



Simulation Technologies and its Place in Lean Manufacturing in the High Pressure Die Casting Industry

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Introduction

Much has been discussed, debated, reported and critiqued about the overseas competition facing the US casting industry. The diecasting industry too has had its fair share of this debate, and discussions are set to continue in many diecasting related forums and conferences on this issue. It is no secret that the US diecasting industry has lost some market share to overseas competition. However, those who work in the diecasting industry clearly know that there are many diecasting and tooling companies doing very well in these difficult times. In fact, these companies have not only remained competitive, but have also expanded their operations. One is forced to pause and ask, "How are some diecasters doing so well, while others are not?" "What is the secret to the success of these die casters?"

Well, the answer is not very elusive. A visit to some of these companies and casual discussions with the staff will indicate several key features that clearly distinguish them from other diecasters. These are:

1. The so-called 'middle management' is very lean, and the management and technical personal have adapted to a multi-skilled environment.
2. They have better business plans and a clear vision for the future. If they foresee a threat to their business, they become proactive in mitigating such a threat –"deal with it now rather than later", appears to be their motto.
3. Many are specialized – they stick to things they can do best (e.g., automotive versus non-automotive, magnesium versus aluminum, certain types of alloys etc.).
4. Many have educated and well-trained people who understand the diecasting business and clearly understand their role in the company.
5. Many are upgrading machines, adapting new technologies, streamlining, and automating operations.
6. Many diecasting companies are providing early product development support to the OEM's.
7. Many are relentlessly pursuing continuous improvement.
8. Many are secretly and successfully benchmarking their operations with their competition.
9. Many are increasing throughput - reducing variation, reducing waste, and eliminating non-value added activities, to name a few.
10. Many measure what they do –they are well aware of the fact that if they don't measure, they don't know where they are, and don't know how further they are from their goal.

It is thus logical to conclude that diecasting companies who have not implemented the above strategies and have tolerated mediocre performance in the past are facing difficult times and are losing business. The concepts of continuous improvement, benchmarking and

lean manufacturing aren't new, and form part of the ISO 9000. Articles on their implementation have been published (1,2,3). Considering the above-mentioned strategies, one may then pose hypothetical questions such as:

“What would be the outcome if average diecasters benchmarked themselves against the best in the country?”

“Will this improve the overall quality and competitiveness of the industry?”

Strategy	Questions	How can simulation help?
Early product development support	<p>Do you provide early design support?</p> <p>Do you provide early product manufacturing support?</p> <p>Do you want to drive upfront cost effective design changes that are ergonomic from a manufacturing capability?</p> <p>Do you want to build strong customer relationships early on in the process?</p>	<p>Quick, early simulations can be carried in a matter of hours:</p> <p>(a) To locate best ingate positions</p> <p>(b) For early solidification analysis</p> <p>(c) To evaluate stress distributions</p> <p>(d) For concept part/gating layout</p> <p>(e) For rigging/mold design</p>
Continuous Improvement Program (CIP)	<p>Do you advocate CIP?</p> <p>Motivation to implement CIP may involve improvements in cycle time, die design, runner design, scrap output and process control</p>	<p>Simulation technologies can contribute to CIP if time and effort is spent on analyzing die design, runner design, cycle time of castings that warrant improvements.</p>
Benchmarking	<p>Do you know who your competition is?</p> <p>Is someone quoting less then you are quoting?</p> <p>Is your competitor using simulation tools?</p> <p>Is your toolmaker using simulation tools?</p> <p>Is the OEM paying for the simulation costs?</p> <p>Is the toolmaker capturing simulation costs?</p> <p>Is simulation tool based in-house, or is it engineering work contracted out on a job-to-job basis?</p>	<p>Simulation can be leveraged to help transform the company into a Best Practice Company.</p> <p>Consider contact engineering in the first instance, to make sure that the technology is right for your company.</p>
Increased throughput	<p>Is there variation in the product?</p> <p>Is there downtime that is related to bad die design?</p> <p>Are there stoppages to clean the die of solder?</p> <p>Are there frequent stoppages to clean die flash?</p> <p>Is the die getting too hot, and is the die flashing?</p> <p>Is there porosity in the gate after trimming?</p> <p>Is there part distortion and is the casting cracking?</p> <p>Is there additional rework?</p>	<p>Simulation technologies can help identify the root cause of many diecasting problems.</p> <p>Try simulation on jobs that need immediate corrective action.</p>
Measurement	<p>Is there an acknowledgement that there is high scrap?</p> <p>How much is as-cast scrap and machined scrap?</p> <p>Has anybody measured scrap dollars in-house?</p> <p>Do you have scrap returned from customer?</p> <p>Is scrap increasing production time?</p> <p>How much is scrap costing the company?</p> <p>Have you measured scrap after introducing simulation technologies and measured the benefits?</p>	<p>Measure scrap before and after the implementation of simulation technologies. The return on investment (ROI) will be surprising.</p>

Table 1: The table shows the role of simulation technologies in a typical diecasting company.

“Do average companies have what it takes to radically re-organize their business to confront the challenge of overseas competition?”

“Are technologies available to help diecasters become more competitive or to maintain competitiveness?”

This paper discusses application of simulation technologies in diecasting companies striving to implement lean manufacturing and therefore increase their overall competitiveness.

Simulation capabilities in the diecasting industry

Penetration of simulation technologies into the diecasting industry sector has been somewhat slow. However, if one surveys the casting industry outside the diecasting industry where simulation technologies have been well accepted, a clear trend emerges. With some reservations, one can state that many companies who have implemented simulation technologies 5-10 years ago are still in business, and many of those who have not been progressive enough to consider the benefits of simulation have downsized or have gone out of business. This may bring an immediate question to the mind of a diecaster who may ask, “How will my diecasting company benefit from simulation technologies?” The answer lies in a more detailed understanding of the last five strategies listed earlier. If one decides to apply these strategies to a diecasting plant, it must be done after confronting some of the fundamental questions that underline these strategies. These are listed in Table 1.

Many die casting companies do not consider the issue of scrap seriously enough. Not enough

time is actually spent measuring it, assigning a dollar value to it, and analyzing its impact on the bottom line. For example, it has become customary in the diecasting industry to quote a scrap value an order of magnitude lower than what it really is (1-2%, if it is 10%). To a question such as “Doesn’t scrap cost you money?” the answer is often, “Oh, we don’t lose anything, we just burn it” (meaning remelt it). Literature is available on the calculations of scrap dollars for typical diecasting plants (4, 5). The scrap must be evaluated in terms of dollars against the backdrop of some of the following difficult questions.

- How many part numbers actually account for 80% of scrap related dollars (Pareto analysis)?
- What is the casting production penalty to make up for lost production?
- What is the cost of machining related production time due to machined scrap?
- What is the scrap-remelting penalty?
- Is your scrap with inserts melted separately? How many inserts are lost? What is the total cost assigned to this whole exercise?
- How much floor space is wasted to quarantine scrap?
- How many man-hours are wasted dealing with scrap related issues?
- Are you quietly advocating a part salvage strategy within your company by sorting and reworking the customer rejects?
- What is the transportation costs associated with scrap?
- How many supplier points are lost due to scrap returned by the customer?

- What are the chances of you being retained as the supplier based on scrap output?
- Is real scrap within estimated values of the initial quotation? If not, is the part really profitable or is it manufactured to keep the customer happy (because of other jobs)?

Initial tooling design versus improving existing tooling

The application of simulation tools in a diecasting company may be approached in two ways. Keeping the long-term strategies in mind, simulation technologies may be used to improve existing tooling concurrently with its utilization as a front-end tool for new casting and tooling design. While the latter may be considered as being proactive in minimizing defective castings early on in the design process, the former may be considered a continuous improvement activity. Early product design and development support is crucial in providing many cost effective alternatives to the customer. Early simulations allows the presentation of several early designs and manufacturing concepts to the OEM, so much so that the final results may be unconventional, yet progressive in terms of cost, lead time and manufacturing methodology.

Improving existing tooling

For components manufactured by a diecasting company, a scrap analysis will reveal the familiar ‘Pareto rule’ i.e., 70-80% of the scrap generated in dollar terms comes from 20-30% of the part numbers. So a strategic plan must be drawn wherein these ‘top scrap generators’ are quickly analyzed for potential

filling problems, shrinkage defects and die temperature related defects. CAD models of the parts are usually available in some form or the other, and all that is needed is a rough gating/ingate design from a runner system that is available off the floor. A die can then be enveloped around the solid model, and cooling lines inclusive of fountains can be easily sketched into the die. Once the CAD geometry of the casting and the runner system is available, drawing the die and water line using the software is an effortless exercise. A simulation can then be run to identify potential problems and develop an understanding of why they exist resulting in several potential solutions. Some solutions, such as minor changes to the gate may be easily identified and implemented. Other more detailed changes may have to wait until the cavity inserts become due for replacement.

Initial tooling design

The success to the production of a high quality diecasting is dependent upon the early interaction between the diecaster, tooling supplier and the OEM. The part designer who is usually located within the OEM industry designs the part based in general design principles, functionality and assembly requirements. Engineering input in terms of part filling strategies, gating locations, solidification, parting-line development, drafts, areas to be machined, feature changes etc. from the diecaster and tooling supplier will lead to a robust tool that is capable from a manufacturing standpoint. It is in the supplier's interest to that this early product development support is provided to the OEM, thereby reducing lead-time and minimizing manufacturing related problems.

The most important cost in the manufacture of a diecasting die is the special steel (H13) insert and the associated cost in machining the insert to make it suitable to diecast a good part. In a survey carried out amongst various toolmakers, it was found that more than 55% of manufacturing hours (Figure 1) were spent working on the cavity alone (6). In general, for a two cavity die (an example); the cavities blocks are made up of (a) shot block (b) runner insert (c) cavity 1 insert (d) cavity 2 insert and (e) slides. Following are important issues that will determine the overall tooling costs.

1. The ingates feeding the casting are usually cut into the cavity insert, and any major casting related problems whose root cause lies in a flawed ingate design might lead to cutting and TIG welding of the insert. This will lead to drastic reduction in the life of the insert steel around the welded areas. Areas around the weld heat check rapidly, sometimes reducing the insert life by up to 50%. H13 steel is expensive and any mistakes in ingate and runner design can render the real tool as a prototype tool. Simulation capabilities must be used for the evaluation of early layout strategies thus avoiding expensive trial and error type tooling development.
2. As seen in from Table 2, several stages of the diemaking process are capital intensive. Activities such as drilling water lines, heat treatment, grinding inserts etc., add significant costs to the diemaking process. Placement of water lines and oil lines should be optimized prior to drilling. Drilling a lot of water lines and then being selective in their

usage during production is bad practice, and adds unnecessary cost to the manufacture of the insert. Drilled water lines that are not used during production weaken the die. Further the thermal balance of the die is disrupted because they empty lines contain still air, which in turn are insulators rather than cooling media.

3. Electro discharge machining (EDM) activity in particular is very expensive. The greater the depth of the cavity, the longer is the required carbon electrode.
4. Placement of overflows and designing key vacuum runners and their junctions are critical for any diecast tool. Filling simulations will indicate last areas to fill in a diecasting, thus enabling the toolmaker to accurately place overflows and vacuum runners. Placement of overflows, vacuum runners and their junctions by guesswork is too costly and will considerably extend the tool try-out period.
5. Die trials or tool try-out is a major exercise that involves several key diecasting and tooling personnel, and a diecasting machine that has to be taken out of the production schedule. Die trials typically extend from one shift for a small tool (400 ton) to up to four shifts for a large tool exclusive of die set up and die removal. If a die trial is unsuccessful, the die has to be transported and then completely stripped to make modifications to the inserts. The die modifications may include additional EDM work. All of these will add significant costs of the overall tool development process.

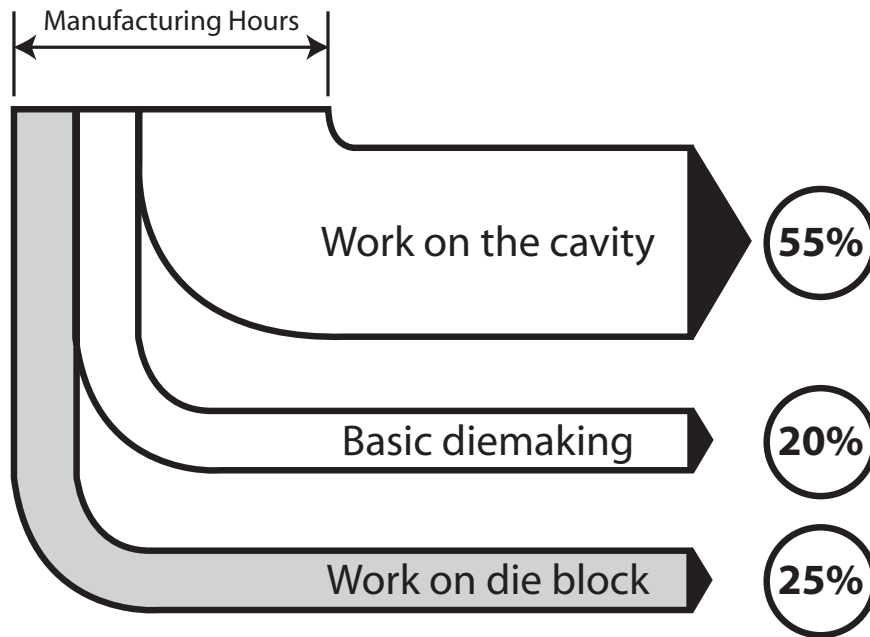


Figure 1: Manufacturing hours spent working on cavity and cavity inserts (6).

Casting tool manufacture	Comment
Concept design, modeling, development of parting lines	Labor intensive, high cost
Rough cut material	Low cost
Machine cavities	Medium cost
Machine slides	Medium cost (H13 steel)
Machine Bolster	Medium cost
Machine Electrodes	Medium cost
Drill water lines	Low cost
Rough cavity forms	Medium cost
Drill ejection	Medium cost
Heat treatment	Medium cost
Grind inserts	High cost
Finish machining	High cost
E.D.M	High cost
Wire cutting	High cost
Fit insert, Fit slides, Polish cavities	Labor intensive, high cost
Bed die, Die assembly	Labor intensive, high cost
Ist Die trial	High cost
II Die trial (if necessary)	High Cost
III Die trial (if necessary)	High Cost

Table 2: Engineering stages of a typical diecasting die-manufacturing program.

Case Study – Magnesium Instrument Panel

Magnesium is making major inroads into the automotive sector because of its superior flow properties through very thin walls. Part weight reduction, image and technological issues, and interest in research and development appear to be factors that are favorable towards magnesium diecastings. Since transportation cost is a function of volume of shipments, there are credible opinions in industry that point out that large thin walled structural parts produced locally, rather than off shore, are a preferred source of supply. Some common automotive parts currently in production and under evaluation are instrument panels, steering column brackets, floor panels, doors, accessories and others. An engineering project involving the optimization of the instrument panel (IP) made from magnesium alloy AM60 is discussed in this section. The instrument panel is approximately 140 cm long, 50 cm wide and 40 cm deep (see Figure 2)

If one applies the initial tooling cost breakdowns described in above

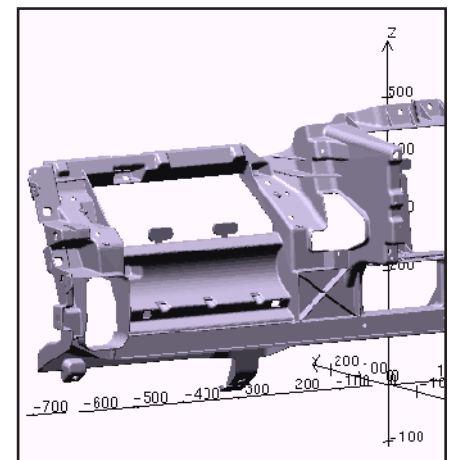


Figure 2: Figure showing one half of the instrument panel cast using magnesium alloy AM60. The whole panel is approximately 140x50x40 cm (scale shown in mm).

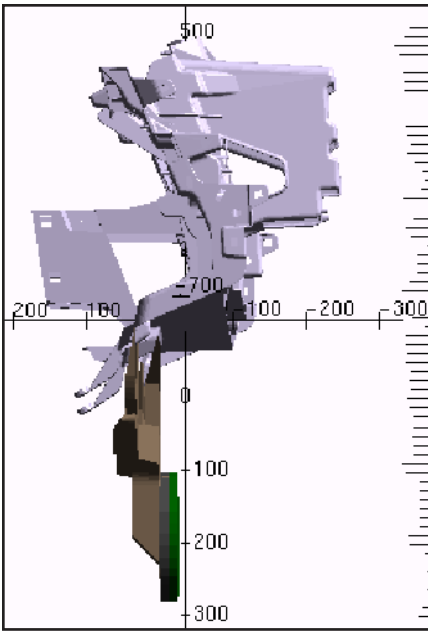


Figure 3: Side view of the instrument panel shows the approximate depth of the panel to be 40 cm (the scale in mm). If one assumes the parting line to be in the middle of the side view, the EDM depth into each insert (cover and ejector) will exceed 20 cm.

to a large single cavity die such as the instrument panel, the total die making costs will be in excess of half a million dollars. Two inserts; cover and ejector die combined with several slides comprises the IP tool. The side view (Figure 3)

shows several features extending deep into the inserts. Assuming the center of the axis as the parting line (Figure 3), the depth to EDM the inserts into each cavity (cover and ejector half) is approximately 20 cm. A part of the runner feeding the instrument panel is incorporated into a separate insert, and feeds the casting so that metal flow path to fill the IP is shortest (~50 cm). The runner system was designed by the die caster and provided for analysis. However, the heating/cooling lines were not made available. Thus, the objective of the simulation project was limited to the following:

- (a) To analyze the flow in the runner, gating and ingates and to optimize the flow dynamics.
- (b) After optimization of the runner system, to analyze the flow pattern and identify areas in the casting those fill last.
- (c) Based on the first iterative filling pattern, request with the OEM design changes that are likely to improve filling of the part. Develop preliminary

parting line concepts and present these to the OEM.

- (d) To optimize the location of vacuum runner and their junctions, and carry out final filling analyses by applying vacuum to the cavity.
- (e) Based on the final filling pattern optimize and finalize parting lines and insert layouts.
- (f) To provide tooling personnel with preliminary die temperature results that would indicate thermal differentials within the inserts. This information could be used for the placement of cooling and heating lines in the die.

The optimization of the part was carried out using process coupled proprietary simulation software MAGMAhpdc. The discussion in paper broadly follows the iterative steps followed in optimizing the IP (which are also in-line with the objectives of the simulation listed above). The expected outcome was a fully optimized die that incorporated correctly designed gating, overflows and vacuum runner. The fully optimized tool was expected to achieve first-shot success.

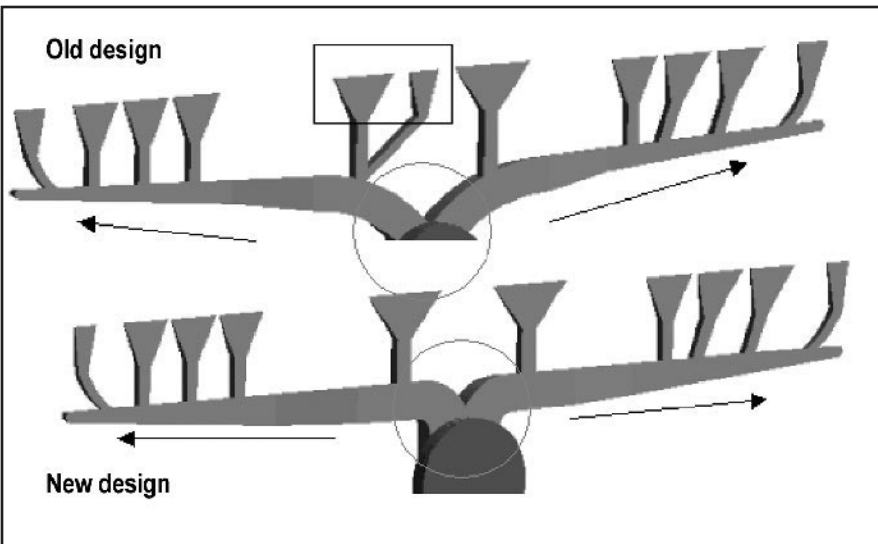


Figure 4: General differences between the old (as received) and new gating design. Several changes were made to the gating design, which included changes to the delta region, reduction in the approach angle and modifications to the helper runners. In addition, the main runners were increased in cross-sectional area so as to retain additional superheat for improved filling.

Runner Optimization

Two preliminary simulations were carried out with all required process parameters provided by the customer. Correct slow shot speed, fast shot speeds and cavity fill times were calculated. Inputs also included correct plunger diameter, sleeve length, etc. The first to second stage changeover point was set at the runner-full position (i.e., metal at the gate). Both simulations were carried out with a casting temperature of 650oC (1202oF) and

a constant die temperature of 250°C (482°F). For the first simulation, a cavity fill time of 90 ms was used, and the simulation results showed metal in several upper areas of the instrument panel dropping below the liquidus temperatures of 619°C (1146°F). Therefore, the second simulation was carried out with a 60 ms cavity filling time, and this simulation showed an improvement in terms of metal temperature (during filling) in comparison with the previous version. The drop in metal temperature -- in light of the absence of adequate die warm-up with heating/cooling lines -- was considered to be within reasonable limits to manufacture a high quality panel taking into account the overall wall thickness, casting size and flow tortuosity. All subsequent simulations were carried out with a cavity fill time of 60 ms.

Attention was then focused on the filling pattern in the runner and the ingates where the flow pattern was carefully investigated. The gating system provided for the simulation analysis was designed by the die caster using first principles an empirical approach. The appearance of the runner was streamlined (Figure 4), and the panel was fed by a series of feeders (sometimes termed as helper runners). The design strategy of the runner system was to manipulate the complex momentum and velocity profiles of the metal front during the slow shot, so that the metal front reaches all the ingates via the helper runners more or less at the same time. This flow pattern was highly desired, as it would allow the metal to flow across the panel uniformly. Even with the best set of hand calculations, it is extremely difficult, even for an experienced gating designer, to predict

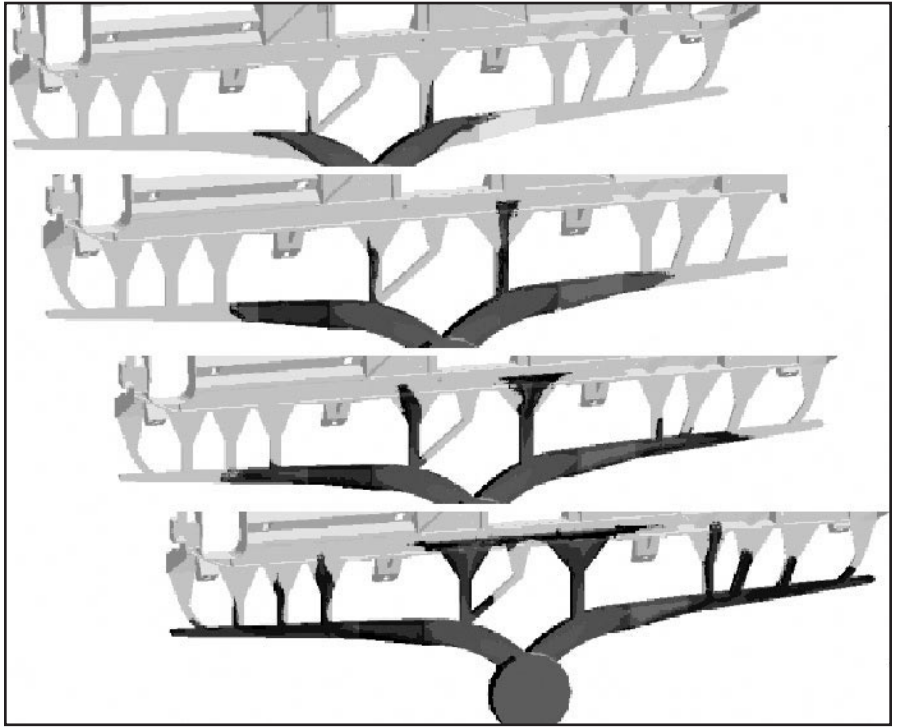


Figure 5: Flow of metal in the runner in the as-received design. The flow clearly shows premature filling through the feeders or helper runners close to the delta region. Early filling (pre-fill) in certain areas of the casting was not acceptable and warranted changes in runner design.

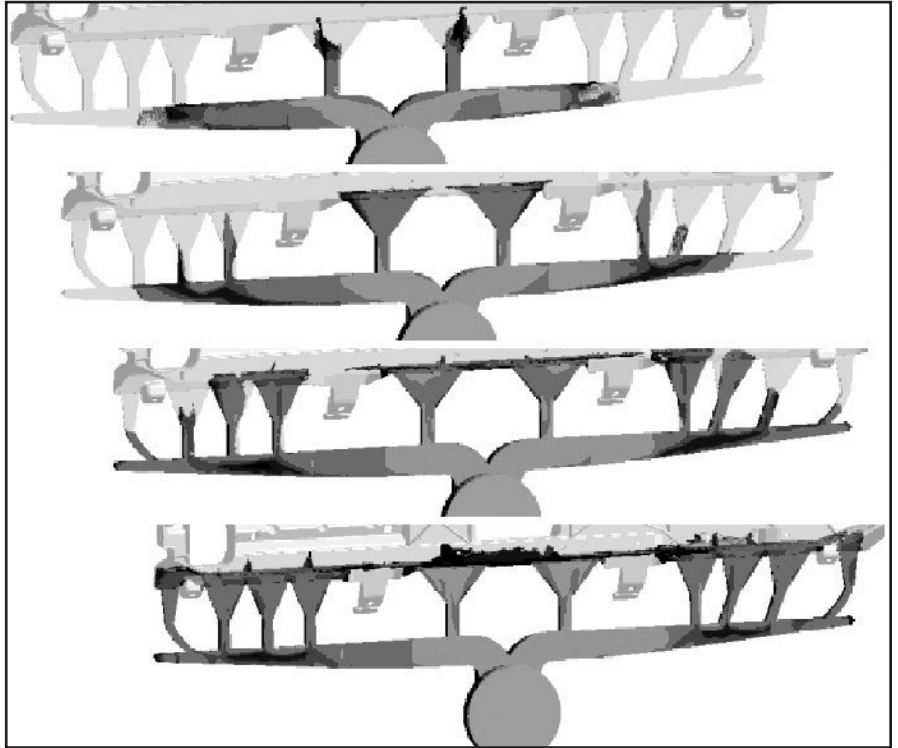


Figure 6: Flow of metal in the runner after modification to the runner design. An improved metal flow in the runners was realized after incorporating all the geometry changes that were considered important to the flow dynamics within the runner and gating system.

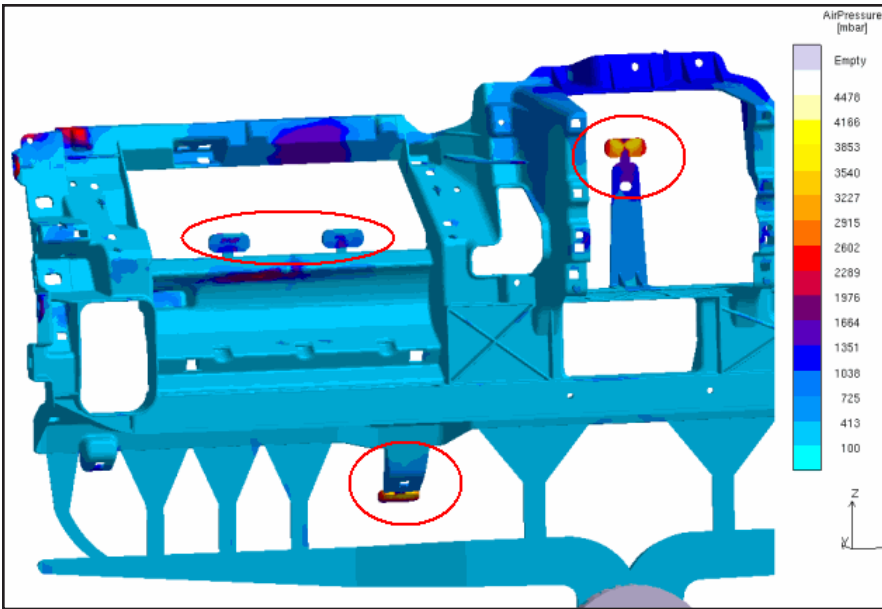


Figure 7: An Air Pressure result after completion of filling using the new runner design viewing the IP from the cover die. Overflows placed in the castings are circled. After 100% fill, overflows and upper regions of the IP show areas that have high Air Pressure. This result file, along with the results of the filling pattern, was used to finalize the overflows and vacuum vents that are shown in Figure 8.

metal flow in the runner system. Analysis of the flow in the runner system showed critical flaws in its design, which are shown in Figure 4 and Figure 5. The changes that were necessary included: modifications

to the delta region, approach angle of the main runner, increasing the cross sectional area of the main runner, and changes to the feeders (helper runners).

After incorporating these improvements (New design, Figure 4), a third simulation was carried out with minor changes to the process

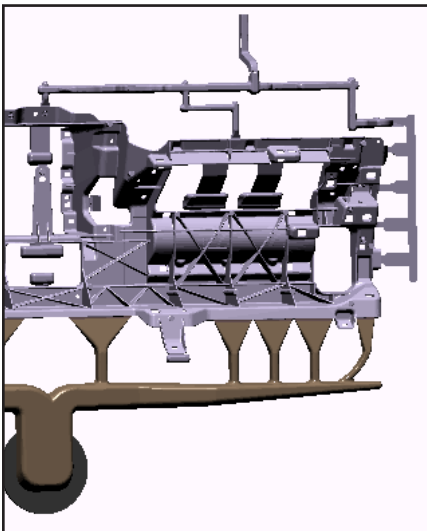


Figure 8: View of the casting from the ejector die showing optimized areas in the casting containing overflows and vacuum vents. These were finalized after analyzing the filling pattern and the Air Pressure results. This final geometry was then used for the final simulation with the application of vacuum to the vacuum vents.

parameters. This filling simulation revealed an improved filling pattern in the runners, ingates and into the casting. These improvements may be visualized from Figure 6, and improvements over the previous design (Old design) may be listed as follows:

- (a) The early fill in two main helper runners in the vicinity of the delta regions was reduced, and this avoided premature filling of the IP just above the delta region.
- (b) The metal flows further through the main runner, thus enabling early filling of the smaller helper runners.
- (c) The metal arrived (subsequently) at all the ingates of the helper runners just before the transition of slow to fast shot velocity (activated just before 35% fill in Figure 6)

The redesign of the geometry of the main runner, gating and ingates was considered satisfactory, and the flow pattern in the IP was then analyzed after incorporating the new gating design.

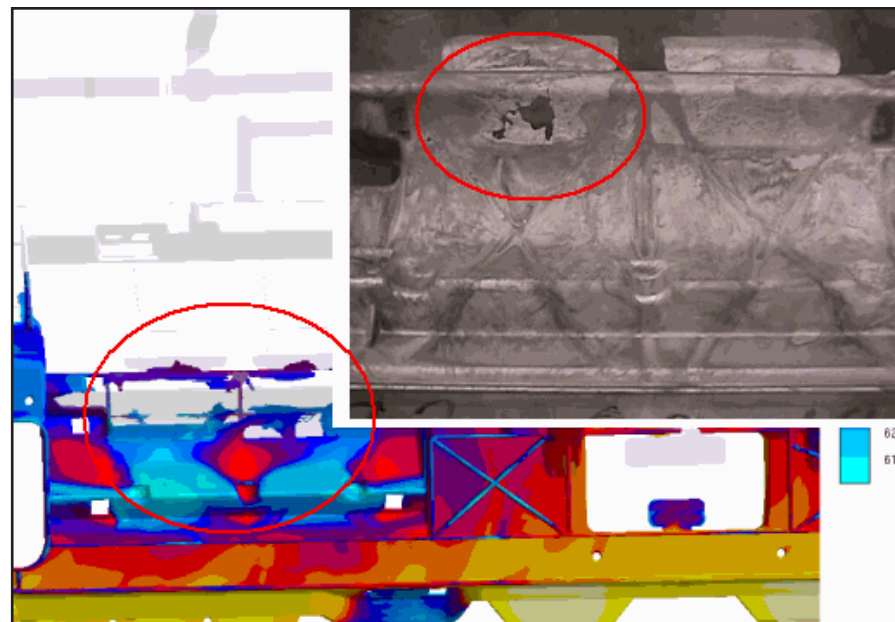


Figure 9: Poor filling in a webbed region of the IP (short shot).

Optimization of Flow in the Panel and Location of Vacuum Vents

Analysis of the simulation results used for design optimization of the runners, gating and ingates yielded useful information in terms of identifying overflow locations on the IP. Some of these overflow locations were easily identified and are indicated in Figure 7. The strategy was to carry out a filling simulation using the new runner design along with the overflows. Since use of vacuum was planned on the die, finalizing overflows and vacuum vents in the upper portions of the panel geometry was not possible, as the new runner design was expected to change the filling pattern within the IP.

A powerful feature within MAGMAhpc is the use of vents or Air Channels, generating result files that are called Air Pressure. This means that if a vent or Air Channel is placed anywhere in the cast geometry, to simulate expulsion of air out of the cavity, the software will output result files called Air Pressure. The significance of Air Pressure must be clearly understood. It indicates in terms of magnitude (mbar) the amount of retained air pressure in areas (or groups of control volumes) in the cast volume. Ideally, vents are placed on overflows, or if vacuum is applied to the cavity, vacuum vents act as escape routes for air displaced in the die cavity. However, if one is unsure of the placement of overflows and vacuum vent junctions, then a unique way of identifying areas that require overflows and vacuum junctions is to place a vent in the main runner and to 'trick' the simulation tool to output Air

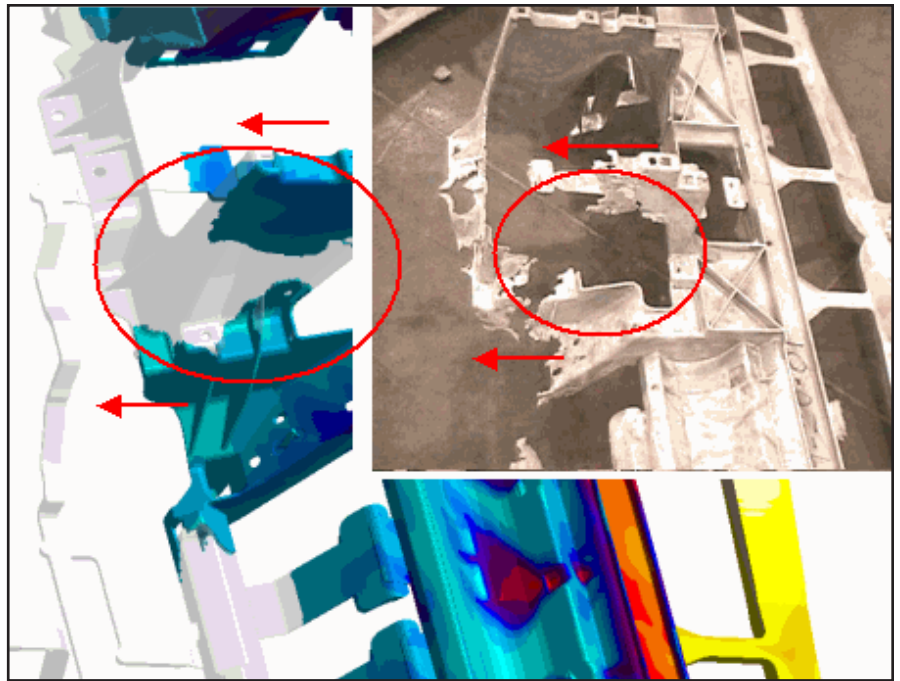


Figure 10: Filling around the instrument mounting area of the IP showing a good match with the short shots. The short shot appears to surge ahead due to the momentum of the metal, which is typical in short shot situations. In simulation results, however, at a given percentage fill, the simulation is frozen along with its momentum history.

Pressure results. Placing a vent on the main runner fools the simulation into thinking that the die cavity is being vented. When the metal travels past the runner, it will first block the vent before continuing to fill. Once the vent is blocked by the flowing metal -- by virtue

of the cavity being a watertight model -- all the cavity air is forced to stay within the die cavity. As the metal fills the cavity, it displaces air ahead of the fill front causing the retained air to rise in pressure. If, for example, there is turbulence and air is trapped because of this

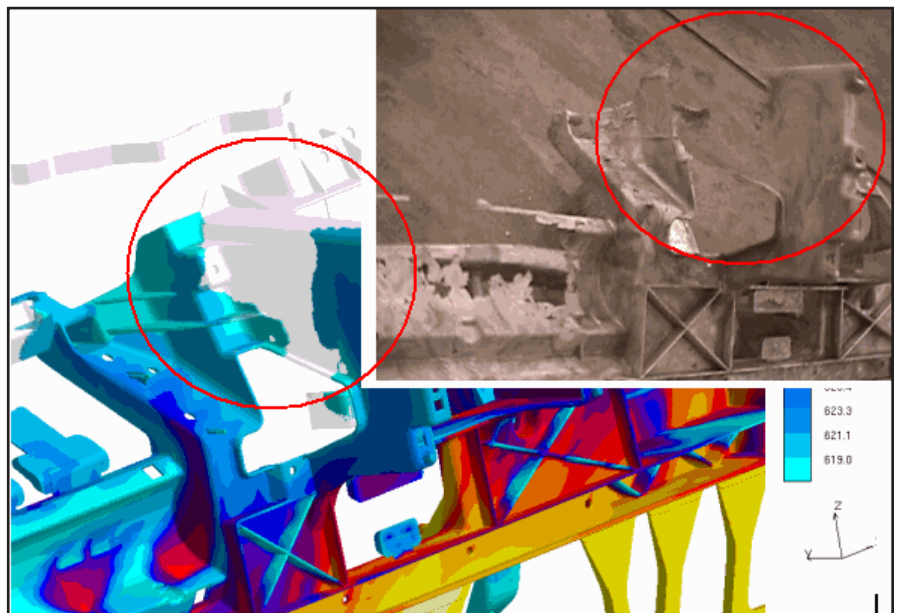


Figure 11: Close-up of an area shown in Figure 10. Again, a good correlation between simulation result and short shots can be seen.

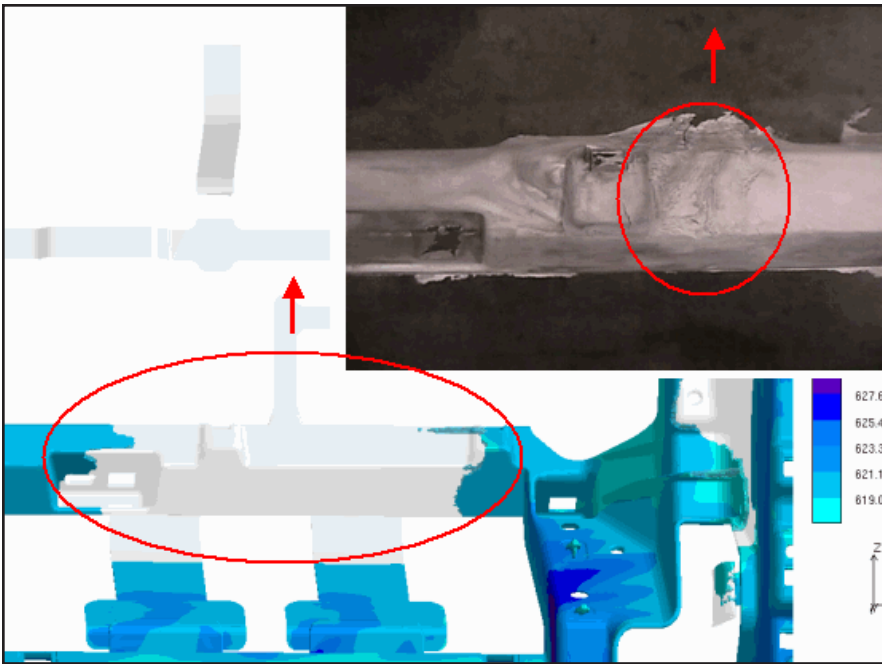


Figure 12: A merging metal front in the upper area of the IP. The metal merged in the short shot in the same location that was predicted by the simulation.

turbulence, this area will show-up as a high Air Pressure area in the result file. Similarly, the last areas to fill will show-up as high Air Pressure areas within the casting, and these high Air Pressure areas warrant the placement of overflows. If overflows and vacuum vents are already placed, or are

finalized using a previous iteration, then high Air Pressure areas must ideally be within the overflows and the vacuum vents, thus yielding a high quality diecasting. The magnitude of Air Pressure plays an important role in the interpretation of the result files. A qualitative Air Pressure limit may be applied to

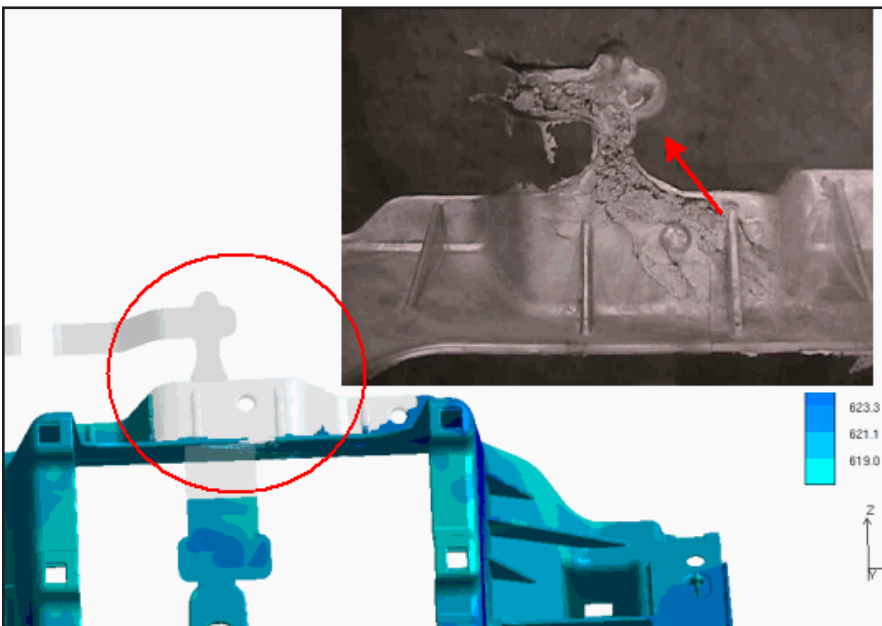


Figure 13: Another example of merging metal fronts in the upper area of the IP. It can be seen that the right-hand side metal front merges away from the vacuum vent outlet both in the short shot and the simulation.

areas in the casting that need attention, and as an example, an Air Pressure of greater than 2000 mbar within the casting may be considered a cause for concern requiring corrective action.

Figure 7 shows an Air Pressure result file that clearly identifies areas of high Air Pressure within the IP. The simulation was carried out with a vent on the main runner. It can be seen from Figure 7 that high Air Pressure areas exist within the overflows, and many upper regions of the IP show additional areas of retained air. In the upper regions of the IP, the filling pattern was carefully analyzed, especially in terms of merging metal fronts and last areas to fill. Vacuum vent outlets and their junctions were then finalized, and the placement of these, along with additional overflows, are shown in Figure 8. This geometry was then used for the final simulation with the application of vacuum to the die cavity.

It is outside the scope of the paper to discuss the details of the final filling simulation. However, the next section contains examples of short shots obtained during the die casting trial. The short shots obtained during the casting trial are correlated with the filling results obtained in the final simulation.

Correlation of simulation with short shots

The discussion on the simulation of the instrument panel would not be complete without a correlation of the simulation results using short shots. Several pictures of the IP were taken during the die sampling trial and compared with the final simulation that was carried out with the application of vacuum to

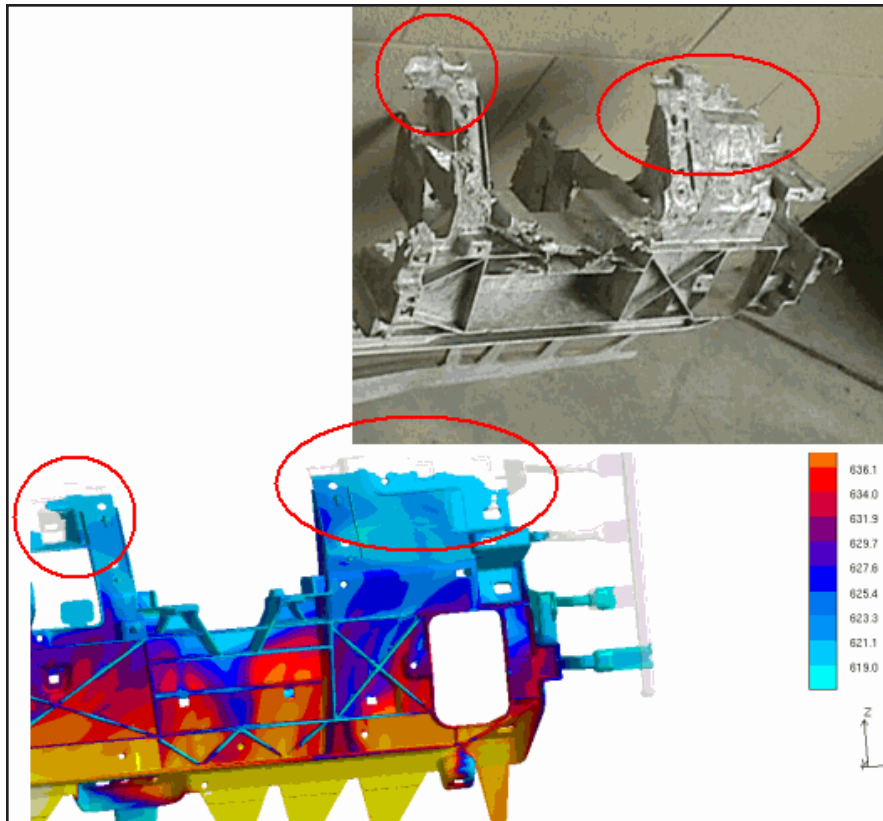


Figure 14: Right-hand side of the IP, viewing from the cover die side showing a good correlation between the short shot and simulation result.

the cavity. Figure 9 – Figure 14 show comparisons between the simulation results and reality.

Cost savings

Significant cost savings may be realized using simulation technology very early on in the product development stage. The instrument panel featured in this paper clearly illustrates the upfront proactive efforts that were necessary in driving design changes to optimize runners, ingates, overflows, vacuum vents and vacuum vent junctions. Also, simulation efforts showed areas within the IP that needed design changes that are not discussed in this paper. Local areas within a casting can be examined for flow behavior in greater detail. These issues, if not dealt with early on can be ‘show stoppers’ in a well-planned die trial. Many upfront changes results

in a tool that increases the probability of a successful first die trial. Experience shows that even in a successful first tool trial, minor changes to the mechanical workings of the die and dimensional changes to the die are generally inevitable. Nevertheless, from a manufacturing stand point, a lot of time and effort is saved upfront by avoiding many trial and error changes on the tool. Many times these efforts can reach a critical mass, especially during peak production and when several new tools are trialed. This may result in chaos, frustration, lack of motivation, lack of confidence and moral, loss of several man-hours, and ultimately the loss of several hours of important manufacturing time.

Concluding comments

This paper demonstrates how diecasting companies striving to

be lean in their overall business environment can benefit from simulation technology. The effective use of simulation technology may be considered as a significant aspect of a multi-faceted strategic plan to achieve competitiveness in a diecasting company. The technology can be used as a front-end tool to engineer a diecasting that is robust and capable from a manufacturing viewpoint. The future in the diecasting industry is for those casting and tooling suppliers who strive to reduce cost by minimizing tooling trials and associated costs while meeting customer specifications and delivery deadlines. Lean manufacturing has a strong place in the diecasting industry and will shape the status of the US diecasting industry for the years to come.

References

1. Schroer.BJ, Adams.M, Stewart.S, Compton.P.J: Continuous Process Improvement the Quick Steps Way, Quality Progress, Feb 1998, p85-89.
2. Wiarda.E.A, Luria.D.D: The Best-Practice Company and other Benchmarking Myths, Quality Progress, Feb 1998, p91-94.
3. Herman.E: Benchmarking for Lean Manufacturing (in Diecasting), Metal Casting and Surface Finishing, May-June 1993, Vol 39, No5-6, p34-37.
4. Puckett.J.D: The Real Cost of Scrap, Die Casting Management, Sept-Oct, 1986, p37-39.
5. Creese.R.C: Scrap Cost Calculations Revisited, Die Casting Management, Jan-Feb, 1987, p20-24.
6. Heuel.O: Diemaking costs can be cut – with off-the-shelf Elements, Casting Plant and Technology, Vol 9, No 4, 1993, p20-25.



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Winston started in the diecasting industry in 1993 as an intern working in the area of magnesium diecastings with the Casting group, CSIRO Division of Manufacturing Technology, Melbourne. Between 1995 and 1997 he was based at the Cooperative Research for Cast Metals Manufacturing (CMM), Brisbane where he continued his work on the microstructure and mechanical properties of magnesium die castings. In 1997, he moved back to Melbourne and worked as a Process Engineer and R&D Coordinator in Mett diecasting Pvt Ltd, a leading producer of aluminum automotive die castings. Joining Harvard Industries Inc. in 1999, he initially worked in Product development at the technical center in Farmington Hills, Michigan and then as a Metallurgist and Die cast support specialist at Harvard's St. Louis Die Casting Plant, Missouri.

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Carlos Engel has been with Lunt Manufacturing Co. Inc. for over nine years and has held positions of senior tooling engineer and project manager. Prior to joining Lunt, Carlos was employed by Toyota Machinery USA as a manufacturing, project and applications engineer for horizontal and vertical CNC and turning centers.

At Lunt he currently heads the Advance engineering and Product design department with responsibilities for providing manufacturing expertise to OEM's in conceptual product design, merging consumer function structural product requirements while improving manufacturing to reduce cost and time to market, providing design direction and training to automotive OEM's to decrease cost and providing technical support to sales group and cost estimating.

Carlos he is currently pursuing his masters program in business management and enjoys spending time with his family. His favorite out door activity is playing and coaching soccer.
