# Carburizing for Our Troops

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Supporting our troops in times of war requires sacrifice, perseverance and innovation. The heat treating community was asked to perform a vital service for the war effort and vacuum carburizing answered the call.

The brave men and women serving in Iraq and fighting the war on terrorism have faced constant obstacles these past three years. Although we are painfully aware of the insurgent bombings and the constant fighting, a less obvious foe is the local geography and atmospheric conditions of the Iraq countryside. The sand of this desert nation causes constant abrasion, as well as wear and tear on the equipment and firearms of our troops. Battlefield conditions tend to abuse firearms, particularly the components making up the trigger assembly (Fig 1), which have been wearing out or malfunctioning at an alarming rate, causing grief and life-threatening conditions. This introduces the need for unexpected maintenance and increased concern for the troops.

Bob Hill, President of Solar Atmospheres' Hermitage, Pa. facility, was approached by a customer specializing in high technology machining and asked if there may be a way to improve the surface hardening of their trigger components being sent to the front. Bob offered the services of Solar's new low-torr range single-chamber vacuum-carburizing furnace. The benefits of the process include improved wear resistance, case depth uniformity, and bright clean parts with minimal distortion.

Low-torr carburizing is followed immediately by high-pressure gas quenching in the same chamber. The gas-quenching system reduces distortion on cooling, and the furnace system itself is designed to provide exact temperature control and precise control of acetylene gas mixtures and flow rates for optimum case depth uniformity.

The success of this project required a research and development effort. Although the component material is 9310 alloy steel, chemistry variations can cause problems. Taking into account the actual lot chemistry, the k value (carburizing constant) for Equation 1 could be calculated.

$$D = k\sqrt{t} \qquad (1)$$

Using this equation, one can determine the time (t) needed to get a specific case depth (D). Equation 1 does not, however, indicate the diffuse time/boost time ratio ($R = \tau_\delta/\tau_\beta$). Alloying elements such as nickel and chromium can vary in 9310 materials, and these elements influence the amount of retained austenite and carbide formation, which may occur during the carburization process. Therefore, adjustments must be made to the carburization process to ensure that the carbon has diffused in accordance with the requirements, and that there is not too much carbon on the surface, resulting in carbide or retained austenite formation, which affects the hardness profile. By raising the R value in the process, boost time is decreased and the diffuse time is increased, resulting in a reduction in the residual carbon on the surface, thereby decreasing the possibility of carbide formation and austenite retention.

Once the carburizing process had been optimized, the post-carburization processes such as in-situ gas quench, tempering, and freezing were addressed. It is the post-carburizing treatment that will ensure the conversion from an austenitic structure to a martensitic structure, which will ultimately improve the hardness traversal of the part and provide protection from wear and tear as the part is used in the final product.

Metallographic analysis allowed fine tuning of the post-carburizing treatment to provide a uniform carburized case, required by the customer, and to achieve excellent metallurgical properties with minimal distortion for an extended wear life of the trigger components (Fig 2).

The carburization process used produced an effective case depth of 0.011 in. (Fig 3) and a high-quality tempered martensitic microstructure with no primary carbides and minimal retained austenite.

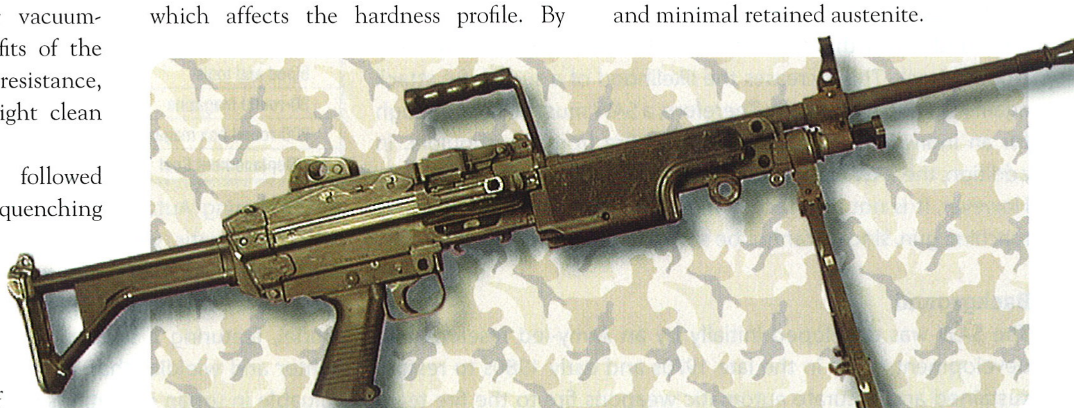

**Fig. 1 Squad Automatic Weapon (SAW) showing trigger assembly**

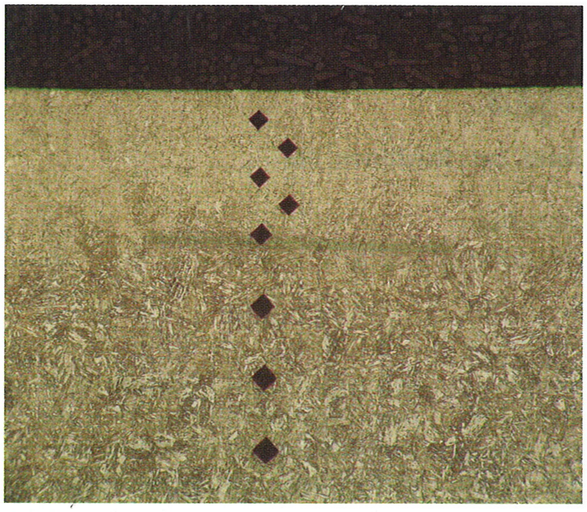

Fig 2 Carburized Trigger Photomicrograph

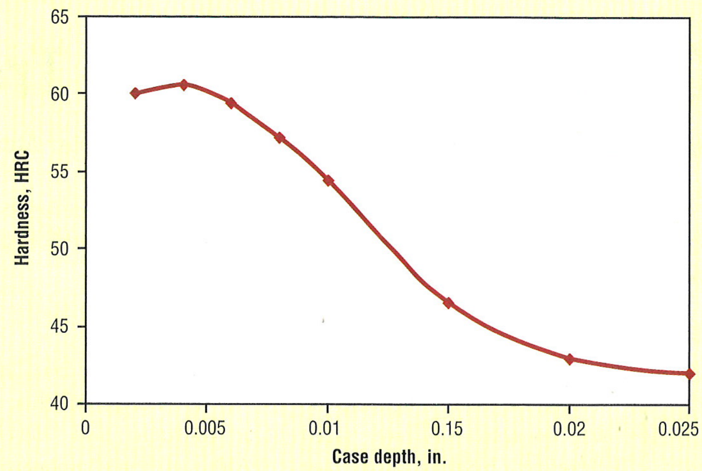


Fig 3 Case Depth and Hardness Profile

The R&D efforts of the Solar carburizing team have gone from the laboratory to the production stage and over the past several months, Solar has provided its customer with thousands of successfully carburized parts (Fig 4). Trevor Jones, process engineer states, "This current effort on the trigger components has enabled Solar's vacuum carburizing to move from research and development to full production. Solar Manufacturing's vacuum-carburizing furnace (Fig 5) has provided case hardening with excellent turnaround. The cycle is quick, and the process has achieved excellent metallurgical properties with minimal distortion for extended wear life."

Solar is proud that its vacuum carburizing R&D efforts and its new production capabilities have provided reliable trigger components, which should improve the quality of the military equipment, help lessen the maintenance requirements in the field, and increase the confidence of our troops. **IH**

## Squad Automatic Weapons

**The automatic rifle is a vital part of the squad leader's arsenal. The squad automatic weapon (SAW) is a light or general-purpose machine gun, usually equipped with a bipod and firing a rifle-caliber bullet from a standing, kneeling, or prone position. It is used to provide suppressive fire for an infantry squad.**

The basic use of this weapon is to force enemy troops to take cover and reduce the effectiveness of their return fire while friendly troops attack. This increases the likelihood of a successful attack against an enemy position. Therefore, a SAW must be light enough for an individual soldier to carry and fire from the shoulder. In addition, the SAW can be used to defend against a massed assault. However, it is not as effective in this role as a medium or heavy machine gun, since it cannot be set up to cover preset arcs of fire.

### Background

The SAW was developed initially by an Army-led research and development effort in the late 1970s and early 1980s to restore sustained and accurate automatic weapons fire to the fire team and squad. The SAW filled the void created by the retirement of the Browning Automatic Rifle (BAR) during the 1950s because other automatic weapons had failed as viable "base of fire." Operation Iraqi Freedom saw the advent of the M249 Para-SAW for some U.S. Army and Marine Corps infantry units. This updated model, featuring a shorter barrel and collapsible buttstock, is lighter and wieldier than its precursor. It has proven especially valuable in urban operations such as room clearing where tight spaces decrease the effectiveness the full size SAW.

**Table 1 Performance Specifications**

| Feature | Description |
|---|---|
| Primary function | Hand-held combat machine gun |
| Effective range | 3281 feet (1000 meters) for an area target |
| Maximum range | 2.23 miles (3.6 kilometers) |
| **Rates of fire** | |
| Maximum | 1000 rounds per minute |
| Cyclic | 725 rounds per minute |
| Sustained | 85 rounds per minute |
| **Weight with:** | |
| bipod and tools | 15.16 pounds (6.88 kilograms) |
| 30-round magazine | 1.07 pounds (.49 kilograms) |
| 200-round box magazine | 6.92 pounds (3.14 kilograms) |
| **Unit Replacement Cost** | $4,087 |

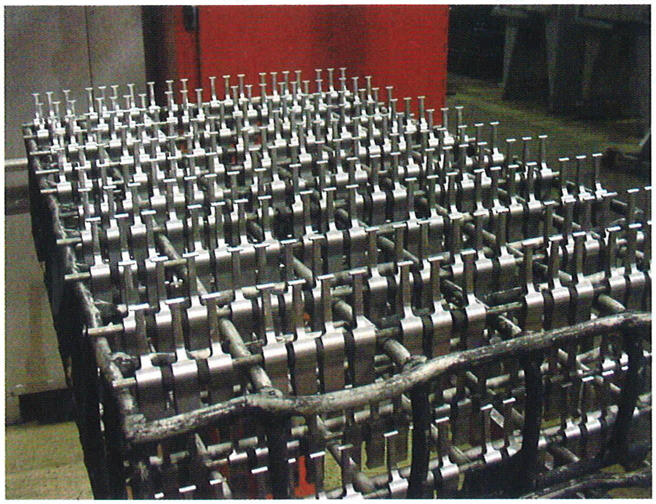

**Fig 4 Typical Production Load of Triggers**

**Fig 5 Production Vacuum Carburizing Furnace**

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## References:

1. Osterman, Virginia, *Development Experience in Low – Torr Range Vacuum Carburizing*, Industrial Heating, September 2005.
2. Herring, Daniel H., *Practical and Scientific Aspects of Low Pressure Vacuum Carburizing*, Industrial Heating, 2001 Heat Treating Conference Proceedings, ASM International.
3. Antes, Harry, *A Method for Calculating the Gas Flow Rate for Vacuum Carburization*, Heat Treating Progress, July/August 2005.

Additional related information may be found by searching for these (and other) key words/terms via BNP Media LINX at www.industrialheating.com: carburizing, case depth, carbon diffusion, retained austenite, carburization, martensitic transformation

## Ammunition

The SAW is equipped to fire the improved NATO standard 5.56 mm cartridge. The preferred combat ammunition is a four-and-one mix allowing the gunner to use the tracer-on-target (TOT) method of adjusting fire to achieve target kill.

## Performance Features

The Squad Automatic Weapon (SAW) is an air-cooled, belt-fed, gas-operated automatic weapon that fires from the open-bolt position. It has a number of impressive performance features (Table 1) including a regulator for selecting either normal 750 or maximum 1,000 rounds per minute rate of fire.

When used as a machine gun, the SAW requires a tripod, a T&E mechanism, and a spare barrel. These items increase stability, the ability to make minute adjustments in aiming, and the ability to fire greater than three-round bursts. Because machine guns are not as mobile as automatic rifles, they normally remain with and form the key weapon of the base-of-fire element.

**SAW in Action in Iraq**