ASCO Sintering Co.

Contract Manufacturer of Precision Powdered Metal Parts

Precision Powdered Metal Gears – Net Shape to AGMA 8 Certification at reduced cost

Executive Summary

- **Asco produces over 16,000,000 precision gears per year with tolerances as tight as 0.00015"**
- **Short Run to Six-sigma with zero defects**
- **Achieve final net shape without expensive and time consuming secondary operations.**
- **Eliminate material waste and scrap lowering cost per part compared to other processes.**
- **Consistent section densities within a given part and part-to- part consistency.**
- **Non-Destructive Tested 100% Certifiable stock to AGMA 8**

Gear Processing at ASCO Sintering – Design and processing factors directed at achieving the extreme precision required for an AGMA 8 rated Gear Certification.

ASCO Sintering began its Powder Metallurgy (PM) operations back in 1964 and today is a leading manufacturer of a wide range of PM precision products, including production of over 16,000,000 gears per year to six sigma. The company possesses many years of engineering experience in PM design and manufacture. **ASCO** has, over time, developed innovative and proprietary tooling designs offering ever more precision and shape complexity during the compaction process. Of course the same innovation and experience applies to the processing parameters applied to six-sigma zero defect standards.

Because PM manufacturing is a poorly understood process please accept this background which will be helpful in understanding how the processing variables are controlled to eliminate "part to part" and "within part" variation: the PM manufacturing process entails starting with a raw material in the form of atomized metal powder. These highly engineered raw materials fill a die cavity and are then compacted at room temperature at compaction pressures which may exceed (50) tons per square inch (689.5 MPa).

The benefits of this process orient around capturing the final net shape without expensive and time consuming secondary operations. Inherent in the process is eliminating material waste and scrap. The "green" preform is ejected from the die and then, as a second separate operation, is processed thru an atmosphere controlled furnace where these metal particles are fused together. (Note: we do not melt the metal powder but use a solid state diffusion bonding mechanism) The retained porosity is predictable and controllable with its size predetermined by the prior particle size. Once the part is out of the furnace it could be considered a finished part or it could be machined, heat treated for higher strength or plated.

Gears are mechanical hardware that are used to transmit motion, speed, and directional change between axes. Gears are also highly engineered, with complex geometry and require high accuracy which makes them extremely well suited for manufacture in the conventional (mold and sinter) Powder Metallurgy Technology of **ASCO.** Very high production rates with robotic support yield production rates of thousands of parts per hour making for low cost production.

ASCO can design, engineer and manufacture gears that are tailored to provide optimum performance in your specific application. Gear forms available in PM include spur, helical, half worm, bevel, miter, sprockets, gear racks and epicyclic gear assemblies (sun, planetary and carrier).

So, what are the processing elements and how are they controlled that allow ASCO to achieve precise gear systems?

PM Tool and Part Design:

Fig. 1 Clutch rotor assembly consisting of four parts – an armature, rotor blank, bearing and pinion gear. The assembly operates in a motor drive for automatic sliding minivan doors and opening and closing tailgates. The parts are made to a net shape, except for the rotor which requires a turning operation on the hub. Innovative tooling provides the required part density to satisfy magnetic and strength properties of the rotor

The process starts when a table of gear data and a 3D solid model or CAD file are uploaded to **ASCO's** web-site. **ASCO** is assisted by using state of the art gear design software provided by SOLIDWORKS using Gear Trax. It is essential to have a design that can actually be made; by exchanging files we start a collaborative design process based upon the fundamentals of PM manufacturing. Once completed this guarantees that the final part design is locked and is used to generate the compaction tooling.

Controlling density: Within the part/between parts:

PM Manufacturing that the parts checked dimensionally in the green state will be a product of the tools themselves. It is also known that size change during sintering is very common. Size change during sintering can be a function of several things (furnace fixtures) but is mostly a function of density. Typically, areas of high density will shrink less than areas of low density. This differential shrinkage is synonymous with distortion. It should be noted that powder composition is also a factor.

Fig. 2 A sinter-hardened steel planetary gear system, featuring a carrier with an integrated sun gear and three planetary gears. The system is used in multiple stacks for gear reduction in a single-use, portable, physician-operated surgical device. In addition to the integrated pinion gear, the carrier includes three posts that extend above the flange with a 2 to 1 length-to-diameter ratio. Proprietary press mechanisms were required to achieve the post density, as well as a proper post-to-flange bond. The carrier is pressed, sintered and tempered to net shape. By integrating the posts to the flange through advanced PM manufacturing techniques and by the elimination of a secondary heat- treating operation through the use of modern sinter-hardening materials, the new part design achieved a 60% cost reduction.

ASCO's solution is to control density at the press. This is done with mechanical withdrawal compaction presses ranging from 4-220 tons that utilize the latest in electronic press control. Robotic offloading parts from the press eliminate errors induced by human touch. Most importantly, **ASCO** uses hybrid mechanical-pneumatic designs to deliver the powder into the die. These servo-mechanical and fluidized feed systems provide exact weight consistency. When this is combined with dynamic load-cell feedback technology from the tool members themselves control over the entire process is provided. This is especially important for section densities within a given part but also for part-to- part consistency within the run and from run to run.

PM Tool Fabrication – Benefits:

This PM compaction tooling is another key element in Powder Metal Gears-

PM tooling (dies, punches and core rods) is manufactured using tool steel and/or carbide by wire EDM. During assembly they are ground, fit and polished to a micro finish with tolerances as tight as 0.00015" This tolerance is necessary so that the powder will not bind the tooling. Tooling of this precision will produce parts with the same degree of precision. So, rather than CNC machining parts individually across potentially several set-ups, the PM tooling provides consistency of involute form and its relationship between pitch diameter and the outside gear diameter. Since "Total Composite Error" (TCE) and "Tooth-Tooth Error" (TTE) measurements are controlled by the tooling, the same degree of accuracy is realized.

Using hard tooling for gear profiles has another benefit in that the gear measurement specification can be designated as the static measurement over wire (MOW) or the more dynamically favored test radius (center of gear to Pitch Diameter). These can be independent of one another allowing adjustability in the circular tooth thickness.

Of course involute tooth forms manufactured with plastic or other prototype methods such as SLS (Selective Laser Sinter) or DMS (Direct Metal Sintering) can be easily converted to PM manufacturing.

Non-Destructive Tested 100% Certifiable stock:

Fig. 3 This idler pulley is made for a major snow blower manufacturer. The component is made from a machineable grade of FC-0208-50. The splines and precision bores are all pressed in net shape with only the pulley grooves being machined. Bearings are press fitted into the bores and these parts see constant engagement / disengagement during operation. Part strength and freedom from manufacturing defects are all important.

Verifying dimensions and AGMA Gear Quality:

ASCO Sintering Co. is committed to the principles of SIX SIGMA/Lean Manufacturing with (16) Green Belt Engineers staffed at all levels of the company. ASCO Sintering knows Gears. Gear quality is measured dynamically on a Vari-Roll gear-testing instrument utilizing master gears certified by the National Institute of Standards and Technology. This system using the Vari-Corder can provide a written record of the gear data.

Fig. 4 Automation is successfully integrated at ASCO with robotic systems helping to reduce the number of employees required to maintain 24 hour operation at the manufacturing facility

At **ASCO Sintering** we are industry leaders in the implementation of both Acoustic Resonance Testing and Acoustic Emission Testing. These advanced state of the art inspection techniques allow for 100%-Certified stock to be provided. Manufacturing defects can be detected and suspect product contained, allowing for analysis and corrective action activities to take place. The principal entails testing the parts without damaging the parts and measures them against a known standard. This is combined with our real-time "Networked SPC" data collection to ensure only the highest quality product is shipped to our customers. While we prefer functional part tests, mechanical testing is also available. Our services also include prototype development, flexible supply chain solutions, like Kan Ban, JIT, and a Quality System that is **ISO-9001:2008 Certified.**

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