Insulin Pen Marking —
Anatomy of a Solution

Case Study

Insulin injection pens are literally lifesaving devices, allowing millions of diabetics to administer medication to themselves whenever needed. For insulin pens to work, they need to be easy to use, and it is absolutely critical that they deliver an accurate dose. To achieve this, the pen's dosage selection mechanism must be manufactured to high precision. But these are plastic parts, produced in high volume, and cost is a factor. This article reviews how three organizations – laser system supplier Coherent, Scandinavian machine builder (and Coherent sales partner) Masentia, and assembly equipment manufacturer SVM Automatik (a Stevanato Group brand) – partnered to develop a cost-effective production solution for precision marking the scales of insulin injection pens.

Partnering for a Solution

SVM Automatik A/S (Silkeborg, Denmark) was asked by a major pharmaceutical company to supply a volume production system for performing accurate, high-speed marking of injected molded insulin pen dosage selectors. SVM is the business unit within Stevanato Group, a provider of integrated solutions for pharma and healthcare, specialized in developing and manufacturing assembly and packaging machines.

The dosage selector on these pens is a rotating scale, and the user simply twists a knob on the pen to line up a number on the scale drum with a fiducial mark. Typically, this scale drum is a spiral. That is, it rotates several times, and advances laterally as this is done, to access the entire range of possible doses. Several marks must be placed around the circumference of this part with high spatial accuracy in order to ensure correct dosing.

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Figure 1. The user twists a knob on the pen to select their dosage.
It is essential that the administered dosage is accurate.

Laser marking seemed to be the only viable option to meet the quality, throughput and cost goals for this application. Ink marking becomes prohibitively expensive in very high-volume production applications such as this due to the cost of consumables (ink). Plus, the contact nature of ink printing creates uptime and reliability issues. Molding the scales directly into the parts also wasn't an option because this particular company produces a number of variants for their own customers, and each of these would then require a separate (expensive) tool.

While SVM has extensive experience in automation, they reached out to Masentia A/S (Odense, Denmark), another local company that is one of the largest independent suppliers of advanced industrial production equipment, to get a best-in-class solution for laser technology. Masentia frequently partners with Coherent in the development of laser-based systems.

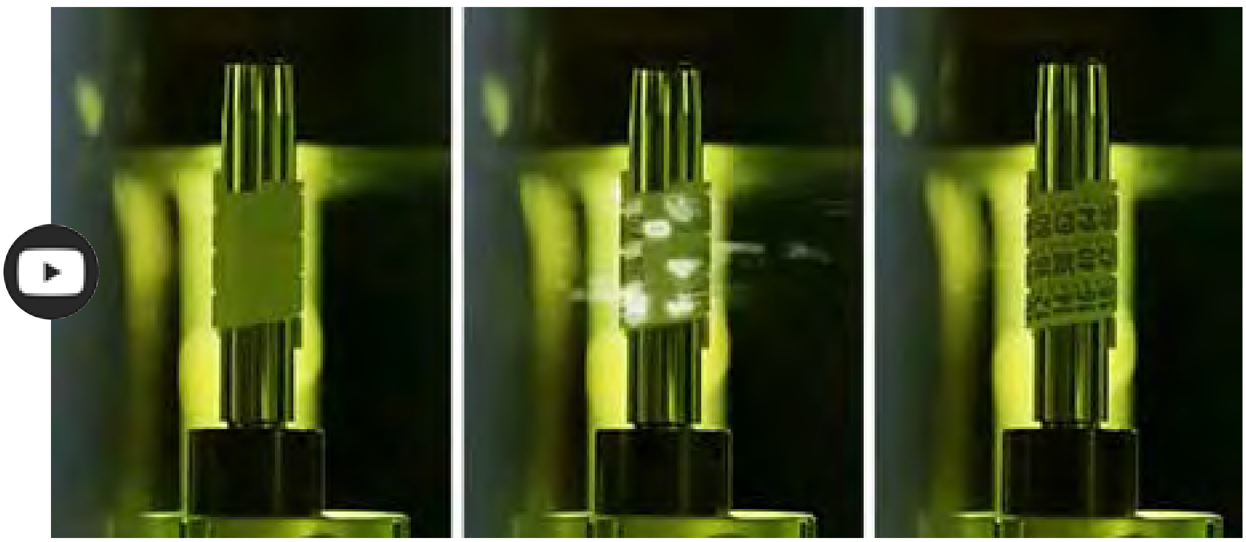

Figure 2: (left to right) A molded plastic part is automatically positioned within the system, and then simultaneously marked around its entire circumference by multiple lasers. This process takes less than two seconds.

Application Requirements

These development partners were tasked with engineering a solution that met a number of specific requirements. The most important of these were:

- **Accuracy:** Insulin pens have been shown to consistently deliver dosage errors of under 5%, especially at larger doses. This translates into an allowable mark position error of tens of microns for this application.

- **Speed:** The user's throughput requirements for this task necessitate a cycle time of about 2 seconds for the marking operation itself.

- **Legibility:** Mark contrast and legibility must be sufficient so that the scale can be read easily, and there is little chance of confusion or error. Black letters on a white background were chosen to meet this condition.

- **Cost:** Cost-of-ownership and cost-per-part considerations include consumables, system energy consumption, and machine downtime.

Additionally, SVM wanted to develop a customizable system which they could readily adapt for other customers and applications. So, system flexibility was also a consideration.

Achieving Accuracy

The dose selector drum is an injection molded part. Variations in the molding process, and temperature related changes in physical dimensions (because the parts cool after molding, and the time interval from molding to arrival at the marking station isn't consistent), create unit-to-unit differences in part dimensions. To meet the mark placement accuracy specification, these differences must be measured and then compensated for by the marking system.

To accomplish this, the designers integrated a vision system that measures marked parts periodically and determines mark placement accuracy. The injection molding tools contain several individual cavities, and typically all the parts in a single batch from the same cavity are consistent in size. Consequently, it's not necessary to sample parts 100%. Rather, they are sampled occasionally; if parts are out of specification, a correction factor is calculated and applied to the laser scanning system and the previous parts are scrapped. This same correction is then used subsequently for every part that came out of the same mold cavity until the next measurement.

Coming up to Speed

The process speed requirement was addressed utilizing multiple laser markers in each marking station which operate simultaneously. Systems incorporating either four or six laser markers were made for the particular end user in this application. This approach allows simultaneous marks to be made around the entire circumference of the part, in a single operation, without any part rotation or movement.

Figure 3: The Coherent PowerLine E Series are flexible laser markers that can be configured with diode-pumped solid-state lasers having output at 1064 nm, 532 nm, or 355 nm. They are intended for applications that require marks with excellent legibility and high production throughput. This application utilized a laser marker with 40 W of IR output.

The particular laser markers in these systems are the Coherent PowerLine E 40, which incorporate a 40 W (at 1064 nm) diode-pumped, solid-state laser, two-axis galvanometer scanner, scan optics, control/interface electronics, and Visual Laser Marker (VLM) control software. To minimize system complexity and cost, Coherent designed the scanning system and beam delivery optics to have sufficient depth of focus so that all the marking can be performed on the cylindrically curved surface of the part without the need for dynamic focusing of the laser. Implementing this requires that the VLM software pre-distort the mark to compensate for the part's cylindrical shape (that is, to produce a final mark on the curved surface that doesn't look distorted when viewed by the user).

Back to Black

Another reason for the choice of the 40 W laser with 1064 nm output is that it delivers the necessary combination of process speed, mark contrast and legibility. Specifically, it produces carbonization in the plastic which yields a very dark mark on the white plastic. Operating with the infrared output of the laser, rather than frequency shifting it to a shorter wavelength, increases efficiency, and therefore minimizes electricity consumption.

COHERENT

Putting it All Together

The laser marking, part transport and vision systems must all work together seamlessly in order to get consistent, accurate part marking at acceptable throughput and yield rates. This requires careful design of the interface and communication between these components. This, in turn, involved close cooperation between the various vendors tasked with developing and integrating these modules into a single system.

"The quickest and most cost-effective way to develop a system that utilizes several different technologies that must work together seamless is to have each of the development partners focus on what they do best," notes Teddy Schultz, Sales Director, Masentia. "In this case, Coherent brought their extensive expertise in laser process development to identify the right laser and establish the optimum laser operating parameters for this application. And, they built a laser marking engine that would deliver the required performance and reliability, meet cost targets, and interface with the rest of the marking system. Then, Masentia installed and configured the laser marker within the overall system. Our expertise is on integrating laser technology with other system elements, like vision and mechanics. Finally, SVM packaged all this, and also designed and produced the robotics and specific hardware and software necessary to integrate it within the customer's other production equipment. Additionally, SVM worked with the end user to ensure that their requirements were understood and translated into realistic design specifications."

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Conclusion

Laser-based materials processing systems typically comprise several distinct elements, including part motion/part handling, the laser and beam delivery optics, machine vision for process monitoring and quality analysis, control electronics and software, and a software human-machine interface. Successfully integrating all these elements, and seamlessly controlling the interplay between them, is essential in achieving the optimum combination of process quality, throughput, yield, and hence, cost per part. And, because of the range of technologies involved, it often takes multiple organizations, each with expertise in a specific area, to create the entire solution. Thus, cooperation and partnership between specialized development groups is often as important to successfully implementing a new industrial laser process as the underlying technologies themselves.

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