Re-write of 'Pressure Sensors in the Injection Mold' by Robert Vaughan

"Pressure Sensors: The Nerve System of the Molding Process"

In today's new world mold makers must reinvent their business to add unique value to the customer as part of their offering. Adding a molding nerve center using mold pressure sensors and understanding how to use it can add a new dimension to what the mold builder brings to the table. As with anything, understanding the details involving pressure sensors and their use is key to adding value. This article will give the mold maker basic knowledge on the benefits of pressure sensors. It will also provide an understanding of the different types and styles of pressure sensors, how they are placed in the mold, and how the mold maker can utilize the nerve center during the tryout phase to reduce his costs and add capability to the ultimate customer.

<u>Benefits of Pressure Sensors</u>

Today most of the leading molders are utilizing pressure sensors in their business in some way. This is because the nerve center developed from the pressure sensor information can allow the molder to be more profitable by eliminating inspection costs, getting processes up and running quickly and knowing when something is abnormal so that corrective action can be taken before rejects are made. Also, the molder may want the flexibility to move molds from one press to another, or one location to another, without redeveloping the process. Mold pressure sensors allow this to be achieved. The molder is selling his press time. Someone, somewhere along the line has bid the time needed to test a new or refurbished mold before going into production. Because we are all working on tight timelines, it is important for the molder to have at his fingertips the best technology available to assist him in setting the mold and gaining valuable information. As the mold is cycled through the mold trial, information gained can then be transferred to the molder in the form of a template as shown in Figure 1.

Today the mold maker has to do more than make a rock solid mold to print. The customer wants him to build a mold with correct shrinkages that can be easily filled so critical dimensions can be easily held over time. Often the mold maker is not at the mold trial to see and learn about processing but is asked to correct molding deficiencies without really knowing how the mold was processed. Mold pressure sensors can allow the molder to see, after the fact, whether or not the process is being run as it was intended to be, so that corrective action is a result of a true need to modify a mold rather than simply to correct the process.

<u>Purpose of Pressure Sensors</u>

Keeping it simple, pressure sensors measure plastic pressure at strategic locations along the route from the machine nozzle to the cavity as a part is filled, packed, held, and cooled. Sensors can also be placed in the machine nozzle, hot runner systems, and cold runner systems, but for the best information they are placed in the cavity areas of the mold. This is where we will focus. Sensors read pressure at their location. This information is then sent to monitoring or control systems so that the process can be better controlled from inside the cavity where the part quality is actually made. By correctly monitoring this information, recording it and developing process control approaches, the mold can be the focus of the process and can be moved from press to press with confidence that the parts can be reproduced on a machine-independent basis.

Pressure Sensor Options

There are two common technologies used in mold pressure sensing. Strain gauge sensors have been predominant in the U.S. for a number of years and are probably more common. The other technology is piezoelectric technology utilizing signals generated from pressurization of quartz crystals. This technology is utilized much more in Europe than in the U.S., however, both are commonly used. While there are specific benefits to each, generally if properly employed, both technologies can give robust and accurate readings and are generally a matter of customer preference. Each technology generally requires different signal conditioning to obtain analog signals to be used by conventional data acquisition systems and inputs to the machine for the display on the machine controller.

A third option, which blurs the distinction between these two, is a digital or Lynx™ sensor from RJG. This sensor outputs digital information directly from the sensing source onto a digital network. This makes the use of each of these two technologies transparent to the user and simplifies both the setup and the calibration which many times is the key to easily adapting this technology in the field.

Pressure Sensor Styles

There are two styles of pressure sensors being used in molds today, the flush mount and indirect approaches. The so-called flush mount approach uses a sensor, which is installed close to the cavity by machining an installation hole from behind the cavity to allow the sensor to be flush with the cavity surface. This is shown in Figure 2. Cabling is then brought out through the mold as appropriate to the connector on the outside surface of the mold. One advantage of this type of sensor is that it does not see the forces of ejection, however, in some high temperature applications it can be over-temperatured, which makes the installation problematic.

The other style sensor is the indirect sensor, which comes in two configurations, the slide and the button. These sensors use the force exerted by plastic on an ejector or stationary pin, which transmits the force to the sensor which is either in the ejector plate or the clamp plate of the mold. Indirect sensors are most commonly placed in the ejector plate of a mold beneath an existing ejector pin. However, in high temperature applications or when low force sensors are used for small pins, many times the sensors are placed in the clamp plate of the mold and the pin is utilized through an ejector sleeve or utilizing a transfer pin, both shown in Figures 3 and 4. The benefits of the transfer pin are that an existing ejector pin can be utilized while the sensor is not exposed to the forces of ejection. Also, in fast cycle, high speed ejection situations the sensor is not exposed to the rapid acceleration and deceleration of the ejector plate.

While slide style sensors were most common in the past, today button style sensors are usually employed. This is because slide style sensors, while they can be easily removed and relocated, can also slip out either fully or partially and cause erroneous readings.

Button sensors are generally far more reliable, especially in production, and are preferred whenever possible. When using indirect sensors, the size of the sensor is based on the area on the end of the ejector pin used to transfer the pressure of the plastic to the sensor. Whenever possible, it is best to use a single size in a given mold so that all sensors will be the same to eliminate setup or calibration errors by the user.

Regardless of the type of sensor it is always best to design the need into the mold at the start of the project. When the sensor is added after the design is approved or manufacturing has begun, compromises are often needed. One key to sensor reliability is to not let cables exit the mold and be free to move around. Sensor connectors should be anchored to the mold in a way that cables will not be exposed to damage. Then additional cable is used to go from the mold to the data acquisition system.

Where to Locate and Why

It is important that pressure sensors be properly located to get the maximum information for the molder. While there are many specific exceptions to the rule, sensors for process monitoring should be located near the last one third of the cavity to fill. Sensors for controlling the process by transferring the press should be in the first one third of the cavity. For very small parts sometimes the sensor is located in the runner system. However, this is a compromise that does not allow gate seal to be observed using the sensor. It is important to realize that when a short shot is developed, zero pressure at the end of cavity is present and so for sensing short shots and automated part containment the end-of-cavity sensors are key. Today, using digital sensors by RJG, it is easy to put sensors in every cavity and simply have one network wire from the mold to the press. This allows one hundred percent insurance against short shots being delivered to the customer by simply installing the sensors at the end of cavity without any further process control interface to the machine.

One of the biggest values provided for and by the mold maker is the rigorous mold tryout using the instrumented mold. This allows a process to be set up and optimized on the first or second tryout and then utilized for every subsequent tryout to minimize the number of trials necessary. Once this is done, and the mold has been qualified with correct dimensions and capabilities, the templated process can accompany the mold to the molder and be set up. A mold builder who understands this process could guarantee that he could help the molder make the transfer directly to their production equipment as part of the value of the mold. This could be handled directly by the mold builder, or in some cases, by a third party who has the equipment and understands the methodology. This truly gives the mold build a new set of values to the molder and ultimately to the OEM who owns the tool.

Molders who embrace the use of mold pressure sensors as the center of a ‘smart mold’ can generate new value to their customer and add overall capability to the value stream. This means embracing mold pressure sensors rather than thinking of them as a necessary evil asked for by the molder. Mold builders, by embracing this technology, could become a positive force in developing an optimized process for molders who are increasingly understaffed, especially in the process developing area. This can truly give the mold maker another dimension in his value to his customers.

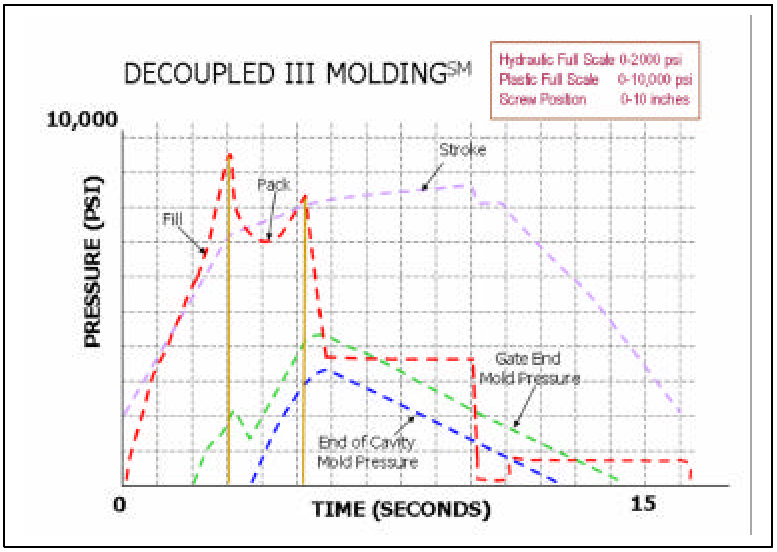

Figure 1: Mold Pressure Template

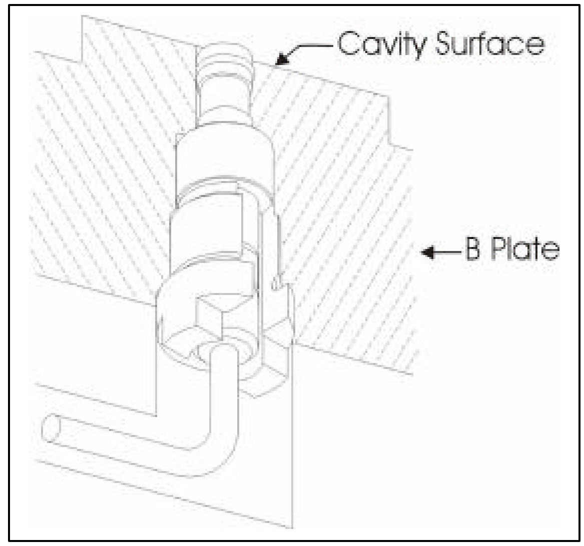

Figure 2: Flush Mount installation

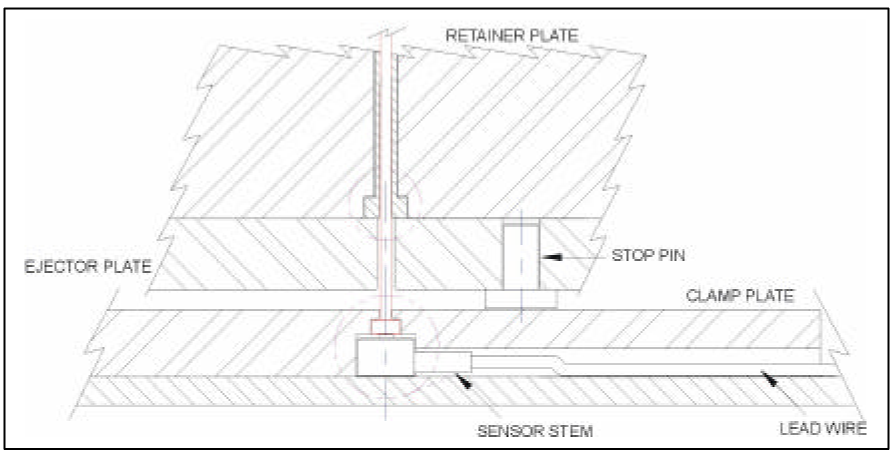

Figure 3: Indirect sensing through an ejector sleeve

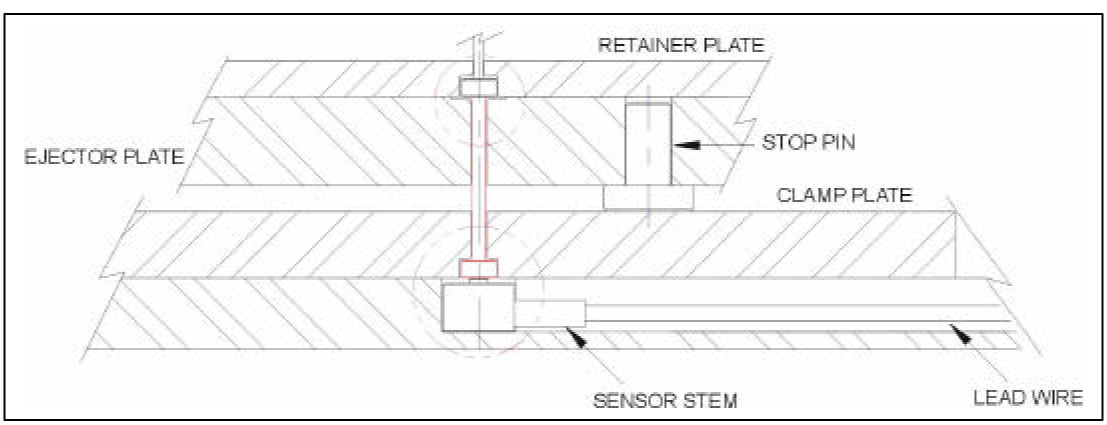

Figure 4: Indirect using a transfer pin