Pushing the Limits of Extruding Magnesium Profiles

Mag Specialties is a privately owned magnesium extrusion company, headquartered in Denver, CO, with manufacturing operations in Mexico. Drawing on their long history in magnesium, the company produces profiles (Figure 1) and other products for a variety of industries, including automotive, aerospace, cathodic protection, construction tools, oil and gas, nuclear energy, renewable energy, defense, and specialty products. As part of their growth strategy, the company is investing in the installation of a third extrusion press that will better enable them to serve growing industries.

Figure 1. Example of a magnesium profile, produced at the Mag Specialties facility in Nuevo Laredo, Mexico.

"Mag Specialties has been growing quickly the past couple of years and if we would like to maintain this pace of growth, we will need additional capacity to support new large customers, especially in automotive and aerospace, our two key strategic markets," said Nes Abdulrahman, vice president, Sales & Marketing for Mag Specialties. "We are striving for continuous innovations by combining our experience in magnesium extrusions and the latest extrusion technology. We hope to push the limits and improve on what is possible for magnesium profiles shapes and tolerances."

Company History

The history of Mag Specialties is rooted in two major North American magnesium companies—Timminco and Dow Magnesium. Timminco started operations in 1934, operating a primary magnesium smelter, casthouse, and extrusion plant. The company launched the first Pidgeon plant under the guidance of Dr. Lloyd Pidgeon. Today, this remains the main process for producing magnesium, mostly in China which represents 80% of the worldwide magnesium industry. In May 1998, Timminco acquired Dow Chemical's magnesium extrusion operations in Denver, CO, in order to diversify its assets.

Dow Magnesium developed its own electrolytic process under the guidance of Herbert Henry Dow in 1916. The electrolytic method produces magnesium from brine rich in bromine, chlorine, sodium, calcium, and magnesium. The company saw growth as it supported wartime efforts throughout WWI and WWII. With the sale of its extrusion assets to Timminco in 1998, however, Dow began to see an end to its long legacy in the magnesium business. This was primarily due to competition originating from magnesium producers in China and elsewhere, which eroded profit margins.

When Timminco took over the Dow Magnesium extrusion operations, many of the employees continued on under the new ownership. The production technology, extrusion equipment, and customer base were also transferred to Timminco. In 2008, with the increasing intensity of competition from China, Timminco moved its magnesium extrusion equipment and operations from Colorado to Nuevo Laredo, Mexico.

In 2011, Mag Specialties was formed when its founders acquired the extrusion production technology, equipment, and operations located in Mexico from Timminco. Many of the employees, having decades of experience with either Dow or Timminco, remained with Mag Specialties. The company continued to produce magnesium extrusions in the form of profiles and anodes, serving the existing customer base.

Operations & Capabilities: The Mag Specialties division in Nuevo Laredo houses the company's magnesium manufacturing capabilities. It currently operates two extrusion presses—a 500 ton and an 1,800 ton—using billet supplied from China, which the company audits on a regular basis. Along with its extrusion capabilities, the company provides secondary operations in-house, including CNC machining (Figure 2), wire EDM, lathing, TIG and MIG welding, assembly, heat treating, and anode fabrication (Figure 3). The facility's quality testing capabilities include optical emission spectrometry, 2D optical imaging, mechanical testing, metallography, as well as surface coating tests, such as salt-spray, Taber abrasion, cross hatch, and hardness.

Figure 2. Mag Specialties provides CNC machining for post-extrusion fabrication.

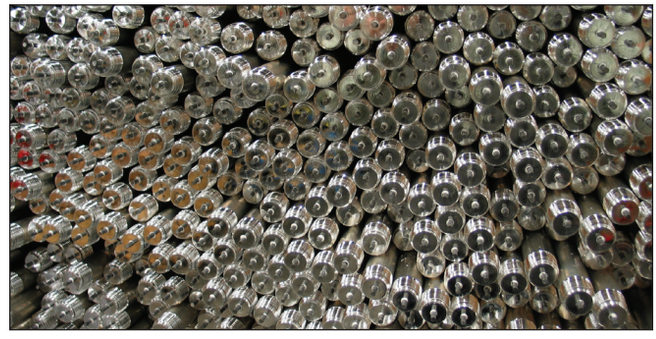

Figure 3. Example of machined capped anodes for cathodic protection in residential and commercial glass-lined water heaters.

The Nuevo Laredo facility is ISO9001-2015 certified. Following investments into the quality control systems at the site in 2018, the company also has a letter of conformance for the automotive quality standard IATF 16949:2016, while working towards full registration.

For specific projects that require additional manufacturing steps, Mag Specialties is able to draw on the services of integral service suppliers to provide further machining, surface treatments (passivation, anodizing, or coating), or other capabilities. For example, the company works with MESCO Manufacturing of Greenburg, IN, for large-scale machining and with Henkel and other surface coating shops for finishing requirements.

Extruding Magnesium

Although Mag Specialties extrudes both magnesium and some aluminum, the company's core competency remains with magnesium. The company has extruded over 9,000 shapes in over 20 different magnesium alloys. It is able to produce profiles in a variety of standard alloys and forms, as well as many special shapes (tube, hollow, and semi-hollow) tailored to fit a customer's requirement. Profile sizes range from a minimum of 0.047 up to 9.000 inches in diameter. The company is also able to achieve thin wall thicknesses down to 0.028 inches (0.7 mm) in tolerances as tight as ±0.006 inches (±0.15 mm).

"The dimensional tolerances that can be held in magnesium and aluminum are comparable," said Abdulrahman. "Just as aluminum extruders are working to achieve significantly tighter tolerances than specified by ASTM in order to address the stringent demands of the automotive and aerospace industries, Mag Specialties also currently meets or exceeds ASTM dimensional tolerance standards."

Extrusion presses for both magnesium and aluminum are similar. "However, we do customize our extrusion equipment based on our experience, which cannot be disclosed due to their proprietary nature," said Abdulrahman. He explained that in regards to quenching and handling, working with magnesium is slightly easier. Unlike common 6000 series aluminum alloys, which typically require water quenching to ensure the profile properties, most conventional magnesium alloys do not require a water quench after extrusion. Instead, a T5 oven heat treatment is sufficient to produce precipitation hardening and obtain maximum tensile properties. In addition, due to magnesium's decreased tendency to dent or scratch compared to aluminum, handling tends to be easier.

One of the challenging areas for producing magnesium profiles is extrusion speeds due to the material's formability restraint. "Magnesium has a hexagonal close packed (HCP) atomic structure compared to aluminum, which has a face centered cubic (FCC) atomic structure," noted Abdulrahman. "This tends to lower the formability of magnesium versus aluminum at room temperature and, to a lesser extent, at elevated temperatures. While magnesium does gain additional slip planes at elevated temperatures to accommodate deformation, it does not extrude as fast as aluminum." The die technology is also different in magnesium compared to aluminum, even for the exact same profile. Therefore, the company typically works to design and produce their own dies optimized for magnesium production.

One of the ways Mag Specialties works to combat some of the challenges associated with magnesium is through development of new alloys in order to improve formability and increase extrusion speeds over commercial grade alloys. "This is an on-going effort and we've seen some success in this regard," said Abdulrahman. "In addition, we have designed multi-hole extrusion technology specifically for magnesium, which allows us to close the wide gap with aluminum in terms of productivity and cost reduction."

Engineering

Mag Specialties works directly with the automotive, aerospace, and other industries, providing engineering support as needed. This includes alloy selection and development, 3D model prototyping, conceptual FEA analysis using SolidWorks software (Figure 4), cost optimization analysis, and custom tooling design. The company cooperates with its billet supply chain to produce new alloys, with prototypes being tested on its 500 ton press. In some cases, the company will run tests on its 1,800 ton press, if required for larger profiles. One example of the company's engineering work is the development of new magnesium alloys for use in commercial aircraft seats, which have been independently tested by a qualified third party lab in the U.S. to meet the Federal Aviation Administration (FAA) flammability test requirements.

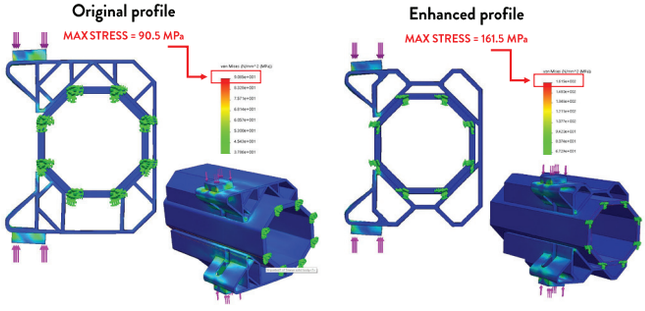

Figure 4. Example of a design optimization performed by Mag Specialties using FEA analysis in order to improve the manufacturability of an extrusion profile.

For the automotive industry, Mag Specialties works to develop new alloys, profiles, and products that meet the strict requirements of the industry. "We are part of a supply chain that supplies a forging grade magnesium alloy used in the production of magnesium wheels," said Abdulrahman. "We are also in development with a Tier 1 company for the application of magnesium extrusions in an instrument panel assembly (IP beam)."

As part of the U.S. Automotive Materials Partnership LLC (USAMP), a branch of the U.S. Council for Automotive Research (USCAR), Mag Specialties participated as part of the "Magnesium Front End" project team, which also included Ford, Chrysler, and General Motors (GM). Mag Specialties produced a new magnesium alloy (ZE20) in the form of billet, which was extruded into profiles and also studied in the as-cast condition. The experimental ZE20 alloy in cast billet form was found to offer extrusion rates comparable to baseline materials, such as AZ31 or AM30, while providing dramatically reduced tension/compression and mechanical property asymmetry.

New Extrusion Press

Mag Specialties is currently expanding its extrusion capabilities with the installation of a new press line planned for completion in June 2019. Designed by SMS group and built by OMAV (Figure 5), the 28 MN (3,174 ton) extrusion press will enable the company to both upgrade its technology and provide new capacity.

Figure 5. The 28 MN extrusion press under construction in Italy.

"Mag Specialties conducted an exhaustive search of press manufacturers in both Europe and China," explained Abdulrahman. "The SMS group was selected for the new press due to the high reliability, longevity, and precision of their press lines. As we take on an ever increasing complexity of profiles with tighter tolerance requirements from our customers, we felt these benefits combined with our experience in magnesium extrusions would give us the highest probability for future success, especially in the automotive industry."

The press line will be housed within the same building as the company's existing two presses. In order to make room within the building for the new press, the company is shifting existing storage currently within the building to additional storage compartments that are being constructed outside. The new line will include a complete OMAV handling system, including billet furnace, intensive quenching, puller system with flying cut saw, a full length runout table, stretcher, and finishing saw. The entire operation will be controlled from a central station using computer assisted direct extrusion (CADEX) management software. Abdulrahman explained, "We are investing in state-of-the-art extrusion technology supported by CADEX in order to further improve the tolerances we can hold."

Future Developments

As Mag Specialties works toward finishing the installation of its new press line and ramping up production, it already has plans for addressing its potential future growth. The company aims to continue its success through ongoing reinvestment into its infrastructure in the form of new press technologies and secondary operations and personnel through training, skill development, and hiring. In addition, they plan to make an initial public offering (IPO) in the future, which will enable them to move from being privately owned to a publicly traded company. "The IPO will allow us to reinvest back into our company, which may take the form of backward vertical integration into our raw material sources in China, such as mining, extraction, alloying, and casting," said Abdulrahman. The company is also considering investing in a second extrusion plant, which may be located in China and would provide added stability and security. "We are cognizant of the needs and prospects of back-up production capability for our customer base, especially those in automotive," said Abdulrahman. "We will begin the next round of exploration for future press requirements soon based on customer feedback." ■