# Meet the Next Generation of Tool Steels

...developed to take on the demanding tasks of blanking, forming and trimming the latest-greatest HSLA and AHSS sheet steels.

BY PATRICIA MILLER

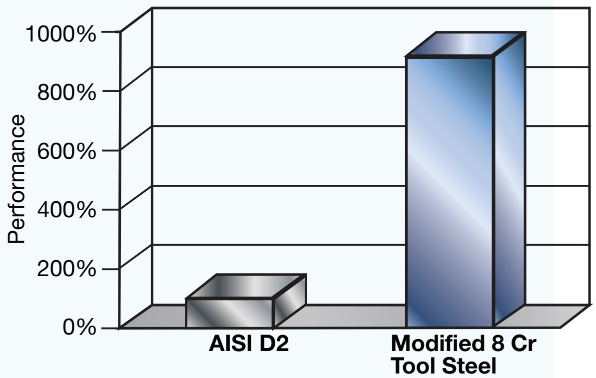
Changes within the automotive industry with respect to crash worthiness, while still meeting ongoing criteria for reduced fuel consumption, have catapulted the industry toward the use of high-strength low-alloy (HSLA) and advanced high-strength steels (AHSS), for critical functional components previously produced from mild steels. As automotive OEMs celebrate these accomplishments, metalformers are left with the difficult tasks of blanking, forming and trimming these new steels, which places escalating demands on the tooling being used.

Metalformers working with these new alloys no longer can depend on conventional tool steels, such as AISI D2, to give them the production performance they're used to seeing. Therefore, tool-steel grade development and improvements in production methods are working in tandem to allow the manufacture of new higher-strength, tougher and more ductile tool steels. These new tool steels are made possible only by an improvement in steel homogeneity and purity resulting from improved remelting technology and from the third generation of powder-metal (PM) alloys.

*Patricia Miller is senior technical manager, Bohler-Uddeholm Corp., Elgin, IL: 800/638-2520, www.bucorp.com.*

### Case Study: 8 Cr Tool Steel Outperforms D2

Stamping the luggage-rack crosstie shown here, of a hot formed and hardened steel (22MnB5, 1.25 mm thick), overloaded the AISI D2 cutting punch and lead to premature edge chipping. The switch to a new 8 Cr cold-work tool steel, formulated via electroslag remelting, dramatically improved tool life.




## New Grades Developed Through Remelting

Enhancements made to the electroslag remelting (ESR) process have enabled tool-steel providers to develop cleaner and more homogeneous alloys. This special remelting technology ensures low micro- and macro-segregation and gives the tool steels the cleanliness and homogeneity required for optimum performance in service. The table below shows the composition of two of these new 8 Cr cold-work tool steels.

The excellent property profile of these 8 Cr steels also serves to bridge the

**Tool Steels Manufactured with Electroslag Remelting**

| | C | Si | Mn | Cr | Mo | V | Additions |
|---|---|---|---|---|---|---|---|
| Modified 8 Cr tool steel (K340) | 1.10 | 0.90 | 0.40 | 8.30 | 2.10 | 0.50 | Al and Nb |
| 8 Cr + Vanadium tool steel (K360) | 1.30 | 0.90 | 0.35 | 8.75 | 2.70 | 1.20 | Al and Nb |

| Enhanced PM Alloys | C | Cr | Mo | V | W | S |
|---|---|---|---|---|---|---|
| A11 (K294) | 2.45 | 5.2 | 1.3 | 9.7 | – | 0.09 max |
| M4 (S693) | 1.33 | 4.1 | 5.0 | 4.1 | 5.9 | 0.02 max |

gap between the 5- and 12-percent chromium steels. Their well-balanced chemical composition and the ESR process afford a homogeneous tempered martensitic matrix, largely responsible for their relatively good toughness.

Adhesive wear is one of the primary types of damage encountered during the use of cold-work tools. Contact between the tooling and the workpiece leads to local material adhesion. The subsequent separation of the workpiece from the tool involves micro-crack formation, which does not always take place exactly in the original contact area and thus causes additional adhesive wear. Both of these new 8 Cr alloys exhibit very high resistance to adhesive wear.

To evaluate the resistance to abrasive wear of these alloys, the pin-on-disc method was used and weight loss after certain time intervals was measured. The modified 8 Cr alloy performed similarly to the 12 Cr grade, while the 8 Cr + V grade exhibited improved abrasive-wear resistance compared to the 12 Cr steels.

## High-Performance PM Steels

Highly alloyed steels are difficult materials to cast, because of the presence of high amounts of alloying elements (chromium, tungsten, molybdenum and vanadium) and carbon in these alloys. These elements segregate during solidification and form a carbide network, which makes the cast steel very brittle.

During hot working, the network is elongated and individual large carbide particles may be reduced to smaller sizes, but the final product will still have a rather coarse and nonuniform microstructure. Laws of nature provide the driving force for segregation, therefore the only remedy is to not give the law of nature enough time to act. If an ingot is small enough, it can be made to solidify so quickly that segregation is reduced to negligible levels—this is the basic idea behind producing highly alloyed tool-steel powders by atomization. A standard cast ingot needs hours to solidify, while a powder particle needs only fractions of a second for complete solidification. That means a powder particle is a very small ingot.

Solidification time greatly affects alloy microstructure and therefore the PM alloys' metallurgical and mechanical properties. Uniformity of structure is exhibited over the entire cross section; the tool steels produced exhibit an increase in toughness and fatigue strength by as much as 20 percent.

## PM Selection

Two new tool-steel grades that have resulted from enhancements made to the PM process are depicted in the table above, the first an AISI A11 cold-work tool steel (K294) and the second an AISI M4 high-speed PM tool steel (S693).

The success of these alloys is well recorded. The A11 cold-work tool steel serves in applications requiring a high degree of compressive strength and wear resistance, such as blanking and trimming operations where abrasive wear and edge retention are critical success factors. And, M4—a universal high-speed steel that can achieve hardness levels of 64 Rc—gets the call in high-pressure applications. The high-temperature tempering of both of these PM alloys provides a stable substrate for coatings.

Advancements to the powder-metallurgy production process now permit finer distribution of the sulfides within these alloys, which has lead to improved uniformity and enhanced mechanical properties. Their more uniform and homogeneous structure minimizes the negative impact of sulfide additions into the matrix, while still providing improved machining characteristics. **MF**