



**Copper Development
Association Inc.**
Copper Alliance

**The net effect is
greater profits
for shops
and lower
per-part costs for
their customers.**

The Economic Value of Brass Recycling and High-Speed Machining

Introduction

The real economic and production advantages of brass lie in the unique combination of its favorable net material cost and high-speed machining potential. While many shops prefer brass because of its high machinability, some of their customers may shy away from specifying the material because of its higher initial cost compared to, for instance, steel, stainless steel or aluminum. But what those design engineers may not realize is that in addition to providing an ideal material for precision parts, brass's high residual scrap value gives it a competitive edge. In fact, high recycling rates for brass help eliminate the potential for waste and keep materials in use, upholding the principles and conferring the benefits of a circular economy. As a result, establishing the real value of brass requires consideration of its recycling and manufacturing economics.

In the big picture, shops running brass can obtain three fundamental advantages to advance their bottom lines. First, working with brass helps shops realize the full performance potential of their machine tools, with speeds, feeds and metal removal rates that steel and stainless steel workpieces cannot sustain, as well as longer tool life. Second, shops can earn a higher return on their scrap materials with brass – and as a result, their net material costs are more consistent and manageable than with other metals. Finally, brass's superior recyclability decreases the need for virgin material and thus further reduces the cost of producing brass bar stock as well as the environmental footprint of that process. The net effect is greater profits for shops and lower per-part costs for their customers.

To understand the overall benefits of brass as it relates to part quality, production efficiency and overall profitability requires investigating the combination of net material cost, sustainability and machinability. That investigation begins with an overview of some key recycling features of common production metals.

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Recycling Brass

The inherent material properties of brass remain unaffected by the process of recycling, and brass scrap offers 100% recyclability combined with high residual value – steel may be the world’s most recycled material by volume (Steel Recycling Institute), but brass scrap retains much more of its value. Shops that produce brass parts can therefore avoid waste and transform their chips back into cash that offsets the purchase price of the raw material. Provided that shops avoid contamination with impurities from other metals and alloy grades, brass can reenter the materials market an infinite number of times and contribute to a sustainable circular economy.

Recycling Steel

Annual use of scrap in North American steel production reaches nearly 70 million tons (American Iron & Steel Institute). In 2014, steel’s overall recycling rate stood at 86%, with two-thirds of new steel produced from recycled material. Although ferrous scrap constitutes more than 60% of the total volume of all scrap processed in the U.S., it falls below 50% of the total value traded (Institute of Scrap Recycling Industries, Inc.; Steel Recycling Institute). Compared to new steel, recycled steel requires only 44% as much energy to produce (Leblanc, 2018), which further energizes the need for recycling.

Recycling Aluminum

The sheer amount of energy required to produce aluminum from new material propels strong recycling programs. Discarding one aluminum can causes waste equivalent to spilling half the can’s volume in gasoline – and recycling aluminum uses only 5% to 10% of the energy required for new material production, a fact that has resulted in recovered aluminum being the dominate source of the material in the U.S. (The Aluminum Association). However, aluminum scrap tends to take up more volume than

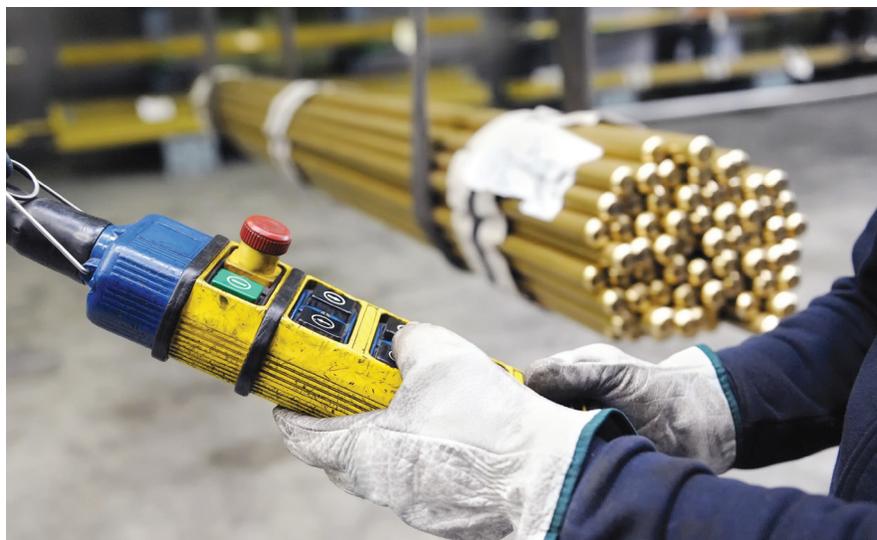
Shops that isolate their chips and maintain the provenance of the material as much as possible can **achieve greater returns on their scrap.**

the equivalent weight of other metals, which adds cost and complexity to the recycling process.

Recycling vs. Downcycling

To achieve the best results and return the highest percentage of scrap material to the market, the precision machined products industry must maintain high-quality swarf. The keys to maximizing scrap value include careful separation of certain alloy families from one another, with the highest prices paid for single-source material. When the scrap stream contains a mixture of alloys, prices fall and quickly enter the realm of downcycling, which returns a lower value for scrap material because the product requires costly additional steps before it can be re-manufactured. These steps include processes such as controlled dilution to bring impurity concentrations down to manageable levels.

For these reasons, maximizing part-production profitability requires careful management of swarf. Shops that isolate their chips and maintain the provenance of the material as much as possible can achieve greater returns on their scrap.



Cost vs. Value

When manufacturers specify metals for part production, they evaluate multiple criteria, including production-process requirements, part specifications and deployment, raw material cost, and scrap recyclability. All metals can achieve some measure of recyclability for the three basic forms of scrap: home scrap, which originates in the mill itself; prompt scrap, the byproduct of manufacturing; and obsolete scrap, produced through demolition or when products reach their end of life. These three forms

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of scrap typically constitute three value tiers because of the increasing potential for contamination as the distance between the material and the mill increases.

Clean scrap generated by machine shops falls into the second tier and is a valuable re-melting feedstock that mills rely on to produce new bar stock. Shops purchasing bar stock from mills may participate in scrap buy-back programs where the scrap they generate is cleaned and dried to remove machining lubricants and then returned to the producing mill at a negotiated rate. Anecdotally, brass scrap may be reclaimed in these closed loop arrangements for somewhere between 75% to 90% of the upfront cost of the bar stock, while steel scrap may only command between 10% to 25%.

Residual scrap value is an important variable in manufacturing economics that is sometimes overlooked. Design engineers that place greater emphasis on the upfront raw material cost rather than the net cost may be missing out on potential profits. For example, the hypothetical value comparison between brass and steel shown in the table below demonstrates that selecting a material with a lower purchase price could result in higher net material costs for the shop. In this scenario, which is based on small volumes of bar stock purchased from a distributor, the upfront raw material cost of steel is 46% less than brass. However, after factoring in the scrap resale value, the net cost comparison reveals that brass is actually 8% less expensive than steel.

Hypothetical Net-Cost Value Comparison for Identical Quantities of Brass and Steel

Material	Bar Stock Weight ¹	Total Cost of Bar Stock ²	Bar Stock Unit Cost	Calculated Scrap Unit Value ³	Weight of Generated Scrap ⁴	Total Scrap Resale Value	Net Material Cost
C36000 Brass	260.1 lb	\$1,500.00	5.77 \$/lb	4.62 \$/lb	169.07 lb	\$781.10	\$718.90
12L14 Steel	240.3 lb	\$865.05	3.60 \$/lb	0.54 \$/lb	156.20 lb	\$84.35	\$780.70

¹ 15 round bars for each material in 6' lengths at 1" diameter; C36000 density = 2.89 lb/ft, 12L14 density = 2.67 lb/ft.

² Prices retrieved May 11, 2020, from <https://store.buymetal.com/brass/round-bar/brass-round-bar-c36000-h02-half-hard-1.0.html> and <https://store.buymetal.com/carbon-steel/round-bar/12l14/carbon-steel-round-bar-12l14-1.html>.

³ Assumes brass scrap retains 80% residual value of the upfront bar stock cost, and steel scrap retains 15%. Calculated scrap values are not intended to reflect current market prices or conditions and are provided only for illustrative purposes based on relative residual value as a percentage of raw material cost.

⁴ 65% turnings ratio (i.e. amount of chips removed to make parts relative to the weight of the starting material).

Thinking of scrap as a valuable product and being mindful of net costs when specifying materials can help manufacturers boost their profits while contributing to the sustainable production of raw materials. Brass embodies

these circular economy principles – and this helps keep costs down for all segments of the value chain. While the high scrap value and attractive net cost of brass fare well compared to other materials, the production advantages of brass are further enhanced through high-speed machining on modern machine tools.



High-speed Machining and Equipment ROI

Machinability gives brass advantages that other metals cannot match. This enables shops not only to realize the full potential of their advanced high-speed machine tools, but also to achieve a faster return on equipment investments. A material's machinability has a direct impact on machine throughput, which typically has the largest impact on a shop's profitability. Machinability is measured on a universal index, which assigns a score to materials on a scale from 1 to 100 based on standardized testing (Thiele et al. 1990). C36000 free-machining brass has a maximum rating of 100; 12L14 steel has a rating approximately one-fifth of brass at 21.

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To illustrate the economic advantages of brass in a production context, consider a shop that makes the same part with a 65% scrap ratio on two identical machines with a \$500,000 purchase price over a one-year period. One machine runs brass and the other steel. Using the basic net-costing example above as a starting point, the historic raw material costs for bar stock are adjusted down to account for the increased purchase volume, with the same relative cost ratio between the materials retained for consistency. The residual scrap values as a percentage of the raw material costs are also held constant (i.e. 80% for brass, 15% for steel). Based on the superior machinability of brass, it is conservatively assumed that the part cycle time in brass is one-third faster than steel. For simplicity, it is assumed that the price of the part is \$5.00 in both materials, and that the annual operating costs for machine financing, labor, machine maintenance, perishable tooling, and utilities are also the same.

The dual benefit of brass's high scrap value and superior machinability gives shops a competitive edge and helps them get the most out of their investments in modern machine tools with advanced capabilities.

Production-Scale Material Value Comparison on Identical Machines over the Course of a Year

Brass (C36000)	VS	Steel (12L14)
\$5.00	Part price	\$5.00
60 seconds	Cycle time	90 seconds
120,000 parts	Throughput ¹	80,000 parts
\$600,000	Revenue	\$400,000
\$2.85 / lb.	Bar stock unit cost ²	\$1.64 / lb.
\$2.28 / lb.	Scrap unit value	\$0.25 / lb.
0.0100 lb.	Part weight ³	0.00925 lb.
\$9,771	Raw material cost	\$3,467
\$5,081	Scrap value	\$344
\$4,690	Net material cost	\$3,123
\$275,000	Other operating costs ⁴	\$275,000
\$320,310	Profit	\$121,877
1.6 years	Machine payback period	4.1 years

¹ One 8-hr. shift/day, 250 days/year.

² Costs of both brass and steel fluctuate with market conditions, but the assumptions made here are consistent with prices that have existed in recent years. There is no intent to imply that the prices assumed here are current; however, they reasonably represent the metals' relative market prices.

³ Part weight difference calculated with material density ratio (C36000 = 0.307 lb/in³, 12L14 = 0.284 lb/in³).

⁴ Includes labor, machine payments, equipment maintenance, perishable tooling, and utilities.

This example demonstrates how focusing on the upfront costs of bar stock can give shops a misguided perception of a material's value, particularly when optimizing part-processing economics and justifying the cost to upgrade equipment. The dual benefit of brass's high scrap value and superior machinability gives shops a competitive edge and helps them get the most out of their investments in modern machine tools with advanced capabilities.

Brass: The Real Bottom Line

Brass carries a machinability score of 100 out of 100, the highest of any production metal. Despite this manufacturing advantage, conventional machining handbook recommendations often underestimate the machinability of brass by up to 85%, leading many shops to run jobs at slow speeds and feeds under the mistaken impression that brass requires conservative production parameters. In actuality, brass makes an ideal material for use on modern machine tools, with high throughput and long tool life. By comparison, production of steel and stainless steel workpieces results in longer cycle times and increased operating costs due to higher tool wear and greater energy usage.

Even when market prices fluctuate, brass retains its value and supports the manufacturing bottom line.

Combined with these sizable production advantages, the recyclability of brass yields a high-performance metal that enables shops to better control their net material costs and accelerate the payback on equipment upgrades. These savings at the shop level are passed on to their customers that specify brass. Even when market prices fluctuate, brass retains its value and supports the manufacturing bottom line.

To run the production-scale value comparison above with your own figures, use our [profitability calculator](#).

To explore recycling options and scrap values in your area, find local recycler contact information through the [Institute of Scrap Recycling Industries](#).

About the Copper Development Association

Copper Development Association Inc. (CDA) is a U.S.-based, not-for-profit trade association of the North American copper industry, influencing the use of copper and copper alloys through research, development and education, as well as technical and end-user support. CDA is committed to promoting the proper use of copper materials in sustainable, efficient applications for business, industry and the home.

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