MPIF Examines State of the Powder Metal Industry

Dean Howard, PMT, President, MPIF

This is an excerpt from Dean Howard's yearly State of the PM Industry article from MPIF.

Thanks to material development and additive manufacturing opportunities, it's important for the gear and power transmission industries to monitor the trends, technologies and future forecasts in the powder metal market.

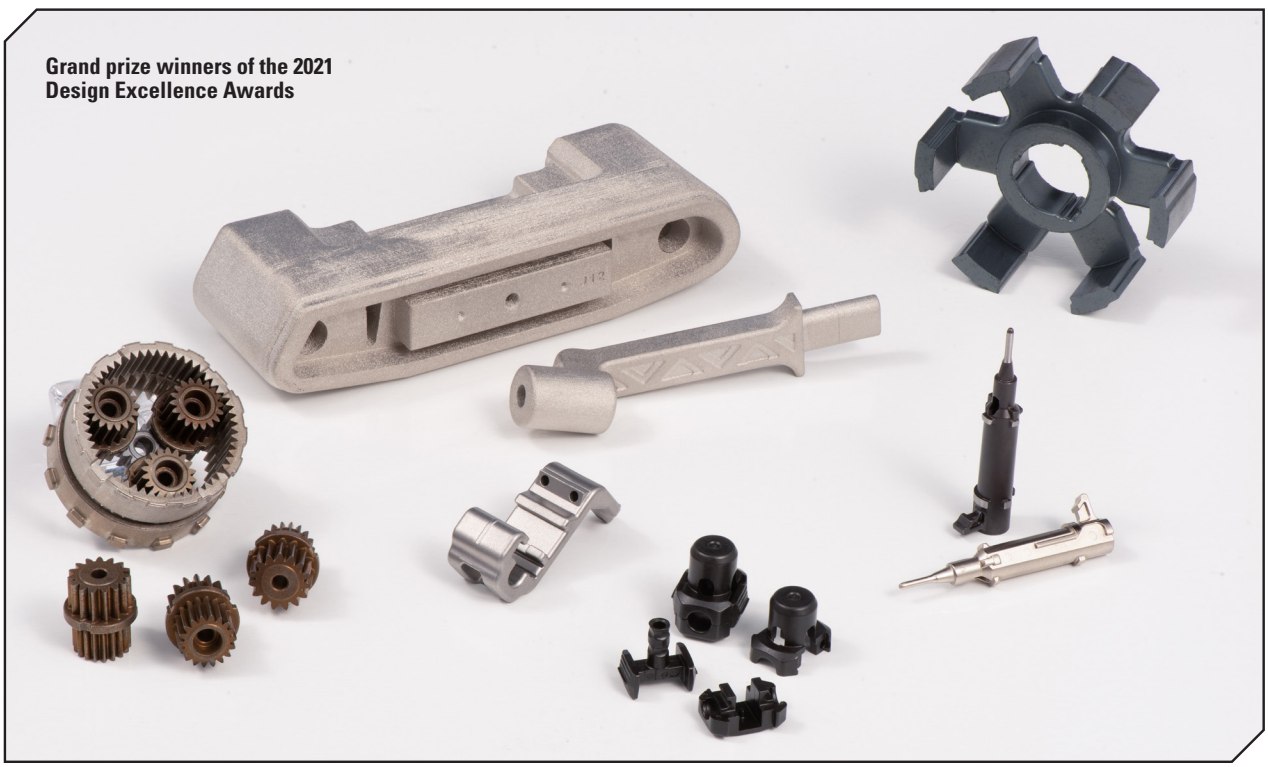
The Impact of the Pandemic

During the pandemic, manufacturing in North America was disrupted, hitting the PM industry especially hard, as the automotive industry, the primary consumer of PM parts, came to a standstill. Shelter-in-place mandates resulted in more people cooking at home and provided time to renovate kitchens, garages, and laundry rooms. This was great for PM suppliers to small and large appliance manufacturers, until inventories of finished goods were exhausted, as assembly lines were shut-down due to the mandates.

Healthcare providers were constantly in the news, receiving the praise that they deserved for going above and beyond, treating those that required medical assistance because of this horrible virus. However, many elective surgeries, those that required metal injection molding (MIM) components, were postponed, stalling deliveries, and increasing inventories. The North American oil rig count, an important barometer for the drilling industry, dropped more than 50% in 2020, compared with 2019. When drilling rigs are active, supplying many industries that rely on petroleum-based products, they consume tungsten carbide inserts for drill heads, made from metal powders, but again, demand was not required.

This is just a small example of how the PM industry was impacted by the pandemic. The trickledown effect resulted in a flurry of cost-cutting solutions, including wage and benefits cuts, furloughs, permanent lay-offs, retirements, and temporary plant closures for facilities deemed as non-essential. Some government programs, such as the Paycheck Protection Program, helped many small to medium enterprises stay afloat, while other programs intended to help the displaced workforce became a hinderance, as some displaced workers received more money for staying home and did not return when they were called back to work.

However, the PM industry is a resilient consolidation of many forces, which found its inner strength to rally and became stronger as a result of these turbulent times. I am unaware of a single North American PM company that permanently closed its operations as a direct result of the pandemic. Many companies' representatives report that their organizations are working mandatory overtime due to shortages of skilled workers and engineers, while setting new production levels because of pandemic induced solutions. We are all survivors, and the PM industry is still alive and well, landing back on its feet, well on its way to recovery. Let's take a deeper dive.



Grand prize winners of the 2021 Design Excellence Awards

New Material Development

Several PM parts makers report that the future for PM will be to supply value-added, near-net shape parts that have cost-effective lean-alloy materials with high material utilization rates. To help accomplish this, powder producers are improving and developing new materials that exhibit higher green strength, excellent machinability, increased compressibility, and have their sights on increasing the development and use of soft magnetic composites (SMC).

SMC materials have an integral role in the future of electric vehicles, as well as home appliances and other electric devices. Advances in magnetic modeling are allowing engineers to create more efficient designs with the 3-dimensional manufacturing capabilities of SMC materials, that are not constrained by 2-dimensional construction limitations of laminated steel. SMC materials operate at very high frequencies without hysteresis and eddy current losses, another advantage over their laminated steel counterparts.

Technology Trends

The Internet of Things, or Industry 4.0, has made its presence known in the PM industry. Augmented intelligence continues to assist and optimize the manufacturing processes through sensors that learn the process and adjust based on data trends. COVID-19 workforce reductions affected many companies' ability to efficiently operate equipment, increasing the demand for automation. From pick-and-place robots at the compacting presses and furnaces to 100% vision system inspections, automation continues to increase.

Compaction presses continue to evolve with sophisticated motion controls, resulting in precise movement of tools with faster cycle times. Fully integrated electric compaction presses are increasing the productivity for tungsten carbide and ceramic high precision cutting tool inserts.

Furnace manufacturers also see the future of SMCs. New approaches to lubricant removal and the ability to cure parts in one continuous cycle will reduce manufacturing costs and increase throughput, while improving handling and quality.

Single transmission bush gear.

Metal Injection Molding and Additive Manufacturing

While general manufacturing was down in 2020, metal injection molding (MIM) and metal additive manufacturing (AM) performed much better. Domestic and globally produced MIM and AM fine powders (less than 20 micrometers) consumed in North America increased an estimated 3-5% to 3,741-3,809 mt (4,125-4,200 st). Low-alloy and stainless-steel made up the bulk of the powders consumed.

Improving powder quality, most recently driven by AM, including a narrower particle size distribution range, greater sphericity, fewer satellites, and less internal porosity, will improve throughput, mechanical properties, and overall process consistency. Typically, these powders are manufactured by gas atomization, but capacity has been added recently for plasma atomization and research continues to develop water-atomized low-alloy materials for MIM and AM. Industry sources don't see radical changes on the horizon for injection molding machines, other than applying Internet of Things utilities and augmented intelligence to reduce labor while increasing productivity. AM build machines continue to evolve. Office-friendly small units to production scale are being released monthly. Multi-laser units continue to increase speed, build size, consistency, and robust properties for performance parts. Bi-directional single-pass binder-jet units are resulting in speeds up to 100 times faster than other metal AM platforms.

There continues to be a need for additional thermal treatment equipment for MIM and AM. MIM and AM binder-jet processes require de-binding prior to sintering, and most direct laser sintering process require stress relieving after printing. Research activities continue to provide new insight into identifying ideal temperature and atmosphere conditions for more efficient energy utilization and process optimization.

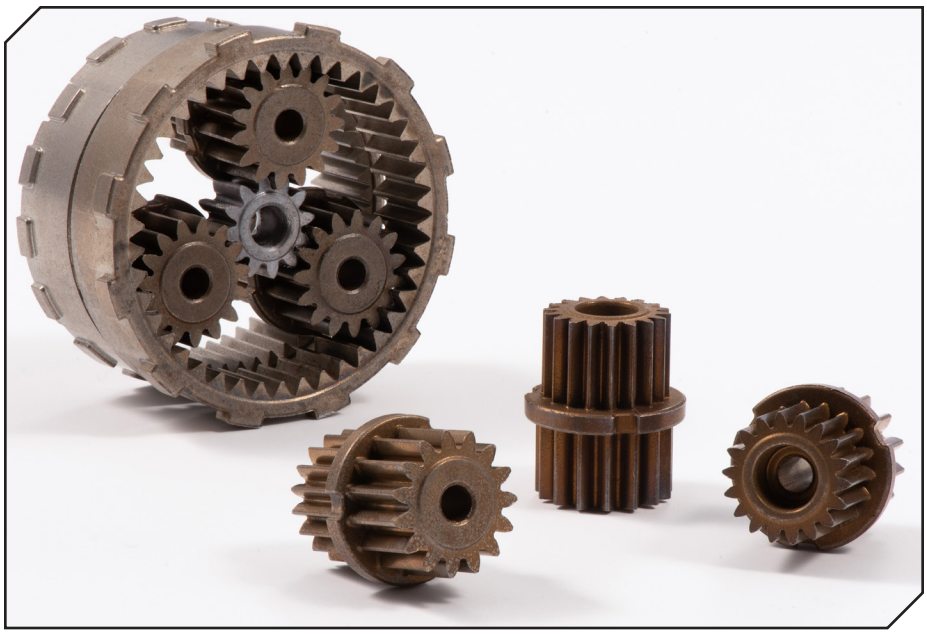
It is safe to say that the partition between MIM and AM processes is disappearing. At least a dozen MIM companies have added in-house AM capabilities or are collaborating with others, bringing parts to market quicker, using

the same powders, without the need for tooling. When quantity levels justify, the parts can be moved to MIM.

The Future of PM

The MPIF Technical Board continues to keep a keen eye on lean alloys, advanced PM steels, SMC, and lightweight materials. The Technical Board is also studying processing variables and their influences on variation in material properties and dimensional stability in PM parts. The latter review concerns how materials react to heat treatment and compacting with the goal of achieving closer tolerances and reducing the need for extensive machining. Additionally, during 2021, the Technical Board will assess and update the PM Industry Roadmap, most recently revised in 2017, to ensure that our industry has identified the technology challenges to remain the preferred metal-forming solution.

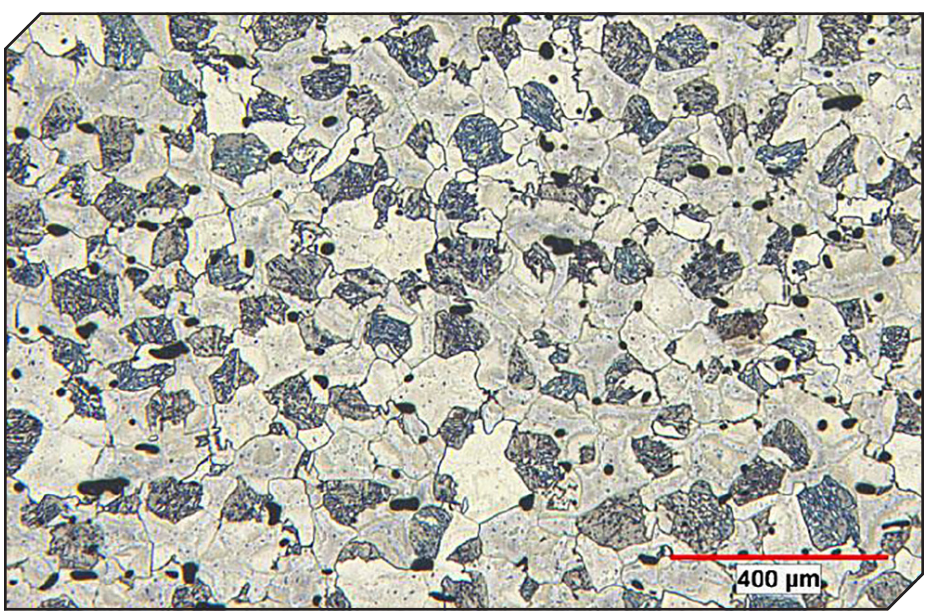
The Center for Powder Metallurgy Technology (CPMT) continues to work on numerous projects. Ongoing investigations include corrosion prevention, impact testing of gear teeth, joining PM components, variation reduction in the PM process and fatigue testing. The variation reduction investigation is a collaboration with the MPIF Technical Board, and the fatigue study is in coordination with the MPIF Standards Committee, resulting in new data for the MPIF Standard 35-SP.



Phoenix stepped planetary gear

MPIF, CPMT, and the National Science Foundation (NSF) have been champions of advancing the PM technology through educational outreach. Over the past 4 years, over 200 engineering students have been awarded conference grants through the efforts of these organizations. The grants provide the opportunity for the PM industry to showcase the technology to some of the brightest young minds that will someday, hopefully, select PM as their metal-working solution. MPIF, the European Powder Metallurgy Association (EPMA), and the Asian Powder Metallurgy Association (APMA) have continued collaborating to advance the technology through the Global Powder Metallurgy Materials Property Database. Launched back in 2004, the updated database is easier to navigate, download data, and best of all, it puts materials property data into the hands of the parts designers for free. The writing is on the wall. Whether we like it or not, the automotive industry will change due to ambitious efforts to curb the production of ICE propelled vehicles by 2035, and the trickledown effect will affect the entire PM industry. I believe the industry will be able to adapt and overcome, but we will need the mindset and resources to adjust to the changing environment.

There are unlimited opportunities for metal powders. Some of the most interesting research relates to sustainable solutions for our planet. For a digital copy of the PM Industry report, contact Dora Schember at 609-452-7700 or *dschember@mpif.org*.



The cross-section of the FSLA material shows the dual-phase microstructure after heat treatment. By the heat treatment, the proportion of the different phases and the grain size can be adjusted to achieve unique physical properties (photo courtesy of GKN Powder Metallurgy).

Dean Howard, PMT, President, MPIF.

PM Design Award Winners

The winners in the 2021 Powder Metallurgy (PM) Design Excellence Awards competition, sponsored by the Metal Powder Industries Federation (MPIF), demonstrate outstanding examples of PM's diversity. From electric vehicles to golf putters, these components use PM's flexibility to push forward new concepts and process controls to demonstrate the inexhaustible well of capabilities PM can marshal in the service of component design. Designers continue to choose PM for complex and critical applications such as automotive, medical devices, consumer products, hardware, and more. Six Grand Prizes and sixteen Awards of Distinction have been given in this year's competition.

Grand Prize Awards

A Grand Prize in the Automotive—Chassis Category for Conventional PM components was awarded to Phoenix Sintered Metals LLC, and customer Dana Incorporated, for a stepped planetary gear used in a ridged rear axle gear box for battery electric light commercial vehicles. It was essential to be able to deliver tight dimensional control for this complex shaped part. The five-level pinion is made using FL-4405-100HT. No other metal forming technology could provide the part geometry at a commercially competitive price.

In the Aerospace/Military/Firearms Category for MIM components, a Grand Prize has been awarded to ARC Group Worldwide for an enclosed striker used in the firing mechanism of a commercial handgun. The part is made in a 2-cavity mold, and strategic tool design and staging was implemented. Postsintering, HIP and heat treatment are performed to increase mechanical properties. The position of the tip to the primary body of the component is critical for part functionality. The parts are finished with an Enickel coating.

A Grand Prize has been awarded to Parmatech Corporation in the Hand Tools/Recreation Category for Metal AM components for a 316L stainless steel putter head made for Cobra Puma Golf and used in the King Supersport-35 golf putter. The use of AM technology allowed designers to place or remove material strategically to optimize mass distribution, stiffness, and the development of the unique lattice structure eliminated the need for supports during the sintering process. The flexibility also allowed production of both right- and left-hand versions of the putter head and hosel without the need for tooling changes.

A Grand Prize has been awarded to ARC Group Worldwide in the Hand Tools/Recreation Category for MIM components, for a quick disconnect assembly used for a variety of small handheld devices like binoculars, cameras, and firearms. Utilizing MIM allowed for a near-net-shape molded assembly and enabled the incorporation of smooth transitions and rounded edges as well as the elimination of any machining marks on the visible portions of the parts.

In the Hardware/Appliances Category for Conventional PM components, a Grand Prize has been awarded to Metalpo Ind e Com Ltda and their customer Groupe SEB — Arno Clock Krups Panex Penedo Rochedo, for a soft-magnetic composite (SMC) superior and inferior stator for a monophase induction motor for a ceiling fan. The component was specifically designed for the PM process to take advantage of the 3D magnetic flux, resulting in less copper wiring, a 76% reduction in the mass of the motor, and 35% less energy consumption and quieter operation.

In the Medical/Dental Category for MIM components, a Grand Prize has been awarded to OptiMIM for a compression frame used in Nextremity Solutions Lapidus System for holding and aligning the targeting drill guide during tarsometatarsal fusion. The parts are produced using MIM-420 stainless steel in a single cavity open and shut mold with two slides. The first forms the rectangular opening and the second the two holes at a 60° angle on the opposite end of the frame. The parts are sized in a die with two slides so that forces can be applied in perpendicular directions to the parts.

Awards of Distinction

In the Automotive—Transmission Category for MIM components, an Award of Distinction has been given to ARC Group Worldwide for a worm gear used in a transmission locking mechanism. MIM processing was selected because of the complexity of the helical gear teeth and the adjacent shaft geometry. Custom staging furniture is used for sintering the parts which require no secondary operations to be functional in the mating assembly.

In the Automotive—Transmission Category for MIM components, an Award of Distinction has also been given to Indo-MIM Pvt. Ltd. for an oil spray piston cooler. The MIM-4605 parts are used in the engine of heavy vehicles and were previously made by machining. Holes are formed by two different slide pins at different angles in the tool, and the side core has to travel through the center pin with a delay mechanism.

In the Aerospace/Military/Firearms Category for Metal AM components, an Award of Distinction has been given to 3DEO Inc. for a 17-4 PH stainless steel casing extractor for Glock brand pistols. A hybrid AM approach is used to make the parts that offers the robustness and accuracy of CNC machining and the scalability of MIM while overcoming the drawbacks of each process. The part has a complex geometry with several small, critical features.

In the Aerospace/Military/Firearms Category for MIM components, an Award of Distinction has been given to Indo-MIM Pvt. Ltd. for a frame chassis, part of a pistol assembly. The parts are made using MIM-17-4 PH in the H900 condition. Prior to MIM the parts were machined from bar stock by the customer. The MIM parts meet

80% of the required part features with the remainder being machined by the customer, reducing the machining cycle by 70%.

In the Aerospace/Military/Firearms Category for MIM components, an Award of Distinction has also been given to Advanced Powder Products Inc. and their customer Savage Arms for a bolt handle for a hunting rifle. The part assists with loading the next round of ammunition and in removing the shell after it has been fired. The complex curvature and intricate design presented challenges with molding and sintering. MIM processing was able to convert a two-piece design machined from bar stock to a single piece MIM part.

In the Lawn & Garden/Off-Highway Conventional PM components Category, an Award of Distinction has been given to Sintergy Inc. and their customer Knott Brake Company for a drum brake shoe for off highway units. The parts have localized infiltration to improve the region subject to wear. The PM parts replaced a three-piece weldment and passed extensive durability and performance testing.

In the Lawn & Garden/Off-Highway Conventional PM components Category, an Award of Distinction has also been given to Singhal Sintered Pvt. Ltd. for bush speed gears for tractor transmissions. The previously forged parts have an inner diameter spline with a step. Maintaining the tight spline tolerance during the heat-treatment process was challenging. Finishing operations include OD grinding and face grinding.

In the Hand Tools/Recreation Category for Metal AM components, an Award of Distinction has been given to 3DEO Inc. and their customer Blackland Razors for an open comb base plate used in a double-edge safety razor. A hybrid AM approach is used to make the parts that offer extremely tight dimensional tolerances that set the blade gap for this shaving razor.

In the Hand Tools/Recreation Category for Conventional PM components, an Award of Distinction has been given to Nichols Portland LLC for a positive displacement gerotor assembly for customized performance-racing fuel pumps. Racing applications require higher delivery pressures with fuel formulations that provide very low levels of lubricity. A novel material was developed to meet these needs in which a wear resistant hard phase is dispersed within a matrix.

In the Industrial Motors/Controls & Hydraulics Category for Conventional PM components, an Award of Distinction has been given to Capstan for a coupling handle used to prevent accidental disconnects. Previously a casting, conversion to PM permitted elimination of the casting gate, incorporation of a locational pin-button hole, and lettering. The coupling handles are used to provide improved pressure and temperature control capabilities in fluid power controls for a wide variety of applications.

An Award of Distinction has been given to Indo-MIM Pvt. Ltd. in the Industrial Motors/Controls & Hydraulics Category for MIM components for a casing and ground used in industrial gas sensors. Both parts require high magnetic permeability and low coercive field strength. The ground has many holes and threads, and the casing is a complex part with thin walls, sectional differences, and three threaded holes on the outer walls.

In the Hardware/Appliances Category for MIM components, an Award of Distinction has been awarded to Indo-MIM Pvt. Ltd. for a knob shaft, clutch, knob shield, core plug, core body, and control sleeve actuator used in door locks. The previously machined stainless-steel parts have intricate profiles, thin walls, multiple holes, blind threads, aesthetic requirements, and sectional differences adding to the complexity of the part.

In the Hardware/Appliances Category for MIM components, an Award of Distinction has also been awarded to ARC Group Worldwide for a key blade used in an electronic security system. Sintering requires custom staging to minimize distortion of the delicate geometries critical to part functionality. The parts require two sizing steps to ensure twelve critical dimensions meet the customer specifications. Fitment to the mating part and the aesthetic appearance of the primary visual surface was essential.

In the Medical/Dental Category for MIM components, an Award of Distinction has been given to ARC Group Worldwide for a pusher used in the ratcheting assembly for the consistent placement of high viscosity adhesives in incisions, used as an alternative to sutures or staples in surgical procedures. Strategic tool design, venting, and a 3-plate pin gate allow complete material fill of the complex part geometry, keeping distortion to a minimum and allowing tight profile and dimensional requirements to be maintained.

An Award of Distinction has also been awarded in the Medical/Dental Category for MIM components to Alpha Precision Group — Metal Injection Molding and their customer Elite Biomedical Solutions for an LVP door latch for an IV pump. The component has a tight tolerance on the hole position for the assembled roller. In use, the roller is latched on to a mating component that the company also makes to complete the latch/hook mechanism. The parts are made in-house from start to finish and the machining and multi-stage assembly are considered value added to the customer.

In the Electronics/Electrical Components category for MIM components an Award of Distinction has been awarded to Indo-MIM Pvt. Ltd. for a ceramic sensor used in an electronic device. The awards were presented here during the 2021 International Conference on Powder Metallurgy & Particulate Materials (PowderMet2021) and co-located conference Additive Manufacturing with Powder Metallurgy (AMPM2021) and Tungsten2021.

www.mpif.org