Five-star software and four-wheel-drive

Complex parts for hillclimber require CAD/CAM magic

Nobu Okawa reviews the imported solid model of the transfer case housing and cover before beginning the Mastercam toolpathing process.

Chances are, if you've watched national motorsport races, ogled at the latest concept cars or had experience with specialized military vehicles, you have come in contact with the California-based Rod Millen Group–gearheads extraordinaire.

In Millen-designed competition vehicles, such as the four-wheel-drive Toyota Tacoma Unlimited Class Hillclimb Vehicle, a critical factor is minimizing weight. With regard to racecar parts, it's a factor in winning. Weight affects handling, acceleration, braking and total car performance. Accordingly, Millen engineers often use multiple pockets and slots to minimize component weights.

These pockets are not the simple shapes one might expect. They often have protruding irregular bosses. All edges and corners, except at the mating plane and pocket bottoms, are designed with complex corner and outside radii to reduce stress concentrations.

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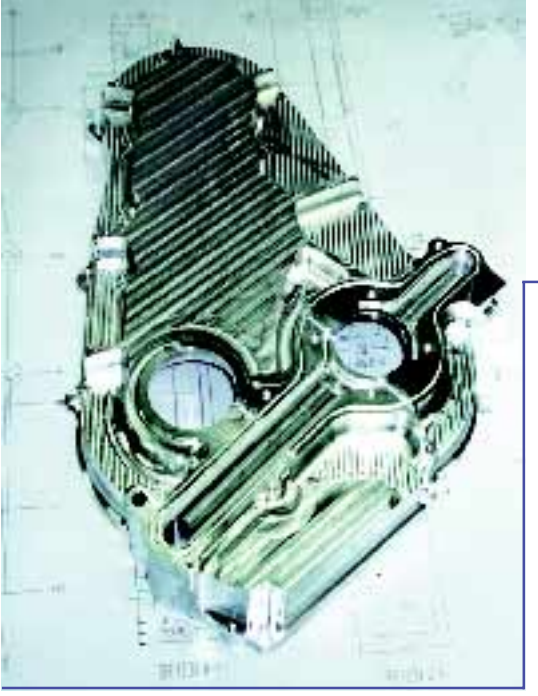
Although large numbers of these parts are not required, their accuracy, finish and speed of production are of the utmost importance. Many parts are machined directly instead of casting or other secondary operations, often saving time and money.

But for this phase of Rod Millen production to be successful, the CNC machinist must produce a part with complex surfaces quickly and without mistakes—and much of this burden falls on the CAD/CAM software.

Machining goals

Generally speaking, a transfer case is an engineering marvel to begin with. In a four-wheel-drive vehicle, this gearing device splits engine output between the front and rear wheels.

Now take a look at the transfer case housing for Toyota's Rod Millen-designed 4WD Toyota Tacoma Unlimited Class Hillclimb Vehicle. That housing represents the way advanced CAD/CAM features enable machinists to accomplish the engineers' goals. Specifically, how easily solid modeling is imported and machined with 3D rough toolpathing; how intelligent feed rate optimization keeps production at maximum efficiency; and how 2D finish toolpaths make accurate, high-tolerance finishing automatic. In short, the transfer case housing reflects how state-of-the-art CAD/CAM software helps wrangle the power of 900 "horses."



An inside look at the transfer case housing for the Tacoma, designed to be as light as possible yet serviceable throughout the racing season. Consider the complex pocketing and subtle radii.

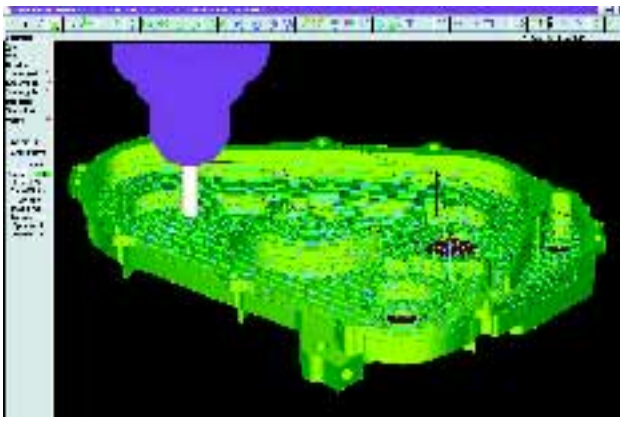
CNC programmer/operator Nobu Okawa says Mastercam software "is powerful enough to manipulate almost any solid file and create, analyze and correct for bad surfaces in associated surface files prior to machining. The impressive thing about Mastercam's CAD engine is that it's really designed for machinists."

Each transfer case housing, with its variety of pocket sizes, steps and bosses, is machined from 18″ × 10″ × 2″ 6061-T6 aluminum. Okawa first drills the assembly bolt holes, which serve as locating points for the whole machining process. "I start 3D machining inside first using a ¾″ end mill," Okawa says, "rough it all, and cut the outside edges with a ½″ 3-flute end mill. Then I turn the piece over and rough the front side with the ¾″ tool. I leave 0.020″ to 0.030″ on both sides for the finish path."

He says he uses Mastercam's multisurface "pocket" roughing toolpath for each side because of the complicated part features and the varying depths of the pockets. "The pocket roughing toolpath automatically avoids the radius area of each pocket. Otherwise, I would have to leave ¼″ of stock, making the finish pass with 2D toolpaths and small stepovers of smaller tools unproductively slow. I have also found over time that Mastercam's fully associative toolpaths make reprogramming so much easier when engineering calls for modifications to these unique parts. We just make a change to the model or the tooling and Mastercam updates the toolpath."

Intelligent feed rate

The job of accelerating the roughing process while protecting the tool and the part finish is then handed over to Mastercam V8's Intelligent Feed Rate Optimization function. Okawa sets a few parameters, including the highest usable feed rate and the slowest feed rate demanded by maximum material volume. The program allows this combination to be



The inside finish toolpath is created with contour and pocket toolpaths generated with 'radius in' and 'radius out' entry and exit.

saved as a stock parameter for future use in similar applications.

Once activated, Intelligent Feed Rate Optimization links itself to the toolpath and automatically reduces feed rate anywhere cutting conditions change—in deeper pockets, for instance. "Without feed rate optimization," notes Okawa, "I would have to use the slowest feed rate over the entire piece. This might take 25 percent longer. With our kind of production schedules, we can't afford any extra time."

The inside finish toolpath is created with contour and pocket toolpaths generated with "radius in" and "radius out" entry and exit, and a 10-percent overlap to minimize tool marks. Okawa achieves the bearing bore tolerance of 0.0005″ by using the "fine bore drill" cycle with 0.01″ stepover. This cycle retracts the boring bar to Nobu's specified distance of 0.010? at the end of the bore cycle so that damage does not occur to the accurately finished bore surface.

Outside finishing, including 0.06″ rounded edges, uses a corner rounding end mill over the 3D toolpath. Where rounded edges meet a solid plane, the surface mating is especially complex. Here, as in other parts of the transfer case housing and cover, Mastercam's constant scallop toolpath creates a constant finish over even the most complex geometry.

The Tacoma has hit a few bumps in the road recently, including the loss of sponsorship in 2001. But it's ready to race again, with the kind of results it posted in 1999. That year, the Tacoma took 1st overall, 1st in the unlimited class and clocked 10:11.15, nudging Millen's own track record of 10:04.06. Not a bad track record for the Rod Millen team—especially for one very proud programmer/machinist named Nobu Okawa. **Mastercam/CNC Software Inc., Tolland, CT, *www.RSLeads.com/204tp-267* or circle 267.**

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