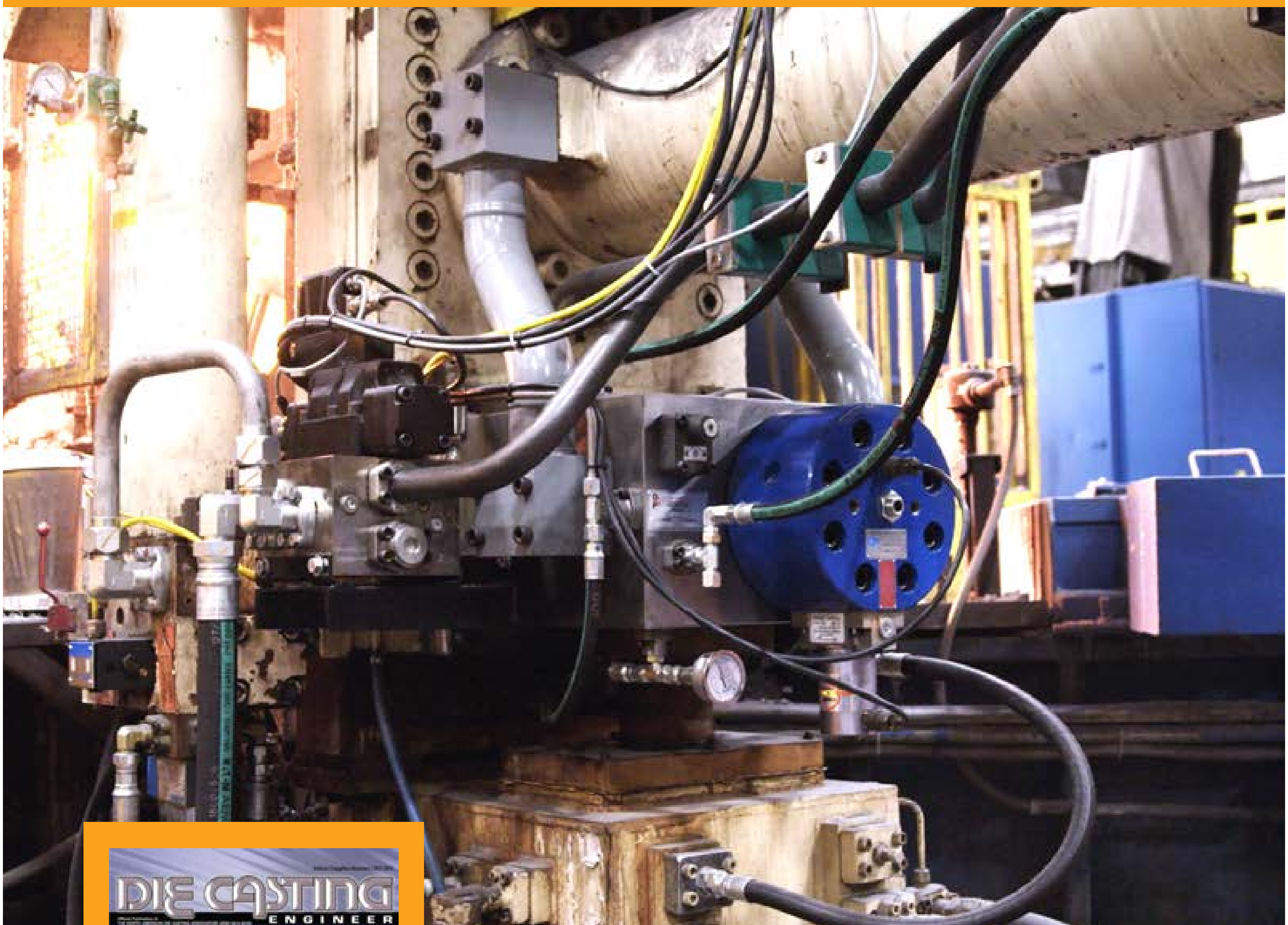
Control Upgrade of 1200 Ton Cold Chamber Die Casting Machine



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Control Upgrade of 1200 Ton Cold Chamber Die Casting Machine

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For die casters, improving overall equipment efficiency is a process metric that is a prime target for overall improvement in output and improved profits. As the industry continues to look for castings for products that were previously made from other technologies; open machine capacity could be an issue. In order to meet these needs, finding new ways to extract increased productivity out of your casting operation is becoming vitally important.

A great way to boost both OEE and machine utilization is to increase injection performance. On the range of industrial machinery, die casting machines require a higher scale of size and complexity – this is a function of the great forces and high speeds associated with injecting large quantities of molten aluminum into a near-net shape. Considering the size and complexity of the hydraulic circuits of die casting machines, there are no 'quick fixes.' However, there are many options to consider when the overall machine is in good condition (i.e. Linkage is sufficient, Close Coupled Shot Accumulator, Robust Machine Design, etc…), but injection performance is lacking.

Many die casting machines in use today were developed at a time when servo hydraulic technology was not ready for the demanding casting environment. More seasoned veterans of the casting industry may still cringe when hearing the words "servo controlled," but what they don't realize is that significant advances in technology and its adaptation on die casting machines have been made since those days! With this article, we will share the results of a control upgrade of a 1200 ton cold chamber DCM we retro-fitted in August 2014 for our customer, MPG.

Figure 1 *– Operator Side View of Meter-Out Hydraulic Circuit Upgrade.*

MPG is a leading global designer and supplier of metal-formed components and assemblies for automotive applications, operating numerous facilities worldwide. The primary die dasting location in Twinsburg, OH has 24 die casting machines, with each machine utilizing a Visi-Trak Monitoring System to track and analyze machine performance.

At the end of 2013, MPG was investigating ways to improve performance across all machines and identified a single machine that was due for an upgrade. By analyzing the data gathered by their original monitoring system, they found that they were not getting consistent performance across several critical parameters. In particular, they considered measures that would improve the consistency of the following 4 parameters:

- Intermediate Shot Velocity
- Calculated Start of Fast Shot
- Fast Shot Velocity
- End of Shot Position

In addition, on-site quality checks through visual and X-Ray inspection indicated that parts manufactured on this machine had variations for acceptable levels of porosity. Of the above parameters, the most challenging to control with the existing factory supplied hydraulic circuit was the consistency of the fast shot velocity and the end of shot position.

End of shot position was predominantly challenging, resulting in many occurrences of flashing the die. When the die is almost completely full, there is much inertia with the hydraulic cylinder's forward momentum. Without a robust Low Impact system offering the capability of controlling this momentum, the clamp end can become overwhelmed and the result will be aluminum on the die surface. Excess aluminum on the die surface needs to be cleaned off the surface of the die prior to commencing operation, otherwise the die lifetime becomes compromised. The issues related to excess aluminum on the die accounted for a large portion of downtime on this machine.

The machine was still outfitted with the original equipment control system and hydraulic circuit for controlling the injection process. The basic working principle is based on separate valves operating for the various phases of injection. There is a proportionally controlled valve for controlling the slow & intermediate portions of advancing the cylinder. At the point when the metal is at the gates (also referred to as start of fast shot or P2) a separate larger throttling valve which is piloted by a series of five solenoid valves can position the main poppet of the throttling valve in 64 positions. The 64 valve positions correspond to the various shot velocities desired. The valve is opened to a predetermined position by energizing various combinations of the five solenoid valves, and then when the cylinder reaches the P2 position, a fast shot PO check valve is opened allowing for acceleration during metal injection to the die cavity. When the cavity is almost full, the 'impact' valve will energize to allow for low impact and then the 'shot poppet close' valve will energize to fully close the fast shot PO check. This system runs in open-loop so variances will result in inconsistencies.

When considering the upgrade, a number of objectives were defined. The first factor considered was the overall condition of the machine. In this instance, the overall machine condition was acceptable and because of this, we initially focused on the shot end. A completely new shot end was also in consideration and would have been very beneficial. However, there was a high cost associated with a new shot end, as well as a longer delivery time. With the large workload MPG was experiencing, any upgrade needed to be accomplished in a minimal amount of time. There was simply too much work scheduled on the machine to allow for a significant machine outage.

The second consideration was to look at ways to decrease operating costs. Some examples included: machine downtime, maintenance personnel time spent to fix the machine, lost productivity, cost of scrap and spare part replacement purchases. At times these costs can be overlooked, but are detrimental to the efficiency and profitability of any manufacturing organization.

The third consideration was to improve the capability of the machine in order to keep up with market demands. The die casting industry is increasingly being looked at to provide complex shapes, thin-walled parts and components with large projected areas. High Integrity practices are becoming more widely used, and an important component of High Integrity casting is to incorporate closed loop control that will run with unrelenting repeatability and consistency.

After reviewing these objectives, Visi-Trak recommended an upgrade package that included the Sure-Trak2™ Shot Control System, 80mm Olmsted SV Cartridge Valve piloted with a Woodward HRT R-DDV Servovalve®, a Conversion Manifold, Total-Trak2™ HMI, Visi-Trak® 20-Pitch Tail Rod and Transducer Assembly and an option for proportional control of Intensification Pressure.

The most vital component of the project was the Olmsted SV Cartridge Valve, which is specifically engineered for the rigorous die cast injection process. The aforementioned slow/intermediate and fast phases of injection, along with low impact, are all accomplished with use of this valve, which has a lightweight gate assembly and a unique flow window to accommodate rapid acceleration as well as controlled deceleration. Two critical feedback loops are provided to enable true closed loop control of the shot cylinder. A Linear Variable Differential Transformer (LVDT) provides throttling valve position feedback. The shot stroke sensor provides the critical outer feedback loop to insure the speed programmed follows the velocity commanded through the motion controller.

A turn-key solution was requested, incorporating all phases of the upgrade from tear down and install to start-up and sign-off. Visi-Trak developed a project plan timeline and began to work on the install plan for disassembling the existing system and installing the new components. We coordinated with suppliers, subcontractors, engineering, scheduling and operations in order to organize the effort. When designing the manifold, Visi-Trak was able to ensure that they could reuse the tank line, resulting in significant cost saving during the installation.

When manufacturing and pre-assembly work was finished, disassembly began on a Friday. By the following Friday, hydraulic and electrical installation was complete. Start-up and tuning required an additional 2 days, which meant that in just over one week, the machine was producing castings. After the first casting was produced it was taken to the X-Ray machine for inspection and passed without fault.

During the first few months of operation, MPG witnessed dramatic decreases in machine downtime, at which point several capability studies commenced.

First, the trend chart for the four parameters comprising the objectives of the project was reviewed. Below are the results with the vertical blue dashed line demarcating when the upgrade took place. A marked improvement for slow, intermediate, and fast shot velocities was observed. As well as showing an improvement, end of shot position became more reliable and adjustable. Calculated start of fast shot showed moderate improvement.

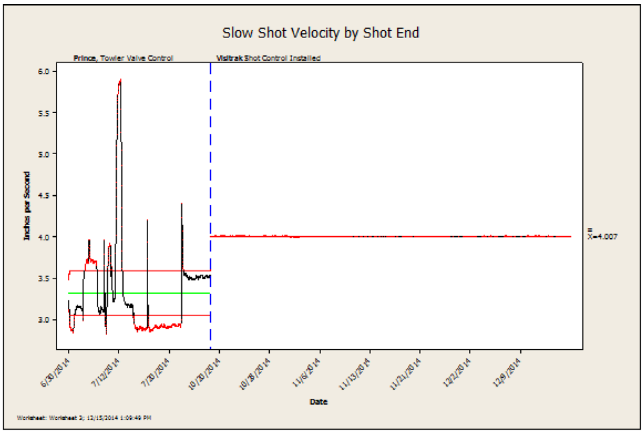

Figure 2 - Slow Shot Velocity - Disturbances in this velocity can contribute to trapped gas porosity.

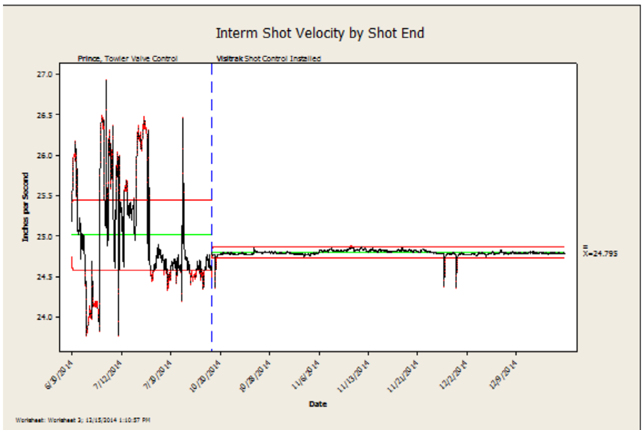

Figure 3 - Intermediate Shot Velocity - Variance in this velocity can contribute to trapped gas porosity.

The data showed significant improvement in the parameters most critical to the project. Die flashing occurrences were drastically reduced, resulting in almost complete elimination of the problem.

MPG also experienced an increase in machine uptime, improved efficiency, less maintenance time spent on the DCM and improved part quality. Altogether, this accounted for an 8 month ROI.

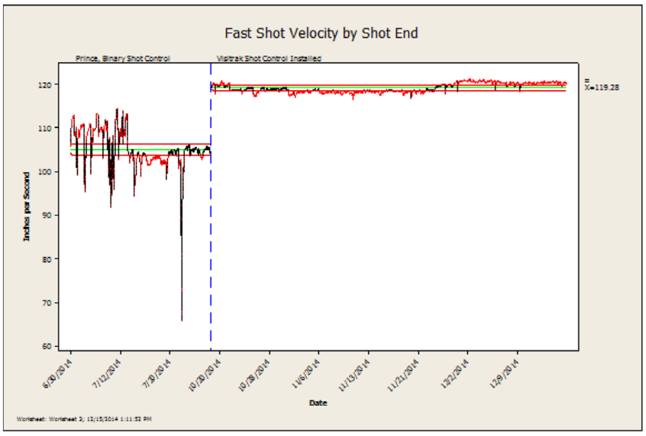

Figure 4 – Fast Shot Velocity – Variance in this property can result in inconsistent cavity fill and porosity.

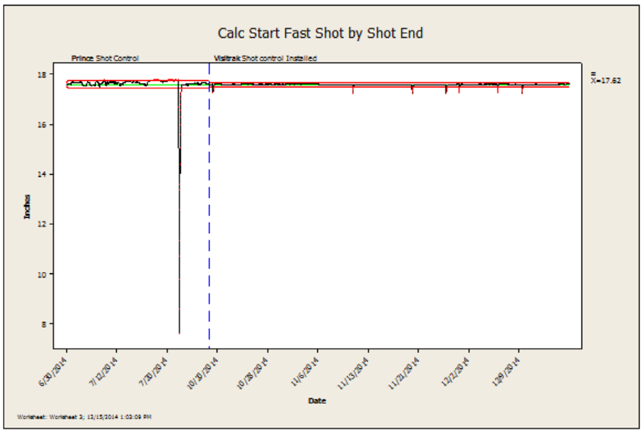

Figure 5 – Calculated start of fast shot.

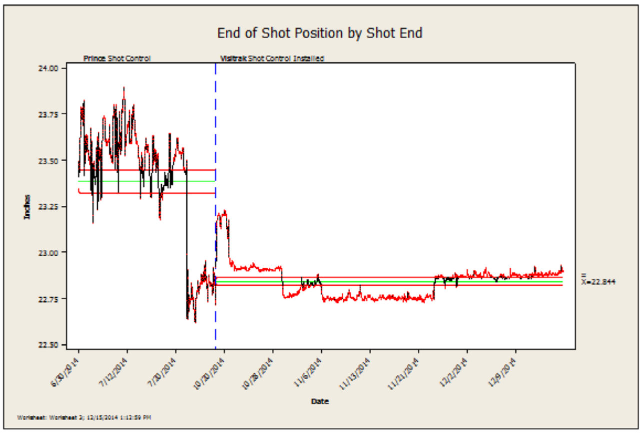

Figure 6 – End of Shot Position – Variance will result in flashing the die, scrapped parts & significant machine down time.

Machine utilization was also measured in comparison to other machines. Three machines running the same part at the same time were studied. Over the period of the study, it was measured that the upgraded machine performed with 20 percent better machine utilization as compared to the two other machines running the original supplied control configuration.

After installation, two unanticipated results were found after one year of machine operation: there were no downtime instances for hydraulic leaks on the shot end and there were no spare part replacements after one year of operation. Previously, shot end hydraulic leaks and shot end repair were in the top 5 reasons for downtime on this

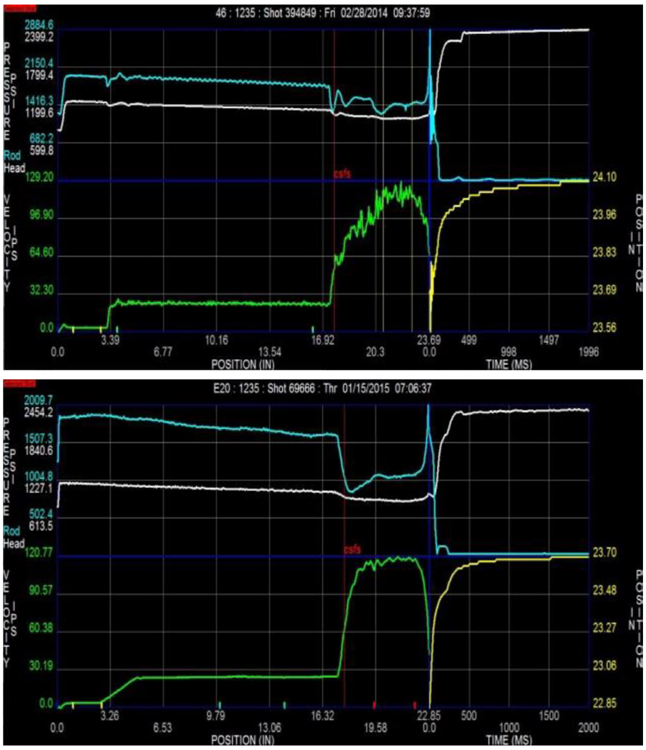

Figure 7 – Before and After Shot Traces displaying improved injection performance with ramping capability in slow/intermediate phase and decreased Fast Shot Rise Time.

machine. The higher response of the valve/control system has minimized spikes in the hydraulic system and moved these downtime reasons to 10th or higher place.

Also, in the U.S., when it comes to heavy machinery, we do not have an obsolescence mentality (as is common in other geographies). Some machines are truly past their useful life, but many die casting machines should be carefully examined and their data studied to investigate the potential benefits of upgrading.

With the success of the first machine upgrade, five additional machines were approved for upgrade in 2015. With the experience gained on the first install, hydraulic and electrical install of subsequent upgrades was shortened to three days, further increasing the benefits gained from MPG's implementation of Visi-Trak upgrades.

Figure 8 – View from the Helper side – 1 year of operation with no components replaced and no downtimes for Hydraulic Leaks on the Shot End.