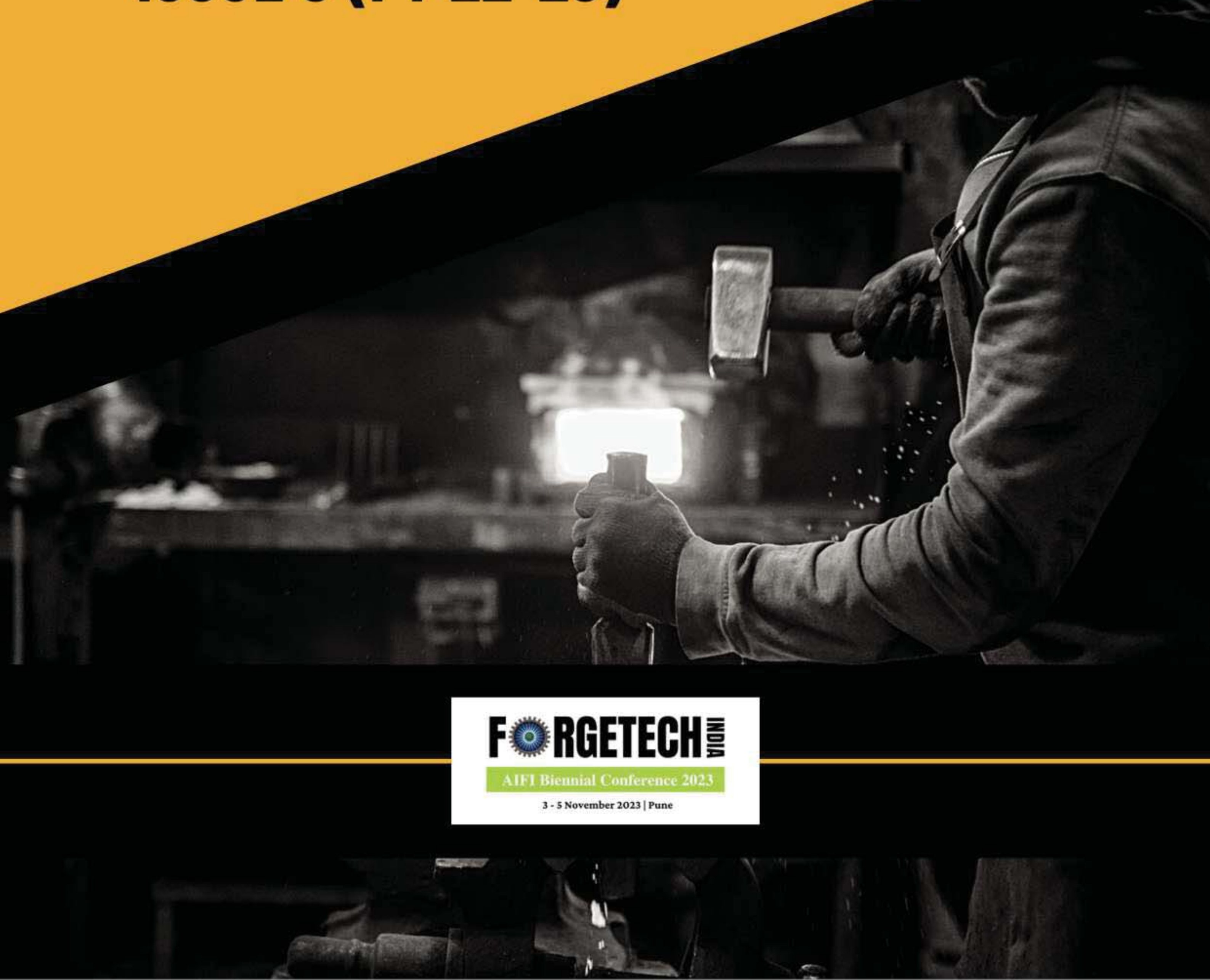
AIFI

Association of Indian Forging Industry

FOCUS

ISSUE 3 (FY 22-23)



FORGETECH INDIA

AIFI Biennial Conference 2023

3 - 5 November 2023 | Pune

IMPROVING DIE PERFORMANCE FROM A VIEW OF A TOOL STEEL PRODUCER

by Philipp Görts

In order to be competitive as a producer, cost optimization has always been the top priority. In the field of metal forming, a significant lever can be increasing the tool life, especially in series production. In addition to setting the right forging parameters, the selection of the die material and the hardness of the tools used in production are important factors. The metalworking industry in particular is in a state of upheaval and is under constant pressure from global competition. Also, the change in mobility is gaining pace and already taking place. This affects all manufacturers of large series, who have to deal with competing manufacturing processes and the elimination of components due to the switch to electric drives.

The service life of a forging die is determined by many different influencing factors. In addition to preheating and maintenance of the die, the machining and forging process also influence the service life of the die. The reasons for failure of dies can be summarized as cracking, plastic deformation and wear, with wear describing about 70 % of the reasons for failure [1].

Since tool wear is the main reason for failure of forging dies, the approach to reduce wear is an efficient way to extend die life. According to the German industry standard DIN 50320 [2] wear is described as the continuous material loss from the surface of a solid body caused by mechanical reasons. The wear mechanisms are distinguished in adhesion, abrasion, tribological reactions, and surface breakdown. Usually, not only one but a combination of those wear mechanisms is involved in the degradation of a surface. The wear mechanisms occurring during forging are, in particular, abrasion, surface breakdown and adhesion, with tribological reactions being of secondary importance. According to different studies [3-5] and further practical experience, wear occurs mainly where large quantities of forging material move over the tool surface with high surface pressure and relative speed, accompanied by high heat transfer.

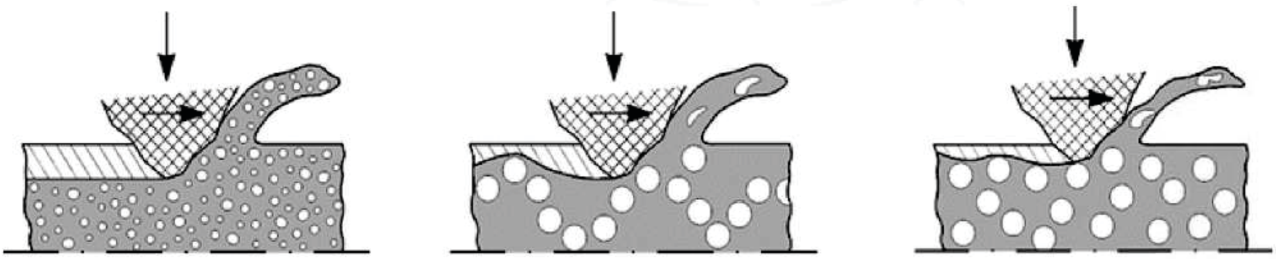
Influence of the microstructure on wear

The microstructure, and in particular the hard phases known as carbides, have a major influence on wear due to the effectiveness of the wear mechanisms mentioned above. The influence of the microstructure is described below in relation to abrasive wear. Basically, the hardness of the tool steel used can be increased to minimize abrasive wear. There are two ways to increase the hardness: The first way is to increase the hardness of the martensitic structure. This can be done by increasing the carbon (C) content.

The second way is through the precipitation of carbides, so-called precipitation hardening. This is based on the precipitation of iron carbides and primary carbides.

As shown in Figure 1, the abrasive wear mechanism also depends on the size and distribution of carbides in the matrix, as well as on the shape and size of the abrasive material.

Very small and finely distributed carbides do not resist abrasion as well as larger, inhomogeneously distributed carbides. Only carbides with a certain size and a homogeneous distribution exhibit adequate abrasion resistance.



Fine homogeneous distributed carbides	Bigger carbides in a network structure	Homogeneous dispersion of bigger carbides

Figure 1: Influence of carbide size and distribution concerning wear resistance (according to Berns [6]). Large homogeneously distributed carbides provide the highest wear resistance.

A homogeneous distribution of carbides can only be achieved by sufficient forming of the hot-work tool steel. It is the combination of sufficient forming and proper heat treatment of the tool steel results in a fine martensitic microstructure and carbides of appropriate size and distribution which are essential for a high wear resistance.

Tool steel solutions for forging dies

Simply increasing the hardness of a die, however, does not usually lead to success. While a low hardness favors wear, a high hardness can favor the risk of tension cracks. It requires an intensive coordination between hot-work tool steel, forging process and parameters, and forged component, in order to provide the optimum tool performance. This also explains why there can be no universally applicable hot-work tool steel that provides the best results for all forging processes.
Particularly for wear-intensive forging dies (e.g. blocker dies in press forging), Kind&Co has developed the premium hot-work tool steel Cr7V-L which has established itself well on the market and convinces with significant improvements of performance compared with standard steels. In comparison to H13/1.2344, the chromium content in Cr7V L is increased for an even higher wear resistance. For a higher hardness, the carbon content is increased as well (compared to H13). This improved chemical composition allows the tool steel Cr7V L to provide a more advanced hardness and wear resistance at the same time.

Although the general capabilities of a hot-work tool steel is determined by its chemical composition, the metallurgical melting processes, the forging process and the heat treatment in the steel mill drastically influence the property profile of a steel. By optimizing these parameters, the best combination of properties for the intended application can be achieved.

In Figure 2, the microstructure of Cr7V-L with the appropriate process technology and heat treatment shows fine-grained martensite with distributed carbides, which meets the requirement profile for wear intensive forging dies.

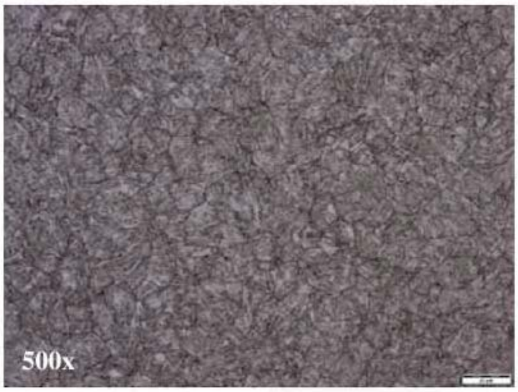


Figure 2: fine-grained martensitic microstructure image of Cr7V-L in 500x magnification

In many different applications, the use of Cr7V-L has significantly increased tool life. For example, in the manufacture of crankshafts, the tool life was increased by 43 % by switching from H13 to Cr7V-L. When manufacturing a suspension part for the automotive sector, the die made of H11 usually failed due to micro-cracks and wear. By switching to Cr7V-L, the service life could be increased by over 40 %.

In addition, the premium steel Cr7V-L has proven to be advantageous especially in the pre-forging stage. The temperature of the work piece is at its highest in this forging stage. Therefore, good tempering resistance is required. The pre-forging stage is where most of the forming takes place. Here, the material flow is greatest at the die surface, which leads to intensive abrasive wear.

While wear is the main cause of failure for blocker dies, for finisher dies it is mostly cracks in tight radii and less frequent wear. In the finisher forging stage the dies are subjected to slightly lower thermal and abrasive stresses than in the pre-forging stage. Higher demands are placed on keeping tight forging tolerances. Therefore, tool steels with higher toughness are required to prevent or delay cracking. With the premium steel LMF, Kind&Co offers a material concept tailored to the growing requirements in finisher dies. LMF is the economical solution for finisher dies, providing good wear resistance with high toughness and improved tempering resistance. Due to its property concept, it is also ideally suited for modern aluminum forging, where high toughness is required due to the adhesive tendency of aluminum. Usually tool steels for aluminum forging are remelted using the ESR-process (in order to provide more toughness). However, Kind&Co has adapted the production concept for this steel so that it can dispense with the expensive remelting process step. By eliminating the need for a remelting treatment, LMF is a cost-effective alternative for tool steels for finisher dies in steel forging and for aluminum forging.

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