Importance of fracture toughness on the performance of coated tool steel

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Abstract

In forging, stamping, punching and fine blanking applications tools are exposed to very demanding contact conditions, including high impact loads, high contact pressures, elevated temperatures and wear. Thus tool surface is subjected to complex combination of mechanical, thermal and tribological loads, which lead to fatigue, chipping, plastic deformation, galling and wear of the tool. As the market, especially automotive industry focus toward the use of new light-weight high-strength materials, which are more and more difficult to form, also requirements on tool properties including fatigue and wear resistance are becoming more demanding. One way of improving tool performance, already very successfully proven in cutting tool operations is application of hard wear resistant coatings. However, beside complex shape of forming tools and high tendency of commercial hard coatings to galling, limited load-carrying capacity and impact loading resistance greatly restrict the use of hard coatings in forming applications. Load-carrying capacity of the substrate can be simply improved by increasing substrate hardness. However, under dynamic impact loading resistance to crack initiation and propagation is even more important than wear resistance, with high hardness and high fracture toughness not being properties easily obtained simultaneously. On the other hand, processes including vacuum heat treatment, plasma nitriding and deep cryogenic treatment allow optimization of the tool steel microstructure in respect of obtaining higher fracture toughness while maintaining high hardness.

The aim of the lecture is to highlight the importance of substrate fracture toughness and hardness vs. fracture toughness ration on the performance of tool steel, especially when coated. By using different combinations and parameters of vacuum heat treatment, deep cryogenic treatment and plasma nitriding, resulting in different hardness vs. fracture toughness ratios effect of fracture toughness and the potential for improving load-carrying properties and wear resistance of PVD and PACVD coated tool steel will be discussed, including the effect of coating type (monolayer, multilayer, nanocomposite). At the conference load-carrying capacity evaluation method and results showing the potential of different substrate pre-treatment procedures to tailor mechanical, tribological and load-carrying properties of coated tool steel will also be presented.

Keywords: coatings, tool steel, fracture toughness, wear, load-carrying capacity