Final Report

Project acronym: *AddiZwerk*
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Publishable project summary

In the project AddiZwerk the German-Austrian project consortium consisting of different partners from industry, academia and applied research aimed to enable additive manufacturing (AM) technologies for the development and manufacturing of cutting tools. The project had three main objectives, (a) the assessment of the feasibility of additive manufactured cemented carbides tools via T3DP (Thermoplastic 3D Printing), (b) the feasibility of additive manufactured ceramic tools via LCM (Lithography-based Ceramic Manufacturing), and (c) the feasibility of an additive manufactured toolbody made out of steel and manufactured via SLM (Selectiv Laser Melting).

For the cemented carbides, a determination of the correlation between the feedstock properties (WC-12Co-0,4Cr3C2 - and WC-6Co-0,3Cr3C2) and the process parameters was performed. In addition, defect-free tool blanks for grinding tests were manufactured. Due to the lack of reproducibility in the T3DP process, the focus was placed on determining the feasible material characteristics. The focus in the cemented carbides part was placed on cutting inserts. End mills, unfortunately, could not be produced using the T3DP technology. Comparing the additively manufactured tools to those conventionally manufactured, they showed similar material properties. By means of T3DP densities of 99.9% are achieved. The fracture toughness of additively manufactured tools was eben higher compared to the pressed ones. Grinding tests on the sintered blank revealed no differences in processability to the conventionally produced blanks.

In the course of the project, new materials for the LCM process were developed which enabled the production of both cutting inserts and end mills. Two systems were chosen to meet the high requirements a cutting tool has to fulfill: ZTA (zirconia-toughened alumina) and silicon nitride. Out of these materials new ceramic suspension were designed and optimized. They then were characterized and test geometries were printed to find out the design possibilities and limtations. Crucial ceramic material properties like density and bending strength were evaluated to ensure that they meet the high requirements of the application and they could be achieved. The partners Weller, PTW and Boehlerit provided various designs and it was possible for the first time to manufacture ceramic cutting inserts and end mills using additive manufacturing. The cutting tools were successfully tested in machining operations for different materials. The end mills were tested but are still in need of further optimization.

Using the SLM process, a milling tool with indexable inserts, partially additively manufactured from HSS was developed. Furthermore, conventionally and additively manufactured turning inserts and turning tool holders were developed and used to test various innovative design methods as well as the application behavior of alternative tool materials under different cooling lubrication strategies. In this context, a systematic approach for the design and layout of hybrid tool concepts was developed, which allows the additive design of tool bodies based on conventionally manufactured, standardized interfaces with high positioning accuracy. Furthermore, different design methods for ceramic inserts, manufactured additively using the LCM process, were tested. They were then produced with different chipbreaker geometries and cooling channel structures. These tools were successfully validated with conventional and additively manufactured tool holders in an external longitudinal turning process, and process windows and suitable tool materials were identified on this basis. Analogous tests were carried out with carbide tools in which cooling channels were introduced by a die-sinking EDM process. Based on the improvements achieved in the additive manufacturing process during the project, various cutting edge geometries and concepts for the production of ceramic end milling tools were further tested. In several iteration steps, the concentricity error was continuously reduced and, in parallel, the grindability of the sintered SN ceramic shank material was demonstrated. The tools produced in this way were successfully tested in application tests by PTW for machining aluminum, compacted graphite iron and titanium alloy and by Weller using various steel alloys and plastics.