HOTSEAT

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A discussion of the 3D heat-treatment process called Direct Metal Laser Sintering.

SELLING THE WHEEL, a book by Jeff Cox, tells the story of Max, a stone-age entrepreneur who creates the wheel and is looking to market his invention and endeavors to seek advice from several experienced sources. It's such a new and unheard of method of moving that Max thinks the potential is unmatched in the history of mankind.

Fast forward to the 1980s and I'm witnessing, during an ASM International tour of Sandia Labs in New Mexico, a demonstration of a device called "rapid prototyping" now called 3D printing or, more accurately, additive manufacturing. Like Max's wheel, it's a product looking for applications and potential to improve the manufacturing process for all mankind if you believe the marketers.

Now leap again to the 21st century. 3D printing is a manufacturing process that is fascinating to watch. For those unfamiliar with this technology it takes the concept of ink-jet printers and marries it to injection molding, creating items that, by any other method, would be either impossible to manufacture or too expensive to be practical.

Think of that ink-jet printer as it smoothly traverses back and forth across the printer platform laying down a thin layer, about 0.005 inches [0.127 mm] thick of melted ABS plastic and continues until one layer of an image is complete. Then it again does the same motion, but this time the printer head raises off the previous layer and deposits another 0.005" [0.127 mm] layer. This sequence with input from a 3D solid model CAD program continues until a full-sized, hold-in-your-hand crescent wrench fully operating with rotating thumb wheel appears like magic.

This is Fused Deposition Modeling, a subcategory of 3D printing, a technology invented decades ago that is now attracting investors as a method of manufacturing almost anything in a final ready-for-use process. An amazing example of this technology was described to me by Robert E. Bailey III, Capt. USAF, assistant professor, Department of Engineering Mechanics, Center for Aircraft Structural Life Extension (CAStLE). Rob describes how a thermal plastic model V8 engine complete with operating connecting rods, pistons, all of the usual parts is made. Many commercial components are manufactured this way today and most are made from ABS thermal plastics. For example, air intakes for automobiles would be a typical item if they could be produced en masse, but here's the rub: the crescent described above took four hours to make. Due to the "make anything" capability, additive manufacturing technology is attracting users such as NASA, the military, medicine, dentistry, and of course the automotive industry.

This is great stuff but what does it have to do with gears? In addition to ABS thermal plastics, metals are also being printed, but with a different 3D process called Direct Metal Laser Sintering. This process, according to Rob Bailey, directs a printer head-mounted laser to scan a bath of powder metal like Inconel, 17-4 PH, or ferrous alloy in a similar layer-by-layer fashion that instantly fuses metal particles to each other wherever the laser is directed. When complete, only the metal particles that have fused to form the part are lifted from the metal powder intact, ready for further processing if required. Because the metal is essentially melted, the microstructure resembles a casting and as such will likely be brittle, necessitating further heat treatment.

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It's entirely possible to make ferrous gears, but with today's technology this may require further processing to increase density or heat treatment to improve durability in industrial or automotive applications. Obviously one big advantage of additive manufacturing is net shape or near-net shape forming saving material and machining time. Other metals like cobalt, stainless steel, and titanium are also being printed into various shapes. Today, implants for hips and knees are being printed via Direct Metal Laser Sintering technology in Europe.

But it's a huge leap forward to create ready-made gears that can stand up to the strength and wear durability required for automotive applications. The ones to advance the technology to make ferrous products more durable will be the recipients of the research dollars. Just think of an automotive differential housing, ring gear, planetary and sun gears, and bearings all made in one operation. Sounds like a huge stretch with all of the technology that's required to make those components today, but you can bet somewhere in some laboratory it's being investigated.

How is it possible that parts made this way that can move separately, like connecting rods and crescent wrench thumb wheels? Again, Rob Bailey describes how the print head applies a special filler material where space between two opposing parts must exist then continues to apply the ABS plastic. When the wrench is complete it's immersed in water, which dissolves the filler material, leaving the independent parts free to move.

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