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Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988

Annual Report of the Metals Initiative For Fiscal Year 1996

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Office of Industrial Technologies
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EXECUTIVE SUMMARY

The Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988, commonly referred to as the Metals Initiative, was signed into law on November 17, 1988 (Public Law 100-680). The Act (15 U.S.C. 5101 et seq.) has the following purposes:

- increase energy efficiency and enhance the competitiveness of the American steel, aluminum, and copper industries; and

- continue research and development efforts begun under the U.S. Department of Energy (DOE) program known as the Steel Initiative.

As required by section 8 of the Act, the Secretary of Energy has prepared this annual report for the President and Congress describing the activities carried out under the Act during fiscal year 1996 (15 U.S.C. 5107). These activities are summarized in the remainder of this executive summary and are detailed in a subsequent section. Other sections describe the appropriation history, the distribution of funds through fiscal year 1996, and the estimated funds necessary to continue projects through fiscal year 1997. Participants in the Metals Initiative projects have provided the requisite non-Federal cost-sharing for each project, as discussed in the chapter on industry cost-sharing.

During fiscal year 1996, the Metals Initiative supported four research and development projects with the U.S. steel industry:

- Steel Plant Waste Oxide Recycling and Resource Recovery by Smelting with American Iron and Steel Institute (AISI);

- Electrochemical Dezincing of Steel Scrap with Argonne National Laboratory and Metal Recovery Industries (U.S.), Inc.;

- Rapid Analysis of Molten Metals Using Laser-Produced Plasmas with Lehigh University; and

- Advanced Process Control with AISI.

There are three Metals Initiative projects with the aluminum industry:

- Evaluation of TiB2-G Cathode Components with Reynolds Metals Company;

- Energy Efficient Pressure Calciner with the Aluminum Company of America (Alcoa); and

- **Spray Forming of Aluminum, also with Alcoa.**

Steel Projects

The **Direct Steelmaking Project,** concluded in March 1994, developed a potential replacement for the coke oven/blast furnace process used to produce molten pig iron. The process performance is optimized by the use of coals containing lower levels of volatile matter and low gangue content iron ore pellets. A proposal was received for scale-up of the direct ironmaking process, however, funding from the DOE was not available. The developments led to the **Steel Plant Waste Oxide Recycling and Resource Recovery Program** described below. The pilot smelter developed for the Direct Steelmaking Program was modified to demonstrate its utility for the Steel Plant Waste Oxide Recycling and Resource Recovery by Smelting Program. The experimental program, completed in December 1994, demonstrated the complete conversion of all forms of steel plant waste oxides, including those high in zinc, to useful products. The products are molten pig iron, slag for roadbed or cement production, clean off-gas as fuel, and a zinc-rich raw material for the non-ferrous industry. The pilot plant trials have established that savings to the extent of 25 percent of energy used in the blast furnace and coke oven processes to produce hot metal are achievable in this process. An AISI proposal for a commercial demonstration plant to convert 500,000 metric-tons-per-year of waste oxides to 250,000 metric tons per year of hot metal was submitted to the DOE in April 1995, but funding was unavailable. Although the experimental work was completed in December 1994, efforts by the industry are continuing to seek means for implementing the technology on a commercial scale.

The objective of the **Electrochemical Dezincing** of Steel Scrap project is to design, construct, and operate a commercial dezincing plant to demonstrate a two-step process for the continuous dezincing of steel scrap. The products from this process are clean, dezinced steel scrap and metallic zinc. A scrap dezincing process could save the Nation approximately 50 trillion BTUs of energy per year. The operating cost benefits to the steel industry are estimated to be $140 million per year compared to the cost of using non-scrap sources of iron units. Additionally, the United States could realize a $100 million decrease in foreign exchange deficit through the reduction of need for zinc imports. The process also has major environmental benefits. The removal of zinc from steel scrap increases the recyclability of steelmaking dust and eliminates zinc from waste water streams. During fiscal year 1996 the owners of the industrial corporate partner dismantled and refurbished the pilot plant and installed a new rotary leaching system increasing plant capacity to 60,000 tons/year. The plant was operated for the dezincing of scrap steel and electrolytic recovery of zinc. Reports were delivered from sub-contracts let in fiscal year 1995 for the cost estimate for a 150,000 ton/year green field dezinc facility and for an evaluation of an alternate leaching system. A patent was applied for and the industrial partner contracted with the University of California Berkeley to conduct research on the development of a fluid bed zinc recovery system. During the year, an electrochemical processing facility was used to test bipolar cell designs and to test electrochemical removal of copper from the caustic on a larger scale.

The objective of the project on **Rapid Analysis of Molten Metals Using Laser-Produced Plasmas** is to develop a sensor-probe that will rapidly determine the chemical composition of molten iron and steel through spectroscopic analysis of laser-produced plasmas. Widespread use of this probe by the carbon steel industry could save approximately 10 trillion Btu per year and could reduce operating costs by $450 million per year. In fiscal year 1996, several new requirements that surfaced while selecting the host site and quantifying the site parameters were addressed. These were fully accommodated, resulting in a number of significant design modifications. As a result, a factor of ten or more reduction in the measurement uncertainty for elemental concentration has been achieved. A commercial probe manufacturer has been selected, and full manufacturing and marketing activity was expected to commence after the deployment of the probe system. The probe technology has been developed to the point that technical risks have been minimized. Further development decisions should be made by the commercial sector on its own without further Federal financial assistance.

A cooperative agreement between DOE and the AISI for the **Advanced Process Control Program** was signed April 29, 1993, initiating this five-year, $23 million program. The program consists of six diverse sensor and control system research tasks that focus on many aspects of steelmaking, with the common goal of on-line measurement of critical product properties. This project brings together the collective resources and capabilities not only of DOE and the steel industry, but also of universities, national laboratories, and advanced technology companies. The successful development of sensor and control system technologies will increase the competitiveness of the domestic steel industry by reducing annual production costs approximately $146 million, which includes an annual energy savings potential of 6.13 trillion Btu. Each project has an independent management structure consisting of a research partner, a steel company that provides technical guidance and in-plant testing of prototypes, and a commercialization partner that markets the technology. This structure will optimize the development and commercialization of the resulting new technologies. During fiscal year 1996, numerous upgrades of a user-friendly computer model for hot rolling plain carbon steels were released to the participants. Another commercial sensor to measure microstructural phases in coated steel was installed at Stelco, Inc. Feedback from the participating companies is being used to upgrade and improve the gauges.

Aluminum Projects

The objective of the **Evaluation of TiB2-G Cathode Components** project is to demonstrate the technical and economic benefits of electrolyzing alumina in commercial cells equipped with graphite-containing titanium diboride (TiB2-G) cathodes. Retrofitting existing alumina reduction cells with wettable cathodes has the potential to save 0.1 quadrillion Btu per year. The first cell began operation at the Kaiser Aluminum, Mead, Washington plant in February 1993 and experienced excessive breakage of cathode elements resulting in modification of element fabrication techniques and redesign of the cell insulation. During fiscal year 1996, a second test cell was constructed including installation of cathode elements, cell start up, cell operation, and cell performance evaluation. Operation of the second cell revealed TiB2-G element breakage similar to that experienced in the first cell. However, cell performance evaluation documented an actual eight percent energy savings in the test cell compared to a Kaiser standard cell with no loss of aluminum production even with reduced element coverage of the anode resulting from the excessive breakage (estimated anode coverage was 40 percent compared to 63 percent target coverage). Further work will determine the causes of element failure and ways to improve element life.

The **Energy Efficient Pressure Calciner** project was started in April 1994. The objective of the project is to develop a process/device, ready for commercialization, to calcine alumina for the Hall-Heroult process. The first part of the project consists of installation of a pilot unit to demonstrate the mechanical reliability of components. Additionally, design and operating data will be obtained for a semi-commercial unit that will be installed subsequently. Changes in methods of operation of the smelters and improvements to the alumina calcination processes are expected to save the industry $160 million annually and 0.01 quadrillion Btu per year. Work during fiscal year 1996 included self-fluidization and production of the first material by the unit. Considerable operating experience was gained during the year. It is anticipated that the project will be completed by the end of the second quarter of 1997.

In April 1994, the Department of Energy entered into a cooperative agreement with Alcoa for the **Spray Forming of Aluminum** project. This five-year process development project will demonstrate the technical and economic viability of manufacturing aluminum sheet by spray deposition. This will be accomplished through pilot-scale, proof-of-principal demonstration tests for the production of commercial automotive sheet alloys, the development of an investment strategy for technology transfer and a plan to commercialize the technology. Industry savings up to $27 million per year are estimated for spray-formed aluminum sheet production. Energy savings up to 0.19 quadrillion Btu per year can be achieved with increased use of aluminum for lightweight automobile structures made possible with spray forming. During fiscal year 1996, Alcoa performed R&D at a much reduced pace due to its budgetary constraints. A major emphasis of this program continues to be the characterization and optimization of the linear nozzle system. Parallel spray characterization work occurred at Carnegie-Mellon University and the University of California - Irvine. Emphasis was given to the microstructural characterization of deposits to quantify porosity, constituent particle size, and grain size. Work was also performed to develop computer models for various aspects of the spray forming process. These models will aid future research, providing operating windows for spray runs and in the design of an Advanced Development Unit, which replaces the Pilot Scale Unit in the original proposal.

The steel and aluminum industries generate large quantities of solid, liquid, and gaseous by-products. Metals Initiative technologies can reduce pollution by saving energy and increased recycling. The annual reduction of 0.31 quadrillion Btu is equivalent to reducing carbon dioxide emissions by 63 million tons per year. Metals Initiative technologies improve product yield, thereby maximizing the total quantity of steel and aluminum produced from a given raw material. Increased recycling is the objective of both the Steel Plant Waste Oxide Recycling and Electrochemical Dezincing projects.

INTRODUCTION

The Department of Energy's Metals Initiative Program managed by the Office of Industrial Technologies is a result of the Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988 (15 U.S.C. 5101 et seq.). The Act has the following purposes:

- increase the energy efficiency and enhance the competitiveness of American steel, aluminum, and copper industries, and

- continue steel research and development efforts begun under the DOE program known as the Steel Initiative.

The Act directs the Secretary of Energy (the Secretary) to re-establish an industrial energy conservation and a competitive technology program to conduct scientific research and development of steel and aluminum technologies. The Act also directs the Secretary to publish an update of the program's management and research plans. The term "management plan" in the original Act refers to the Steel Initiative Management Plan issued in April 1987, and the term "research plan" refers to the Steel Initiative Research Plan issued in April 1988. Consistent with statutory amendments, these plans were updated to include information on the aluminum and copper industries. They were reissued and transmitted to Congress on August 18, 1989, as the Metals Initiative Management and Research Plans. No revisions were made to either plan during fiscal year 1996.

The Metals Initiative Management Plan describes policies and practices that the Department of Energy follows in implementing the program. It defines the roles and responsibilities of organizations involved in the program, which include industry, national laboratories, and universities. The Metals Initiative Research Plan identifies and establishes priorities for research and development activities to increase the energy efficiency and enhance the competitiveness of the domestic steel, aluminum, and copper industries.

Section 8 of the Act requires that the Secretary of Energy prepare and submit to the President and the Congress a complete report of the research and development activities carried out under the Act at the close of each fiscal year. This eighth annual report on the Metals Initiative Program describes research and development activities conducted during fiscal year 1996. This report also describes the actual distribution and anticipated obligation of funds for such activities.

DETAILED REVIEW OF RESEARCH AND DEVELOPMENT PROJECTS

During fiscal year 1996, the Metals Initiative included four research and development projects with the steel industry and three projects with the aluminum industry. The four projects with the steel industry and the prime research partners are:

- Steel Plant Waste Oxide Recycling and Resource Recovery by Smelting with the American Iron and Steel Institute,
- Electrochemical Dezincing of Steel Scrap with Argonne National Laboratory and Metal Recovery Industries (USA), Inc.,
- Rapid Analysis of Molten Metals Using Laser-Produced Plasmas with Lehigh University, and
- Advanced Process Control for the Steel Industry with the American Iron and Steel Institute.

Research and development projects with the aluminum industry are:

- Evaluation of TiB2-G Cathode Components with the Reynolds Metals Company,
- Energy Efficient Pressure Calciner with the Aluminum Company of America (Alcoa), and
- Spray Forming of Aluminum with Alcoa.

All the projects listed above are administered under the Metals Initiative Management Plan.

STEEL PROJECTS

Steel Plant Waste Oxide Recycling and Resource Recovery by Smelting

During August 1993, the Department of Energy agreed to support a project with the American Iron and Steel Institute on Steel Plant Waste Oxide Recycling and Resource Recovery by Smelting. The project was conducted at the same pilot smelter constructed for the Direct Steelmaking project to further develop the smelting process to utilize steel plant waste oxides containing economically recoverable iron units. The project began on April 1, 1994, following the completion of the Direct Steelmaking project on March 31, 1994. Process development work was carried out culminating in the development of a small-scale process for production of molten iron from steel plant iron rich waste oxides. The objective is to develop a process for recycling approximately four million tons annually of iron oxide bearing dust and sludge from blast furnaces, basic oxygen furnaces and rolling mills that a steel industry task force on waste recovery had identified as recoverable. The pilot plant trials have established that savings to the extent of 25 percent of energy used in the blast furnace and coke oven processes to produce hot metal are achievable in this process. Successful recovery will also conserve resources as well as benefit the environment because significantly fewer wastes will have to be disposed in landfills.

Fourteen experimental trials were conducted from April through December 1994 with a variety of waste oxides and fuels, smelting conditions, and off-gas processing conditions. An AISI proposal for a demonstration plant to convert 500,000 metric-tons-per-year of waste oxides to 250,000 metric tons per year of hot metal was submitted to the DOE in April 1995, but funding was unavailable. Although the program completed its experimental tasks in December 1994, work is still being done by the American Iron and Steel Institute, to seek means for implementing the technology on a commercial basis. Work is also ongoing to secure patent protection for a number of improvements that were developed during the experimental portion of the project.

Electrochemical Dezincing of Steel Scrap

The objective of the Electrochemical Dezincing of Steel Scrap project is to design, engineer, construct and operate the first commercial plant to demonstrate a two-step process for the continuous dezincing of scrap steel. Concurrent commercialization and R&D activities are conducted to improve process profitability to achieve market potential. This is the last phase of a product and process development program for dezincing steel scrap started in 1987 with DOE/OIT support at Argonne National Laboratory (ANL) and cost-shared with Metal Recovery Industries, US, Inc. (MRIUSI), a wholly-owned subsidiary of Metal Recovery Technologies, Inc. The design of the demonstration plant is based on the results of this prior research, and operation in East Chicago, Indiana of a pilot plant to demonstrate continuous dezincing of scrap steel. The demonstration plant will be located near steel producers or foundries, and most of the dezinced scrap steel production dedicated to a steel producer or the foundries of an auto maker.

Galvanizing is a process that applies a zinc coating to steel to prevent corrosion under ambient conditions. Unfortunately, when galvanized steel scrap is recycled back into steelmaking and foundry operations, the zinc coating causes operating and environmental problems. This project aims to develop a continuous dezincing process wherein zinc is removed from steel scrap by electrochemical corrosion. This is a two-step process. In the first step, the zinc bearing scrap is charged into a leaching reactor containing a 70-90° Centigrade aqueous sodium hydroxide electrolyte. The iron and zinc immersed in the electrolyte form a corrosion cell resulting in dissolution of the zinc from the surface of the scrap into the hot caustic. The clean scrap is then removed from the reactor, rinsed in water, and recycled. In the second step, the zinc bearing electrolyte is pumped into a second cell and the zinc is electrolytically removed from the solution as a zinc powder. The zinc powder is then sold to zinc consumers or to secondary zinc converters for melting and casting into slab zinc for resale.

The types of prompt scrap (e.g., automobile stamping plant returns) that are being dezinced in this project include hot dipped, electrogalvanized, galvannealed, and galvalume coated materials. The project will also dezinc obsolete scrap (e.g., shredded automobile hulks) and examine methods for removal of tramp copper from obsolete auto scrap. Also of interest are galvanized materials, both obsolete and prompt scrap, that have polymeric coatings.

Four major tasks remain in this project:

1. engineer, construct and operate a 200,000 net ton/year commercial dezincing demonstration plant incorporating process improvements from the results of continuing process and product research and development;

2. university, national laboratory, and industrial research studies to improve process productivity and products value, to increase the intellectual property base, and to determine pilot feasibility of removal of tramp copper in obsolete scrap steel;

3. commercialization activities of licensing, and market development for products and the process; and

4. techno-economic evaluation comprising assessment of capital and operating costs and determination of the markets for dezinced scrap and recovered zinc.

The project is targeted for completion in fiscal year 1999.

Important technical hurdles in this research include: demonstration of continuous operations over a sustained period for both the primary dezincing step and the recovery of zinc powder; purification of dezinc leach liquors; decreasing dross losses encountered during melting the recovered zinc; and extending the dezinc process to remove tramp copper from obsolete automobile scrap.

By the end of fiscal year 1993, Metal Recovery Industries had completed construction of their pilot plant with the exception of a zinc recovery system and had dezinced about 600 tons of automotive stamping plant scrap with over 90 percent zinc removal effectiveness. Eighty tons of dezinced shredded scrap was tested in induction furnaces and judged satisfactory by a captive automotive foundry.

The plant was used in fiscal year 1994 to dezinc an additional 400 tons of automotive stamping plant scrap. A second foundry melt test of 100 tons of dezinced shredded scrap material was conducted successfully, this time in a cupola furnace. A total of 530 tons of dezinced and baled stamping plant scrap was accumulated toward a basic oxygen furnace (BOF) melt test program. Financial problems of the industrial partner resulted in the plant being inoperative for 75 percent of fiscal year 1994. This caused postponement of the BOF melt test, the market development work on recovered zinc products, and the remaining research objectives. However, refined process economic projections of operating and capital costs vs. capacity were used to attract new ownership and venture capital. An engineering firm produced plant layouts and process schematics based on mass and energy balances derived from pilot plant operations. Larger than lab scale tests demonstrated that the dezinc process is able to undercut and remove otherwise robust polyvinylchloride (PVC), polyvinyldiflouride (PVDF), acrylic, and epoxy coatings. A memorandum of invention was filed based on laboratory experiments at the pilot plant for a method to simultaneously remove metallic copper from steel scrap with dezincing.

In April 1995, Metal Recovery Technologies, Inc. (MRTI), purchased Metal Recovery Industries, (US), Inc. The pilot plant was subsequently dismantled for refurbishing and to increase its capacity to 60,000 tons/year. Sub-contracts were let: 1) to the engineering firm that produced the plant layouts to provide a cost estimate for a 150,000 ton/year green field dezinc facility, and 2) to a consultant to evaluate an alternate leaching system. An electrochemical processing facility was constructed at Argonne National Laboratory to test bipolar cell designs and to test electrochemical decopperizing on a larger scale.

In fiscal year 1996, MRIUSI began operation of the refurbished pilot plant with a new rotary dezincing reactor that is producing well in excess of its design capacity with over 98 percent zinc removal effectiveness. A patent has been filed for an "Improved Process for Dezincing Steel." MRIUSI is sponsoring a $180,000, three-year research program with the University of California - Berkeley to determine the feasibility of recovery of zinc from a zincate dezincing solution in a spouted bed electrowinning cell. The larger particle size of zinc from this cell is expected to improve the marketability of zinc to secondary smelters. One of the largest producers of zinc in North America has been and continues to discuss partnership issues with MRIUSI. MRIUSI has obtained a scrap supply contract with GM for 1,500 tons/mo. (about one carload/day) of zinc coated stamping plant scrap from GM plants in Michigan. Negotiations continue for purchase by GM of dezinced scrap for use in their foundries. A northern European steel company, a central

European secondary zinc converter, an Australian non-ferrous mining company, a Japanese auto-maker, and a Korean government environmental contingent have visited the East Chicago plant. All have also shown interest in licensing the process.

Argonne National Laboratory activity in fiscal year 1996 included bipolar cell and electrode design for zinc recovery with an experimental proof of concept using the electrochemical processing facility (EPF) constructed in 1995. Larger than bench scale experiments were conducted for electrochemical decopperizing of galvanized scrap also using the EPF. Reports from contracts let in 1995 were received on an alternate rotary reactor design, and the cost for a greenfield 150,000 ton/year commercial dezinc plant. The Statement of Work for a three-year program for design, construction, and operation of commercial demonstration dezincing plant with associated research for product and process improvement has been prepared. The contract with MRIUSI including cost-sharing, is expected to be signed in fiscal year 1997.

Plans for fiscal years 1997, 1998, and 1999 subject to the availability of funds include design, construction, and operation of a commercial demonstration dezincing plant of nominal capacity of 200,000 tons per year of steel scrap for an integrated steel producer or for the captive foundry of an auto-maker. In addition, product and process research are planned on the issues of zinc product recovery, purity and melting techniques, and tramp copper removal from obsolete auto scrap. Worldwide licensing of the process will also be pursued.

The application of this process to 5 million tons per year of galvanized scrap is estimated to: (l) conserve 0.05 quadrillion Btu of energy per year; (2) reduce raw material costs to the U.S. iron and steel industry by at least $140 million per year; and (3) reduce the need to import at least 100,000 tons per year of zinc at a cost of $100 million per year.

Dezincing of steel scrap has environmental benefits in addition to the recycling benefits. Since iron-rich steelmaking dust captured in the gas cleaning system will not be contaminated with zinc, it can be used as a charge material for sinter or briquetting plants and then recycled back into the blast furnace. Because zinc is toxic to some aquatic plant and animal life, elimination of zinc from scrap will eliminate the problem of zinc in the effluent water from wet pollution control systems used in the steel industry.

In addition, use of dezinced scrap improves operations through: higher yield, increased furnace lining life, and better quality products.

The following technology transfer activities were completed in fiscal year 1996:

Patents

Application of July 17, 1996: "Improved Process for Dezincing Galvanized Steel." Inventors: W. A. Morgan, F. J. Dudek, and E. J. Daniels.

Technical Papers

Dudek, F. J. and E. J. Daniels, "Development of Processes for Recycling Industrial Solid Waste," Industrial Waste Recovery Forum, Joy Recovery Technologies, March 29, 1996, Villa Park, IL.

Koros, P. J., Hellickson, D. A. and F. J. Dudek, "Issues in Recycling Galvanized Scrap," Iron & Steelmaker, 23, No.1, January, 1996, pp. 21-27.

Dudek, F. J. and E. J. Daniels, "Development and Evaluation of Technologies for Recycling Industrial Solid Waste Streams," Symposium on Hazardous Metals Recycling, Southern California Natural Gas and the California Environmental Protection Agency, November 9, 1995, Downey, California.

Koros, P. J., Hellickson, D. A. and F. J. Dudek, "Issues in Recycling Galvanized Scrap," a Chapter in Steel Technology International, 1995-96, 8th Edition, edited by Peter Scholes, Sterling Publications, Ltd., London, pp. 127-133.

Rapid Analysis of Molten Metals using Laser-Produced Plasmas

Rapid Analysis of Molten Metals Using Laser Produced Plasmas (LPP), a project that began in fiscal year 1992 with the signing of a financial assistance agreement with Lehigh University, is completing its fifth year. The Department of Energy funding has supported the project in a joint sponsorship with AISI, CTU 5-2 Consortium, and Lehigh University. The objectives have been to: 1) implement the molten metal calibration protocol for the LPP analysis methodology; 2) implement the methodology in the form of a second generation LPP sensor probe system, which facilitates real time process control by in situ determination of elemental composition of molten steel alloys; 3) deploy such developmental systems in steelmaking facilities; 4) upgrade the systems to a third generation design; and 5) effect technology transfer by selecting a manufacturer of commercial LPP Sensor Probe (LPPSP) systems.

The radically new methodology of insitu LPP analysis of molten metals, as developed at Lehigh University, has been implemented into an LPP sensor-probe system, ready for deployment at steelmaking facilities. The system consists of an LPP sensor-probe head, which is immersed into the molten metal bath for the short duration of measurement, a control console, an umbilical cord connecting the above two units, and a support console providing coolants and pneumatic supports to the control console.

The LPP sensor-probe system achieves real-time, insitu determination of the elemental composition of a steel alloy while it is still in the molten state at some point in the steelmaking process. The current practice requires taking a sample from a molten metal bath, and sending it in solid form to a remote laboratory for analysis, lengthening the heat time significantly. Deployment of the LPP sensor-probe system is conservatively estimated to result in an 8.7 percent reduction in heat time. Other benefits include an estimated 0.4 percent improvement in yield and lower alloy and refractory costs, plus increases in productivity and product quality. The energy benefit is estimated to be 0.01 quadrillion BTUs per year under full application of the technology to the carbon steel industry. LPP analysis of molten metal should find applications in other materials, industries, and environmental remediation such as in radioactive waste disposal.

Among the four of the five objectives that have been met, the deployment objective has been partially realized at present. The full LPP sensor-probe system has been put through trial immersion runs at a foundry, but its deployment at steelmaking facilities has progressed to a stage where various issues of both a financial and legal nature are being incorporated into a formal agreement between a host site and Lehigh University.

The technical issues of a field deployment of the LPP sensor-probe system include systematic analysis of the manufacturing process parameters, site preparation including design and fabrication of an appropriate manipulator of the LPP sensor-probe head and installation of the system in the host facility. There emerged several major new requirements for the system from the operators of the host site facilities and in the course of the technology transfer process. These have been fully accommodated, resulting in a number of significant design modifications. A factor of ten or more reduction in the measurement uncertainty for elemental concentration has been achieved. Several new capabilities have been added such as: water-free cooling of the immersion tube; real time temperature measurement; slag surface level detection; simultaneous measurement of more than 25 elements; option for double measurements per immersion; option for AOD and furnace deployment; and option for miniaturization of the LPP sensor-probe head.

As part of the technology transfer process the University has entered into an exclusive licensing agreement with Bailey Engineers, Inc., as the designated manufacturer of the LPP sensor probe system for steelmaking applications in the territory of the North American continent. The transfer of the technology and design specifications will be completed once Bailey Engineers has exercised the provisions of the agreement following the first full deployment of the LPP sensor probe system.

The scientific and technical progress of the LPPSP project has been a success. The system has been critiqued for performance and survival requirements through interactions with the operators of eight major steelmaking shops while identifying the potential host site facilities. The system has also been scrutinized from the technology transfer standpoint for the LPPSP system as a commercially manufactured instrumentation. The second-generation LPPSP system has been constructed for the purpose of initial deployment in full-scale steelmaking shops. The work on the third-generation system is in progress.

All these systems are expected to be individually exercised using a new large volume molten steel source in addition to the full-scale deployment. The laboratory source, more than 1 cubic foot in molten metal volume, is coming on-line in the Physics research laboratory of the University. Of particular interest is the long-term performance of the LPPSP system under the field deployment conditions.

The process of selecting the host sites has been exceptionally slow and time consuming. The reasons are partly technical but mostly financial and legal in nature, given that the deployment can potentially impact the production schedules of a large manufacturing organization. The bridging step taken for trial immersions at a foundry has proven to be beneficial in identifying the logistical and technical issues and developing the appropriate solutions.

The probe technology has been developed to the point that technical risks have been minimized. Further development decisions should be made by the commercial sector. Since the commercial probe manufacturer (Bailey Engineers) is willing to complete any remaining technical and commercial development related to the probe commercialization, Federal funding for this project is being terminated in fiscal year 1997.

Advanced Process Control for the Steel Industry

The cooperative agreement between the Department of Energy and the American Iron and Steel Institute for the Advanced Process Control project was signed on April 29, 1993, initiating this five-year, $23 million program. The objective of this program is to develop systems for online control of key steps in the production of steel. It consists of six clearly defined projects which harness the resources of the Department of Energy, the steel industry, academia, national laboratories, and advanced technology companies to accomplish the research and engineering advances required to attain this objective.

Each task in the project is an individual research and development project involving:

- one or more research organizations to perform the research through the appropriate investigative, developmental, prototyping, and verification phases;

- a sponsoring steel company to provide technical advice and to install prototype equipment within its production facilities for on-line testing; and

- a commercialization partner--generally an equipment manufacturer with the resources to take the proven technology to market.

The project participants are listed in Table 1.

When implemented in the American steel industry, the technology developed by this program is expected to result in a savings of approximately $146 million per year, which includes an annual energy savings of 6.13 trillion Btu per year.

Table 1. Summary of Participants in the Project on Advanced Process Control for the Steel Industry

	Task A	**Task B**	**Task C**
	Optical Sensors and Controls for Improved Basic Oxygen Furnace Operations	Improved Liquid Steel Feeding for Slab Casters	Microstructure Engineering for Hot Strip Mills
Research Organization(s)	Sandia National Laboratory	Westinghouse and North American Refractories Company	National Institute of Standards and Technology and the University of British Columbia
Commercialization Organization(s)	Insitec Measurement Systems/Berry Metal Company	Westinghouse	Northwest Mettech Co.
Sponsoring Steel Companies	Bethlehem Steel	U.S. Steel	U.S. Steel
	Task D	**Task E**	**Task F**
	Online Mechanical Properties Measurements	Phase Measurement of Galvanneal	Temperature Measurement of Galvanneal
Research Organization(s)	Industrial Materials Institute and National Institute of Standards and Technology	Measurex DMC/ Jet Propulsion Lab.	Oak Ridge National Laboratory and the University of Tennessee
Commercialization Organization(s)	Ultra Optec and Measurex DMC	Measurex DMC	To be determined
Sponsoring Steel Companies	LTV Steel and Weirton Steel	Inland Steel and Stelco, Inc.	National Steel

Task A. Optical Sensors and Control for Improved Basic Oxygen Furnace Operation

Task A is organized in the following principal activities:

- Development of an optical sensor for in situ, real-time measurements of the temperature and composition of Basic Oxygen Furnace (BOF) off-gases that provide an early and direct indication of when the steelmaking process is complete. The off-gas measurement sensor uses an infrared laser beam fired across the mouth of the vessel to a spectrometer that detects molecular interference/absorption within the beam. The instantaneous analysis of carbon monoxide, carbon dioxide, and water in the gases indicate carbon level of the bath with a high degree of accuracy. Initial field trials were completed at Bethlehem Steel's Sparrows Point plant in January 1996. During these trials the tunable diode laser beam was successfully transmitted through the BOF off-gas during oxygen blow, for several heats, demonstrating the technical feasibility of this method. A second series of field trials were completed in June 1996 wherein strong carbon monoxide and carbon dioxide absorption features were observed throughout the blow indicating the possibility of using this technology for determining carbon level in the bath. Efforts are now focused on developing process control algorithms to quantify data collected during these trials and on design and construction of a prototype sensor for long-term endurance trials scheduled for fiscal year 1997.

- Development of optical sensors for measurement of bath temperatures from within existing oxygen lances. An optical sensor, mounted in the tip of the oxygen lance, will be used to measure the temperature of the hot-spot zone where oxygen ignites as it contacts the steel. Since the hot zone temperature drops off rapidly when all the carbon is burned off, it also provides a quick indication of when the target conditions are reached. When the surface of the steel bath is exposed, the bulk bath temperature can also be directly measured with this sensor.

  The lance based sensor was thoroughly tested during a series of on-line trials at Bethlehem Steel's Sparrows Point plant this year. In February 1996, during long-term endurance trials, the sensor operated without mechanical failure for 110 production heats of steel, thus proving the robustness of this sensor. Detailed data collected from these trials are being correlated with actual processing parameters. Initial results show the potential to indicate end point carbon and end point temperature a few minutes before the end of oxygen blowing period.

  During fiscal year 1996, lance-based sensor work was extended to include research and development of automated range-finding techniques to better control refractory wear and measure the level of the metal and slag in BOFs, electric arc furnaces, ladles, and slag pots.

This new on-line process information will be used to develop improved BOF control strategies. Work on this activity is underway and will continue through fiscal year 1997 as data collected from on-line trials are incorporated into existing BOF process control models. Methods will be developed for optimal use of signals from the modular full-scale optical sensors.

Task B. Improved Liquid Steel Feeding

This task was terminated in fiscal year 1995 because the potential value to industry was greatly diminished by improvements in other steel pouring technologies. However, as a result of the research effort, a new refractory nozzle was developed. A patent application has been filed for "An Electromagnetic Valve for Controlling the Flow of Molten, Magnetic Material" in January 1996.

Task C. Microstructure Engineering in Hot Strip Mills

The objective of this task is to develop a predictive tool to relate the properties of hot-rolled products to the process parameters of a hot strip mill. The predictive tool will be a user friendly computer model incorporating information on heat flow and microstructural evolution (grain growth, recrystallization, precipitation, and austenite decomposition), to predict final product properties. In turn, this will help in developing the control strategies for hot strip mills. Using this predictive tool it is possible get different properties from steel of a given composition.

In the fiscal year 1995, the Hot Strip Mill Model for A36 steel grades was released to Advanced Process Control (APC) participants. Continuous feedback from the participating steel companies has been extremely valuable in improving and enhancing the model. During the fiscal year 1996, numerous upgraded revisions of the model were released. Key upgrades include version 3.0 (March 1996) incorporating A36 and DQSK (drawing quality special killed) steel grades with new versions of Finishing Mill and Runout Table models and version 3.2 (May 1996) including Roughing Mill and Downcoiler models. Additional releases are planned throughout the remainder of this project.

Task D. On-line Mechanical Properties Measurement

The objective of this task is to develop an on-line, nondestructive sensing system for the measurement of mechanical properties of low-carbon sheet steels to supplant traditional off-line testing. An essential step in meeting this challenge is the development of reliable sensors to nondestructively monitor the mechanical properties of cold-rolled steel--yield and tensile strength, elongation and strain hardening value on-line. Current determinations of mechanical property measurements are done off-line in time consuming and costly destructive tests. Each year, the steel industry spends about $27 million on these off-line tests which slow down the entire system and raise inventory costs. The development of these sensors will enable producers to know what they are making while they are making it.

During the fiscal year 1996, two non-contact sensor technologies for on-line mechanical properties measurements were pursued: a magnetic method using the Barkhausen Effect developed by the National Institute of Standards and Technologies (NIST); and an ultrasonic method developed by Industrial Materials Institute (IMI) that uses laser-generated and detected ultrasonic waves.

Confronted with excessive prototype development costs and unresolved technical issues, work on the NIST magnetic sensor effort was terminated in December 1995. However, during the course of this research effort, a method of measuring sheet hardness was developed. A patent application has been filed for a "Steel Hardness Measurement System and Method of Using the Same."

Based on early successes in laser ultrasonic laboratory work, this effort has been accelerated and is expected to be completed four months ahead of the original schedule.

This approach uses a laser to excite ultrasonic waves in the strip. The strength of the waves is reduced by irregularities in the microstructure, such as porosity and grain size. Changes are detected by a second laser/interferometry system, translating the acoustic waves into a digital signal for the computer processing.

Predictions of tensile strength, r-value, n-value, and elongation have met and/or exceeded original project targets. Work is continuing on improving the sensor's sensitivity to temper reduction which directly affects yield strength. Prototype design and construction will begin upon completion of this effort. Full scale plant trials are scheduled next year.

Task E. Phase Measurement of Galvanneal

The purpose of this project is to develop an on-line instrument that will determine the distribution of iron and zinc phases in a galvanneal coating. In the galvanneal process, steel is coated with molten zinc. The steel strip is first dipped into a zinc bath and then passed through a Galvannealing furnace. The furnace extends the time the steel is in contact with the molten zinc and enhances migration of the iron from the steel into the zinc coating. During this stage of the process, temperature variations and the distribution of the iron/zinc phases in the Galvanneal steel strip surface directly affect the quality of the end product. The on-line measurement will help in avoiding expensive off-line measurements and off-grade quality products.

This project was successfully completed in the fiscal year 1995. Researchers from the Data Measurement Corporation (now part of Honeywell-Measurex) and the Jet Propulsion Laboratory, working with industry sponsors, Inland Steel and Stelco, Inc., have developed an on-line instrument to determine the microstructural distribution of iron and zinc phases (layers) present in the galvanneal coating. This new technology will allow galvanneal producers to make this measurement on-line to optimize critical product properties demanded by their customers.

In May 1996, the first commercial Galvanneal Phase Measurement gauge was installed and is now operating at Stelco, Inc. This is the first commercial installation of technology developed under the Advanced Process Control Program. Preliminary result of the sensor's real time output indicate that it functions as designed. During the next several months, work will continue on fine-tuning and quantifying the benefits of this instrument. Additional commercial installations are anticipated during the next fiscal year.

Task F. Temperature Measurement of Galvanneal

This project uses phosphor thermography, an outgrowth of uranium refining efforts at the Oak Ridge National Laboratory, to assure accurate on-line temperature control of the Galvannealing furnace. Temperature is the controlling factor regarding the distribution of iron and zinc in the galvanneal coating, which in turn determines its properties. The on-line measurement avoids costly off-line analysis and consequent rejection of the material.

During the production of galvanneal steel, the diffusion of iron into the zinc coating causes a continuous change in emissivity which defeats existing non-contact optical temperature measurement systems. The thermographic phosphor measurement system being developed under this project is unaffected by emissivity. Spots of phosphor powder are placed at intervals on the still-molten surface of the steel strip as it leaves the zinc pot. Using fiber-optics, pulses from a small ultraviolet laser mounted at the exit end of the galvanneal furnace excite the phosphor. Then light detectors measure the time it takes the fluorescence to decay, giving operators real-time data on the strip and furnace temperatures.

During fiscal year 1996, several full scale trials were conducted at National Steel's midwest plant. In February 1996, during extended trials, the sensor operated continuously for 48 hours and temperature accuracies of +/- 3.9 degrees Fahrenheit were obtained. These are well within the project goal of +/-5 degrees Centigrade. These encouraging results have put the project completion one year ahead of schedule.

The efforts for the remainder of fiscal year 1996 were focused on planning for a final demonstration for industry, Government, and potential commercialization partners. Commercialization of this technology is anticipated in fiscal year 1997.

ALUMINUM PROJECTS

Evaluation of the TiB2-G Cathode Components

The objective of the project is to demonstrate the technical and economic benefits of electrolyzing alumina in commercial cells equipped with graphite-containing titanium diboride (TiB2-G) cathodes. Retrofitting existing alumina reduction cells with wettable cathodes has the potential to save 0.1 quadrillion Btu per year. Participants in this project are Reynolds Metals Company, Kaiser Aluminum (Mead reduction plant), and Sigri Great Lakes Carbon.

The first reduction cell with TiB2-G cathodes was put into operation at the Kaiser Aluminum, Mead, Washington plant in February 1993 and operated for 145 days. The operation was hampered by breakage of the TiB2-G cathode elements, causing cell operating voltages to be higher than designed and subsequently causing excessive sidewall erosion and eventual cell failure. Breakage of the TiB2-G cathode elements was thought to be caused by mechanical stresses resulting from elements shorting to anodes during cell operation coupled with internal fabrication flaws in the elements. Cell operating procedures and process control algorithms were modified to minimize the effects of the anode to element shorting. Sigri Great Lakes Carbon evaluated and changed several operating parameters to produce improved TiB2-G elements, three of which were tested under one anode for a two week period. The results of this test showed the improved elements were capable of withstanding the mechanical forces involved in cell operation without failure. In January 1994, Sigri Great Lakes Carbon closed their Elizabethton, Tennessee facility and moved their processing equipment to Niagara Falls, New York.

During fiscal year 1995, Sigri Great Lakes Carbon completed production of 225 improved TiB2-G cathode elements to be used in the second test. Sections of these elements were evaluated by Reynolds for hot strength and found to be superior to those used in the first test. The internal structure of one improved TiB2-G element was examined by Scientific Systems of Austin, TX using computerized X-ray scanning (Computerized Tomography). Results of the scan indicated a high density, relatively crack-free region approximately 10 millimeters thick around the periphery of the stem. Although the scan revealed a multitude of cracks and voids in the interior of the stem, no flow laminations in the neck radius area or cracks penetrating to the surface were observed.

Upon completion of the cell construction for the second test, the second test of TiB2-G elements in the reduction cell began on February 21, 1996, and continued until June 1, 1996. Numerous elements also failed during this test. Out of 96 elements initially installed in the test cell, only 10 survived the test intact. A total of 110 replacement elements were also used during the test. Target coverage of the anode by TiB2-G cathode elements was to be 63 percent; however, inspection snapshots revealed the actual coverage to be 40 percent on April 7 and 31.5 percent at the end of the test. In May, a cell performance study was conducted which documented test cell current efficiency to be 93 percent at 4.27 volts (and approximately 40 percent anode coverage). This represents an actual 8 percent or approximately 60 trillion Btu per year energy savings compared to the Kaiser standard cell tested during the study with no decrease in aluminum production. The energy savings of the TiB2-G cathode element cell is estimated at approximately 13 percent based on target anode coverage of 63 percent, when compared to a Kaiser standard cell. Work planned for fiscal year 1997 will concentrate on determination of the cause of element failure and recommendations for improving element life.

Energy Efficient Pressure Calciner

The objective of this project is to develop a device, ready for commercialization, to calcine alumina for the Hall-Heroult process. Pressure calcination of alumina will increase the competitiveness of the domestic aluminum industry, because:

- the alumina feed stock to the Hall-Heroult electrolytic cell will have improved physical properties, that is, a more uniform particle size and a lower attrition index that produces less dusting and therefore requires simpler environmental controls; and

- the calciner will recover steam for the Bayer process and uses less energy per unit of production due to the lower operating temperature needed for calcination.

The program consists of two phases that will be conducted consecutively. The phases address the equipment development (phase I), the design and economic analysis of a semi-commercial unit (phase Ia), and the construction and operation of the semi-commercial unit (phase II). When implemented on a commercial scale, the energy efficient pressure calciner could save the aluminum industry approximately $160 million annually, or an estimated 3 to 5 percent of the operating cost of the aluminum production to which the process is applied. The estimated energy savings potential is 0.01 quadrillion Btu per year.

During Phase I, construction of a three tube pilot-scale plant (100 kg/h), was completed in fiscal year 1995. Self-fluidization, a major milestone, was completed in 1996. A complete failure of the GEMCO valve required a substitution of a new valve by the Everlasting Valve Co. Additional funding was provided by DOE to complete the economic analysis which is anticipated to be completed by the end of the second quarter of 1997. To date, several hundred kilograms of material have been produced by the new unit.

Spray Forming of Aluminum

Commercial production of aluminum sheet materials by spray deposition is an attractive manufacturing alternative to conventional ingot casting-hot rolling enabling the production of advanced products with reduced energy requirements, lower cost, and improved product characteristics. The first year of the five-year program was completed in April 1995, and work continues to translate bench-scale spray forming technology into a cost effective aluminum sheet production process for commercialization by the year 2000. This will be accomplished in proof-of-principle tests at pilot scale including developing an investment strategy for technology transfer. Major subcontractors on the program include Air Products & Chemicals, Inc., Idaho National Engineering Laboratory (INEL), Massachusetts Institute of Technology, Carnegie Mellon University, Drexel University, and the University of California - Irvine.

To realize the full potential of this technology, it is necessary to optimize the behavior of currently available state-of-the-art linear atomization systems whose spray characteristics are tailored to the continuous production of aluminum alloys. Most important is the need to optimize the design and operating conditions for the efficient production of aluminum sheet products. The benefits of spray forming include:

- Near-net shape process
- Improved properties due to rapid solidification: fine equiaxed grain size, extended solid solubility, reduced segregation
- Wide selection of alloys, coatings and potential for molten metal composites (MMC)
- Reduced operating and capital costs (~13 percent reduction in costs with spray forming vs. ingot casting)
- High production rates and yields

This five-year research and development program encompasses four separate, yet interrelated and interactive tasks, including spray deposition / process development, aluminum alloy product development, design construction and commissioning of an Advanced Development Unit (ADU), and investment analysis. The objectives and accomplishments of each task are as follows.

Process Development - The objectives of this task are to develop an understanding of the spray forming process parameters at bench-scale and larger. These include nozzle design and material selections, mathematical modeling and performance of parametric analyses, identification of thermo-mechanical processing parameters, scale-up, and definition of the desired process operating conditions. Accomplishments during fiscal year 1996 were:

The Alcoa III linear nozzle was a major breakthrough in providing profile control for sheet deposits. Due to its sophistication, the gas pressure control system was upgraded to provide five separate set-points on the control panel. Pressure transducers were also incorporated as part of the control scheme.

- Alcoa's data logger setup was updated to support the new control system.
- A limited number of spray runs with water and metal were performed in support of the nozzle optimization. Water-based tests focused on patternator studies with the Alcoa III nozzle. This was complemented with 15 metal spray tests in the bench-scale unit.
- Metal spray runs were geared toward 3003 and 6111 aluminum alloys which have commercial importance in the automotive industry.
- Carnegie Mellon University (CMU) developed a 3-D model to predict droplet trajectory/thermal history, and a model to simulate the tailored gas concept of the Alcoa III nozzle.

- Alcoa developed a single drop model to simulate splashing.
- Alcoa initiated a three-way relationship with Argonne National Laboratory (ANL) and the University of Puerto Rico - Mayaguez (UPR-M) to perform research on spray forming. Jim Sienicki (ANL), in conjunction with Professor Luis Bocanegra and graduate student Jesse Delgado (UPR-M), performed a paper study and some simple thermal modeling on droplet splashing. UPR-M plans to continue this substrate-side work with equipment recently installed on campus. ANL and UPR-M plan to leverage this relationship to obtain separate DOE and NSF funds respectively.
- As part of the materials development work, Boron Nitride was tested as a nozzle material on the small scale unit.
- University of California - Irvine continued to characterize the USGA nozzle both with water and metal using Phase-Doppler Anemometry.
- Several prototype shroud designs were evaluated with water sprays for future use in the bench-scale unit.

Advanced Development Unit (Design and Construction) - The objective of this task is to design and construct an Advanced Development Unit (ADU), to bridge the technology gaps in scaling beyond the bench unit, and to test the commercial viability of the spray forming process to produce aluminum sheet. The unit will be designed to operate both in an experimental mode and in a semi-production mode. The ADU will be of a modular construction in which prototype modules can be easily attached to test design concepts. The ADU design allows each module to be modified individually so that future plant concepts can be evaluated effectively. Advanced computer controls and data acquisition methods will be used. The progress over the previous contract months was reviewed at a Spray Forming Workshop. The Team generated a preliminary assessment of needs for a Pilot Scale Unit, now called the ADU.

Product/Alloy Development - The objectives of this task are to identify the sensitive spray forming variables leading to rapid solidification and microstructure of selected alloys. Included are the effects of rapid solidification on commercially significant alloys including automotive sheet, and the comparison of the produced sheets with those produced by ingot metallurgy. Accomplishments:

- Performed runs on the small scale (Marko) unit to define effect of spray parameters on the fraction solid in the spray/deposit.
- Dr. Flemings (MIT) studied changes in thermal condition of dropping molten particles, including impingement.
- Spray runs with zirconium levels up to 0.52 were realized while maintaining fine homogeneous microstructure. This has major implications for extending the range of possible alloys which can benefit from spray forming.
- Alcoa formalized a hypothesis on the mechanisms for evolution of the deposit's microstructure via the analysis of photomicrographs and the characterization of the deposit's porosity.

- Both microstructure and mechanical properties have been compared to commercial auto-sheet made via the ingot route.
- Investment Analysis - The objective of this task is to upgrade the aluminum spray forming investment opportunities document. Analysis of energy and cost savings, definition of the capital cost requirements, and identification of the market potential will be included to show the economic viability of aluminum spray forming and for subsequent use in developing investment and commercialization strategies. Alcoa has continued to work with the DOE to update the Office of Industrial Technologies' Project Benefit Analysis.

Technology Transfer Activities

The following technology transfer activities were completed in fiscal year 1996.

Papers and Presentations

Leon, Kozarek. "Use and Characterization of Linear Nozzles for Spray Forming," Euro PM 95.

Pien, Ding, Chyu. "Model of Droplet Flow, Temperature and Solidification in a Spray Forming Process," International ME Congress.

Pien, Luo, Baker, Chyu. "Numerical Simulation of a Complex Spray Forming Process."

Chyu. "Microstructure of Aluminum Alloy Sheets Produced by Spray Forming Using Linear Nozzles" - ICSF III.

Pien. "Modeling of Multi-Phase Transport Phenomena and Solidification in Spray Forming Process with Linear Nozzles" - ICSF III.

APPROPRIATIONS HISTORY AND DISTRIBUTION OF METALS INITIATIVE FUNDS

Steel Initiative funds were first released to the Department of Energy in July 1986. The appropriations history is as follows:

Fiscal Year	*Amount, $*
1986	7,134,000
1987	2,000,000
1988	4,000,000
1989	-0-
1990	16,639,000
1991	17,394,000
1992	17,742,000
1993	17,937,000
1994	19,336,000
1995	5,072,000
Less Recision in 1995	(13,558,000)
1996	4,609,000
1996 adjustment -Defense Contract Audit Agency	239,200
1996 deobligation adjustment from Refractory Containment Research Program	500,000
Total+	99,044,200

The distribution of DOE funds for each project through September 1996 is as follows:

Project	*Amount, $*
Electromagnetic Casting	2,184,000
Superplastic Steel Processing	4,026,000
Spray-Forming Steel	5,908,000
Direct Steelmaking	46,621,200
Steel Plant Waste Oxide Recycling	5,635,000
Direct Strip Casting	2,376,000
Electrochemical Dezincing of Scrap**	2,866,000
Molten Metal Analysis	2,306,000
Advanced Process Control**	13,708,000
Aluminum Cell Cathodes**	3,588,000
Energy Efficient Alumina Calciner**	1,424,000
Spray Forming of Aluminum**	3,848,000
Program Support	4,554,000
Total	99,044,200

In the above table, asterisks denote a project that will be continuing in fiscal year 1997.

+ Amounts reflect gross appropriations and do not reflect adjustments for such activities as the Small Business Innovative Research Program or the spread of Congressional general reductions.

INDUSTRY COST-SHARING

Industry has provided the legally required cost-sharing on each project. The original Steel Initiative program required industrial cost-sharing equal to 30 percent of the DOE share, or 23 percent of the total cost of a project. The new Metals Initiative Program, which replaced the Steel Initiative, increased the required industry cost-share to 30 percent of the total cost of a project. Industry cost-sharing, expenditure, and cost data at the close of fiscal year 1996 as provided by the Idaho Operation Office of DOE are described below:

Waste Oxide Recycling

Total expenditures through the end of September 1996 were $8,308,042. Of this total AISI has contributed $2,682,485 or 32.3 percent and DOE has contributed $5,625,557.

Advanced Process Control Program

Total expenditures through the end of fiscal year 1996 were $14,430,366 with DOE contributing $10,101,256 and AISI contributing $4,329,110 or 30 percent of the total expenditures.

Electrochemical Dezincing of Steel Scrap

Through the end of fiscal year 1996 DOE has obligated $2,866,000 to this project while the industrial participants are estimated to have contributed $2,134,000, which is well over the required 30 percent contribution.

Rapid Analysis of Molten Metals Using Laser Produced Plasmas

The total cost of this project through the end of September 1996 is approximately $2,498,914 with the cost-sharing contribution equaling approximately $767,914 or 30.7 percent of the total.

Direct Steelmaking

The value of the AISI cost-share at the close of fiscal year 1996 was $13,988,796, which is equal to 30 percent of the DOE expenditure of $46,621,236 at the close of fiscal year 1996. These figures have been adjusted from the amount reported last year based on the completed DCAA audit. This project was funded under the Steel Initiative.

Evaluation of TiB2-G Cathode Components

Cost-sharing by industry at the close of fiscal year 1996 is estimated to be $1,330,564. This cost-share represents 30 percent of the total cost of the project through fiscal year 1996, which was $4,435,213.

Energy Efficient Pressure Calciner

Through fiscal year 1996, total project costs incurred were $1,961,700. DOE funded 70 percent of the costs or $1,373,190, while Alcoa funded the balance of $588,510.

Spray Forming of Aluminum

Out of a total estimated cost of $5,498,921, DOE has contributed $3,628,223 or 66 percent and Alcoa has contributed the remaining 34 percent. These figures are through the end of September 1996.

ANTICIPATED OBLIGATION OF DEPARTMENT OF ENERGY FUNDS

The project Waste Oxide Recycling will require no additional funds from the Department of Energy assuming that no unforeseen barriers are encountered.

Continuation of the Advanced Process Control project will require $2,100,000 and $500,000 during fiscal years 1997 and 1998, respectively, assuming funds are available.

Based on the proposal received for a 200,000 ton per year demonstration plant for Electrochemical Dezincing Project, the funds required are: $2,000,000 for the fiscal year 1997. If funding is available, $1,000,000 each will be required during fiscal years 1998 and 1999, respectively.

The project on Rapid Analysis of Molten Metals Using Laser-Produced Plasmas will require no further funds from the Department of Energy assuming that no unforeseen barriers are encountered.

The project Evaluation of TiB2 -G Cathode Components will require no additional funds from the Department of Energy assuming that no unforeseen barriers are encountered.

The project Energy Efficient Pressure Calciner will require no additional funds from the Department of Energy assuming no unforeseen barriers are encountered.

If funds are available, the anticipated funds needed for the project Spray Forming of Aluminum for fiscal years 1997 and 1998 are $1,000,000 and $1,500,00, respectively.

PROGRAM MANAGEMENT

The Department of Energy maintains frequent contact with the many institutions that have an interest in the Metals Initiative, including industry, universities, and government organizations, both state and Federal. The Department of Energy encourages discussion of emerging processes and the Metals Initiative Management Plan before any effort is made to prepare a written proposal.

Proposals continue to be submitted to the Department of Energy for funding consideration under the Metals Initiative Program. Proposals that fail to address the minimum requirements set forth in the management plan are rejected. Those that address the minimum requirements are subjected to a detailed peer review. In fiscal year 1996, a number of organizations expressed interest in the Metals Initiative. It is anticipated that the Department will continue to receive proposals directed towards improved energy efficiency and enhanced competitiveness of the metals industry.

All proposals that address the requirements listed in the Metals Initiative Management Plan must undergo further detailed evaluation. This action is taken without regard to the availability of funds appropriated under the Act for new projects in order to determine the relative merits of proposals if appropriations are made available.

Based on the results of the Metals Initiative Program to date, the Department of Energy has no recommendations to change the Metals Initiative legislation.