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Abstract

The mining of metals from the earth has already proven to be extremely detrimental to the health of humans and the surrounding environment. The problem will only get worse as the world's need for rare and noble metals increases. Many valuable metals go into electronics, and the world becomes increasingly technologically inclined each year.

Thus, there is now a need for proper disposal and recycling of electronic waste, or e-waste. In 2012 alone, 50 million tons of e-waste was disposed of, and this number is only going to grow. However, policies intended to protect employees and the environment from exposure to dangerous substances that may leach during the transit of e-waste render the task difficult. Our team must find a way to create a company that effectively, safely, and legally recycles e-waste, all while turning a profit and competing in a growing, competitive market.

Background

Ideally, all materials used in a cell phone should be reused or recycled. However, our project aims for an ecumenically viable process—a model that can be implemented in a recycling business. Therefore, we decided to focus on the five metals: copper, zinc, iron, silver, and gold. Copper, zinc, and iron have the highest content percentage; Gold and silver have the greatest unit price.

Materials	Percentage (%)	Unit Price (\$/lb.)
Copper (Cu)	49.0	2.28
Zinc (Zn)	21.8	1.05
Iron (Fe)	11.6	0.04
Silver (Ag)	1.5	236.76
Gold (Au)	0.1	18,822.91

Methodology

Iron (Fe)

Due the magnetic property of iron, eddy current separator can sort out iron scrap using a rotating magnet. Other non-ferrous metals will be propelled out of the conveyor belt by the splitters.

Copper (Cu)

Dissolution of copper can be carried out by using sulfuric acid. Magnetic stirrers and carbon steel plates can be used to recover copper from the copper sulfate solution.

Zinc (Zn)

Dissolution of silver can be accomplished using sulfuric acid. Na_2CO_3 can be added to the zinc solution to precipitate zinc as zinc carbonate.

Silver (Ag)

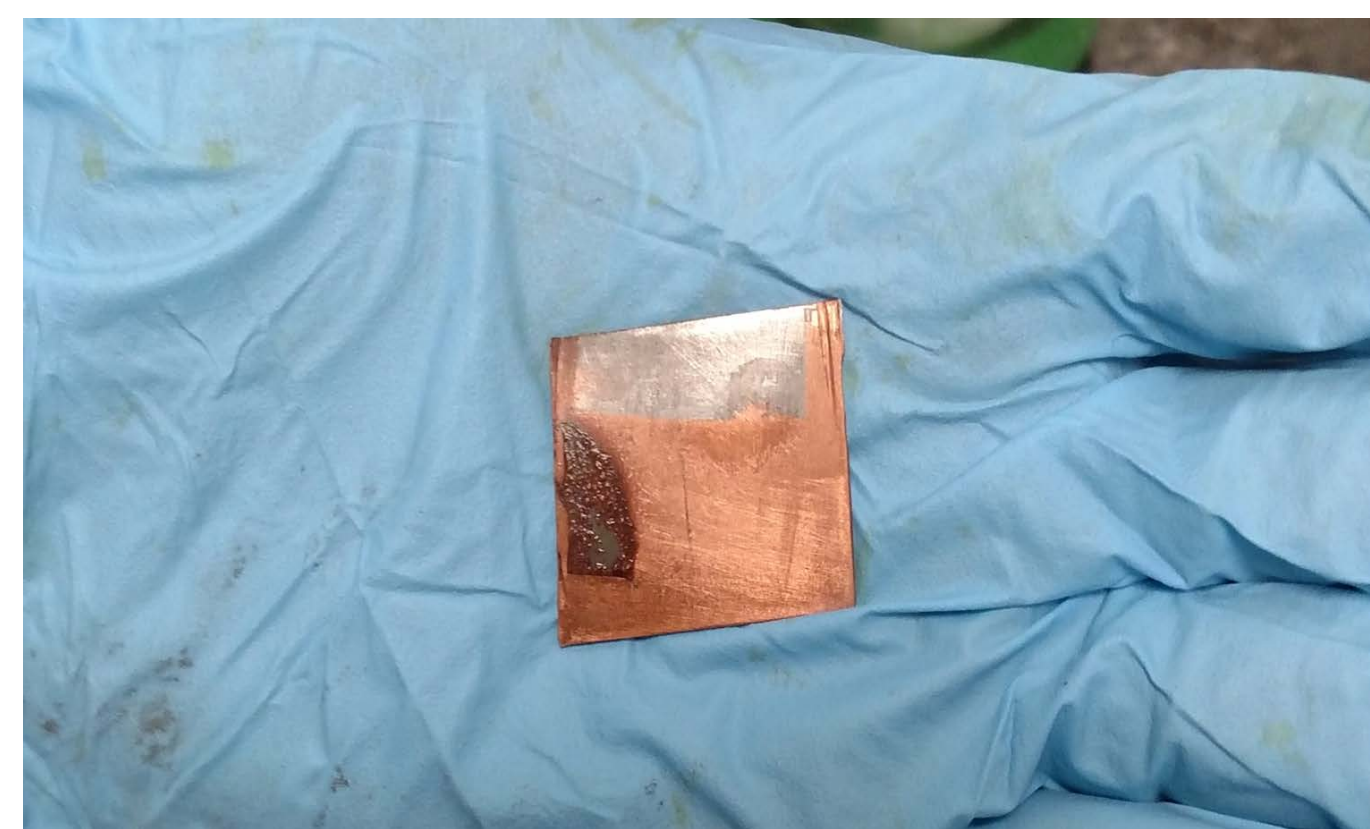
Total dissolution of silver can be accomplished by acidothiourea leaching. After the dissolution process, sodium sulfide ($Na_2S \cdot 9H_2O$) can be added to the leaching solution to precipitate the silver content.

Gold (Au)

Tannin gel particles produced from concentrated tannin can be used to absorb gold. The absorption is accomplished by the oxidization of the tannin gel particles and the reduction that occurs on the surface of tannin when trivalent gold is converted into metallic gold.

Result

Lab research consisted of using sulfuric acid and iron to extract copper from a sample of flue dust. Our particular sample was already treated with a magnet to remove ferrous metals such as iron.



On a chemical level, copper and sulfuric acid react to produce copper sulfate. Hydrogen gas is produced as a byproduct. When a carbon steel plate is left in the solution, iron in the plate is oxidized to iron sulfate and dissolves in the solution while copper sulfate is reduced to metallic copper and deposits on the iron plate. This process is known as cementation and required no external energy for copper deposition.

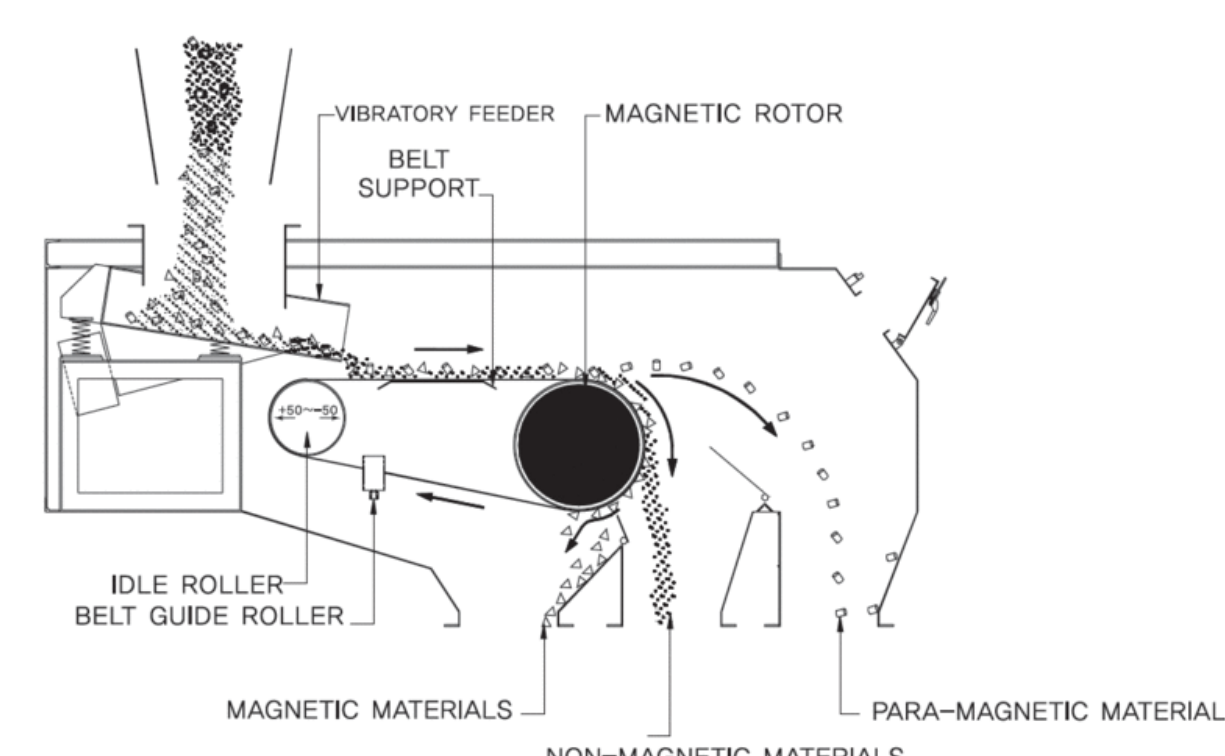
Analysis

Ferrous metals

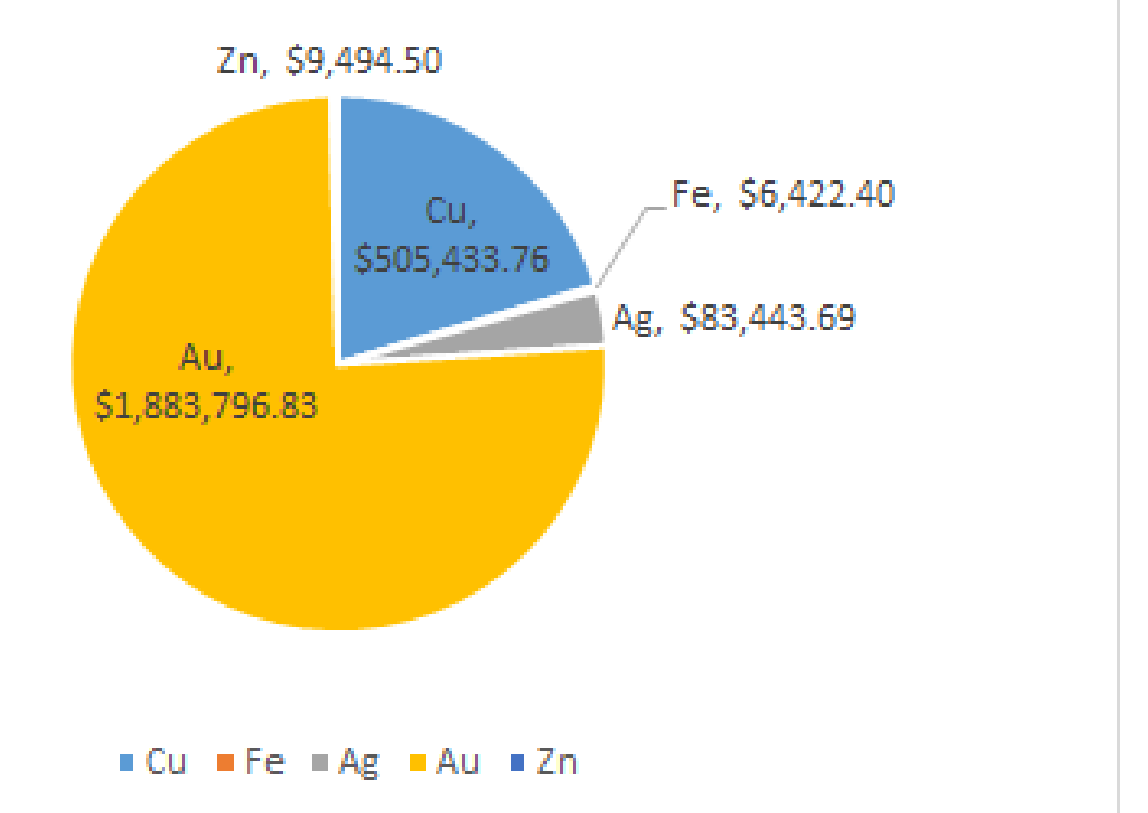
- High amount of Iron
- Corrode easily
- Magnetic
- Examples (mild steel, carbon steel, stainless steel, cast iron, and wrought iron)

Non Ferrous Metals

- Malleable
- Lighter than ferrous metals
- High resistance to corrosion
- Examples (aluminum, brass, copper, nickel, tin, lead, and zinc, as well as more desired metals like gold and silver.)
- nonmagnetic



Revenue Based on Metal



Machine payments	\$	71,000.00
Electricity	\$	214,130.00
Wages	\$	1,547,610.00
Total Expenses	\$	1,832,740.00
Revenue	\$	2,488,591.19
Profit	\$	655,851.19

Assumptions:

- 90% material recovery rate
- Electricity: \$0.10/kWh
- Input: 4 tons of waste per day (1000 tons per year)
- Operational 8 hours/day, 5 days/week, 50 weeks/year
- Negligible cost to acquire waste or to dispose of undesired material
- Any purchases (equipment, facility) can be paid off over 10 years

Conclusion

Through focusing on the extraction of copper, zinc, iron, silver, and gold, we discovered that gold and copper are the main source of revenue. Additionally, we can see from our business analysis that E-waste recycling is a profitable endeavor. We discovered this fact through observing the markets and making an informed business model.

Future Work

We will create a program to work with large technology companies to spread the need to design products for the end of life cycle. Part of the problem with electronic disassembly is that as technology becomes more advanced and portable, disassembly becomes increasingly more complicated. Therefore we need to create standards in the market place for the percent of products that are recyclable or reusable.

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