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Final Report on Scrap Management, Sorting and Classification of Steel

A. Javaid and E. Essadiqi

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CONTENTS

FINAL REPORT ON SCRAP MANAGEMENT, SORTING AND CLASSIFICATION OF STEEL

by

A. Javaid and E. Essadiqi

INTRODUCTION

Iron and steel continue to be the predominant metals used by the automotive and other transportation industries, agricultural and industrial equipment, building and construction, oil and gas, defense, machinery and consumer-goods industries. Together, the automotive, construction and oil and gas industries account for about 70% of Canadian steel demand. Iron and steel offer many advantages such as high strength, ease of fabrication, ease of recycling, availability and relatively low cost. World crude steel production, from the 63 countries reporting to the International Iron and Steel Institute, set a record with the highest ever February figure at 71.1 million metric tons[1]. This represents a 7.5% increase over February 2002 results. Crude steel production in North America totaled 9.7 million tons in February, increasing 4.7% over the same period in 2002. The North American market for steel accounts for over 18% of world demand. Of the North American total, the United States accounts for about 84%, Canada 11% and Mexico 5%.

Steel was being recycled long before current awareness of environmental concerns started. Steel is made via two basic routes.

1. from raw materials including iron ore, limestone and coke along with recycled steel by the blast furnace (BF) and basic oxygen furnace (BOF) route, and

2. from recycled steel via the electric arc furnace (EAF) method.

The primary steel industry is comprised of “integrated steel mills” which produce iron and steel from ores, however, some scrap is used. The BOF process uses a minimum of 25% recycled steel. The secondary steel industry known as “mini-mills” uses EAF technology to produce steel from scrap, and this process uses virtually 100% recycled steel. Recycling of scrap plays an important role in the conservation of energy because the re-melting of scrap requires much less energy than the production of iron or steel products from iron ore. When one ton of steel is recycled, 2500 pounds of iron ore, 1400 pounds of coal and 120 pounds of limestone are conserved[2]. Also, consumption of iron and steel scrap by re-melting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment. Steel production from scrap charge has been reported to require 74% less energy than production from virgin ore materials and results in 64% less environmentally harmful CO_2 gas emission[2]. Use of recycled scrap steel in EAF steel making, and to a lesser extent in integrated plant steel making, has been increasing as result of economic forces to improve processing and production efficiency as well as legislative forces related to sustainable development and environmental concerns.

CURRENT STEEL RECYCLING

The recycling cycle is well established for the steel industry, and there has been a significant increase in the use of recycled scrap. This trend is expected to continue and grow because of the increased availability of cheap automotive scrap. Steel is the world's, as well as North America's, most recycled material. The North American steel industry annually recycles millions of tons of steel scrap from recycled cans, automobiles, appliances, construction materials and other steel products. It has had an average recycling rate in excess of 50% since World War II and over 60% since 1970[2]. In fact, the industry's overall recycling rate is nearly 68%. In 2002, over 72 million tons of steel and iron was recycled in steel mills and foundries in the United States, while over 15 million tons were recycled in Canada[2,3]. Steel is the engine that drives the recycling of many consumer goods, as can be seen with the virtual 100% recycling rate of automobiles, the nearly 80% recycling rate of appliances, and the almost 60% recycling rate of steel packaging[2]. Additionally, millions of tons of steel and iron from demolition projects are diverted from the waste stream to the recycling stream. This results from steel's magnetic properties, which make it the easiest material to separate from the solid waste stream.

Canada's metals recycling sector is both mature and extensive, comprising in excess of 2800 companies and individuals involved in the collection, processing, sales, recovery and recycling of recyclable metals and metal-bearing materials. Steel scrap recycling represents the largest tonnage of recycled material in Canada. The recycling rate of steel in Canada is more than 65% and, since 1990, Canadian steel producers have increased the amount of scrap steel that they recycle by 26%[3]. Steel's overall recycling rate is higher than that of aluminum, paper and glass combined and greater than all other metals combined (including aluminum, copper, nickel, chromium, zinc)[3].

SOURCES OF STEEL SCRAP

The iron and steel industry recycles three types of scrap: "home", "new", and "old" scrap.

Home Scrap

Home scrap is internally generated in the steel production process when steel mills and foundries manufacture new steel products. This form of scrap rarely leaves the steel-making production area. Instead, it is returned to the furnace on site and melted again. Technological advancements have significantly reduced the generation of home scrap which accounts for approximately 29% of total scrap[4].

New Scrap

New scrap (also called prompt or industrial scrap) is generated in steel-product manufacturing plants and includes such items as turnings, clippings and stampings leftover when a part is made during manufacturing processes. This material is typically sold to the scrap metal industry that processes it for sale to steel mills and foundries. It accounts for approximately 23% of total steel scrap[4].

Old Scrap

Old or post-consumer scrap results when industrial and consumer steel products (such as, automobiles, appliances, buildings, bridges, ships, cans, railroad cars, etc.) have served their useful life. Old or post-consumer scrap accounts for approximately 48% of total scrap[4].

A major challenge in recycling scrap is to maintain the quality of steel products and minimize contamination with other metals. Potential residual element contamination may come from the recycling of automobiles and municipal scrap. Ferrous scrap metal from old automobiles in North America amounts to about 10 million tons per year[5]. Use of recycled scrap steel in steel-making processes has been increasing, and this trend is expected to continue and grow because of the increased availability of cheap automotive scrap. As a result, levels of residual impurity elements entering the steel-making process from scrap feed are increasing with increased scrap use and repeated recycling. The ability to control the detrimental effects of these residual elements, and the need for more efficient refining technologies to recycle future scrap feed, are major concerns.

Close to 52 million cars are manufactured each year and, considering their relatively short service time (between nine and thirteen years), their disposal has a significant impact on the environment[6]. As it did with the development of the 3-L sub-compact car, government pressure has led to dramatic changes in this aspect of the automotive industry. For example, the British government recently signed an agreement with the Society of Motor Manufactures and Traders, the Motor Vehicle Dismantlers and the British Metals Federation, among others, to increase automobile recycling to 85% of the average vehicle weight by 2005[7]. In order to achieve this goal, separation of automobile component materials must be improved to minimize contamination of the metal streams during recycling. Clean, well-sorted scrap is crucial to cost-efficient recycling.

CLASSIFICATION OF STEEL SCRAP, INTERMEDIARY PRODUCTS AND WASTE

The infrastructure for collecting and recycling steel scrap has been successfully established for more than a century. The scrap industry is composed of three important levels of expertise. Processors buy the scrap from a variety of sources, including industrial plants, government facilities, farms, auto dismantlers, railroads, shipyards, building dismantlers, demolition operations, and municipalities. At their plants and facilities, they prepare the scrap for reuse employing a variety of techniques such as torching, cutting, baling and shredding. Brokers are the intermediaries between the processors and the industrial consumers or users of scrap, and they assist the processors in locating markets for their prepared scrap and help the industrial consumers find a supply of the ferrous scrap products they need to run their manufacturing operations. The industrial consumers are the mills and foundries that purchase the processed scrap, re-melt it, and manufacture a new steel product from it. The scrap consumer closes the recycling circle and actually enables recycling to occur since the steel is now being returned to the market place.

Steel is not a single product. There are currently more than 3,500 different grades of steel with many different properties - physical, chemical, environmental - 75% of which have been developed in the last 20 years[1]. The most critical step in a metals recycling operation is the identification and sorting of metals into groups of similar materials. These groups represent a marketable commodity that has been defined for the ferrous recycling industry by the Institute of Scrap Iron and Steel (ISIS).[8] Other information concerning recycling alloy specifications and applications is readily available from industry groups such as the American Iron and Steel Institute (AISI), from producers of various alloys, and from the technical literature[9,10].

Ferrous scrap is sorted and processed into various grades for re-melting in steel-making furnaces. The types of ferrous metals being recycled can be classified into two grades: ferrous scrap and ferrous waste and intermediary products[11]. Appendices A and B contain a more detailed list of iron, steel and stainless steel scrap, intermediary products, and waste[11]. The common grades of iron and steel scrap include[11]: heavy melting steel; No. 2 heavy melting steel; No. 1 and No. 2 hydraulic bundles; No. 1 and No. 2 bushelling – prepared; plate and structural steel; hydraulic silicon bundles; No. 1 bushelling (clips); short shoveling steel turnings (crushed); machine-shop turnings; mixed turnings and borings; cast iron borings; No. 1 machinery – cast; mixed cast; No. 1 and No. 2 shredded scrap; briquetted steel turnings – alloy free; briquetted steel turnings – alloyed and foundry steel.

The North American iron and steel making processes are complex and generate by-products. As an example, for many decades, a by-product of iron making was a product called blast furnace slag. Approximately 600 lbs of slag are generated per ton of hot metal produced[2]. This slag is now recovered and used in road building, railroad ballast, fertilizer, glass-making, and other commercial applications. The recovery and reuse of these slags conserves tens of millions of tons of other natural resources every year. Likewise, during the coke-making process (coke is a material used in the iron-making process), large quantities of gas are produced. These gases are recovered, cleaned, and reused so that we can save valuable energy thus reducing our dependence on natural gas for reheating and other process energy requirements. This same process captures off-gases from the iron-making process itself, and once again these gases are processed and reused as fuel.

The common types of iron and steel intermediary products and/or waste include[11]: steel-making slag (BF, BOF and EAF); spent pickle liquor; flue dust (BF, BOF and EAF); waste sludge (BF and BOF); filter cake (BF and BOF) and millscale.

STEEL SCRAP SORTING AND PREPARATION TECHNIQUES

The numerous sources and forms of ferrous scrap require the use of numerous scrap sorting and preparation techniques to remove the contaminants and/or recover other valuable materials (i.e. non-ferrous metals) prior to entering the steel-making process.

Manual Sorting and Preparation

Large items such as ships, automobiles, appliances, railroad cars and structural steel must be cut to allow them to be charged into a furnace. This can be done using shears, hand-held cutting torches, crushers or shredders. Manual sorting obviously involves the removal of components from the scrap by hand. It is most suitable when miscellaneous attachments have to be removed from the scrap (i.e. radiators from scrap cars, plastic end tanks from radiators) or when manual off-loading is unavoidable. The separation of metallics from non-metallics is also often accomplished manually.

Scrap Size Reduction Processes

A wide range of equipment is used to reduce the size of large scrap material into pieces small enough to enable consolidation, shipment and subsequent feeding into furnaces. The equipment used to accomplish this includes shears, flatteners, and torch-cutting and turning crusher. This equipment is usually operated by dealers and processors who prepare the scrap to be fed into the steel mills.

Baling Press: Loose scrap that has a high surface area and low density (i.e. lathe turnings) must be compacted by baling or briquetting. A baling press is a heavy piece of processing equipment that uses up to three hydraulic rams to compress the scrap that requires greater density before re-melting. With 600 horsepower, the largest baling press can take three flattened autos without engines and in less than two minutes produce a 5400 lbs bale that is 36 in. by 24 in. by 60 in.[4] At 100% efficiency, this machine will process just over 40 lbs of scrap per hour.

Briquetter: In a briquetter, small scrap is compacted into pockets as it passes between two counter rotating drums; compaction can be assisted with heat depending on the material.

Shear: The hydraulic guillotine shear slices heavy pieces of steel including I-beams, ship plate, pipe and railroad car sides. Shears vary in size from 300 tons to more than 2000 tons of head force[4].

Shredding

Shredders or fragmentizers can reduce old automobile hulks into fist-sized pieces using massive hammer-mills. A medium-size shredder uses 36 hammers weighing 250 lbs each to pound auto hulks to pieces[4]. Although the predominant raw material for the shredder is automobile hulks, "white goods" (household appliances such as stoves, washers, dryers, and refrigerators) and other large items can also be shredded. Depending on its size, a shredder can process from

1500 to more than 20 000 tons of scrap per month. The shredding process produces three types of material: ferrous metal (iron and steel), shredder residue (light fraction) and shredder residue (heavy fraction). The two residue fractions, either singularly or collectively, are frequently referred to as automotive shredder residue (ASR). “Shredder fluff” is the term given to the low density or light materials, which are collected during the shredding process for cyclone air separation. Each ton of steel that is recovered produces about 300 kg of ASR, comprised of plastics, rubber, glass, foam and textiles, contaminated by oil and other fluids[5]. The ferrous metals are recovered by the shredder operator using magnetic separation and sold to steel mills. The ASR heavy fraction contains primarily aluminum, stainless steel, copper, zinc and lead. The non-ferrous and ferrous metals are recovered from the ASR heavy fraction, either by the shredder operator or by non-ferrous metal separators who purchase the ASR from the shredding industry. Heavy media separation and eddy current separation are the technologies primarily used to recover the metallic material from the ASR heavy fraction.

Magnetic Separation

Magnetic separation is used when a large quantity of ferrous scrap must be separated from other materials. Permanent magnets and electromagnets are used in this process. The latter can be turned on and off to pick-up and drop items. Magnetic separation can be of either the belt-type or the drum-type. In the drum, a permanent magnet is located inside a rotating shell. Material passes under the drum on a belt. A belt separator is similar except that the magnet is located between pulleys around which a continuous belt travels.

Magnetic separation has some limitations. It cannot separate iron and steel from nickel and magnetic stainless steels. Also, composite parts containing iron will be collected and could contaminate the melt. Hand sorting may be used in conjunction with magnetic separation to avoid these occurrences.

Eddy Current Separation

Eddy current separators are used to separate non-ferrous metals from waste and ASR. The process generally follows the primary magnetic separation process, and it exploits the electrical conductivity of non-magnetic metals. This is achieved by passing a magnetic current through the feed stream and using repulsive forces interacting between the magnetic field and the eddy currents in the metals.

The simplest application of the process is the inclined ramp separator. This uses a series of magnets on a sloped plate covered with a non-magnetic sliding surface such as stainless steel. When a feed of mixed materials is fed down the ramp, non-metallic items slide straight down, while metals are deflected sideways by the interaction of the magnetic field with the induced eddy current. The two streams are then collected separately. Variations of the eddy current separator include the rotating disc separator, in which magnets are arranged around a rotating axis. Yet another system uses a conveyor with a head pulley fitted with magnets. Both systems rely on the varying trajectories of materials either affected or unaffected by magnetic fields, to make the separation.

Heavy-Media Separation

Recovery of recyclable materials is often achieved using a heavy-medium separation (HMS) to recover non-ferrous metals from ASR. This process utilizes a medium normally consisting of finely ground magnetite or ferrosilicon and water. By varying the relative proportions of the solids, the relative density (or specific gravity) of the medium can be adjusted. The specific gravity of the medium is typically half way between the density of the two materials being separated. Once separated, the products/materials are allowed to drain, and the medium recovered is then returned to the process. Any medium still adhering to the product/material is removed by a water spray. The resultant solution is passed through magnetic separators to recover the medium. The effluent is then reused as spray water. HMS separations can be conducted in an open bath to achieve a separating force equal to the force of gravity. For smaller particles, the forces of medium viscosity tend to work against the separating force. In these cases, cyclonic separators are employed which effect a separation at several times the force of gravity.

Color, Density, Magnetic, Spark, Chemical and Spectroscopic Testing

Scrap materials are typically identified by skilled sorters using a limited number of physical and chemical tests. These tests rely on object recognition, color, apparent density, magnetic properties, nature of spark pattern when ground on an abrasive wheel, chemical reaction to reagents, chemical analysis and spectrographic analysis[12].

Physical properties such as color, density and relative hardness can be used to quickly separate certain classes of materials. For example, copper and brass can be identified by color, while lead can be recognized by both its density and relative softness. Differentiating between alloys of similar grades and compositions can be more difficult; in these cases, magnetic testing, spark testing, and chemical and spectroscopic analysis can be used. Magnetic testing can also be used as iron, nickel and cobalt are ferromagnetic, as are low-alloy stainless steels. Therefore, while magnetic testing cannot be used to differentiate between alloys, it can classify alloys into their series. Spark testing involves grinding an alloy on an abrasive wheel. The color and length of the spark can be used to identify the alloy. There is a spectrometer that analyzes the spectra given off from the spark and compares it with standards to identify the alloy, but this unit is not truly portable and is therefore not widely used. Various optical and X-ray spectrometers can be used to identify the composition of alloys. Thermoelectric testing involves using the Seebeck effect to identify materials. These thermoelectric devices contain two probes made of the same metal, one heated and one at ambient temperature. When they contact the scrap, a potential difference is generated that is characteristic of the metal being tested. Chemical spot tests are also used whereby reagents such as acids are dropped on the metal and the reaction is observed. Quantitative chemical analysis can be used to confirm the exact composition of the alloy.

Decoating Techniques

There are currently a number of processes used in industry for decoating steel scrap.

Dezincing

Any zinc-bearing scrap included in the charge will result in discharge of zinc oxide in the flue dust. The main source of zinc is galvanized steel sheet scrap. The removal of zinc using thermal methods can be accomplished using various techniques.

1. The galvanized parts are heated to a high temperature (>900ºC) at which the zinc evaporates.

2. The galvanized parts are heated to a temperature sufficient to embrittle the coating which is then removed by abrasion.

3. Heating and subsequent removal of the coating is accomplished by shot blasting.

Zinc removal can also be carried out using chemical techniques in which ammonia leach or caustic soda is used to dissolve the zinc coating from galvanized scrap.

Detinning

Tin-bearing scrap (i.e. food containers and auto bearings) in steel recycling affects the surface quality of the steel products because tin segregates to the grain boundaries and causes surface scabs during working. Some of the processes being used for detinning the tin-plate scrap include electrolytic and alkaline detinning.

Incineration

Some scrap processors use incineration to remove combustible materials including oil, grease, paints, lubricants and adhesives.

NEW STEEL SCRAP SORTING TECHNOLOGIES

PORTABLE OPTICAL EMISSION SPECTROMETERS

Portable optical emission spectrometers are evolving as important tools for the on-site sorting and identification of metals[13,14]. Their analytical precision and accuracy, while not as good as laboratory systems, are more than adequate for sorting mixes and most grade verification requirements. A portable spectrometer is capable of separating different types of steel in addition to separating at least 90 to 95% of the individual grades that make up each type of steel.

COLOR SORTING

Color sorting is one of the first automated sorting processes to be used industrially, and it was developed by the Huron Valley Steel Corporation (HVSC), which is the world's largest non-ferrous scrap sorter. Over the last decade HVSC has used this technique to sort zinc, copper, brass and stainless steel. Color sorting is based on computer image analysis, where the color of each metallic piece is detected. Pieces whose color lies within a specified range are automatically directed out of the feed material. In order for this to work properly, a singling mechanism is used to produce a chain-like profile of scrap particles before the image detector. HVSC's color sorter has proven to be very accurate, producing metal purities over 98%[15]. This purity is possible because this sorting method is independent of particle size and shape[15]. The technological advancement of computers over the last decade has greatly increased the speed of real-time image analysis. Due to the advancement of industrial color sorters over the last few years, the ability to effectively sort different metals with slight color variations has improved dramatically.

LASER-INDUCED BREAKDOWN SPECTROSCOPY

Laser-induced breakdown spectroscopy (LIBS) is a scrap sorting system that determines the actual chemical composition of each piece of scrap in a fast and economical manner to achieve the highest quality scrap possible. LIBS technology was first developed by the Los Alamos National Laboratory in the early 1980s for a wide variety of applications[16,17,18]. However, it was not until the early 1990s that this technique was implemented for the analysis of solid metal pieces in a joint project with Metallgesellschaft. The results of this project showed the practicality of this technique to accurately determine the elemental composition of metallic scrap[19,20,21]. However, the focus of their project was on the identification of the matrix element and not on the complete spectral analysis of all elements in the scrap.

While it has many advantages, LIBS does have its limitations. The biggest drawback is that the surface of the scrap must be free of paints, lubricants, or adhesives, since the pulse laser can only penetrate a depth of thirty angstroms or less on the surface of the metal.

X-rays can also be used instead of a laser to illuminate the surface of the scrap. X-ray fluorescence (XRF) has been used for alloy identification, and a number of commercial devices, both portable and hand held, are already available.

APPENDIX A - CLASSIFICATIONS OF IRON AND STEEL SCRAP, INTERMEDIARY PRODUCTS AND WASTE

COMMON GRADES OF STEEL SCRAP

Punchings and Plate Scrap

Punching and plate scrap have the following desirable characteristics: they are generally clean, free from rust, melt with high yield and are of known composition. Materials from stamping plants are usually low in carbon, manganese, phosphorous and sulfur.

No. 1 Busheling Scrap

- (a) Similar to punchings and plate. For the most part this grade contains more steel clippings (up to 12 in. in length) and is often marketed as a mixture.

- (b) Clean steel scrap not exceeding 12 in. in any dimension; includes new factory busheling (e.g., steel clipping, stamping, etc.). Does not include old auto body and fender stock. Free of metal that is coated, limed, vitreous enamelled, and electrical sheet containing over 0.5% silicon.

New Black Sheet Clippings

For direct charging, maximum size 8 ft by 18 in., free of old auto body and fender stock, and metal that is coated, limed, vitreous enamelled, and electrical sheet containing over 0.5% silicon.

Shredded Clippings

Shredded clippings represent another factory grade of scrap. Resembles shredded automobile scrap (ferrous fraction) with similar density.

No. 1 Bundles

- (a) Tightly compacted bales of light gauge scrap produced in hydraulic balers. The material is collected from press shops, and it consists of clean sheet, strip, and trimming which could have been sold as punchings and plate scrap or as No. 1 busheling scrap.

- (b) New black steel sheet scrap, clippings or skeleton scrap, compressed to charging box size, and weighing not less than 75 lbs/cu ft. (Hand bundles are tightly secured for handling with a magnet.) May include Stanley balls, mandrel wound bundles or skeleton reels, tightly secured. May also include chemically de-tinned material. May not include old auto body and fender stock. Free of metal that is coated, limed, vitreous enamelled, and electrical sheet containing over 0.5% silicon.

No. 2 Bundles

- (a) Contain significant amounts of steel sheet that has been galvanized or otherwise coated with zinc. Not only do the contaminants result in a poor quality melt, but also the yield is poor – only about 70%.

- (b) Old black and galvanized steel sheet scrap, hydraulically compressed to charging box size and weighing not less than 75 lbs/cu ft. May not include tin- or lead-coated material or vitreous enameled material.

No. 3 Bundles

Old steel sheet, compressed to charging-box size and weighing not less than 75 lbs/cu ft. May include all coated ferrous scrap not suitable for inclusion in No. 2 bundles.

Electric Furnace Bundles

Electric furnace bundles are merely smaller version of No. 1 bundles and are so named for their better suitability for charging through the smaller doors of electric arc furnaces.

Prompt Silicon Grades

Prompt silicon grades consist of punchings, trimmings and skeletons from high-silicon electrical sheet. These represent very pure grades in terms of tramp elements but are high in silicon, which restricts their use.

Flashings

This grade, also called "forging scrap", consists mainly of croppings, and often includes defective forgings. This grade of scrap shows the effect of forging temperatures, mainly in the form of scale.

Heavy Home Scrap from Steel Mills

"Home Scrap" includes items such as ingot butts, billets, blooms, slab crops and rail crops.

Railroad Wheels and Track Materials

Railroad materials represent a class of scrap where impurities are generally low. Users of this scrap should consider that railroad materials are being alloyed increasingly with chromium and molybdenum. It must also be remembered that most of the earlier cast iron wheels have been replaced with medium carbon steel forgings.

Cut Plate and Structural Scrap

This type of scrap is sold under several different codes, depending on the size of the pieces: one code permits length up to 5 ft, width up to 24 in. and thickness up to ¼ in. These grades are more commonly used for charging large electric furnaces than for cupolas.

No. 1 Heavy Melting Steel

- (a) This grade is characterized by a higher percentage of impurities than is found in cut plate and structural scrap, as well as higher alloy content because it generally consists of high-strength low-alloy (HSLA) steels. It is usually available in lengths under 5 ft for charging into BOF's and large arc furnaces.

- (b) Wrought iron and/or steel scrap ¼ in. and over in thickness. Individual pieces not over 60 x 24 in. (charging-box size) prepared in a manner to ensure compact charging.

No. 2 Heavy Melting Steel

- (a) This grade differs from No. 1 (above) mainly in that the lower limit of thickness is 1/8 in., and more coated steel is allowed.

- (b) Wrought iron and steel scrap, black and galvanized, 1/8 in. and over in thickness, charging-box size to include material not suitable as No. 1 heavy melting steel.

Shredded Scrap

- (a) Generally similar to shredded clippings (discussed above) except that shredded scrap is likely to contain more shreddings from auto bodies, and may contain more plastics, aluminum and other contaminants.

- (b) Homogeneous iron and steel scrap, magnetically separated, originating from automobiles, unprepared No. 1 and No. 2 steel, miscellaneous baling and sheet scrap. Average density 50 lb/cu ft.

Shredded Clippings

Shredded 1000 series carbon steel clippings or sheets. Material should have an average density 60 lb/cu ft.

Shredded Tin Cans for Re-melting

Shredded steel cans, tin coated or tin free, may include aluminum tops but must be free of aluminum cans, non-ferrous metals except that used in can construction, and non-metallics of any kind.

Auto Slabs

Auto slabs have essentially the same chemical composition as No. 2 bundles but provide a greater yield because they contain less trash.

Briquetted Steel Turnings

Briquetted steel turnings are classified in accordance with several codes including a number of types (and grades of purity) that depends on whether or not the turnings are mixed with cast iron borings.

Steel-making Slag Scrap

Steel-making slag scrap is generally considered to be a low-grade melting material and is priced accordingly. This material consists of irregular steel nuggets that have been separated magnetically from crushed slag. Melting yield usually ranges from 70-80%.

Machine Shop Turnings

These include clean steel or wrought iron turnings, free of iron boring, non-ferrous metals in a free state, scale, or excessive oil. May not include badly rusted or corroded stock.

Machine Shop Turning and Iron Borings

These are the same as machine shop turnings but include iron borings.

Shoveling Turnings and Iron Borings

Same as shoveling turnings but including iron borings.

COMMON GRADES OF CAST IRON SCRAP

Broken Ingot Molds and Stools

This grade of scrap is derived from worn-out ingot molds, and since it is not well suited for BOF steel-making, most of it goes to the foundries. This grade is comprised of fairly high-quality cast iron that is generally low in tramp metals.

Drop-Broken Machinery Cast

By definition this grade (also called No. 1 machinery-cast) is machinery cast and must show evidence of having been machined, thus designating it as a good grade of relatively soft iron.

Auto Cast

This grade is generally comprised of the powertrains from trucks and buses. For the most part steel components are “stripped out” and sold separately as scrap.

Cupola Cast

Cupola cast iron scrap is a designated grade that can be virtually any grade of iron except stove plate, burnt iron or brake shoes. It is often known as “mixed cast”.

Briquetted Cast Iron Borings

Briquette borings have become a prominent grade of cast iron scrap. Various grades of borings are available.

Stove Plate

Stove plate consists of thin sections that were purposely cast from high fluidity iron, and thus contains much silicon and phosphorus.

Burnt Iron

Burnt iron consists of burnt stove plate, grates, furnace parts, fire pots and annealing boxes and tubes. It represents the lowest grade of cast iron scrap.

WASTE FROM THE STEEL-MAKING INDUSTRY

BF Flue Dust

Blast-furnace (BF) flue dust consists of iron-oxide particles, oxides, carbon and lime, and it generated by the blast furnace during smelting and collected in the air pollution system (i.e. bag house). It typically consists of iron oxide and 1.5% zinc.

BF Waste Sludge

Blast furnaces often use a ‘wet scrubber’ to capture the dust particles from off-gases produced during operations. The resultant sludge consists of oxide particles suspended in water, and it usually contains 30-60% water.

BF Filter Cake

Filter cake is blast furnace waste sludge that has been de-watered for easier handling and transportation; it contains 15-20% water.

BOF Flue Dust

This flue dust consists of iron-oxide particles generated by the basic oxygen furnace during steel making and is collected in the air pollution system (i.e. bag house). It typically consists of iron oxide and 1.5-4.0% zinc.

BOF Waste Sludge

Integrated steel mills often use a ‘wet scrubber’ to capture the oxide dust particles from off-gases produced in the basic oxygen furnace. The sludge consists of iron and zinc-oxide particles suspended in water; the sludge usually contains 30-60% water.

BOF Filter Cake

BOF waste sludge that has been de-watered for easier handling and transportation and contains 15-20% water is refered to as BOF filter cake.

EAF Flue Dust

This consists of iron oxide particles generated in the electric arc furnace during steel making, and it is collected in the air pollution system (i.e. bag house). The majority of the dust is iron oxide with 10-15% zinc and trace amounts of lead, cadmium, chromium and arsenic.

BF Slag, BOF Slag and EAF Slag

Slag is a by-product of steel-making generated in BF, BOF and EAF processes, and it is primarily non-metallic. BF, BOF and EAF slag contains high calcium levels, and it is used as an aggregate in the construction industry.

Millscale

Steel mills produce mill scale, which is primarily iron oxide and is reused/recycled.

Spent Pickle Liquor

The term "spent pickle liquor" refers to solutions containing soluble metals and acids. Spent acid is often regenerated on site to recover the acid for reuse and the iron oxide as product. This acid may also be a source of iron used to remove phosphates from sewage in treatment plants.

APPENDIX B - STAINLESS STEEL CLASSIFICATIONS

COMMON GRADES OF STAINLESS STEEL SCRAP

200 Series Stainless Steel Scrap Solids

200 series stainless steel scrap solids include all types of clean AISI Series Stainless Steel Scrap Solids, which contain a maximum of 0.5% copper.

Stainless Steel Scrap

Stainless steel scrap consists of clean 18-8 type (300 series) stainless steel clips and solids containing a minimum of 7% nickel, 16% chromium, a maximum of 0.5% phosphorous, and 0.03% sulphur and are otherwise free of harmful contaminants. Typical scrap comes from the manufacture of sinks, tanks, pipes, etc.

Stainless Steel Turnings

Stainless steel turnings consist of clean 18-8 type (300 series) stainless steel turnings containing a minimum 7% nickel and 16% chromium, and are free of non-ferrous metals, non-metallics, excessive iron, oil and other contaminants.

400 Series Stainless Steel Scrap

This grade consists of clean 400 series stainless steel containing 0% nickel and 10-17% chromium, and is otherwise free of harmful contaminants.

STEEL-MAKING WASTE AND BY-PRODUCTS

EAF Flue Dust

EAF flue dust consists of particulate matter containing metallics, oxides and other inorganics generated by electric arc furnaces during steel making and is collected in the air pollution control system (i.e. bag house).

EAF Slag

EAF slag is generated as a by-product of the steel-making process using electric arc furnaces and is primarily non-metallic.

Spent Pickle Liquor

These are solutions containing soluble metals and acids that are too low in acid strength or too contaminated for further use.

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