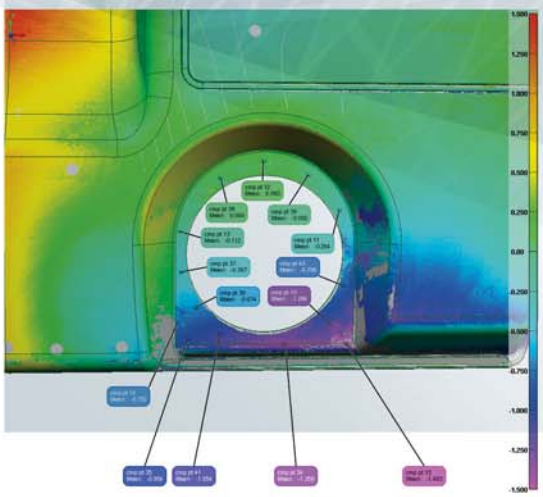
InnovMETRIC Software

CASE STUDY



ShapeGrabber and InnovMetric Help Molder MPC Make Timely Auto Parts Production Decisions

Company overview

Customer

MPC

MPC Incorporated, Walworth, Wisconsin, USA, is a large, high-volume injection-molder of under-hood components sold directly to the automakers. The company is a full-service supplier of thermoplastic injection, extrusion and suction blow molded assemblies and subassemblies.

MPC's solutions for product design and manufacturing encompass engineering, analysis, prototype support and tooling as well as on-time, low-cost production molding. The privately held company employs over 1,000 people in three Wisconsin plants and 500 in Mexico. MPC stands for "Miniature Precision Components."

The business partner

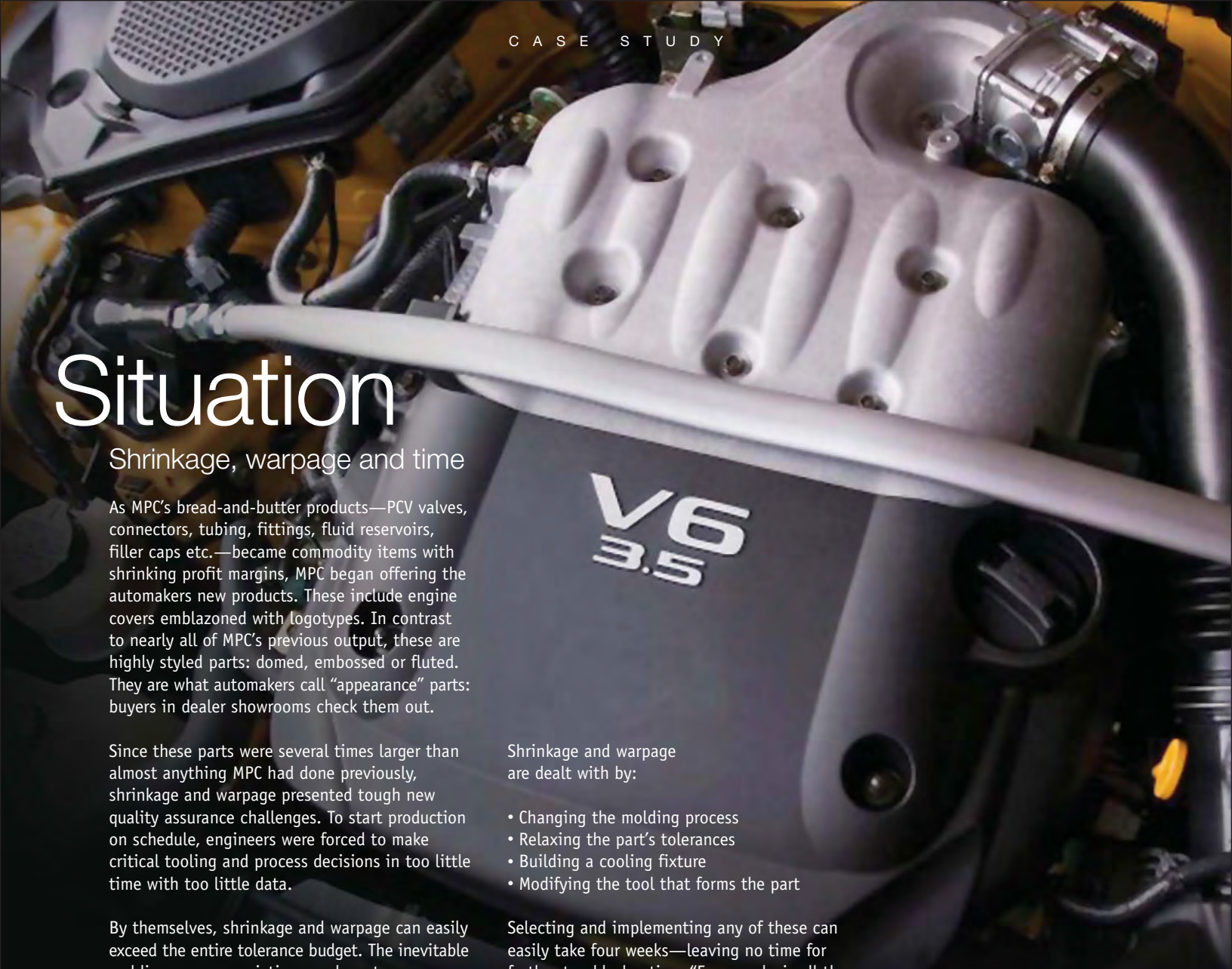
ShapeGrabber Industrial 3D Inspection

ShapeGrabber Incorporated, Ottawa, Ontario, Canada, designs, manufactures and markets cost-effective 3D laser scanners and 3D laser digitizers for inspection, modeling and reverse engineering.

Its scanners and digitizers bring speed, accuracy and full coverage to computer-aided inspection of complex shapes. ShapeGrabber gives designers accurate and timely feedback from prototypes and lets production staff make rapid pass/fail decisions, confident that the entire part's surface has been inspected.

PolyWorks®

Total Point Cloud Inspection and Reverse-Engineering Solution



Situation

Shrinkage, warpage and time

As MPC's bread-and-butter products—PCV valves, connectors, tubing, fittings, fluid reservoirs, filler caps etc.—became commodity items with shrinking profit margins, MPC began offering the automakers new products. These include engine covers emblazoned with logotypes. In contrast to nearly all of MPC's previous output, these are highly styled parts: domed, embossed or fluted. They are what automakers call "appearance" parts: buyers in dealer showrooms check them out.

Since these parts were several times larger than almost anything MPC had done previously, shrinkage and warpage presented tough new quality assurance challenges. To start production on schedule, engineers were forced to make critical tooling and process decisions in too little time with too little data.

By themselves, shrinkage and warpage can easily exceed the entire tolerance budget. The inevitable molding-process variations push parts even farther out of specification.

As always with the automakers, time is the essence of the business relationship. MPC allows itself just four weeks after receipt of a mold to start production and submit sample parts.

Dimensions need to be within a tolerance "budget" of +/- 5 mm (about 0.200 inch). That has to accommodate all process, material and tooling variations.

Gregory Clark
Inspection specialist
MPC Inc.

Shrinkage and warpage are dealt with by:

- Changing the molding process
- Relaxing the part's tolerances
- Building a cooling fixture
- Modifying the tool that forms the part

Selecting and implementing any of these can easily take four weeks—leaving no time for further troubleshooting. "Four weeks is all the window we have to tweak and stabilize the molding process," Clark said, "and we have to cover a lot more than shrinkage and warpage."

MPC solved its shrinkage and warpage problems using a ShapeGrabber 3D laser scanner and the point-cloud-based inspection software suite PolyWorks, from InnovMetric Software Inc.

Savvy MPC management turned the solution into a pair of competitive advantages:

Faster time to market and a higher degree of quality assurance!

Why touch-probing, mold-flow analysis and photogrammetry fall short

The big difficulty molders face with shrinkage and warpage is that they have separate causes. Shrinkage is material related; it ranges from 2% to 14% and may vary between resin batches. Warpage is related to cooling and the designer's use of thick and thin sections. Successfully addressing these dimensional and tolerance challenges requires a lot of analysis and calculation plus years of experience.

Moldmakers start designing a new tool with estimated shrinkage values from the plastic resin's material safety data sheet (MSDS). To deal with warpage, moldmakers apply their knowledge of gates, vents and water lines. But until a tool is built and run, shrinkage and warpage are only educated guesses.

Prior to laser scanning and point-cloud-based inspection, molders had no surface-inspection tools that were both comprehensive and quick. The best available methods were touch-probing with a coordinate measuring machine (CMM), mold-flow analysis and photogrammetry. All fell far short.

Touch-probing

Touch-probing misses tiny bumps, sags and, as Clark pointed out, "more subtle things like a warpage shift in the pitch of a pair of X and Y points that twists another point out of its Z tolerance." This is why thoroughly inspecting a surface requires 500,000 three-dimensional (3D) points and sometimes a million or more, rather than the few hundred that touch-probing provides.

Moreover, Clark added, "the CMM takes seven working days to set up a job, two more days to measure, and another five days after that to crunch all the data. Because the CMM is always busy, we may need to wait another seven days to get a place in the queue. So with point-by-point methods, we have at best only two tries to get it right."

Mold-flow analysis

Mold-flow analysis is computer simulation that predicts how a resin will shrink and warp based on the location and size of the tool's gates. There are three big drawbacks:

- Nominal dimensions are used rather than actual inspection data from the part; subsequent mold revisions can't easily be accommodated.
- Predictions of warpage are theoretical and digital only. Moving beyond mold-flow's virtual realm requires refinements that moldmakers may refuse to provide.
- Like any simulation, mold-flow analyses contain implicit assumptions and numerical values that might not hold up in the real world.

"We need to know what actually happened in the mold, not what was supposed to happen," said Clark. Mold-flow analysis is also costly—up to $12,000 per tool—and usually consumes two of those allotted four weeks.

Photogrammetry

Photogrammetry is literally measuring with high-resolution photography. Photogrammetry captures surfaces several times larger than laser scanners do but glued-on targets may be required for alignment. Once the photos are digitized, they can be readily compared with a downloaded CAD file, or can be uploaded to a CAD file as a surface patch.

Photogrammetry was tried as an alternative to check fixtures and gages for engine vacuum harnesses. "The inspection problem is that they are different for each engine," Clark said. "In the 13 years I have been here, we have bought over a thousand gages that probably cost a total of $3.5 million. These are black parts so they photograph poorly if at all," he added, "and we always have issues of ambient light and depth perception in the Z axis."

The data MPC needs

Solution

To inspect plastic parts, MPC uses the ShapeGrabber Ai810C scanner. This multi-axis scanner is the most automated 3D scanner available on the market today, and allows the user to request a complete part scan with a single mouse click: the system does the rest.

This ease of use is due to the use of multiple scan axes (horizontal and vertical), as well as a 3rd rotary axis on which the part is placed. All of these axes are calibrated into the same reference frame, such that multiple scans are automatically aligned. By setting up the required scans for a given part ahead of time, the complete set of scans is easily automated.

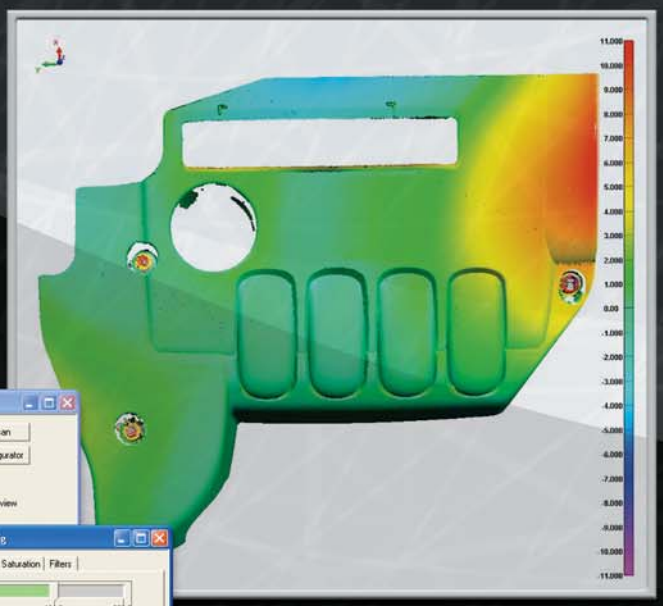
The setup process only takes a few minutes due to the very large depth of field (DOF) of the ShapeGrabber scan heads. This large DOF allows the scans to be setup using a simple and intuitive graphical user interface since it is not necessary to closely follow the complex contour of the part like most other scanners.

The ShapeGrabber scan heads acquire the data a speeds varying between 18,000 and 150,000 pts/s, so that it only takes a few minutes to generate a complete point cloud representing the part. This data file is then easily processed by PolyWorks Inspector to complete the inspection process.

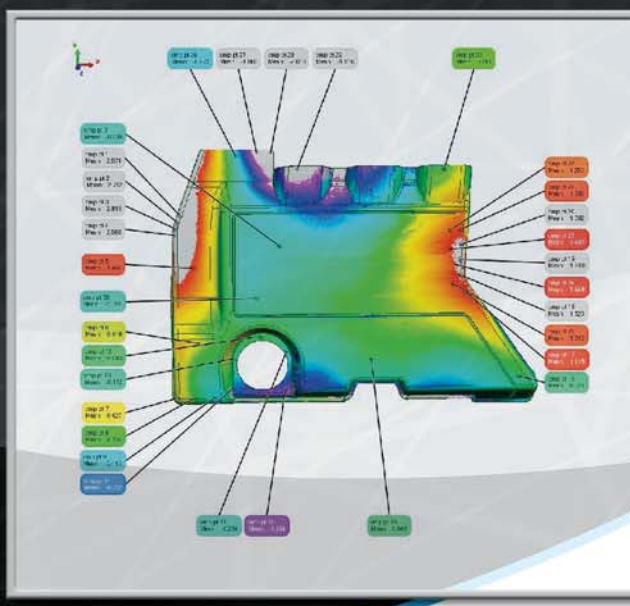
The combination of speed and ease of use of the ShapeGrabber scanner makes the scanner accessible to a larger number of users, and reduces the setup and inspection time, drastically reducing the inspection cost compared with alternative methods.

in 15 minutes instead of days

User interface



Color map of data-to-CAD comparison



Picking specific comparison points

Point-cloud-based inspection in PolyWorks

MPC's engine cover inspections are now done with full-color maps of tolerances in the PolyWorks/Inspector™ suite. PolyWorks compares the millions data points obtained by the ShapeGrabber scanner to the reference CAD model. MPC specialists sets tolerances in PolyWorks to determine the acceptable and non-acceptable deviation between data points and CAD model. The display uses the entire color spectrum from red (plus tolerances, too much material) to blue (minus tolerances, too little material).

Because the color map's tolerance band is adjustable, it's an excellent tool for what-if analyses. "The color maps let us see what is really going on inside the mold, which surfaces are affected by changing a tolerance, and by how much," Clark explained.

"What the color map really shows us," he added, "is how the plastic part floats inside the mold. We know the material of the part will shrink into its proper dimensions and the warp during cooling will bring it into the shape its designer called for."

If MPC engineers need to check something not originally specified in the inspection layout, they just click on the point in the data or add points by rescanning. In either case, it's just a matter of minutes.

Before, the CMM had to be reprogrammed. "To add even a single touch-probed point, you had to start all over again," Clark said. "That never takes less than two days."

For users at MPC and its customers, ShapeGrabber and PolyWorks was the only system that could:

- **Keep pace with production rates and inspection frequencies**
- **Pass standard repeatability and reproducibility (R&R) tests that certify inspection systems**

In an R&R test, an operator measures a feature on 10 parts three times. Then a second operator measures the same feature on the same 10 parts three more times and the results are compared. PolyWorks and ShapeGrabber successfully passed these tests.

All the other laser-based approaches were way too slow. None of them could gather the necessary data in less than two or three hours.

Gregory Clark
Inspection specialist
MPC Inc.

Finally, enough time for tough production decisions

"Within minutes, instead of two or three weeks, scanning gives us all the surfaces data we need to choose among the production options," said Clark. "We get the alignment and formatting from PolyWorks in very close to real time. Finally, we have enough time to make the tough production decisions."

He added, "because we can gather all the dimensional and tolerance data we need in so quickly, we have several additional days to engineer and analyze each job. That extra time is a huge help as we decide whether to seek looser tolerances, modify the tool, change the process in some way, or have a cooling fixture made."

The time gained also means engineers can go back for a second look. This might include suspect areas in a new batch of sample parts. "ShapeGrabber and PolyWorks help us throughout the entire setup process," Clark noted.

"We believe MPC achieved a two-week return on investment (R-O-I) with ShapeGrabber and PolyWorks," he added. "They have given us two new competitive advantages: uncompromising quality assurance and speedy starts on production."

ShapeGrabber™ Ai810C scanner

With 3D scanning and point-cloud-based inspection, we now have several additional days to make critical business decisions. ShapeGrabber and InnovMetric help us throughout the entire setup process.

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Inspection specialist
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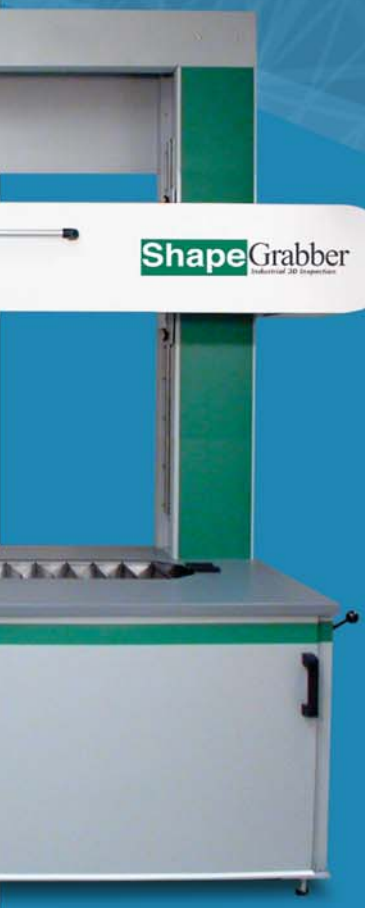

Benefits

Succeeding in a demanding new market

The real test of the effectiveness of a new technology is whether its benefits extend beyond needs of the users in their everyday tasks. In the larger enterprise, those benefits show up in speedier starts for production, more engineering and analysis time, and increased flexibility of methods.

ShapeGrabber and PolyWorks score on all three points:

- Improved quality assurance that helps MPC make sure parts will be molded as required—before samples are submitted to customers.
- Eliminating numerous additional dimensional checks, allowing tools and processes to be locked down sooner for production.

- Increased inspection flexibility, which allows more production options to be evaluated and more time for mold design and tryout. That translates directly into MPC's new competitive edge—better parts sooner—and happier customers.
- Shortened time to market. While rivals waste days or weeks with touch-probe inspections, MPC gathers 500,000 to a million-plus points on a surface in minutes.
- An enhanced ability to penetrate new markets. MPC moved in one jump from strictly functional, seldom-seen parts to highly stylized, right-in-the-buyer's-face engine covers.

PolyWorks®
By InnovMetric Software Inc.

InnovMETRIC Software

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