Zukunft Bau

Abstract „3D-Weld“

Titel

"3D printed steel alloy nodes for bionic support structures."

Starting situation

Filigrane, material-saving, strength- and stiffness-adapted load-bearing structures made of metal are becoming increasingly important. Such structures make it possible not only to incorporate individual aesthetics into buildings or to create iconic architectural masterpieces, but also to generate stress optimised structural solutions based on nature (bionics). The motivation to produce a light knot structure with maximum stability is often coupled with the desire for a minimal and adapted use of materials as well as low manufacturing costs. This requires a manufacturing technology for load-bearing structures with dimensions greater than 900 x 500 x 400 mm made of metallic materials.

Aim of the research project

The investigation is carried out on both numerical and real models. On the basis of the numerical, parametric models, a multitude of different models of differing system specifications can be examined and evaluated with regard to the load-bearing capacity of the nodes made of steel. The verification and validation of the numerically determined results is carried out via accompanying experimental load tests on spatial models. In this context, measuring systems for the three-dimensional recording of deformations during the manufacturing process and the load analysis are also used.

In addition to the numerical and experimental considerations, recommendations are developed regarding the material specifications for the 3D printing of metallic nodes by means of arc technology, which will be of increasing interest for further planning tasks and material combinations.

Due to the individual character of the investigation structure, different states can be set with regard to geometry, strength and stiffness states. Individual scenarios are presented for this purpose.

The research project pursues an interdisciplinary character, whereby new approaches for efficient, stiffness- and strength-adapted node constructions are developed experimentally and numerically. Based on the previous experience in the production of metallic structures by means of arc technology and the further knowledge in generative manufacturing, future fields of application will be pointed out. The aim is to achieve both technology transfer and scalability to scale. In cooperation with researchers and practitioners in the fields of arc and robotics technology and materials technology, suitable material combinations for the execution of adaptive node constructions in load-bearing structures with bionic character will be determined. In this context, generatively manufactured node constructions made of steel alloys are investigated and suitable manufacturing technologies, in particular welding sequences, are analysed and developed, taking into account the criteria of a reproducible and robust manufacturing process for near-net-shape and low-distortion structures. The 3D printing technology will be discussed against the background of the material-technical, mechanical applicability and with regard to an economic, sustainable use in the building industry. For the transfer of 3D printing technologies to the size and load scale of the building industry, systems are to be favoured which can be used immediately in practice with little adaptation.

Conclusion

In this research project WAAM could be used as a suitable manufacturing technology for the production of structural structures with bionic character. Furthermore, it could be shown that wire-based, additive manufacturing using gas metal arc welding can produce structures made of low-alloy steel with strengths close to the manufacturer's specifications of the welding filler materials, which are almost identical in the direction of build-up and transverse to it and thus can produce isotropic material properties. Furthermore, it was presented to what extent topology optimization as a method of numerical simulation can improve the stiffness of the nodes and thus reduce the prevailing stresses. Using a demonstrator, it could be shown that it is possible to reproduce the manufacturing process using certain simplifications by means of weld structure simulation. The experimentally determined material characteristic values for the filler metals make it possible to dimension the structural nodes according to the stress. With the help of demonstrators, the producibility of topologically optimized structural nodes could be ensured by means of WAAM.

Key data

Short title: 3D-Weld

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Project partners:
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Linde AG
EWM AG
RSB Rudolstädter Systembau GmbH, Rudolstadt

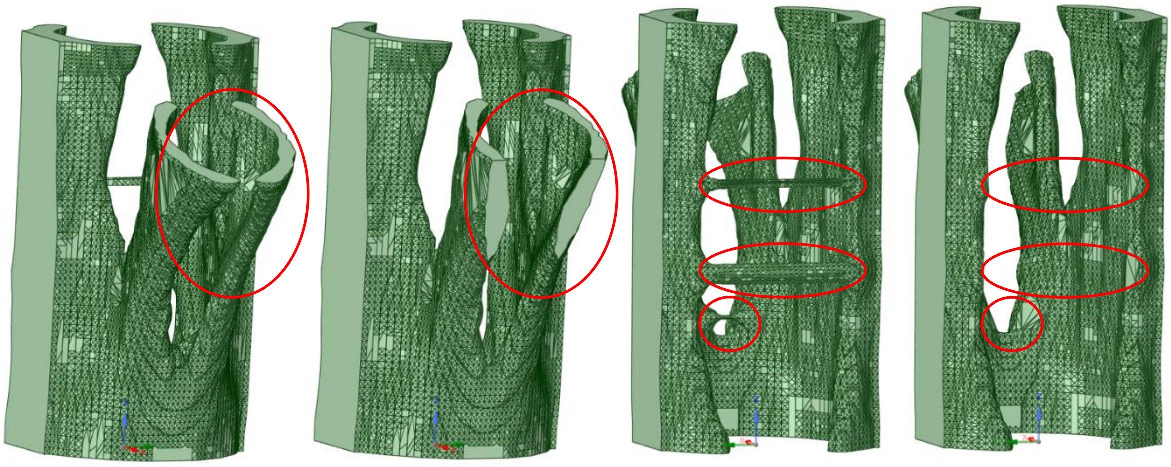
Total costs: 207.416,05 €

Share of federal grant: 140.000,00 €

Project duration: 24 Monate

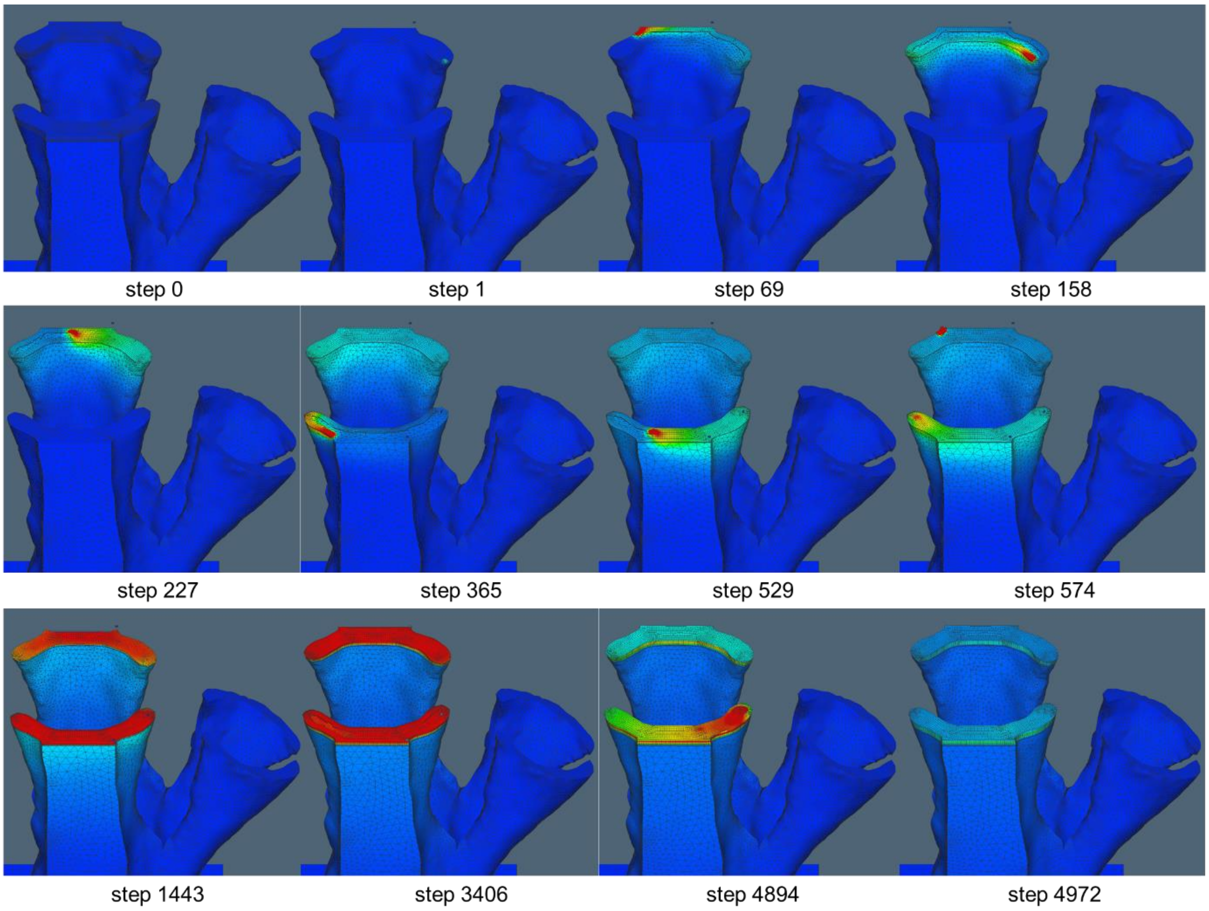
FIGURES:

picture 1: Additively produced top flange knot with vertical and diagonal bars



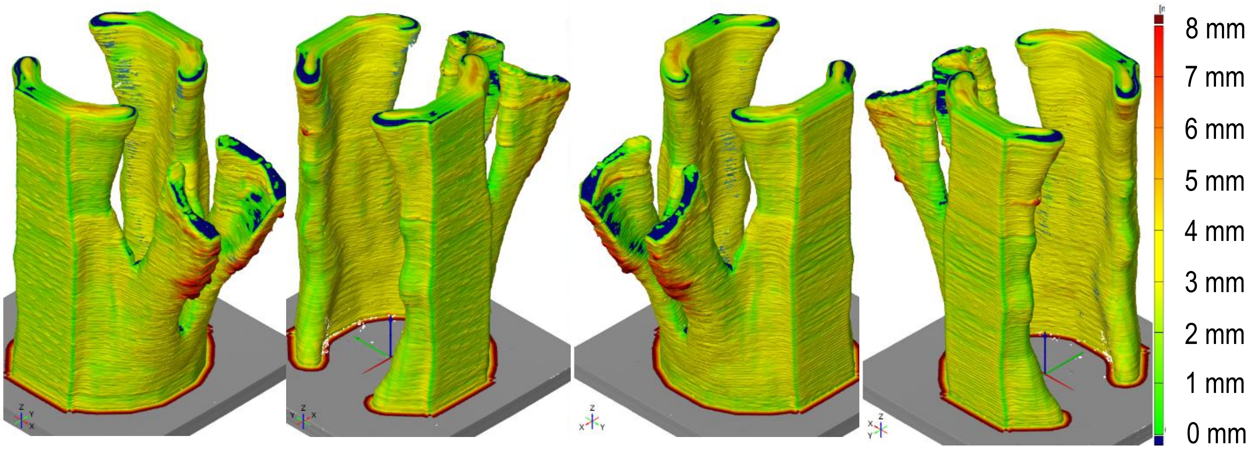
topology optimized | improved producibility | topology optimized | improved producibility

picture 2: Improvement of the producibility of the 30° inclined joint (red framed areas show the differences between the topology optimized geometry and the one with improved manufacturability)

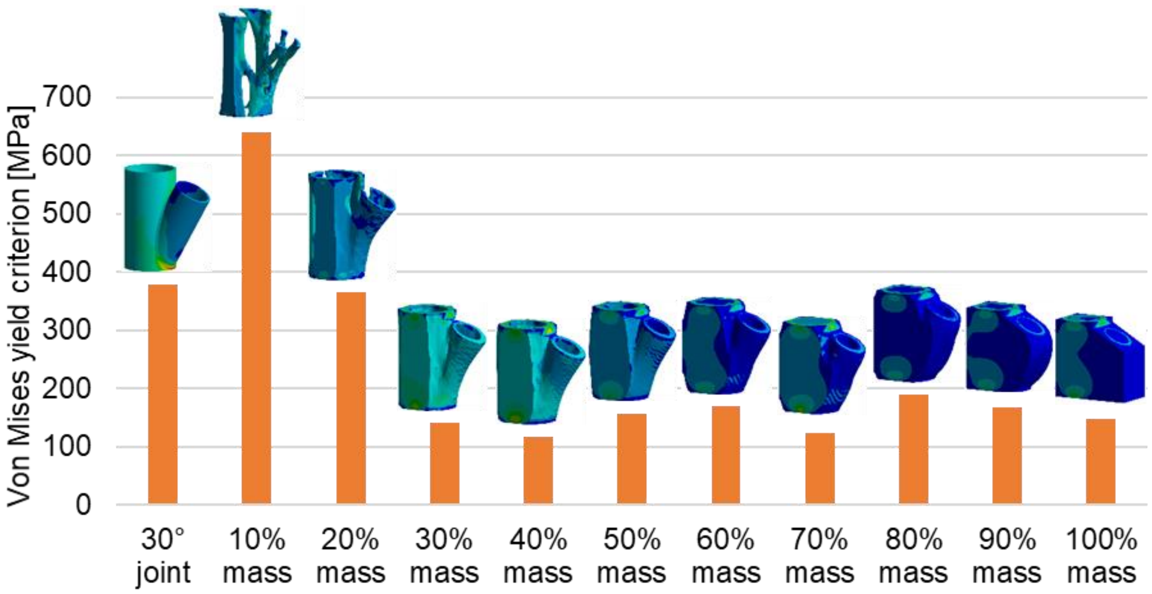


picture 3: Simulation of additive manufacturing (manufacturing steps) using Simufact Welding

picture 4: additivly manucatured, topologyoptimized 30° diagonal joint



picture 5: additivly manucatured, topologyoptimized 30° diagonal joint, form deviation to CAD file



picture 6: 30°diagonal joint: von Mises yield criterion in relation to the residual mass fraction after topology optimization