Effect of Filler Material Selection and Shrinkage Restraint on Stress Strain Build Up in Component Welds

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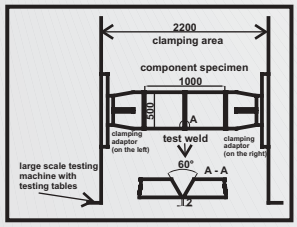
Abstract

Shrinkage restraints affect the stress strain build up during welding at components. Thus, the effects of filler material selection at restrained components are highlighted in this contribution for butt joints of plates and supermartensitic stainless steel (SMSS) tubulars. It turned out that forces and stresses transverse to the weld can significantly be reduced by selecting overmatching filler materials.

Test Conditions



Clamping scheme for linear welded components in the large-scale test device

Orbital welding of a supermartensitic stainless steel (SSMS) pipe in the component test facility

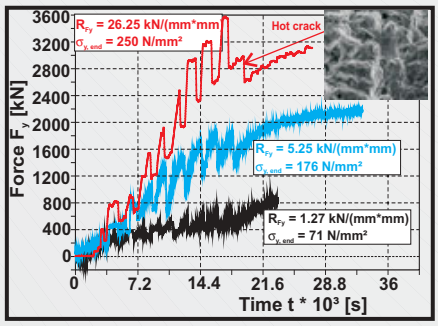
Mechanical properties of the base and filler materials

Material		Yield point R_{eH} in Mpa	Tensile strength R_m in MPa	Elongation A in %	Reduced area z in %
Plate	S355N	466	518	26.1	65.7
Wire	EN 756– S3	560	606	28	72
Plate	S460ML	506	566	30.9	66
Wire	EN 12534 - G4CrNi2Mo	782	904	19	58
Pipe	Supermartensite 1.4418m	672	924	29	61
Wire	Supermartensite 1.4418m	712	964	16	56
Wire	Duplex 1.4462	543	703	27	58

Results and Conclusions

Effects of the Intensity of Restraint

- Dependent on the restraint intensity R_{Fy} and on the thermo-mechanical effects during welding and cooling, characteristic reaction force histories occur in transverse direction to the weld during linear and orbital multi-pass welds of realistically restrained large specimens.
- An increasing restraint intensity R_{Fy} produces higher force amplitudes with each bead and an increase of the reaction stress transverse to the weld after cooling.
- In very stiff structures, the structural load may reach a level of up to 70 % of the base material yield point due to reaction stresses.

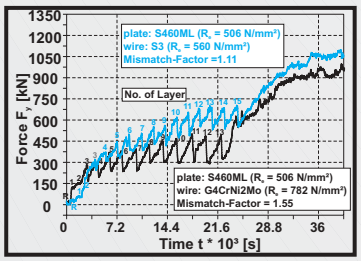


Transverse reaction force versus time at different restraint intensities *(submerged-arc welding of butt joints)*

Effects of Filler Material Selection

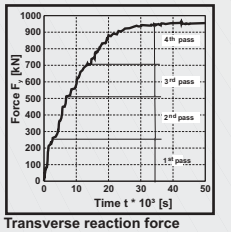
- In linear as well as in orbital welds the weld metal transformation behaviour generally exerts a major influence on the reaction forces and stresses transverse to the weld.
- In particular at supermartensitic stainless steel pipes, unequal microstructures of the weld metal and the base material can cause significant interactions between the stresses produced in the near field during welding and cooling and the transformation-specific changes in volume.
- Careful selection of the filler material can contribute to minimize the loads introduced into components during welding and cooling
- Realistic testing of component welds regarding the stress strain build up at respective shrinkage restraints can only be performed in specially designed test facilities.

Submerged-arc welding of butt joints

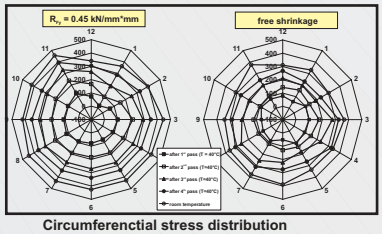


Transverse reaction force versus time at different weld metal strengths M in relation to the base material *(R_{Fy} = 1.32 kN/(mm*mm))*

SMSS pipe welded with undermatching DSS filler wire

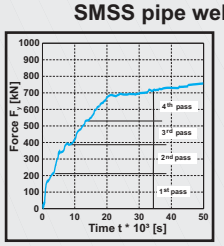


Transverse reaction force versus time

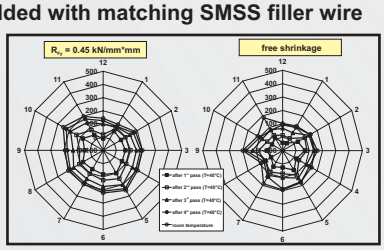


Circumferenctial stress distribution measured by strain gages in the near field

SMSS pipe welded with matching SMSS filler wire



Transverse reaction force versus time



Circumferenctial stress distribution measured by strain gages in the near field

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