Ultrasonic assisted diamond turning of conventional and additive manufactured steel materials

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Abstract

The excessive tool wear of diamond tools during the machining of steel typically prevents the application of steel molds for optical manufacturing. However, in recent years the application of ultrasonic assisted machining of steel dramatically reduced the tool wear by a superpositioned elliptical vibration motion of the diamond tool. Tough the influence of the generation of the material was not yet taken into account. In this investigation steel alloys generated with electroslag remelting (ESR) and additively selective laser melting (SLM) were machined with diamond tools at various cutting speeds. The hypothesis was, that the generation of a workpiece with SLM offers positive effects to the ultrasonic assisted machining on otherwise identical steel compositions due to a different material structure. The surface roughness of the newly machined surface was measured on various steels with different compositions and generation methods and the roughness was correlated with the cutting distance as an indicator for the tool wear. An optical surface (Sa < 10 nm) was archieved with each steel type investigated (1.2083, 1.2379, 1.2343, 1.2709, 1.4404), whereas different cutting speeds (1.5 m/min, 3 m/min, 4.5 m/min) had little or no influence on the resulting surface roughness. This result was affiliated with a small change of effective cutting speed due to a high superpositioned ultrasonic induced speed. With new tools the machined surfaces exhibited a relatively low roughness, but after a specific cutting distance roughness raised rapidly. This critical cutting distance changed with the steel types and material generation methods. Further investigations will correlate the critical cutting distance with different steel compositions and material generation methods.
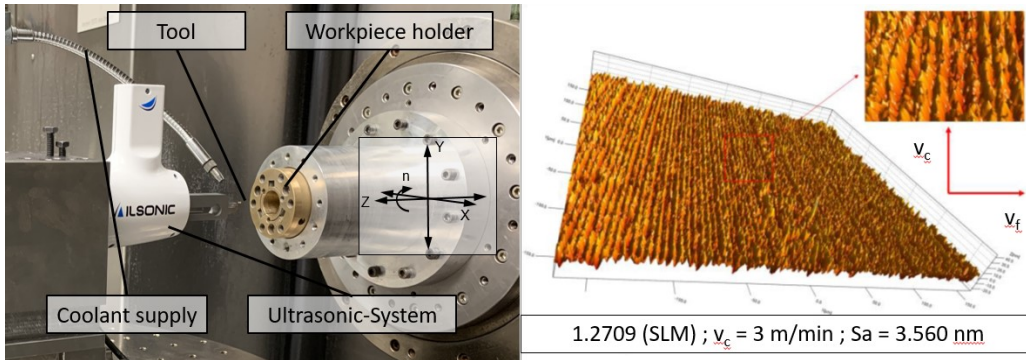
Figure 1: Experimental setup for ultrasonic assisted machining (left), ultrasonic assisted machined surface of a steel generated with SLM (right)