OREGON METALS INITIATIVE

2008 - 2009 Annual Report

Prepared By:
Public Affairs Counsel
P.O. Box 12945, Salem, OR 97309
503.363.7084 (Ph) / 503.371.2471 (Fx)
pacounsel@pacounsel.org

Oregon Metals Initiative
2008 - 2009
Annual Report

MISSION AND GOALS:

The Oregon Metals Initiative, Inc. (OMI) is a consortium of metals industry companies and research institutions that pursue research to improve the long-term competitiveness of the metals industry and the research infrastructure in Oregon. Oregon's metals industry is a vital part of the state's economy. The Oregon Employment Department projects that direct primary metals manufacturing and fabricated metal product manufacturing jobs will hover around 25,000 in Oregon until 2018.[1] Metals industry firms are involved in a diverse range of activities including primary metal production, manufacturing of fabricated components, designing and building a wide range of specialized machinery and transportation products including trucks, railcars, ships, and aircraft components. In addition to the direct economic impact provided by payrolls, metals firms play an important role in providing demand for products and services produced by other Oregon businesses such as intra-industry sales of metals industry products, business services, energy, and transportation.

OMI was established in 1990 as a mechanism to both support and enhance the competitive position and contribution of the metals industry to Oregon's economy and, more generally, to the national economy. The organization is managed by a 10-member board of directors which includes both industry and research (university) representatives. Mark Nelson, of Public Affairs Counsel, currently serves as OMI's Executive Director. The following are OMI's objectives:

- Develop new technologies and new applications of existing technologies;
- Increase metals research capacity, accessibility and infrastructure;
- Encourage collaboration on research between the metals industry and Oregon's scientific research institutions; and
- Improve the competitive position of Oregon's metals industry.

The objectives are met through joint industry-academic research projects. Interested companies work with one of two research institutions, currently Portland State University and Oregon State University, to develop project proposals. Every July, the OMI Board meets for its annual meeting. At this meeting, the Board reviews the proposals to ensure they meet the criteria established in the by-laws. The Board then determines which projects will be funded up to the level of available

[1] Data from 2010.

matching funds. The Oregon University System provides the matching funds to the industry funds on a 1:1 basis. It is the availability of the matching dollars that renders OMI feasible. With the matching support, the industry has been able to undertake research that would not have been pursued at all or at this time, and research institutions have benefitted from the invaluable experience of conducting this research and working with industry.

The Oregon State Board of Higher Education states, "Since 1990, the Oregon Metals Initiative has exemplified the concept of successful private-public partnerships… OMI is the model the Chancellor's Office hopes other industries will emulate in the next biennium." (OSBHE Docket 4/17/98).

PARTNER ORGANIZATIONS:

- Oregon State University
- Portland State University

2008-2009 PARTNER COMPANIES:

- American Bridge (1 project)
- Blount (1 project)
- Boeing (1 project)
- Cascade Steel Rolling Mills (3 projects)
- Daimler Trucks North America, LLC (1 project)
- DeMarini Sports (1 project)
- EST & D (1 project)
- FEI Company (1 project)
- Hewlett Packard (1 project)
- Northwest Pipe Company (2 projects)
- PCC Structurals Inc. (2 projects)
- Sheldon Manufacturing (1 project)
- Wah Chang (2 projects)

INVESTMENT:

During Fiscal Year 2008 – 2009, $457,170 from the industry was matched. Funds were matched on a 1:1 basis with the state. All funds go to the research institution, with none being earmarked for administrative costs.

TABLE OF CONTENTS:

ELECTROSLAG WELDING TECHNOLOGY APPLICATION DEVELOPMENT

Participating Company: American Bridge Company

Company Contact: John Callaghan

Participating University: Portland State University

PSU Principal Investigator: William Wood

PROJECT SUMMARY:

The construction of the new Oakland Bay Bridge in California requires joining of complexly shaped, thick sections 10m in length for the single tower design. These sections welded in position in the bay require vertical welds with limited access. Conventional multipass arc welding would be very difficult. This project is developing a single pass vertical welding process, electroslag welding, to meet the fabrication requirements of this bridge design. The project is currently ongoing.

The technical and physical weld requirements, weld lengths, limited access and very thick sections would make conventional welding extremely time consuming, and require highly skilled welders to work in confined spaces. The automated electroslag welding process can make the three inch thick 10m long vertical welds in a single pass and require reduced personnel access during welding and welding time for each of the 27 welds would be reduced many times.

The project implementation will be used in the erection fabrication of the single tower of the new bay bridge. The skill levels of welders and welding engineers will be raised as the new technology is transferred to production fabrication applications.

This project will result in the world's longest electroslag welds of this type and one of only a few instances where this welding practice has been used for field fabrication as opposed to within a fabrication facility. A host of technical process and metallurgical obstacles have presented challenges throughout the project.

The research has strengthened technology development and transfer from the university to industry and has provided graduate and undergraduate students the opportunity to learn firsthand some of the challenges inherent in moving from a design to an extremely large fabricated structure.

BUSINESS SUMMARY:

The construction of the new San Francisco-Oakland Bay Bridge, (SFOBB), in California requires field welding of the tower base sections. These sections are made of thick steel plates up to 100mm or 4" thick. The sections are 10m or approximately 35'-0 tall. The sections are to be joined together with 20 weld joints. These vertical up field welds must be made in place. The geometry of the individual parts and pieces is very complex. This project goal is to develop and refine a single pass vertical up welding

process for these joints. The process is electroslag welding. The electroslag process is substantially safer and less risky than conventional multipass arc welding such as FCAW. The project is ongoing.

There are several problems in the industry that this project is attempting to solve. This project is attempting to develop qualified procedures for the first major bridge welds done by electroslag in many years. This project is developing and refining the electroslag procedure so that welder safety can be improved, the time workers will be exposed to the welding process is substantially reduced from FCAW and also there are no preheat requirements. The time that workers will be required to work in confined space will be reduced. The electroslag welds are much more consistent in quality than FCAW welds and therefore less time is spent making repairs. Electroslag welds will make the construction of the SFOBB tower base feasible.

Estimated cost savings can be broken down into four parts. The electroslag process deposits weld metal more rapidly than FCAW or SMAW. This saves time. There is no preheat requirement for electroslag welding and this saves resources. The electroslag process is safer than the FCAW or SMAW processes and in turn prevents injuries and accidents, increasing cost saving. In terms of money spent, the cost of the research plus the cost of the electroslag welds will probably exceed the cost of making the welds with conventional methods, however the cost of the electroslag welds alone will be less than the cost of making the welds with conventional methods and the new technology developed by PSU-OGI can be applied to other electroslag welding operations.

Because electroslag welding is virtually defect free when compared to FCAW or SMAW, resources are used more efficiently due to the lack of defects and the related reduced repair costs. The deposition rate of electroslag welding is substantially greater than that of FCAW or SMAW and this enables welds to be completed in much less time. The savings in human-hours is on the order of 50% or better. An electroslag weld has a lower cost due to a number of factors including reduced human hours, near zero repair rates, no preheat requirement, and increased worker safety. Working on this project in Portland with PSU-OGI has enabled us to use a number of local companies including testing labs, UT testing services, engineering services, and local steel fabricators and erectors. Specific to the SFOBB, approximately a dozen welders will be involved in the making of the electroslag field welds in the base of the tower. The skills of these welders will be improved as a result. In addition, the knowledge base of several engineers has increased.

The use of electroslag welds to join the tower base sections of the SFOBB is an important factor in the constructability of the bridge. It is likely that the designers knew of the process and counted on the further development of the process in order to build the bridge. The refinements developed at PSU-OGI should make electroslag welding an attractive alternative for other bridge designers when considering the joint of thick plates. Other industries that weld thick plates can also apply the procedures developed through this project. This would include other types of construction welding, fabrication of large plate weldments, and ship yard welding. At this time it isn't known if this project will lead to a new patent or patent application.

The PSU-OGI High Bay Facility on North Walker has been the location of most of the work for this project. All of the resources in the High Bay that can be used for electroslag welding have been used for electroslag welding. The scanning electron microscope at North Walker and the scanning electron microscope downtown have been used for this project. There have been a number of occasions where we have drawn on the expertise of other members of the PSU-OGI community for this project.

The body of knowledge with respect to electroslag welding has been enlarged as it is applied to the field welding of thick plates to bridge standards. The contractor has been lucky enough to have the opportunity to work with world class researchers in an environment devoted to furthering the technology and developing further refinements of the technology. The contractor has been able to draw on the full depth of talent available at PSU-OGI for this project. The contractor is very grateful for the use of the many plant and equipment resources at PSU-OGI.

CHARACTERIZATION OF HARD THIN WEAR RESISTANT COATINGS

Participating Company: Blount

Company Contact: Charlie Moore, John DeHaven

Participating University: Portland State University

PSU Principal Investigator: William Wood

PROJECT SUMMARY:

A worldwide effort is underway to develope alternative material solutions for electrodeposited hard chrome coatings due to deposition related health hazards. PSU is partnering with Blount in an effort to develop alternatives to electrolytically deposited chromium used in Blount's manufacturing technology. Non electrolytic deposition technologies based on Titanium and Zirconium are being considered. PSU is characterizing deposits relative to quality, hardness, and microstructure. The project is currently ongoing.

The EPA is reducing the hexavalent Cr allowable generated during electrodeposition. If the process were banned in the U.S. it would significantly impact Blount's manufacturing technology. The alternative technology will replace current technology that has been used for decades. A benefit was elimination of a hazardous manufacturing waste stream. Enhanced skills were developed to characterize hard thin films using microhardness, optical and electron microscopy. Benefits from this industry-research partnership are expanded collaborative research into alternative manufacturing processes previously not researched at either Blount or PSU.

BUSINESS SUMMARY:

The project researched coatings for special-application tools, including alternatives to electrolytic hard chromium. This phase of the project is completed, leading to the pursuit in the next fiscal year of developing several of the many coatings that were studied during this project.

The problem the industry faced was to find a coating that could meet or exceed the present coating for our applications. This required a coating with associated process parameters that could satisfy the performance characteristics for the tools without adversely influencing their engineered character.

The estimated cost savings and efficiencies gained are unknown as of yet. No additional jobs were created during or from this project. There were no new markets captured with this project and the potential for new products or markets is yet to be determined. This project has not lead to a new patent or application.

COMPUTER SIMULATION OF ROCKMAN HARDNESS TEST

Participating Company: Boeing

Company Contact: Janet Podell

Participating University: Portland State University

PSU Principal Investigator: Hormoz Zareh

PROJECT SUMMARY:

The objective of this project in simplest terms was to develop a novel finite element model for Rockman "rebound" hardness tester. The model was used to verify the experimental results previously obtained and can be used in future verification of relative hardness values for different alloys under different residual stress regimes.

The project was completed on time. The research introduced a graduate student to the multiple aspects of the concept of nonlinear analysis. The researcher used the experience gained in the course of conducting the research to enhance the advanced graduate level course in Finite Element Modeling. Furthermore, a collaborative journal publication has been submitted for publication to ASTM International Journal and is currently under review.

BUSINESS SUMMARY:

The objective was to develop a novel finite element model for Rockman "rebound" hardness tester. The model was used to verify the experimental results previously obtained and can be used in future verification of relative hardness values for different alloys under different residual stress regimes. This project was completed on time.

It was suspected that residual stress was influencing the hardness results from the tester. It was reasoned that if residual stress influenced the tester results that the tester could be used to provide residual stress indication. This information would be useful in resolving machining problems.

It is difficult to estimate the cost savings as the knowledge is used for case by case trouble shooting. An added efficiency gained from this project is that it avoids the scraping of high value metal. The skill levels of several engineers were enhanced but no additional jobs were created. A novel approach to indicating residual stress was investigated. The research did not lead to a new patent or patent application but a joint paper was published.

The research introduced a graduate student to the multiple aspects of concept of nonlinear analysis. The researcher used the experience gained in the course of conducting the research to enhance the advanced graduate level course in Finite Element Modeling. Furthermore, a collaborative journal publication has been submitted for publication to ASTM International Journal and is currently under review.

DEVELOPMENT OF AN IMPLEMENTATION STRATEGY FOR CONTINUOUS IMPROVEMENT TOOLS AND TRAINING

Participating Company: Cascade Steel Rolling Mills

Company Contact: Jonathan Ostling

Participating University: Oregon State University

PSU Principal Investigator: Toni L. Doolen

PROJECT SUMMARY:

Cascade Steel provides the Western U.S. and Canada with high quality steel products produced from recycled scrap metal produced in a state-of-the-art electric arc furnace steel mill. Cascade Steel's products include reinforcing bar (rebar), coiled reinforcing bar, wire rod, merchant bar as well as other specialty products.

A formal benchmarking at Gerdau Ameristeel helped determine that Cascade Steel would benefit from a formal structured problem solving method. This structure includes criteria for identifying key problem areas and criteria for solution evaluation, including return on investment metrics. After a review of the continuous improvement literature and an initial analysis of Cascade Steel, Root Cause Analysis and A3 reports were identified as the most appropriate overarching tool set. These tools are aimed at helping the organization transition from a current product-focused quality assessment system to a process-oriented quality management system.

Along with these tools, training materials were developed and presented to assist the employees of Cascade Steel in understanding how to properly use these tools. Support is currently being given to ensure proper resources are available to sustain current efforts when utilizing Root Cause Analysis and the A3 report. Current efforts are being put towards documenting roles and responsibility for program management, project tracking, results reporting, including program maturity assessment and communications. Additionally key process indicators (KPIs) for continuous improvement are being linked to business goals, e.g. productivity, quality rates and costs are being established and monitored.

Cascade Steel had recognized potential for improvements throughout their organization. To be able to be more competitive, Cascade Steel must be able to systematically address problems in the current processes. In order to successfully address these problems, they must have the proper tools to analyze and resolve the issues. It had been difficult to track progress made when an issue occurred without formal documentation processes. It had been observed that projects designed to address problems had failed due to the lack of detailed analysis, planning and follow up. This resulted in wasted time, effort and resources when attempting to improve business practices.

This project provided a tool for everyone to use to identify and systematically solve problems throughout Cascade Steel. This tool is simple enough for anyone to use and the training provides a foundation for an employee to be engaged in any project where there is a stakeholder in the process. Our assessment of Cascade Steel helped identify the primary stakeholders who could utilize process-orientated continuous improvement tools when addressing key health, safety and quality issues. The benchmarking of Gerdau Ameristeel helped identify best practices related to the deployment of

continuous improvement training within a multi-level organizational structure. Training, along with standard procedures documentation has been developed for current and future projects. Training is currently being provided by Oregon State University personnel, but the goal is for all training held in regards to utilizing the Root Cause Analysis tools and A3 reports to be done internally by the organization. The training materials developed as a result of this work include learning outcomes, suggested tools and practices, training examples, tool templates and an outline of a set of deployment processes. Evaluation of the training material will be supported by identified personnel at Cascade Steel to ensure it is most fitting to the current needs. Along with formal training, one-on-one mentoring of line personnel in all phases of the continuous improvement process, including tool identification, tool application and results reporting has been supported by OSU personnel and will be supported by Cascade Steel employees.

Various projects have led to reductions in capital, labor and resources used. After a group of experts in the Rolling Mill of Cascade Steel used the A3 report, they were able to reduce the time it took to change over the equipment from 170 minutes to approximately 50 minutes. A group from the Melt Shop was able to use the A3 problem solving process to help the department to understand the root causes for various wastes and non-value added activities and was used to help them justify an investment in new equipment. The A3 report was utilized in the shipping yard to help reduce the number of underweight freight carts by an anticipated 50%. The original number of freight cars underweight was 71% and it has recently been reduced to 65%.

The A3 report has also been used in the Engineering Department at Cascade Steel. Key engineers used the A3 report to help standardize their process for naming and storing their drawings, which will make it possible for any engineer to find a drawing in less then 15 minutes. It can currently take up to 2 hours to find a drawing and if one is not found then the engineer has to recreate the drawing. The quality department is utilizing the A3 report and Root Cause Analysis tools to help improve the layout in the lab to improve the work flow for sample testing and data entry. The improvements made will help significantly reduce the amount of motion and transportation necessary when processing a sample. More precise estimates will be made upon analysis of the improved processes.

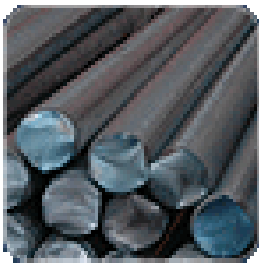
The technical and interpersonal skill levels of seven employees of Cascade Steel have been raised through their involvement in both internal and external training to prepare them in the implementation and facilitation when implementing an A3 report in a group setting. More specifically, their skill levels have been elevated both in the area as a team leader, as well as a participant in implanting lean principles in their work environment. Throughout Cascade Steel, 24% of the employees have been involved in continuous improvement projects which include having been through basic training on the creation and use of A3 reports.

No new markets were captured nor were any new products developed. Currently the research did not lead to a new patent or patent application. The initial benchmarking of Gerdua Ameristeel and detailed interviews with Cascade Steel personnel provided a unique insight into the current manufacturing process and troubles faced within the industry. Further exploration of various manufacturing companies in the Pacific Northwest is being planned to ensure more Cascade Steel employees continue training to be able to “see” waste and related actions. Through interviews and a survey of the literature, an initial set of evaluation criteria was developed. These criteria are currently being used to evaluate the effectiveness and efficiency of training provided to the employees of Cascade Steel. The data gathered from this evaluation will help further improve the training materials to fit the current needs of the employees at Cascade Steel. It will also provide a deeper understanding of the importance of various factors before, during and after training events.

Throughout this project, engineering management and manufacturing tools and techniques were researched and restructured to best address the current problems Cascade Steel has been facing. Through multiple iterations, much has been learned in terms of what has proven to be effective with the employees. This knowledge has been passed on to the instructors of various Industrial Engineering courses at Oregon State University to help the students better understand potential roadblocks one may face in industry.

Assessment data is currently being collected to enable a detailed evaluation of the effectiveness of the provided training. In particular, both the immediate impact, as well as the longer-term impact of the training activities will be evaluated using data collected at different points in time, e.g. immediately following training completion, at 3 months, 6 months, etc. The assessment of the continuous improvement implementation and training will contribute to the current body of knowledge, which is still in its infancy. Cascade Steel has already shown great progress in understanding and addressing various forms of waste throughout the organization. The teamwork required to tackle these problems have brought more unity and understanding between all levels of employees. Current efforts are focused on ensuring all current efforts are sustained and beneficial to all employees of Cascade Steel.

BUSINESS SUMMARY:



Example of hot-rolled steel products

This project is focused on identifying continuous improvement tools and developing training materials and processes to support the deployment of the tools across functions and departments at CSRM. The ultimate goal of the work is improved product quality and more effective and efficient production processes. Some of the practices identified as training challenges during the first stage of the project, e.g., not training on days off, coming in during the short work week, have informed the standards put into practice. A number of drivers have produced this result. There is strong evidence of the importance of the environment (economic challenges) in driving how things are done.

The issues faced by CSRM that led to the development of this work included difficulties in establishing priorities for each department to determine which Continuous Improvement (CI) projects should be the focus. In addition, many departments found it difficult to introduce changes as the projects required buy-in from individuals working on multiple shifts. Previous efforts also fell short as departments often failed to include input from other departments in the planning and implementing changes. Finally, some projects were difficult to assess the impact as project leaders failed to include financial analyses as part of the planning work. This project was undertaken to address these challenges.

The projects undertaken as part of this project have led to reductions in capital, labor and resources used. One of the tools introduced to help manage CI project and implementation activities is the A3 Report, a tool developed by Toyota. After a group of experts in the Rolling Mill of Cascade Steel used the A3 report, they were able to reduce the time it took to change over the equipment from 170 minutes to approximately 50 minutes. A group from the Melt Shop was able to use the A3 problem solving process to help the department to understand the root causes of various wastes and non-value added activities. The results of this analysis were used to help justify a financial investment in new equipment. The A3 report was also utilized in the Shipping Yard to help reduce the number of underweight freight carts. The number of freight cars underweight prior to this work was 71%. As a result of the improvements implemented as part of the A3 report, underweight carts have been reduced to 65%.

So far there has been limited recording of the total cost savings for projects. This recognition has pushed for a better documentation of the cost, cost savings, and time savings which have been brought about through the use of the A3 report in managing continuous improvement projects. Establishing regular meeting times has helped condense the amount of time necessary to convey and discuss information in regards to the progress of projects among all impacted staff. Through feedback from the staff, the team members have been pushed to present the material in less than 30 minutes which has helped decrease the time spent by employees in meetings. Also, staff are more sensitive about double-booking meetings and are more consistently communicating changes to the meetings that are made, i.e., time, location, attendance, etc. Throughout the meetings in which employee involvement is key, it was been recognized that the ratio of employees to manager plays a key role to ensure that honest feedback is received and to ensure that all employees feel comfortable providing input.

One new job title of 'Quality Systems Supervisor' was created as a result of establishing a more permanent focus on quality. No new markets or new products were developed with this project. Nor did the project led to patent or patent application.

This project has enhanced communications between employees. Enhanced communication was driven by the need for everyone to have the same understanding of the goals of the CI project and the role of each participant. A change in style of communication also took place when the CI leaders started to ask the employee questions instead of just providing instruction, which enhanced the rapport between union and non-union employees. Employee involvement has been further encouraged by the employee's supervisors. For example, recently employees have gained hands-on experience implementing the practice of 5S. The practice of 5S makes it so the employees can utilize their working space more efficiently by sorting, setting in order, cleaning, standardizing, and sustaining. Communication has also been established among the business and continuous improvement leaders before initial team meetings are held to collect data and to create plans. This planning speeds up the amount of time between starting a project with team members and creating an implementation plan to address root causes. This planning also helps in identifying the employees who will be able to best understand the problem, which ensures that the root cause analysis can be more thorough and that implementation will be more successful. It has also been helpful to have a few key continuous improvement leaders coordinate meetings and projects to help keep projects on track. A new tool has also been introduced. Specifically, filming processes as part of the evaluation has proven to be an effective tool to encourage input from all team members. The contributions of all team members have also been more widely recognized so the progress made reflects upon the whole team, instead of just the ideas of a smaller number of project leaders.

An overall vision is currently being worked on to help everyone involved understand the need to move away from status quo. The CI team has been challenged with determining a way to establish priorities of projects for each department and working with a group of employees who have schedules that vary widely. This has pushed the team to ensure that everyone is included throughout the continuous improvement process. Along with including all necessary employees, the executive level employees have been challenged with maintaining ownership of the projects in their area. This has also pushed the leaders to share responsibility and has encouraged managers to reach out to other departments and to include input from representatives from other departments. These new relationships have created a more common understanding of the challenges that arise across departments.

DEPLOYMENT OF AN IMPLEMENTATION OF CONTINUOUS IMPROVEMENT TOOLS AND TRAINING

Participating Company: Cascade Steel Rolling Mills

Company Contact: Jonathan Ostling

Participating University: Oregon State University

PSU Principal Investigator: Toni L. Doolen

PROJECT SUMMARY:

Through the OMI program, Cascade Steel Rolling Mills, Inc. and Oregon State University faculty PI Professor Toni Doolen have worked to create training tools and materials for the manufacture of steel. Recently this work has been pursued under two OMI projects entitled "Deployment and Implementation of Continuous Improvement Tools and Training" (begun May 2009) and "Deployment and Implementation of Continuous Improvement Tools and Training Extension (begun September 2009)". As the titles suggest, these projects are closely related, the second being additional activity in the same topical area as the first. Due to this close relationship, one report will be submitted at the conclusion of the second project covering both.

OPERATIONS CHARACTERIZATION AND OPPORTUNITY ANALYSIS OF CASCADE STEEL PRODUCTION SYSTEM

Participating Company: Cascade Steel Rolling Mills

Company Contact: Jonathan Ostling

Participating University: Oregon State University

PSU Principal Investigator: Toni L. Doolen

PROJECT SUMMARY:

Through the OMI program, Cascade Steel Rolling Mills, Inc. and Oregon State University faculty PI Professor Toni Doolen have worked to create training tools and materials for the manufacture of steel. Recently this work has been pursued under two OMI projects entitled "Deployment and Implementation of Continuous Improvement Tools and Training" (begun May 2009) and "Deployment and Implementation of Continuous Improvement Tools and Training Extension (begun September 2009)". As the titles suggest, these projects are closely related, the second being additional activity in the same topical area as the first. Due to this close relationship, one report will be submitted at the conclusion of the second project covering both.

ROBUST COMMERCIAL VEHICLE CONTROL, ROUTING AND OPERATION

Participating Company: Daimler Trucks North America, LLC

Company Contact: Derek Rotz/ Ingrid Philippon

Participating University: Oregon State University

PSU Principal Investigator: Kagan Turner

PROJECT SUMMARY:

This project aimed to improve the fuel efficiency of commercial vehicles through the use of adaptive algorithms that reduced the impact of modeling assumptions and unknown factors. The project is complete.

Because commercial trucks are heavy objects moving at speeds of 50-60 miles per hour, their fuel efficiencies are heavily impacted by design and operating decisions. If the design is considered fixed (as it will be for this project) improving the fuel efficiency of such trucks solely relies on operating decisions. Many algorithms currently exist for determining the optimal speed of a commercial vehicle based on estimates of mass, air resistance, environmental conditions, etc. However, all such models rely on approximations and assumptions that can lead to inaccurate overall estimates of the optimal operating parameters.

This project has led to improving the accuracy of cruise control estimates of speed by 5% - 40% depending on the operating conditions and modeling assumptions which translates into potentially significant fuel cost savings. The improvement in the accuracy of estimates of speed can lead to better use of current cruise control algorithms, improving their efficiency. Additional jobs or existing jobs raised skill level were not directly affected. This work is the starting point for improving an existing product. The potential to install new and improved predictive cruise control algorithms in commercial vehicles is huge.

The student received models and data from a real world example that significantly enhanced their understanding of the topic. Applying the algorithms to a real world problem prepared the student for a

career as an engineer. The project sponsor (Derek Rotz, Daimler) and principal investigator (Kagan Turner, OSU) have collaborated on larger, nationally competed proposal calls. The seeds planted in this project may lead to significantly larger collaborations benefiting Daimler, OSU and Oregon, both technologically and financially.

BUSINESS SUMMARY:

This project aimed to improve the fuel efficiency of commercial vehicles through the use of adaptive algorithms that reduced the impact of modeling assumptions and unknown factors. The project is complete.

Because commercial trucks are heavy objects moving at speeds of 50-60 miles per hour, their fuel efficiencies are heavily impacted by design and operating decisions. If the design is considered fixed (as it will be for this project) improving the fuel efficiency of such trucks solely relies on operating decisions. Many algorithms currently exist for determining the optimal speed of a commercial vehicle based on estimates of mass, air resistance, environmental conditions, etc. However, all such models rely on approximations and assumptions that can lead to inaccurate overall estimates of the optimal operating parameters and cause tracking errors on the desired cruise control speed.

This project has led to reducing tracking errors of the desired cruise control speed by 5% - 40% depending on the operating conditions and modeling assumptions which translates into potentially significant fuel cost savings. The improvement in the accuracy of estimates of speed can lead to better use of current cruise control algorithms, improving their efficiency. Additional jobs or existing jobs raised skill level were not directly affected. This work is the starting point for improving an existing product. The potential to install new and improved predictive cruise control algorithms in commercial vehicles is huge.

The student received models and data from a real world example that significantly enhanced their understanding of the topic. Applying the algorithms to a real world problem prepared the student for a career as an engineer. The project sponsor (Derek Rotz, Daimler) and principal investigator (Kagan Turner, OSU) have collaborated on larger, nationally competed proposal calls. The seeds planted in this project may lead to significantly larger collaborations benefiting Daimler, OSU and Oregon, both technologically and financially.

ALUMINUM BAT PERFORMANCE (PHASE IIX)

Participating Company: DeMarini Sports Inc.
Company Contact: Ed Vander Pol
Participating University: Portland State University
PSU Principal Investigator: David Turcic

PROJECT SUMMARY:

DeMarini Sports is a world leader in the development of high performance softball bats and baseball bats. All of these bats are manufactured from high-strength aluminum, in contrast to solid wood bats used in professional baseball. In order to improve bat design, DeMarini seeks a basic understanding of the factors that affect bat performance. The proposed continuing study will refine the softball and baseball bat high speed test apparatus and experimental methods to further improve the reliability and precession of the measurement of the impact mechanics of aluminum bats and the effects of material properties and bat structure on the bats' response characteristics.

To maintain as the leader in high performance softball and baseball bats, DeMarini Sports needs to test and understand materials behavior under test conditions and to provide input into the design and construction of a softball or baseball bat. Based on the results of this effort, DeMarini Sports was able to analyze various constructions and the impact on bat performance.

The graduate students had the privilege of working on a real world problem and further developed their mechanical design and instrumentation skills.

The instrumentation and visualization capabilities at Portland State University were enhanced by working with DeMarini Sports.

Project has been completed.

BUSINESS SUMMARY:

DeMarini Sports is a world leader in the development of high performance softball bats and baseball bats. All of these bats are manufactured from high-strength aluminum, in contrast to solid wood bats used in professional baseball. In order to improve bat design, DeMarini seeks a basic understanding of the factors that affect bat performance. The proposed continuing study will refine the softball and baseball bat high speed test apparatus and experimental methods to further improve the reliability and precession of the measurement of the impact mechanics of aluminum bats and the effects of material properties and bat structure on the bats' response characteristics.

DeMarini Slow Pitch Bat

To maintain as the leader in high performance softball and baseball bats, DeMarini Sports needs to test and understand materials behavior under test conditions and to provide input into the design and construction of a softball or baseball bat. Based on the results of this effort, DeMarini Sports was able to analyze various constructions and the impact on bat performance.

This new capability will provide input into new designs. A patent is being considered. This project has been completed.

DEVELOPMENT OF ELECTROSLAG WELD PREHEATING PROCEDURES

Participating Company: EST&D

Company Contact: Dan Danks

Participating University: Portland State University

PSU Principal Investigator: William Wood

PROJECT SUMMARY:

Conventional electroslag welding for low carbon steel alloys does not require preheat or post welding supplemental external (to the weld itself) heating due to the high heat input inherent in the electroslag welding process. EST&D application requirements include high carbon steel alloys with complex shapes. For these applications supplemental heating may be required. The project explored the use of supplemental external heating in association with the electroslag welding process.

The results of this project are being incorporated in continuing technology development efforts.

Current technology solutions use an exothermic welding process for joining irregular shaped high carbon steel alloy. There is an inherently high level of non metallic inclusions in exothermic welds that lead to an unacceptable incidence of failure and therefore a limit upon load rating. With proper development the electroslag welding process has potential to provide stronger and higher quality welds for joining high carbon steel.

Successful implementation of this technology will result in a new welding technology that will require manufacturing welding equipment and a high volume of welding consumables. This project contributed to student skill building in the areas of weld microstructure analysis. As such, it contributes to the overall skill sets of the materials research group. This research contributes to the overall knowledge base for electroslag welding and its application at PSU.

BUSINESS SUMMARY:

Conventional electroslag welding for low carbon steel alloys does not require preheat or post welding supplemental external (to the weld itself) heating due to the high heat input inherent in the electroslag welding process. EST&D application requirements include high carbon steel alloys with complex shapes. For these applications supplemental heating may be required. The project explored the use of supplemental external heating in association with the electroslag welding process.

The results of this project are being incorporated in continuing technology development efforts.

Current technology solutions use an exothermic welding process for joining irregular shaped high carbon steel alloy. This process has a high rate of failure due to weld defects. This project continues to develop alternative electroslag joining technology to result in a more reliable welding process.

Until the technology is commercialized it would be difficult to calculate cost savings but potentially billions of dollars. Several local resources are used to produce electroslag welding consumables including metal fabrication (laser cutting, steel supply), cast refractory (ceramic), and consumable insulators.

Stemming from this project two company owners have a raised skill level. No additional jobs were created but the skill levels for all involved in the project (6 total) were raised. New products are still under development. If successful, the product will enter the current market worth approximately $600,000,000/year in North America.

The work was part of a current patent application. This project used laboratory specimen prep, microscopy, general fabrication, machining, space, and power of the research facility. The benefit of this project is continued collaboration between EST&D and PSU.

INVESTIGATION OF MATERIALS AND PROCESSING FOR ELECTRON OPTIC ELEMENTS

Participating Company: FEI Company

Company Contact: Greg Schwind

Participating University: Portland State University

PSU Principal Investigator: J.Devletian, Pl

PROJECT SUMMARY:

Systems using charged particles for imaging such as scanning electron microscopes, transmission electron microscopes, and focused ion beam systems are continuously striving for improved resolution. The resolution of these systems has significantly improved in recent years to the extent that further improvement requires addressing issues routinely ignored in the past. One such issue is the inside bore of the electron optical lens and aperture elements. Extremely small changes in the potential distribution across these surfaces can have a significant effect on the electron beam and hence the system's performance. This effect/problem increases as the system's beam voltage decreases. Since the performance at low beam voltage is a significant market driver, it will give FEI a competitive edge in the market if this problem can be solved.

FEI Helios NanoLab DualBeam incorporating both the LMIS and SE sources

The material properties that can affect the potential distribution are grain size, the change in grain size over time, the machining method, post machining processing, the method the raw material is manufactured (hot pressed or cast), purity of the material and reaction with background gases. In addition, the material must be high vacuum compatible and have good high voltage properties. This combination makes it a challenging materials problem. This project will explore the commonly used materials for this application to find the optimum raw material and manufacturing process to obtain reproducible and improved performance. This project was successful in design and testing is on-going.

The problem was to explore the commonly used materials and to find the optimum raw material and manufacturing process to obtain reproducible and improved performance of high power plasma ion sources.

This project enhanced the research skills of the team by making them identify problems and develop critical thinking skills. We were able to understand the mechanism to improve performance of ion sources. The industry was better able to understand the scientific method of research from this project.

BUSINESS SUMMARY:

Systems using charged particles for imaging such as scanning electron microscopes, transmission electron microscopes, and focused ion beam systems are continuously striving for improved resolution.

The resolution of these systems has significantly improved in recent years to the extent that further improvement requires addressing issues routinely ignored in the past. One such issue is the inside bore of the electron optical lens and aperture elements. Extremely small changes in the potential distribution across these surfaces can have a significant effect on the electron beam and hence the system's performance. This effect/problem increases as the system's beam voltage decreases. Since the performance at low beam voltage is a significant market driver, it will give FEI a competitive edge in the market if this problem can be solved.

The possible improvements have been identified and are being tested or implemented. Further improvements based in the increased knowledge of the problem are being explored.

Liquid Metal Ion Source (LMIS) used in Focuses Ion Beams (FIB) Microscopes

The problem that the industry faced was the charge particle microscopes are now achieving sub-nanometer resolution. The smallest perturbation in the parts of the column where the charge beam passes in close proximity, such as an aperture, will degrade the optical performance. The problem was addressed by analysis of materials and exploring different materials and manufacturing processes.

A cost savings is realized from an increase in the first pass yield which reduces the labor needed to build the product. The improved performance and reliability of the system increases the company's competitiveness in the market. In addition it may result in less frequent in-field maintenance which increases customer uptime and reduces company and customer cost.

The primary benefit of this industry/university collaboration is access to a material science expert and his extensive lab without having to make the very large investment that would be required to replicate the expertise inside the company.

HIGH PERFORMANCE PIEZOELECTRIC MATERIALS AND DEVICES FOR MEMS APPLICATIONS

Participating Company: Hewlett Packard

Company Contact: Peter Mardilovich

Participating University: Oregon State University

OSU Principal Investigator: Dave Cann

PROJECT SUMMARY:

This OSU/HP project is focused on the development of MEMS (microelectromechanical systems) devices for piezoelectric actuator applications. The project has been underway since early fall with three faculty members (David Cann, Brady Gibbons, and Mas Subramanian) and their students working on different aspects, including materials development, thin film fabrication and device characterization.

OSU researchers are looking at many issues, but the primary goal is to develop a material that is environmentally benign that can substitute for the current lead-containing material, lead zirconate titanate. In particular, OSU researchers are evaluating the fabrication and performance of these materials under different environmental conditions.

The estimated cost savings is difficult to quantify – at OSU the OMI component of the funding has greatly expanded the scope of the project such that 3 faculty members are able to contribute to the project. OSU researchers have been able to access HP facilities and have developed an excellent and effective collaboration. This is a growing technical area, with significant research activity currently going on in Japan and the European Union. We are currently working on a number of invention disclosures.

Students played an important role in this project. They often presented their results at biweekly meetings, and, over the course of the project, they became very familiar with the industrial research environment. This was an excellent collaboration for everyone involved in the project.

BUSINESS SUMMARY:

This project involves the development of Pb-free MEMS technologies for future HP products. Of particular interest is the effect of environmental conditions on the performance of the MEMS devices both during fabrication and during operation.

There are strong driving forces in industry to remove hazardous materials such as Pb from electrical components, and with replacement materials it is important to evaluate their performance characteristics in the device. OSU researchers are investigating many facets of this issue, from new material development, to performance optimization and failure analysis.

There is no easy way to evaluate this quantitatively – however the OSU-HP relationship is an effective mechanism for research and development. OSU researchers work closely with HP researchers, and the project is directly related to HP's product development.

This project is expected to have a long range impact, and it has great potential for HP. There are currently no patent applications, but there are several in development. Students have been involved in all aspects of the project. Students have learned a lot about industrial research and they will be better prepared for their future jobs after graduating. OSU and HP have a strong relationship and this project has been a significant contribution to that relationship.

RESEARCH AND DEVELOPMENT OF PROTOTYPE RESTRAINT SYSTEM FOR SMALL DIAMETER SPIRAL PIPE GASKETED JOINTS

Participating Company: Northwest Pipe Company

Company Contact: Randy Ridgley

Participating University: Portland State University

PSU Principal Investigator: Jack Devletain

PROJECT SUMMARY:

Describing this project in simplest terms; working within a research and development team structure, a number of concepts for restraint systems for small diameter pipe gasketed joints were developed and tested to determine physical properties and limits in real world applications. The Materials Science Department at Portland State University worked with Northwest Pipe engineers to narrow the field of possible successful designs for restrained joint attachments to pipe.

This project is finished. The problem that the industry faced was that key variables influencing performance of a restrained gasketed pipe joint needed to be identified so they could be controlled in the design process. The project enhanced the skills of the team because they would identify the problems. Students learned to develop critical thinking skills. Portland State University was better able to understand the expediency of alternative pipe joint systems and the students were better able to understand the scientific method of research.

Photo taken at the Portland Plant of Northwest Pipe Company

BUSINESS SUMMARY:

This project examined a number of possible designs for mechanical restraint systems to be used in steel pipelines in conjunction with rubber gasketed pipe joints. Right now the field of candidate systems was narrowed to allow future efforts to be concentrated on only the most promising of designs. The concept of this project is to develop a non-welded steel pipe connection system that will maintain its integrity under varying pressure and thrust conditions.

Cost savings to the company would be minimal – cost benefits would be to the customers. We would expect an increase in personnel to produce a successful line – perhaps as many as 3 to 5 positions at Northwest Pipe's Portland Plant. Products would compete in small diameter pipe markets not currently served by Northwest Pipe in this region. It is undetermined if a new patent would be appropriate.

Photo taken at the Portland Plant of Northwest Pipe Company

Northwest Pipe personnel gained appreciation of the value that Portland State University, Materials Science Department, brings to the industry in the region. A better understanding of how to approach research and better critical thinking was also gained through the association.

SCHEDULING AND RESCHEDULING OF METAL PIPES

Participating Company: Northwest Pipe Company

Company Contact: Ed Martin/Jack Cobb

Participating University: Oregon State University

OSU Principal Investigator: R. Logen Logendran/Lin Reilly

PROJECT SUMMARY:

Describing the project in simplest terms; it was the development of a scheduling algorithm to schedule the various jobs that belong to projects received from customers by the company. The objective is to minimize the tardiness of all jobs in a schedule. The jobs are also weighted, this is to take into account of the priorities associated with them. More specifically, three different priorities: low, medium, and high, were used to make that distinction in the algorithm developed for solving the problem. The project has been completed.

The company didn't have a formal, algorithm-driven methodology to schedule the various jobs received from customers in an effective yet an efficient manner. This project enabled them to be able to do that.

The company was given a software program with numerous user-interactive features that will generate the schedules for jobs automatically. The software program can be used by the company to generate the schedules. This effort significantly eliminated the effort previously required to *manually* develop the schedules. This would amount to a significant savings in human-hours. When the manual approach was used there was no guarantee that the solution chosen to be implemented was of the highest quality. The algorithm-driven approach, as developed in this project, ensures that the solutions implemented on the shop floor were indeed high quality. The research did not lead to a new patent or patent application.

This project enabled a MS student to work as a graduate research assistant (GRA) for a period of one year. The findings from this project with additional work on model building and statistical experimentation would result into their MS thesis.

The project has produced a conference presentation, which the MS student presented at a national conference in October 2009. Currently, work is in progress to write up a paper for a refereed conference proceedings. When the student completes the work for their MS thesis, a comprehensive paper will be written and submitted to a journal.

BUSINESS SUMMARY:

OSU was to develop a scheduling algorithm capable of producing start and end times for setups as well as runs of all jobs released during a given time frame. OSU has developed the algorithm program and provided a copy to Northwest Pipe. Northwest Pipe is in the process of building an interface between the algorithm program and its current production database, which will in-turn provide the data to the algorithm to analyze.

The problem the industry faced was that delivery requirements from customers constantly changed which affected the production processes. Northwest Pipe needed a way to quickly analyze the effect of the changes to the delivery requirements so that the production schedule can be modified to minimize the delay impact to any and all jobs. Preliminary testing of the algorithm looks very promising.

The project will be used to create and analyze possible production schedules, to help maximize the cost and time efficiency of pipe production and delivery. The project anticipated that efficiencies in manufacturing would result from a better scheduling system. This could be in excess of $100,000 per year when a complete system is integrated.

Northwest Pipe would expect to save more than 1,000 hours per year in machine setup and breakdown time throughout the facility when an integrated scheduling system is implemented. No new jobs were created, however skills will be enhanced in implementing an integrated scheduling system. No new markets were created or anticipated and there is not a new patent application pending. This project did provide some insight into programming logic by all those on the team.

Certainly, because of this project, the knowledge of skills available at OSU have been brought out. There is the possibility of future projects between Northwest Pipe and OSU.

THERMOPHYSICAL PROPERTIES OF FSX 414

Participating Company: PCC Structurals Inc.
Company Contact: Kevin Ronan
Participating University: Portland State University
PSU Principal Investigator: Victor Li

PROJECT SUMMARY:

The industry partner, PCC Structurals Inc., conducts finite element analyses of metal castings to evaluate the feasibility of casting various alloys to designed geometries with minimal defects. The reliability of the analysis results is dependent on the accuracy and consistency of solidification properties of alloys entered in the finite element analyses.

There are many sources of solidification properties with different models and databases. This project is geared towards finding the best model and database to obtain accurate and consistent solidification properties of cast alloys. This study compares the consistency and accuracy of solidification properties from different sources. The project has been completed.

It is estimated that with the better solidification properties, finite element analyses can effectively guide the design of casting process to reduce casting defects and the amount of rework at least 50%. This can translate into tens of millions of dollar savings per year at PCC.

The project results in increased knowledge base and technical know how to optimize alloy selections and process designs, from mostly experience based to science based, from qualitative to quantitative approaches. This project has led to the increase in the skill levels of the existing engineers.

This project has led to a much better understanding for the research team and students of the alloys and their solidification behaviors. It also improved the understanding of the research team and students on the practical issues that the industry is facing. This project has led to shorter turn-around time for the process development for the industry.

BUSINESS SUMMARY:

Describing this project in simplest terms this project conducts thermophysical modeling of several different chemistries of a cobalt-based superalloy, FSX-414. The primary defects that the industry faced were intermittent casting defects which caused both rework and scrap. The modeling data for this project was compared to experimental data to establish whether a link between the two could be established as a step toward a cost-effective alloy optimization process.

Reduction of expensive casting trials necessary for optimizing alloy chemistry help with cost savings; such trials typically exceed $10,000. Improved manufacturing efficiency due to scrap and rework reduction was gained. No additional jobs were created as a result of this work.

This work was applied to an existing product already in production. It does have the potential in the long term, to leverage toward other alloy systems and/or castings. This project didn't lead to a new patent or patent application.

The data from this project was used as part of a Master's of Materials Science thesis. From this the university has participated in other projects related to the core research. This project is completed.

CASTING ALLOYS AND PROCESS DESIGN

Participating Company: PCC Structurals Inc.,
Company Contact: John Peng
Participating University: Portland State University
PSU Principal Investigator: Victor Li

PROJECT SUMMARY:

The industry partner, PCC Structurals Inc.,, conducts finite element analyses of metal castings to evaluate the feasibility of casting various alloys to designed geometries with minimal defects. The reliability of the analysis results is dependent on the accuracy and consistency of solidification properties of alloys entered in the finite element analyses.

There are many sources of solidification properties with different models and databases. This project is geared towards finding the best model and database to obtain accurate and consistent solidification properties of cast alloys. This study compares the consistency and accuracy of solidification properties from different sources. The project has been completed.

It is estimated that with the better solidification properties, finite element analyses can effectively guide the design of casting process to reduce casting defects and the amount of rework at least 50%. This can translate into tens of millions dollar savings per year at PCC.

The project results in increased knowledge base and technical know-how to optimize alloy selections and process designs, from mostly experience based to science based, from qualitative to quantitative approaches. This project has led to the increase in the skill levels of the existing engineers.

This project has led to a much better understanding for the research team and students of the alloys and their solidification behaviors. It also improved the understanding of the research team and students on the practical issues that the industry is facing. This project has led to shorter turn-around time for the process development for the industry.

BUSINESS SUMMARY:

DESIGN AND FABRICATION PLAN FOR A SLIDE-OUT PLATFORM

Participating Company: Sheldon Manufacturing
Company Contact: Catherine Sidman
Participating University: Oregon State University
OSU Principal Investigator: John Parmigiani

PROJECT SUMMARY:

This project consisted of designing, prototyping and testing a slide-out platform and a footswitch - controlled powered door to the sponsor's product, a shaking incubator. The prototype is currently undergoing extended beta testing.

Two problems are solved with this project. First, it is now possible to open the door using a footswitch. Often users of the incubator carry trays of flasks, and hands-free access to the incubator chamber is very useful. Second, the incubator platform (the horizontal surface inside the incubator holding the flasks containing the specimens), can now, via a footswitch, slide-out of the chamber allowing easier loading and unloading.

This project has no cost savings. The sponsor will have a more marketable product, command a higher selling price and get a higher profit margin with the features added to the incubator stemming from this project. The focus of this project is product enhancement and improvement. Potentially jobs could be created via increased sales of the enhanced unit. The amount of jobs potentially created is unknown at this time.

New markets were absolutely created. Competitor's units do not have these features and it is expected that increased sales and profits will result from this project. It is possible that this project will lead to a new patent, it is currently being explored.

This project provided design, fabrication and testing experience and education to four undergraduate engineering students. A number of instruments were purchased for the principal investigators laboratory including power supplies, load cells and scales increasing the capabilities of the research facility. A relationship has developed between the principal investigator and the sponsor that has lead to a larger project in 2009-10.

BUSINESS SUMMARY:

This project is to define, design, demonstrate, and test modifications to our SI9 shaking incubator that allows hands free opening of the chamber door and slide out of the shaking platform while maintaining or improving existing key performance indicators without adding substantially to the cost to build.

The project has been developed through demonstration and validation and is now in extended beta test in an end user (research) environment.

The problem that the industry faces is that this product is often sold stacked and the lack of a slide out platform can make it very difficult to load and unload. This project gives us a competitive advantage to those competitors who do not have slide out platforms.

There is no cost savings relative to the existing model, but improved features should make sales at a higher price point while maintaining a margin for greater profitability. This project targeted providing enhancements and did not focus on material or labor cost reductions. In this market, we are endeavoring to maintain and hopefully improve market share – avoiding job losses and potentially contributing to overall workforce growth. This product enhancement allows for competition at a higher level. Product variations such as environmental controls could increase market offerings. The research did not lead to patent or patent application. This project allowed us to expand the project team with a minimum of internal resource commitments. This industry-research relationship has given us additional sources to test new ideas cost effectively and provided a forum for exchanging ideas on organization, techniques, and collaboration.

ELECTRON MICROSCOPY ANALYSIS OF TITANIUM AND HAFNUIM ALLOYS

Participating Company: ATI Wah Chang

Company Contact: Melissa Martinez

Participating University: Portland State University

PSU Principal Investigator: William Wood

PROJECT SUMMARY:

The project was aimed at characterization of titanium and hafnium alloys following thermomechanical processing using the advanced tools available at PSU: scanning and transmission electron microscopes and focused ion beam milling machines.

The project is complete although new questions need to be answered as a result of the completed work, a second series of specimens are ready for examination. The project provided engineers at ATIWC with valuable feedback on the alloy microstructures produced by thermo-mechanical processing.

This project provides characterization on a finer scale than possible at ATIWC of the microstructures produced by thermomechanical processing so that embrittling microstructures can be identified when correlated with mechanical testing and avoided once identified. If the project continues this should result in a reduction in alloy lots that fail mechanical tests thereby reducing scrap.

The research engineer working on the project gained valuable expertise on the SEM,TEM and FIB. The faculty member applied techniques and strategies used in the microelectronics industry to characterize specific micron, sub-micron and nanoscale microstructures that have been correlated with poor mechanical properties. This provides site specific characterization, and in-turn, an understanding of mechanisms of change in alloys on a scale not possible before for the research team and the local metals industry in general.

BUSINESS SUMMARY:

The intent of this project was to understand the links between processing, structure, and properties of some of our titanium and hafnium alloys through the use of advanced microscopic techniques. This project was designed to help us understand how processing influenced the structure and ultimately the properties of our materials.

This project is complete for now, although future work may be pursued to look at the samples, and others, in more detail.

The additional understanding of the processing-structure-properties of our alloys will help us to design more efficient processes to produce them. Ultimately a better understanding of our materials will help reduce the time and money needed to produce them. About five employees were involved in the project. Their knowledge of FIB, TEM and SEM was certainly expanded through working directly with PSU and Dr. McCarthy. No new markets were created and this project didn't lead to patent.

Internally we do not have access to the type of microscopy facilities available at PSU. Through the OMI project we were able to learn more about the techniques and how they can be applied to our materials. The engineers on the ATI Wah Chang side were exposed to a more detailed microscopic study of our materials.

ATI Wah Chang benefits from knowing who to go to and the capabilities available at local universities. We will continue to strengthen our relationship with local Oregon universities, especially with the help of the OMI program.

PROCESSING EFFECTS ON ELECTRICAL PROPERTIES OF HIGH PURITY NIOBIUM

Participating Company: ATI Wah Chang

Company Contact: Melissa Martinez

Participating University: Oregon State University

OSU Principal Investigator: Bill Warnes

PROJECT SUMMARY:

Residual Resistivity Ratio (RRR) is an electrical measurement used to determine the purity of very high purity metals. The information from this project will be used to improve the understanding of the effects of sample preparation on the resulting RRR of high purity ingots at ATI Wah Chang, and improve measurement techniques at OSU.

The large sample set has been delivered to OSU and the testing is more than half done. The anticipated completion date is mid-March, 2010. The problem that the industry faced is that the melt processing of high purity metals is very expensive, and increasing the purity requires multiple vacuum melt cycles. Economics dictates increasing the size of the melt ingot, but this can lead to variations in the chemical purity throughout the ingot. This project was developed to look at the effect of sample preparation methods on the RRR.

Historically, RRR has been thought to be extremely sensitive to different sample preparation methods. As high-RRR ingots are quite expensive to produce, it would be hugely detrimental to have the product be of a high RRR but test as a lower value due to the method in which the sample was produced.

Improvements in processing can lead to efficiencies in process resources, reduced processing time and lower processing costs. Realization of these savings must await full analysis of the results of this project.

The study involved an existing product. No new products were developed, but the results will be influential in addressing present market for the product. Two graduate students were trained to perform the extensive RRR testing required. This provided an opportunity for exposure to cryogenic (low temperature) testing techniques, along with electrical characterization of materials.

The testing has revealed some interesting and, at present, unexplained variation in the magneto-resistive properties of these materials that may lead to a future proposal either through OMI or through federal funds.

BUSINESS SUMMARY:

This project was conducted to look at the effect of different sample preparation methods on the RRR or residual resistivity ratio measurement on ultra-high purity niobium materials. Knowing how differences in the preparation method effects the Residual Resistivity Ratio (RRR) measurement will allow ATI Wah Chang to be sure we are measuring the underlying behavior of the material, as opposed to measuring a reduced value due to residual stresses or other degradative features induced during preparation of the

measurement sample. The review of the samples from different preparation techniques has been completed.

Niobium RRR ingots are both time consuming and expensive to produce, requiring multiple electron beam melts to produce an ingot of appropriate purity which can be converted to final product. Final product must be certified to a RRR value which is used as an estimate of the thermal conductivity of the material. If samples are not prepared appropriately for testing, the results of the RRR test may not be truly representative of the material. As the industry heads towards more pure material (higher RRR values) it is critical that we understand what effects preparation methods have on the test results. ATI Wah Chang wants the results of the RRR test to be representative of the underlying material, not be effected by the sample preparation method.

Approximately 20 employees were involved in producing the RRR samples for this test. No new markets or products were developed. However, understanding how the sample preparation method effects the RRR measurement will allow us to pursue additional opportunities in the market as the industry trends towards higher purity materials.

Multiple engineers critically reviewed the process of niobium RRR production and the effects of small changes on the test results. This project exposed engineers to the RRR process and helped them become more familiar with the high energy physics market.

Working through OMI has allowed us to work on a project we may not have had the funds to do otherwise. Additionally, building closer ties with our local universities allows us to take better advantage of their offerings to the industry.