Performance and Testing of the Ferrous Metals Recovery System at Recovery 1

Irving Handler and Kelly Runyon are to be highly commended for at least three things:

1. They begin by a complete description of the problems that they encountered in extracting and marketing ferrous scrap from solid waste. They detail the problems: (a) they extracted much less ferrous scrap than predicted, (b) their initial extraction system resulted in 15 percent contamination in the extracted ferrous scrap, and (c) the income from sale of this ferrous scrap was much less than anticipated.

2. They detail the tests they conducted that showed that there is only 3.74 percent ferrous scrap in the incoming waste stream, or 50 percent of the amount predicted before the plant was built.

3. They detail the things that they have done to improve the marketability of the Light Ferrous Scrap.

Both authors and their employers have done the resource recovery industry a very big service in presenting this paper. The facts of life are not nearly as pleasant as were our exotic dreams of the early 1970's. But resource recovery will become a viable industry only if we understand its wants as well as we understand its potential benefits.

Why, I wonder, has it proven impossible to devise a sampling procedure that accurately determines the percent of ferrous scrap in solid waste? In 1973, NCRR devised what I thought was a highly accurate sampling method. They used this method in New Castle, Delaware, New Orleans, and elsewhere. The method involved the random selection of an appropriate number of households in each of four income groups—selected from U.S. Government census data— as being representative of the population. In New Castle County, this sampling procedure (some of which was subcontracted by NCRR to AENCO) showed that the solid waste of New Castle County contained 5.7 percent ferrous scrap. Similar NCRR tests in New Orleans indicated 8.8 percent ferrous scrap.

In extracting ferrous scrap from the New Castle County Plant in 1973-1977, we observed that we were recovering slightly less than 3 percent, by weight, as ferrous scrap (including contamination that was less than 5 percent, by weight, of the ferrous scrap). We considered that our operations were not efficient in extracting the ferrous scrap. Specifically, we considered that our magnet system was probably inefficient in extracting magnetic material, and we also considered that we were spending too much time with the magnet turned off (while changing collection trucks).

We were wrong on both counts. The ferrous scrap just doesn't seem to be there at the 5.7 percent level. Our best current estimate—based on ad-hoc tests that involve weighing what we hope is a representative load, running it through a shred-
ing system, running it under a magnet, and re-run-
ing the nonmagnetic material through the sys-

tem — indicates that the solid waste of New Castle

County contains only about 3.5 percent ferrous

scrap. The New Castle County Plant extracts about

2.9 percent of the incoming material as ferrous

scrap. This indicates that we lose about 17 percent

of the ferrous scrap in the incoming wastes. We

have observed that our percent recovery is highest

on days when we process less waste — which

indicates that our overhead Dings “Hockey Stick”
Magnet misses some magnetic material when the

burden depth is high. This was expected.

In any event, our observations tend to confirm

the observations made by the authors of this paper.

Meanwhile, the Delaware Solid Waste Authority

has conducted four tests to determine the ferrous

content of New Castle County’s wastes. Their

method of sample collection involved dumping

the contents of four trucks that collect from dif-
f erent parts of New Castle County. The contents

of these four trucks were mixed and quartered,
using a front-end loader. One quarter of the well-mixed
solid waste was delivered to the Bureau of

Mines Laboratory in Avondale, Md.. The waste

was run through the very well-designed BuMines

Pilot Plant, and it was determined, on four oc-
casions, that there was more than 8 percent fer-
rous scrap in each of the four quartered samples.
How could this be? I suppose that there is some-
thing about the routes of the four trucks, or may-
be the day of the week, or maybe the mixing pro-

cedure that results in a determination of more than
8 percent ferrous in the solid waste stream. Or,
less likely, there really is more than 8 percent fer-
rous scrap in New Castle County’s wastes.

The point is that apparently valid sampling

procedures resulted in determination of 5.7 per-

cent (NCRR, 1973) and more than 8 percent

(DSWA, 1978) ferrous scrap in New Castle

County’s solid waste.

Based on seven + years experience in operating

the New Castle County Shredding Plant, I am con-

vinced that the solid waste of New Castle County
contains only about 3.5 percent ferrous scrap. I

know that on a day-by-day operational basis, we

extract only about 2.9 percent ferrous scrap from

the wastes of New Castle County.

Could it be that Waste Management and NCRR

are missing 50 percent of the ferrous scrap in the

wastes processed at Recovery I? Could it be that

AENCO and New Castle County are missing 50 per-

cent of the ferrous scrap processed in New Castle?

I suppose it’s possible, but I doubt it. Rather, I

think that the sampling procedures used to pro-
ject ferrous content are suspect. But I wonder —
because we have all read that Ames, Iowa recovers
about 8 percent ferrous scrap. The steel industry
produces about 5.5 million tons of steel cans (in-
cluding barrels) per year. If there are about
135,000,000 tons of solid waste generated annu-
ally, one would suspect that the solid waste stream
should contain about 4 percent steel cans. We

estimate that about 75 percent of the magnetic
material that we extract is steel cans — the remain-
der being other ferrous scrap. Thus, one could make
a case that there should be about 5.3 percent fer-
rous scrap in the waste stream. Could it be that
the total amount of solid waste produced in the
United States is substantially greater than 135 mil-
ion tons per year? If, for example, there were
really 209 million tons of waste, then one would
expect to find 3.5 percent ferrous scrap in the

waste stream which is about what I think is there.

One would have thought that, after having spent
many millions of dollars in waste composition

studies and in market analyses, such a simple mat-
ter as the ferrous content of the waste stream
would be well-known to EPA. It should be obvi-
ous that such is not the case.

Financial planners, however, are more interest-
ed in revenue from sale of products — as opposed
to being interested in the quantity of product. We
all hope that the methods of upgrading the ferrous
scrap reported in this paper will result in high and
stable market prices for the ferrous scrap.

One of the many problems with resource re-
covery is that well-meaning planners project in-
come from ferrous scrap sales as follows:

\[
\frac{\text{(8 percent Ferrous)}}{100} \times \frac{\text{($40/ton ferrous)}}{\text{($20/ton ferrous)}} = \frac{\text{$3.20/ton}}{\text{of incom-

\text{ing waste)}}
\]

When the truly recoverable percent of ferrous
scrap — and the true arms-length market price —
are taken into account, the real projection should be:

\[
\frac{\text{(3 percent Ferrous)}}{100} \times \frac{\text{($20/Long ton)}}{\text{($2,240)}} = \frac{\text{$0.54/ton}}{\text{of incom-

\text{ing waste)}}
\]

Thus planners tend to overestimate the income
from sale of ferrous scrap by a factor of about 6!
As an example, Moody's has reported that the consultant's projections for income from sale of ferrous scrap from the Resco's Saugus, Massachusetts Plant was $307,000 for 1977. Actual ferrous income was $17,000. In this case the estimate was off by a factor of 18! I do not know if low market prices, shortage of waste or a low percent of ferrous scrap were responsible for this shortfall in income. Probably a combination of these three factors were responsible.

I speak for our company, and I hope that I speak for the industry, in thanking Irving Handler and Kelly Runyon for presenting a highly-informative and well-researched paper.

Discussion by

Ronald D. Kinsey, President
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The paper presented by Irving Handler and Kelly Runyon is an interesting summary of the evolution of the ferrous metals recovery at the New Orleans facility. Unfortunately, it documents the misfortunes of a resource recovery facility designer who violated the first rule of successful resource recovery which is: “Design the recovery system to produce a product which meets the requirements of a specific buyer”. While it is unfortunate that the facility designers neglected that maxim, it is encouraging to learn that the design has finally evolved into one which applies it.

There are some points in the paper that should properly be clarified. In the Introduction, the description of the process Line Two states that the ferrous metals recovery system was placed after shredding and before the main air classification system. There is no mention of the ferrous metals recovery system for process Line One. In the original system configuration, nearly half of the light gage ferrous metals reported to the trommel “unders” and completely bypassed the shredding systems. This, in turn, was probably one of the largest contributors of the difficulties they experienced in contaminants and low density ferrous materials.

The statement that the primary product, light ferrous scrap, was to be sold to Proler International for detinning prior to use in copper precipitation is erroneous. While Proler International owns and operates chemical detinning facilities, historically only clean can plant scrap is chemically detinned by Proler. All of the ferrous materials from New Orleans Recovery One and similar resource recovery facilities purchased by Proler is shredded and burned in a controlled temperature rotary kiln to remove lacquers and organic contaminants as part of the preparation process for precipitation iron. That process does not remove the tin. It would be more correct for the offending sentence to be revised to read “... sold to Proler International for preparation for use in copper precipitation”. Similarly, a few lines further down in the Introduction, a paragraph ends “... these parameters are important to the detinning process”. In this sentence the word “detinning” should be replaced with the word “precipitation”.

The description of the original ferrous metals recovery system philosophy also specifically addresses ferrous metal recovery from shredded refuse, but does not acknowledge the magnetic retrieval from the unshredded trommel underflow. In the original system design description, it is unfortunate that the system designer selected electro-magnetic drums to magnetically retrieve the ferrous metals. Drum magnets have never been particularly successful in retrieving ferrous metals from the shredded MSW stream. Much better performance has been obtained by the utilization of suspended multiple magnetic belt systems in this application. It is quite possible that the drum magnet would function efficiently on the trommel underflow material if the burden depths where sufficiently low.

Some of the problems described in the ferrous concentrator can probably be attributable also to the unshredded cans being fed to the system.

On page 173 of the Proceedings, in the section entitled “Raw Waste Sampling,” there is an error in item 6; “other minimum” should read “other aluminum”.

On page 184 of the Proceedings, reference is made to the ASTM Sub-Committee on Ferrous Metals which is erroneously identified as E-38.03; the ferrous metal Sub-Committee is actually E-38.02.

AUTHORS' REPLY

To Ronald D. Kinsey

We will respond to this discussion by referring to its paragraphs in sequence.

Paragraph 1. At the initiation of the ferrous
metals contract, product requirements were not clear to the buyer. The situation was one of a "learning curve" for both Buyer and Seller. Also, during 1973-1974 when the ferrous recovery system was being designed, little formal data was available on design and operations of such refuse shredding and materials recovery installations. What Mr. Kinsey calls the "first rule" was actually followed to the practical extent possible at the time.

Paragraph 2. It is the authors' position that the term "shredding" refers to work done by both Shredding Lines 1 and 2. This should give a relationship of the two lines with respect to the ferrous metals recovery system; however, we do accept that perhaps this relationship could be stated more clearly.

Paragraph 3. In 1974, Proler International's intent was to de-tin the scrap ferrous metals. Upon doing so, they found it uneconomical due to the level of contamination of the scrap. Presently, Proler is burning the scrap ferrous in a controlled atmosphere. During the fall of 1980, they will de-tin the improved scrap ferrous now being supplied them. Should the tests be successful, Proler will de-tin the scrap ferrous on a continuing basis.

Paragraph 5. Again, as in Paragraph 1's response, during 1973-1974, we found little meaningful data on performance of electro magnets when used in shredded refuse systems. The number of such plants that were operational then was miniscule. Information sharing was done reticently. Vendor discussions were the most frequent source of information. Then, it was a matter of comparing prices and expected performance before selecting magnets.

In the "Performance and Testing . . . " paper, Table 3 clearly shows the high efficiency of the drum magnet on the trommel underflow. There is no need to speculate on magnetic drum efficiency in this situation.

Paragraphs 7 & 8. Corrections of errors are always appreciated.

ADDENDUM

The reviewed ferrous recovery system had its equipment "bumped" on January 29, 1980. On January 30, 1980, material was introduced to it and the shakedown mode was begun. This was reached one month later than scheduled. Major cause of the delay was use by the erection contractor of an inexperienced crew. Finally, WMI, the general contractor, offered an incentive bonus, and the last of the erection contract was quickly completed. Ferrous recovery activities were discontinued for approximately 40 percent of the 12 week system erection period.

Major operational problems occurred immediately. The #207 air knife lacked sufficient air velocity to blow all the light ferrous into the chute feeding the shredder. An estimated two-thirds of the light ferrous fell into the heavy fraction chute, ending up as non-recoverable material. Sheave changes were made to speed up the fan rpm. Final air flow never reached the design value because maximum fan blade tip velocity was reached first. Pivoting the air knife splitter blade toward the heavy fraction leg in an effort to deflect some of the light ferrous back to the shredder caused secondary problems. Heavy fraction ferrous discharge area was reduced, encouraging jams. Ferrous collected on the inclined gate and would cause brief shredder motor surges when it fell into the shredder. A last major problem was the build up of a positive air pressure in the air knife itself. A closed loop design air system had been installed, with air from the knife returning to the knife via the cyclone. Air flow did not balance well and debris blew out of the knife legs, creating housekeeping problems. To date, the air knife has not been totally satisfactory.

The other area of major shakedown difficulties was the #208 shredder. Some ferrous product was impacted upward by the hammers and fell into the air knife heavy fraction leg. At least two three-groove power bands that drive the rotor have been burned due to slippage when the rotor was jammed because of wire balls, heavy ferrous items of long chordal dimensions or round shape, or the slugs of light ferrous re-entering the shredder. Hammer material has not been acceptable. The first set of 16, made of mild steel, processed 80 tons (72.6 t) of ferrous during 100 hr of operation. Deformation of the hammer pin bore and the surface contacting a stop pin, as well as working face erosion, required changing to the second set of hammers. The only difference between hammer sets was the number of surfaces hard faced. The first set had 3 surfaces and the second had 5 surfaces hard faced. After 140 hr of operation and about 180 tons (163.3 t) of product, more of the same problems occurred on the second set. A new and different design of hammers has been purchased. These have been hard faced on one surface and recently installed. The new hammer design has more mass and the center of mass has been shifted.
to a greater distance from the pin bore. This will provide more inertia for the hammers and should reduce deformation from the stop pin. New hammers are made from H.T. 4140 steel, quenched to a Brinnell hardness of 435-450. There has not been sufficient time to evaluate hammer performance.

Less serious problems in shakedown occurred and for the most part have been resolved. More metal enclosures were added to various equipment areas to reduce debris, #210 belt magnet was shifted about 40 in. (102 mm) backward to improve metal separation, and #211 organics discharge conveyor had 3 in. (76.2 mm) high cleats added, 3 ft (0.9 m) apart, to prevent roll back of material.

Two rail cars of ferrous material collected from the revised system were received at Proler International’s Vinton, Texas plant around the end of March. Here are the results:

Car #1 - 69,500 lb (31.5 t) net carload weight
23.4 lb/ft³ (375 kg/m³) density
3.5 percent contamination

Car #2 - 73,400 lb (33.3 t) net carload weight
24.8 lb/ft³ (397 kg/m³) density
8.8 percent contamination

Customer reaction was encouraging. Proler wanted more of the same product. Since the second car load did not meet contamination specifications, its data would be omitted, while the values from the next four car loads would be averaged with the first load. Should specifications be met for product cleanliness and minimum car load net weight, the purchase price would then be the Birmingham #2 bundle price.

System processing rate has not reached the values shown in Fig. 10 – Process Flow Chart. When the primary shredding line, with the trommel unit, processes refuse at approximately 85 ton/hr (21.4 kg/s), light ferrous is collected at 1 ¼ ton/hr (0.44 kg/s) and losses are ¼ ton/hr (0.1 kg/s). Losses are primarily due to the light ferrous misreporting from the #176 ferrous concentrator and the #207 air knife. When the shredding line with no trommel is operating, the rate of light ferrous production reaches 1.6 ton/hr (0.4 kg/s), an increase from the previous 1.3 ton/hr (0.33 kg/s). This increase was due to the pivoting of #171 electromagnet to adjust magnet height over the belt conveyor beneath, thereby increasing magnet efficiency. This magnet is now positioned at slightly above 18 in. (0.46 mm) from the conveyor belt. Most of the processing time since system start-up has been put on the shredding line without a trommel in it.

By April 9, 1980, the revised ferrous recovery system was considered operational and was producing an improved product. Improvements would still be needed in the shredder and then the air knife. The Engineering Team signed the project as completed. The surge bin and mobile crane were not considered necessary and were not installed. Total project capital cost was $176,000.

CORRECTION

An error was made in the text of the original technical paper. It concerns hammer material. The initial set of hammers for the secondary shredder was not made of manganese alloy, as originally printed. The material was mild steel.