PROCESS AUTOMATION IN ACTION
Process Automation In Action!

Defect Prevention

- less scrap
- reduced metal & energy costs
- greater OEE
The Porosity Problem

Trapped Gases  Material Separation  Shrinkage Porosity
The Porosity Problem

- Excessive porosity creates unexpected mechanical properties in the finished casting:
  - Creates blistering in parts requiring heat treatment.
  - Reduce ductility leading to cracks during deformation.
  - Reduce conductivity in applications like electrical rotors
  - Leads to leakage in pressure-tight castings
Sleeve Fill Phase – Too Slow?

Air Trapped in Sleeve

Reflected wave front
Sleeve Fill Phase – Too Fast?

Wave Front

Air Pocket
Cavity Fill Phase – Critical Slow Shot Velocity
Cavity Fill Phase
Consistent Results
Ohio State Water Analog Simulation

- Discovered importance of acceleration control to critical slow shot velocity
Programmable Velocity

Constant Acceleration

17.4" at 80" per second
Real-time Computer Simulation
Customer BDW Technologies

- **Problem**: 10% fallout due to material separation porosity
- All other critical parameters within limits
- **Why the defect?**

Porsche Suspension Part
SUSPECT: Turbulence during dosing
SOLUTION: custom swivel launder developed to provide laminar flow during metal delivery
Swivel Launder

Shot sleeve (1)
Launder spout (2)

Fill position

Home position
Swivel Launder

Description:

- The swivel launder allows a laminar metal flow into the shot sleeve. Thus will assure an excellent metal quality in the shot sleeve.
- The reduced drop height and lower flow rate of the melt during the metering sequence will extend the life time of the shot sleeve - in some cases by factor 10 or more.
- The condition of the shot sleeve is essential when applying a powerful vacuum (< 0.7 PSI) to the cavity. Any significant leakage between the shot sleeve and the shot tip will cause a prefilling of melt into the cavity prior to fast shot!
- BDW technologies has developed the design of the launder and the swivel jig in order to achieve a high melt quality level for weldable and heat treatable diecastings.
Process Automation In Action!

Determine Cause of Part Variation

less scrap
happy customers
greater OEE
Jack,

We had a problem at [Major Automotive Manufacturer] and your monitoring system helped us solve it.

They had vacuum valves blocking at regular intervals. They suspected that it was either biscuit thickness, high speed changes, or possibly blue gremlins.

Here is the trace... - Mr. M
NOTES:

Trend Chart

-- plunger penetration

Stable temperature after break – Does Morris have some screens for this – do they need 3 shots or 15 to get back up?

Brian Asquith Paper?
... We right clicked on the screen and chose “Trends”. I checked the usual suspects – the slow and high speed shot... as you can see we were getting sudden jumps.
... by comparing this to the cycle time record we were able to determine that they had a breakdown at the same time they had the jumps.

These were determined to be times they had to clean the die and filled vacuum valves.

The intensification data proved very telling...
...So as a result of running the monitor overnight and doing 15 minutes of investigation we now know:

- The process is stable.
- The machine is performing OK
- They need to set an alarm for squeeze distance below 10mm so they can quarantine those parts

Mate, this system is amazingly easy to use and gives you useful data quickly!

- Mr. M
Intensification Squeeze Dist. VS Impregnation level Leak % (>7.49 cc/min) before C/M activity (28222 Data Points)

6.64% Overall impregnation rate

Intensification squeeze distance (X-Axis) is the distance the shot piston moves during the high pressure phase of the casting injection cycle (post impact). This data shows the larger our squeeze dist. reading the lower our leak rate tends to be.

The red graph shows intensification squeeze dist. distribution during the study. Each point represents a given number of castings made with a specific squeeze dist. In this case 4159 castings were made with an 9mm squeeze distance.

The blue graph indicates reject rate % of castings produced with the corresponding squeeze dist. In this case .5.55% of the 4159 castings produced with an 8mm squeeze dist. were rejected as leakers >7.49 cc/min. and impregnated.
Results after counter measures

- $10k per year savings in impregnation costs
- + 6700 less scrapped parts
- Greater detail coming in case studies section
The preferred intensifier profile

- **Solidification begins** as soon as the metals stops moving.
- **Intensification must initiate** just prior to or as soon as the plunger stops.
- The effect of intensification is reported as “Plunger squeeze distance”.
- To be effective, **the gate must remain open while the intensification pressure is applied**.
- This can only be assured when it is properly displayed. A numerical total of plunger squeeze does not tell the whole story such as when the die blows and all the plunger squeeze occurs instantly.
- **Plunger squeeze can be calculated**. See the following slide.
Calculating Plunger Squeeze

Shot wt. 19.260 Lbs.
Shot volume 192.6 cubic inches
Tip dia. 3.750 inches
Tip area 11.04 Sq. in.

0.3139 inches, plunger travel

Plunger travel during intensification to 100% eliminate porosity.
(Generally, the actual measured value will only be about 30 to 40% of the calculated maximum.)
Process Automation In Action!

Reduced Set-up Time

turn around jobs more quickly
less downtime
less start-up waste
greater consistency
Define shot in engineering units

Precision shot control and recall for future set-ups
Monitor and compare shots to master profile
Process Automation In Action!

Document Machine Capabilities

run the right part on the right machine
less scrap
greater OEE
Document Machine Capabilities - Before

- 160-ton cold chamber machine.
- As delivered maximum capability was only 50 IPS, (1.27 MPS), not 196 IPS (5 MPS) as specified.
- Head side pressure is low until impact.
  - This confirms no back pressure on the rod side.
  - Restriction is on the head side.
Before, Fast Shot valve 5 turns open Maximum capability.
160-ton Cold Chamber

No orifices are shown in either cartridge valve.
Tests

- No orifice is shown in the schematic.
- Disassembled the head side fast shot cartridge valve cover to inspect for restriction.
  - Found a 0.8mm orifice in valve #4.22.
  - Removed and retested the maximum fast shot.
5.3 MPS After, Orifice Removed: Fast Shot valve 5 turns open
After

- Maximum Fast Shot is **now 215 IPS, (5.5 MPS)**
- Slight pressure build up during the peak of the fast shot indicates some back pressure is beginning to develop on the rod side.
Table 1.
Compliments of Eastern Alloys. [www.ea.com](http://www.ea.com)

### MACHINE PROCESS SETTINGS

<table>
<thead>
<tr>
<th>Job Title:</th>
<th>Frech 580</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Pressure (psi):</td>
<td>2320</td>
</tr>
<tr>
<td>Back Pressure (psi):</td>
<td>0</td>
</tr>
<tr>
<td>Cylinder Diameter (in.):</td>
<td>4.133858268</td>
</tr>
<tr>
<td>Plunger Diameter (in.):</td>
<td>2.362204724</td>
</tr>
<tr>
<td>Tailrod Diameter (in.):</td>
<td>0</td>
</tr>
<tr>
<td>Plungerod Diameter (in.):</td>
<td>0</td>
</tr>
<tr>
<td>Shot Speed (%):</td>
<td>100</td>
</tr>
<tr>
<td>Machine Description:</td>
<td>580</td>
</tr>
</tbody>
</table>

### METAL AND DIE DATA

**ALLOY**

<table>
<thead>
<tr>
<th>MAGNESIUM</th>
</tr>
</thead>
<tbody>
<tr>
<td># of cavities:</td>
</tr>
<tr>
<td>Total Weight (lbs):</td>
</tr>
<tr>
<td>cd value:</td>
</tr>
<tr>
<td>Minimum Gate area (in^2.):</td>
</tr>
<tr>
<td>Gate area increment size (in):</td>
</tr>
</tbody>
</table>

### DATA OUTPUT

| Max Metal Pressure (psi): | 7105.00    |
| Max Flow Rate (in^3/s): | 1722.3     |
| Max Flow Rate^2 (in^3/s)^2: | 2966436.1 |
| Density (lbs/in^3): | 0.06     |

---

**PQ² explained**
PQ² explained

Graph 1:
Compliments of Eastern Alloys. www.ea.com
PQ² Explanation

- The above examples illustrate the maximum capability calculated for the shot profile for machine in the following slide.
- It correctly calculated that the fast shot would stabilize at 5.0 MPS due to the restriction of the gate.
PQ² at work
PQ² (Continued)

- Both of the previous slides are examples of the gate limiting the fast shot velocity.

- When the metal reaches the gate, the fast shot decelerates to “equilibrium”. That is when the force and resistance are balanced.
Process Automation In Action!

Evaluate Process Repeatability

less scrap
happy customers
greater OEE
BEFORE

UBE Shot-end and
Conventional UBE controls
on 800-ton machine
Stall between creep and fast shot can cause metal porosity due to turbulence.

Head pressure build-up: Gate restriction causes drop in velocity due to no dynamic adjustment capability.
Drastic pressure variation shot-to-shot will cause part fill variation and increase scrap.

Stall problems consistent across all shots.
AFTER

New retro-fit shot-end
and integrated controls
on same model 800-ton machine
Rock-solid adherence to master shot profile shows amazing repeatability.
Precise Repeatability
shot-to-shot with continuous overlay

Continuous Ramp
constant acceleration reduces turbulence in slow shot and decreases porosity
Process Automation In Action!

Squash Machine Problems

less downtime
less waste
longer tool life
greater OEE
A delay in the intensifier rise time as shown in Figure 1. will often result in excessive porosity.

Figure 1.
Multiplier/Intensifier, as supplied

- The shot profiles on the previous slide were taken from a Wolniak rebuild.
- Originally, the hydraulic supply for the multiplier/intensifier was from the main shot accumulator.
- The supply pressure was metered through a Vickers Pressure Reducing Valve.
Economical Multiplier/Intensifier Modification

- Added 5 gallon accumulator
- Pressure reducing valve to regulate accumulator pressure.
- Check Valve added.
A common problem in die casting

Before: 128 MS. delay

After: Immediate response

Figure 1.

Figure 2.
Process Automation in Action

Implementing SPC

Improve quality
greater OEE
Implementing SPC
Process Automation in Action!

Improved Operational Insight

better planning
greater uptime
greater OEE
Monitor Downtime

Current Shift Downtimes
08/16/04 07:30 -- 12/07/04 07:30

Track causes of downtime
## Production and Cycle Data with Optional HMI

**Total-Trak**

<table>
<thead>
<tr>
<th>Cycle Counters</th>
<th>Setpt.</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shot Count</td>
<td>1500</td>
<td>32767</td>
</tr>
<tr>
<td>Part Count</td>
<td>4</td>
<td>-12925</td>
</tr>
<tr>
<td>Scrap Counter</td>
<td>10000</td>
<td>9711</td>
</tr>
<tr>
<td>Oil Temperature</td>
<td>5</td>
<td>11000</td>
</tr>
<tr>
<td>Oil Temp. Low</td>
<td>0</td>
<td>8000</td>
</tr>
<tr>
<td>Die Temperature</td>
<td>3</td>
<td>1500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>Alarm</th>
<th>Actual</th>
<th>Cycle-1</th>
<th>Cycle-2</th>
<th>Cycle-3</th>
<th>Cycle-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tie Bar #3</td>
<td>230</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
</tr>
<tr>
<td>Tie Bar #4</td>
<td>230</td>
<td>226</td>
<td>226</td>
<td>226</td>
<td>226</td>
<td>226</td>
</tr>
<tr>
<td>Tie Bar #2</td>
<td>230</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
</tr>
<tr>
<td>Tie Bar #1</td>
<td>230</td>
<td>227</td>
<td>227</td>
<td>227</td>
<td>227</td>
<td>227</td>
</tr>
<tr>
<td>Unbalance Alarm</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Tonnage</td>
<td>920</td>
<td>903</td>
<td>903</td>
<td>903</td>
<td>903</td>
<td>903</td>
</tr>
</tbody>
</table>

**Cycle Timers**

<table>
<thead>
<tr>
<th>Cycle Timers</th>
<th>Actual</th>
<th>Cycle-1</th>
<th>Cycle-2</th>
<th>Cycle-3</th>
<th>Cycle-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cycle</td>
<td>0.00</td>
<td>30.001</td>
<td>30.001</td>
<td>30.001</td>
<td>30.001</td>
</tr>
<tr>
<td>Die Close Fast</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Die Close Slow</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Die Locking</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Ladle Sequence</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Shot Sequence</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Part Curing</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Die Open Cush</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Die Open Fast</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Die Open Slow</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Part Removal</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
<tr>
<td>Sprayer Cycle</td>
<td>0.00</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
<td>3276.7</td>
</tr>
</tbody>
</table>
Process Automation in Action!

Improved Quality Control

better parts
happy customers
informed Q.A. staff
actionable data
REALTIME MONITORING & VISUALIZATION TERMINAL
Process, Production & Maintenance Personnel get instant access to process information from each machine

PART TRACEABILITY
Automated Marking Systems

Unique ID
2D Data Matrix or Pin Stamp

DCM Cell #1
with Universal Data Collection Terminal

QUALITY CONTROL DATA BACK-UPS
Automatic Quality Control Backup of data on shift, day, week, month and yearly basis

PART INFO AND QUALITY CONTROL WORKSTATION
Q.A. and Plant Management

DCM Cell #n
with Universal Data Collection Terminal

NETWORK
From DCM to Shop office, Back Office or Remote Locations

REALTIME REMOTE WORKSTATIONS
Plant Engineering and Management - Complete Process Insight from the other side of the plant or across the globe.
And even more….

- Design experiments to understand relationships and causes of variation
- Accrue production information including scrap and downtime data

Improve understanding *and* margins