

**You might be surprised to learn how long powder metal materials have been in use, and understanding its past will give you a true appreciate for its current applications.**

**P**owder metal technology is older than that of cast iron. Although the use of powder metals has been in existence since 3,000 B.C., and utilized by both the Egyptians and Incas, it is only in the 20th century that it has gained widespread use in manufacturing. It was in the early 1900s that the first successful industrial application of P/M was used for the tungsten filament in electric light bulbs. In the early thirties it made its appearance in metal cutting shops, being used for tungsten carbide cutting tools. In the second World War P/M was in common use. Circa 1960 we see some of the first gears produced by this method. In the sixties P/M gears were in automobiles—a GM six-speed transmission contains 26.1 lbs of P/M material—and aircraft engines in the eighties. Since that time spur, helical, bevel, spiral face gears, and racks have been produced. Internal and external teeth can be produced in the same ring gear, and keyways can be molded into the ID during processing.

The first major improvement in its manufacture arrived with the technique of hot isostatic pressing, introduced by the Batelle Memorial Institute in 1960. This allowed metal powders to be consolidated with reduced porosity. In the United States the first use of a commercial forging process using heated compacts occurred in 1965, and the nineties saw powder forging, injection molding, warm compacting, and die compacting used to produce gears. Spraying and treatments such as carburizing and vacuum sinter hardening widened the number of applications. Heat treatment is basically as it is with wrought steel, with the possible exception that P/M mate-


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rial carburizes faster. The surface and core have approximately the same carbon content, and the porosity influences the carbon penetration.

In 1985 Gorham International obtained U.S. patent 4,591,482 for a new process named pressure assisted sintering. This allowed a number of alloys to be fully densified with much lower isostatic pressures. Surface densification of the highly stressed region is carried out so the core is unaffected. The many benefits include a pore-free case and porous core, improved gear geometry, and tolerance from rolling with a precision die. The teeth can also be crowned. The production techniques, combined with new alloys, continue to improve the gear quality. Near fully dense gears are possible with less than 1 percent residual porosity.

Gears for the automobile industry are forged. The method is to form a “green compact” that has been pressed into shape

at room temperature, a preform, which is then sintered, producing a net shape. The mass produced pieces are then forged to reach their final density. Isostatic pressings can be hot or cold and produces complex shaped parts by compacting in a pressurized fluid. Conventional injection molding machines are fed with a variety of P/M materials and any other required ingredients. While conventional technology did not produce the bending performance of wrought steel gears, however, advanced techniques—including shot peening—has to all practical purposes eliminated, if not markedly reduced, the disparity.

A series of tests were performed in Germany, with the results fully reported in ASME/AGMA 2003 at the International Power Transmission and Gearing Conference. The Metal Powder Industries Federation and ANSI/AGMA produce standards that are cross-referenced with ISO and ASTM. MPIF standards are divided into three categories: Material Specifications, Test Methods, and P/M Press Safety. The material standard contains 11 material systems. Also provided is information on machining, hardenability, coefficient of thermal expansion, fracture toughness, and corrosion resistance. Machining being sometimes required for drilling cross holes and improving inside diameters. The Test Standard contains information on surface finish measurement (Std. 58), preparation of test specimens (Std. 60), determination of oil content and interconnected porosity (Std. 57), and determining Charpy Impact Energy (Std. 59). With the support of MPIF, ANSI/AGMA standard 6008-A98 was produced to assist in clearing up any confusion between the gear supplier and their client. 

### ABOUT THE AUTHOR:

William P. Crosher is former director of the National Conference on Power Transmission, as well as former chairman of the AGMA's Marketing Council and Enclosed Drive Committee. He was resident engineer-North America for Thyssen Gear Works, and later at Flender Graffenstaden. He is author of the book *Design and Application of the Worm Gear*.