Improved formability of laser welded tailored blanks in TRIP steels, C-Mn steels, stainless steels and aluminium alloys

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Abstract

This work was performed with the intention to improve the forming characteristics of laser welded tailored blanks of high strength steel, duplex stainless steel and aluminium alloys. Three methods were proposed for reaching improved formability: the addition of filler wire in order to alter the composition of the weld metal and to fill gaps, the use of a shielding gas other than helium in order to influence the viscosity of the melt and post-weld heat treatment in order to temper or anneal the martensitic weld metal.

The post-weld heat treatment was performed with a defocused laser beam in two different ways. One included welding and cooling off to room temperature followed by low speed heating in one scan. The other included welding followed directly by high speed heating in nine scans. The process parameters influencing the heat treatment (i.e. the spot diameter on the workpiece surface, the scanning speed and the laser power) were analysed using a temperature distribution equation. To finally determine the process parameters, measurements of the absorption of the laser beam on the welded surface were performed.

The following material combinations were welded: TRIP 700 to TRIP 700, Docol 1000 DP to Docol 1000 DP, LDX 2101 to LDX 2101, LDX 2101 to Docol 1000 DP, TRIP 700 to Rephos 260, AA6063 to AA6063, AA6082 to AA6082 and AA6063 to AA6082. The weld, of each material combination, performed at the highest speed giving a visually good result was chosen for further analysis. The analysis performed included visual examination of the weld cross-section, hardness test of the weld cross-section, X-ray of the weld, tensile test perpendicular to the weld and Erichsen cupping test of the weld.

The autogenous weld of TRIP 700 to TRIP 700 showed a formability value of 60% relative to the formability of the TRIP 700 grade itself (where 70% is
considered a good value). The hot weld heat treatment gave slightly improved formability. The cold weld heat treatment is believed to be able to improve the formability but failed due to remelting of the surface. The autogenous weld of Docol 1000 DP to Docol 1000 DP showed a relative formability of 87%. This value could not be improved by the methods tried. The autogenous weld of LDX 2101 to LDX 2101 showed a relative formability of 92%. This value could not be improved by the methods tried. The autogenous weld of LDX 2101 to Docol 1000 DP showed a relative formability of 40%. The addition of filler wire increased the relative formability to between 50% and 60%. The heat treatments are believed to be able to improve the formability but failed due to surface remelting. The autogenous weld of TRIP 700 to Rephos 260 showed a relative formability of 54%. The cold weld heat treatment increased the relative formability to 65% and further optimisation should be possible. The aluminium alloys were laser welded with the addition of either AlMg5 or AlSi5 fillerwire. The physical properties of the welds were compared to those of friction stir welds (FSW). All laser welded samples contained more or less central pores. Formability failure was due to surface defects. The laser welded samples showed large scatter in tensile and formability properties. The best results of the laser welds matched the average of the FSW samples.