

CASE STUDY

Metalworking – Heat Treatment: Distortion Reduction on Automotive Pinion Gears

QH MARTEMP™ 1340 (formerly MAR-TEMP™ 355)

The Challenge

A global Automotive OEM manufacturer was heat treating pinion gears used in large pickup trucks in his US manufacturing sites. The parts were furnace-heated, carburized, and quenched to attain a martensite structure. The quenching process involved cold quench oil and a racking method that held 32 parts stacked in a pyramid formation with the pinion heads pointed downward.

During quenching, the shaft in these parts exhibited distortion of up to 2 mm, causing:

- Extreme rework with nearly all the parts needing to be straightened
- High scrap rate
- Short fatigue life and high residual stress of the pinion gears
- Increased transmission noise with the installed part
- Excessive warranty costs due to failures of transmissions

The company was looking to reduce this distortion and improve the part quality.

The Solution

Quaker Houghton proposed a comprehensive solution to the problem. They recommended the use of an accelerated hot quench oil, QH MARTEMP™ 1340 (formerly MAR-TEMP 355), and conducted a thorough evaluation of the heat treatment process. By transitioning from a cold quench oil to a mar-tempering oil, the thermal gradients were significantly reduced, thereby minimizing the thermal and transformational stresses, residual stresses, and distortion. To gain a deeper understanding of the quenching and the rack design interaction, the QH team utilized advanced Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) software to simulate the effects of the quenchant flow.

Our team of experts devised a racking system composed of 40 parts with the pinion heads oriented upward and arranged offset to ensure proper flow

The Benefits

With the implementation of QH MARTEMP™ 1340 and the modified approach, the quenching process:

- Realized \$17 million in savings as reported by the automotive OEM
- Increased production by 25% by utilizing the new racking design
- Significantly decreased the distortion rate from 2mm down to 0.01mm
- Achieved a substantial reduction in rework, scrap, and warranty costs
- Resulted in decreased noise in the transmission
- Gained a long-term customer with our expert methodology

Process and Equipment

PRODUCT TITLE	PRODUCT INFORMATION
Parts	Pinion Gears ANSI 8620 steel
Equipment	Quench Tank
System Size	3500 Gallons (several systems)
Process	Oil Quenching

circulation. Leveraging the power of CFD, we conducted a simulation for the flow distribution in the quenching tank, flow uniformity around the workload, and agitation to determine the heat transfer coefficients. FEA was then used to assess the distortion level, residual stress, and temperature, ensuring a comprehensive evaluation of the solution.

After extensive iterations and scenario testing, the simulation data validated the racking system, mar-tempering product parameters, and agitation rates, resulting in the elimination of distortion in the pinion gears.



The Product

QH MARTEMP™ 1340 high performance accelerated hot quenching (martempering) oil is designed for applications where minimum distortion is required. Its short vapor phase and a very high cooling rate allows for optimum hardness and physical properties in heat treatment applications. The product has a high flash point, excellent oxidation, and thermal stability which will ensure maximum oil life under arduous operation conditions.

This quenching oil can be used at temperatures up to 375°F (190°C). QH MARTEMP™ 1340 has been used applications at a temperature range of 250°F to 350°F (121°C-177°C) in sealed furnaces for distortion control on critical high precision components such as bearing rings or automotive transmissions parts in through hardened, carburized and carbonitrided steels.

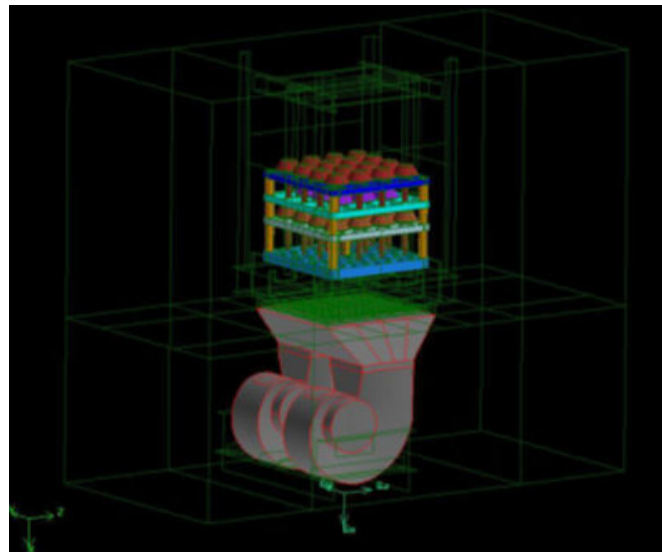


Figure 1: CFD design to evaluate the proposed quenching process with QH MARTEMP™ 1340