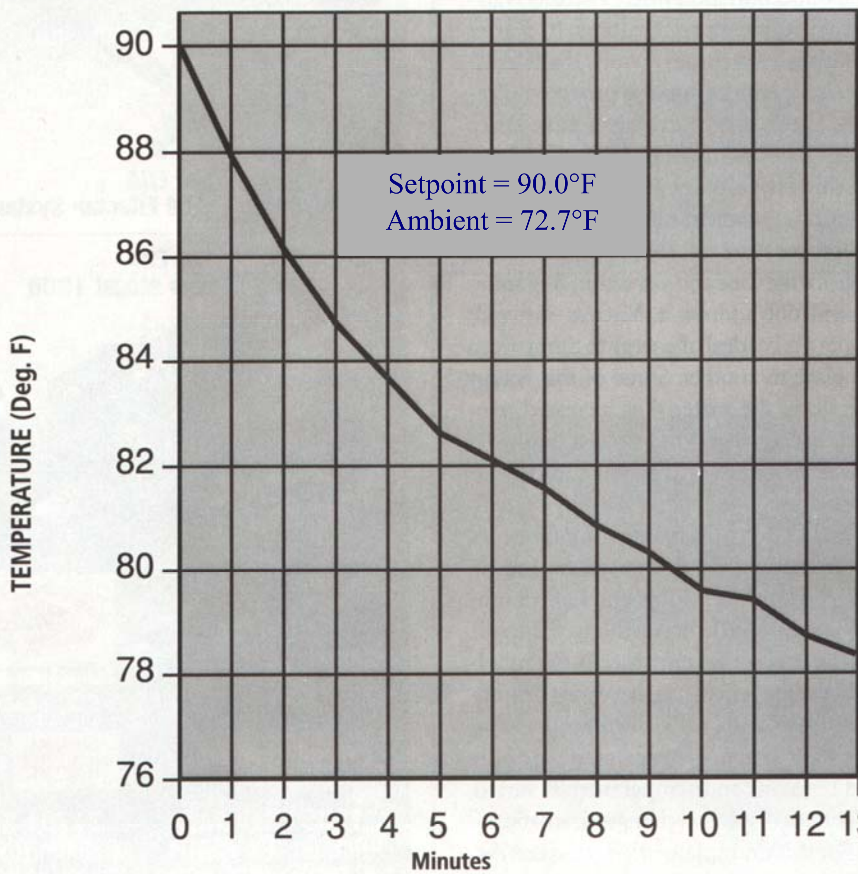


Figure 4: Extruded Adhesive Test

Figure 5



applications? A similar experiment, extruding beads of high-viscosity adhesive, shown in Figure 4, produced strikingly similar results with a 4:1 change in bead width and volume over 40 degrees. In both the PVC Anti-Chip and the Extruded Adhesive applications, a 10-degree change in temperature would mean the difference between a good part and a reject. Like experiments demonstrate the same impact on streaming and swirling applications. This means that large variations in any dispense pattern can be eliminated by controlling the temperature of the material while holding the pressure/flow settings constant. This is due directly to the temperature/viscosity relationship.

Control of temperature can have other significant effects as well. It is easy to understand that the higher the viscosity of a fluid, the higher the pressure required to move it through a spraying system. Adhesive applications often require materials with vis-

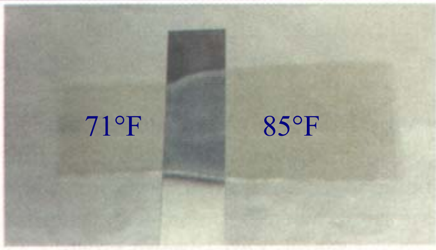


Figure 6: The effect of leaving gaps in the temperature control envelope

cosities in excess of 1 million cps. Even with thixotropic materials, at these viscosities pumping pressures can reach 5,000 psi. Operating in this range requires expensive hoses and other components, which increase system cost. The steep viscosity vs. temperature curve makes it possible to reduce system pressures by increasing the material temperature and taking advantage of the resulting reduction in viscosity. This reduces the pumping pressure required to move the material through the system reducing the cost of the components and the subsequent wear-and-tear on them during use.

Care must be taken in the design and implementation of the temperature-conditioning system. Often, it is mistakenly thought that short hoses between sections of the system don't have a significant effect on system performance. Nothing could be further from the truth. This can be demonstrated by excluding the gun from the temperature conditioning envelope. Figure 5 shows that thermal transfer from the gun to ambient occurs very rapidly. All appears well under repetitive cycling, but when the system is allowed to sit idle for more than a few minutes (breaks, shift changes, etc.), the effect is dramatic. Figure 6 shows the effect on the process when the gun is allowed to reach a 71 degree ambient in a system set to run at 85 degrees. While the lower, ambient temperature material in the gun is being sprayed, the pattern is narrower and the deposition is thicker. As the conditioned material reaches the gun, the fan pattern widens and the deposition thickness drops proportionately. This is clearly in keeping with the effects demonstrated in Figure 2 and, for most applications, would be considered unacceptable.

It is clear from this evidence that the impact temperature has on the quality of performance of any dispensing system cannot be overstated. This is especially true in robotic applications, designed for the express purpose of creating a stable, repeatable process. This one simple, often overlooked parameter can be the difference between the implementation of a successful, reliable system and an ongoing headache. RW

Michael R. Bonner is the vice president of engineering and technology for St. Clair Systems Inc., which supplies process temperature control systems for paints, sealants and adhesives to the automotive industry.

See advertiser index on pages 56 and 57