FORMABILITY ANALYSIS OF TAILORED BLANKS IN SINGLE POINT INCREMENTAL FORMING

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Abstract

In this thesis, formability of monolithic and tailored blanks made of metallic and polymer sheets in single point incremental forming (SPIF) is investigated through prediction of forming limit curves (FLC), incremental sheet forming (ISF) tests and metallurgical characterizations of the incrementally formed blanks. Two aluminium alloy sheets namely AA5083 and AA7075, and polycarbonate sheet were used to study single point incremental formability (SPIFability) of tailored blanks. Initially formability of aluminium alloy AA5083-sheet in SPIF is investigated through FLCs and maximum formable wall angle considering different forming parameters and conditions. Theoretical FLCs for SPIF predicted by deformation instability method (DIM) were found to be higher than the experimental ones determined by ISF tests. SPIF was found to give 60-80% higher formability compared to that for conventional forming in terms of limit strains for varying strain paths in case of AA5083 sheet. The maximum formable wall angle was improved for lower step depth but not significantly increased for higher forming speed. The SPIFability was seen to get further improved at elevated temperature compared to that at room temperature. Microstructure studies revealed grain refinement in the deformed sheet by SPIF forming, and microhardness values in the deformed sheets were observed to increase for incrementally formed parts compared to that of the as received sheet. SPIFability of friction stir tailor welded blanks (FS-TWB) made of dissimilar aluminium alloy sheets namely AA5083 and AA7075 in SPIF are investigated using FLCs and ISF tests at both room temperature and elevated temperature. Initially FS-TWBs were made with optimal process parameters such as tool shoulder diameter, welding speed, and tool rotational speed maximizing ultimate tensile strength and percentage elongation determined through experiments and response surface methodology. A combination of lower rotational speed, higher weld speed and a moderate tool shoulder diameter was found to produce optimal weld quality within the considered ranges of the input parameters. FLCs and maximum formable wall angle for FS-TWBs with optimal weld quality were determined using DIM and ISF tests. Formability was observed to be lower for FS-TWBs compared to both base sheet materials in SPIF, and it was increased in case of heat-assisted SPIF. FLCs were determined for the tailor laminated blanks (TLBs) made of AA5083 and PC sheets and compared with that of the base sheets. Formability of AA5083/PC and AA5083/PC/ AA5083 laminated blanks was seen to be higher than PC and AA5083 sheets for plane strain case. Optical macrographs of the cross-sections of the incrementally formed TLBs showed a sharp decrease in the thickness distribution compared to that for the monolithic sheets. It was seen that failures like bump structure, delamination and tearing could be reduced in SPIF of TLBs employing discontinuous tool-path instead of the conventional continuous tool path.