ENERGY AND TECHNOLOGY ASSESSMENT OF ZINC AND MAGNESIUM DIE CASTING PLANTS

**U.S. Department of Energy Project
No. DE-FG36-05GO15097**

TECHNICAL REPORT

CLOSE-OUT

**Twin City Die Castings Company
And
North American Die Casting Association**

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EXECUTIVE SUMMARY

Twin City Die Castings Company of Minneapolis, Minnesota, Twin City Die Castings Company was awarded project No. DE-FG36-05GO15097 to perform plant wide assessments of ten (10) die casting facilities that produce zinc and magnesium alloy castings in order to determine improvements and potential cost savings in energy use. Mr. Heider filled the role of team leader for the project and utilized the North American Die Casting Association (NADCA) to conduct audits at team participant plants so as to hold findings specific to each plant proprietary.

The term of the project was one year and the amount of the U.S. Department of Energy funding totaled \$100,000. Industry provided \$113,113 of in-kind funding support.

The intended benefits of the project were to improve energy use through higher operational and process efficiency for the plants assessed. An improvement in energy efficiency of 5 – 15% was targeted.

The primary objectives of the project was to: 1) Expand an energy and technology tool developed by the NADCA under a previous DOE project titled, “Energy and Technology Assessment for Die Casting Plants” for assessing aluminum die casting plants to be more specifically applicable to zinc and magnesium die casting facilities. 2) Conduct ten (10) assessments of zinc and magnesium die casting plants, within eight (8) companies, utilizing the assessment tool to identify, evaluate and recommend opportunities to enhance energy efficiency, minimize waste, and improve productivity. 3) Transfer the assessment tool to the die casting industry at large.

Answers provided by the individual die casting facilities to questions contained on the energy and technology assessment tool, as well as the results of the physical audits conducted at the facilities, revealed potential opportunities for applying technologies that could improve energy use and reduce costs for the facility.

The die casting facilities participating in the project were:

- Twin City Die Castings Company (Project Leader), Monticello, MN
- Twin City Die Castings Company, Watertown, SD
- Del Mar Industries Inc., Gardena, CA
- Premier Die Casting Company, Avenel, NJ
- Davenport White Metal Casting Company, Davenport, IA
- INTERMET Corporation, Palmyra, MO
- INTERMET Corporation, Monroe City, MO
- Brillcast Inc., Grand Rapids, MI
- SPX Contech, Mishawaka, IN
- Spartan Light Metal Products, Mexico, MO

It should be noted that the recommendations of cost savings, energy conservation/energy efficiency enhancement, waste minimization, and productivity improvements made are the result of an assessment with particular focus on die casting technology and in no way reflects negatively on any of the facilities that participated in this program.

The recommendations were divided into four categories: **Immediate** – actions that could be taken immediately; **Process** – actions relating to process changes, alterations, etc.; **Capital Investment** – actions requiring investment of capital; and **Additional Opportunities** – opportunities noted during the plant assessment that do not fall into any of the other three categories.

A total of 435 improvement opportunities were identified at the ten facilities assessed with the highest number being 58 and the lowest being 26 (Spartan Light Metal Products¹). Specific recommendations were offered for each opportunity.

The general recommendations were:

- Each facility should consider developing and implementing a formal written energy management program. The program would be separate from the program derived from the detailed energy audit of the facility. It would provide scope, purpose and details for an ongoing energy management program. It is also strongly recommended that the program be communicated to all levels of the organization.
- It is suggested that each plant develop an inventory of all plant equipment and measure the amount of energy consumed by each equipment item. The installation of energy use measurement devices on larger energy consuming equipment should be strongly considered for tracking energy consumption. The devices should have the capability of recording energy use over a broad period of time. Information derived from the recordings would provide a basis of more closely controlling energy use.
- Heat recuperation is not utilized at nine of the ten the facilities. The potential exists for reclaiming heat and utilizing it to improve melting rates as well as reducing plant heating costs. It is recommended that the facilities contact melting furnace suppliers and solicit assistance to reclaim

¹ *Spartan Light Metal Products, Mexico, Missouri participated in an Industrial Assessment Center audit in May 2003. The audit was conducted by Iowa State University utilizing funding provided by the U.S. Department of Energy under the supervision of the Center for Advanced Energy Systems at Rutgers, The State University of New Jersey. In addition to initiating a number of the recommendations from the audit, Spartan has also been very aggressive in implementing programs in numerous areas to maximize its resources for improving its processes and cutting costs.*

waste heat from the reverberatory furnaces to preheat metal charges. Although the technology for this activity may not currently be fully available, an opportunity for both the facility's and a furnace manufacturer to develop the technology has the potential for good energy savings through reuse.

- Utilizing new cast materials technologies offers an opportunity to reduce or eliminate the occurrence of scrap due to the lack of compliance to various metal properties. Tailoring an alloy to yield specific properties may also lead to new business opportunities. In addition, enhancing material properties offers an opportunity for reduced casting section thickness and shot weight (amount of metal cast).
- Opportunities for energy efficiency improvement exist through the application of new die materials and advanced coatings. Materials with higher heat diffusivity may provide reduced cycle times and advanced coatings may further extend the life of die components and decrease repair frequency over the currently utilized coatings.
- Computer modeling and process technologies are utilized to some degree at all facilities. Additional modeling techniques can assist in developing designs with higher casting and process friendliness, reducing cycle times, and hitting target dimensions with tighter tolerances for thinner wall designs, as well as, reducing the occurrence of dimensional non-compliance issues.
- Further information on implementation and utilization of design aids, process technologies, and cast and die materials is available through NADCA and may assist in applying new technologies successfully on the shop floor to yield the highest energy improvements and cost reductions.
- If the recommendations and suggestions for implementation are found to be cost justified and economically feasible by the facilities, it is anticipated that the resulting net effect will be a 10% to 20% savings in energy use for the facility. Projected savings may be realized through a 10% increase in productivity in the die casting operations, a 30% to 40% improvement in die life, and a 10% to 15% reduction in scrap. Efforts will be made to measure the actual improvements at the ten facilities within six–twelve months after implementation of the suggested technologies.
- It should be noted that the recommendations and suggestions that have been made are the result of an assessment with a particular focus on die casting technology. It is recommended that a detailed energy audit as conducted by the DOE Industrial Assessment Centers (IAC) be conducted at the nine facilities that have not been audited by an IAC and the findings utilized in further developing a formal program for conserving and reducing energy use.

A presentation to aid in reporting/presenting findings to plants within the die casting industry at large has been established and may easily be tailored to address specific improvement opportunities sited through the use of the assessment tool. The information included in the presentation was formulated to assist in encouraging the plants to implement and use new die casting technologies.

Since completing the presentation and assessment tool, NADCA has initiated the roll-out of the energy and technology assessment to other die casters in North America.

The benefits of this project were expected to be improved energy efficiencies through operational and process improvements for the plants assessed and as well as an enablement of improved energy efficiencies for die castings plants that were not assessed under this project but who will be able to utilize the results and programs developed in this project. An energy efficiency improvement of 5-15% was targeted for this project. This target objective equates to approximately 23-70 Billion Btu/year savings in total for the plants assessed and 1.7-5.1 Trillion Btu/year savings potential for the entire die casting industry.

INTRODUCTION

This project had three primary objectives. The first being the expansion of the energy and technology assessment tool developed for aluminum die casting plants by the North American Die Casting Association (NADCA) under a previous project to include additional questions and answers that were relative and more specifically applicable to zinc and magnesium die casting facilities.

The second and main objective of the project was to utilize the expanded assessment tool to perform on-site audits at ten (10) die casting plants that produced zinc and/or magnesium die castings in an effort to identify opportunities for improved energy efficiency. Eight die casting companies participated, two of which offered two plants each for a total of ten assessments. The facilities are listed below.

- Twin City Die Castings Company (Project Leader), Monticello, MN
- Twin City Die Castings Company, Watertown, SD
- Del Mar Industries Inc., Gardena, CA
- Premier Die Casting Company, Avenel, NJ
- Davenport White Metal Casting Company, Davenport, IA
- INTERMET Corporation, Palmyra, MO
- INTERMET Corporation, Monroe City, MO
- Brillcast Inc., Grand Rapids, MI
- SPX Contech, Mishawaka, IN
- Spartan Light Metal Products, Mexico, MO

The third objective of the project was to transfer the assessment tool to the die casting industry at large.

The cost of energy represents a large portion of overall expense in the die casting process. In many instances, energy has been found to be the third highest expense in the operation, right behind materials and labor. A typical breakdown of energy use in die casting is projected to be: melting 55%, holding molten metal 22%, die casting 11%, trim 3%, and non-process 9%.

Through several DOE and Cast Metals Coalition funded research projects, as well as projects funded by other sources sponsored by NADCA, technologies have been developed that can enhance the energy efficiency of the overall die casting operation. Based on the technical developments that have been proven through research to conserve energy and reduce costs, it is estimated that a 10% to 20% energy savings through a 10% increase in the productivity of the die casting operation, a 30% to 40% improvement in die life, and a 10% to 15% reduction in scrap, is achievable for die casting plants.

APPROACH

The approach to achieving the first objective involved conducting a review of applicable technologies and completed NADCA sponsored research and development projects to identify those technologies that focused specifically on various aspects relating to energy efficiency in zinc and magnesium die casting and are directly transferable to the die casting shop floor. In some cases, projects have been implemented by a die casting industry partner who participated in a specific project in order to validate laboratory test results. In these instances, the successes noted by an industry partner have been captured and form the basis for the estimated amount of energy savings/efficiency improvements. In addition, a review of new and emerging technologies was accomplished. Upon identification of applicable results from these projects, questions were added to the aluminum die casting assessment tool. All questions listed on the aluminum die casting tool were reviewed and modified, where appropriate, to ensure that they directly applied to the zinc and magnesium processes. Finally, additional questions based on present knowledge and best practices were formulated and included to complete the assessment tool. The questions were made specific enough to determine awareness or use of a technology and were phrased in a fashion that would result in a response of “Yes” or “No”. The phrasing was such that a “No” response is indicative of a lack of use or awareness of a specific technology and an opportunity for improvement.

The approach to accomplishing the second objective involved the distribution of the revised tool to each of the ten (10) plants with a request that the assessment tool questionnaire be completed and returned to NADCA. Personnel from each plant provided answers to the questions and returned the questionnaire for review and preparation for an on-site audit at the respective facility. The results of this pre-assessment from each facility assisted in providing some insight where potential opportunities for improvement existed for applying technologies that could potentially enhance energy efficiency and reduce costs.

The next step in the process was on-site audits conducted at each plant, and an individualized report of findings prepared and a presentation of results provided for each plant. For expertise, consistency and neutrality in conducting the audits, reporting the findings and presenting results, NADCA was utilized as the sole source of the audits and reports.

The approach in the third objective was to provide the assessment tool to the general die casting industry through NADCA and its various means of information dissemination. Providing the assessment tool to other plants in North America enables replication and the potential for energy savings to those who use the tool.

ASSESSMENT OF DIE CASTING FACILITIES

Most energy conservation/efficiency programs utilized in manufacturing facilities are dedicated to the use and control of water, natural gas, and electricity used in the operation of production equipment, air compressors, lighting, heating, and ventilation. The information that follows touches on some of those areas, but the main thrust is to provide recommendations for defining energy savings relative to the management of resources and implementation of the most recent and emerging technologies that are specific to the die casting process.

GENERAL COMMENTS

Every individual from each of the ten facilities that participated in this program were friendly and very helpful in providing information relative to machine, facility and tool maintenance and energy use programs. NADCA commends them for their efforts and thanks them for their participation.

Recommendations and suggestions provided in each of the reports to the participating facilities by NADCA are not indicative of gross deficiencies or the misuse of energy. The recommendations and suggestions were provided for further enhancing each facilities energy efforts and to encourage the implementation of new energy related die casting technologies.

The recommendations were divided into four categories: **Immediate** – actions that could be taken immediately; **Process** – actions relating to process changes, alterations, etc.; **Capital Investment** – actions requiring investment of capital; and **Other Opportunities** - opportunities noted during the plant assessment that do not fall into any of the other three categories. General recommendations can be found in the Audit Recommendations section below and more specific recommendations and opportunities for improvement can be found in the Audit Results section below.

As was the case during the initial development and use of the aluminum assessment tool, each die casting facility was informed that though the tool utilized a number of questions that could be normally expected to appear in a general energy audit, this tool posed additional questions of a technical nature that may not be thought of as applying to energy use. An example in point is as follows.

Many die casters do not relate to the details that comprise the cost of energy used when scrap castings are produced. Molten metal (i.e., aluminum, zinc, magnesium) injected into a steel die casting tool can often stick to the die casting tool as the metal solidifies to produce a casting. The result is that the die casting process is interrupted when the die casting machine is idled in order to remove the stuck casting from the tool. A number of things can cause this problem, such as worn surfaces in the die casting tool cavity, insufficient amounts of die

lubricant (or parting compound) on the tool cavity surface, tool cavity temperature control (too hot due to insufficient cooling), rate of flow of metal into the die cavity and a number of other process conditions can either individually or in combination cause castings to stick in the tool. The end result however is always the same, a scrap casting.

However, beyond the scrap produced, an amount of energy used in the whole die casting process is lost but the cost of that energy remains. When a casting is scrapped, a replacement casting must be produced for the customer, and to do that additional energy use is required. A brief scenario on the production of a scrap casting:

- The die casting machine used in this case is a cold chamber machine.
- The metal is injected into a steel die but instead of solidifying as is intended, sticks to the die surface resulting in a stuck and scrap casting.
- The scrap casting is removed from the die, placed in a container with other scrap castings, gates, runners, and biscuits and transported to the melting area to be re-melted. (If the melting is accomplished at the machine, the casting goes back into the melting furnace at the machine.) If the scrap is transported back to the melting area, it is most usually done using a motorized truck (lift truck/tow motor).
- The scrap is dumped into the melting furnace and is re-melted.
- The molten metal is then transferred from the melting furnace to a ladle, transported back to the machine and into a molten metal holding furnace.
- The die casting machine cycle begins with metal being dipped from the holding furnace either by a human operator or by an electrically operated ladling device and is poured into the shot sleeve of the die casting machine.

Using this scenario, costs associated with producing this scrap casting translated into the form of energy used, were explained to the die casters as follows:

Electricity for operating the die casting tool lubricator to begin the casting cycle.

Air for applying die parting/release/cooling compounds (referred too as die lubricant) to the die surface. **Electricity** for operating an air compressor to produce the air.

Air for blowing off excess die lubricant. **Electricity** for operating an air compressor to produce the air.

Natural gas or electricity to maintain heat in the molten metal holding furnace.

Electricity for operating the hydraulic and electrical systems that close and lock the machine to allow injection of molten metal.

Electricity to operate the device (called the molten metal ladler) that moves metal from the holding furnace and deposits it into the cold chamber of the die casting machine.

Electricity to initiate pumps to cause hydraulic pressure to inject molten metal into the die for producing the casting.

Electricity to maintain hydraulic (and mechanical) pressure to hold the die closed (locked) during the metal injection cycle and while the molten metal solidifies in the (die dwell cycle).

Electricity to unlock and open the machine at the end of the die casting cycle.

Electricity to operate a robot or extractor that removes the die casting from the die and either places it on a chute, conveyor or into a trim press where the gates, runners and flash from the casting. **Electricity** to operate the conveyor or trim press.

Electricity to pump hot oil or cooling water through the die casting tool to maintain proper temperature.

Electricity to pump cooling water through a die casting machine heat exchanger to maintain proper cooling water.

Fuel (propane) required for the lift truck/tow motor to transport the metal from the melting furnace to the die casting machine holding furnace.

Other costs associated with a casting scrap:

Metal loss when the scrap casting is re-melted. (Most die casters rate their metal loss associated with melting in the range of 3% - 7%. Some loss rates are even higher.)

Cost of producing combustion air (**electricity** for combustion air blower) and **fuel (natural gas or electricity)** to re-melt the scrap.

Natural gas or electricity to melt the metal. This number can be enormous if the equipment is not maintained in good operating order. Natural gas systems not properly tuned to maintain proper and complete combustion of the fuel results in excess amounts of fuel being used and/or metal chemistry being altered. Electrical elements in electric furnaces failed or failing causes higher electrical energy use and longer periods of time to melt the metal.

Molten metal holding furnaces operated by use of natural gas not properly tuned to maintain proper and complete combustion of the fuel results in excess amounts of **fuel** being used and/or metal chemistry being altered.

Molten metal holding furnaces operated by use electrical elements in electric furnaces failed or failing causes higher **electrical** energy use and longer periods of time to melt the metal.

Wear and tear on the transport equipment plus higher use of **fuel**.

Wear and tear on the melting equipment. (Results in energy use for repair.)

Die casting machine life is reduced. (Results in energy use for repair.)

Die casting die life is reduced. (Results in energy use for repair or replacement dies.)

AUDIT RECOMMENDATIONS

- Each facility should consider developing and implementing a formal written energy management program. The program would be separate from the program derived from the detailed energy audit of the facility. It would provide scope, purpose and details for an ongoing energy management program. It is also strongly recommended that the program be communicated to all levels of the organization.
- It is suggested that each plant develop an inventory of all plant equipment and measure the amount of energy consumed by each equipment item. The installation of energy use measurement devices on larger energy consuming equipment should be strongly considered for tracking energy consumption. The devices should have the capability of recording energy use over a broad period of time. Information derived from the recordings would provide a basis of more closely controlling energy use.
- Heat recuperation is not utilized at nine of the ten the facilities. The potential exists for reclaiming heat and utilizing it to improve melting rates as well as reducing plant heating costs. It is recommended that the facilities contact melting furnace suppliers and solicit assistance to reclaim waste heat from the reverberatory furnaces to preheat metal charges. Although the technology for this activity may not currently be fully available, an opportunity for both the facility's and a furnace manufacturer to develop the technology has the potential for good energy savings through reuse.
- Utilizing new cast materials technologies offers an opportunity to reduce or eliminate the occurrence of scrap due to the lack of compliance to various metal properties. Tailoring an alloy to yield specific properties may also

lead to new business opportunities. In addition, enhancing material properties offers an opportunity for reduced casting section thickness and shot weight (amount of metal cast).

- Opportunities for energy efficiency improvement exist through the application of new die materials and advanced coatings. Materials with higher heat diffusivity may provide reduced cycle times and advanced coatings may further extend the life of die components and decrease repair frequency over the currently utilized coatings.
- Computer modeling and process technologies are utilized to some degree at all facilities. Additional modeling techniques can assist in developing designs with higher casting and process friendliness, reducing cycle times, and hitting target dimensions with tighter tolerances for thinner wall designs, as well as, reducing the occurrence of dimensional non-compliance issues.
- Further information on implementation and utilization of design aids, process technologies, and cast and die materials is available through NADCA and may assist in applying new technologies successfully on the shop floor to yield the highest energy improvements and cost reductions.
- It should be noted that the recommendations and suggestions that have been made are the result of an assessment with a particular focus on die casting technology. It is recommended that a detailed energy audit as conducted by the DOE Industrial Assessment Centers be conducted at the eight facilities that have not been audited and the findings utilized in further developing a formal program for conserving and reducing energy use.
- If the recommendations and suggestions for implementation are found to be cost justified and economically feasible by the facilities, it is anticipated that the resulting net effect will be a 10% to 20% savings in energy use for the facility. Projected savings may be realized through a 10% increase in productivity in the die casting operations, a 30% to 40% improvement in die life, and a 10% to 15% reduction in scrap. Efforts will be made to measure the actual improvements at the ten facilities within six to twelve months after implementation of the suggested technologies.

BENEFITS

The benefits of this project are improved energy efficiencies through operational and process improvements for the plants assessed as well as the potential for improved energy efficiencies for die castings plants that are not assessed under this project. An improvement in energy efficiency of 5 - 15% was targeted at the onset of the project.

As was described in the proposal for this project, zinc and magnesium die casting shipments are estimated by NADCA to be 326,000,000 lb/year and 101,000,000 lb/year, respectively. A benchmarking study entitled Energy Use in Selected Metal Casting Facilities – 2003 and conducted by Eppich Technologies showed that the energy used to produce zinc and magnesium die castings is 7056 Btu/lb shipped and 12,830 Btu/lb shipped respectively. Based on these numbers, the current estimate for the total energy usage for zinc and magnesium die casting plants in the U.S. is 2.3 Trillion Btu/year and 1.3 Trillion Btu/year, respectively. The ten facilities assessed in this project team utilize approximately 210 Billion Btu/year for the production of zinc and 250 Billion Btu/year for the production of magnesium die castings for a total of approximately 460 Billion Btu/year. Therefore, these plants represent 9% of the zinc and 19% of the magnesium die casting production in the U.S. The estimated savings based on the results of the assessments performed in this project is 7 - 12% and could be achieved through the opportunities identified as described in the **AUDIT RECOMMENDATIONS** section. This level of savings can result in from the assessment of the project team facilities will yield a savings of 32 - 55 Billion Btu/year.

Some of the companies within the project team have plants in addition to those for which an assessment was conducted. These additional plants consume 17 Billion Btu/year for zinc and 65 Billion Btu/year for magnesium die casting production. Replicating the energy and technology assessment in these facilities would yield an additional savings of 6 – 10 Billion Btu/year at a 7 – 12% savings level. The companies within the project team also have plants that produce aluminum die castings. The assessment tool was produced for aluminum through a previous project, and therefore will be as applicable to the aluminum plants as it will be to the zinc and magnesium plants. Since the companies within the project team have yet to perform an assessment of their aluminum plants, replication could provide a greater energy savings. At an estimated 4.3 Trillion Btu/year for the total aluminum die casting production within the project team, there is an opportunity for 300 – 515 Billion Btu/year savings for aluminum and therefore a total combined savings opportunity for zinc, magnesium and aluminum of 338 – 580 Billion Btu/year.

Although it may not be reasonable to assume that replication will take place throughout the entire U.S. die casting industry, at a total estimated energy use of 3.6 Trillion Btu/year for zinc plus magnesium, an opportunity exists for a savings

of 250 – 430 Billion Btu/year which would elevate the savings opportunity to 2.4 – 4.1 Trillion Btu/year for zinc, magnesium and aluminum at 7 – 12% savings for a current total industry usage of 34 Trillion Btu/year. It is more reasonable to estimate replication at 30% of the industry resulting in savings of 0.7 – 1.2 Trillion Btu/year.

THE ASSESSMENT TOOL

The initial hard copy assessment questionnaire was utilized on the initial audits then slightly modified and improved as experience was gained from the on-site audits. Subsequently, an electronic assessment tool was developed after experienced was gained in utilizing the hard copy assessment tool. The electronic assessment tool was used for the last four audits.

Comments on the audit questions and answers

The assessment tool contains one hundred seventy-six questions that are segregated into nine categories. A brief description of the categories are:

1.0 General - asks questions pertaining with the policies management has in place to communicate goals and objectives to everyone in the facility concerning use and tracking of energy use in the facility.

2.0 Equipment and Maintenance - category asks questions pertaining to metering, electrical demand and use, record keeping, maintenance programs for equipment and facilities.

3.0 Cast Materials - questions metal processes, chemistry, scrap cost and correlation to die casting machines, tooling, and process.

4.0 Die Materials - asks questions pertaining to die casting tooling materials, tool processing and processes and maintenance and of tooling.

5.0 Design Aids - questions utilization of modeling simulation of products to improve product quality, proper operation and fit of tooling to die casting machine, and to improve first time trial capability of tooling.

6.0 Sensors and Controls - questions the use of technology such as process monitoring, infra-red sensors for determining heat in tooling and facility equipment, and casting weight control.

7.0 Die Technologies - questions the capability of the facility to control important characteristics of tool steels in order to prolong the tool life and to reduce the potential of premature failure.

8.0 Process Technologies - questions process control including cooling water control, “start-up” shots on the die casting machine and die cast tooling lubrication.

9.0 Waste Management - asks questions that may seem out of place in an energy audit but based on the answers provided by the facility and the particular processes used to produce products in the facility can lead to potential energy savings for the facility.

AUDIT RESULTS

1.0 General

Summary Comments

Everyone in an organization should have an understanding of the direction, goals and objectives senior management is striving for in order to improve the opportunities for success. Therefore, management must take the lead if an energy program is to succeed.

1.1 Has Executive Management provided directives concerning energy management at this facility?

All ten facilities audited answered “**NO**”. As is noted in the next question, energy management is a primary goal of the organization, but management has not communicated this goal to everyone in the organization.

1.2 Is energy management one of the primary goals of this organization?

Two of the ten facilities audited answered “**NO**”. The cost of energy is one of the major factors associated with producing die castings representing approximately 5-7% of total operating costs therefore it should be one of the primary goals.

1.3 Does this facility have a written energy conservation policy?

Nine of the ten facilities answered “**NO**”. A detailed written energy conservation policy is necessary for the development of overall energy conservation plan. The policy should provide goals and objectives for reducing energy consumption and for achieving savings.

1.4 If a written policy is in effect, is it communicated to every employee?

Nine of the ten facilities answered “**NO**”. Everyone must know the plan and direction that management wishes the organization to go.

1.5 Is there an energy management system in place at this facility?

Nine of the ten facilities answered “**NO**”. The term “energy management systems” can have dual meanings. The question was intentionally phrased to be open ended to determine how individuals view their organizations. Most individuals understood the question to mean a properly designed, installed and energy management system that works to control energy use in machinery and equipment. The question was more intended to determine if an energy management system was in place where planning, execution, follow-up and control were the prime factors. As it turned out, nine of the ten facilities have good potential opportunities for improvement and fans, have proven to conserve energy.

Concerning the energy management systems that do control machinery and equipment, many do not have to be elaborate and costly to provide savings.

1.6 Is energy consumption tracked?

Nine of the ten facilities responded that they track energy consumption. Upon completion of the audit process all ten now indicate that they track the consumption. Tracking is important for determining exactly where and how much energy is being consumed and for providing a means for evaluating and controlling the consumption.

1.7 Does management review energy costs?

All facilities answered “**YES**” to this question. However, the reviews occur after the fact. In all cases except one, the costs were tracked as a variance to budget when it was too late to do anything to reduce energy use.

1.8 Is one individual assigned the duties as Energy Manager?

Six of the ten operations are small in size (100 or less people employed) with limited staff members. Therefore, one or more individuals perform many tasks and energy management may not be given the attention required to make it effective. It was strongly recommended that the assignment should be given to someone as part of his or her other duties and that this assignment should be one of the individual’s **primary** responsibilities. Without emphasis on this aspect of the operation, the level of energy control and conservation desired may never be achieved and the potential for dollar savings will be lost.

1.9 Has an energy audit been conducted at this facility?

Eight of the ten facilities answered “**NO**”. Of the two facilities that had received audits, one had taken a very proactive approach and had implemented a number of recommendations. In fact, this particular operation had strong control on their manufacturing, quality, safety, cost containment, environment programs. Opportunities for audits to be performed free of charge are often available by utility suppliers, equipment manufacturers, and Industrial Assessment Centers (IAC) at twenty-six universities that are sponsored by the U.S. Department of Energy. The average implemented savings following an IAC assessment have been \$57,000. The IAC site has numerous case studies across many industries illustrating where savings have been obtained.

2.0 Equipment and Maintenance

Summary Comments

Based on the answers provided and the audit results, numerous opportunities are present at most of the facilities that participated in this program. By in large, the most effective return for investment and effort could be derived from installing and utilizing metering devices, performing diagnostic testing and maintenance on melting equipment, water and utility supplied energy, and instilling discipline in systems. A better understanding of utility supplied services could benefit a number of the participants.

2.1 Does this facility utilize energy metering devices? (If "Yes" - Please check all that apply: Electric Meters __, Gas Meters __, Water Meters __, Individual Meters on specific equipment _____ Other __.)

Eight of ten answered “Yes” to this question. However, it was learned during the on-site audits that the eight had only the meters supplied by their utilities supplier. It was additionally determined that except for one of the ten, all facilities accepted the readings of each meter as printed on the invoices for payment submitted each month by the utilities suppliers.

2.2 Have metering devices been investigated or evaluated for use?

Seven of ten answered that investigation and/or evaluation had occurred. Two had installed individual meters on specific equipment and one had a meter on the melting equipment. One of the facilities has since placed an order for a meter for the melting equipment and has plans to install meters on additional equipment.

2.3 Does this facility monitor its electrical demand?

Unless someone is specifically assigned to the function of monitoring demand, it is generally not accomplished. There was no indication at any of the facilities that this action was taken.

2.4 Does this facility have dual fuel (natural gas/propane/fuel oil) capabilities?

Most facilities do not have this capacity nor do they see a benefit in investing dual fuel equipment.

2.5 Are gas fired furnaces checked on a regular schedule to ensure proper turndown ratio combustion of fuels? (If "Yes", how is accomplished? Oxygen monitoring in stacks? Other__.)

Maintaining the proper combustion ration of air to gas will insure a more economical and energy efficient furnace operation. Gas fired furnaces consume the largest amount of energy in a die casting operation.

One die caster uses only electric furnaces so this does not apply. Two die casters do not check their furnaces on a schedule, but one began the program within two weeks after the audit occurred. The remainder of the die casters indicated that they did check their furnaces on a regular schedule, but after the audits and discussion, it is believed that a number of them will alter their programs to perform more complete checks.

2.6 Does this facility use propane powered rolling stock (Lift trucks)?

All of the facilities use propane or electric powered lift trucks.

2.7 Are records kept on the volume of propane used for each vehicle?

None of the facilities track the volume of propane used on a truck by truck basis.

2.8 Are the vehicle engines maintained on a regular schedule?

All of the facilities maintain engines on a schedules basis.

2.9 Are records kept on the maintenance of these vehicles?

All of the facilities keep records of such maintenance.

2.10 Are records kept on this activity?

Proper records maintained on this activity can provide important information relating to energy consumption and the necessity to perform checks on a more frequent or less frequent basis.

One die caster uses only electric furnaces so this does not apply. Six facilities maintain records on the checks. Of the three die casters that do not maintain records one die caster stated that he would begin with the beginning of his scheduled checks.

2.11 Are furnaces checked regularly for refractory condition and air leaks?

Forty percent of the die casters included in this audit did not check furnaces for refractory and air leaks on a regular basis. Information was provided to all the participants in the assessments concerning the benefits of performing these checks. The information included an example of the amount of energy loss experienced as a result of air entrainment into melting and holding furnaces where dross (oxides) develops on the surface of the molten metal and insulates the metal to the point that much heat source can not contact and maintain the proper metal temperature. The result is a high use and loss of energy.

2.13 Is heat recuperation used on gas fired melting furnaces?

Only one of the ten locations utilized heat recuperation on their gas fired melting furnaces. One die caster indicated that he was planning on checking into the feasibility for his furnaces.

2.14 Is heat recuperation used for any purpose in the facility?

Only one of the ten locations utilizes any form of heat recuperation.

2.15 Are ingot/sows/scrap for re-melt preheated prior to introduction into the molten metal bath of the melting furnaces?

All die casters except one indicated that they preheat their materials before introducing them into the molten metal bath. At the end of one audit, one die caster began making plans to allow preheating of materials.

At one location where the die caster answered yes on the assessment form additional information was provided by the auditor that could improve the preheating process and potentially greatly reduce the energy use on this activity.

2.16 Are molten metal holding furnaces inspected regularly for proper operation and refractory condition?

All facilities answered "Yes" to this question.

2.17 Are electric holding furnaces inspected regularly for element wear?

Where electric holding furnaces were utilized, no facility utilized any type of meters on their furnaces. In all cases, the auditor described the benefits of a small investment of capital (less than \$150.00 per most furnaces) to install basic voltage meters on each furnace. The meters would read the voltage consumption of the furnace elements and could provide an indication of when elements failed or were failing with a rise in voltage.

2.18 Are records maintained on holding furnace inspections?

Sixty percent of the die casters audited maintains records on furnace inspections. The auditor recommended that the three who do not maintain records begin doing so as regular inspections can help determine potential problems with the equipment and allow time to make necessary adjustments and repairs before a situation becomes a problem.

2.19 Are holding furnaces covered with insulating materials when not in use?

A considerable amount of energy can be conserved when holding furnace dip wells are covered with insulating materials. The exposed surface of molten metal to the atmosphere loses large amounts of heat every minute. In addition, molten metal surfaces exposed to the atmosphere encourage the growth of oxides on the metal surface. The oxides can lead to product quality issues if allowed to go unchecked.

2.20 Are air compressors maintained on a regular schedule?

All facilities answered "Yes" to this question. They all understand that compressed air is essential to their operation.

2.21 Are air leaks repaired as they occur?

At the time of the audits six of the ten facilities indicated that they repair air leaks as the leaks occur. At the end of the audits, after discussing the energy cost of producing compressed air the remaining four facilities indicated that they would implement programs to improve maintenance and to reduce air loss through leaks.

2.22 Is sufficient air pressure and volume of air available to meet the plant needs?

All facilities answered "Yes" to this question.

2.23 Is intake air for air compressors drawn from inside the facility?

Eight of ten answered “Yes” to this question. The reason for the question is that in a number of facilities, air is drawn from inside the facility to supply air compressors. Depending upon where the compressors are located within the facility, hot or wet air may be taken in by the compressor and this heat or moisture can cause the compressor to operate less efficiently and consume additional energy.

2.23 Does the facility compressed air pressure exceed 90-95 psi?

Ninety to ninety-five psi compressed air pressure is normally quite sufficient to operate die casting equipment. When pressures begin to exceed ninety-five psi it is generally wise to review the reasons for this requirement as compressed air is expensive to generate.

Fifty percent of the die casting facilities audited indicated that the air pressure utilized in the facility exceeded ninety to ninety-five psi. In almost all cases, the reason for this high end use was due to the design of the air distribution systems. Most facilities had undergone building growths at one or more times and the additional air systems were simply added to the existing systems without much regard to the design for balancing the systems. In almost all cases the capital cost to re-engineer the air systems prohibitive. Recommendations were made to invite compressed air specialists in to review the systems in an effort to find solutions to the situations.

2.24 Does this facility have a program for repairing hydraulic oil leaks?

Most facilities repair oil leaks on an as required basis and when the time allows unless the volume of oil being leaked from a machine is so great as to cause the machine to under perform. What some die casters do not account for is that in some instances just a small amount of oil leaking from a machine can affect the performance of the machine to the point that the die casting process parameters are not met and the result is the production of die castings that may not meet specifications.

2.26 Does this facility have a program for monitoring and recording die casting machine cooling water temperature?

Eight of the ten facilities monitor and record cooling water. One of the remaining two is taking action to perform this function.

Cooling water temperature is one of the key parameters of die casting. If the cooling water temperature becomes too hot or too cold problems can be encountered with producing die castings. Water that is too hot can cause the dies to overheat and cause castings to stick in the die cavities. The result is scrap. In addition, the cycle times of the machines will

increase with increased heat and the potential for dies to be damaged and crack also increases.

If the water is too cold, the molten metal may cool too fast and cause the castings to be scrap.

2.27 Are die cast machine heat exchangers inspected and maintained on a regular schedule?

Die casting machines are equipped with heat exchangers that function to cool water used internally on the machines. These exchangers require periodic inspection and cleaning to insure proper operation. If not properly maintained the exchangers can corrode from minerals in the water and lose their cooling efficiency. The loss in cooling capability can result in increased water temperature and die casting machine problems that can lead to increased use of energy and potential casting product problems. Seven of the ten facilities have maintenance programs that address this particular issue. The remaining facilities indicated that they either did not have problems or that they would investigate improving maintenance on the exchangers.

2.28 Is the facility cooling water treated?

Eight facilities treat their cooling water to prevent mineral build-up in die casting machines and die casting tooling. Two facilities indicated that the water used in their manufacturing processes was sufficiently treated by the supplying utility and did not require further treatment.

2.29 Is the facility cooling water re-circulated?

Eight facilities re-circulate their cooling water thereby helping to reduce the amount of water used in their processes. After having participated in the auditing program, one facility that did not re-circulate water began investigating the cost effectiveness of installing re-circulating equipment.

2.30 Is tap water use for cooling process equipment and air compressors monitored to ensure it is not being wasted?

Six of the ten facilities answered "Yes" to this question.

Many times cooling water is allowed to flow freely through the equipment without considering the amount of water being used. As an example, one large facility consumed approximately 125,000 gallons of water per day in their die casting process. By instituting a program of finding and eliminating water leaks and excessive use and re-circulating the water, the

facility was able to reduce process water use by 75%. The facility also eliminated discharge to the local waste treatment facility as well.

2.31 *Are records maintained on annual water use? (If "Yes", please provide a copy of the records.)*

It is recommended that a record of water use be implemented for the purpose of determining the amount of water used in the facility. One die caster implemented a program to control water use and was able to reduce the consumption of water by 45%. The cost of energy for pumping water and costs for water consumption and water treatment were considerable.

2.32 *If water use records are available, are process water and sanitary broken out separately?*

None of the facilities separated process and sanitary use/costs.

2.33 *Does this facility use energy efficient lighting throughout the facility (plant and office)?*

In all cases except one, the lighting is a mixture of fluorescent, HID and mercury vapor lamps.

2.34 *Is re-lamping accomplished on an established schedule?*

Most lighting is replaced as it is needed.

2.35 *Are there areas of the facility such as storage or warehousing where lighting levels can be reduced?*

In most cases the lighting was poor in the die casting operations. There was only one instance where a reasonable potential for shutting off lights.

2.36 *Are timers installed in the facility that will automatically turn off lights at predetermined times?*

In most instances turning off lights would not prove to be cost effective. However, in many offices, restrooms, and areas not occupied could be controlled with motion/time switches to turn off lights when the space is not occupied.

2.37 *Does this facility have power factor correction equipment installed?*

One of the ten facilities utilized power factor correction equipment. One other facility had investigated the possibility.

2.38 Has power factor correction activity been coordinated with the local electric provider?

Only two facilities have coordinated power factor correction with the local electrical provider. The general assumption among the remaining facilities was that the electrical provider supplied the most economical service possible.

The auditor suggested that each facility that had not contacted their provider to do so if for no other reason than to confirm that they were receiving the best service possible.

2.39 What is the power factor on incoming power? _____

Nine of ten facilities did not know what their power factor or if it was leading or lagging. In the facilities where the power factor was understood the assumption was that it was satisfactory and the electrical utility supplier checked and maintained it in proper order. It is a good business practice for the facilities to know if their electrical service is being provided at the best efficiency and cost.

2.40 When electrical equipment is purchased, are energy efficient motors specified?

The responses varied from one "Yes", one "No" and no answers at all from eight facilities. The general response was that due to the economic turndown over the past few years little equipment, if any, had been purchased. The nine facilities did respond that they would look into energy efficient motors when they purchased equipment in the future.

2.41 When electrical motors fail are they repaired ____ replaced ____?

Every facility answered that depending upon the circumstance; the motors were either repaired or replaced.

2.42 If electrical motors are repaired, is the efficiency of the motor operation checked?

All ten answered "NO". When motors are repaired, for the most part, the efficiency of the motor is correct. However, on a rare occasion a motor may not be properly re-wound and one of the results is an inefficiently operating piece of equipment that under performs and can use excess energy.

2.43 If electrical motors are replaced, are they replaced with energy efficient motors?

Seven facilities indicated that they attempt to replace standard motors with energy efficient motors where possible.

According to some facilities, energy efficient motor have not been available for perfectly match existing motors.

2.44 Is this facility on a load shedding program with its electric power supplier?

Shedding electrical loads are not normally done in die casting operations as an abrupt disruption in power to die casting machines can result in castings becoming stuck in tooling and cause considerable casting scrap. Load shedding can be accomplished and has the potential to save energy but it requires very close coordination between the electric power supplier and the die caster.

Questions 2.45 and 2.46 were included in the assessment only to attempt to determine if the facility had experienced any frequent and significant problems with disruption in energy from its utility supplier. If either problem were the case, suggestions would have been made to consider alternate energy sources such as generators to produce electric power in cases of emergency.

2.45 Have any forced electrical shutdowns been required of this facility by the electric power supplier?

Three facilities indicated that in the past ten years they had experienced only one power outage.

2.46 Has this facility experienced a "brown out" situation?

Six facilities indicated that they had experienced "brown out" situations but not of a significant nature to warrant the capital investment for the installation of generators to produce electricity.

2.47 Does this facility utilize/seek alternate natural gas sources/transporters for more favorable rates?

One of ten does not seek alternate sources.

2.48 Does this facility, in particular the manufacturing areas, have insulated walls and roofs?

Six of ten facilities answered "Yes" to this question. Two of the remaining facilities are located in warm climate areas and did not feel the need for insulating the buildings. The remaining two facilities had no plans to install insulation.

The significance is for the insulation is obviously to maintain heat in the winter months and to attempt to reduce heat entrainment into the building during the warm seasons thereby assisting in reducing the energy use for environment control.

2.49 Are airlocks utilized on overhead doors to maintain heat in the building during cold weather periods?

Only four facilities utilize airlocks. The remaining six facilities saw no need for airlocks as entry to the buildings and had no plans to install them. All six facilities not using airlocks did indicate when questioned that efforts were made to keep doors closed when not in use most particular in the cold months of the year.

2.50 Has the plant air environment balanced to provide a stable atmosphere? (Does not have a negative air pressure in the facility.)

Eight of the ten facilities have provided means to balance the air environment. Negative air pressures in a die casting facility can have an adverse effect on the casting process by pulling air into the facility from the outside environment. The flow of air, particularly in cold weather months can affect molten metal temperatures as it passes over the surfaces of open wells of melting and molten metal holding furnaces. The result can be lowered metal temperatures, increased oxide growth in the metal and potential scrap casting production.

2.51 Does this facility use down draft fans to pull hot air from the ceiling areas for additional heat reclamation in winter months?

One facility is located in California and consequently does not experience the cold weather as do the other facilities.

Four of the remaining nine facilities have and use down draft fans to assist in circulating heat to heat their buildings. Five others indicated that they investigate the possibility of using the fans.

2.52 Are gas and electrical use separated for the office space and the manufacturing operation?

Only three facilities have the office space and manufacturing space gas and electricity separated. Most facilities allocate gas and electricity use on a square foot of floor space basis.

The primary use of gas in the die casting operation is in the metal processing and handling areas and the largest consumer of electrical energy is with the large motors used to operate the die casting machines.

The best means for determining the energy use of a facility is to install energy metering devices on various pieces of equipment and track the energy used.

2.53 During down periods in the operation are all non-essential equipment (lights, heaters, air compressors, etc.) shut-down or idled?

All answered “Yes” and completely understand the energy cost and waste of not following this practice.

2.54 Does this facility have an energy management system to automatically control heat/cooling?

None of the facilities audited have energy management systems in place.

The three primary reasons given for not installing EMS’s were 1) the system was expensive to install; 2) the systems are expensive to maintain; 3) most are unreliable.

The next five questions (2.55, 2.56, 2.57, 2.58 and 2.59) pertain to use of boiler systems in the die casting operations. Only two facilities operate boiler systems.

2.55 Does this facility utilize boilers to supply heat/steam?

2.56 If this facility utilizes boilers to supply heat/steam fired by natural gas is the natural gas combustion system inspected and adjusted for maximum operating efficiencies?

One facility answered “Yes”.

2.57 If this facility utilizes boilers to supply heat/steam fired by natural gas is the combustion air preheated?

One facility answered “Yes”.

2.58 If this facility utilizes boilers to supply heat/steam fired by fuel oil is the fuel oil combustion system inspected and adjusted for maximum operating efficiencies?

One facility answered “Yes”.

2.59 If boilers are used in this facility are condensate return tanks insulated?

Neither of the two facilities that employ boilers has condensate tanks insulated. Potential energy savings in hot water heat loss can be achieved by insulating the tanks.

2.60 Has this facility investigated the replacement of V-belt drives with cog belts?

Nine of the ten facilities had not investigated cog belts as replacement for V-belt drive systems.

NADCA Cost Savings Opportunity #1 (see Appendix) provides a calculation that shows potential annual savings that may be achieved by using cog belts. This opportunity was shared with each facility.

The next four questions (2.61, 2.62, 2.63 and 2.64) address preventive and predictive maintenance programs for die casting machines and equipment. These programs were discussed and suggestions made to each of the facilities to review their programs and to include additional items to be checked that are relative to energy savings opportunities

2.61 Does this facility have a formal preventive maintenance program for die casting machines?

Nine of the ten facilities have a formal preventive maintenance program.

2.62 Does this facility have a formal predictive maintenance program for die casting machines?

Three facilities have a formal predictive maintenance program.

2.63 Does this facility have a preventive maintenance program for all equipment?

Eight facilities have a preventive maintenance program for all equipment.

2.64 Does this facility have a predictive maintenance program for all equipment?

Only two facilities have predictive maintenance programs for all equipment.

3.0 Cast Materials

Summary Comments

Section 3 centers on potential savings relating to metal loss resulting from melting ingots and sows, re-melting scrap and reclaiming dross. This section also asks questions pertaining to the maintenance of proper metal chemistries and mechanical properties and correlation scrap to various aspects of the die casting process.

It was determined that a number of opportunities exist at each of the facilities.

3.1 Does this facility use multiple alloys for casting?

All answered "Yes".

The answers to the next two questions were relatively scant due to the fact that the numbers reported by the participating facilities were not quite complete. In some cases the individuals from the participating facilities did not have the information available to answer these and other questions that relate to financial matters.

3.2 *What is the metal melting loss rate for this facility? _____ %*

The melting loss rates reported were 3% on the low range and 7-10% on the high end. Only six die casting operations reported their numbers as an answer to this question.

Where possible, through brief observation of each of the facilities melting and handling practices, the auditor believes these numbers to be in a relatively correct range.

3.3 *How is the metal loss rate calculated? (Mass Balance __, Weigh __ __, Other ___. Please check all that apply.)*

Three die casters reported that the metal loss rates in their facilities is calculated by weight and one die caster by mass balance.

The remaining six die casters did not answer the question.

3.4 *What is the metal loss due to dross? _____*

The average metal loss due to being contained in dross was reported to be in the range of 3% - 5%. One facility reported the loss at 30%.

The auditor estimated that in almost all cases except one, the metal loss was slightly higher than reported and therefore presented an opportunity for cost reduction. The opportunities were discussed with each facility.

3.5 *How is dross loss determined? (Mass Balance __, Weigh ____, Other__.)*

Dross loss was reported by only three facilities to be determined by mass balance (metal in vs. metal out) or by weighing the dross.

3.6 *Does the facility toll its dross?*

Nine die casters send their dross out for reclaiming the metal that solidifies in the dross. They all expect that they get the equivalent of one-half to one-third of the weight of the dross back in recyclable metal.

The auditor felt that with minor changes in the means used by all but one die caster, additional savings in dross processing could be achieved and in doing so, energy savings in the entire system of dross conversion could be realized.

3.7 Does the facility de-gas its molten metal?

De-gassing molten metal is employed to assist in removing gas from the metal in order to improve metal quality and to reduce the possible of producing castings that contain gas porosity.

Two facilities de-gas the molten metal. When questioned, all others indicated that either de-gassing had been investigated and determined that it was not required, or that there had been no reason determined to use de-gassing in the process.

3.8 Does the facility blend any of its alloys?

None of the facilities blend any alloy.

3.9 Has the facility determined costs pertaining to re-melting scrap?

Six of the facilities indicated that costs pertain to re-melting scrap were known. However, when questioned about how the cost detail was derived and using some of the examples of energy used as described in this report on pages 9, 10 and 11 it was relatively evident that some of the pertinent detail in the calculations was missing. Therefore, it is fairly safe to assume that the actual costs pertaining to re-melting scrap is higher than most die casters believe. If this assumption is correct, more opportunities for energy reduction and cost savings, or at the least, cost avoidance may be possible.

The remaining four facilities answered that the costs had not been determined. The opportunity for savings, cost avoidance and energy reduction in these facilities may also be quite possible.

3.10 Does the facility control metal chemistry to tighter limits for casting than the specified alloy chemistry ranges?

Only two of the facilities audited control metal chemistry to tighter limits than the specified alloy chemistry ranges. Both use the control to meet their customer requirements.

All other facilities state that they had no reason to control tighter than specified ranges.

3.11 Does the facility specify metal chemistry ranges to meet specific product

requirements?

Seven facilities responded “Yes” to this question.

3.12 Is metal chemistry checked regularly as received?

Some die casters rely solely upon the certifications of metal chemistry as supplied by the metal supplier. This was the case with two of the facilities audited in this program. The other eight facilities perform test sampling on their metal at the time it is received to insure that the metal meets the required chemistry specifications.

The importance of the metal chemistry is that variances in elements in the metal can have detrimental effects on casting product quality and mechanical properties, and may adversely affect die casting tooling.

Where more than one type of metal alloy is used in the manufacture of die castings it is very important that the scrap is segregated so as not to accidentally mix the two. If mixing of two alloys should occur, the metal chemistry is highly likely to be changed and will then be out of specification.

3.13 Is metal chemistry checked regularly in metal holding furnaces?

Seven of the ten facilities check metal regularly at the metal holding furnaces to insure the metal meets the specified chemistry.

The facilities that indicated that they do not check metal at holding furnaces reported no problems with metal chemistry – which they were aware of.

3.14 Is metal checked regularly directly from the melting furnace to ensure proper chemistry as a result of re-melting scrap?

Seven of the ten facilities check metal regularly at the metal holding furnaces to insure the metal meets the specified chemistry.

The facilities that indicated that they do not check metal at holding furnaces reported no problems with metal chemistry – which they were aware of.

3.15 Does this facility cast AM50 and/or AM60 alloys?

Five facilities cast AM50 and/or AM60 alloys.

- 3.16 *If this facility casts AM50 and/or AM60 alloys and the products produced are utilized for structural applications are the alloys regularly checked to ensure that they are free from metallic inclusions and impurities that could affect the integrity of the finished product?*

All facilities falling into this question category answered “Yes” to these questions and can ensure the integrity of the finished cast product.

- 3.17 *Is metal chemistry check regularly in castings prior to shipment?*

Only one of the facilities performs chemistry checks on their castings prior to shipment. The remaining facilities are sufficiently satisfied that their metal chemistry is maintained within specifications and none indicated that any problems had arisen from any of their customers pertaining to metal chemistry.

- 3.18 *Does the facility differentiate its scrap rates by (die cast ____/____, secondary finishing ____/____%, machining ____/____%, customer returns ____/____%. Check all that apply and provide rates for each item checked.)*

Nine of the ten facilities define scrap rates pertaining to the areas listed in this question. The one facility who did not also had an abnormally high rate of scrap overall. This facility indicated that consideration would be given to developing means to differentiate the cause of scrap.

- 3.19 *If this facility produces magnesium castings, does it utilize a protective cover gas on its melt surfaces that is not SF-6 based?*

Of the five die casting operations that use protective cover gases three use gases that are not SF-6.

- 3.20 *What protective cover gas is utilized?*

SF-4, HF 134A,

- 3.21 *Is scrap correlated to tooling life?*

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

- 3.22 *Is scrap correlated to machine maintenance?*

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

3.23 Is scrap correlated to die lubrication?

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

3.24 Is scrap correlated to die cooling?

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

*3.25 What is the internal scrap rate? **Percent** _____.*

Six facilities listed their scrap rates. The high range for magnesium was 15.2% and the low range was 2%.

The numbers were somewhat slanted in two cases as one or two products had very high scrap rates and inflated the overall number.

In one case, the rejection rate for the product was very high (30%) due to the extremely tight specification requirements and difficulty of producing the casting.

Work is on-going in all facilities to reduce scrap rates for basic economic and customer satisfaction reasons. After the assessments some of the die casters saw the need for added emphasis on reducing scrap.

3.26 Is any scrap related to metal issues?

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas

had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

3.27 Is any scrap due to improper metal chemistry property levels?

Nine of the ten facilities audited indicated that they did correlate their scrap to this area. The one facility that did not correlate scrap to the areas had the highest scrap rate of all the facilities. At the completion of the assessment with the facility utilizing no correlation data the facility management indicated that a program for assessing scrap would be developed and implemented.

3.28 Have any marketing efforts related to providing a unique set of die cast properties (metal chemistry) for customers been made?

Seven facilities reported that they had made efforts to produce a unique set of die cast properties for some customers.

The success or continuing efforts in this area were not reported.

3.29 If this facility produces zinc and/or magnesium products has it experienced product issues related to creep properties?

Four facilities reported that they have experienced product issues related to creep properties.

3.30 If creep related properties have been an issue, has this facility been able to support its customer concerning creep?

The four facilities reporting problems with creep indicated that they have been able to support their customers.

3.31 If this facility produces zinc and/or magnesium products has it experienced product issues related to mechanical properties?

Five die casters answered "Yes" to this question but indicated that for the most part the problems are solved.

3.32 If this facility produces zinc casting products & the design criteria specifies zero draft, has the facility been able to achieve zero draft?

Five facilities answered "Yes". The majority of the other facilities indicated that zero draft has not been specified on the product they were producing.

4.0 Die Materials

Summary Comments

Soldering and sticking of metals in die casting tools and its high contribution to the production of scrap has been discussed at some length in this report. The soldering mechanism in zinc die castings differs from that of aluminum. The control of die temperatures and molten metal in tight ranges, the condition of the die surfaces, die casting tooling temperature control and the proper application of lubricants is necessary to reduce or eliminate soldering when die casting zinc.

The use of alloying elements used to achieve desired properties and to minimize the production of scrap is unique to aluminum, zinc and magnesium. Responses to questions specific to zinc and magnesium indicated that most facilities that participated in this project work to insure that specifications are held to tight compliance and that processes are monitored to maintain consistency. However, even with emphasis placed on the processes, room for improvements and energy savings are still available to most participants.

4.1 Has the facility eliminated the need to polish casting dies during production runs?

The thermal cycling of a die casting die during its operation causes the die surface to wear and often crack. When the wearing and cracking effect occurs, castings will become stuck in the die cavity. Maintaining a polished surface finish in the die cavity helps to reduce the sticking problem.

Other problems can occur in dies to cause the sticking as well. Improper metal temperatures and chemistry (high iron content), inadequate die lubrication application and improper water cooling of the die , as well as many other variables all can individually or together cause castings to stick to the die cavity.

The problems are encountered by seven of the operations audited. Only three of the operations indicated that polishing during production runs had been eliminated.

4.2 Are die surfaces maintained in a highly polished state?

Six of the ten operations indicated that die surfaces were not maintained in a highly polished state. The same operations answered in question 4.1 above that polishing dies during production runs was still required.

A part of the correlation is that polished surfaces in die casting dies assists in eliminating soldering and stuck castings. Other process parameters such as those stated in the response in question 4.1 above can contribute to problems.

4.3 Have die surfaces that are prone to soldering been provided with adequate internal cooling?

All facilities answered “Yes” to this question indicating that adequate internal cooling of their die casting dies had been accomplished. However, in questions 4.15 and 4.16 (see below) some of the facilities indicate problems still occur.

4.4 If the facility produces zinc die castings, has a proper temperature range been developed and maintained in the dies to prevent soldering?

Six of the facilities produce zinc die castings and answer “Yes” that proper temperature ranges had been developed and maintained. The remaining three facilities do not produce zinc castings.

4.5 Does the facility utilize high-speed milling for tooling repair?

Six facilities perform tooling repair in-house and utilize high-speed tooling. The remaining four facilities perform minor tooling repair in-house and send large or complex tooling work to outside tool shops.

4.6 Has handwork in tool repair been reduced/eliminated?

An equal split of fifty percent have reduced or eliminated handwork and fifty percent have not.

Much of the issues for requiring handwork center on the type of castings being produced and the design of die casting tooling.

4.7 Has the facility reduced the number of tooling repair machines by replacing conventional machining centers with High Speed Centers?

Three facilities answered “Yes” to this question. The remaining facilities do not employ tooling repair machines and send large or complex tooling work to outside tool shops.

4.8 Has the implementation of high-speed machining resulted in reduction/redeployment of manpower?

The same answer applies to this question as in question 4.7

4.9 Does the facility purchase tooling from shops which utilize high-speed machining?

All facilities answered “Yes” to this question.

4.10 Has the use of high-speed machining reduced the cost and lead-time of purchasing tooling?

All facilities answered “Yes” to this question.

4.11 Has the facility eliminated the need to perform maintenance on specific die inserts during production runs?

Six facilities answered “Yes”.

Depending upon the detail and physical size of inserts used in die casting dies, some inserts are inherently more difficult to maintain. Given the physical and thermal stresses applied to the inserts during the casting process where very high hydraulic pressures are exerted on the inserts and the high thermal cycling that occurs, some inserts are prone to damage and rapid deterioration.

It is important that inserts that are subject to these problems be well designed and properly maintained in order to prevent damage which in the long term can result in the production of scrap and hence, wasted energy.

4.12 Does the facility utilize special alloys for critical inserts in dies?

Six facilities answered “Yes” to this question. Two of the other facilities indicated that special alloys would be investigated.

4.13 Does the facility utilize refractory alloys for inserts with temperature control problems?

Only one die casting operation answered “Yes” to this question.

A paper presented at the 2005 NADCA/AFS Casting Congress entitled, “Evaluation and Application of an Alternative Die Material Using Simulation Technology for the High Pressure Die Casting Industry” showed the impact of not only the use of a refractory insert but the vital importance of providing water-cooling for that insert.

Evaluation of the tooling cost/casting for the current die material being used against that of a properly designed and cooled insert made from a refractory material could show the benefit of using refractory alloys.

4.14 Has the facility increased production rates by using special die materials for critical inserts?

Eight facilities answered “Yes” to this question. One other facility indicated that special materials would be investigated.

4.15 Has the facility eliminated the need for cleaning die cavity components during production runs?

Fifty percent of the respondents answered “Yes” and fifty percent answered “N” to this question.

Please refer to questions 4.1 and 4.2

4.16 Has the facility eliminated excessive soldering on die inserts?

Seven of the respondents answered “Yes” and three answered “No” to this question.

Please refer to questions 4.1 and 4.2

Questions 4.17, 4.18, 4.19 and 4.20 pertain to evaluation of and specification of surface treatments for die inserts, core pins and die cavity surfaces to improve die life and casting quality and productivity. Significant research has been sponsored by NADCA at universities on the surface treatment of die casting steels with good results. The application of this technology as well as other coating technologies developed by private organizations has also shown successful results.

4.17 Has the facility evaluated commercial coatings or surface treatments for specific inserts?

Eight of the ten facilities have evaluated coatings and surface treatments.

4.18 Does the facility specify coatings or surface treatments on core pins or inserts?

Six facilities specify coatings or surface treatments on core pins or inserts.

4.19 Does the facility specify coatings or surface treatments on die cavities?

Six facilities specify coatings or surface treatments on die cavities.

4.20 If the facility specifies coatings or surface treatments on core pins, inserts and/or die cavities is the thickness of the coatings specified?

Four facilities specify coatings or surface treatments on core pins, inserts and/or die cavities.

4.21 Does the facility have a program for maintaining the cooling lines?

All facilities answered "Yes" to this question.

4.22 Does the facility utilize premium H-13 steel in the construction of its die casting dies?

All facilities answered "Yes" to this question.

4.23 Are die casting dies heat treated/stress tempered at the time of major refurbishing/rebuilds?

Heat treating/stress tempering die casting dies assists in prolonging the life of the die. Seven of the ten facilities make a practice of treating dies with these processes when refurbishing and rebuilding dies. The remaining three facilities understand the benefits of the process and take under consideration the possibility of employing the process when the opportunity exists.

*4.24 Are die heaters used to pre-heat dies before placing them into production status? (If "Yes", what type? **Gas Heater**__, **Gas Torch**__, **Electric Heater**__, **Hot Oil**__.)*

All facilities utilize one or more types of heaters to pre-heat dies before placing them into production status.

Where gas and electric heaters and gas torches were used to pre-heat dies the auditor questioned and discussed the means the heaters were employed relative to the die surfaces and the length of time used to bring the dies to operating temperatures. In almost all cases the auditor suggested that the procedures for pre-heating dies with gas torches and heaters could be more efficient and if gas trains and nozzles with control equipment were employed to control fuel ratios as opposed to allowing open gas flames to impinge on the die surfaces.

The auditor also discussed the need to bring the heaters, both gas and electric, as close to the die surfaces to be heated as possible and to apply insulation of some type around the areas being heated to restrict the heat from escaping the areas of the die requiring heat.

4.25 How many shots are generally made on the start-up of a die before normal production commences?

The numbers varied from three shots to over twenty-five shots. Various reasons were given for the numbers but all understand the need to reduce start-up shots to the least number possible. The discussions relative to the cost of energy for making start-up shots (which has been explained at various points in this report) was taken well by every facility and may

possibly cause additional emphasis to be placed on reducing the number of shots a die casting machine makes upon start-up.

*4.26 Please list reasons for tooling repairs/failures: **Cracks, water leaks, breakout, erosion, heat checking, other.**)*

All facilities had some type of failure as listed in the question and are aware of the cost relative to producing scrap that results from the condition of the tool. After the audits were completed, the facilities had additional information concerning the hidden costs associated with energy consumption relative to producing scrap with tooling that was in need of repair or replacement.

4.27 Are dies heat treated to the latest NADCA recommended procedure? What is the date of the version _____?

All facilities answered "Yes" to this question.

4.28 Is die/insert hardness reclaimed? At what HRC level? HRC_____

All facilities answered "Yes" to this question.

4.29 For coatings used on core pins please list the coating and the coating supplier.

All facilities indicated use of core pin coatings of some type but did not provide supplier data.

4.30 If the facility requires heat treating/stress tempering of dies at the time of refurbishment or rebuild does the plant provide the heat treatment facility with written specifications for the heat treatment?

Eighty percent answered "Yes" and two answered "No."

4.31 Are certified samples of die steels required by the plant of all die steels purchased?

Forty percent answered "Yes" and sixty percent answered "No." The facilities that answered "No" indicated that in their experience there had not been any reason to obtain steel samples as the steel supplier and heat treatment facilities with which they did business provided written certification that the tools were produced and treated to the proper specifications.

5.0 Design Aids

Summary Comments

Many die casters use some form of computer modeling and/or simulation to assist in the design and evaluation of die casting tools and products. As with the industry in general, the facilities participating in this program use technology to varying degrees as well. Some work using this technology can be time consuming, but the results of the work are generally worth the time invested. Most of the participants could receive additional benefits in the production of tooling and casting products if more work were modeled and simulated.

5.1 Have the die designs used by the facility been modeled to evaluate potential die deflection?

Four percent indicated that modeling to determine die deflection is accomplished. In some of the cases, the die casting tools are quite small in size and are not prone to deflection therefore modeling for this issue is not done. In one or two other cases, the possibility of reducing casting scrap might be improved if modeling for deflection was accomplished.

5.2 Do ejector dies have sufficient support pillars?

In nine of the ten cases the facilities answered “Yes” to this question. The remaining facility is aware of the problem and has takes measures to rectify the problem on a case by case basis.

5.3 Do the edges of the ejector inserts extend beyond the ejector rails?

The extension of ejector inserts beyond ejector rails is intended to assist in the proper sealing off of the die halves in order to produce a good casting. The extension of rails helps to account for some mis-match of the die halves at the parting line. This practice is used by some die casters but as is evidenced by the number of “No” answers to this question, most die casters attempt to maintain good parting line match without the need to extend ejector inserts beyond ejector rails.

Seventy percent of the die casters answered “No” to this question.

5.4 Are dies positioned on the platen to provide equal load to each tie bar at clamp?

NADCA sets forth recommendations for positioning dies on the platens of die casting machines to assist in insuring that equal loads are applied to each tie bar at the clamping (locking up) of the die casting machine.

When dies are off-set on die casting machine platens, unequal loading of tie bars at clamp can occur and can create a number of problems that can

result in damage to the machine, damage to the die, and the production of scrap castings.

5.5 Does the facility participate in design decisions with customers?

The die caster possesses knowledge relative to producing castings that can be very important to the customer when determining product characteristics. The die caster can assist the customer by explaining what features on the product will be difficult to produce and suggest alternatives in design to gain the end result the customer requires. In addition, the meeting of the minds between customer and die caster helps the customer to understand what the process is capable of and assists the die caster in understanding the customer specification requirements.

5.6 Does the facility utilize CastView to evaluate preliminary designs?

CastView is a NADCA designed product that can assist the die caster in the evaluation and improvement of his/or her product designs. Other computer simulation programs are available to the die caster and a number of the die casters utilize systems other than CastView. NADCA desire is to assist the die caster in improving his or her casting abilities with the use of this computer aided product to improve bottom line profits and to avoid and eliminate costly mistakes in casting design. As has been stated in other answers to questions in this assessment tool, mistakes in die casting results in scrap castings and in the long term, wasted energy.

5.7 Do the facility's customers value the design input capabilities of the plant?

Seven facilities indicated "Yes" to this question. The three facilities indicating "No" offered no particular reasons for their customer's lack of value for the service.

5.8 Has the plant been able to obtain needed design modifications as the result of analysis capabilities?

Eight of the facilities indicated that they have been able to obtain required design modifications resulting from analysis of problems with the product designs. No particular reasons were provided by the two facilities as to why the requests for design changes were denied by the customer.

The following six questions pertain to the use of computer modeling simulation in designing and evaluating die casting tooling. First time success with die design where no cooling modifications are required to properly cool locations in the die to eliminate hot spot that contribute to die soldering, casting defects, off tolerance dimensions on the casting and to reduce die sampling which all results in the production of scrap casting and excessive use of energy.

5.9 Does the facility utilize computer simulations to solve quality problems?

Eight of the ten facilities answered “Yes”.

5.10 Does the facility always have first time success with new die design (No cooling modifications required?)

Four of the ten facilities answered “Yes”.

5.11 Does the facility utilize computer simulations to determine how to optimize die temperature and how to bring dies to operating temperature quickly to minimize wasted time and to reduce the amount of scrap castings?

Four of the ten facilities answered “Yes”.

5.12 Has the facility eliminated the need to modify newly designed tooling to correct dimensions?

Seven of the ten answered “No”. Some of the problems result in issues with such as machining the tool and metal shrinkage when the die casting solidifies.

The question did not address the amount of modification required to correct dimensions. In recent times these modifications have been greatly reduced with the use of computer modeling and simulation. Modifications do require expending of additional energy to make.

5.13 Has the facility eliminated the need to modify newly designed tooling to correct casting defects?

Four of the facilities answered “Yes”. A number of variables are present in the die casting process and if all are not closely controlled, casting defects may be encountered. As in question 5.12, this question did not address the variables inherent in the die casting process but modeling simulation can provide information that can increase the success rate of producing castings with fewer casting defects.

5.14 What is the average number of samples required on a new die casting before all corrections are completed and the die is approved for production?

This question deals with the number of times a die casting tool must be sampled in order to have all dimensions and characteristics meet the customer’s required specifications. The average number of samples required is 2 to 3 times by the die casters audited in this program. This is a significant improvement over the sampling of tools in past years when it

was not uncommon for a tool to be required to be sampled up to 7 or 8 times.

The primary reasons for the improvements has been the development and use of computer modeling and design programs for designing tools and the use of computer controlled machining equipment for building the tools.

6.0 Sensors and Controls

Summary Comments

Utilizing sensors and controls in the die casting process are additional tools that can assist the die caster in improving processes and reducing or eliminating problems. The plants participating in this program do use some sensors and controls in their processes, but could possibly improve their efforts by investigating and employing additional means.

6.1 Does the facility utilize sensors in die casting dies to detect air gaps (or incomplete closing and matching of die surfaces at lock-up?)

Gaps at the parting line of the die or misalignment of the die can be a source of scrap production by allowing flash to develop on the die parting line and around slides and cores in tool. In addition, as has been discussed at other points in this report, temperatures in the die casting tool cavities may be monitored with the use of sensors.

The technology development of this process has been available for some time, but has not generally been accepted by the industry due to the maintenance and care required in utilizing the technology.

Only three of the facilities utilize the technology.

6.2 Are die casting machines equipped with automatic tie bar adjusting devices?

Automatic tie bar adjusting devices assist the die caster maintenance and set-up personnel in more quickly adjusting the proper tension on a die casting machine in order to ensure it proper operation of the closing and locking-up of the machine at the beginning of the casting process. Proper tensioning of the tie bars helps to insure that the halves of the die casting tool are properly locked in position to allow metal to be injected into the tool for producing the casting.

Improper locking of the die in position can lead to castings being produced out of specification, and hence result in scrap.

The automatic tie bar adjusting devices are included as optional equipment on new die casting machines. These adjusting devices may be

added to machines as after market as options but can be costly to purchase and install.

Four of the operations audited in this program have this equipment installed on all or some of their machines. The remaining operations indicated that, 1) they are confident and satisfied with their present method of tensioning their equipment or, 2) they do not feel that there is cost justification for installing the equipment on the machines.

6.3 If "Yes", are records maintained on tie bar loading/settings?

Six of the operations maintain records on the tie bar loading/settings on their die casting machine regardless of whether they employ automatic tie bar adjusting equipment or do not.

The record keeping practice is a good method for assisting in reducing machine set-up time and as a baseline for diagnosing die casting machine problems when problems arise that possibly involve the machine being out of proper adjustment.

Energy use or savings in setting up a die casting machine or in trouble shooting problems on a machine are associated with the non-production time the machine is operating and using energy during set-up or diagnosing problems. Energy is being used but castings are not being produced.

In the following three questions (6.4, 6.5 and 6.6) the facilities audited utilize either pyrometers or infra-red cameras to check die casting temperatures or apparatus as described in question 6.6.

6.4 Are infrared camera's used to assist in determining temperatures in die casting dies?

Six facilities use infra-red cameras

6.5 Are pyrometers used to assist in determining temperatures in die casting dies?

Seven facilities use pyrometers.

6.6 Are infrared camera's used to assist in determining potential electrical problems in apparatus such as switchgear, control panels, etc.?

Six facilities use infra-red cameras for the purposes described in this question. The remaining four facilities indicated that they may contract this service after hearing of the benefits and the potential for improving energy

consumption and reducing the risk of potential electrical equipment failures.

6.7 Does this facility utilize process control monitoring on all die casting machines?

Process control monitoring requires a considerable capital investment but can greatly assist in developing successful processes on die casting machines.

Five of the facilities audited utilize some type of process monitoring equipment and achieve a fair amount of success with it. The other five facilities indicated that they have investigated the use of the monitoring equipment, but due to the high capital investment the equipment had not been pursued.

6.8 Are castings weighed on a periodic basis as a quality control measure?

Only fifty percent of the ten facilities stated that periodic weighing of casting is used to ensure casting quality. Castings weighing less than the specified weight can frequently result in scrap at the customer location. The scrap casting most generally is the responsibility of the die caster and the result is that a replacement casting has to be provided to the customer. The result is lost revenue and increased energy consumption for having to recycle the scrap casting and producing a replacement.

If the casting weight is more than what the customer specification calls for, the die caster is losing profit by “giving away” material. When one considers a few ounces of material in every casting sold, and the volume of castings sold is in the thousands or tens of thousands, it is easy to see the amount of profit that is being given away.

7.0 Die Technologies

Summary Comments

The significance of insuring that die steels are produced and heat treated/stress tempered to strict specifications is extremely important in the die casting industry. Die casting tool is very expensive and the steel used in die casting dies undergoes significant heat cycling with every casting produced. Die temperature ranges fluctuate several hundred degrees when each shot of molten metal is injected into the die cavity under high pressure and then cooled quickly when the casting is removed from the die.

Most all die casters purchase tool steel from highly reputable suppliers and rely on the suppliers expertise to supply top quality products, produced to rigid specifications. Likewise, when die casting tools require rebuilding or refurbishing,

die casters also rely on heat treating operations to bring the steel back to the proper specifications.

If tool steels are not produced or heat treated properly the life of the tool can be greatly reduced. Therefore the die caster must take proper measures to ensure that the producer or heat treating operation maintains the stated specifications.

7.1 If required heat treating/stress tempering of dies is required at the time of refurbishment or rebuild does the facility provide the heat treating facility with written specifications for the heat treatment?

See answer to 4.30

7.2 If the facility does not specify the heat treatment process is the process the responsibility of the heat treat facility?

Sixty percent of the facilities answered “Yes”, twenty percent answered “No” and twenty percent answered that it did not apply to them.

7.3 Are certified samples of die steels required by the facility of all die steel purchased?

See answer to 4.31

8.0 Process Technologies

Summary Comments

All facilities that participated in this program have made concerted efforts toward improving the production processes and have shown satisfactory results. The audits helped the facilities to become more aware of the benefits of keeping informed of the technological developments being made through NADCA's research and development efforts.

8.1 Does this facility monitor cooling water temperatures?

Large fluctuations in the temperature of die cooling water that is outside process parameters can potentially cause problems in the casting process and can contribute to product scrap, premature die casting machine and tooling failure.

8.2 Does this facility maintain records on cooling water temperatures?

Recording keeping can assist the die caster in trouble shooting problems associated with the production of die castings.

8.3 *How many "start-up" shots are most generally made at the beginning of a die casting production run? (5 - 10 ____, 10 - 15 ____, 15 - 20 ____, **More than** ____.)*

Start-up shots are the number of castings produced at the time of starting a die casting machine after it has been idled for some period of time such as after a machine shutdown for replacing dies, maintenance, or after a weekend or holiday shutdown. The shots are scrapped. Therefore, it behooves the die caster to work to produce the fewest number of start-up shots as possible to: 1) conserve energy, 2) reduce wear and tear on the die casting machine and die, 3) reduce the amount of metal loss; 4) improve the number of good castings produced.

8.4 *Does this facility utilize more than one die casting lubricant in its die casting process?*

Two facilities used one lubricant, seven facilities used two lubricants and one used three.

8.5 *If this facility uses more than one die casting lubricant, how many are used? (**Please list the number of lubricants used.** _____.)*

The facilities that used two or three lubricants in their casting processes produced multiple alloys such as zinc, magnesium and aluminum. It is not uncommon in the industry for die casters to use more than one die lubricant due to the nature of the alloy being used to produce castings or to some issues encountered with a particular casting design.

The fewer lubricants required helps to reduce the amount of energy required to mix and maintain the lubricants. Two types of lubricant may require more than one batching system and hence multiple pumps, transfer systems and associated equipment.

8.6 *What is the ratio of water to die lubrication used in the die casting process? (**Please indicate the ratio of water to lubricant:** _____).*

Each facility has expended considerable amounts of time and effort in determining the best lubricants and mixtures for producing their particular products. The ratio of water to die lubricant concentrate varied with each location but all were within the normal ratios generally used in the industry.

The reason for the question was that it has generally been proven in the die casting industry that high ratios of water to lubricant material works well in the production of many die casting products and reduces the cost of the lubricant concentration. Ratios of water to lubrication concentration from 80:1 to 100:1 are quite common.

8.7 Does this facility use synthetic lubricants?

All facilities use synthetic lubricants in their processes.

9.0 Waste Management

Summary Comments

All facilities audited have spent time and effort in researching the potentials for cost savings concerning utilizing waste materials. Some possibilities were noted during the audits for potential savings to some degree. In all cases, capital investment would be required.

All facilities properly maintained the required records where necessary to meet local, state and federal requirements for disposing of materials.

9.1 Does this facility process the waste water it generates?

Six of the facilities audited process the waste water it generates. The remaining four either did not use large amounts of water or found processing costs to be too high to warrant purchasing, installing and operating the processing equipment.

*9.2 If "No", how is the water processed? (**Public Waste Treatment**____, **Hauled off-site for disposal**____.)*

The three facilities that have their water process off-site utilized public waste treatment or approved disposal sites.

9.3 Does this facility process the solid waste it generates?

The common reason for all but one facility not processing the solid waste it generates is that it was more economical to have it processed off-site.

The reason for this question was to determine whether it would be feasible for the facilities to utilize various solid wastes for use in reducing energy use. Two such instances could have been the installation of a trash compactor to compact cardboard and paper for re-cycling or to install/or convert a boiler system to utilize combustible materials for fuel.

*9.4 If "No", how is the solid waste processed? (**Landfill**____, **Other**____.)*

The degree of solid waste varied with each operation. In almost all cases the solid waste was taken off-site to land fills.

9.5 Does this facility re-circulate and re-use die lubricants?

Only one facility re-circulated and re-used die lubricants. The other facilities did not re-circulate due to various reasons such as not having a central collection system for all die casting machines, or that re-circulation had been investigated and found to be uneconomical to pursue.

9.6 Does this facility re-circulate and re-use hydraulic oils?

Only four of the facilities re-circulated hydraulic oils. The main reasons for not re-circulating was stated as being too difficult to capture, not enough waste oil to make the re-circulation economical and the oil had too much die lubricant and other materials mixed with the oil.

9.7 Does this facility re-circulate and re-use machining coolants?

Five of the facilities audited re-circulate and re-use machining coolants. The remaining five either do not have enough machining coolants to make the re-circulation economical or they do not perform machining.

9.8 Does this facility maintain records on solid waste disposal? (If "Yes", please provide copies.)

Where required, all facilities maintain records on solid waste disposal in accordance with state, federal and local requirements.

DISSEMINATION OF INFORMATION TO THE INDUSTRY

Information on the development of the electronic NADCA Energy Assessment Tool as well as the information derived from this project will be disseminated to the die casting industry in the form of articles in the NADCA Die Casting Engineer and LINKS magazines and newsletters. Information will be posted on the NADCA website along with the assessment tool. The assessment tool is available for download from the website and on CD-ROM. Broadcast e-mail and fax notifications concerning the availability of the tool will also be accomplished by NADCA. After the close of the project, NADCA will consider an assessment service for plants that may need assistance in utilizing the tool and procedure established through the project effort.

A transaction paper concerning the energy program and assessment tool was presented at the 2006 NADCA/AFS Metalcasting Congress in May, 2006 at Columbus, Ohio. Other distribution of information concerning the program will occur at the NADCA Plant Managers Conference in September 2006 and future NADCA/AFS Metalcasting Congresses. In addition, the NADCA Energy Savings Manual publication has been updated with information from this project and is available through NADCA Publications.

CONCLUSION

Die casting is a highly technical process with over one hundred parameters that must be controlled to produce quality castings. The process relies heavily on thermodynamics, fluid mechanics, heat transfer, metallurgy and other characteristics to operate. As was explained in the introduction of this report, every one of these characteristics utilizes energy in one way or another. Depending on how the die casting process is controlled, energy use can be used wisely and efficiently or wasted.

Opportunities for energy savings are available in every die casting operation that have the potential for allowing the facilities to achieve 7-12% and possibly higher in energy reductions and cost savings. A commitment of resources and personnel to implement the recommendations provided in the plant assessments will assist the facilities to achieve some of these savings.

The implementation of programs that are well founded on a management strategy that first includes a strong commitment from senior management in each organization to place energy conservation as a priority equal with customer satisfaction, quality, safety, and financial success is imperative. Next, a program needs to be developed and implemented to realize the goals. All personnel must understand the organizations goals. Support from management in the form of training personnel as well as other means necessary to achieve the goals. Specific individuals must be given the responsibility and be accountable for seeing that the program stays on track.

Without knowing where and how much energy is being consumed it is quite difficult to control use. Therefore, the installation and utilization of metering devices to track use is essential. Knowledge of the amount of energy being used at the end of a reporting period is too late to do much about controlling use on a real time basis. Utilizing metering devices will allow quick action to be taken to rectify problems. Justification for the capital expense of purchasing (or leasing) and installing meters may be made through the energy savings achieved through the use of the meters.

Die casters need to take actions to enhance energy efficiency and conserve energy by constant follow-up, seeking new and improved methods for energy conservation and keeping abreast of new and emerging technologies that will assist in the success of the programs. Utilization of resources such as those provided by the U.S. Department of energy, NADCA, energy and equipment suppliers, Industrial Assessment Centers and contract experts in the field of conservation can be very beneficial to the die caster.

DEFINITIONS

The following is a brief list of die casting term definitions contained on the assessment tool and in this report. A complete list of definitions is contained in NADCA's *Dictionary of Die Casting Terms*.

Alloy – A substance having metallic properties and composed of two or more chemical elements, of which at least one is metal. Alloy properties are usually different from those of the individual alloying elements.

Biscuit – The cylindrical plug of metal formed by excess metal in the shot sleeve of a cold chamber machine

Casting – The product that results from the solidification of molten metal in a mold or die.

Casting Cycle – The total number of events required to make each casting. For die castings, the casting cycle generally consists of solidification time, machine movement and sequencing time and the operator's manual movements.

Casting Extractor – A mechanism that automatically and/or manually reaches into the space between an opened die casting die, grips the cast shot, pulls the shot free of the ejector pins and removes it from the die area.

Casting, Removing Stuck – The process of removing a casting that was not ejected from the die. A casting bent or stuck in the die may require chiseling and melting of the casting and must be done with great care to avoid damage to the die cavity

Cavity Surface – The surface of the die casting die that forms the casting

Cold Chamber Die Casting Machine – A die casting machine in which the injection mechanism is separated from the reservoir of molten metal at the machine.

Core – A part of a die casting die that forms an internal feature of the casting and is a separate piece from the cavity. A core may be fixed in a stationary position relative to the cavity or may be actuated through some movement each time the die is opened.

Cover Gas – A mixture of gas and air used to protect and minimize oxide formation on the surface of molten metal.

Creep – Plastic deformation of metals held for long periods under stresses less than the normal yield strength.

Creep Resistance – The unit stress that will cause a specified amount of creep in a given time at a constant temperature.

Die – The tooling used in a die casting machine for imparting the shape to the casting.

Die Area - The area located between the two halves of the die casting die when the die is in an open position.

Die Life – The number of usable castings that can be made from a die before the die must be replaced or extensively repaired.

Die, Locking – The application of force by the die casting machine upon the die casting to hold the two halves of the die together when molten metal is being injected into the die cavity.

Die Materials – The materials that are used to build dies. These materials are primarily tool steels.

Die Release Agent (Die Lubrication) – A chemical substance sprayed on the die faces to facilitate removal of the casting from the die cavity.

Dross – Metal oxides in or on the surface of molten metal.

Ejector Pins – Pins attached to an ejection plate on the die casting die used to move the casting from the die cavity upon the metal solidification cycle.

Hot Chamber Die Casting Machine – A die casting machine in which the injection mechanism is immersed in a reservoir of molten metal at the machine.

Ingot – A mass of die casting alloy or metal cast into a convenient shape for storage, shipping and melting.

NADCA – North American Die Casting Association

Parting Line – The surface formed by the separation of the die halves.

Shot – The injection of metal into the die cast die.

Shot Sleeve – A tube-like component used in a cold chamber die casting machine into which molten metal is poured and forced into the die cavity.

Sow – A large ingot usually weighing over 1000 pounds.

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