



LASER BEAM WELDING OF ULTRA-HIGH STRENGTH STEELS

Task

Whoever deals with the lightweight design for vehicle manufacturing cannot get around ultra-high strength steels. For this reason, there have been developments toward alternative qualities of high strength steels, whose strength can be enhanced by hot stamping or twinning-induced plasticity. In both processes, however, there has not been a process window for laser beam welding due to the material's increased carbon content. This is particularly true for hardened materials. In view of introducing such materials into this manufacturing sector, these process windows – an assessment of weldability and the appraisal of their properties – need to be identified.

Method

In welding trials upon thin sheet metal, process parameters were developed for several representatives from ferritic-martensitic chromium steels, nickel-alloyed bainitic and martensitic hardened steels and high manganese austenitic steels. The first were welded in a normalized as well as in a hardened state. Subsequently, metallographic inspection was used to investigate the welding microstructure, which in turn led to a better understanding of the factors enabling weldability. Hardness measurements were carried out in the welded zone to estimate the expected mechanical properties.

1 *Microstructure of weld in 1.4034.*

2 *Microstructure of weld in Fe-0.4C-4Ni-1.5Cr-0.5Mo.*

3 *Molten line in a strip cast Fe-0.29C-27.3Mn.*

Result

Martensitic-hardened high-alloy chromium steels with carbon contents from 0.02 to 0.46 weight percent can be welded in normalized state when standard heat treatment is used. In applications for manufacturing tailored blanks, the heat treatment can be omitted. After hot-stamping, the weld will show slightly reduced hardness as compared to the hardened base material. A prerequisite of welding hardened steels for assembly purposes is an in-situ pre-heating and tempering, in order to maintain the toughness of the weld zone. The same is true for bainitic-hardened steel with 0.4 percent carbon and 4 percent nickel. Hardened metal sheets can be tempered at temperatures of up to 450°C without sacrificing strength. For high manganese austenitic steels with 0.3 percent carbon and 17 - 30 percent manganese, the formability is not impaired by the welding seam.

Applications

Ultra-high strength stainless steels can be utilized where their intrinsic corrosion resistance, along with high strengths of up to 1.9 GPa, is required, as in utility vehicles and railway cars. Nickel-alloyed Temper Tough™ is an all-round steel that is tolerant of hardening defects due to its transformation behavior. Steels containing high amounts of manganese are currently under development and hold great potential for saving energy during forming because of their ability of work hardening by twinning.

Contact

Dipl.-Ing. Martin Dahmen
Telephone +49 241 8906-307
martin.dahmen@ilt.fraunhofer.de
Dr. Dirk Petring
Telephone +49 241 8906-210
dirk.petring@ilt.fraunhofer.de