CERP

Casting Emission Reduction Program
www.cerp-us.org

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Energy Reduction Projects

Technikon # 1411-815

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United States Environmental Protection Agency
CISA
AFS
UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH
USCAR
DaimlerChrysler Ford Motor Company General Motors

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Energy Reduction Projects

Technikon # 1411-815

This report has been reviewed for completeness and accuracy and approved for release by the following:

Senior Facilities Engineer	*// Original Signed //*	
	Miles Johnson	Date
V.P. Operations	*// Original Signed //*	
	George Crandell	Date

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Executive Summary:

Technikon formed an energy committee from participating CERP companies and participants. The goal of this committee is to review and evaluate methods and technologies within the foundry industry which could have a positive energy impact and life cycle benefits for the production of metal castings. Included in this study is the evaluation of energy and new manufacturing technologies that have the potential to reduce life cycle costs of foundry operations.

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1.0 INTRODUCTION:

1.1. Background:

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Research Consortium (ERC), a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC); the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). The US Environmental Protection Agency (US EPA) and the California Air Resources Board (CARB) also have been participants in the CERP program and rely on CERP published reports for regulatory compliance data.

1.2. Technikon Objectives:

The primary objective of Technikon is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing arena has been specially designed to facilitate the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. Report Objective:

This report documents the evaluation by the energy team of multiple projects and the ultimate selection of two energy savings projects and one subject for a paper:

- Improved Ladle Preheat System
- Plasma Treatment Casting
- Foundry of the Future Roadmap

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2.0 COMMITTEE FORMATION:

2.1. CERP Committee Members:

An energy committee was formed from participating CERP companies and participants with the goal of evaluating methods and technologies that would lead to reduced energy costs and environmentally friendly foundry practices. The core membership of the committee included:

George	Crandell	Technikon, LLC
Cliff	Grupke	Daimler-Chrysler
Vic	LaFay	Hill and Griffith
Gary	Mosher	American Foundry Society (AFS)
Mark	Osborne	General Motors (GM)
Jim	Schifo	KERAMIDA Environmental, Inc
Steve	Sikirika	Gas Technology Institute (GTI)
Rob	Stork, Chairman	General Motors (GM)
John	Sullivan	General Motors (GM)
Alex	Voronel	VIG Industries
Michael	Wrazen	US Army
Bill	Ziemba	Ford

2.2. Meeting Schedule

The energy team meetings were held as shown in Table 2-1.

Table 2-1 Energy Team Meeting Schedule

Meeting Date	Meeting Location
November 8, 2004	conference call
December 21, 2004	conference call
January 26, 2005	Gas Technology Institute, Des Plaines, IL
February 17, 2005	Technikon, LLC, McClellan, CA
June 15, 2005	Gas Technology Institute, Des Plaines, IL
September 14, 2005	GM – CDVC, Saginaw, MI

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3.0 ENERGY PROJECT EVALUATION AND SELECTION

3.1. Historical Uses of Energy in Foundries

To achieve the optimal return of investment, the committee focused on potential energy savings projects that were derived from the identification of how energy is used within the foundry industry:

- Primary Use - 70 to 80 % of a foundry's energy:

  1. Melting (studies suggest 55% of total)
  2. Heat treating operations (if existing)
  3. Ladle heating operations

- Secondary Use:

  1. Cleaning and finishing operations
  2. Mold and core making
  3. Molding line equipment
  4. Sand handling, cooling, and reclaim
  5. Dust fume collection
  6. Compressed air systems
  7. HVAC
  8. Process cooling water systems
  9. Domestic hot water heating systems

3.2. Projects Considered

1. Regenerative burners
2. Dehumidification of blast air for cupolas
3. Indirect heating
4. Lost foam quench at dump station
5. Reduce exhaust volumes

6. Determine dew point temperatures of pouring, cooling and shakeout and control exhaust volume
7. GM Bond® core binder system
8. Compressed air usage reduction
9. Process water reduction in lost foam molding
10. Waste heat recovery
11. Benchmark study on foundry energy use
12. Air heating and movement.
13. Elimination of melting by locating foundry near a steel mill
14. Off-site melting for aluminum
15. Foundry of the future low emission/low energy technology applied to sand ductile iron and precision aluminum areas
16. Immersion tube heater element evaluation
17. Improved ladle preheat system
18. Plasma treatment of casting risers

3.3. Selected Projects

3.3.1. Improved Ladle Preheat System:

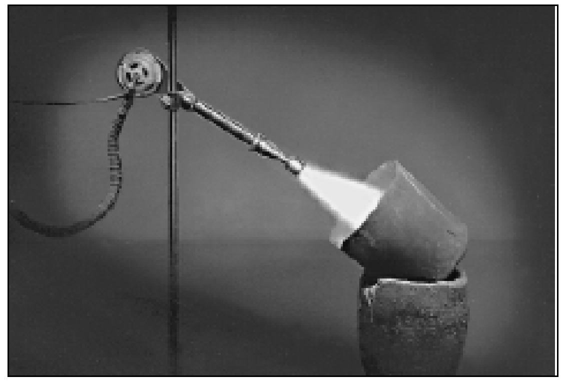
3.3.1.1. *Scope*

The objective of this project is to reduce natural gas usage to preheat ladle prior to metal being transferred with a more energy efficient ladle preheating system.

Ladle preheating is necessary in order to have metal that is at the suitable pouring temperature. A room temperature ladle significantly chills molten metal and radiation losses from a ladle holding molten metal are very substantial. Consequently, the foundry compensates for the heat loss by pre heating the pouring ladle and superheating the metal in the melting or holding furnace, so that when the ladle gets to the pouring station, the metal is at the correct temperature.

Preheating of ladles with natural gas is a common method of sustaining the correct temperature (Figure 3-1). Preheating the ladle however, consumes a considerable amount of natural gas. This is a wasteful practice that consumes energy. The full extent of the wasted energy becomes apparent when the cumulative effect of the many ladle transfers are considered over the course of a year. Other costs accrue due to chills and increased scrap levels from pouring low temperature iron.

Figure 3-1 Natural Gas Ladle Preheater



3.3.1.2. *Anticipated Benefits*

Natural gas savings ranging from 10% to 30% can accrue depending on plant practices and present equipment.

3.3.1.3. *Implementation Plan*

In an effort to make the preheating process more energy efficient, Technikon proposes that this project be considered for the 2005 CERP effort. If the project is approved, Technikon, LLC will:

- Lead and coordinate a nine-month program whereby a prototype Improved Ladle Preheating System will be designed, engineered, and field-acceptance tested at the vendor site and then shipped to GM Power Train located in Defiance, Ohio for field testing.
- Provide an Eclipse Preheater System which has the potential of being partially integrated into the prototype Ladle Preheater to be supplied by the vendor.
- Document base line information at the GM Power Train Site.
- Document energy-use, emissions and preheating-cycle information at the GM Power Train Site.
- Prepare a final technical report.

3.3.2. Plasma Treatment Casting

3.3.2.1. *Scope*

Netanya Plasmatec, LTD. has developed a Plasma Treatment Casting (PTC) process (Figures 3-2 and 3-3) that uses a plasma generator to improve the yield and quality of castings through supplying extra heat to the metal in the mold. For aluminum casting, the improved yield has the potential to save energy because the riser size can be reduced by up to 70% (Figures 3-4, through 3-6).

Additionally the process is particularly useful for improving the quality of ferrous cast metal ingots, bars, billets, blooms and slabs. Plasmatech's PTC method combines and integrates the following treatment methods to affect the metal during its crystallization in the mold:

- Influence of concentrate energy source.
- Intensification of heat exchange in liquid metal.
- Controlled heating of the metal in specific ingot regions.
- Hot isolation of top portion of the ingot.
- Super-position of the electromagnetic fields: Longitudinal, Transversal and Rotational.
- Blowing the melted metal with ionized gases.
- Gas pulsation inside the melted metal.
- Nucleation.

Figure 3-2 Natural Gas Ladle Preheater

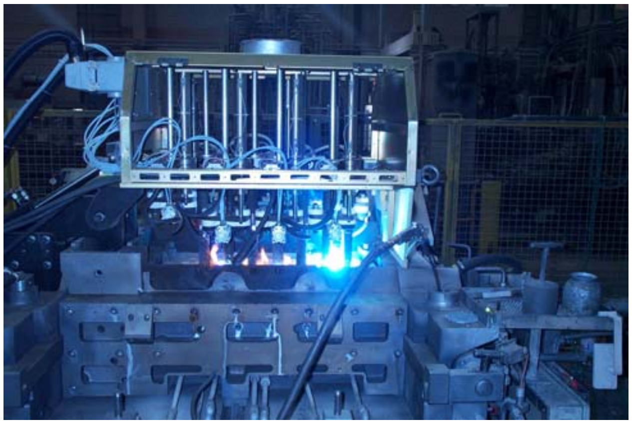


Figure 3-3 PTC System with Exhaust Hood in Semi-Permanent Molding Machine

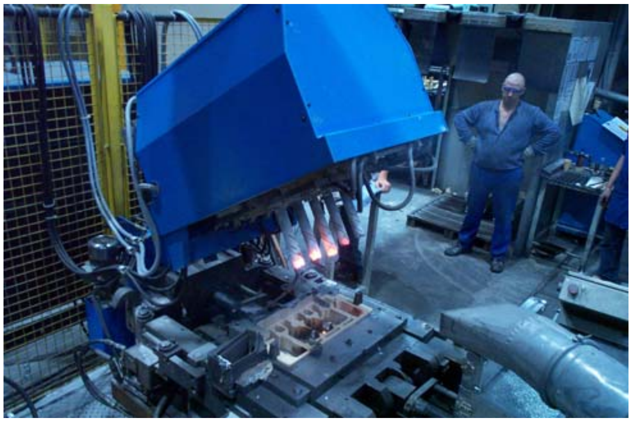


Figure 3-4 Reduction of Riser Mass by 70% by Reducing Risers From 19kg to 6kg and Reducing Total Casting Weight from 39kg to 26kg

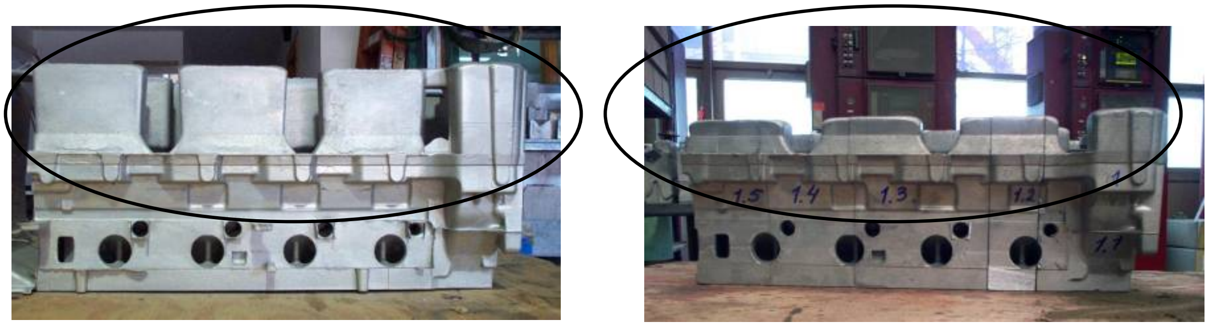


Figure 3-5 Saving 17kg of the riser's mass. Casting 37kg Instead of 54kg for the Same Net Product

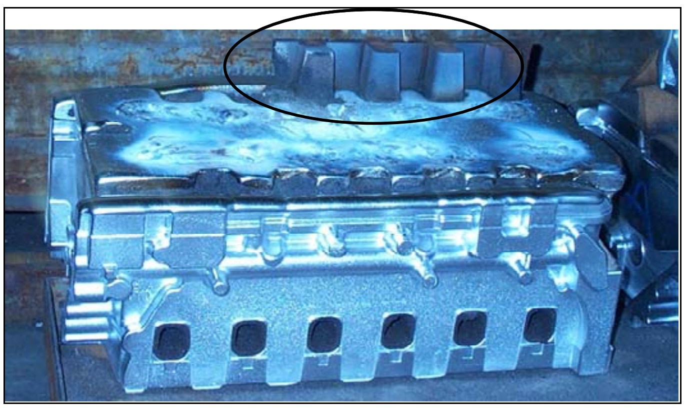
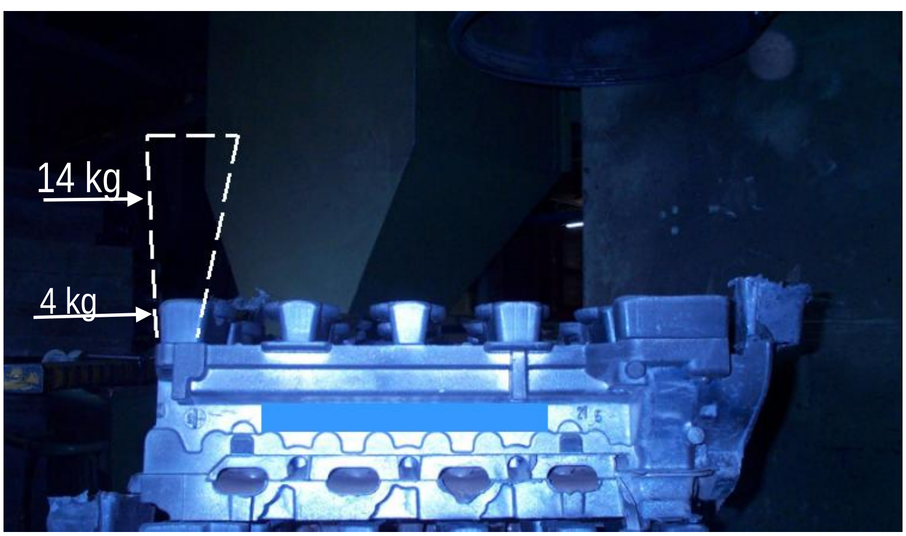


Figure 3-6 Saving 10% of the Riser's Mass Reducing Casting Weight from 36kg to 26kg



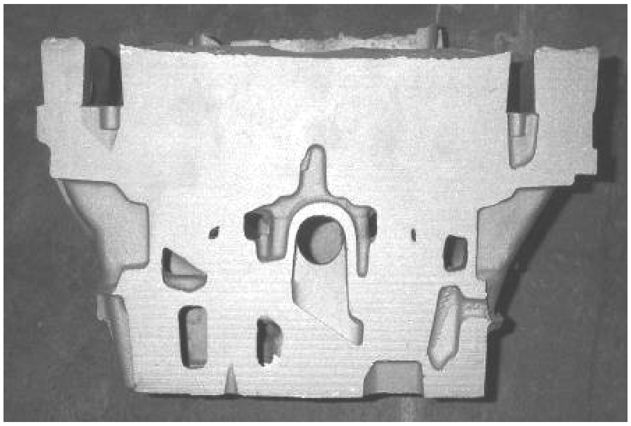
Current riser is 4 kg. Previously (white dashed line) the riser was 14 kg.

3.3.2.2. *Anticipated Benefits*

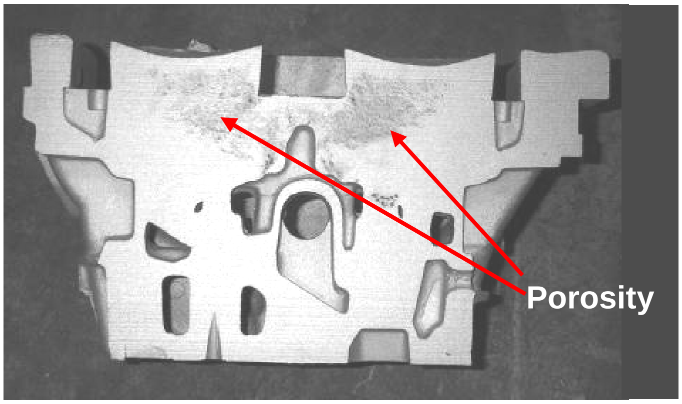
Preliminary test results indicate several improvements both in aluminum castings and steel ingots as a result of the PTC process. The method is also promising for other metal treatments, including most casting methods such as lost foam casting, continuous casting and semi continuous casting. It is anticipated that the PTC process will achieve multiple business advantages over conventional methods by:

- Reducing energy consumption
- Eliminating shrinkage blowhole.
- Eliminating internal and external cracks
- Eliminating porosity (Figure 3-7).
- Reducing segregation and grain size
- Structure refinement
- Producing higher quality end products with improved mechanical properties.

Figure 3-7 Cylinder Head with and without PTC Process



Section View of Cylinder Head Treated With PTC Process



Section View of Cylinder Head without PTC Process

3.3.2.3. *Implementation*

To test these processes Technikon, LLC proposes that this project be considered for the 2005 CERP effort

- Over see testing of the Plasmatic system at GM Casting Development and Validation Control (CDVC) in Saginaw, Michigan.
- Prepare final technical report.

3.3.3. Foundry of the Future

3.3.3.1. *Scope*

Global foundry environmental criteria discussions lead to the concept of defining foundry operations that would include the most environmentally sound technologies. The following is a description of the processes that would be considered:

Melting Department

- Use of clean scrap for melting operations
    - Use of low hazardous air pollutants (HAP) containing metals and organics in iron and steel
    - No mercury switches or lamps
    - No wheel lead counterweights
    - Scrap Inspection program (on-site or at scrap supplier location.)

- Melting Equipment
    - Electric Induction Furnace
        - Use of low HAP, low volatile organic compound (VOC) containing iron and steel scrap
        - Use of baghouse for particulate material (PM) emission control
        - Designed abatement requirement – < 0.005 gr. / dry standard cubic feet (dscf)

    - Cupola
        - The use of dry cupola slag handling system
        - Use dry dust collection system with dust treatment
        - Optimal use of water as a cooling medium
        - Energy recovery of cupola wetcap / shell cooling water
        - Use of a high temperature baghouse with dust treatment
        - Designed abatement requirement: < 0.005 gr. / dscf

- Electric Arc Furnace
  - Use clean scrap
  - Use dry baghouse meeting 0.005 gr./dscf and full capture hood system capture

Foundry Department

- Use of a dry baghouse on the pouring and cooling lines and shakeout for PM emission control. Designed abatement requirement – < 0.005 gr. / dscf.
- Seacoal replacement products for greensand molding systems
- Selection and use of sand additives that reduce the emission of HAPs and VOCs
- Advanced Oxidation (AO) system for sand cooling and mixing

Core Room

- Use of low emission or inorganic binder systems
- No triethylamine (TEA) scrubber systems would be required
- Sand Reclamation: All scrap core sands should be able to be easily reused without thermal reclamation

Heat Treat Department

- Minimized heat treat of castings through use of in-mold cooling methods

Finishing Department

- Control exhausts from grinders and shot blast cleaning units to <0.005 gr/dscf
- Potential of HEPA filtration to reuse air back into facility (cold weather climates only)

Energy Use

- An energy management system is to be in place to reduce/conserve energy use within the facility to minimize the affects of energy production on the environment

Water Pollution Control

- Process cooling systems should use closed loop with no discharge

Solid Waste Management

- All waste should be profiled and disposed of in a manner that protects the environment and meets local disposal/reuse requirements
- By using clean scrap and reduced organic systems, solid waste will not be hazardous leading to improved recycling opportunities

Hazardous Waste Management

- All waste should be profiled and disposed of in a manner that protects the environment and meets local disposal/reuse requirements
- Pollution prevention programs should be in place to reduce or eliminate hazardous waste

Toxic Release Inventory Management

- An accounting of all toxic releases should be kept by the facility and a program in place to eliminate or minimize toxic releases
- Selection of less toxic core binders and sand additives should minimize reporting requirements

3.3.3.2. *Anticipated Benefits*

- This study provides a road map for foundries to follow leading to environmentally friendly operations based upon green technology

3.3.3.3. *Implementation*

- Technikon, LLC proposes that this project be considered for the 2005 CERP effort to study and calculate potential cost of operation for the "Foundry of the Future" and to document the hurdles to be overcome to reach this goal

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4.0 SUMMARY

The Technikon Energy Team has been meeting since November 8, 2004 and has developed three proposals:

- Plasma Treatment Casting (PTC) demonstration project to improve the yield and quality of castings with a concomitant reduction in energy costs.

- Improved ladle preheating system prototype project to develop a more energy efficient ladle preheating system.

- Foundry of the future project to study and calculate the potential costs and document the hurdles to overcome to reach this goal.

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APPENDIX A ACRONYMS AND ABBREVIATIONS

AO Advanced Oxidation system

CDVC Casting Development and Validation Control, General Motors, Saginaw Michigan

dscf dry standard feet

gr. Grams

HAP Hazardous Air Pollutants

HVAC Heating, ventilation and air conditioning

GM General Motors

PM Particulate Material

PTC Plasma Treatment Casting

TEA Triethylamine

VOC Volatile Organic Compound

HEPA High Efficiency Particulate Arresting