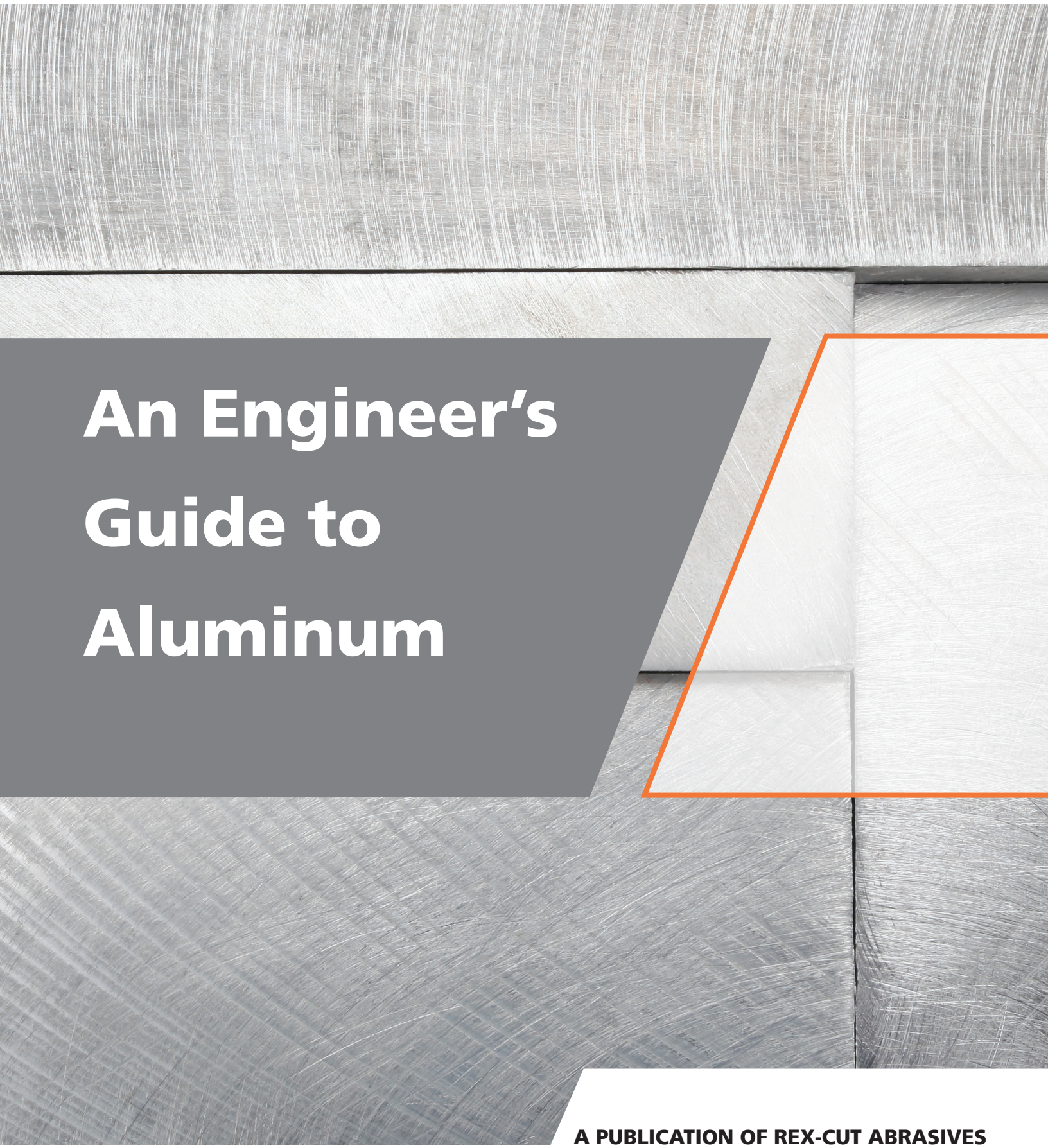

An Engineer's Guide to Aluminum

A PUBLICATION OF REX-CUT ABRASIVES

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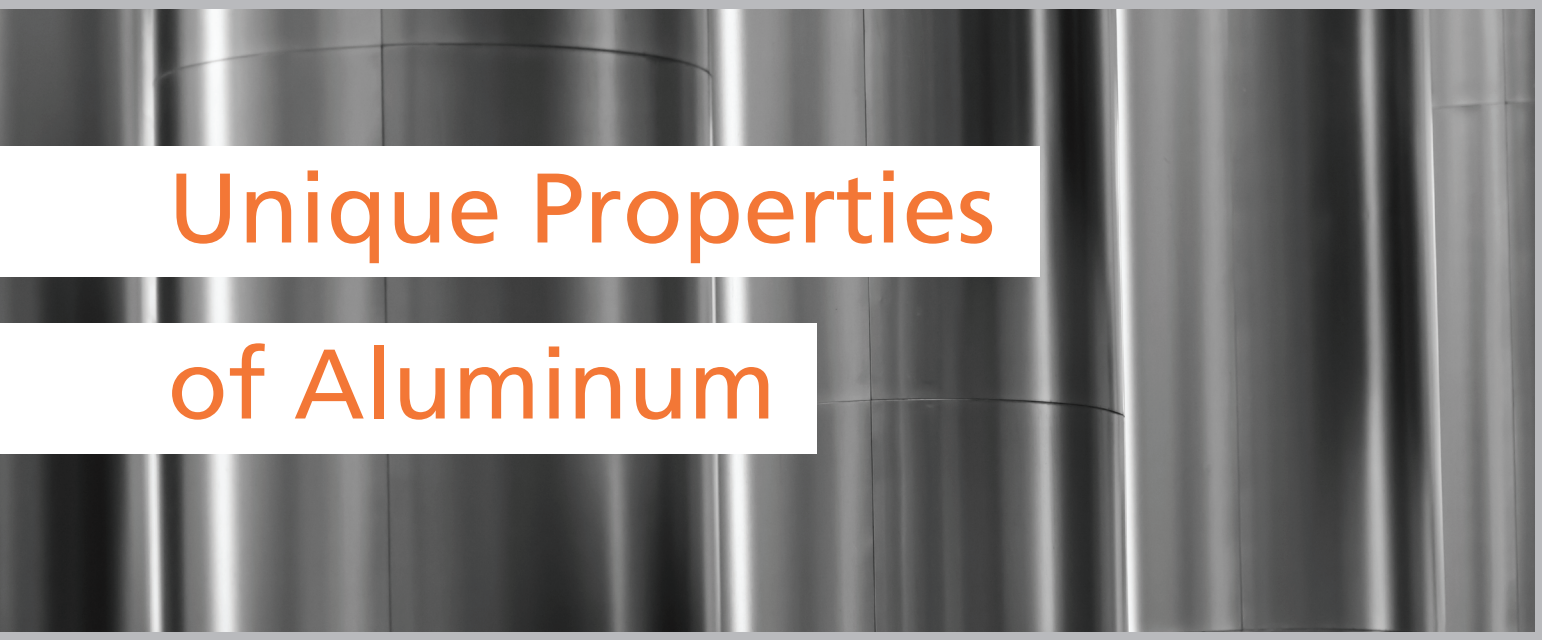
Aluminum is 75 to 80 percent of the makeup of modern aircraft, used extensively in marine fabrication, and comprises much of the floating envoy to our outer reaches in the International Space Station. Alloyed aluminum is increasingly used in automotive manufacturing and other manufacturing industries due to its impressive strength to weight ratio.

Read this guide to understand why aluminum is a metal of choice in aerospace and marine fabrication, how to avoid costly mistakes in handling and processing aluminum, and ways to ensure competitive fabrication in an increasingly global market.



Unique Properties of Aluminum

Like all metals, alloying aluminum produces a range of new attributes including increased durability, flexibility, strength, heat-resistance, and other properties useful for fabrication. Engineers and welders alike benefit from understanding the basic properties of aluminum and which alloys are best suited to each application.

Corrosion resistance Passivation is the formation of a protective aluminum oxide layer aluminum spontaneously produces when it comes in contact with oxygen in its environment.

This is a unique property of aluminum and few other metals. In steel, for instance, iron oxides formed on the surface are porous, allowing further corrosion underneath the surface of the metal. Aluminum's unique non-porous oxide layer is extremely robust and protects the metal from corrosion without needing to coat or otherwise treat the final product.

Strength and Ductility

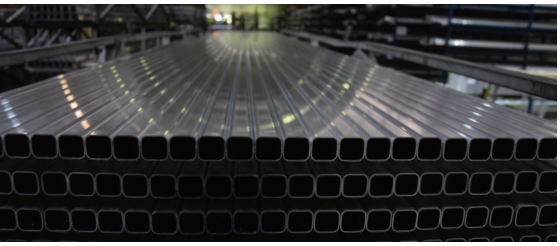
Alloyed aluminum (such as with manganese, silicon, copper, and magnesium) has a higher tensile strength than pure aluminum, although aluminum alone is a strong metal for its weight.

With heat ductility three times that of steel, aluminum is often the choice for fabricating cold plates or heat exchangers used in military or aerospace applications. Aluminum's versatility also makes it the material of choice in the International Space Station, such as the 2219-T6 aluminum alloy used extensively on the interior and exterior of the cosmic laboratory.

Recyclable

Aluminum is a sustainable metal because it is 100 percent recyclable and lends itself to such a variety of applications.

Cutting, Welding, and Drilling



Selecting proper cutting methods per application will minimize finishing time and help ensure a quality final product.

Typical aluminum cutting methods include:

Tool	Description	Advantage
Circular saw	Can be used for straight cuts for aluminum fabrication, but be sure to get the right size blade or you run the risk of very dangerous safety hazards	Fast and inexpensive option
Band saw	Innovations in band saw technology allow for band saws to enter and exit the cut slowly, and speed up in the middle of the cut to prevent blade damage	Great for thicker aluminum (over 6 inches in diameter) and for shops switching between aluminum and other materials
Laser	Best for cutting complex shapes fast.	Quick cutting speed and less heat affected zone than plasma. Can produce part accuracies better than 0.002”.
Waterjet	Cut 2D objects with precision and no heat-affected zone	No mechanical stress and can cut thicker metal without distortion. Can produce part accuracies better than 0.002”.
Plasma	Cut aluminum at high speeds per amp, saving on nitrogen and associated costs of cutting found in laser cutting	lower cost of equipment than laser cutting and flexibility of cut types on pieces over ¼ inch thickness. Can produce part accuracies better than 0.008”. Tip: Use an argon/helium mixture to ensure a flame that cuts without damaging the aluminum
Cut-off Wheel	Best option for quick cuts, free cutting, on-site projects, precision cutting for piping, tubes, rails and sheet metal	Specific aluminum non-loading wheels, cut cool and fast.

Post-cut Processes

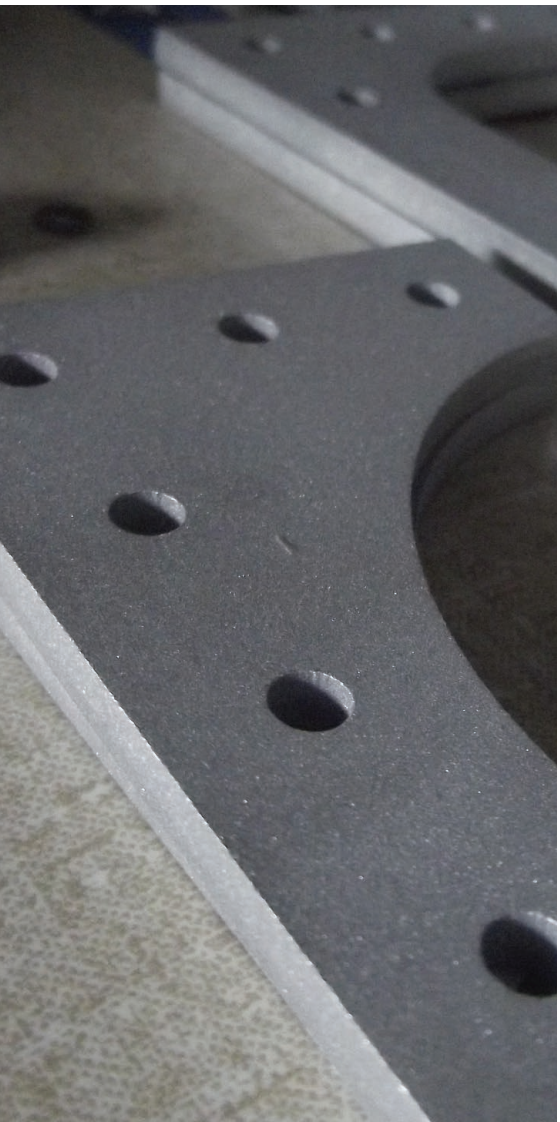
Chamfering

Due to its relative softness compared to other commonly used fabrication metals (steel, stainless steel) aluminum is easier to chamfer. If your final project requires chamfered edges, a laser cutting machine or beveler will create a precise chamfer. If you are applying a pre-weld chamfer, in many cases you can get by using a grinding wheel suited for aluminum

Deburring

After cutting or drilling aluminum you may have to contend with removing burrs, and there are myriad methods of deburring aluminum. Taking the time to analyze each project at hand will help you decide the most efficient, cost effective, and appropriate approach.

- **Considerations:** Take into account the length of the burr, number of edges, and size and height of the burr(s) to choose the best deburring method



- **Methods:** The best method to debur aluminum depends on the length of the burr, cutting surface area, and the sheer volume being fabricated. A few common deburring methods are:
    - **Brush deburring** - Safe and effective, but the brush typically hits all surfaces, not just the edges. Brush deburring can affect the surface of the metal as well as the edge.
    - **Abrasive jet machining** - Uses a high-speed stream of abrasive particles propelled by gas, but prone to health and environmental concerns and it requires a dust collection chamber
    - **Robotic deburring** - Precise, accurate, and quick deburring, however, takes a lot of time to set up and can be expensive for smaller operations
    - **Manual deburring** - Most widely used for deburring, quick and easy to set up, but can be prone to user error by non-qualified operators

Taking the time to investigate chamfering or deburring methods best suited for your specific application can often save you time and reduce scrap parts. Talking to your suppliers about your current methods and results is a great place to start.

3 Aluminum Welding Mistakes to Avoid

Welding aluminum is different than welding steel, but not necessarily more difficult. Beware of these common welding mistakes to ensure quality fabricated parts.

1. Choosing strongest alloy

While there are many elements that alloy well with aluminum, increasing tensile strength and overall workability, not all aluminum alloys are created equal. In fact, you may be shooting yourself in the foot by choosing a durable aluminum alloy over the best aluminum alloy for the job.

Here's why:

- Structural design limitation is typically in deflection, not in strength
- The alloy may not be able to be welded with conventional techniques without hot cracking
- If the project isn't structural in nature, you'll be necessitating expensive and time-draining workarounds for you and your welders

2. Wrong Direction

Using the push technique on aluminum can result in weld defects such as pinholes and a sooty appearance. Lincoln Electric recommends sticking with the pull technique for maximum shielding-gas coverage and less weld contamination.

3. Aluminum build-up on grinding wheel

Grinding aluminum can lead to chips of metal coating the surface of the grinding wheel or disc. In other words, the stuff you're grinding can clog the grinding wheel preventing the abrasive grain from doing its job. There are two main remedies for this issue:

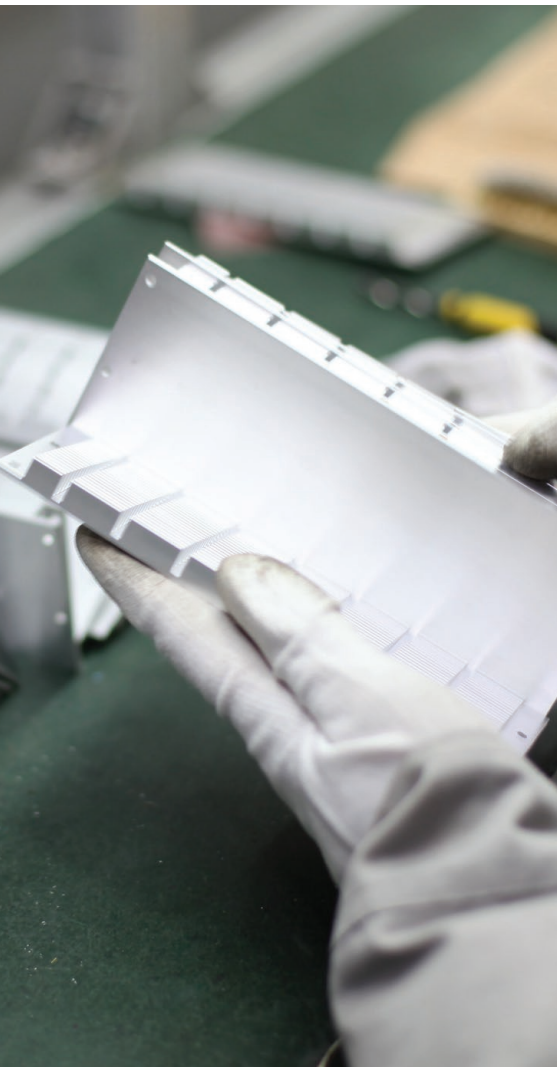
- **Waxes and pastes:**
  It is about as simple as it sounds - apply waxes or pastes to the grinding wheel to keep the aluminum bits from adhering to the grains or the spaces in between them. Obviously cleaning the wax or paste after grinding and blending welds is important for esthetical reasons, but it's extremely important if you are beveling before welding. Make sure the metal is very clean before welding or the wax will compromise the integrity of the weld.

- **Non-loading wheels:**
  A naturally non-loading wheel, like Rex-Cut's Type 27 Max Flex, gives operators precision control and a uniform finish, without the hassle of wheel-coating or removing residue afterward.

An Ounce of Prevention

When the final product ships, you want to ensure that your customers come back to you because of the quality they expect.

Ensure product stability by avoiding corrosion, fatigue, and the wrong type of alloys.



Avoid corrosion

The most common types of corrosion are pitting corrosion and cracking corrosion. There are two types of cracking corrosion: stress corrosion (caused by pitting) and chemical corrosion.

Follow these guidelines to prevent aluminum corrosion:

1. **Always use a MIG (Metal-inert Gas) welding process** or other gas-shielding welding process to protect the metal's surface during welding. A shielding gas protects the aluminum's surface and a constant electrode welding stream gives the consistent heat that highly-ductile aluminum requires.

2. **Know your alloys:** Use filler alloys based on more than tensile strength. Consider ease of welding, strength of weld, weld ductility, and corrosion resistance in filler alloy selection. For more on filler alloy selection, read this in-depth analysis by Alcotec.

Chemical corrosion results from a chemical trigger of the wrong alloys (magnesium and copper in particular) through the heat of the welding gun.

Drill well

Drilling can be another overlooked aspect of working with aluminum that leads to corrosion. The aluminum alloys drilled most often are the very sturdy 6061 and 7075. Aside from slowing down and setting the voltage at a proper heat, here are some tips for drilling aluminum the right way:

- Use a geometry or drill angle
- Use through-coolant
- Remember that a higher speed means better tool life and a better surface finish, so don't be shy to speed it up within reason

> "The threshold for aluminum is something like 60,000 sfm, which is enormously fast."
> - Jason Hout, global DHM (deep hole machining) product and application specialist for Sandvik Coromant Co., quoted in CTE Magazine

The Impact of Global Aluminum Production

In 2016 the United States' global share of aluminum production was at a low of two percent, compared to 16 percent only 16 years prior. An April 2017 U.S. News article said that President Trump is signing an executive order that will investigate whether dependence on foreign aluminum is compromising national security. Whether or not aluminum's origin is cause for alarm, understanding the global aluminum market will help you to predict and protect your bottom line when it comes to aluminum production.

The demand for aluminum increases with the introduction of "green" requirements on fuel efficiency and environmental impact. According to The Aluminum Association's website, aluminum contributes to more than one percent of the U.S.'s Gross National Product (GDP) and creates 713,00 jobs in the United States from production through processing and use.

Whether you are determining the optimum design for a new product or ensuring you are up to speed in a meeting with the executives in your company, here are a few ways to stay abreast of developments and economic impact of the aluminum market for your plant's production costs:

- **The Monthly Aluminum Price Outlook**: This resource is provided by Harbor Aluminum and gives an overview and in-depth statistics for aluminum performance and price predictions
- **The World Bank's Commodity Market publications and data**: Monthly, quarterly, and yearly analyses and predictions from the World Bank on all major global commodities, including aluminum

Understanding the global pricing trends for aluminum and other metal commodities can help you predict the economic impact on your suppliers and buyers of your products.

Take advantage of aluminum's lightweight and corrosion-resistant properties for your production the right way. Manufacture aluminum products within your tight tolerances with the right alloys, correct welding and finishing procedures, and with an understanding of trends in aluminum supply and demand.

Learn more about Rex-Cut Abrasives' aluminum cutting and deburring wheels today!

www.rexcut.com

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