# Investigation of tribological behavior in machining of AM tool steels

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Additive manufacturing (AM) offers excessive possibilities to produce complex geometries in advanced metallic materials. New opportunities in material design is obtained for numerous of different metals, also for more complex ones such as tool steels. Especially hot tool steels are used in extreme tribological environments, e.g. hot forming, which puts high demands on the properties and accordingly the microstructure. Such a new hot tool steel designed by considering the possibilities of AM is the steel Heatvar (©Uddeholm AB), produced by powder bed fusion (AM-LBF). The excellent tribolocial performance in demanding applications, especially due to precipitation of secondary carbides, makes it difficult to produce by AM and also difficult to machine. AM products is usually considered as near net shape products but because of poor surface integrity still machining has to be performed. However, regarding machining of AM tool steels the knowledge today is very low, especially for new designed materials. Therefore, present study focuses on detailed characterization of refined 2D cutting tests of as build Heatvar (called AS) and heat treated Heatvar (called HT). Analysis where made by using High speed imaging (HSF), temperature measurements (IR) and force measurements. Post analysis of the cemented carbide cutting tool as well as the machined tool steel were performed by FEG-SEM.

For both samples smooth chip formation is obtained. The similarities are significant regarding number of segments and shear angles, but the deformation in micro scale differs to a large extent. A more pronounced and localized deformation in the primary shear zone is obtained for HT as compared to AS which most likely depends on the higher hardness, i.e. an increase of 20%. Further, the machined surface of AS material shows bigger deformation depth and rougher surface as compared to HT, but on the other hand, HT shows some crack formation in the machined surface.

The higher hardness and more complex deformation mechanisms of HT as compared to AS results in a 15 % higher temperature developed in the primary shear zone as well as in the cutting tool material close to the tip. However, the rake face of the cutting tool show the opposite trend. In this area the AS material show the highest temperature, most probably due to more pronounced material transfer and friction heat. Accordingly, the two different steel conditions results in different tribological interaction in machining but both of them show anyhow good machinability.

**Keywords:** AM, machining, tool steel, cemented carbide, wear.

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