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Processing of nanoparticle-enhanced tool steels by means of Laser Metal Deposition (LMD) for the additive manufacturing of customized bulk forming tools

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In tool making, the focus of Laser Metal Deposition (LMD) is actually set on the repair of worn out tools, or the deposition of wear- and corrosion-resistant coatings. According to the state of the art the established materials are low-carbon maraging tool steels and customized powders such as Stellite 21. In contrast to traditional hot- and cold-work tool steels, which are typically used as material for bulk forming tools, those types of steels possess an excellent weldability due to the low-carbon content. However, for the majority of applications in the field of bulk forming the mechanical strength and wear resistance of low-carbon tool steels especially under thermal and dynamical load is not sufficient. In this context, the use of traditional high-carbon tool steels is absolutely necessary. The processing of traditional tool steels such as 1.2343 [1, 2] or 1.2358 [3] by means of LMD has already been proven within the scope of several scientific studies. Thereby, the focus was, among others, set on the resulting microstructural and mechanical properties. Within the scope of these investigations it could be demonstrated that after an appropriate post-heat treatment the mechanical properties of specimens manufactured by means of LMD are comparable to the mechanical characteristics of post-heat-treated specimens fabricated by subtractive manufacturing technologies.

A promising approach to enhance the mechanical strength and to improve the practical performance of additively manufactured tools could be to modify the initial tool steel powders with certain kinds of nano-scaled additives prior to the manufacturing process. In the presented work the processing of 1.2343 powder modified with carbon black or tungsten carbide nanoparticles in varying concentrations by means of LMD is investigated in detail. The scientific aim was to identify the influence of the added carbon black nanoparticles on the process ability, the microstructure and mechanical part properties. For that purpose, specimens were generated and analyzed with respect to relative density, inner defects, microstructure, Vickers hardness, chemical composition and mechanical characteristics. We could prove that by adding those types of nanoparticles to the initial powder, the final microstructural, chemical and mechanical properties can be manipulated. By this way the mechanical hardness and mechanical strength can be significantly enhanced in comparison to the unmodified tool steel samples [4].

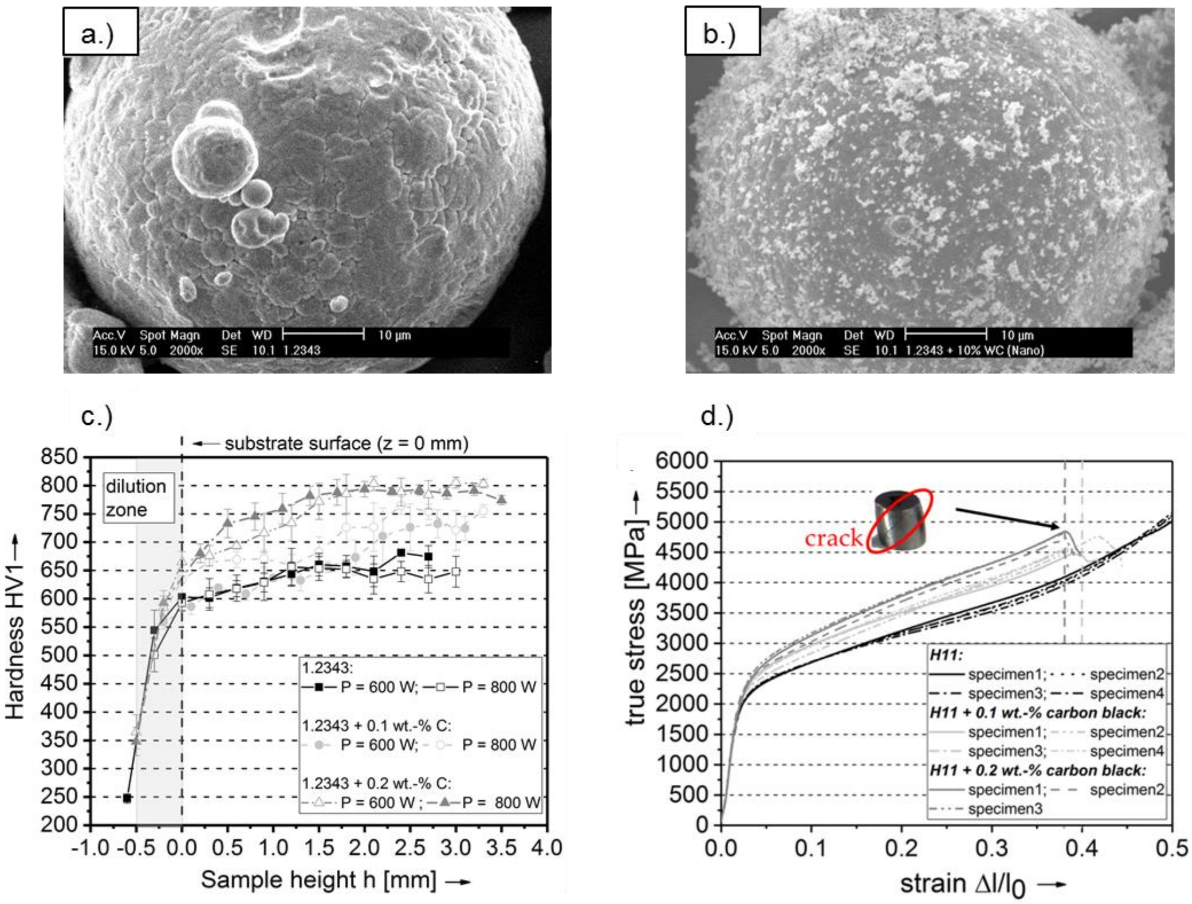

Fig. 1. SEM-image (a) of unmodified tool steel powder (x 2,000); (b) with 7.5wt.% WC nanoparticles; (c) hardness profiles of samples manufactured on basis of different tool steel powder mixtures [4] and (d) stress-strain curves of the tested specimens [4]

References:

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