[2008]

St Marys Pressed Metals/ DEP Sludge to Powder Metal Final Report

Jim Aiello/ John Weible

[ABSTRACT]

Iron Calcium (FeCa) Residual waste material from water purification operations can be converted into usable raw material for potential remanufacture. The residual waste (Sludge by-product) is generated at Pennsylvania Department of Environmental Protection (DEP) acid mine run-off reclamation. These projects are aimed at cleaning up contaminated water sources resulting from abandoned coal mines. The idea is to remove and reclaim the Iron/Iron Oxide that is contaminating the water. This Iron Oxide could then be reprocessed into a powder and put back into the manufacturing cycle as raw material.

Table of Contents

Introduction and theory	**Page 3**
Work Associated with Grant Approval	**Page 4 - 10**
Work Associated with Invoice 1	**Pages 11-16**
Work Associated with Invoice 2	**Pages17-22**
Work Associated with Invoice 3	**Pages 23-26**
Conclusion	**Pages 27**

Schematics for Sludge Bearings and Control - Attachment 1

Life Testing Results from Product Assurance - Attachment 2

Introduction:

Drainage from abandoned coal mine sites is the single largest threat to the Appalachian environment, according to the Environmental Protection Agency. Runoff water from these mines is often laced with environmental poisons such as toxic metals. These metals create sediments which in turn deplete aquatic growth and can stunt terrestrial growth in close proximity to the stream. These runoff streams also cause orange and blue plumes of pollution that stain the rivers and streams.

The form of pollution that St Marys Pressed Metals has created their study around causes the orange plume. This pollution appears orange because it contains oxidized iron (rust). The Department of Environmental Protection (DEP) has created a system of removing the iron from the runoff water. The process which DEP is utilizing creates a byproduct FeCa (iron calcium) or Sludge. St Marys Pressed Metals theorized that the FeCa that was being removed from the mine runoff stream at the Brandy Camp Elk County facility could be turned into a powder that could then be blended into other metals and sintered.

St Marys Pressed Metals is a quality sintered parts manufacturer locater in Ridgway, Elk County. This company holds an inherent recognition and appreciation for the region's asset based resources. They have the knowledge and ability to blend, press, sinter and size powder metal parts. This knowledge combined with their commitment to environmental stewardship establishes a viable partnership for this study.

The Theory That Drives the Study:

Iron calcium (FeCa) residual waste material from water purification operations can be converted into usable raw material for potential remanufacture. The residual waste (sludge by-product) is generated at Pennsylvania Department of Environmental Protection (DEP) acid mine run-off reclamation. These projects are aimed at cleaning up contaminated water sources resulting from abandoned coal mines. The idea is to remove and reclaim the Iron/Iron Oxide that is contaminating the water. This Iron Oxide could then be reprocessed into a powder and put back into the manufacturing cycle as raw material.

Work Associated with Grant Approval

October 2002

This is a written description detailing efforts by St. Marys Pressed Metals in conjunction with Arnold P/M Consulting to convert a residual waste by-product from water purification processes into a metal powder composite material suitable for consolidating and sintering, with the intention of producing finished components. After initial analysis, other appropriate applications were considered which include, but are not limited to additive for paint/pigments or cement, or net-shape formed refractory materials.

The “by-product” is reddish brown in color and the consistency of bread dough; it is mostly water. Our first introduction to the material was at a visit to the Pennsylvania Department of Environmental Protection’s facility in Brandy Camp Elk County. We returned with the material and reduced it thermally to determine the content of metals (chart 1 page 5). The first processing step was to remove the water, which left a grayish/red material that looked like cinders, large irregular shaped particles. This material was then crushed into a consistency appropriate for pressing. After crushing and screening, lubricants were blended in, to provide die release properties. The resulting material was classified as non-free flowing powder. We then pressed the material into a common round (bushing/bearing) geometry. The pressing test was cut short, due to the material “clogging-up” the tooling. The resulting parts were then sintered. The parts were very weak, but the results were encouraging. Additional work was needed to make the material more appropriate or “friendly” to the powder metallurgy process.

Methods & Procedures

October/November 2002

Thermal reduction of the material was accomplished with an electric sintering furnace, the material was placed on a slow moving conveyor belt which passes through the furnace, according to a specified heating curve. An oxide reducing atmosphere of nitrogen/hydrogen protects the material. After the material was reduced it was crushed into smaller particles using a mortar and pestle. The material was then sieved to classify particle size and finally a small amount of paraffin based lubricant was blended with the material to provide die release. The material was then tested for Apparent Density, Flow, and Screen Analysis; these are ratings for metal powders used in industry to quantify “green” properties. After further thermal processing, we conducted similar sintered properties testing.

Chemical Analysis, Thermal Reduction Parameters and Photomicrographs

Chart 1 – Initial analysis of sludge from bucket on October, 2002

ELEMENTS	RESULTS
Aluminum	3.6%
Nickel	.11%
Manganese	3.6%
Chromium	<.02%
Zinc	.004%
Calcium	26.0%
Magnesium	3.08%
Copper	.04%
Molybdenum	<.01%
Barium	<.01%
Iron	34.0%
Silicon	5.3%

DEP SLUDGE REDUCTION

Chart 2

Furnace #3 1400/1800/1800/@2.00rpm

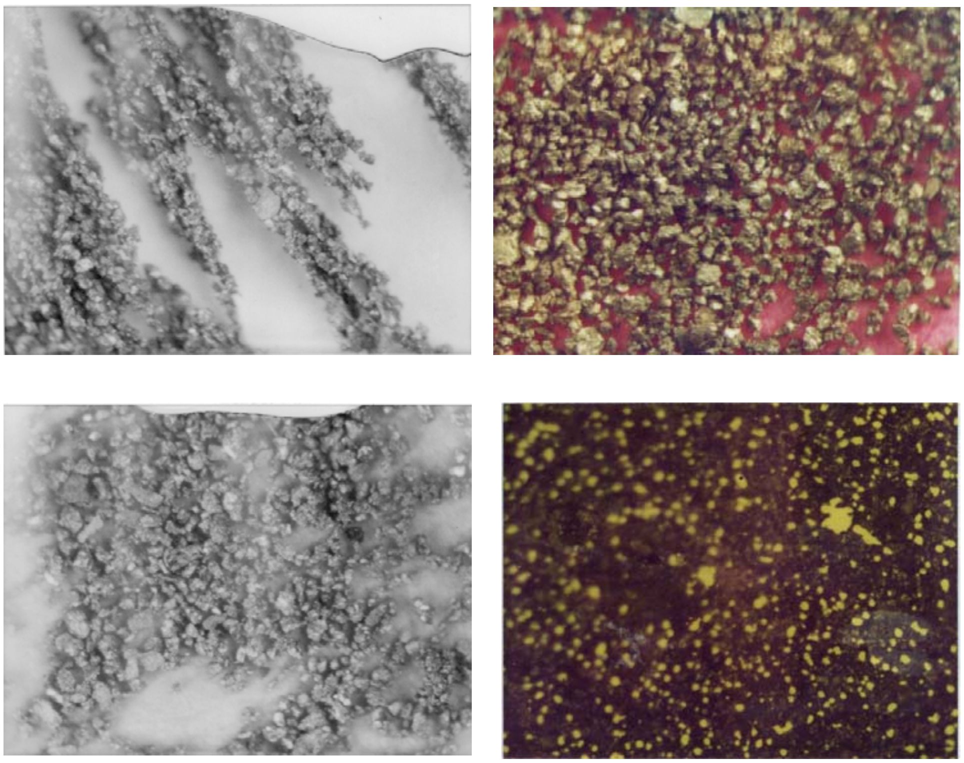
150/1300/15 H2/N2/Air

Original Weight 937 grams
Weight after reduction 114 grams

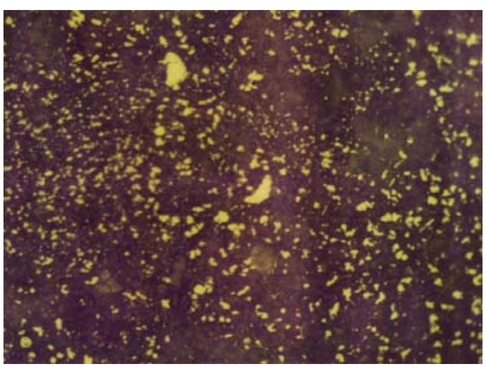
87.8 % weight loss

	1	**2**
Original Weight & Boat	8.3734	11.2160
Weight Boat	6.9731	8.8269
Original Weight	1.4003	2.3891
Dried Weight & Boat	7.4560	9.8804
Dried Sample Weight	0.4829	1.0535
% change	-65.5%	-55.9%
Sintered F2 1000/1540 @ 6.5 140/700 H2/N2		
Sample & Boat	7.1252	9.0795
Sintered Sample Weight	0.1521	0.2526
% Change from Dried		
% Changed from Original	-89.2%	-89.4%
COMPOSITION		
• Approximate	60% Water	
	30% Oxide	
	10% Magnetic Metal (Iron)	

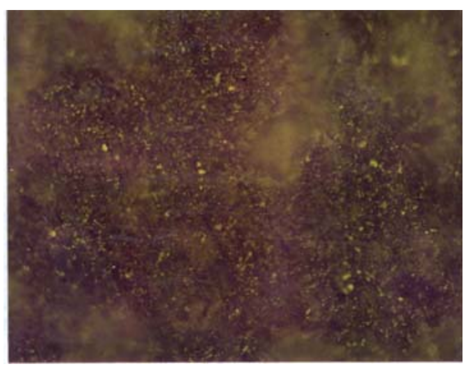
Metallurgic Properties as viewed through an electronic microscope



NITAL ETCH – 500X



NO ETCH - 500X



MARBLED – 500X

Chart 3

All testing is done in accordance with:

American Society for Testing and Materials (ASTM)
Metal Powder Industries Federation (MPIF)

December 2002

The next processing step was to determine if the material could be pressed to form a compaction. A common round geometry was chosen and the material was pressed. At this juncture, we ran into some difficulty, due to the non-free-flowing nature of the resulting powder; delivery from the powder hopper to the die cavity became impossible after the first 20 pieces. The material had a tendency to “bridge” which blocked the opening of the die cavity. The next pressed shape would not have such a thin wall feature as the first. To try and improve the flow with a larger cavity, but to make more parts, we needed to make more powder. Approximately 40 pounds of additional “by-product” was delivered and subsequently processed as listed above. After grinding/screening, this left about 3 pounds of suitable powder. One exception worth noting at this point is a difference in the appearance of the material. The material came out of the grinding operation with a greenish-gray color as opposed to the grayish-red appearance of the initially processed sample. We have not yet accounted for this.

January 2003

At this time we started to consider ratios of raw material. We also started referring to the powder as Iron Calcium, Fe/Ca powder. One possibility for new applications, we considered was being able to produce a lighter part. We also decided to mix the Fe/Ca powder with non-ferrous grades and evaluate bearing properties. Adding elemental powders to aid sintering is the next step. We decided to try the following blends (as illustrated in chart 4).

Iron/Calcium Powder Blend Option

Chart 4

Blend #1 100% Fe/Ca .75% lube AAD - 1.18 g/cm3

Blend #2 90% Fe/Ca 10% Cu .75% lube AAD - 1.29 g/cm3

Blend #3 60% Fe/Ca 40% Bronze .75% lube AAD - 1.7 g/cm3

Blend #4 20% Fe/Ca 80% Bronze .75% lube AAD - 2.64 g/cm3

* All the blends are considered non-free flowing

Perhaps one of the materials listed above would exhibit acceptable bearing characteristics. It is possible that a lighter bearing could be produced and the presence of the Calcium would not be detrimental. We plan to attempt to produce some bearings from the above list and test them for suitability.

February 2003

Finally, we had a chance to press additional bearings; the above listed material compositions were pressed and sintered. Data pertaining to mechanical and physical characteristics of the bearings has been tabulated and is listed below in Table 1.

Table 1

Maximum Pressed Density:

Blend #1 = 2.42 g/cm^3
Blend #2 = 2.60 g/cm^3
Blend #3 = 3.26 g/cm^3
Blend #4 = 4.96 g/cm^3

Sintered Properties of Fe/Ca:

	Blend #1	Blend #2	Blend #3	Blend #4
"K" Value	2,881 psi	2,794 psi	570 psi	11,000 psi
Hardness	no reading	16 Rf	75 Rh	13 Rh

Limitations & Obstacles:

March 2003

The biggest single problem utilizing this material is the low density. It will not be possible to increase the density significantly without removing at least some of the calcium that is present; or otherwise diluting the percentage of Fe/Ca to a point that higher density of the green compaction can be achieved. By targeting bearing applications, where controlled porosity is a benefit, the low density of the material may work for specific applications. These non-ferrous additives will also aid/enhance sintering. The K Value for blend #4 is equivalent to bearing material grades called out in MPIF Standard 35

April 2003

There may be a use for this material as a "lightning" additive. Weight reduction is a common goal in modern manufacturing, a product that is lighter than traditional bearings, but with better mechanical properties and longer life than plastic or Teflon bearing.
The very low density of the material will cause some delivery problems of material to die cavity. It is considered non-free-flowing powder.
Can the Iron be reclaimed before the calcium (lime) is introduced to the process, possibly magnetic deposition; this has yet to be determined.

Work Associated with invoice 1

March 2004

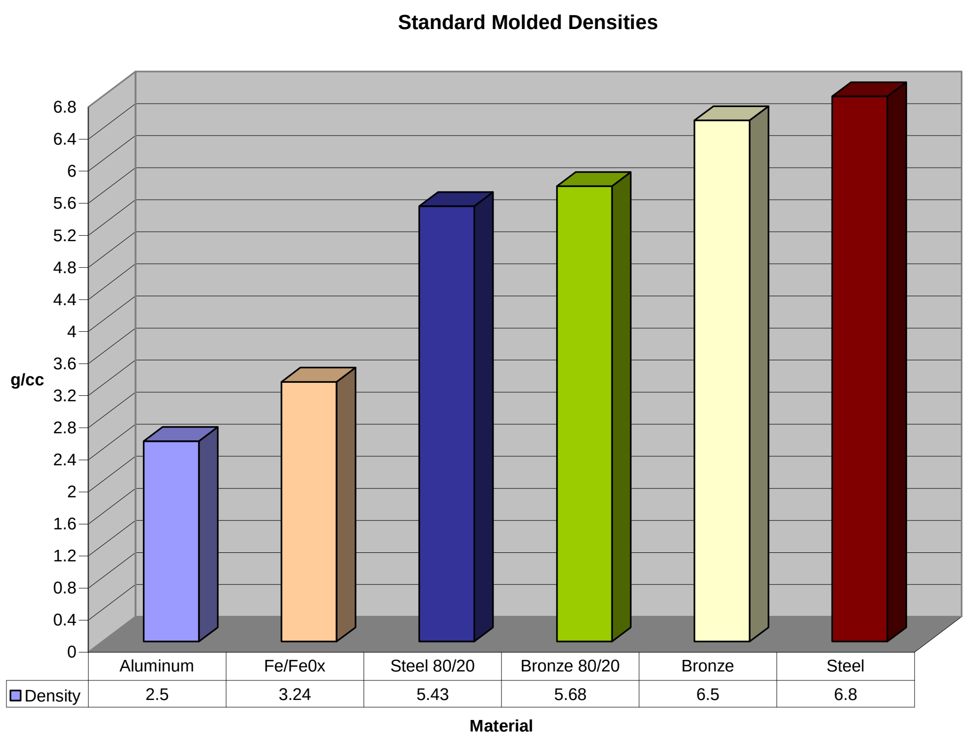
In the spring of 2004 a series of meetings at St. Marys Pressed Metals brought together several key players to discuss some interesting aspects of the Fe/Ca material, and what steps to take next. The meetings were attended by representatives from St. Marys Pressed Metals, Pennsylvania Department of Environmental Resources, PennTap, North Central Regional Planning and Development Commission, Norbert Arnold Consulting, and Penn State University. Dr. Sheetz of Penn State had some very specific analysis done on samples of Fe/Ca Bearings. The sludge bearing appears more ceramic than metal, small particle size etc. Many different potential applications were discussed. Funding opportunities were explored. A long list of questions to be answered was drawn up; questions that include but are not limited to. Cost-benefit analysis, the cost associated with the transport of the sludge, de-watering, processing costs and many other scientific, metallurgical, administrative, and political questions concerning the production of usable raw material from acid-mine discharge residual material (sludge). The next step that St Marys Pressed Metals took was another round of material processing.

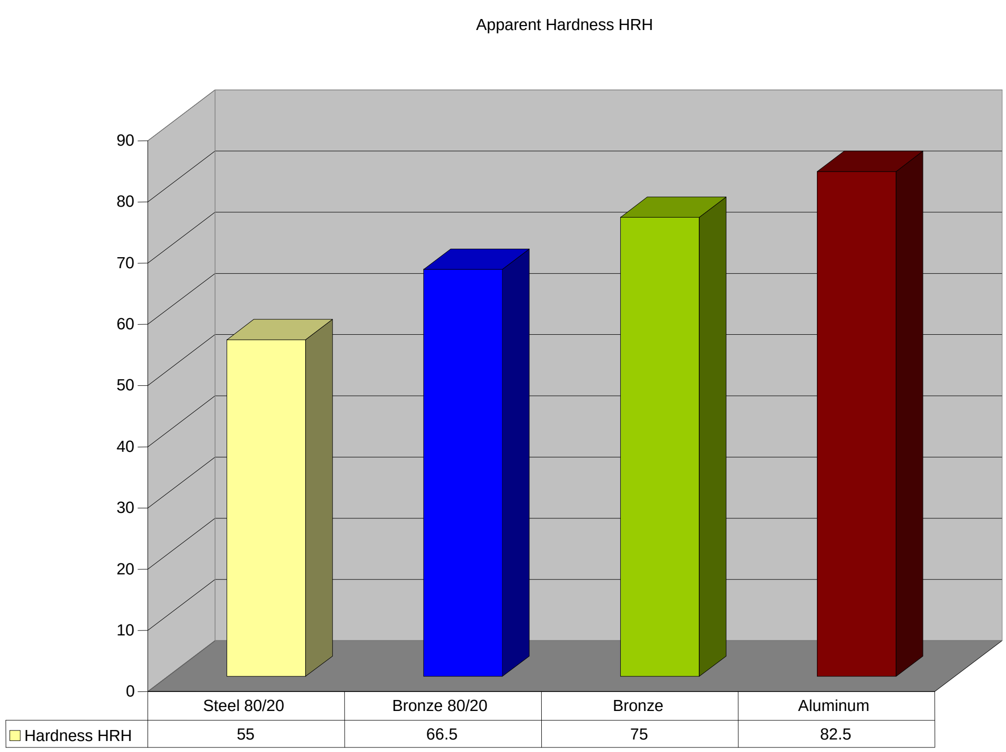
2005

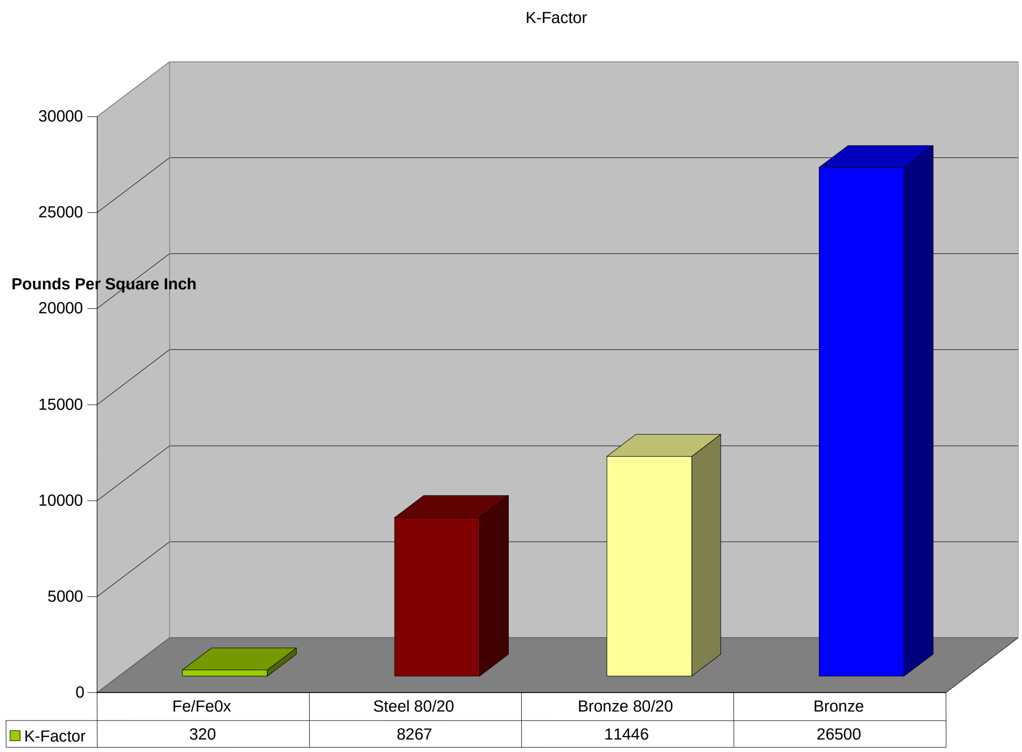
Brandy Camp II - We pressed and sintered blends and gathered some dimensional and strength characteristics of bearing. However, most of this year was spent applying for and not getting grants. Finally, North Central received word about receiving money to continue testing in November 2006. John Weible, the Business Development Coordination for North Central, was to administer the grant, specifically testing mechanical (life) properties of potential material.

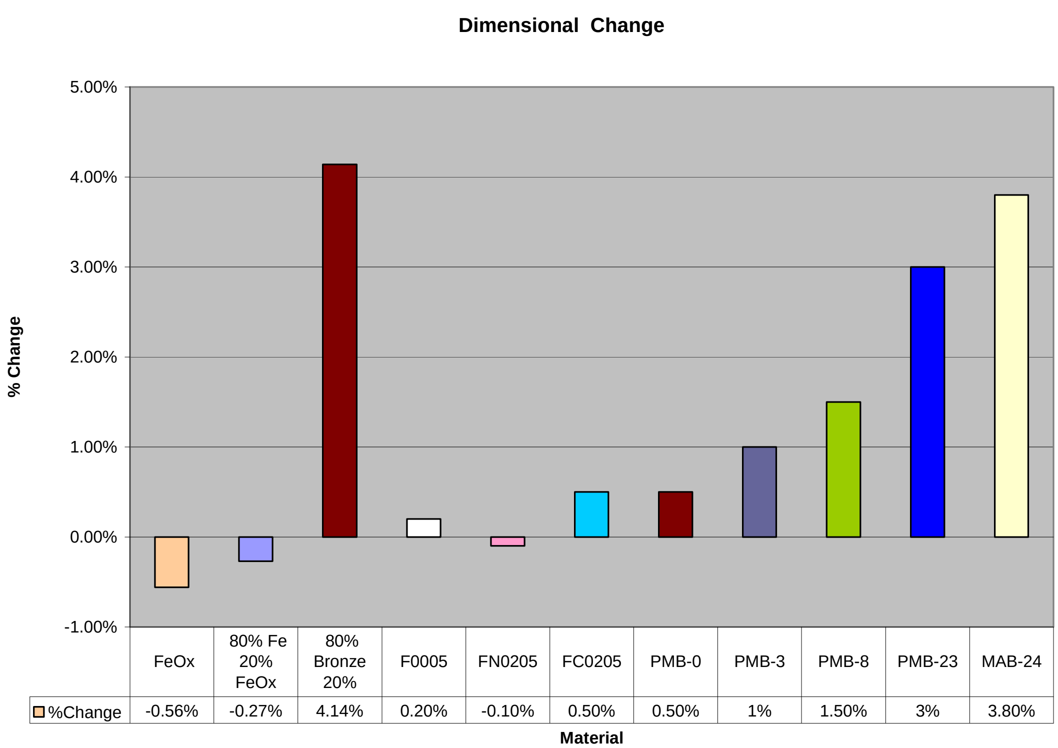
Additional data is included on the following pages

Insert K-Factor and dimensional comparisons






K-Factor
Pounds Per Square Inch
30000
25000
20000
15000
10000
5000
0
Fe/Fe0x
Steel 80/20
Bronze 80/20
Bronze
K-Factor
320
8267
11446
26500


Dimensional Change
% Change
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
-1.00%
FeOx
80% Fe 20% FeOx
80% Bronze 20%
F0005
FN0205
FC0205
PMB-0
PMB-3
PMB-8
PMB-23
MAB-24
%Change
-0.56%
-0.27%
4.14%
0.20%
-0.10%
0.50%
0.50%
1%
1.50%
3%
3.80%
Material

November 2006

More sludge was obtained from the Brandy Camp reclamation project and the entire procedure described above was repeated. Utilizing data we discovered in the first thermal reduction, we decided on a temperature of 1850F and a protective atmosphere of nitrogen and hydrogen. After thermal reduction and subsequent operations grinding and milling it resulted in a similar yield and we ended up with approximately 4 pounds of powder to work with. It was also suggested at this time to try some low temperature reductions at 400F with the remaining sludge. I would also note that we dried a small amount of sludge in a microwave oven. We plan to attempt the compaction of these powders as well.

January 2006

Powder processing is detailed below – Brandy Camp III Fe/Ca

Summary: Production of Metal Powder from Acid Mine Water Treatment Residual By-Product.

Work Sessions – SMPM and Arnold P/M Consulting participated in 6 hour weekly work sessions to discuss and define the specific requirements of turning sludge into powder, these all important discussions included but were not limited to, reducing temperature, gaseous protective atmosphere, methodology and potential yield.

January 9 2006 – 9:00AM-2:00PM 5 HR

Initial work session for DEP grant project – Discussions were centered on optimum temperatures for reduction of sludge. Also, discussions were held concerning tactical and strategic goals and potential applications for the sludge parts. We want to look for compelling reasons why this material will **not** work.

January 19 2006 – 9:00AM-2:00PM 5 HR

Accomplished initial test reductions of sludge, Small amounts of material were passed through the furnace. We will need to obtain chemical composition of material. Chemistry of the material will be site specific, with wide varieties of elements and ratios, resulting from different geographical locations.

January 26 2006 – 9:00AM-2:00PM 5 HR

St Marys Pressed Metals worked with #1 Furnace to reduce 40 pounds of sludge, into gray colored irregular shaped pieces resembling cinders, which will be milled into powder. Discussions of methodology continued. There are probably many methods that would accomplish our goals. But we need to concentrate on the technologies and equipment that are available to us, and that we are familiar with.

February 1 2006 – 9:00AM-2:00PM 5 HR

There were discussions of temperature, atmospheres, and time and effect on yield. Low temp and microwave potentials were also considered.

February 7 2006 – 9:00AM-2:00PM 5 HR
Continued processing the "powder" in the modified ball-mill, and we started discussing potential testing requirements. Nanoparticle potential needs to be pursued.

February 15 2006 – 9:00AM-2:00PM 5 HR
Ball-Mill is "down" and processing is stalled. The meeting became strategic almost philosophical ranging between paving roads and bridges, the fact of the materials ceramic like properties, to potential future extraction of the valuable Iron from any source of contaminated water.

February 22 2006 – 10:00AM-2:00PM 4 HR
Straightened out the problem with the mill and are back on-line.
We held tactical discussion of sieve process for powder when milling is completed.

March 2 2006 – 9:00AM-2:00PM 5 HR
Powder is ready to be classified.
Blending became our main topic of discussion, tempered by discussions of possible applications for 100% Fe/Ca Oxide Powder

March 8 2006 – 9:00AM-2:00PM 5 HR
We finally have determined the ratios we will blend 80/20 with bronze and steel.
We discussed at length the pros/cons of an Aluminum blend.

March 15 2006 – 9:00AM-2:00PM 5 HR
The powder is blended with lubricants and/or alloying elements

March 22 2006 – 10:00AM-2:00PM 4 HR
Today's meeting focused on tactical issues such as yield, effect of flow on production, conventional processing parameters as a priority to keep cost down. More specifically, the equipment requirements needed to scale-up and match the Brandy Camp operation was put forth as ultimate processing.

April 5 2006 – 9:00AM-2:00PM 5 HR
Pressing tests begin with the produced material blends.
Initial complications regarding bridging and poor flow are apparent, particularly with the 100% Fe/Ca. The 80/20 blends are better, but this is a characteristic (flow) that will need some improvement.

April 12 2006 – 9:00AM-2:00PM 5 HR
Test pieces are sintered.
Discussions centered on the information that we are now gathering concerning densities and flow.

April 20 2006 – 7:45AM
Status Update: Kathleen Mc Ginty Secretary, Department of Environmental Protection.
Cancelled

May – No Meetings Next Meeting Scheduled for June 8th

June 8th – Meeting Cancelled next meeting scheduled for June 28th

Contractual Cost to date.
Participants included:

Jim Aiello	-$35.00/hr – 53 hr total
Art Aiello	-$35.00/hr – 53 hr total
Will Frick	-$25.00/hr – 53 hr total
Jolene Krise	-$20.00/hr – 53 hr total
Norb Arnold	-$75.00/hr – 53 hr total
John Calla	-$30.00/hr – 53 hr total
Jim Caribardi	-$25.00/hr – 53 hr total

Sub - Total Cost $13,250.00

Equipment and Materials Cost

Machines/Equipment:

Sintering Furnace	80 hrs@ $75.00 / HR -	$6000.00
Modified Ball Mill	240 hrs@ $15.00 / HR -	$3600.0
Sieves/Screens	60 hrs@ $15.00 / HR -	$900.00
Blender	12 hrs@ $15.00 / HR -	$180.00

Sub - Total Cost $10,680.00

Final Cost 1st Invoice $23,930.00

Work Associated with invoice 2

After the June 28th meeting was cancelled St. Marys Pressed Metals entered into its busy summer production schedule and were unable to work on the project regularly. We stayed very busy through the summer and surprisingly, through the holidays and unfortunately the Fe/Ca sludge project were given less priority. The principal players did finally get to sit down in February 2007 to restart the program. A meeting was held on February 8th to detail the status and discuss the upcoming task items to complete the evaluation of bearing properties that could be expected. The meeting was attended by representatives of Pennsylvania DEP, North Central, and SMPM, Water and Material experts were also in attendance. We detailed the two remaining components of the project, producing "sized" bearings and life-testing of the as–sized bearings. One personnel change at SMPM has resulted in a new laboratory technician on the project; Caleb King will be doing powder characterization on the blends before molding.

One important accomplishment over this period of months was physical testing comparisons that were done with as-sintered parts produced from Fe/Ca and the two Fe/Ca Blends. This data collection was done during the summer and fall of 2006 as time allowed. Density, Hardness, K-Value, and Dimensional Change are important characteristics used to qualify P/M bearings and are indications of their suitability for various applications. Below are 4 charts which illustrate the physical properties of Fe/Ca and Fe/Ca Blends in comparison with several standard material grades…

February 15th 2007 10:00am – 8:00pm

Powder characterization begins in the laboratory at SMPM.

Apparent Density is the first characteristic to be tested.

Apparent Density is an important measure of a material characteristic inherent in the powder. It determines the all-important fill ratio and is a key quality control determining lot to lot consistency of powders. In conjunction with AD we studied the Flow characteristics of the blends. All three tested materials are considered non-free flowing. This will translate into potential processing problems, non-free flowing materials require mechanical help in flowing to the die cavity, the mechanical help is often in the form of vibrators which encourage segregation of the powders. Hopefully as we refine our process we will be able to improve the weak flow characteristics.

All blends considered non-free-flowing. You will find the results from this testing on the following page.

Apparent Density D.E.P. (Arnold Meter)

Blended	I	Blended	II	Un-Blended	III
Mass	Vol.	Mass	Vol.	Mass	Vol.
I	I	II	II	III	III
1.) 58.64	2.93	1.) 58.99	2.95	1.) 34.09	1.72
2.) 58.67	2.93	2.) 59.17	2.96	2.) 34.77	1.74
3.) 58.80	2.94	3.) 58.70	2.94	3.) 34.25	1.71
4.) 58.68	2.93	4.) 58.95	2.95	4.) 34.67	1.73
Avg. (AD)	2.93g	Avg. (AD)	2.95g	Avg. (AD)	1.72g

PA= Arnold Apparent Density, g/cm3

M= Mass of powder

V= Volume of hole, 20 cm3

PA=M/V

PA= Mass/Volume=Mass/20cm3

March 1st 2007 10:00am – 8:00pm
Sieve analysis was today's task item.
Below you will find the results we found.

Sieve Analysis D.E.P.	

Blended I	Blended I	Blended I
Partical Size	Mesh Designation #	% of Wt. (Avg)
> 180	Weight In Sieve 80 mesh	**1.7%**
< 180 >150	Weight In Sieve 100 mesh	**2.2%**
<150 >106	Weight In Sieve 140 mesh	**3.5%**
< 106 >75	Weight In Sieve 200 mesh	**12.4%**
< 75 > 45	Weight In Sieve 325 mesh	**42.7%**
< 45	Weight (-325 mesh) In Pan	**37.1%**
	Total	**99.6%**

Blended II	Blended II	Blended II
Partical Size	Mesh Designation #	% of Wt. (Avg)
> 180	Weight In Sieve 80 mesh	**3.4%**
< 180 >150	Weight In Sieve 100 mesh	**8.9%**
<150 >106	Weight In Sieve 140 mesh	**19.0%**
< 106 >75	Weight In Sieve 200 mesh	**27.3%**
< 75 > 45	Weight In Sieve 325 mesh	**29.0%**
< 45	Weight (-325 mesh) In Pan	**12.2%**
	Total	**99.8%**

Un-Blended III	Un-Blended III	Un-Blended III
Partical Size	Mesh Designation #	% of Wt. (Avg)
> 180	Weight In Sieve 80 mesh	**9.4%**
< 180 >150	Weight In Sieve 100 mesh	**12.5%**
<150 >106	Weight In Sieve 140 mesh	**19.7%**
< 106 >75	Weight In Sieve 200 mesh	**17.9%**
< 75 > 45	Weight In Sieve 325 mesh	**28.1%**
< 45	Weight (-325 mesh) In Pan	**12.4%**
	Total	**100.0%**

All testing is done in accordance with ASTM…

March 1st was also the launch date of the tooling required to produce what will be known as part number 2621-1. This is the designated part number for a bearing produced with 20% Fe/Ca and 80% Bronze. In order to manufacture tooling that will produce bearing to exact dimensional requirements requires compensation for processing operations, and all materials respond differently to these processing operations. Bronze generally expands 1% but the Fe/Ca blend is expanding 4% (as shown in previous graphs) A work session that included toolmaker Jim Geer and Quality Manager Jolene Krise along with Jim Aiello determined the "die size" which is the jumping off point for any new part number. Once sizes are established drawings will be issued and tool construction will begin. Tooling is material specific and this material did not have any dimensional change characteristics to base our compensation ratios on until we collected that data from earlier testing (Brandy Camp II).

March 8th 2007 Tooling Work Session

Jim Aiello, Jim Geer and Jolene Krise started to work on the development of the tooling. The Group also worked on the factory order sheet that needed to be produced to simulate a real life production situation. It was decided that a parts run totaling 300 80/20 sludge blend parts would be produced, as well as a parts run totaling 300 normal blend parts would be created as a control group.

March 15 2007 8:00AM-4:00PM 8HRS

Jim Aiello & Jim Geer continued to work on the design and development of the tooling need to produce a functional product. They have to take the expansive nature of this blended powder into consideration in the design of the tooling. It is determined that two sets of tooling will be needed for this project. One set will be used to run the 80/20 blend of sludge powder. The second set will be used to run the control group of the normal blend powder. Jolene Krise & Brian Leitzel worked on the details of the printable versions of the design documents, worked on compiling the functionality of the product that will be produced (what are similar parts already in production being used for, what are other possible part, that could be made from the 80/20 sludge blend.

March 29 2007 8:00AM-4:00PM 8HRS

Jim Aiello & Jim Geer The construction of the first set of tooling was started.

Aril 5 2007 8:00AM-4:00PM 8HR

Jim Aiello & Jim Geer completed the construction of the first set of tooling for the project; this tooling is in the process of being checked. Construction on the second set of tooling was started.

April 24 2007 1:00PM-3:00PM 2HRS

John Weible met with Art & Jim Aiello to discuss the progress of this project, and what the time line looked like for the production runs to start for the 80/20 sludge blend bearing. The group also talked about the real world testing that would occur on phase three of this project…

Contractual Cost

Participants included:

Jim Aiello	-$35.00/hr – 53 hr total
Art Aiello	-$35.00/hr – 5 hr total
Caleb King	-$25.00/hr – 16 hr total
Jim Geer	-$25.00/hr – 48 hr total
Brian Leitzel	-$25.00/hr – 8 hr total
Jolene Krise	-$20.00/hr – 24 hr total
Norb Arnold	-$75.00/hr – 0 hr total
John Calla	-$30.00/hr – 0 hr total
Jim Caribardi	-$25.00/hr – 0 hr total

Sub - Total Cost $4310.00

Equipment and Materials Cost

Machines/Equipment:

3 Sets of Tooling @ $2500.00 per set Sub - Total - $7,500.00

Total Cost Second invoice $11,810.00

Work Associated with invoice 3

Week of May 29th 2007 Work Session(s)
Jim, Jolene, Caleb - 20 hours
Prepared Final Audit inspection sheets for all parts and materials

May 30th 2007
Jim Aiello and Art Aiello Meeting with John Weible North Central

June 14th 2007
Jim Aiello, Jolene Krise, Caleb King, Jim Geer, Art Aiello – 4 hours
Review of Final Audits
Bearing testing requirements

June 18th 2007
Jim Aiello, Caleb King – 4 hours
Oil Content and Porosity

June 19th 2007
Jim Aiello, Caleb King – 4 hours
Oil Content and Porosity

June 21st 2007
Jim Aiello, Jolene Krise, Caleb King – 8 hours
Preparation of samples for metallurgical analysis (mounted specimens)

June 25th 2007
Jim Aiello, Caleb King – 4 hours
Preliminary preparations for microstructure analysis

June 27th 2007
Jim Aiello, Caleb King – 8 hours
Final preparations for microstructure analysis

June 28th 2007
Jim Aiello, Jolene Krise, Caleb King, John Calla – 8 hours
Microstructure evaluation

July 11th 2007
Jim Aiello, Jolene Krise, Caleb King, John Calla – 8 hours
Microstructure evaluation

July 19th 2007
Jim Aiello, Jolene Krise, Caleb King, John Calla – 8 hours
Microstructure evaluation

July 26th 2007
Jim Aiello, Jolene Krise, Caleb King, John Calla – 8 hours
Microstructure evaluation

August 9th 2007
Jim Aiello, John Calla, Norb Arnold – 8 hours
Microstructure evaluation and review

August 23rd 2007
Jim Aiello, Caleb King, John Calla – 4 hours
Preliminary laboratory report preparation

August 30th 2007
Presented request for quotation to Product Assurance for life-testing

September 9th 2007
Jim Aiello, Art Aiello, Jolene Krise, Caleb King – 2 hrs
Received price quotation number QF 4.4.3
Group met to go over quotation

September 10th 2007
Jim Aiello, Art Aiello, Jolene Krise, Caleb King – 2 hrs
Purchase order number 7008 issued for life-testing to Product Assurance
Group met to issue and review purchase of life testing

October 3rd 2007
Received Preliminary report from Product Assurance

October 16th 2007
Jim Aiello, Art Aiello, Jolene Krise Caleb King, Norb Arnold – 2 hours
Discussion of report from Product Assurance, called to speak w/Bart Nelson.
Left message to arrange short meeting

October 18th 2007

Jim Aiello, Jolene Krise, Caleb King – 8 hrs
We updated all inspection records and process sheets. Final versions of all paperwork to be included in official record

October 19th 2007 – 1 hr

Jim Aiello and Jolene Krise met with Bart Nelson
Life-testing scheduled

November 8th 2007 – 8 hrs

Jim Aiello, Jolene Krise, Caleb King
Wrap-up Phase II testing, formalize and include documentation into permanent official record

December 13th 2007

A meeting was held at St Mary's Pressed Metals to talk about the final invoice for this project. The participants of this meeting were as followed, Dan Sammarco and Bob Oshaben representing DEP, Jim Aiello and Art Aiello representing St Mary's Pressed Metals and John Weible representing NCPRPDC the Grantee. At this meeting it was determined that St Mary's Pressed Metals neglected to include the pressing sintering and sizing of the control group bearing and also, the pressing sintering and sizing of the blended sludge bearing. At this meeting it was suggested that a final revised budget should be submitted. This revised budget will reflect all actual cost involved with this project. Dan Sammarco also suggested that a final summary of the project be submitted after the submission of this invoice. Jim Aiello indicated that a project summary would be completed.

Contractual Cost		
Participants included:	Jim Aiello	-$35.00/hr – 119 hr total
	Art Aiello	-$35.00/hr – 8 hr total
	Caleb King	-$25.00/hr – 112 hr total
	Jim Geer	-$25.00/hr – 4 hr total
	Jolene Krise	-$20.00/hr – 87 hr total
	Norb Arnold	-$75.00/hr – 10 hr total
	John Calla	-$30.00/hr – 44 hr total

Total expenditure ---------------------------------- $11,155.00

Pressing Sintering and Sizing of Control Group Bearing - $12,024.38

Pressing Sintering and Sizing of Blended Sludge Bearing - $14,758.12

Product Assurance, INC Testing - Preliminary Evaluation - $250.00

Product Assurance, INC Testing – Complete Analysis/
Comparative Testing - $5000.00

Total Cost Third Invoice $43,187.50

Conclusion

In conclusion it has been determined that the sludge that is extracted daily from the Brandy Camp mine drainage system, could plausibly be use in the powdered metal production facilities around the region. Within the following attachments your will find schematics for a functional bearing created from the sludge along with the data collected from in the life testing of the bearing , as compared to a commonly used powder metal bearing that was used as a control for the testing. However, it has not yet been determined whether the cost associated with the bearing production would be financially conducive to the lower end market that a bearing of this composition would draw. To determine whether or not the sludge bearing is a marketable item a Cost-Benefit Analysis including the following areas would have to occur.

- The cost associated with the transport of the sludge.
- The cost associated de-watering.
- Processing costs.
- The cost associated with other scientific studies, including metallurgical.
- The cost associated with administrative and political questions concerning the production of usable raw material from acid-mine discharge.

It has been determined that the DEP could save on shipping and land fill cost if it were to dehydrate the sludge prior to exportation to the landfills or other blending sites. By dehydration the overall amount of sludge can be reduced by up to 90%. Fifty pounds of wet sludge will produce on average five pounds of sludge powder.