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THE SOUTH EAST ASIAN IRON AND STEEL INSTITUTE (SEAISI) ELECTRIC ARC FURNACE DUST AND SLAG TREATMENT WORKSHOP

KUALA LUMPUR, MALAYSIA
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A Project of:

The South East Asian Iron and Steel Institute
and
The World Environment Center

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I. Affiliation, Mission and Purpose

From September 5-8, 1993, Mr. Alan B. Sarko, Director of Marketing, Inorganic Service Corporation, a Division of Inorganic Recycling (IR) Corporation, visited Kuala Lumpur, Malaysia and participated in the South East Asian Iron and Steel Institute's (SEAISI) workshop: *Electric Arc Furnace Dust and Slag Treatment*. The purpose of attending this conference was to provide SEAISI workshop participants with a comprehensive understanding of the IR recycling vitrification process in handling EAF dust and to describe the benefits of recycling, and to introduce various products that can be produced from recycled EAF dust. Mr. Sarko's participation was sponsored by the U.S. Agency for International Development (USAID) through WEC's Cooperative Agreement in support of the U.S.- Asia Environmental Partnership (US-AEP).

II. Executive Summary

A. **Purpose.** The purpose of attending the SEAISI Conference in Malaysia was threefold.

1. To explain briefly the current position of both government and industry in handling electric arc furnace dust residuals (EAF) in the United States.

2. To give an overview of the IR Vitrification Process and explain why it is a viable alternative in handling EAF dust residuals.

3. To give an overview and actually present a series of recycled products produced from EAF dust residuals.

B. **Findings and Recommendations.**

1. **General Observations.** It was quite interesting to meet and talk with steel industry representatives outside the United States. I felt that like many steel representative of the U.S., there is a deep concern for protecting our environment. However, unlike the United States, most of the governments of the countries represented at the conference do not have a comprehensive environmental policy in place. Governmental requirements were a primary force in driving waste handling in the United States. The participants at the conference were confident that governmental waste handling mandates will be forthcoming shortly. Some of the primary driving forces for instituting mandatory waste handling and environmental compliance in Korea, Japan and Southeast Asia are the following:

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i. The recognition of a global economy which will mandate pollution control in order to manufacture and sell goods worldwide.

ii. Lack of land space.

iii. Concentration of pollution in urban areas which could affect drinking water and land resources.

iv. The education of the population regarding environmental concerns.

At this conference there were many environmental papers attempting to find some answers both on a practical and economical basis. Most realized that the problem will grow as the area industrializes. The solutions presented basically concentrated on just three areas:

1. Waste minimization;
2. Stabilization and encapsulation;
3. Reclamation.

2. **Waste Minimization Discussion.** The theory behind waste minimization is very sound: if you don't produce it you don't have to dispose of it. Certainly the steel industry in Asia must study waste minimization and ultimately implement it as soon as possible. Many fine papers discussed this area extensively, including those presented by Mr. Ken Minnick of the United States, Mr. Talwoo Lee of Korea, and Professor Dr. Ban Bong Chou of Korea. Long term study and practice in this area will help reduce waste generation. However, as we have learned in the U.S., it will not eliminate it. As the area continues to industrialize, how not to generate waste becomes a bigger problem. Waste minimization, although helpful, will only provide a partial solution. Industry, however, is controlled by economics and economics currently dictate that it is cheaper to produce waste rather than eliminate it through minimization practices. There also is some waste produced that never will be eliminated.

3. **Stabilization and Encapsulation Discussion.** Stabilization and encapsulation techniques were presented by Dr. Liou Ding Chung of Taiwan. Most of the conference attendees that I spoke with did not feel that these techniques had much of a future. Stabilization and encapsulation of heavy metal waste streams temporarily fix the problem but, as we have found in the United States, this requires a great deal of land space, Asia does not have the luxury of being able to use large tracts of land for this purpose. Also, if somehow the waste in the ground becomes destabilized, or the protective materials encapsulating the waste fracture due to water penetration, freeze/thaw activities, or in-ground chemical reactions, the waste will eventually come out and we

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will have to deal with the pollution again.

4. **Reclamation Discussion.** The bulk of the conference dealt with reclamation of heavy metals and in particular, zinc reclamation. The basic problem with this area is that it deals with only a percentage of the EAF dust residual. Typical steel mill dust in the United States and in Asia as well contains between 15 to 20 percent zinc. In many instances this concentration is even lower. The elements that make EAF dust hazardous are chromium, cadmium and lead. Zinc is not considered a hazardous element in the U.S. Although zinc reclamation is a very good technology, it also, like waste minimization, focuses only on part of the problem. The best secondary zinc smelter cannot reclaim 100% of the zinc in the EAF dust residual. Even if this was possible what happens to the 80 - 90% residue left over? This remaining 80 - 90% also happens to contain primary heavy metal toxic contaminants, namely, chrome, cadmium and lead. The main reason steel mills focus on zinc recovery is because of economics. Zinc recovery will pay for some of the waste disposal; however, if it costs more to dispose of the residue than what the reclaimed zinc brings, a problem soon surfaces. This is presently what is occurring in the United States as residue disposal is becoming more expensive.

5. **Vitrification.** The paper that I presented on recycling and vitrification dealt with these issues. It was the only paper providing an alternative that will handle all of the EAF dust generated. The system both chemically and physically changes the residual materials making them nonhazardous, inert and reusable. A more detailed discussion can be found in Section III. Alternatives, such as vitrification, which addresses the whole problem and not just a portion of it, need to be pursued.

C. Future Follow-up Opportunities

This conference provided a good opportunities to begin to explore and discuss these alternatives. Several individuals at the conference requested a visit to our operations in the United States to see the vitrification recycling technology first hand. Some attendees have already made inquiries on how to implement recycling and vitrification in Japan. I have already had many preliminary discussions with Workshop participants. Meeting and staying in contact with them and continuing to encourage environmental consciousness and interest in our process should be ongoing. I believe as Southeast Asia becomes more industrialized, governmental regulations tighten, and the problems mentioned in this report become more severe, more companies will seek knowledge of vitrification and recycling. It is my opinion that the presence of vitrification and recycling technology in Korea, Japan and Southeast Asia is only a matter of time.

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III. Presentation

SUMMARY

Inorganic Recycling Corporation (I.R.) has developed a unique process in today's marketplace which chemically fixates inorganic hazardous waste to produce inert, nonleachable ceramic products. This proprietary process is an important alternative to landfill disposal and its ensuing problems. The I.R. Process is an EPA recognized RCRA exempt recycling system. Federal and State EPA recycling acknowledgements are available.

1. SYSTEM APPLICATION

1.1 Amenability

Any material which is predominately composed of inorganic compounds such as metal sulfates, metal carbonates, metal phosphates, etc., would be amenable to this system. Metallic compound mixtures, drag-ins or variations of either concentration or constituency will not adversely affect this technology. The physical state of the inorganics (liquid, slurry, sludge or solid) is not significant. This system will not process scrap metal materials or organic wastes.

1.2 Waste Stream Examples

The examples provided here are not all inclusive but will provide an understanding as to the range of inorganic wastes for which this technology may be employed. The I.R. Process has been applied to the following waste streams:

a. Filter Cake from Waste Treatment of Plating and Coating Operations (F006);
b. Residual Ash produced by Municipal Incinerator Operations (M.I.A.);
c. Electric Arc Furnace Dust from Steel Manufacturing Operations (K061);
d. Waste Products from Glass or Frit Manufacturers;
e. Soils contaminated with Inorganic Materials (RCRA, CERCLA or Superfund Cleanup);
f. Industrial Ash.

2. ENGINEERING THE I.R. SYSTEM

2.1 Capacities

Although the I.R. System can be designed to process most any quantity of generator feedstock, the average I.R. System will process 40 to 50 tons per day. Additional capacities can be handled for larger generators by adding processing components. Fixed base systems can also be downsized to handle 20 tons per day.

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2.2 Construction Requirements

A 50 ton per day unit requires the following:

1. Building - 10,000 to 30,000 square feet;
2. Tractor-trailer space for loading and unloading;
3. Bulk Storage Tanks - process chemical storage;
4. Utilities -
   - Water - 20 - 30 gallons per minute;
   - Electrical - approximately 150 KW;
   - Gas (Natural or Propane), oxy-fuel, fuel oil - quantity varies with input materials.

2.3 Quality Assurance/Quality Control

The laboratory creates a detailed test sequence and logs all pertinent data during production operations. This is to verify that the system chemistry and equipment are operating properly. Process controllers and logs are used to monitor recycling equipment parameters; tests are conducted on incoming chemicals, generator feedstock materials and outgoing products to assure consistent production results.

2.4 Mixer-Reactor Section

The recycling equipment is divided into two major categories. The first of these categories is the Mixer/Reactor Section. All incoming generator materials are handled on a batch basis. Typical mix batches range from one to five tons. A sample of the generator batch material is tested prior to entering the reactor. This verifies that the materials are within the process variability established during the laboratory formulation series. After this is confirmed, the material is entered into the reactor. A series of chemicals are then added to the generator feedstock. On completion of blending, the material is pumped to a surge system. The surge system compensates for any time delays between the mixer and the vitrification system.

2.5 Vitrification

The function of the Vitrification Unit (Vit unit) is to provide the energy needed to complete the endothermic reaction resulting in the ceramic products. The surge system places the reacted/blended material into the unit at a controlled rate. Vit Unit temperature is determined during the formulation sequence in the laboratory and is a function of the feedstock constituents. The reacted/blended material becomes vitrified and molten. No combustion or destruction of the feedstock occurs during this operation. The molten material flows out and is captured by an exit system. This system may be operated on a dry or wet basis. The dry system functions with the molten material falling into molds, where it is cooled and ejected. In the wet system, the molten material falls into a water tank, fracturing the material, after which it is exited by an auger. The product, derived from either the wet or dry system, is tested for leachability, product specifications and quality. It is then packaged and shipped to the purchaser.

2.6 Scrubber

Part of the vitrification phase includes a comprehensive air scrubber system. Particulates may be picked up by the Vitrification Unit air system. Particulates of micron diameter and above are captured via knock-out boxes and other technologies such as venturies. These are filtered through standard filter presses with the resultant cake recycled to the front of the mixer/reactor system.

Anions may fume during kiln operations and may be picked up by the air system as well. Packed tower technologies are used to react and capture these anions. Secondary products are produced from these streams. As an example, plating and coating waste streams often contain a percentage of sulfates. During Vit Unit operations a percentage of the sulfates will gasify to sulfur dioxide. The sulfur dioxide is reacted in the packed tower with sodium hydroxide producing sodium metabisulfite, which is packaged and sold.

3. PRODUCTS

3.1 Ceramics

The key products produced by the I.R. Process are considered ceramic. Ceramics may be defined as any material composed of inorganic elements, which, when exposed to high temperatures, create solid matrix structures through crystal covalent bonds. At a molecular level, these materials may be crystalline or noncrystalline, in which silica or alumina act as the matrix building blocks. The material produced is sized to one-half centimeter or less, bulk bagged in one ton bags and shipped to specialty aggregate manufacturers. These manufacturers size and blend the materials for final product use.

The following are examples of the uses of the I.R. product:

3.1.1. Architectural Products

a. Wall tile	b.	Sinks and tubs
c. Floor tile	d.	Laboratory counter tops
e. Patio stones	f.	Fireproof wallboard
g. Mosaics	h.	Brick, Block
i. Vanities	j.	Roofing Media

There are many small markets which have applied the IR Products for the manufacturing of pen sets, picture frames, statues, etc.

3.1.2. Abrasive Products

a. Sandpaper	b.	Grinding media
c. Shot blast	d.	Buffing compounds
e. Grinding wheels	f.	Polishing compounds

3.1.3. Refractory Products

a. High temperature bricks
b. Insulation Material

4. CONCLUSION

The IR Process was developed over a ten year period of time. This system is fully operational on a commercial basis. Plants have been constructed and are being used by Fortune 100 corporations to manufacture a value added product from inorganic residual feedstocks. The USEPA has thoroughly analyzed the IR Process and has recognized and acknowledged its ability to recycle inorganic hazardous waste.

IV. Discussion and Findings

A. **Technology questions posed by conference attendees.** Questions focused mainly on three areas:

i. Costs;
ii. Products produced by the process;
iii. Volume throughput and space required for the IR Process.

1. **Cost Discussion.** Cost of the IR Process will vary depending upon the constituent analysis of the EAF dust residual, plant labor rates, plant utility rates, chemical additive costs and availability of additives. In the United States costs vary from about $100 to $200 per ton of EAF dust processed. This cost includes amortized capital, labor, utilities, chemical costs, maintenance costs, insurance and overhead. Return from product sales will also vary, depending upon what product is produced. As an illustration, asphalt fillers, roofing granules and medium grade sand blasting media can return anywhere from $3 to $50 per net ton while abrasive and architectural media can return $25 to $100 per ton. Generally the IR system is highly competitive with hazardous waste stabilizing, land disposal and zinc reclamation costs.

2. **Product Discussion.** As was shown, products produced from the IR process are ceramics. They can be used as feedstock for such applications as tile, buffing and polishing compounds, sand blasting media, and refractory compounds. One attendee asked if we can make jewelry out of these materials. My answer was: "Why not?" The applications for these feedstocks are only limited by one's imagination.

3. **Volume Throughput and Space Discussion.** The last questions of concern was primarily about space; something that there is very little of in this region of the world. The IR system is usually based in a plant facility where the inorganic waste residuals are generated. This does not have to be the case if space is a limiting factor. Generally, one IR vitrification system handles

between 5,000 and 10,000 tons of input EAF dust annually. The system is modular so it can be made relatively easy to handle. To handle less than 5,000 tons per year, although possible, would not be likely due to the economics of the system. The space requirement needed for a single IR vitrification line with an average capacity of 7,500 ton per year is approximately 10,000 to 15,000 square feet, which equates to approximately 1,000 to 1,500 square meters.

B. **Summary of Findings.** Regarding the relevancy of the IR technology to conference participants and the needs of Southeast Asia countries, we firmly believe that the IR recycling vitrification technology will eventually be used in Japan, Korea and Southeast Asia. As these areas become more industrialized and environmental laws made more strict, the IR recycling technology and technology like it, will become more in demand. (Reasons for this increase in demand are explained in the executive summary of this report.) The IR system provides a complete solution to the problem of generating heavy metal contaminants.

C. **Follow-up Activities.** Activities such as contacting participants and other Asian concerns is already beginning. We have already received requests for U.S. plant visitations of the IR system. We believe that actually seeing the system operating is an important factor for creating credibility among the prospective users of the system.

We also will need to learn more of the environmental regulations of the Southeast Asian countries as well as Japan and Korea. Ceramic product marketing benefits will also need to be developed. All of these things will take time and a great deal of work. However, with diligence it can be accomplished. We expect activities to increase considerably within the next two to three years.

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APPENDIX A: WORKSHOP PROGRAM

SOUTH EAST ASIA IRON & STEEL INSTITUTE

SEAISI EAF WORKSHOP ON DUST & SLAG TREATMENT
6TH & 7TH SEPTEMBER 1993
MOHAR ROOM, HOTEL NPC, Jalan Barat, Petaling Jaya
WORKSHOP PROGRAMME SCHEDULE

6th Sept 93: (Monday):

0830-0845	Arrival of Committee Members & Participants.
0900-0915	Opening Speech By Dr. Baik Duk-Hyon.
Session I:	**On Minimization of Dust Generation During Operation: (Chairman : Mr. Tsai)**
0915-1000	Presentation by Mr. Kenneth Minnick, Consultant, Paper: "Minimisation of Dust During Generation On Electric Arc Furnace Steelmaking".
1000-1045	Presentation by Mr. Southwick of Southwick & Assocs.
1045-1115	Coffee Break
1115-1230	Discussion
1230-1350	Workshop Lunch Break at NPC Hotel, Poolside Restaurant.
Session II:	**Advanced Technology on Dust Collection: (Chairman: Mr. Leo Selleck)**
1400-1445	Presentation by Mr. Talwoo Lee, Chairman of Korea Cottrell Co. Ltd.
1445-1530	Presentation by Mr. Yoji Nomura, Deputy General Manager (Resources Recycling Engr. Dept) of Aichi Steel Works. Paper: "EAF Dust Treatment In Japan"
1530-1600	Coffee Break

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1600-1645	Presentation by Prof.Dr. Ban Bong-Chan of Suncheon National Univ., College of Engineering, Korea.
1645-1800	Discussion
1930	Dinner Hosted by MISIF (Attendance By Invitation from MISIF)

7th Sept 93: (Tuesday):

Session III: Waste Material/Slag Treatment:
(Chairman : Dr. Choi)

0830-0915	Presentation By Mr. Brian Lightfoot, Executive Director of Ausmelt Pty Ltd, Australia. Paper: "EAF Dust Treatment Using Ausmelt Top-Submerged Lance Technology"
0915-1000	Presentation By Mr. Alan Sarkos from Inorganic Recycling Corpn, Ohio, USA. Paper: "Vitrification of EAF Dust"
1000-1030	Coffee/Tea Break
1030-1115	Presentation by Dr. Liou Ding-Chung, Research Scientist of I.T.R.I., Union Chemical Labs, Taiwan. Paper: "Stabilization/Solidification Treatment of Electric Arc Furnace (EAF) Steel Dust".
1115-1230	Discussion
	End of Workshop Sessions.
1230-1345	Workshop Lunch at Hotel NPC, Poolside Restaurant.

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BIOGRAPHICAL DATA

Alan B. Sarko, Director of Marketing, Inorganic Service Corp., a division of Inorganic Recycling Corporation.

Mr. Sarko holds a Bachelor of Arts degree from Michigan State University, and a Juris Doctorate degree from the Detroit College of Law. Prior to joining Inorganic Recycling in 1985 he was Chief Executive Officer of one of the largest demolition companies in the Midwest. His past responsibilities included overseeing several large scale projects for companies such as Ford Motor Company, GM, Chrysler, Dow Chemical, AEP, BASF and Republic Steel.

His primary responsibility for Inorganic Service and all Inorganic Recycling subsidiaries include developing a customer base for recycling services and sale of all recycled products generated from the IR recycling systems.

He has also been a Company liaison for technical and permitting matters with the United States EPA and various state environmental regulatory agencies.

Specifically, Mr. Sarko has coordinated the development of recycling facilities with the USEPA Risk Reduction Engineering Laboratory, Cincinnati, Ohio; USEPA Waste Management Division Region 5, Chicago, Illinois; USEPA Hazardous Waste Management Division Region 6, Dallas, Texas; USEPA Hazardous Waste Divison Region 3, Philadelphia, Pennsylvania; USEPA Pollution Prevention Division Region 4, Atlanta, Georgia.

He also coordinated the development of recycling facilities with solid waste, air, water and recycling divisions of the State of Ohio EPA, State of Michigan Department of Natural Resources, and the State of Arkansas, Department of Pollution Control and Ecology.

He completed a training course and is certified by the USEPA for hazardous material incident response operations. Other continuing education certificates include certificate of completion for Hazard Professional Symposium - Pollution Engineering, May 1985; Hazardous Waste Management Training Certificate, Hazmat Association, June 1984; Hazardous Waste Management Certificate for Safety - Michigan State University, April 1984; and Detroit Business Exchange Estimating Certificate, May 1973.

He has conducted seminars and authored articles on the recycling of inorganic heavy metal residuals. Included are the following:

1. Seminar for the Ohio Manufacturers Association, Columbus, Ohio, seminar subject: recycling of electroplating and other heavy metal residuals. April, 1988.

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2. Seminar for the EPRI Center For Materials Production (CMP) sponsored by the Carnegie Melon Research Institute, Pittsburgh, Pennsylvania, seminar subject: recycling electric arc furnace dust residuals. March 1992.

3. Seminar for the Association of Iron and Steel Engineers (AISE) in Dallas, Texas, seminar subject: recycling electric arc furnace dust residuals. April 1992.

4. Seminar for the Institute of Advanced Manufacturing Sciences, Inc. (IAMS) an Edison Technology Center, Cincinnati, Ohio, seminar subect: recycling electroplating residuals and environmental compliance. May 1993.

5. Authored an article for the U.S. Air Force Tech-Tip publication under the U.S. Air Force Technology Opportunities Program, October 1990.

6. Authored an article for the Hazardous Waste Consultant, a bi-monthly publication of McCoy and Associates, Inc., July/August 1990.

7. Co-authored an article for 33 Metal Producing Magazine, a Penton publication, March 1992 regarding electric arc furnace dust recycling.

8. Co-authored an article for Iron and Steel Engineer Magazine environmental issue August 1993 for the Association of Iron and Steel Engineers (AISE).