HOTSEAT

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WHAT DO MAX THE STONE-AGE ENTREPRENEUR, Ben Franklin, and your daughter's hamster have in common? All have contributed indirectly to the latest development in [EV] electric vehicles: Motor-in-wheel locomotion. This ongoing development was recently announced by Ford to advance their EV effort where the (stator and rotor) windings of an electric motor are integrated into the center of the wheel, on all four wheels.

The concept of a wheel-motor is not new, having its beginnings in the late 1880s with dozens of variations over time as enabling technologies improved. Presently, Ford is offering a twist by designing the independently controlled wheels to rotate almost 90 degrees, providing a unique parallel parking assist. The primary difference between motor-in-wheel technology and existing systems is the lack of a transmission and drivetrain, resulting in a drive-by-wire transportation system that provides for enhanced drivability and safety, not to mention more usable space.

GM (and others, no doubt) are working on their particular drive-by-wire variations to help them conform to 2025 CAFE standards. Hybrids are the most common version of EV with a small internal combustion engine that powers a generator. The generator then, in turn, powers the electric motor and/or charges the battery and provides power after it has lost its initial charge. Until batteries for a non-hybrid EV can hold a charge for at least 200–300 everyday, stop-and-go miles, they will always be a minor player.

It's no surprise that the most direct and cost effective route to improved fuel mileage is the continued refinement of existing automobile technology, namely the internal combustion engine and associated drivelines. As the number of speeds in an automatic transmission increase, the horsepower required to move a car from zero to 70 mph is reduced. The advantage of multiple speeds in a transmission can be immediately felt when skipping a gear in a manual transmission, especially when driving a four-cylinder car. It's then very easy to see how a smaller engine can be made more effective with a transmission with 10 or more speeds.

I mentioned several columns ago that gas nitriding has been the recipient of considerable interest by automotive transmission suppliers, either OEM or tier one providers. So much has distortion become an issue that the added material cost for nitride capable steels is becoming a common denominator for many. And with the advancement of hard turning technology, gears can be fully machined after heat/quench and temper, because the 26 to 32 HRC is easily machined even with conventional tools. To duplicate the tooth root-to-root core hardness values to that of carburized and quenched lower alloy steels, grades such as 4140 are tempered 50°F to 100°F (10°C to 37°C) above the nitriding temperature so the core hardness can be preserved with the sometimes long nitriding soak times. Nitriding in the traditional sense has been perceived as a very long process with 40 to 60 hours not uncommon. However, for multi-speed automobile transmissions, especially the higher speed gears, long processing times are not required. As automatic transmissions move to double-digit speeds the load that any one gear is expected to endure is that much less, thus shallower nitrided case depths will suffice. Tooth wear, however, is still a requirement and nitriding can easily provide that parameter.

Moving a car from a standing start per unit of time requires substantially more energy than is required to keep it moving, thus lower speed gears will require higher strength and deeper case depths so carburizing is likely to still be in the program.

Due to the sheer number of gears needed per year for the quantity of cars produced even for one manufacturer, continuous endo carburizing furnaces have been the standard for production, and for critical gears, special quench processing is required for distortion control. That presents two options: oil press quenching and HPGQ (high pressure gas quenching). Press quenching except for unique considerations can only be practically done with continuous furnaces mainly pushers, whereas HPGQ is a batch process. That's not to say HPGQ couldn't be employed from pushers—it's been done, by AFC-Holcroft. That leaves the OEM and tier one supplier with a decision: Which are the most cost effective when capital equipment and operating cost are the metric?

One of the requirements depending on a gear's mass when HPGQ is considered is the hardenability of the steel. This also happens to be the same constraint with nitriding, because the steel must have sufficient alloy to not only achieve the core hardness but retain that hardness during hours of process time. Since nitriding is also a batch process, the determining factor becomes how many parts can be processed per hour in one batch to meet the high volume needs of the auto industry.

In HPGQ, the overall load and an individual gear's mass are critical considerations when quenching for hardness uniformly. However, size is not an issue in gas nitriding, because a fast quench speed is not required.

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