Green Manufacturing Initiative

Annual Report 2010

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Table of Contents

Introduction 1

Projects 2
- Energy 2
  - Bell's Brewery 2
  - Borrough Corporation 2
  - Erdman Machine 2
  - Herman Miller Energy Center 2
  - Overhead Door Efficiency Project at Armstrong International 3
  - Oven Door Seal 3
  - Renewable Powered Waste Compactors. 3
  - Waste Heat Recovery 4
  - Wind Energy Storage Facility 4
- Materials 5
  - Autophoretics 5
  - Mixed Polymers 5
  - Ottawa Gage 5
  - Polystyrene recycling 6
  - Waste Powder Paint 6

Experience & Knowledge
- DM Strategist 8
- DOE Software Tools/PHAST 8
- Green Design Software 8
- Green Products 9
- Green Product Certifications 9
- Life-Cycle Analysis 9
- ISO 14,000 and 50,000 Series 9
- Financial Incentives 10

Research Partners 11
- West Michigan – E3 and Michigan Industrial Energy Center (MIEC) 11
- DOE ALLY 11

Green Manufacturing Industrial Consortium 12
- Site Assessment Tools 12
- GMIC Facility Site Assessment 12

Other 13
- Electric Vehicle Battery – Wind Energy Storage System

Presentations and Talks 14

Industry Partners 15

Staff/ Faculty/Students 16

Budget 18

Introduction

The Manufacturing Research Center (MRC) at Western Michigan University received nearly $1 million in federal funds (Department of Energy) to establish and develop a Green Manufacturing Initiative. This initiative provides a conduit between the university and industry to facilitate cooperative research programs of mutual interest to support industry's green (sustainable) goals and efforts.

Faculty and students from the College of Engineering and Applied Sciences (all departments), the College of Arts and Sciences (Chemistry, Physics, Biology and Geology), the College of Business, and the Environmental Research Institute and Environmental Studies program participate in the Green Manufacturing Initiative activities.

In parallel with the federal funding, a Green Manufacturing Industrial Consortium has been established to integrate industries into this initiative program, providing a direct link between the university and industry.

Greening your manufacturing operations has never been more necessary. In addition to the operational savings that greener practices can bring, emerging market demands and governmental regulations are making the move to green a necessity for success. The Green Manufacturing Industrial Consortium (GMIC) provides a non-competitive/pre-competitive environment specifically for this purpose. The GMIC meetings provide a forum for open discussion between members/potential members to discuss joint project ideas.

Projects

Energy

Bell's Brewery

The GMI developed an energy profile for the expansion of the Bells Brewery facility. The procedure included analyzing various combined heat & power systems, and conduct economic analysis to determine the optimal combined heat and power systems for their operation. The GMI is also conducting an anaerobic digestion feasibility analysis for the spent grains (waste barley, hops, and malt.)

Borrough Corporation: Solar/Wind Charging of Electric Fork Lifts

The work at Borrough Corporation combines two unique elements. The first of which involves analyzing the energy consumption of their current forklift fleet and then estimating how much a new forklift fleet with new batteries and chargers would perform by comparison. For the second element, we provided assistance with the fitting and sizing of a renewable energy system (wind, solar, or combined wind/solar) that would offset approximately 10% of their annual forklift fleets energy demand.

Erdman Machine

This project used multi-institutional with the collaboration of MCC, GVSU, HOPE College, MAREC and WMU. The Erdman Machine/Silver Creek Energy vision is to develop an integrated renewable energy systems demonstration park. Erdman Machine purchased an OOC WWTP which various cultivation (cash crop, fuel crop, and algae) and bio-energy processing (biodiesel transesterification, ethanol fermentation, methane anaerobic digestion, and biomass CHP). The GMI conducted the feasibility analyses, mass & energy balances, economic analyses and sensitivity analyses for the various bio-energy systems. GMI is also assisting with grant writing to obtain additional funding for the project.

Herman Miller Energy Center

A manufacturing process produces approximately 10,000 tons of a solid biomass waste per year. This waste is the primary feedstock for biomass burner systems used to produce process steam. The biomass burner system was originally designed to produce combined heat and power (CHP); however, the steam turbine was replaced with a pressure reducing value (PRV) upon failure. The enthalpy drop across the PRV is currently considered lost heat. The GMI is evaluating the technical and economic feasibility of PRV replacement options along with opportunities to improve the efficiency of the condensate return system with sensory, control, and communication equipment.

Overhead Door Efficiency Project at Armstrong International

The objective was to analyze the cost associated with operating the overhead door heaters on an annual basis and analyze the air movement through the overhead doors in numerous plants. The goal was to increase the efficiency of the overhead doors by providing alternative solutions.

In conclusion, the overhead door heaters consumed considerably less heat than the boilers generated. The excess heat loss was the bulk of the expense. While recording door cycles, it was concluded that drivers can keep the doors open less than one minute. Several low cost solutions are available that will decrease how long the doors are open. Once the changes are implemented the return on investment is expected to be less than two years.

Oven Door Seal

A large contribution to the energy intensity required to make a product comes from process heating; specifically ovens. In continuous ovens, there are no opportunities to close oven doors to contain the escaping heat. Few solutions have been explored, and most without an analytical approach to quantify improvements in energy consumption. Oven door seals, such as blowers that push hot air back into the oven, have been implemented with results that show improved temperature profiles and reduced oven energy usage. A computational fluid dynamics (CFD) model will be designed to simulate the air velocity and temperature profiles in the oven, which will be verified through temperature and air velocity instrumentation. The oven seals will then be modeled and a comparison in performance will be made to determine the effectiveness of the seal.

Renewable Powered Waste Compactors (SP Industries)

A company that builds trash compactors and would like to locate then in remote areas, are interested in using renewable energy to power their motors. Both solar and wind options are considered, along with the required battery capacity. Motor size and daily run time are used to calculate total energy needed on a daily basis. A spreadsheet was constructed to allow many inputs to evaluate the needed installed capacity of either solar or wind for easy calculation based upon factors such as motor size and compactor location (e.g. wind capacity factor, hours of ideal sunlight, battery temperature de-rating).

Waste Heat Recovery

Waste heat recovery deals with the reclamation and subsequent utilization of thermal energy from a process which would normally be wasted. Over the past twelve months we at the GMI have been scouting out new technologies, techniques, and companies in the field of Waste Heat Recovery (WHR). This field is typically broken into two categories; Passive and Active. Passive waste heat recovery entails gathering excess thermal energy then using it in a secondary thermal process. For example, capturing hot flue gas from a combustion process and using it to preheat the fuel source. Passive WHR can dramatically increase efficiency and eliminate energy intensive secondary processes. Active WHR converts excess thermal energy into work. An example of this is an Organic Rankine Cycle (ORC) engine which generates electricity from "low temperature" steam. Active WHR can directly impact utility savings once implemented. We have become familiar with dozens of techniques and applications as well as formed connections with contractors and system manufactures for use in future GMIC projects.

Wind Energy Storage Facility

Wind turbines often generate electricity during the grid off-peak hours. Attempts to store wind energy are being investigated and evaluated. The ability to store wind energy in reused electric vehicle (EV) batteries for peak application will allow for improved wind energy efficiency, as well as extend the life of manufacturer rejected and post-consumer EV batteries. Different models of EV manufacturing rates and consumer purchase projections are used to estimate the availability of the batteries. The wind capacity required to charge the batteries is compared to estimated additional capacity to be installed per the Michigan Renewable Portfolio Standard. Preliminary results show only a fraction of Michigan's installed wind capacity would be used to charge the batteries, leaving enough power to charge Michigan's EV's and continue to supply the grid.

Materials

Autophoretics

Autophoretics (A-coat) is a coating process used to adhere a polymer protective coating to steel components. Environmentally speaking, A-coat is exceptionally clean compared to alternatives. It does not emit VOC's or contain hazardous chemicals, yet can be easily reconditioned and recycled. However, due to consumer demands, manufacturing companies are now looking beyond their four walls, far up the supply chain, to evaluate the total environmental impact of a product's materials. Currently A-coat uses a Polyvinylchloride (PVC) polymer coating, which gives off chlorine gas, during the manufacturing process. Due to this, a West Michigan manufacturing company is evaluating conventional autophoretic paint cost and performance against a greener epoxy based A-coat, and also a powder paint alternative. This company sponsored an in depth laboratory study of A-coat to evaluate the protective qualities of this material with regard to corrosion, long-term adhesion, and longevity/durability. The purpose of this study is to ascertain if powder paint or epoxy A-coat would be equivalent or superior to conventional A-coat while decreasing environmental impact.

Mixed Polymers

One of the largest waste streams that a manufacturing company will produce is polymer waste. Many companies will discard waste polymer coatings, packaging, and scrap material. However, due to contamination, differences in polymer types and general lack of recycling knowledge the majority of waste polymers are deposited in landfills. Therefore, we at the GMI initiated an investigation into mixed polymer waste to better understand the problem and develop a base of knowledge. This investigation focused on understanding the origins of polymer wastes. Additionally the study took into account different methods for preventing waste as well as technologies, techniques, and organizations which can utilize mixed polymer wastes.

Ottawa Gage

Ottawa Gage, a precision manufacturer of hand-crafted gages and measurement instruments serving the automotive, aeronautical and heavy construction industries, requested assistance with their Hexavalent Chrome Plating process. They were interested in lowering the energy intensity of the process as well as the hazardous waste level. The WMU team collected data on the operational aspects of the process and engineered a solution that incorporated a number of changes and additions to the process as well as changes to the operational management of the chrome operation. Changes included a redesign of the tanks, replacement of tank liners with longer life liners, a reduction in operational hours through improved scheduling based on demand data, the addition of a Porous Pot to recondition the plating bath's along other

recommendations. The result of the recommended changes equated to a 90% reduction in the hazardous waste stream and a 53% reduction in electrical costs.

Internal Review of Polystyrene to Determine Problems When Recycling

This study focused on why polystyrene is harder than most other polymers to recycle and the current methods that could be used to overcome the challenge. The purpose of this project was to develop a base of knowledge for waste material reduction as well as to generate continuing applied research applications in the field of polymer recovery and recycling to benefit the consortium member companies.

Waste Powder Paint

Through our activities with industry over the past months we have become aware of a growing problem with the lack of outlets for waste powder paint. WMU has been encouraged to assist Michigan (primarily West Michigan) manufacturers in coming together to share ideas on this issue and to explore the possibility of working together on an ultimate solution to the problem. The overall success of this initiative is greatly enhanced by the willingness of participants (sometimes competitors) to work together on this problem. It is widely felt that this is a non-competitive issue and that if we all can get to a better level of performance with regard to diverting this material from the landfill, we all win.

This effort was launched on April 19, 2011, with an initial meeting of the Waste Powder Paint Users Group. It was obvious form the level of interaction and open sharing of information that this is a high level issue within the six companies represented in the initial meeting, several of which who were direct competitors. The group confirmed a need and desire to work on both ends of the problem, i.e. process inefficiency leading to excessive waste material and a lack of an adequate outlet (other than landfill) for disposal. Disposal costs (landfill) were identified as minimal and therefore the economics of disposal is not a driving force. Rather the stated desire of several of the companies to have zero landfill is the driving force behind their interest. Economics on the process inefficiency, however, was identified as being in excess of five million dollars (purchase cost of material) within this small group of companies.

The roll of the GMI/GMIC with regard to this research area is three fold:

- Serve as a neutral party among competitors to coordinate group activities and create and maintain a collaborative environment
- Conduct research leading to the identification or development of outlets of sufficient capacity for waste powder paint generated within the group
- Conduct research into application methods, techniques and equipment leading to a significant reduction in the level of waste generated (increased transfer efficiency)

Before the initial meeting of the Waste Powder Paint Users Group, a survey was sent out to several companies in order to access the magnitude of the problem. The results from the six companies

involved in the initial meeting were overwhelming. Between the six companies, nearly 1.5 million pounds per year of waste paint is being generated. At an average cost in the region of $3.50 per pound, this equates to a waste stream with a yearly value of about 5 million dollars (purchase price). Disposal costs and concerns further complicate the issue. The survey results identify clearly that this a huge problem for manufacturers using this process. Any improvement will not only help to divert materials from landfill, but significantly improve the bottom line as well.

Experience and Knowledge

DM Strategists – Real-Time Process Monitoring Software Development

The GMI teamed up with DMStrategists to integrate cutting edge sensory equipment with a proprietary Oracle-based data mining program developed by DMStrategists. Further software development will include automated data analysis, reporting, and benchmarking against other manufacturing organization and government standards. System applications are energy management, emergency notification, and lifecycle cost analysis platform development.

DOE Software Tools/PHAST

The US department of energy has created a series of computerized assessment tools for evaluating and quantifying various industrial processes. These tools allow for assessments of compressed air systems, process heat, steam, cogeneration, electric motors, and much more. We at the GMI have since gained a base of knowledge in these tools and have begun to apply them in our facility assessments and various research projects. Presently we have conducted multiple studies using the Process Heat Assessment Survey Tool (PHAST) which studies the efficiency and losses which occur in manufacturing process which require heat. We have applied the PHAST tool in the assessment paint cure ovens, heated wash stations, and baking ovens. We have since used the results of these analyses to determine areas of improvement as well as to investigate the feasibility of waste heat recovery implementation. Additionally, we have employed the compressed air tool called AirMaster+ at one facility with an additional facilities slated. Furthermore we have also utilized the sections of the Combined Heat and Power (CHP) tool in an ongoing research project.

Green Design Software

Whether you are developing a new product or re-designing an existing one, software packages with built-in green design capabilities provide a useful tool for assisting to create green products. Green software packages such as a the EcoAudit tool by GRANTA, or the Sustainability Xpress tool within DS Solidworks are both examples of how green design and material selection are the foundation of any green product. We are developing expertise with the Solidworks Sustainability Xpress tool. This tool allows you to select product materials, location of manufacture and use, and manufacturing processes to provide you with an overall environmental product footprint encompassing areas such as the products Carbon Footprint, Water Eutrophication, Air Acidification, and Energy Consumption. The values provided by the Sustainability Xpress tool come from PE-International, a world leader in product life cycle assessment.

Green Products

As shifts occur in the manufacturing world to create more and more products that are environmentally friendly, business professionals are pushed to make sure their products are as green as possible. As we work to minimize the impact our products have on the environment, we create "green" products. A green product can generally be defined as a product that, from raw material extraction and processing to use and end-of-life disposal, lessen its impact on the environment as thoroughly as possible. At the Green Manufacturing Initiative, we are committed and continue to explore was to help companies create green products and have appropriate products certified as being green."

Green Product Certifications

We are increasing our expertise and knowledge of a variety of Green Product Certification systems. These product certifications require a deep understanding in several areas such as material use, product design, energy, water, atmosphere, chemical use, life cycle assessment, and social responsibility. Landscape Forms has volunteered one of their products as a test case. We will guide them through the level Certification process designed by the Business and Institutional Furniture Manufacturer's Association. Other certification systems are Cradle to Cradle, Green Seal, and SMaRT Certification.

Life-Cycle Analysis

Life-Cycle Analysis (LCA) addresses the triple-bottom line impact from the acquisition of raw material to end-of-life use of a consumer product. The LCA requires detailed information from the suppliers, the manufacturers, and the waste-management service; however, there is no standard process accepted across the board. The GMI follows the DOE suggested LCA methodology with consistency throughout the supply chain. The LCA can be used to track embodied energy and carbon in a product for carbon accounting purposes, qualify the product for a green/sustainable certification, and identify potential areas for improvement in the supply chain.

ISO 14000 Series and ISO 50000

The ISO 14000 series, most notably known for ISO 14001, Environment Management Systems, serves as a foundation for companies wanting to develop environmental policies ranging from management systems, developing product labels, and conducting life cycle assessments. Understanding and complying with the various ISO 14000 series standards is important for providing your member companies with solid, third party verification of your companies' environmental practices.

In addition to ISO 14000, the Green Manufacturing Initiative is eagerly awaiting the release of ISO 50000, Energy Management Standards. The standards are set to encompass procedures that will help to manage and report energy consumption.

Financial Incentives

Besides the environmental benefits of becoming more energy efficient, there are also numerous financial incentives and rewards. Many utility companies such as Consumer's Energy and DTE offer industrial energy efficiency programs, in which companies receive discounts as well as finds to help offset implementation costs of energy efficient products. There are also numerous state incentives and grants for energy efficiency and alternative energy. At the federal level, numerous corporate incentives exist including the Business Energy Investment Tax Credit and the High Energy Cost Grant Program (from the USDA). These financial incentives are meant to help companies become more energy efficient while improving their bottom line.

Research Partners

West Michigan - E3 and Michigan Industrial Energy Center (MIEC)

WMU, through the Green Manufacturing Industrial Consortium (GMIC), has partnered with the Michigan Manufacturing Technology Center (MMTC) to promote and support the roll-out of the EPA-E3 (Economy, Energy, and Environment) program in West Michigan (WM-E3). This program benefits consortium members by enabling access to a pair of operational assessments supported through the E3 program. The first assessment is performed by the Michigan Industrial Energy Center (MIEC) housed at the University of Michigan. The focus of the MIAC's effort is on energy, leading to the identification of energy saving opportunities throughout the operation. The second assessment targets the integration of lean and green opportunities. This assessment is performed by a team from the MMTC. It targets one specific "value stream" in the operation and provides an in-depth analysis of all aspects of that value stream and the corresponding improvement opportunities related to lean and green improvements. A WMU student/faculty team provides a third assessment in between the MIEC and the MMTC to aid in the identification of the specific value stream to be targeted by the lean/green assessment. The WMU assessment targets a handful of high opportunity areas for data collection and analysis in the areas of material waste (recycled, reprocessed or land fill), and energy waste specific to process heating, compressed air, material handling, and environmental conditioning. Assessment results are compiled, resulting in a categorized/quantified list of project opportunities. The GMIC team, in conjunction with the MMTC, works with the consortium member to select a project from the compiled list to fully develop. A student/faculty team from WMU develops an engineered solution for the selected problem while the MMTC supports the project by assisting the consortium member with implementation financing (through the SBA) if needed.

DOE ALLY

DOE ALLY is used to expand industry access to resources and accelerate reductions in industrial energy intensity, the Industrial Technologies Program (ITP) works cooperatively with *Save Energy Now*® ALLY Organizations—U.S. trade associations, suppliers, utilities, state organizations, universities, non-profit organizations, consultants, and other groups. On this Web site you'll find information on how your organization can participate as a *Save Energy Now* ALLY.

http://www. 1.eere.energy.gov/industry/suveenergynow/ally.organizations/html

Green Manufacturing Industrial Consortium

Site Assessment Tool

The GMI site assessment process is designed to identify potential projects for GMIC members by methodically addressing resource efficiency, waste management, and value stream management. This process is supported by the University of Michigan, Industrial Assessment Center (IAC) and Michigan Manufacturing Technical Center (MMTC). The assessment produces a comprehensive resource assessment, process summary, and list of potential project areas. Projects are then chosen based upon technical feasibility, economic potential, and company preference.

GMIC Facility Site Assessment

Site assessments are for the purpose of reducing waste and decreasing environmental impact. The assessment is conducted in several phases to provide a quick, low impact study. Through cooperation with the member company, pre-audit forms allow this assessment to be accomplished within as little as three visits to the facility. This assessment focuses primarily on energy usage, via systems and material usage. Systems covered by this assessment include compressed air, process heating and HVAC. Material usage is also evaluated in order to help decrease waste and handling. Finally, material handling throughout the facility is examined for possible improvements that reduce energy and increase production speed.

Other

IEEE VPPC Conference Papers (website: (http://scholarworks.wmich.edu/greenmanufacturing/

Electric Vehicle Battery – Wind Energy Storage System

The proposed concept utilizes the electric vehicle (EV) battery waste stream as a means to store wind energy to increase wind energy capacity factor, improve utilization, and make more efficient use of EV batteries prior to recycling. Michigan is an ideal location for such a facility because many of the battery and automotive manufacturers are located here. A 200 MW wind farm can charge a battery farm which consists of all reject and post-consumer batteries and all EVs located in Michigan by 2015. Michigan is on track to meet a 10% renewable portfolio by 2015 with over 1100 MW of planned new wind projects to be installed. Therefore, Michigan has the wind capacity to charge EV battery wind-storage facility and all of Michigan consumer EVs.

Presentations and Talks

Green Manufacturing - Lessons from Henry Ford March 10, 2010

Green Manufacturing Preview Event March 31, 2010

Business Practices in Energy Efficiency April 6-7, 2010

Green Manufacturing Expo Charlotte, NC April 28-29, 2010
Green Manufacturing Kick Off Event May 5-6, 2010

Sustainable Manufacturing Summit May 11-12, 2010

Engineering to Improve the Operations of Manufacturing Enterprises May 13, 2010

Sustainability: Take the Next Step May 25, 2010

Southwest Michigan Sustainable Business Forum Meeting Aug. 5, 2010

Industrial Energy Efficiency Forum, IN Aug. 10

SME Green Manufacturing Webinar Series Aug. 2010

Green Seal™ GS-C1 Pilot Standard Webinar Sept. 15, 2010

Green Manufacturing Expo Rosemont, IL Sept. 28-30, 2010

Assembly & Automation Technology Expo, Waste Heat Recovery Workshop, IL Sept. 29-30 (Sean)

Lean to Green Manufacturing, OH Oct. 26-29 (Dave)

Green Growth Conference and Expo Oct. 13-14, 2010

GreenUp: Michigan Green Chemistry Conference Oct. 20, 2010

Energy Champions: Lower Cost and Environmental Impact Oct. 19 - Dec. 14, 2010

2010 International Conference On Sustainability: Energy, Economy, Environment Nov. 12-14, 2010

Michigan Manufactures Tech. Center, Explore Green Manufacturing Nov. 16

Purdue Energy Efficiency & Sustainability Workshop: Fundamentals of Compressed Air Nov. 17 2011

Energy Champion: Explore Green Manufacturing Dec 15, 2010

Industry Partners

Research Partners & Interested Companies

Armstrong International
Bell's Brewery
Borg Warner
Borroughs
Cascade Engineering
Consumers Energy
Cummins
DENSO
Eaton
Erdman Machine
Fabri-Kal
Flowserve
Haworth
Heinz
Herman Miller
IAC
Johnson Controls
Kalsec
Kellogg Company
Kohler
L3 Communications
Landscape Forms
Mead Westvaco
Metabolics
Noble Polymers
Ottawa Gage
Perrigo
Post (Ralcorp)
SP Industries
Steelcase
Stora Enso
Subaru
Sustainable Research Group
Unist
Whirlpool

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GREEN MANUFACTURING INITIATIVE

DIRECT COST SUMMARY STATEMENT

CODE	ITEM	BUDGET	AS OF 12/31/10	COMMITTED	TOTAL SPENT	BALANCE
4701	**PERSONNEL**	**$394,696.00**				**$ 394,696.00**
3631	Temp Appt		$ 39,745.01		$ 39,745.01	$ (39,745.01)
3218	Fringe Appt		$ 21,554.02		$ 21,554.02	$ (21,554.02)
4353	Contracted svcs		$ 5,000.00		$ 5,000.00	$ (5,000.00)
SUB TOTAL						**$ 328,396.97**
4702	**GRAD STUDENT**	**$ 74,878.00**				**$ 74,878.00**
3511	Student		$ 29,136.37		$ 29,136.37	$ (29,136.37)
SUB TOTAL						**$ 45,741.63**
4703	**UNDER GRAD**	**$ 25,000.00**				**$ 25,000.00**
3511	Student		$ 9,712.13		$ 9,712.13	$ (9,712.13)
SUB TOTAL						**$ 15,287.87**
4710	**FRINGE**	**$ 89,706.00**				**$ 89,706.00**
3911	FICA		$ 4,720.39		$ 4,720.39	$ (4,720.39)
3912	Retirement		$ 3,146.89		$ 3,146.89	$ (3,146.89)
SUB TOTAL						**$ 81,838.72**
4713	**TRAVEL**	**$ 15,000.00**				**$ 15,000.00**
4360	In State		$ 3,232.11		$ 3,232.11	$ (3,232.11)
4359	Out of State		$ 799.55		$ 799.55	$ (799.55)
4370	Conferences		$ 905.00		$ 905.00	$ (905.00)
SUB TOTAL						**$ 10,063.34**
4716	**SUPPLIES**	**$ 6,483.00**				**$ 6,483.00**
4482	Printing		$ 920.16		$ 920.16	$ (920.16)
4570	Supplies		$ 3,575.62		$ 3,575.62	$ (3,575.62)
SUB TOTAL						**$ 1,987.22**
4718	**CONSULTING**	**$ 10,000.00**				**$ 10,000.00**
4320	Consulting		$ 1,031.25		$ 1,031.25	$ (1,031.25)
SUB TOTAL						**$ 8,968.75**
4716	**OTHER**	**$ 3,600.00**				**$ 3,600.00**
4364	Meal		$ 2,714.42		$ 2,714.42	$ (2,714.42)
4340	Postage		$ 15.30		$ 15.30	$ (15.30)
SUB TOTAL						**$ 870.28**
4737	**TUITION**	**$ 49,149.00**				**$ 49,149.00**
4101	Tuition		$ 5,121.84		$ 5,121.84	$ (5,121.84)
SUB TOTAL						**$ 44,027.16**
TOTALS		**$668,512.00**	**$ 131,330.06**		**$ 131,330.06**	**$ 537,181.94**
FUNDS REMAINING						**$ 537,181.94** *