Innovations in Forging Technology

Efficient component manufacturing by process combination of casting and thermomechanical treatment

Authors: Dr.-Ing. Tim Lehnert, M.Sc. Nadine Lehnert

Speaker: Dr.-Ing. Tim Lehnert

Tim Lehnert

After graduating from the Technical University Bergakademie Freiberg in the field of "Vehicle Construction: Materials and Components", he began his career as a research assistant at the Fraunhofer Institute for Machine Tools and Forming Technology Chemnitz in the department of bulk metal forming in 2010.

The focus of his scientific work, which is backed up by corresponding specialist publications, is on process and technology development in the field of hot forging. Numerous applicationoriented projects have been designed and successfully completed for both lightweight construction materials and high-temperature alloys. The focus was on the process-specific determination of process windows for the validation of simulation results.

In June 2022, a PhD was awarded at Chemnitz University of Technology on the topic of "Knowledge-based technology for the efficient forming of highly stressable molded parts made of heat-treatable steel".

The current activities are strongly characterized by the transfer of the dissertation results achieved to industry.

Abstract

Molded parts are often subjected to stresses with high load gradients during use. Such complex and differentiated stress profiles are particularly relevant in the powertrain of commercial vehicles and large engines. In Germany, over 1.8 million tons of steel are produced annually by hot forging to molded parts weighing between a few grams and a ton. The conventional process chain is as follows: hot forming of rolled semi-finished products → mass pre-distribution → die forging for final shaping. Up to 25 GJ of energy are used per ton of finished component. Heating accounts for 80 % of the total energy requirement. The potential for saving energy lies in using the process heat remaining in the material for the subsequent production stages.

One approach to significantly reducing energy consumption in the production of steel components and cutting CO2 emissions is to combine the main production groups of casting and forging. Research into this combination of processes has been ongoing since the 1960s. Despite the attractive production data, this type of production has not yet become established on an industrial scale. The spatial integration and timing of the two processes require considerable changes. The process combination conditions for the production of aluminum alloy components are more favorable. This type of production has established itself industrially under the name "Cobapress".

This paper presents the CTMT process (casting + thermomechanical treatment), a technology in two versions, 1-stage and 2-stage, which is based on the temporal combination of casting and thermomechanical treatment. The key factor is to produce an initial forging mold using casting technology and then to form it into a near-net-shape component. In the less stressed areas of the cast component, this shape corresponds to the final shape. In the highly stressed areas, it is designed to be formable. In the subsequent work step, the cast parts are partially forged. Process-related geometry errors in the cast parts are thus closed and the mechanical properties are significantly increased locally thanks to the controlled microstructure formation.

The scientific requirement for the implementation of the CTMT process was to substantiate the process stages of casting and thermomechanical treatment, to determine the corresponding technology parameters and to create the basis for process simulation and, above all, for digital process control.