ISSUES IN RECYCLING GALVANIZED SCRAP

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ABSTRACT

The quality of the steel used for most galvanizing (and tinplate) applications makes scrap derived from their production and use a premier solid charge material for steelmaking. In 1989 the AISI created a Task Force to define the issues and to recommend technologically and economically sound approaches to assure continued, unhindered recyclability of the growing volume of galvanized scrap. The AISI program addressed the treatment of full-sized industrial bales of scrap. The current, on-going MRI (U.S.) – Argonne National Laboratory program is focused on “loose” scrap from industrial and post-consumer sources.

Results from these programs, issues of scrap management from source to steel melting, the choices for handling zinc in iron and steelmaking and the benefits/costs for removal of zinc (and lead) from scrap prior to melting in BOF and foundry operations are reviewed in this paper.

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INTRODUCTION

The consumption of galvanized steels has expanded steadily, Figure 1, the result of the many beneficial attributes of this sophisticated modern product. As shown in Figure 2, this growth has changed the traditional share of galvanized steel in the shipment of cold and hot rolled steels to the trade. Figure 3 illustrates the resultant rise of the content of zinc-bearing steel in the most important scrap grade purchased by producers of flat rolled steels, No. 1 bundles, busheling and clips. Similar trends have been noted by the foundry industry. Within the next few years post-consumer scrap, that is, material recovered when automobiles, appliances, etc., end their useful life, will show the effects of increased use of galvanized steels with the ultimate potential for recovery of nearly three times the zinc already available in the scrap steel stream.

The steel sheet which is the substrate for zinc coatings is among the highest quality steels produced due to its chemical "purity," e.g., carbon, sulfur, phosphorus, nitrogen, etc. Thus, full, unhindered consumability of this material is essential for the steel industry for operating as well as commercial reasons. By the late 1980's, LTV Steel and other producers\(^1\)\(^\text{--}\)7 initiated internal programs to define and to resolve issues that could influence the continued recyclability of zinc-coated scrap.

Industry-wide attention to the recyclability of galvanized steels led the AISI Committee on Technology to form a Task Force in 1989 to define the issues to be resolved to insure continued recyclability of this type of scrap. In the initial phase, the Task Force was charged with definition of the issues that arise from use in EAF (electric arc furnace), BOF (basic oxygen furnace) and foundry operations of galvanized scrap, including environmental implications, and to explore the technologies and the economics associated with introduction of a zinc removal step prior to melting zinc bearing scrap. The impetus to regain recyclability of the iron units contained in BOF dust was also to be considered: the current practice of landfilling the material...
causes in excess of 1% loss in iron yield for the blast furnace -- BOF complex at nearly every integrated plant.

The AISI Task Force\(^1\) identified technological effects and the options for continued use of galvanized scrap. An action plan for a demonstration of technical soundness, cost and steelmaking environmental benefit of a then new process for de-zincing scrap in the form of full-sized industrial \textit{bales} was developed: electrolytically aided caustic leaching was the technology of choice. A large-scale BOF test constituted the second part of the AISI program.

Following the AISI dense bale treatment trial, the logical approach was to work with loose scrap in two forms: largely flat pieces, circa 50 cm x 75 cm, originated (General Motors) as stamping plant \textit{clips}, and \textit{shredded}, about fist-size and shape, produced from the same stamping plant scrap stream. This led to an industrial prototype plant study of zinc removal from \textit{uncompacted} scrap initiated by MRI (U.S.) at a new facility in East Chicago, Indiana. This program\(^8\) is co-funded by the DOE and is the joint responsibility of Argonne National Laboratory and MRI (U.S.). Several interested companies, including LTV Steel, Bethlehem Steel, General Motors, Luria Brothers, National Materials Trading, and Noranda, Inc. have participated in the technical planning. Assessment of scrap quality is based on induction furnace (foundry) and BOF melting tests. Impressive early results from this program are presented below but will need to be confirmed as experience is gained at increased throughput rates and with the stabilizing effect of the yet-to-be started electrowinning operation. Work will start to optimize the quality ( = value) of the recovered zinc. Particular attention is to be paid to prevention of surface oxidation of the zinc to facilitate its use, perhaps as make up to the spelter in hot-dip galvanizing operations.

In parallel, other programs based on different technological approaches have been initiated off-shore and taken to small commercial plant production levels\(^{4-7}\).
DEFINITION OF THE ISSUES

The main components of the galvanized scrap puzzle will be reviewed in the following sections: scrap management, and the steelmaking and resultant environmental effects of entry of zinc with the scrap. Understanding of the latter was enhanced greatly by the results of the first degalvanized scrap trials.

Scrap Management

There are several sources of zinc-bearing scrap in the industrial cycle:

- Steel plants, at their coating facilities, generate coil ends, edge trim and pup coils; furthermore, as most of these plants generate a variety of coated products, i.e., conventional hot dip, galvanneal, electrogalvanized, iron-zinc and zinc-nickel alloys, which all too often are mixed in the mill scrap system. This represents 2 to 5% of galvanized steel production and is included with prompt scrap.

- At the stamping plants, for example at General Motors where some 1.6 million tons per year are generated, only 16% of this is kept segregated and either sold or consumed uncoated. This, of course, suggests that the balance or 84% of generation, is mixed (coated versus uncoated) to a significant extent. In this same setting, of the foundry feed that is required to be uncoated, approximately 60% is generated in-house . . . leaving the balance to be acquired from a shrinking pool of uncoated scrap, Figure 3. In any case, about 15 to 20% of sheet shipments return as prompt scrap, which is mostly mixed.

- Post consumer scrap, which is the ultimate fate of all steel. The gradual rise in the galvanized content of steel shipments, Figure 2, will, in turn increase the incoming zinc load. At present the foundry and the EAF segments of the industry are exposed to this; however, as degalvanizing also results in removal
of oils and paints, such scrap would become useable by the integrated flat rolled producers.

Zinc-free prompt industrial scrap is increasingly difficult to obtain; the reason is illustrated in Figure 3. The price of truly “black” scrap is climbing as the foundry and steel industries search for it and to the extent the scrap industry expends labor to find it and/or maintains separation, i.e., prepares it. Demolition scrap, historically a good source of zinc-free scrap, is a source of paint and lead contamination.

Efficient management of a melting system, i.e., to smooth out the sharp peaks in zinc levels in individual heats, can require knowledge of how much zinc is entering the furnace charges for both operational and environmental reasons. In addition to the ever increasing galvanized content of industrial steel scrap (Figure 3), assessing the actual quantity of zinc contained in industrial steel scrap on a real time basis is a difficult if not impossible task. Figure 4 shows the zinc analyses of twenty randomly chosen pieces of scrap from 100 tons of No. 1 industrial fragmentized steel scrap purchased recently by General Motors. The average of these samples is 2.39% Zn with a sample standard deviation (σn-1) of 2.59%. The trend in steel scrap processing, especially steel scrap related to the automotive industry, is headed in the direction of more fragmentized or shredded scrap.

Members of the scrap processing industry have expressed fear that the value added by dezincing scrap or the costs incurred in using coated scrap could make integrated mills look for alternatives such as high hot metal ratios (where possible) and to let the high quality coated scrap flow to the EAF producers. At several plants experience has also shown the EAF process to have finite tolerance limits to zinc loading unless there is a furnace enclosure (doghouse) as well as extensive ladle metallurgy available to remove zinc from the liquid steel. In time, as the high galvanized sheet containing automotive hulks and worn out appliances begin to flow to the steel industry, the EAF operators will have to consume large quantities of this
material: The zinc load is growing and the capacity of the EAF process to accept it may become limiting.

Thus, the importance attached to the Argonne National Laboratory – MRI (U.S.) program for treatment methodologies for shredded scrap which is a prime feed for EAF and foundry operations.

**Steelmaking Effects**

The inclusion of galvanized scrap in steelmaking charges causes the introduction of zinc (and small amounts of lead) below the surface of the liquid steel in the steelmaking vessel. Zinc affects the environmental performance of steelmaking shops, ladle metallurgy facilities and foundries. Penalties range from the loss of recyclability of BOF dust/sludge to sinter plants, to injury to product quality through release of residual zinc during solidification of cast sections. For ironmaking (blast furnace, cupola, foundries) and for induction melting, penetration of zinc into the vessel lining and/or buildup of scabs on the walls bring on severe operating and refractory penalties.

In the BOF, the first step in the chain occurs during charging. The low vaporization temperature of zinc (907°C at 1 atm) and the low (but significant) solubility of zinc in liquid iron alloys\(^9\)\(^{10}\) have the combined effect of causing rapid volatilization of zinc upon addition of the hot metal. The zinc (oxidized) leaves the mouth of the tilted BOF vessel hopefully for capture by the hood. In the EAF, the first wave of oxidized zinc vapors enters the building when the furnace roof is swung off for “back charges.” In EAF shops, these fumes are captured by the building roof or canopy collection systems.

Upon completion of charging, zinc trapped in the scrap, in bales or at the bottom of a packed pile of uncompacted clips, is released into the liquid and may pass through to the gas collection system or may go into solution, aided by the high
ferrostatic pressure at or near the bottom of the BOF vessel\textsuperscript{9}. This is particularly troublesome for late melting, densely compacted bales. Laboratory studies\textsuperscript{9,10} show solubilities as high as 1\% Zn for deep melts. At BOF turndown and/or tapping some of the dissolved zinc is released as fumes. Industry experience has shown that part of the lead introduced, either as an alloy of the zinc, or originated separately from other scrap sources, mostly follows zinc in its travel through the metallurgical/environmental system. A small portion of the lead accumulates on/in the bottom of the steelmaking vessel where it can cause significant damage.

The sensitivity to zinc during steelmaking differs markedly for the BOF and EAF. Approximately 65\% of all steel is produced in the BOF process which uses less scrap per ton of steel produced (20 to 25\% of total charge in North America in contrast to the 75 to 100\% scrap for the EAF) but the BOF is far more sensitive to this issue. The BOF process is faster (20 minutes per cycle versus 40 to 90 minutes for the EAF) so there is far less time available to vaporize off the zinc; furthermore, with considerably deeper metal pools in BOF vessels, there is a greater tendency to retain zinc in the liquid steel.

The next major step in the metallurgical cycle generally involves ladle treatment; during which the steel, although at a depth of say 4 to 5 m, is stirred by induction or with gas and, in modern facilities for production of high grade sheet, bar, or tubular steels, is subjected to vacuum. Zinc retained in the steel after the steelmaking step is removed to significant extent by ladle stirring and totally by exposure to vacuum. This, of course, creates other streams in need of clean up: the baghouse catch or the contact water and resultant sludge.

Zinc that is not removed prior to casting is released during solidification when solubility in iron/steel drops to near nil. There are numerous anecdotal references in the industry to fuming during casting, to zinc “rimming” of ingots, zinc-coated “shiny” blowholes in cast billets, etc.
Environmental Issues

Technology

Meltshop waste gas handling systems have either (dry) electrostatic precipitators (BOF), the capture efficiency of which is affected deleteriously by the presence of zinc oxide in the gas, baghouses (EAF and foundry) or wet scrubbers, for which the water and sludge treatment cost and operability difficulties escalate with the presence of zinc oxides.

The value of BOF dust or sludge is diminished by the presence of zinc as recycling of this otherwise high grade iron oxide (50 to 60% Fe) to the blast furnace is prevented by the presence of the zinc. Traditionally, the internal recycling path in steel plants with operating sinter strands had been to include the BOF dust in the feed to the sinter plant. The rise in zinc content has precluded this; in part due to the presence of other recycled zinc bearing materials in the sinter feed. To maintain blast furnace burdens to below the accepted limit of 0.3 kg Zn/t HM, at LTV Steel a limit of 0.2% Zn would be applied to the BOF dust (versus a current Zn content ranging from 5 to 12%). Thus, what should be a valuable source of recyclable iron units (credit) is sent to landfill at a cost.

EAF dust cannot be landfilled if it contains in excess of 15% Zn; if it contains the typical 20 to 40% Zn, the zinc is a benefit because the thermal treatment process operator gives the steel producer a credit for zinc units in the dust. Thus, removal of zinc from the scrap would result in loss of this credit to offset the treatment cost but would improve the working environment in EAF shops.

The processes used to treat EAF dusts, which may contain up to 40% Zn in flat rolled producing shops do not allow for economic treatment of BOF dusts because processing costs and the low zinc credits would be unfavorable. Thus, despite Fe content in excess of 50%, BOF dust or sludge is sent to landfill, where it may be over
75% of the solids disposed from a steelworks equipped with a sinter plant although only 25 to 30% in plants without sinter capability.

**Experimental Results - Zinc in Steelmaking**

The learning from the melting tests (LTV Steel, Indiana Harbor Works BOF Shop) may be useful in illustrating the path of zinc in steelmaking systems. It is important to note that zinc and lead removals from the 540 t of treated bales were about 65 to 70% as calculated from the reported analyses of the BOF precipitator dust. As shown in Figure 5, the zinc content of the BOF dust reflects the zinc load into the process. The range shown for “black scrap” is indicative of the “memory” effect in the large precipitator system, wherein long sequences of heats must be sampled to arrive at steady-state conditions. In Figure 6, the effect of the zinc content of the scrap on pickup of zinc by the contact water in the vessel hood is observed... as is the reduction available with removal of all zinc from the charge.

The effects of even the partial reduction of zinc and lead in the BOF charge could be traced through the ladle metallurgy facilities, including ladle furnace and vacuum treatment, Figure 7. Zinc and lead contents of water sent to the treatment plant from the BOF hood and the degasser correlated with the nature of the BOF charge. Removal of zinc at the ladle furnace, as indicated by higher zinc content of the dust, resulted in reduced zinc loading of the vacuum furnace condenser (contact) water. This offers the opportunity to manage the process stage for final removal of zinc from the system.

**DEGALVANIZING PROGRAMS**

Review of the technologies available in 1990 led the AISI Task Force[1] to conclude that as baled scrap is of main interest in BOF operations, the MRI Inc. approach of electrolytically-aided caustic leaching (Figure 8) was to be the first candidate for investigation. In the large masses of scrap in bales, the effect of the
electrochemical boost appeared to be enhancement of penetration by the caustic into the center of the bales and into tight crevices between scrap pieces that had been squeezed together. The current ANL/MRI (US) program for "loose" scrap is based on the same chemical principles, Figure 9. In both cases, a critical adjunct to the removal of zinc from scrap by dissolution in caustic is the recovery of the zinc by electrowinning. This provides for a significant potential benefit in credit for zinc sales and, of course, for re-use of the main chemical reagent, the caustic. However, the complexities in this approach to recovery of zinc cannot be ignored.

Since the initial (1990) examination by the AISI other technologies for zinc removal have matured. Of particular interest are the two processes based on vacuum distillation that have been taken to small scale commercial operation. Presentations of these\textsuperscript{4-7} are to follow in this program

**AISI Program\textsuperscript{1)**

An opt-in program was developed, with nine company sponsorship*. The effort was focused on determining the technical, environmental, and economic viability of removal of zinc and lead from conventional size and density (700 to 1500 kg and 2200 to 2900 kg/m\textsuperscript{3}) bales of scrap. For BOF shops, this is the most important case for scrap clean up, as nearly all loose scrap, clips, etc. from stamping plants are baled for charging into converters.

* Armco (AK) Steel, Bethlehem Steel, LTV Steel, MRI, National Steel, Noranda, Inc., U.S. Steel, WCI, and Weirton Steel.
Details of the test work have been published\textsuperscript{11}. In short, electrolytically-aided caustic leaching of 540 t of bales (prepared using LTV Steel and U.S. Steel generated hot-dipped galvanized steel plant scrap) was the core of the program. Terne plate was added during the baling operation to 135 t to simulate the presence of second phase lead in the scrap stream. Inadvertently, unusual conditions were created: bale bulk density of up to 320 kg/m\textsuperscript{3} with long pieces wrapped around some of the bales; furthermore, pup coils were included in a few bales. Melting of both treated and of "control" scrap occurred at LTV Steel’s Indiana Harbor Works BOF shop.

\textbf{Argonne/MRI (U.S.) Program}

The MRI (U.S.) plant is designed to examine various operational modes, such as caustic temperature, immersion time, scrap sourcing and preparation, etc. Evaluation is based on induction furnace (General Motors)\textsuperscript{11} and BOF melting (LTV Steel) tests.

The expectation for zinc removal in excess of 95\% is being met, as shown in Figures 10 and 11. More consistent zinc removal is obtained with the longer soak time (45 minutes versus 23 minutes) as there are fewer "flyer" points associated with small missed areas on the treated scrap. The misses may be < 75 mm\textsuperscript{2} and probably are due to intimate contact between pieces of scrap or due to entrapment of gas. Extremely low residual sodium analyses have been observed, this is of importance to process acceptability. These early results will need to be confirmed as experience is gained at higher throughput rates (and with the electrowinning circuit in operation).

Analysis of surface contamination with zinc and/or caustic is but a preliminary evaluation of process performance. The first industrial test occurred at General Motors Corporation’s Powertrain Division Saginaw Maleable Iron Foundry\textsuperscript{11}; the 60 t coreless induction furnaces are drained of 6 t every 15 minutes, followed by a 6 t recharge with preheated scrap. The de-oiling action of the caustic causes clean up of the preheater stack, and zinc removal from the scrap resulted in elimination of zinc fuming from the furnace.
The next major evaluation will be at LTV Steel using the Indiana Harbor Works BOF shop. The target for these tests is attainment of a zinc content in the BOF dust that will allow use of the latter as sinter plant feed, that is, $\leq 0.2\%$ Zn and cessation of the current practice of chemical stabilization of the dust followed by landfilling. Currently BOF dust at this plant contains 5 to 12% zinc.

**Zinc Recovery**

An important consideration in the overview of usage of zinc-bearing scrap is the potential impact of removal of the zinc by a method that allows recovery and recycling of this metal. This possibility is of direct interest to the zinc industry, because, long term, the quantity of zinc available for recovery from steel scrap may begin to approach the volume of zinc produced annually in the U.S. (U.S. zinc production in 1993 was about 350,000 t.) Eventually all this steel will return as scrap for remelting, however, as matters now stand, only a part of the zinc will be recovered by the processors of EAF dusts or from recovery in degalvanizing operations. Steel, being the most recycled material, eventually gets remelted but presently nearly all of the iron, zinc and lead units in BOF and foundry capture systems go to landfill and are wasted... due to the presence of zinc and lead brought in by the scrap!

With degalvanizing the steel industry could become a huge zinc mine! This situation led to Noranda, Ltd., a large Canadian zinc producer, to join the AISI Task Force and to Noranda’s continued participation in the Argonne/MRI (U.S.) program.

Zinc recovered during the AISI program from the bales, upgraded at both MRI Inc. and Noranda, had lower impurity contents (Fe, Pb, Al) than found in the spelter samples submitted by each of the member companies. The exception was antimony, which was present in unexpectedly high concentrations and is removed only in part by MRI’s zinc purification process. Credit was assumed at 40% of the LME zinc price to allow for drossing (yield losses) and other cost penalties in its use.
A "first pass" comparison of the caustic leach degalvanizing processes may be of interest, Table 1, although it is too early to quantify differences in process intensity for degalvanizing bales versus degalvanizing loose scrap followed by baling. It is clear, however, that treatment of "loose" scrap can be accomplished in shorter exposure (= residence) time and thus lower cost facilities and higher throughputs are possible for any required treatment volume. Experience with batch and continuous processing indicate that pieces of uncoated, loose scrap can be processed continuously in less than 1 hour, with high zinc removal efficiencies. The dezincing process time for bales can range from 6 to greater than 24 hours, depending on bale preparation. If there is a need to dezinc baled scrap by leaching, it can be accomplished but at substantially increased costs.

The response to leaching of the two basic types of scrap is illustrated in Figure 11. The type of galvanized steel affects the rate and completeness of coating removal. Alloy coatings of zinc such as galvanneal, Galvalume and zinc/iron all react relatively faster in the hot caustic process because of spontaneous chemical dissolution of zinc. Relatively pure hot dipped or electrogalvanized zinc coatings react slowly to hot caustic unless an oxidizing agent or anodic promotion is provided. From earlier tests at Argonne and at Armco, it is known that zinc-nickel coatings tend to be the most resistant to the hot caustic process as the nickel is essentially inert and hinders access of the caustic solution to the zinc.

Figure 12 presents a family of curves to depict the main cost parameters for degalvanizing processes based on caustic. The critical assumptions are given in the figure. It is important to note that processing time, rectification requirements and power consumption for the removal of zinc from galvanized steel are variables which are greatly dependent on the physical form of the scrap and, to a lesser extent, on the type of galvanized steel to be processed.
Because zinc (and lead) leave the steelmaking process almost totally by way of the dusts and sludges produced in the environmental systems, disposal costs and recyclability issues have a direct effect on the economics of using galvanized scrap, which despite these challenges, is the highest quality scrap available for production of sheet steels. Most of the sheet steel that ultimately gets zinc coated is produced in BOF's. We need this scrap and want to recycle it. These issues drive the economics for pre-treatment of scrap.

CONCLUSIONS

- **Degalvanizing technology** is likely to play a major role in the flow of scrap to steelmaking and foundry operations. The extent this processing step is used will depend on the economics of use versus the costs avoided for other, remedial, technologies. Likely many competing process technologies will develop to fill local situations.

- **Competing** process development efforts are underway; happily, differing technical approaches are being utilized. This situation is best for arrival at cost-effective solutions. The objective is total recyclability of the iron, zinc, and lead in the scrap.

- **Degalvanizing of baled** scrap by electrolytically-aided caustic leaching is a viable process but limited to 75-80% zinc removal. (Recent information from Japan indicates that up to 99% is attainable with vacuum aided processes.)

- For **loose scrap**, shredded or clips, processing performance by caustic leaching appears to be ≥ 95% zinc removal. For a large-scale BOF plant, treatment of 30,000 t/mo may be needed at less than $20/t after zinc recovery. Transportation costs may become a consideration if low density scrap has to be moved over long distances prior to treatment and to be followed by baling.
• Environmental performance of steelmaking furnaces charged with degalvanized scrap improves markedly. Whether the bale treatment process, at the observed “worst case” of 70% zinc removal, or the > 97% removal for “loose” scrap are environmentally and economically attractive, depends on site-specific realities such as requirements for reduction of zinc content of BOF precipitator dust, sludge and water, etc. to impact their recyclability. For foundries, zinc related refractory damage is a consideration.

• Long term the technology of choice will involve treatment of loose scrap and recovery of high grade zinc. Results from the ANL/MRIUS program are very encouraging. The competing technologies, reported on in this session are being watched.

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## TABLE I - COMPARISON OF CAUSTIC LEACH DEGALVANIZING TECHNOLOGIES

<table>
<thead>
<tr>
<th>Process Issue</th>
<th>Dense Bale (1 to 1-1/2 t)</th>
<th>Clips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immersion Time</td>
<td>24 - 36 hr</td>
<td>23 - 48 min</td>
</tr>
<tr>
<td>Zinc Removal (%)</td>
<td>65 - 75</td>
<td>95 - 99</td>
</tr>
<tr>
<td>Lead Removal (%)</td>
<td>65 - 75</td>
<td>&gt; 95 (est)</td>
</tr>
<tr>
<td>Retained Caustic</td>
<td>Problem</td>
<td>Nil</td>
</tr>
<tr>
<td>Treatment Cost ($/t*) for &gt; 30,000 NT/mo, 15 to 20 kg Zn recovered/t scrap</td>
<td>25 - 35</td>
<td>15 - 20</td>
</tr>
</tbody>
</table>

*Exclusive of shredding or baling cost as these are incurred in the normal flow of scrap from generator to melter.*
FIGURE 1. SHIPMENTS OF GALVANIZED SHEET AND STRIP TO U.S. CUSTOMERS (BASED ON AISI STATISTICAL REPORTS).
FIGURE 2. GALVANIZED STEEL SHIPMENTS AS PORTION OF ALL SHEET MILL PRODUCTS (SOURCE AISI).
FIGURE 3. ESTIMATION OF GALVANIZED CONTENT IN PROMPT INDUSTRIAL SCRAP

YEAR

1980 81 82 83 84 85 86 87 88 89 90 91 92 93

GALVANIZED IN NO.1 BUNDLE & BUSHING (%)
FIGURE 4. SCRAP SAMPLING STUDY AT GENERAL MOTORS, SAGINAW FOUNDRY (1994).
FIGURE 5: AISI DEGALVANIZED SCRAP TRIALS BOF DUST ZINC VS. ZINC IN CHARGE (280 NT HEATS).
FIGURE 6: AISI DEGALVANIZED SCRAP TRIALS HOOD WATER Zn VS. ZINC IN CHARGE (280 NT HEATS).
Figure 7. Relationship between elimination of zinc at the ladle furnace on subsequent release into the degasser condenser water.
Figure 8. Schematic of the MRI, Inc. bale degalvanizing process.
FIGURE 9. CONTINUOUS DEZINCING OF LOOSE SCRAP MRI (US) - ANL.
FIGURE 10. ZINC CONTENT OF EARLY PRODUCTION SCRAP BY MRI (US). SCRAP IN THE FORM OF STAMPING PLANT CLIPS.
Figure 11. Effect of coating process on removal of zinc by electrolytically aided caustic leaching, MRI (US).
Figure 12. Cost factors vs. production capacity for degalvanizing by dissolution of zinc in sodium hydroxide and recovery of zinc by electrowinning. Capital recovery (ROI) is taken as 33%.