The Economic Benefits of Process Monitoring and Control

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Tangible Benefits:

Source	*Range of Savings*
Reduced Scrap / Reduced Startup Shots / Higher Yields	50-90%
Increased Productivity	25-60%
Metal Savings	3-15%
Reduced Downtime	20-90%
Reduced SPC Manpower	10-30%

Intangible Benefits:

New Business Opportunities
Production Control - Increase Process Predictibility for Improved Scheduling and Just-in-Time Deliveries

Fig 1. Economic benefits achieved with computerized systems ranging from monitoring to closed-loop control

With the utilization of computerized monitoring and control systems, the die cast process has become a repeatable, consistent means for manufacturing high quality castings. These systems have allowed die casters to successfully operate in today's business -- with tighter profit margins and increasingly demanding customer requirements and competitive pressures -- by providing process control tools to improve and certify quality, increase productivity, and significantly reduce scrap and costs.

Fig. 1 summarizes the tangible economic benefits that have been achieved with computerized systems ranging from monitoring (open-loop control) to real-time closed-loop shot control.

Monitoring/Open Loop Control

The monitoring system monitors key variables of the die cast machine and automatically generates alarms any time a critical process variable violates preprogrammed limits. Machine variables such as velocity, metal and die temperature, stroke length, oil pressure, cycle time, impact pressure, and others that influence casting production and quality, are monitored for 100% of the parts produced.

The skilled machine operator now has information that takes most of the guesswork out of adjustments and setup. The monitoring system can also provide a permanent record of quality of each casting produced and compute statistical process control (SPC) charts and reports. The system can help diagnose machine problems and aid in determining the need for preventive maintenance. Equipped with visual and audible alarms, the system will warn the operator of an out-of-tolerance condition during the shot. This aids in detecting defective castings and reducing inspection costs by removing defective castings before they reach the inspectors.

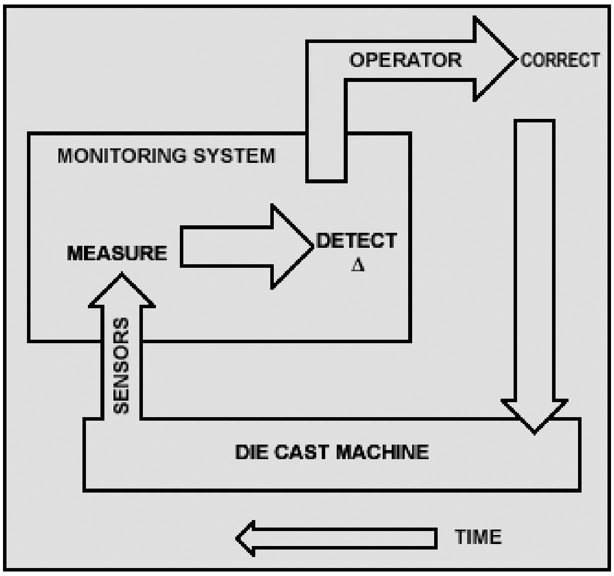


Fig 2. A diagram of monitoring/open-loop control

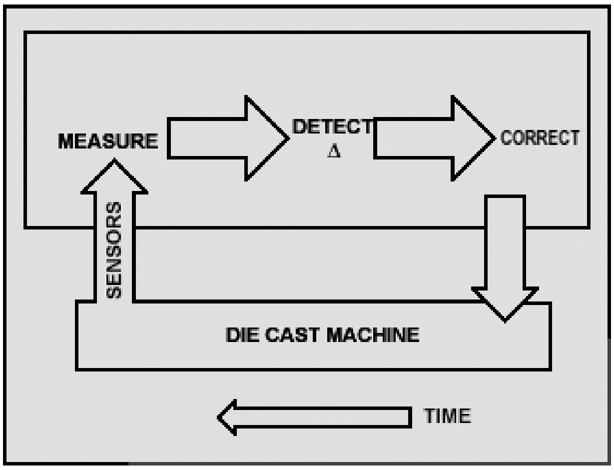


Fig 3. A diagram of closed-loop shot control

The monitoring system, however, cannot use the information it collects to adjust the shot process as castings are made. The operator must interpret the information provided by the system and then adjust the machine so that the next shot produces better quality than the last shot. Because the monitoring system relies on operator intervention in lieu of a feedback loop for corrective action, this type of control is known as open-loop control (Fig. 2).

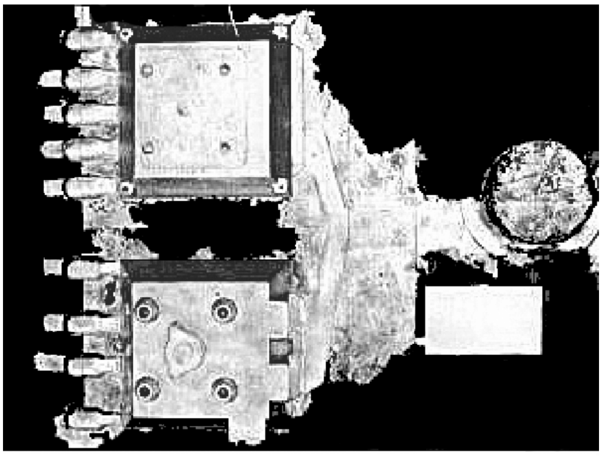


Fig. 4. Casting with flash produced on a 700-ton aluminum die cast machine

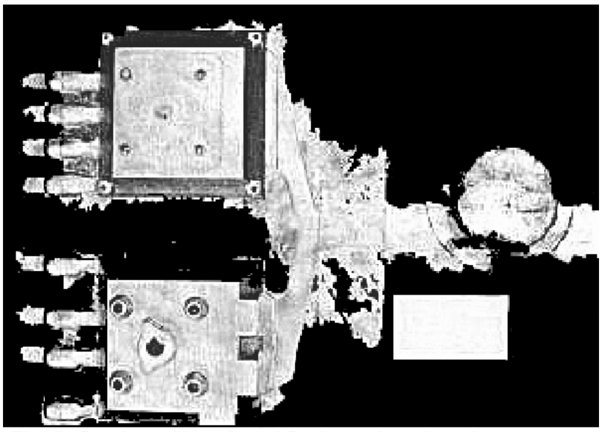


Fig. 5. Casting with reduced flash produced on the same machine with closed-loop shot control

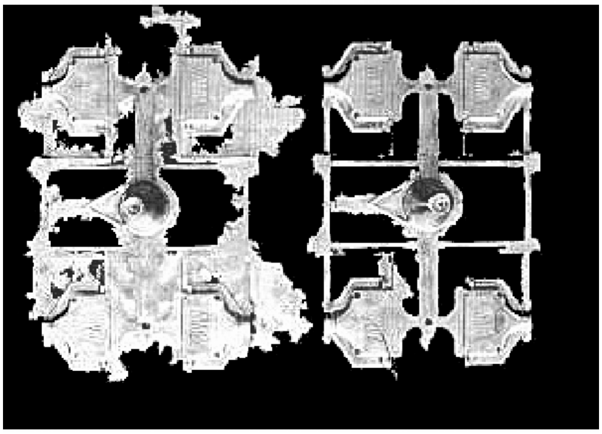


Fig. 6. Casting produced with (right) and without (left) shot control on a 200-ton hot-chamber machine

It can be seen that if an operator can react quickly enough to correct for machine variation, open-loop control con be effective. However, there are several critical shot variables that cannot be satisfactorily adjusted after the shot because of their rapid variations during the shot. For example,

Cost Factors	Units	Present	W/Control
Machine Time	$/hours	$120.00	$120.00
Material Markup	% of actual	110	110
Cycle Rate	cycles/hour	75	78
Cavities	#/die	2	2
Production Rate	parts/hour	150	156
Scheduled Run Time	% of shift	69	69
Die Changes	#/week	3	3
Average Die Change	hours	8	8
Average Downtime	hours/week	0	0
Shifts	#/week	15	15
Shift Length	hours	8	8
Average Machine Utilization	%	49	49
Annual Production	weeks	50	50
Total Scrap Rate	%	10	2
Start-up Shots	# cycles	30	1
Start-ups	#/week	48	48
Average Die Cost	$	$50,000.00	$50,000.00
Average Die Life	shots	125,000	150,125
Meltiing Cost	$	$0.05	$0.05
Melt Cost	$/pound	$0.97	$0.97
Remelt Loss	%	6	6
Metal Density	#/cubic inch	0.09	0.09
Machine Value	$	$200,000.00	$200,000.00
Machine Size	tons	800	800
Machine Hour Rate	$/hour	$82.00	$82.00
Labor	$/hour	$9.00	$9.00
Average Proj. Area	square inches	120	120
Average Flash	inches	0.010	0.010
Running Time	hours/year	2,940	2,940
Machine Depreciation Cost	$/hour	$6.80	$6.80
Gross Production	parts/week	8,820	9,173
Less Start-up Shots	parts/week	5,940	9,077
Net (less scrap shots)	parts/week	5,346	8,895
Die Amortization	$/part	$0.6599	$0.3434
Machine & Labor Cost	$/part	$1.0001	$0.6015
Melt Cost	$/part	$0.4949	$0.3094
Remelt Loss Cost	$/part	$0.2269	$0.0109
Flash Cost	$/part	$0.1200	$0.0240
Part Material Cost	$/part	$3.8800	$3.8800
Total Part Cost	$/part	$6.3827	$51,692.0000
Savings	$/part		$1.2134
Sales Price (with die)	$/part	$5.7279	$5.7279
Volume	parts/year	267,300	444,763
Shiopments	$/year	$1,531,076	$2,547,574
Savings (profit increase)	$/year		$248,492
Less System Depreciation	($63,000/5 years)		($12,600.00)
Taxable Income			$235,492.00
Less Taxes	($235,892 x 43%)		($101,434.00)
After-tax Income			$134,458.00
Ssytem Depreciation			$12,600.00
Net Cash Flow			$147,058.00
Payback Period	($63,000/$147,958)		0.43 year
ROI	($147,058/$63,000)		233%

Fig. 7. Projected ROI generated with a closed-loop shot control system for an 800-ton aluminum machine.

changes in pressure that happen in a few milliseconds can make the difference between an acceptable casting and a reject.

Closed-Loop Shot Control

The closed-loop shot control system provides a means of actively changing the shot process variables during the shot without operator intervention. The system includes the same type of measuring devices as a monitoring system, along with a feedback loop linked to computer-controlled hydraulic valves to correct for fluctuations as they occur in real time (Fig. 3). Therefore, these corrections occur in milliseconds as opposed to operator corrections after each shot, every minute, or whenever the operator decides to reduce variation and hold optimum conditions.

Precise control during all phases of the shot -- and active low impact at the end -- holds optimum injection conditions from shot to shot, setup to setup, to produce consistent, uniform parts with an absence of misfills, flash and porosity problems.

For example, Fig. 4 is a casting with significant flash produced on a 700-ton aluminum machine. Fig. 5 is a casting with reduced flash produced on the same machine with closed-loop shot control.

Fig. 6 shows castings produced with and without shot control on a 200-ton hot-chamber zinc machine. The casting on the left was made without shot control and has significant flash. The flash-free casting on the right was made with shot control, on the same machine.

Savings/Return On Investment Calculations: Monitoring/Open-Loop Control

The following is a conservative example of the projected return on investment (ROI) generated with a centralized monitoring system for a medium-sized aluminum die caster with 10 machines and a capacity of 5 million lb. of metal per year. An investment of $100,000 will be made in the system including machine sensors, system commissioning and plant training.

Assumptions:

- Present scrap rate is 10%
- .7% of all scrap is lost through dross oxides
- Cost of remelting scrap is $0.11/lb
- Alloy cost is $0.52/lb
- Die cast machine operating cost is $75.hr
- The monitoring system will reduce scrap by 50%

Reduced Remelting:

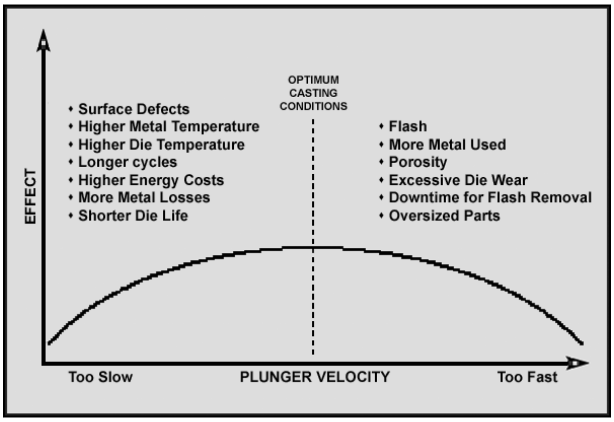
- Present: 5.0 million lb. x 10% x $0.11 = $55,000/year
- With system: $55,000 x 50% = $27,500/year saved

Reduced Metal Loss:

- Present: 5.2 million lb. x 10% x 7% x $.52 = $18,200/year
- With system: $18,200 x 50% = $9,100/year saved

Reduced Machine Time:

- Present: 10 machines need 20,000 hours to produce 5.5 million lb. of castings yielding 5.0 million lb. of poor castings



- With system: 10 machines need 19,000 hours to produce 5.25 million lb. of casting yielding 5.0 million lb. of good castings

Fig. 8. Die cast machine performance.

1000 hours saved x $75 = $75,000/year saved

Total Savings/Year:

• Reduced remelting	$27,500.00
• Reduced metal loss	$9,100.00
• Reduced machine time	<u>$75,000.00</u>
Total	**$111,600.00**
Less system depreciation ($100,000/5 years)	($20,000)
Taxable Income	$91,600.00
Less taxes ($91,600 x 43%)	<u>($39,388.00</u>)
After-tax income	$52,212.00
System depreciation	$20,000.00
Net cash flow	$72,212.00
Paybock period ($100,000/$72,212)	1.4 year
ROI ($72,212/$100,000)	72%

Savings/Return On Investment Calculations

Fig. 7 is a conservative example of the projected ROI generated with a closed-loop shot control system for an 800-ton aluminum die cast machine. An investment of $63,000 will be made in the system including machine sensors, system commissioning and plant training.

ROI Conclusions

As shown in the ROI calculations, on an individual machine basis, the investment for closed-loop control is higher than for monitoring/open-loop control. However, the additional investment for closed-loop is justified because of its attractive projected payback (0.43 year) compared to monitoring/open-loop (1.4 year). This is made possible by providing consistent and uniform parts from shot to shot as optimum casting conditions are maintained in real-time (Fig. 8), yielding increased usable castings and reduced costs.