

Advances in Steel Scrap Shredding and Processing

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Introduction

So that you may understand some of the prejudices that I bring to this presentation, it may be useful to understand something more about me. I am chairman of Newell Industries, Inc. which we believe is the leading manufacturer of shredding equipment in the world. Newell Industries, Inc. also operates an electric furnace foundry, which manufactures manganese and low alloy steel castings, requiring low copper residuals in the finished casting.

In addition, I am an owner of three scrap processing plants, which operate shredders and I have been connected with Newell family shredding operations since 1959.

Therefore, it can be seen that I have prepared these remarks from at least three different viewpoints, as a manufacturer of shredding equipment, as a producer of shredded steel scrap and as a consumer of low copper residual shredded steel scrap.

Around the world the recycling of steel scrap has been a tremendous success. Producing new steel from a scrap based electric furnace operation saves energy, causes less environmental concern and effectively recycles material that might otherwise be wasted. Shredding of that steel scrap before it is charged into electric furnaces has proven to be a key factor in an efficient operation that creates the most value.

In 1973, I made a speech in Brazil, that was titled "Shredded Steel, Yesterday, Today and Tomorrow". At that time, there were far less than 100 scrap steel shredders in the world and they produced no more than 3 million tons of shredded steel for use in steel mills and foundries.

In 1958, there were no shredders in operation and no shredded scrap steel produced. Today, in 1998, there are approximately 700 shredding plants in operation around the world and we think that they are producing at the rate of 40,000,000, or more, tons per year of shredded steel scrap.

We believe that around 20,000,000 tons were produced in North America alone. This represents something like 30% or 35% of all of the scrap steel used in North America. It is interesting to note that in Japan, for instance, only 11% of the total scrap used will be shredded steel scrap. In other parts of Asia the percentage of shredded steel scrap will be even lower. In Europe, it seems that about 20% of the total scrap utilized will be shredded steel scrap. In total, we believe that about 275,000,000 tons of steel scrap are consumed each year by steel mills and foundries around the world. If about 40,000,000 tons of that scrap are presently shredded, this represents about 15% of the total scrap consumed.

The experience of North American steel scrap utilization, with something over 30% being shredded, indicates that a much higher percentage of the world's total scrap supply, in the future, will be shredded as compared to torched, sheared, or baled. This means that the total amount of scrap being shredded could be doubled, even if total steel scrap consumption remains the same. It will be interesting to think about why this should be. We believe that more scrap will be shredded, because the use of shredded steel scrap in electric furnaces adds more value, for less cost, than does the use of any alternative material.

Shredded steel scrap is recognized as a world commodity and is traded around the world in a relatively free market, with buyers and sellers reaching agreed prices based on their perceptions of the value of the product. The price for shredded steel scrap is listed in all of the publications that purport to list the price of raw materials for steel making and shredded steel scrap is almost always quoted at a premium over #1 Heavy Melting scrap steel.

The electric furnace steel maker has been in a constant search to find methods to manufacture better new steel products at an ever decreasing costs per ton. The melter knows that if a higher quality scrap is introduced into the furnace, he can melt more quickly and produce a higher value steel product with low residuals.

Advantages of Shredded Steel Scrap

Shredded steel scrap has many advantages over other types of scrap particularly when used in an electric furnace because:

- 1) There is a high yield of hot metal as a ratio of input shredded scrap.
- 2) The chemistry of the hot metal is more uniform heat after heat.
- 3) The good density means there are less back charges in order to

reach furnace capacity.

- 4) There is less electrode breakage.
- 5) There is longer furnace lining life.
- 6) There is less sulfur in the hot metal.
- 7) There is less phosphorus in the hot metal.
- 8) There is less electric consumption per ton of hot metal.
- 9) There is less air pollution.
- 10) There are less hot spots in the furnace.
- 11) When shredded scrap is mixed with other feed stock the shredded scrap fills the voids providing a more dense mix.
- 12) Shredded scrap lends itself to better material handling techniques.

The introduction of shredded steel scrap into electric furnaces represents a significant change in the practice of steel making and I believe that it will be instructive to consider some of the reasons why this tremendous change has taken place, and then to attempt to look into the future to see what might happen next.

Past History

Sometimes it is jokingly said that "Invention is the mother of necessity", and while that is sometimes true, for example, in the case of the electric tooth brush and similar inventions, it is more often true that "Necessity is the mother of invention." In the case of scrap steel shredding, I believe that it was "economic opportunity and economic necessity" that led to this development.

The economic necessity was a result of restrictions against the open burning of automobiles in order to prepare them for baling into a #2 bundle and the economic opportunity was the need for higher quality scrap at the electric furnace steel mills.

Economic Necessity and Economic Opportunity

Beginning in the late 1950's and early 1960's, a concern developed in North America regarding the quality of the environment. Our cities began to develop air pollution known as smog. It was estimated at the time, that 5% of all of the air pollution existing in our major cities resulted from the open burning of automobiles.

In order to prepare an automobile for baling into a #2 bundle, it was necessary to either hand strip all of the upholstery, rubber and glass out of the automobile or to burn it. Hand stripping and burning were both relatively inefficient, expensive and, of course, in the case of open burning, pollution causing. Even then, most of the non-ferrous metals were left in the processed scrap and, of course, this was reflected in the low price being paid for #2 bundles.

At that time, Newell Recycling Company consisted of 5 scrap processing plants each of them equipped with hydraulic baling presses that had been manufactured by my father, Alton Newell. Our businesses were beginning to be economically squeezed by restrictions against open burning and by the high labor cost of hand stripping an automobile to prepare it for baling.

The combination of necessity and opportunity had led to the beginning of our efforts to process scrap automobiles in a more automated manner with less pollution. In the effort to do this, we found that we could not only process the raw material by shredding much more efficiently but that we could produce a much better quality scrap material for the electric furnace steel makers at the same time. Over the past 30 years, we gradually found that old automobiles are not the only scrap steel item that is best processed by shredding. Equipment developments have allowed us to continue to increase the size, shape and variety of material that is being successfully shredded.

From 1965 and for the next 22 years until the advent of the Newell Super Heavy Duty shredder, the ability of shredders to shred heavy material was about the same. Some of us gradually found that it was possible to shred #2 grades of heavy melting scrap by carefully sorting and by careful inspection but the costs of extensive hand sorting and the danger of getting an unshreddable into the shredder kept the idea from being very popular.

History of the Super Heavy Duty Shredder

During the early 1980's Newell was asked if it would be possible to build a shredder that would process blast furnace slag by shredding so that the included steel could be separated magnetically from the slag. The steel would then be re-melted and the shredded slag would be sold as an aggregate material. We ran a series of tests in one of our own shredders and found that it was very difficult to shred this material because most of the pieces shredded easily, but some pieces were in fact unshreddable. There were several times during the tests when we damaged the shredder and had to stop to make repairs.

Eventually, however, we were able to design equipment to withstand the severe duty. We sold a plant to the Levy Company in Detroit who installed it at the U.S. X. plant at Gary, Indiana. This shredder handled up to 250 tons per hour of blast furnace slag and operated satisfactorily.

Economic possibility (or potential profit) is sometimes, the mother of invention. By 1986, the free market had recognized the value of shredded scrap, and the spread in price at steel mills, between #1 and #2 heavy melting grades of scrap, as compared to normal shredded scrap was large enough to encourage experiments.

Jeff Cole, president of Ferrous Processing and Trading, located in Detroit, Michigan was one of those forward looking people who identified the market. Jeff came to us and asked us if we could build a shredder that could handle the #2 heavy melting grades and some #1 heavy melting grades of scrap with a shredder. Jeff had done some calculations and had decided that, if it were possible to shred these grades of steel scrap for about the same as shearing costs, it should be possible to make good profits. His reasoning went something like this:

- Hydraulic shears process material very slowly compared to a shredder.
- The unprepared material for a shear costs about the same as the unprepared material for a shredder.
- The shrinkage incurred, if it were possible to shred this material, would be much lower than that incurred when shredding normal scrap. (In actual practice several tests indicate that the shrinkage will be less than 10 %.)
- Some non-ferrous material will be recovered and the value of the non-ferrous material will probably at least equal the cost of the shrinkage. (In actual practice we later found that almost 1 % of the material shredded was non-ferrous metal and that it has a high percentage of copper bearing material such as brass valves in it.)
- The market is at least \$10.00 per ton more for shredded material than it is for #1 grades of sheared scrap and \$20.00 to \$30.00 per ton more than it is for #2 grades of sheared scrap..
- Steel mills have been upgrading the type of scrap required because of tighter specifications for their finished steel products, because of the desire to melt faster and to spend less time refining the steel after it has been melted.
- It might be that a further premium could be obtained for this special type of shredded steel scrap.

These observations led to the question "Is it possible to design, build and consistently operate such a shredder?".

We discussed the matter briefly and decided that the lessons learned with the slag crusher could be applied to the shredding of steel scrap and the SUPER HEAVY DUTY NEWELL SHREDDER was born. It was our beginning premise that it would not be possible to shred things that are unshreddable but that it would be necessary to be able to handle them in the shredder with a minimum chance of damage.

During the past few years, there have been an unprecedented number of new shredding plants purchased and almost all of the new plants purchased from Newell have been Newell Super Heavy Duty (SHD) shredders. We are proud to have been selected as the supplier of Super Heavy Duty shredding plants to a number of steel mills, after their engineers have made extensive evaluations. At the moment more than 20 of the SHD shredder plants have been purchased by steel mills, including plants that were recently installed at Guangzhou Iron & Steel in China, Amsteel, in Malaysia and a plant for China Steel in Taiwan.

There is a popular misconception in some people's mind that when trying to justify a shredding plant, it is necessary to count the number of scrap automobiles available and to decide the viability of the shredder based upon this calculation. This is totally wrong since the development of the Super Heavy Duty shredder.

During the past few years, there have been several steel mills in South America and in Eastern Europe who were in the market for a steel shredder. They had looked at their information and decided that, with the number of automobiles in their countries, that the largest shredder that they could use would be a 1000 or 1500 hp plant. We visited them and did a survey on the type of scrap that they were using in their furnaces. In each case, we found that it would be possible to process 75% to 90% of their total scrap in a Newell SHD shredder. The operators were naturally somewhat skeptical and we invited them to visit an operating SHD plant and to see for themselves what could actually be processed. I am proud that in almost every instance, the operators decided to purchase a Newell shredding plant. They found that they could use a 3000 hp or a 4000 hp plant and that they could plan on processing 6000 tons per month and even up to 20,000 tons per month. This was a considerable better result for them than if they had settled for a small typical shredder that was limited to automobiles and similar scrap for raw material to process. Several steel mills have purchased Super Heavy Duty shredders to reprocess scrap that

is being purchased from outside suppliers. They believe that the processing costs will be repaid many times by increased efficiency in their electric furnaces.

An interesting development that has only occurred in the past year is a sudden interest in very large Super Heavy Duty shredders called MegaShredders. At least 10 of these MegaShredders will be installed by the end of 1998. These are machines with 120 inches (3 meters) diameter for the hammer circle and 104 inches (2.6 meters) width at the feeding area. These are typically powered by 6000 hp and are capable of processing tremendous amounts of material per hour (up to 250 tons per hour) which translates to monthly totals of up to 25,000 tons per shift and with multi-shifts, it is possible to process up to 70,000 tons.

The operating efficiencies of this large machine are very impressive. The capital investment is not proportional to the capacity and it takes about the same number of people to operate any size of shredding plant. It is believed that when sufficient amounts of scrap are available, that there is no more efficient way to shred scrap steel than in one of these MegaShredders.

The type of material that can be shredded and some examples of unshreddable material are as follows:

DUTY DESCRIPTION FOR UNPREPARED AND PREPARED SCRAP STEEL

The Newell Super Heavy Duty shredder is suitable for processing scrap material including:

1. Complete cars with or without engines in "as received" or flattened condition.
2. "Pressed and sheared" light iron compacted to not more than 65 pounds/ft.³ (1t/m³).
3. "White Goods" i.e., household appliance, washing machines, refrigerators, etc.
4. Light iron scrap normally classified as #2 heavy melting material, foundry grades of scrap and many grades normally classified as #1 heavy melting material except unshreddable items.

Examples of unshreddable items

- A. 1 inch (25 mm) Cable in more than 50 foot (15 m) sections.
- B. Alloy shaft in excess of 2 inches (50 mm).
- C. Mild steel shafting in excess of 2-1/2 inches (63 mm).
- D. Plate more than 1 inch (25 mm) thick that is more than 1 foot (300 mm) in any direction.
- E. Plate more than 2 inches (50 mm) thick that is more than 6 inches (150 mm) in any direction.

- F. Structural shapes of more than 1/2 inch (12 mm) sections.
- G. Re-bar more than 2 inches (50 mm) in diameter.
- H. High carbon bars more than 1 inch (25 mm) in diameter.
- I. Truck axles rated in excess of 14,000 lbs. (6 metric tons) for front axles and 38,000 lbs. (17 metric tons) for rear axles.
- J. Ingots, billets, and similar types of material.

The above list of items should not be considered exhaustive but rather it should be considered an indicative list of items that can be considered to be shreddable. Items that are less difficult to shred than the above listed items can be shredded on a regular basis. Items that are just slightly above the size and difficulty to shred of the listed items will not normally hurt the shredder. Care should be taken to avoid massive unshreddables, examples of which are 100 mm billets, large shafts, and other solid pieces that weigh 50 kilos or more.

While this machine still does not shred unshreddables, it has a better capacity for handling the unshreddables that do get into the machine. This means that while some separation should be made before the feeding the shredder, it is not necessary to spend excessive amounts of time making manual separations.

The exciting thing about this equipment is that it opens a new area for scrap processing. The theory of upgrade has always driven the scrap processor, take something, process it and produce something of a higher value.

The normal super heavy duty shredded steel scrap is clean with copper content of about 0.15% and has a density of 78 lb/cubic ft. (1.2 ton/cubic m).

Low Copper Residual Shredded Scrap

It is possible with these new designed machines, to produce shredded steel scrap with lower copper residuals. This is done by selecting the materials that are to be shredded, mixing known low residual scrap with normal shredding material, hand sorting some of the free copper from the shredded steel scrap, or by size separating the shredded steel scrap so that the lower copper residual materials can be sold separately. This material normally sells for a premium of \$7 to \$20 per ton over the price for normal shredded steel scrap.

Although in the United States there is only a small cooling scrap market at this time, it is also a premium priced market. Cooling scrap must have density in the range of 2.0 specific gravity and it must be sized so that it will flow through pipes, hoppers and other handling systems. Cooling scrap is used in the steel making process in plants that have continuous casting machines and plants that use Vacuum Degassing systems. Cooling scrap is introduced into molten steel to cool it to the proper temperature for use in the continuous casting machine. We believe that the SHD shredder has a big potential to produce cooling scrap because of the SHD shredder's ability to process heavy scrap into a very dense product.

We believe that the developing countries will bypass the old generation of shredding equipment and move directly to the SHD design. In most of these developing countries, there is not an infrastructure of scrap processors. The steel mills normally are responsible for their own scrap processing. Since the steel makers are more sophisticated, it is expected that they will move to the current "Best World's Practice". Therefore, we expect to see a large developing market for this type of equipment in South America, in Africa and in particular Asia. Since the equipment is not dependent upon old automobiles for material to process, it makes more economic sense to install a Super Heavy Duty shredder than to install a less efficient hydraulic shear or baler.

Economic Justification of Operation

When steel scrap is shredded a value is created that by far exceeds the cost of processing. This means that large gains in profits are possible when compared to any alternative method. The direct costs for shredding will be about \$12 to \$14 per metric ton.

Preview of the Future

Heavier Scrap will be Processed

Quite often, I am asked what will be the next step in the improvement to shredding systems and I have to admit that I do not know. Although, when I look into my crystal ball, the picture is sort of fuzzy, I can see that there are several areas where improvements can be made.

I think that we will see the definition of what is an unshreddable, changed further in the direction of heavier scrap. The new heavy duty shredders will become even more heavy duty.

Heavy scrap has all of the same advantages as normal shredded steel scrap with several additional advantages. Heavy shred has even higher density and in general, lower residuals such as copper. The market seems to indicate that the heavy shred should bring a premium price higher than normal shredded steel scrap and that premium will vary from \$3.00 to \$20.00 per ton.

If a market for cooling scrap exists in the area of the shredding plant, then it can be met with the operation of the SHD Newell TBD shredder. Cooling scrap made with heavy scrap is even better than normal cooling scrap in that it is more dense and it can be more uniformly shaped if the operator chooses to do so through controlling the size of the grate openings. Cooling scrap also commands premium prices of \$30.00 to \$50.00 per ton.

Non Ferrous Metals will increase Returns

Then, I think that there will be further improvements in the separation of non-ferrous metals from the waste material. Several of our associated companies have been very successful in the business of buying residues from shredders and separating the non-ferrous metals out of them. The success is at least partly due to the fact that every waste material line is mined again after the primary treatment. This gives the company a higher rate of recovery than would otherwise be possible.

There are possibilities for better identification of the types of metals available and better methods of separating those metals from each other.

Continuous Charging of Shredded Scrap into Electric Furnaces

In the slightly further distant future, we believe that shredded steel scrap will be continuously fed into electric furnaces in much the same way that directly reduced iron ore pellets are being fed into the furnace through a fifth hole in the roof of the furnace.

There are a number of advantages that would accrue to the operator who is able to solve the handling problems:

- The tap to tap time for the furnace should be lowered because of less time spent with the roof off of the furnace.

- The total energy used to melt each ton of material should be lower because of the conservation of heat from leaving the roof in place longer.
- It should be possible to preheat the scrap with the exhaust gasses, which would further reduce the amount of energy required.

There is really only one problem that must be overcome in order to make this a successful operation:

- The shredded steel scrap must be uniform enough in size so that it flows smoothly out of hoppers. This usually means that it must be dense enough to make the pieces uniform. We believe that this is achievable at about 120 pounds per cubic foot (1.85 tons per cubic meter).
- When the scrap is properly sized, then all of the lessons learned through the use of DRI can be applied to this operation.

Conclusion

Shredded steel scrap as a metallic charge for electric furnaces has gone from no use to a very significant amount of usage in the past 40 years. It has revolutionized the way in which steel is being made. The number of electric furnaces in use has been increasing because many steel products are made more economically in the electric furnace and that is partly due to the availability and quality of shredded steel scrap. The fact that shredded steel scrap generally commands a premium price over most other grades of scrap is the best proof of its value. When electric furnace operators voluntarily pay a premium for a material, you can be certain that they think that it is worth it.

We are proud to have been involved in, and associated with, the development of shredders and shredding techniques and shredded steel scrap and we look forward to continuing to grow with it into the future.