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3-D-Printing with Steel: Additive Manufacturing of Connection Elements and Beam Reinforcements

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Abstract

Automated steel construction manufacturing with robots is no longer just a dream of the future but a reality. The Institute for Steel Structures and Materials Mechanics of the Technical University (TU) of Darmstadt/Germany has two welding robots. These robots are being used to assess various application for Additive Manufacturing. For the construction of steel, Wire + Arc Additive Manufacturing (WAAM) is suitable, which is similar to Gas-Shielded Metal Arc Welding. The wire electrode serves as printing material. With this method we can produce components in layers and achieve deposition rates of 5 kg/h. The components studied in this research project are connection elements such as simply supported girder connections and head plates and reinforcing elements such as stiffeners and beam reinforcements. In this paper topology-optimized structures are presented, which can be printed with the WAAM directly on steel beams.

Keywords: Additive Manufacturing, WAAM, steel constructions, stiffeners, head plates,

1. Introduction / Additive Manufacturing

The topics of 3-D Printing and Additive Manufacturing (AM) are currently very much discussed. The technologies of these processes are progressing rapidly. The printing materials are diverse and also the printing of steel is now easily possible. In Additive Manufacturing, a component is created by adding material, as opposed to milling, which removes material from a body. Selective Laser Melting (SLM) and Selective Laser Sintering (SLS) exist for the Additive Manufacturing of steel [1]. A further method is Laser Metal Deposition (LMD), in which a metal powder is applied to a local molten pool generated by the laser [2]. All these methods are of high accuracy, but also associated with high equipment costs.

For steel construction, Wire + Arc Additive Manufacturing (WAAM), which is similar to Gas Shielded Metal Arc Welding (GMAW), is suitable [3]. The wire electrode serves as printing material. With this method, it is possible to produce large components in layers (see Figure 1) and achieve deposition rates of up to 5 kg/h [4].

Additive Manufacturing in general and the welding process WAAM in particular make it possible to use the material in a targeted manner. Structures can be freely modelled and get almost any shape. Unlike conventional steel construction, economical production hardly limits the form of construction. The customary trade-offs between a cost-effective production and material saving can be omitted. Material only needs to be placed where it is necessary. It therefore makes sense to determine these structures by means of a topology optimization.

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