Enabling Multi-Functional Performance
through Multi-Material Additive
Manufacturing

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Anisotropic fatigue properties of additively manufactured WAAM structures for Demonstrator 2

Additively manufactured structures tend to develop anisotropic properties. The reasons are the distributed heat input and the related local solidification and residual stresses. Especially discontinuous curves in the production path cause heat pockets, which in turn have an influence on the micro- and macrostructure.

To determine the effect of the manufacturing strategy on anisotropic properties in the structural durability of WAAM (Wire Arc Additive Manufacturing) structures from 2319 aluminium alloy, fatigue tests were carried out on a single path WAAM wall with vertical build direction. Fatigue specimens were oriented along, orthogonal to and diagonal (45°) to the build direction to determine the effect of anisotropy, Figure 1. The results, evaluated Fatigue Life Curves, show differences in fatigue life, mainly in high cycle fatigue regime. From horizontal extracted specimens, i. e. specimens orthogonal to the build direction, an increased strength in the long-life fatigue results. The strain amplitudes at $1 \cdot 10^7$ cycles to failure of the specimens oriented in the build direction are approx. 15 to 20 % lower compared with the specimens oriented orthogonal to the build direction. The fatigue test results of diagonally oriented specimens are in between the others.

Figure 1: Specimen orientation and locations of the single path WAAM wall

The difference in fatigue strength is in good agreement with static parameters, e. g. the tensile strength, which also show anisotropic behaviour. The mean value of the tensile strength orthogonal to build direction is 15 % higher as the one in build direction. In the cyclic stress-strain behaviour, no difference is found for the orientations. In fact, anisotropic properties are related to the strength, static and cyclic, but not to the stress-strain relationship.

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