Dr. Die Cast

The Evolution of Process and Machine Controls in High Pressure Die Casting

During the late 90's an acquaintance commented about his company, "We're kicking heck out of the 60's". Of course what he was referring to was the fact that the company was employing mostly 1960's technology in an attempt to meet 1995 quality standards.

If you visit most die casting facilities that have been in business for a few decades, it will be like visiting an industrial museum. You will need to look closely to see the numerous levels of technology that die casting machines have experienced. Some of the technical innovations were very effective; others created a vacuum of technical expertise that was not readily available at the time they were introduced.

Where have we been and where will this take us?

Most of us hold more computing power in our cell phones than was available even a short time ago in our die casting machines.

Typical 1960's die casting machines were operated by mechanical relays. We learned the terms "N.O." for normally open and "N.C." for normally closed. Aside from those two steps, the only other options were the timers. Timer functions were controlled by the "Eagle" motorized timer(s). They were convenient in that when they failed, they could be unplugged and replaced without opening the control panel door. "High-tech" timers meant the motorized timers were replaced with thumbwheel solid state "Eagle" timers that plugged in to the same socket.

Hydraulic controls for pressure, and flow were all mechanically adjusted. There was an occasional "Sequence" valve control that required a great deal of knowledge in order to set correctly. Some of these operated a "Pre-fill" valve. That's another word you won't hear very often today.

Hydraulic pumps were mounted on top of the reservoirs. That was OK then because most companies were using some form of petroleum based hydraulic fluid that only required a low level of vacuum to reach the pump inlet. PCB's were not yet a household word.

Progress in the 1970's dictated that relays should be replaced with "Solid state" "logic" controls. Early versions of these were "hard-wired" panels that had plug-in single function "logic" boards. Troubleshooting was done with the aid of a multi-meter and lots of patience. We learned the language of logic which used terms such as; "AND", "IF", "NAND", "NOT" and "NOR". "Digital Electronic Controls," also known as "DEC" was a major supplier of solid state panel controls during that period. Some timers were included in the solid state boards although we often saw "hybrid" systems that were solid state but continued to use various levels of the "Eagle" timers.

Hydraulic controls during this time had not changed much yet except that water glycol became the fluid of choice for the industry and new machines were built with "charged inlets", that is, the pumps were moved down near the floor so that the pump inlet was gravity charged. This was necessary due to the weight of the water based hydraulic fluids. Older machines that switched over to water glycol simply burned up more pumps. The pump manufacturers probably sent flowers to the insurance companies that mandated the new fluids.

Shot process monitoring was still on the distant horizon for most people. The only instrument available was a Honeywell™ "Visi-corder™". The cost of this instrument was as comparable to that of a new 3 bedroom home and was about half the price of a small die casting machine. Only the big companies such as GM Central Foundry, Hydramatic, Ford Sheffield and Chrysler Kokomo could afford them. Needless to say, there were not a lot of them in use. Shot velocity, acceleration and pressure rise time were abstract ideas and concepts that we discussed and hoped to accomplish but had no concrete method of validating.

In the 1980's Programmable Logic Controls (PLC's) started to show up. There were several companies that were among the early entries that have since disappeared. Some are still household names although not in the field of PLC controls. Programming and troubleshooting was a labor intensive project using a dedicated terminal or a handheld keypad. Timers

Who's Dr. Die Cast?

Robert P. McClintic
Die Casting Consultant

Bob McClintic & Associates
2544 Almar St
Jenison, MI 49428-9108

rmcclintic@ameritech.net
www.drdiecast.com
(616) 669-2932

might be either integral or external similar to the Eagle timer syndrome.

Some attempts were made to control the shot speed using servo valves with PLC interfaces. Early Servo valves were primarily Moog servo valves and they were extremely sensitive to dirt. Most die casting machines were not equipped with the type of filtration system necessary to reach the 5 to 10 Micron filtration levels needed by the Moog valves. The result was most people who owned one of these machines experienced excessive down time and frustration and many simply gave up and returned to mechanically adjusted directional valves.

PLC's became the standard in the 1980's. Competition helped advance the controls and capabilities. PC's were just starting to arrive in the offices and it would be a while before they arrived to the shop floor in any form.

In the early 1980's an oilfield engineer in Texas came to work in the die casting industry. He noticed that there was very little instrumentation on the process. He decided to adapt a memory trace oscilloscope to measure speeds and pressures. It was only capable of displaying the last event. Printing it out would take a few more years! This was the predecessor of our modern process monitoring.

One of the benefits of the information gathered from the early process monitoring equipment was the identification of events that previously were only theoretical discussions. One of those was the hydraulic inertia "pressure spike" at the end of the high speed or fast shot. Accumulators had nearly always been located near the pump(s) on the closing end of the machine. This resulted in several yards of high pressure plumbing between the accumulator and the shot cylinder. The inertia impact created a significant hydraulic pressure spike. This caused a lot of flash and was also destructive to seals and valves. Machine designers started relocating the accumulator bottles nearer the shot cylinder in order to reduce the inertia impact of the fluid in motion. They were initially referred to as "low impact" or "low mass" shot ends. This was the most noticeable benefit of the design change.

In the mid 1980's some machine manufacturers made the leap to a fully servo and proportional valve controlled machines with a PLC controlling and monitoring the entire machine process, speeds, pressures, rise time, etc. Once again technical support and hydraulic fluid maintenance remained the major obstacle to success.

Die cast process monitoring became more affordable as many companies adopted at least a portable monitoring system that could be rolled from machine to machine with the necessary cables, a "string pot" and a pressure transducer. Process validation was primarily asking, "What has changed since I last checked?" Monitoring was labor intensive at best as moving the string pot and transducer(s) from machine to machine could be difficult and in some cases they were competing for space with the furnace operators and material handlers. Effectiveness was dependant on the experience and expertise of the process technician/engineer. The frequency of his checks was limited by his ability to move quickly from one machine to another.

In the 1990's PLC's were standard, although we still saw some manufacturers with redundant systems. Some would have PLC's running mechanical relays! Digital displays, data-liners and a few panel-views are around.

Casting models are no longer 2D drawings or physical wooden replicas but begin to arrive in full 3D as we adapt to Catia, Pro-E, SDRC, etc. (The term models used to describe the contents of a CAD file confused a lot of die makers that were accustomed to receiving wooden models. Even as recently as 1997 I received a call from an angry toolmaker wondering when he was going to receive his (wooden/solid) model. CAD files were transmitted via dial up FTP programs or delivered overnight on a CD-ROM. Die Casting Tool shops had to learn a new skill, auditing for missing radii and incomplete lines.

Die casting flow and solidification modeling begins to parallel the development of the full 3D casting models. We learn new names such as Pro-Cast, Magma, and EKK and wonder who will prevail. As with shop-floor die casting process, the expertise of the computer simulation operator and reviewer will determine the success or failure of most analysis.

PC based plant wide process monitoring systems are no longer a pipe dream but several are implemented throughout North America and are yielding results. The process technician's expertise is more important than ever to interpret and react to the volumes of data that is generated by a plant wide system.

In the late 1990's and early 2000's, machine builders began to integrate PLC's and PC computers. Systems could now program and monitor. MMI (Man Machine Interface) became more common as touch screens and "Panel-views" became more commonplace. On-screen programming and monitoring becomes more intuitive and graphic. Automation integration becomes easier and more reliable as ancillary equipment such as furnaces, ladles, sprayers, and robotic extractors communicate with the PLC or PC.

As of this writing, fully-integrated machines are in operation throughout the world. They are fully programmable and monitoring includes alarm limits deciding the disposition of the casting.

Plant-wide monitoring systems can collect and archive data including the shot profile.

Castings can be serial numbered using a dot matrix system as they leave the machine for full traceability. The part is traceable to the date and machine cycle number that produced it.

Vision systems are being used to monitor castings as they are extracted from the machine to insure that there are no missing overflows or pieces that could damage the tool.

Handheld Thermal imaging cameras are being used to spot check die temperature profiles. These can be compared to a master to identify plugged or disabled heating/cooling lines. The data can also be compared to the thermal simulation to validate operating conditions.

In summary, it is a great time to be in the die casting industry. We have never before had so many tools at our disposal to assist us in our quest to make the best parts better than they have ever been made before.

We must continue to develop and train our people to assume ownership of the systems that are available. Only then will we climb our way back to levels where we are admired and envied by our competition throughout the world.