Copper in End-of-Life Vehicle Recycling

Prepared for
Copper Development Association (CDA)

by

Manufacturing, Engineering &
Technology Group
Center for Automotive Research

Emilio Brahmst, Principal Author

November 2006
- Final Version -

The statements, findings, and conclusions herein are those of the authors and do not necessarily reflect the views of the project sponsor.

Acknowledgements

CAR would like to thank the following organizations for their contribution to this report.

Aluminum Association

Automotive Recyclers Association (ARA)

Automotive Recyclers of Michigan (ARM)

DaimlerChrysler

Delphi

Doug's Auto Recyclers

Ferrous Processing & Trading Company

Ford

General Motors

Institute for Scrap Recycling Industries (ISRI)

Ken's Auto Parts

Louis Padnos Iron & Metal Company

Morris Rose Auto Parts

Nissan

OmniSource Corporation

Steel Recycling Institute (SRI)

United States Council for Automotive Research (USCAR)

Table of Contents

Executive Summary

The intent of this study is to identify the current state of knowledge and efficiency in removing copper components from end-of-life vehicles and to help identify the relationship between component design and copper recycling. Another aspect is the assessment of the attention that copper receives as a result of rising commodity prices.

Original equipment manufacturers are conducting research on the recycling of end-of-life vehicles in order to reduce the environmental impact of their products and in order to comply with strict regulations, especially in foreign markets. GM, Ford and DaimlerChrysler channel most of their research in the United States through the Vehicle Recycling Partnership at the United States Council for Automotive Research. The current emphasis is on the avoidance of hazardous materials and the recycling of plastics recovered from shredder residue. An increased recycling of copper—either through better scrap separation or through different product design—is of no serious concern to automotive companies, as metal recycling is considered a mature process. The auto companies will attempt to continue to maintain a single product design for “global vehicles” despite the influence of local recycling regulations.

End-of-life vehicles are first processed by dismantlers who remove components for reuse and prepare vehicles for shredding, mainly by depolluting these vehicles. Reuse rates vary significantly depending on the vehicle model. Wheels, transmissions and engines (which all contain a significant amount of copper) are the most reused components. Those battery cables and wheels that are not reused are typically removed and disposed of separately. Wire harnesses often remain in the vehicle, as they are difficult to remove and are often not interchangeable with harnesses in other vehicles.

Shredding companies receive vehicles from dismantlers and process those, along with other waste, into materials of different classes and grades. Copper is included in several products. The fraction that is attached to ferrous metals is isolated from the ferrous stream. Copper wires and large copper parts may also be removed separately from the non-ferrous stream. A large amount of copper is also mixed in with brass and zinc in a

product known as heavies. It is assumed that another large amount of copper, mainly from wires and electronic components, is part of the automotive shredder residue.

The major technologies used to separate automotive scrap include shredders, magnets, eddy current and induction sorting. Advanced and emerging technologies will help to increase efficiencies in the sorting of scrap and in reducing product impurities. These include camera devices for color detection and material analysis through radiation devices.

The economics of the recycling business determine the way end-of-life vehicles are processed in the United States. The original equipment manufacturers are working on cost-effective solutions that will improve the recycling rates of end-of-life vehicles. Dismantlers are removing those components for which commodity prices make separate processing economical. Similarly, shredding companies choose their technologies based on global scrap prices.

Customers of shredding companies have varying degrees of concern with the levels of copper in their raw materials. Steel mills have the most stringent requirements, as they can only process material with a minimal amount of copper. Shredding companies are aware of these requirements and they adjust their processes accordingly.

1 Introduction

In 2005, about 6.5 million automotive vehicles were retired from use in the United States; about 95% of these entered the recycling process (Ward's, 2006). It is further estimated that at least 84% of the vehicle's material content is recycled[1]. These numbers show that recycling plays a significant role in the automotive industry. There are many stakeholders in the recycling of end-of-life vehicles (ELVs): Original Equipment Manufacturers (OEMs) design vehicles for production and recycling; dismantlers remove components from ELVs and make parts available for reuse; and shredding companies separate the vehicle's materials and forward it to those who process it into raw materials for new vehicles.

Copper can be found in many automotive components (such as wire harnesses, electronics, and motors) or as alloys in the aluminum of engine blocks or transmission housings. In 2005, the automotive industry in the United States used a total of 803 million pounds of copper for the production of 11.95 million motor vehicles. The way this copper is used in vehicles can be accurately traced (e.g., through the International Material Data System[2]). Nevertheless, it is relatively difficult to understand how the recycling of each individual copper-containing component is impacted by a recycling system that processes not only ELVs but other industrial and consumer goods, as well.

In addition, recycling processes vary by region, depending on regulations. In the United States, the main influences on ELV recycling are EPA regulations on water and air pollution and free market economics of the recycling industry. In contrast, the European market is mainly influenced by EU regulations that currently aim to achieve a 95% recovery and reuse rate of vehicles by 2015. This requires a manufacturer to search for solutions that might differ from those in the United States and from those in markets with different regulations.

[1] Reuse is considered part of recycling in the United States. See also FTC's "Guide for the use of environmental marketing claims" at http://www.ftc.gov/bcp/grnrule/guides980427.htm

[2] http://www.mdsystem.com

The use of materials in vehicles also affects the recycling method. Recent efforts for light weighting, for example, resulted in a shift toward higher value materials, such as aluminum. Nevertheless, the current composition is still determined by vehicle designs from about 20 or more years ago, as the median age of a scrapped vehicle in the United States is estimated to be 16.9 years—according to the Department of Energy (DoE, 2006).

The following report describes the current state of the art in vehicle recycling by focusing on operations that affect the recycling of copper. For this purpose, selected dismantlers and shredding companies were visited and representatives from industry organizations were interviewed. Selected OEMs have also been interviewed to better understand the impact of regulations on their vehicle design and on their research focus.

2 Original Equipment Manufacturers

Automotive companies are concerned about the impact of their products on the environment and react proactively by conducting research and designing vehicles accordingly. OEMs must also abide by recycling regulations that vary across markets. Most notably, Europe passed laws requiring OEMs to increase vehicles' recovery and reuse rates (in stages) to 95% by 2015. This caused vehicle manufacturers to investigate which recycling concepts would be most suitable to achieve this goal. Other countries (such as Japan or Korea) have their own standards potentially requiring automakers to implement different solutions. The challenge for OEMs is to define a strategy that complies with regulations with different goals.

In North America, General Motors, Daimler Chrysler and Ford collaborate within the United States Council for Automotive Research (USCAR) to share technological and environmental concerns. The Vehicle Recycling Partnership (VRP), founded in 1991, is one working group within USCAR. Its mission is to promote an integrated approach to the technical and economic feasibility of recycling for vehicles built in North America for the global marketplace. The OEMs channel most of their domestic research through the VRP. Their major areas of concern involve the processing of plastics and the avoidance of hazardous materials, especially heavy metals.

Recyclers and shredding companies are not members of the VRP, but they are included when defining research tasks or when their contributions are needed. For example, a survey of practices at dismantlers conducted in 1999 was supported by the Automotive Recyclers Association (ARA). Another example involves a project where shredding companies applied advanced methods to recover certain types of plastics from shredder residue (SR)[3].

Interviews with the OEMs have revealed different recycling strategies across markets. Two Japanese OEMs reported that a major focus of their research is on energy recovery

[3] Most shredding companies process automotive scrap with industrial and other scrap as described in Section 4 of this report. Hence, automotive shredder residue is one fraction of the shredder residue.

of Automotive Shredder Residue (ASR). Nissan has built a network of 26 energy recovery plants throughout Japan; these plants recovered more than 72,000 tons of material in 2005. Toyota reported in their 2005 environmental report[4] (Toyota, 2005) that their dismantling system is being designed to remove certain materials (e.g., copper) so that the remaining ASR can be used in their electric furnaces. Japanese regulations appear to encourage OEMs to focus part of their efforts on energy recovery. In contrast, one American OEM reported that they will not rely on energy recovery to meet European regulations. Instead, they will mainly focus on the disassembly of ELVs. Their activities in this area range from the use of proper materials, the development of a coding system, the use of design for disassembly tools and the development of efficient disassembly systems.

It does not seem that recycling concepts in the United States will change significantly as a result of developments abroad. For example, the dismantling of vehicles will likely not be practiced in the United States as is planned in Europe. The market in the United States is largely driven by the reuse of components; in Europe, reuse is often practiced by the sale of components to core buyers or by the export of entire vehicles to countries outside of the EU. Additionally, comprehensive dismantling systems are likely not financially self-sufficient. Similar arguments can be made for current energy recovery technologies.

The OEMs emphasized that they would favor any market-driven solution for the recycling of ELVs in the United States. A VRP project on methods to convert plastics from the SR stream to fuel or gas is one example that domestic OEMs are supporting this view. The ultimate goal is the development of a system that uses advanced technologies for the sorting of scrap and the conversion of plastics to energy, funded by the sale of this energy. This system, if implemented, might also affect copper recycling as all metals will have to be ejected from the SR stream, allowing for their separate processing.

The domestic OEMs indicated that the recycling of copper is currently of no serious concern to them. The recycling of the metal stream is viewed as a process that is generally working well. There are also no considerations to improve the design of parts

[4] http://www.toyota.co.jp/en/environmental_rep/05/download/pdf/report2005.pdf

or components in order to recover more copper in the future. It is known that not all the copper is recovered in the recycling process, but even with high commodity prices, it is assumed that recycling efforts are better utilized in other areas. OEMs have investigated the removal of the wire harness from the ELV; however, this process was identified as too labor intensive compared to the gain in terms of isolated material value.

The authors of this study have found one supplier-sponsored project that could affect copper recycling. Delphi Corporation has conducted research on the recycling of wire harnesses (Diegmann, 2000 and 2002). The major objective was the improvement of the design to increase “environmental friendliness.” One recommendation included design changes to simplify the removal of the wire harness prior to shredding. For example, a different routing of the wire harness through the vehicle could make it accessible at every point; an alternative way of connecting the harness to the body would make it easily detachable. The European units of Ford and Volkswagen have tested some of the recommendations and they have achieved partial implementation in current vehicles. It remains to be seen if these concepts will be fully embraced by OEMs. Our interviews with shredding companies have also confirmed that if wire harnesses were to be processed separately, virtually all the copper from this assembly could be recovered.

3 Dismantlers

The major role of dismantlers is in the removal of automotive components for reuse and in the preparation of the vehicle for shredding. There are more than 6,000 dismantlers in the United States of which about 3,000 companies are either direct or affiliate members of the Automotive Recyclers Association (ARA). A 1997 study for the ARA estimated that about 86% of automotive recycling companies are full-service and employ 10 or fewer people[5].

There are several business models for dismantlers. One model is to buy cars for their scrap value and process vehicles for shredding without selling parts for reuse. Another model is to buy vehicles and recycle them after removing components for reuse. One example is a "you-pull-it" operation where the customer removes the components. "You-pull-it" yards are not the most efficient operations because insurance rates are relatively high and customers often destroy components during the removal process. Vehicles in these yards are stored for a certain period of time before they are prepared for further processing. Another common model is an operation that specializes in certain brands and models in order to benefit from the demand for components from these specific vehicles. Since this model is quite common and has the highest component reuse rates, it will be described in more detail below.

Specialized dismantlers typically buy their vehicles at insurance auctions where accident vehicles are sold. These vehicles are often restricted from reuse and are only sold for the purpose of recycling. The vehicle's value is mainly based on the value of its components in the resale market. After a vehicle is purchased, it is prepared for storage by following certain procedures. First, the vehicle is tested to evaluate the condition of its components. Second, all fluids, the battery, fuel tank, catalytic converter, tires and the mercury switches are removed. Finally, all components of higher value or those that have a high likelihood of being sold (such as the engine, the transmission and the radio) are removed and stored in a warehouse. The stripped vehicle is then stored in the yard where

[5] http://www.a-r-a.org/content.asp?pl=505&contentid=436

additional components might be removed upon request. ELVs are typically processed for shredding after they have been stored for a certain period of time. This time varies according to the vehicle's value.

Dismantlers sell their parts to either wholesale or retail customers. The wholesale segment is the larger portion of the business and tends to involve larger components. Those components are often items no longer covered by a warranty (e.g., engines or transmissions) or components on the outside of the vehicle which need replacement because of an accident (e.g., bumper or door assembly). Wholesale customers are often body shops that perform services for insurance companies or repair shops at car dealerships. The retail business mainly includes smaller components purchased and replaced by the current owner of the vehicle.

One of the most comprehensive studies on the reuse of parts was conducted by Claudia Duranceau from the Vehicle Recycling Partnership and Terry Lindell from the Automotive Recyclers Association (Duranceau, 1999). One of the study's goals was to quantify the contribution of reuse to vehicle recycling. The authors surveyed ARA members regarding the reuse rates of vehicle components; the results for the top 20 components are summarized in Figure 1. Wheels have the highest reuse rate (87%), followed by transmissions (50%) and engines (41%). To evaluate the impact on the reuse of copper-containing components, a comparison between the above data and the actual content of copper in these assemblies is necessary. The Copper Development Association has conducted a study that included an analysis of copper in automotive components (CDA, 1998); the results are shown in Figure 2. Because the component categories in both studies are different, a one-to-one comparison is not feasible. Nevertheless, there is information for two out of the top three most reused components in both data sets. The average transmission contained 1.7 pounds and the average engine contained 1.4 pounds. Nevertheless, the reused fraction of these 3.1 pounds of copper represents a rather small proportion of the 55.7 pounds of copper in the entire vehicle. An in-depth study is necessary to quantify the exact amount of copper that is reused at this stage of the process.

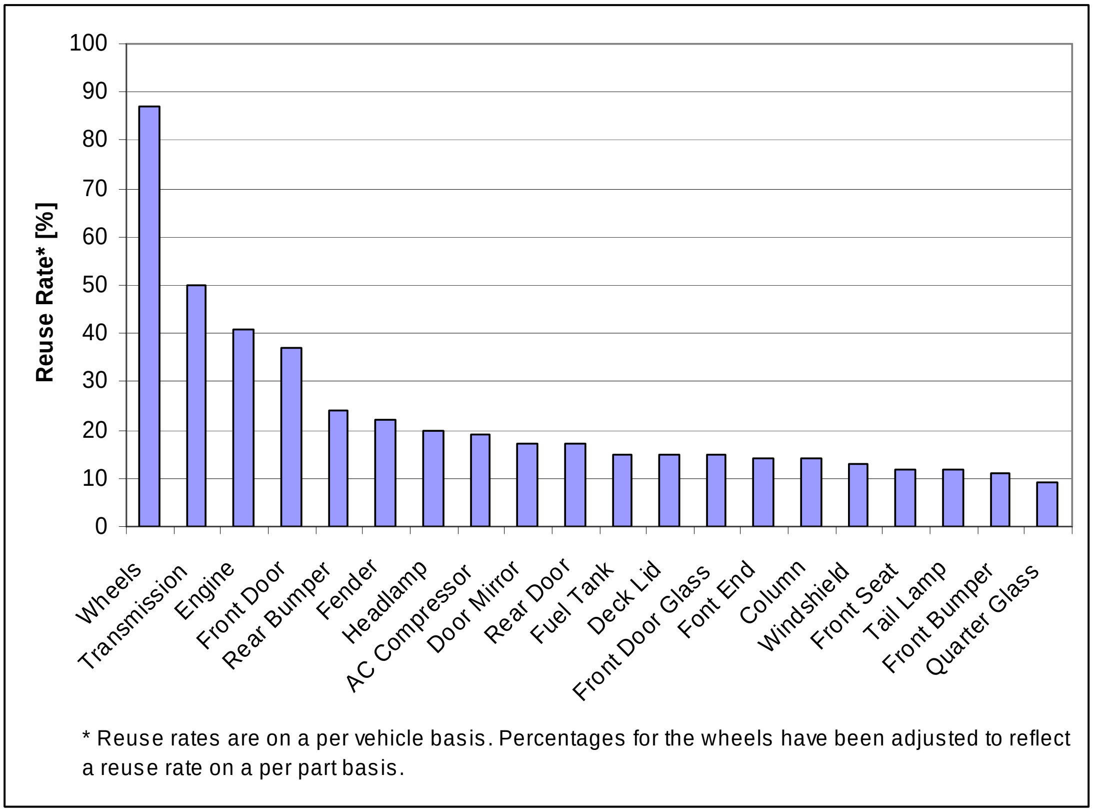

Figure 1: Reuse rate at dismantlers (Duranceau, 1999)

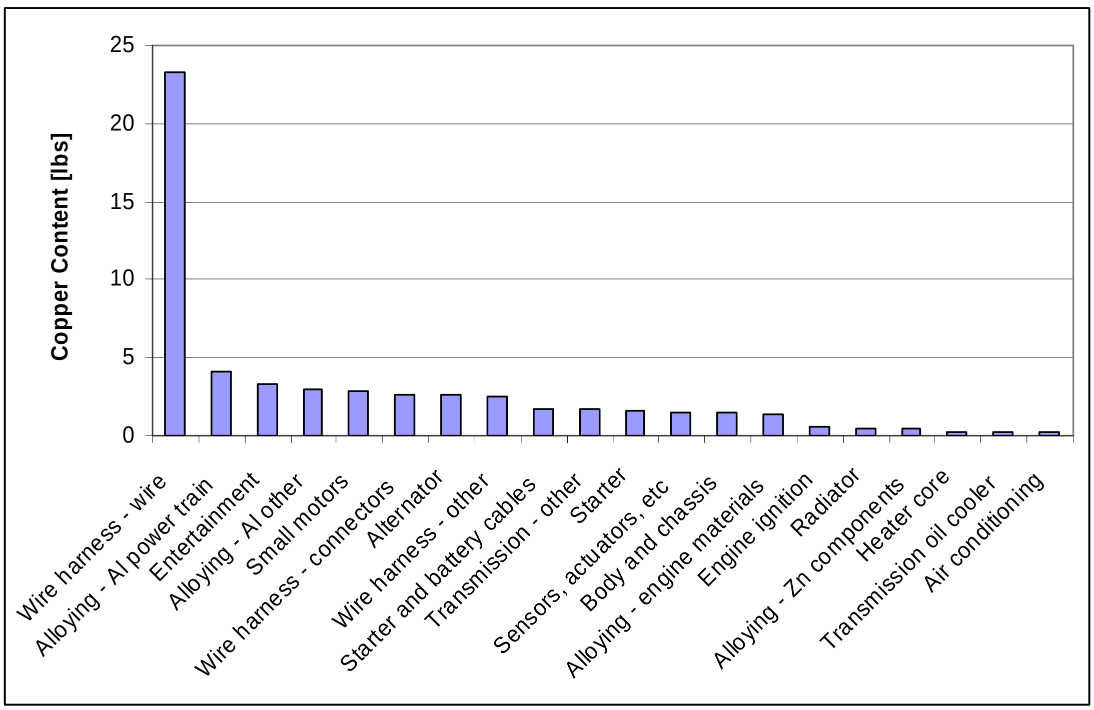

Figure 2: Copper content in cars (CDA, 1998)

The reuse of the wire harness would contribute significantly to higher reuse rates but it is not widely practiced for a variety of reasons. Dismantlers often can not clearly identify whether or not a wire harness can be used for the same model vehicle. One reason is that customization options lead to a variety of wire harness designs, making proper identification nearly impossible. Another reason is that vehicle design differences, caused by varying environmental regulations across the United States, can result in different wiring needs for the engine control system. Due to the complexity of this issue and the potential impact of using the wrong harness, OEMs recommend the replacement of wire harness components by certified dealers. Hence, it is unlikely that the reuse of wire harnesses by dismantlers will be supported in the future.

The alternative for reusing the wire harness is in its removal for separate processing. Several studies have been conducted by dismantlers and by OEMs. Given the current vehicle design, it is not economical to remove the entire wire harness from the vehicle—even with the current high commodity prices. There are some dismantlers that remove the wire harness in the engine compartment for reuse or recycling. Not all dismantlers are aware that shredding companies have processes to shred wires separately (especially for wire from the electronics and telecommunication industries). Some education might help to increase the recycling rates for easily accessible sections of the harness.

Dismantlers do not typically refurbish parts. Anecdotal evidence suggests that some businesses hire mechanics to refurbish certain components. Alternatively, dismantlers might supply specialized shops with some components (e.g., transmissions) for refurbishment and immediate use. It is also possible that some of those dismantled items that do not sell and are disposed of as scrap to so called "core buyers" might be refurbished. Aftermarket and refurbished components compete for the same customer. Because some aftermarket components have become relatively cheap, such as starters, refurbishment is not done as often as in the past. It is difficult to estimate how many components are still refurbished today but it does not seem to be a significant portion.

Many of the dismantlers that inventory their components and parts are connected through one of the major car part exchange networks (e.g., Car-Part.com or Hollander). This tool facilitates trade among dismantlers and helps to accommodate the demand for reused components.

4 Shredding Companies

There are about 212 shredders in the United States and they are run by a total of fewer than 100 companies, most of which are organized at the Institute for Scrap Recycling Industries (ISRI). Shredding companies process a variety of scrap (e.g., ELVs, white goods and industrial waste). Their main task is to shred incoming items and to sort the shred into different classes and grades of material. Most of the output is sold and ultimately processed into new products. The following is a brief description of shredding operations as observed at three facilities: OmniSource, Ferrous Processing and Padnos.

Figure 3: Shredding operation

4.1 Shredding and Material Sorting

The vast majority of ELVs are purchased as flat bodies from dismantlers. Some are also purchased directly from consumers. Dismantlers are required to depollute vehicles prior to delivery. A failure to comply might cause a rejection of the vehicle or the entire batch.

The process flow diagrams of visited shredding companies are shown in Figures 4 to 6. The process starts by loading scrap onto the belt that conveys it to the shredder. There are three different kinds of shredders in operation. In wet shredders, water is added prior to shredding to limit the impact of explosions and to keep the dust to minimal levels. Damp shredders add less water; dry shredders do not add any water. Two of the visited companies use wet shredders and one uses a damp shredder.

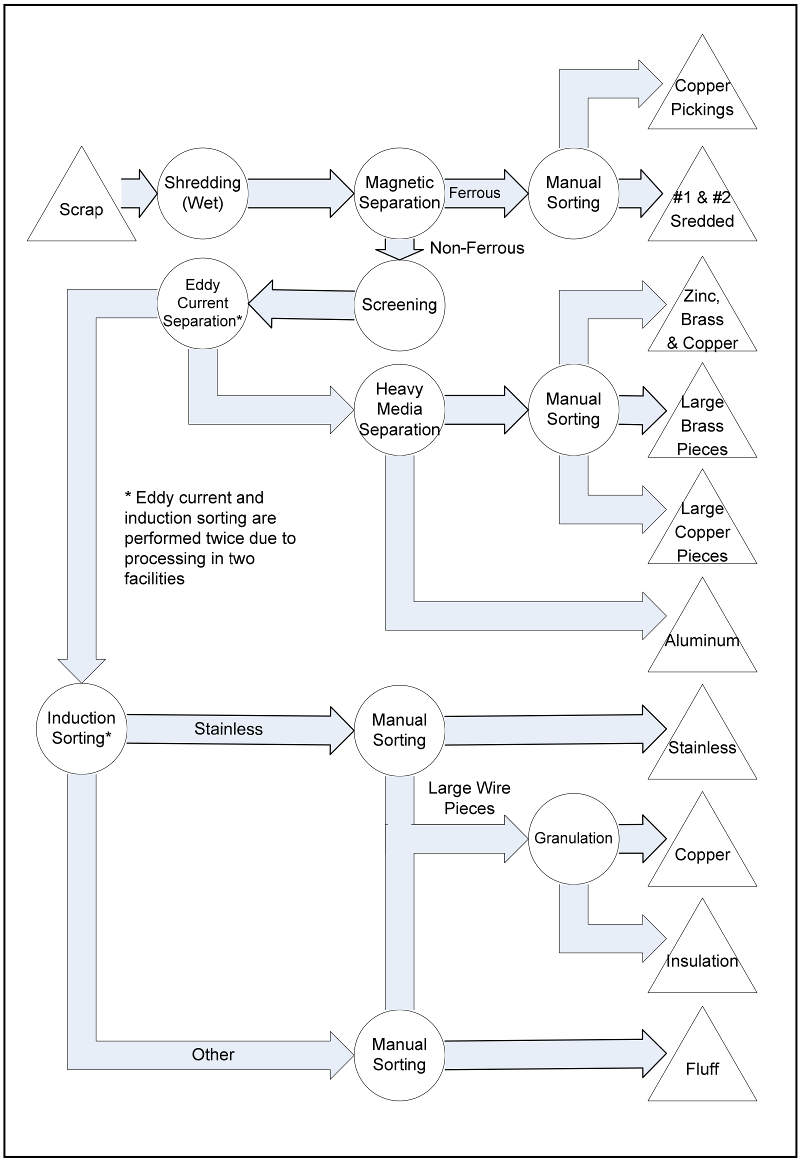

Figure 4: Process flow at OmniSource

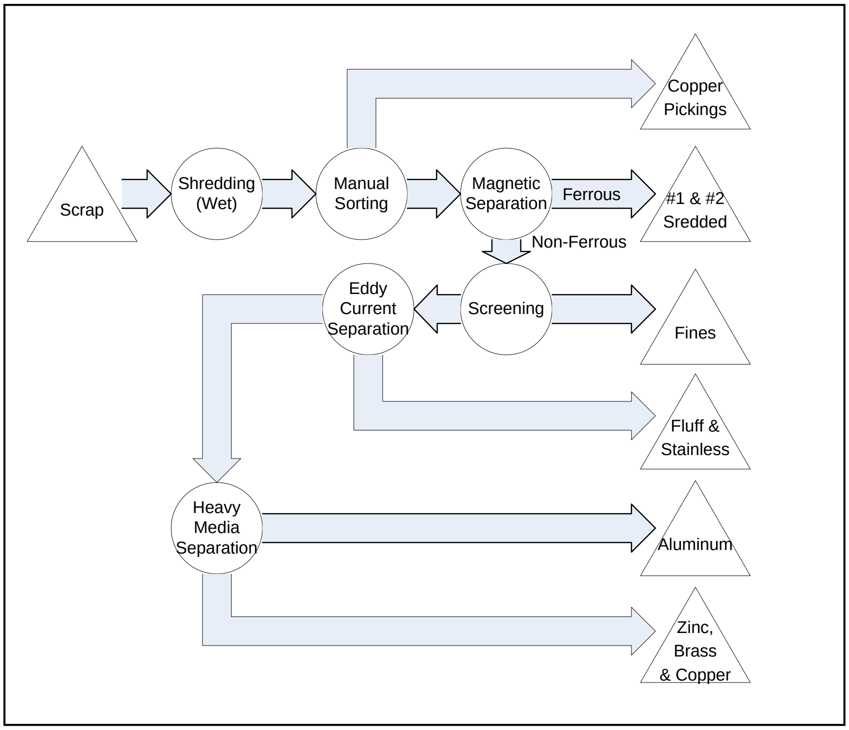

Figure 5: Process flow at Ferrous Processing

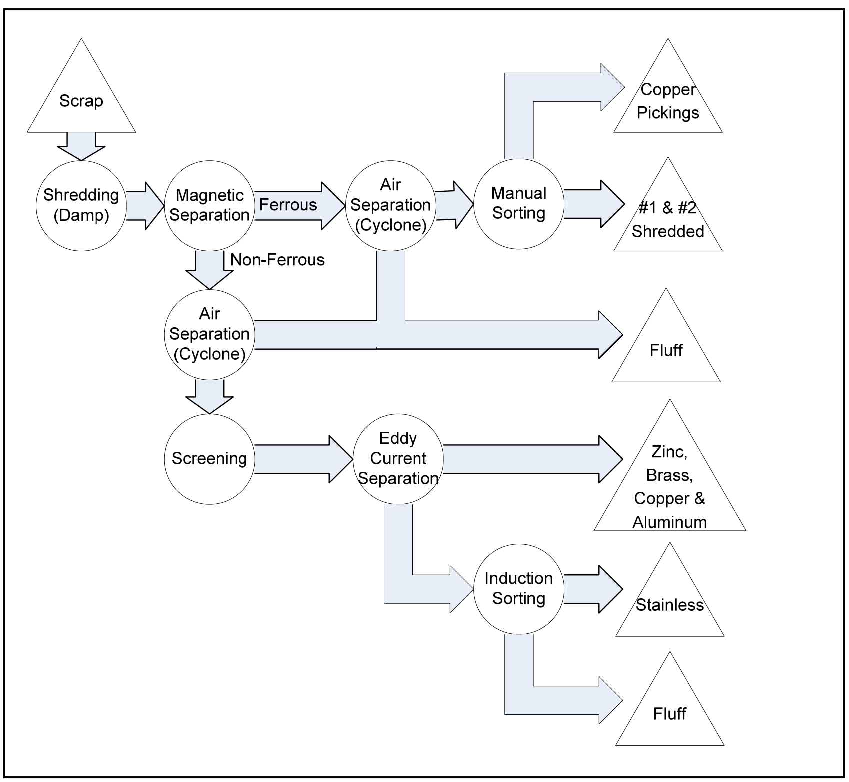

Figure 6: Process flow at Padnos

The feed rate for the shredder is controlled by the feed roller, which pushes the scrap against a rotor equipped with a number of hammers (see Figure 7). These hammers shred the vehicle into small pieces. The throughput of a shredder is mainly determined by the design of the cylinder and by the motor that drives the system. Shredders might be driven by 3,000 hp to10,000 hp motors at 450 to 600 rpm. As the most capital intense component of the operation the shredder is usually well maintained to avoid disruptions of the operation.

Figure 7: Feed roller and rotor

After the scrap is shredded into fist-size pieces, it is separated by a magnet into a ferrous and a non-ferrous stream. It is important to understand that this separation is not perfect as some ferrous pieces are still connected to non-ferrous pieces, causing a certain degree of impurity in each stream. One example is copper wire from electric motors that remains attached to ferrous components in the ferrous stream. These "copper pickings" (see Figure 8) are removed manually. The resulting ferrous scrap is the finished product of the ferrous stream. Depending on its purity, it sold as #1 or #2 shredded (see Figure 9).

Figure 8: Copper pickings

Figure 9: #2 shredded

The non-ferrous scrap is often screened to fractions of similar size, which are processed separately. An eddy current device, which uses principles of electromagnetic induction in conducting materials, is used to isolate non-ferrous metals (except for stainless steel) from this stream. This non-ferrous metal fraction contains mainly zinc, brass, copper and aluminum. Some shredding companies, such as Padnos, ship this product to companies specializing in the further separation of these metals. The other shredding companies process these non-ferrous metals through a heavy media station to separate the aluminum from the zinc, brass and copper. This station works by entering the metals into a heavy medium (such as silicone or sand) and taking advantage of the low density of aluminum which causes the aluminum to float and the other metals to sink. Figure 10 shows a heavy media station that uses sand as a heavy medium.

Figure 10: Separation of aluminum from, zinc, brass and copper

The aluminum is typically sold to a smelter, whereas the zinc, brass and copper are sold to companies that further separate this material. Figure 11 shows the zinc, brass and copper fraction. This mix is sometimes also referred to as “heavies” because it is that part of the scrap that sinks in the heavy medium.

Figure 11: Remaining copper, zinc and brass

The second output of the eddy current station contains almost all of the non-metal items and the stainless steel. This fraction is typically processed by an induction sorting system (ISS) which senses the stainless steel through magnetic induction and separates it from that stream. The remaining items mainly consist of plastics, glass, fabric, foam and a small fraction of metals (see Figure 12); they are also referred to as shredder residue or fluff. This is typically of lesser value and has to be disposed of in landfills[6]. Since any fluids that remained in ELVs are contained in this fraction, the SR has to be monitored for levels of contaminations. It is considered special waste and is disposed of accordingly.

[6] Shredder residue may actually still have positive value, especially in those states that allow the use of fluff as alternate daily cover in landfills.

Figure 12: Shredder residue

It must be noted that the processing of scrap varies depending on technology and economic circumstances. The introduction of ISS and eddy current technologies has significantly changed the separation process and the quality of the output. It is expected that radiation or color detection devices will cause a continuation of this development. The fact that technology is not the only driver can be seen in one example: one dismantler had a process with a color detection station for the separation of zinc, brass and copper. The device became obsolete when buyers from Asia drove up prices for the unsorted product. Hence, global commodity prices can directly affect the way technology is utilized and scrap is processed.

4.2 Process Output

ISRI's "Scrap Specification Circular"[7] (ISRI, 2006) defines grades and specifications for scrap. Regardless of this guide, customers of shredding companies often have their own specifications depending on their products and processes. One example is the copper content allowed in #2 shredded, which may vary significantly. Despite this added complexity, it rarely happens that non-conforming products are shipped to the customer. If a batch contains too much copper (e.g., more than 0.20% in #2 shredded) it would have to be blended with a batch that contains less copper in order to achieve the desired composition.

Given the variety of items that are processed in shredding facilities, the composition and purity of the resulting products largely depend on the fraction of items that enter the process. ELVs, for example, are often mixed with white goods (in given proportions) to obtain certain grades. Klempner et al (Klempner, 1999) surveyed eight shredding companies regarding their inputs and outputs. They found that shredded material at these companies consisted of 45-80% automobiles, 15-50% appliances and 5-15% other items.

OmniSource had specific data (from one facility) on the volume of recovered material in the ferrous and non-ferrous streams, shown in Table 1. It was not possible to track how much material came from ELVs, as this site processed shredded scrap from several plants. Nevertheless, the data might give an impression of the share of recovered material at shredding companies. #2 shredded is the dominant material in the ferrous stream. It can be assumed that ferrous metals from ELVs mainly contribute to the fraction of #2 shredded. The copper content in these fractions is 0.10-0.15% in #1 shredded, 0.21% in #2 shredded and 15-20% in copper pickings. Klempner et al estimates the share of ferrous metals as 70 to 80% of the total output. Aluminum is the largest fraction on the non-ferrous side, followed by heavies. Copper is shown as a separate item because OmniSource has a manual sorting operation in the non-ferrous stream (see also Figure 4). The heavies fraction, which accounts for 20-25% of the non-ferrous output, contains about 10-15% copper.

---

[7] http://www.isri.org/AM/Template.cfm?Section=Commodity_Specifications

Table 1: Share of recovered scrap at OmniSource facility

Stream	Class of scrap	Share of recovered scrap	Total
Ferrous	#1 Shredded	8.5%	100%
	#2 Shredded	91%	
	Copper Pickings	0.5%	
Non-Ferrous	Aluminum	75%	100%
	Brass	1% to 1.25%	
	Copper	<1%	
	Heavies	20% to 25%	
	Stainless	1.5% to 2.0%	

It has been noted that the output is sold to various sources. Table 2 summarizes the customers for the different outputs. The recent demand for many commodities has changed the landscape in the market for scrap. Many items are now sold directly to Asian countries, especially to China. Most of the heavies and many of the copper pickings are manually separated in these markets.

Table 2: Customers of scrap output

Class of scrap	Customer
#1 Shredded	Steel mills and foundries
#2 Shredded	Steel mills and foundries
Copper Pickings	Domestic and international customers
Aluminum	Secondary smelter
Brass	Mill
Copper	Refiner or mill
Heavies	International customers
Stainless	Overseas, if the mix of material is too diverse or domestically, if it is not too diverse

As mentioned above, the SR consists mainly of non-metallic scrap and any metals that are not isolated throughout the process. The automotive SR is a significant share of the overall output. Twenty five to thirty percent of all incoming scrap might ultimately be landfilled. The metallic content in this fraction was estimated by one of the visited companies as 1-1.5%. Estimates at other companies range from 1-11% (Klempner, 1999). Shredding companies confirmed that certain automotive components are prone to be included in the SR. For example, the wire harness has a comparatively large insulation relative to its copper content. It is highly likely that most of the shredded wire harness becomes part of the SR, excluding those sections handpicked by sorters.

Most stakeholders agree that virtually all of the metals outside of the SR stream are being recycled. This includes most of the copper alloy in the housing of engines and transmissions. Also, the copper pickings and the heavies that are processed abroad are likely fully recycled. In contrast, any copper left in the SR stream is landfilled. This portion is significant (as described above). More research is needed to analyze the exact source of copper in the SR stream by ELV component.

4.3 Post Processing

The steel industry recycled about 14 million tons of steel from ELVs in 2005. It is estimated by the Steel Recycling Institute that the overall recycling rate for steels from ELVs is about 97%. Twenty-five percent of steel in each car is made of recycled steel; the remaining steel is used for other purposes. Steel mills typically produce different grades of steel, impacting the grade of shredded steel from shredding companies. Excess copper is a concern in steel production and its content in #2 shredded typically does not exceed 0.2%. As described above, shredding companies are aware of their customers' requirements and adjust their processes accordingly.

The other large customer of scrap is the aluminum industry. It is estimated that aluminum in autos accounts for 5-10% of scrapped automobiles by weight, but represents 30-50%

of its scrap value. Nearly 90% of the automotive aluminum is recovered and recycled[8]. Automotive aluminum contains about 60% of recycled material. As shown above, aluminum is first processed by a secondary producer who produces the grades of material needed for new products. The first step in this process is to control the composition of alloys. Copper content is typically no issue, as this process is designed to compensate for the surplus or lack of copper in shredded aluminum.

[8] http://www.aluminum.org/template.cfm?Section=The_Industry

5 Conclusions

The study confirmed that OEMs conduct a significant amount of research on the design and recycling of automotive vehicles. Since copper recycling is currently not an objective, the impact of these efforts on copper recycling rates is likely low. Dismantlers make a relatively large fraction of selected components available for the reuse market, but the vast majority of copper in ELVs is passed on to shredding companies. Their operations use highly automated systems to separate vehicles into different materials. It was confirmed that all the copper that is part of the isolated ferrous or non-ferrous metals is fully recycled, even if it is further processed abroad. A significant fraction of copper from certain components, such as wire harness or electronics, may not be separated and could find its way into landfills. The study also showed that there is a balance between technology use and the economics in this industry (e.g., as dictated by global commodity and labor prices). A follow-up study that investigates those interdependencies would help to get a better understanding of the industry dynamics.

References

Copper Development Association Inc, December 1998: Copper and Copper Alloys in Automotive Applications 1997 – 2002, internal research paper.

Department of Energy: Transportation Energy Data Book, Edition 25, 2006.

Diegmann, W. et al: Profitable Recycling of Automotive Wiring Harnesses, SAE Technical Paper Series, International Congress and Exposition, Detroit, Michigan March 6-9, 2000.

Diegmann, W. et al: Environmentally Friendly Car Wiring System, SAE Technical Paper Series, International Congress and Exposition, Detroit, Michigan March 4-7, 2002.

Duranceau et al, 1999: Automotive Recycling as Reuse: Investigation to Establish the Contribution of Reuse on Recyclability, SAE Technical Paper Series, International Congress and Exposition, Detroit, Michigan March 1-4, 1999.

Institute of Scrap Recycling Industries: Scrap Specifications Circular, Washington, 2006.

International Material Data System: http://www.mdsystem.com.

Klempner et al: Characterization of Various ASR Streams, SAE Technical Paper Series, International Congress and Exposition, Detroit, Michigan March 1-4, 1999.

Toyota Motor Corporation, Environmental Affairs Division: Environmental and Social Report 2005, July 2005.

Ward's: Motor Vehicle Facts & Figures, Ward's Communications, Southfield Michigan, 2006.