Friction Stir Welding and Deep Drawing of Aluminum Tailored Blanks for Light Weight Automotive Applications

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Abstract

After the invention of friction stir welding (FSW), automotive industries are showing keen interest to apply aluminum tailor friction stir welded blanks (TFSWBs) in vehicle components to further reduce fuel consumption and exhaust emission without deteriorating their strength and stiffness. In the literature, there are lacks in weldability and subsequent formability data of TFSWBs of AA5052 and AA5754 sheets. Since, the above two grades of aluminum sheets can be used for automotive body parts such as inner, outer, and floor panels, which involve drawing of sheets by a rigid punch and die. Therefore, in the present work the fabrication of dissimilar grade TFSWBs using AA5052-H32 and AA5754-H22 with a similar thickness of 2.0 mm and dissimilar gauge TFSWBs using AA5754-H22 with thicknesses of 2.0 and 2.5 mm have been done. A conventional vertical milling machine was integrated with sensors for online monitoring and recording of temperature and power variations during the welding. While fabricating the dissimilar grade TFSWBs the variants namely, tool rotational speed, traverse speed, tool shoulder diameter, and tool pin geometry have been optimized using Taguchi grey based approach for the multiple output responses namely: weld strength, ductility, weld surface roughness, and energy consumption. The observed optimized parametric combination was further used without alteration for fabrication of dissimilar gauge TFSWBs. However, the spindle tilt towards the tool trailing edge was varied up to a great extent and its effect on the weld strength and ductility was analyzed. Thereafter, formability of both the fabricated optimized blanks was evaluated in terms of limiting drawing ratio (LDR) using a conventional cylindrical die. The obtained LDRs of dissimilar grade and dissimilar gauge TFSWBs were further improved by 27% and 14%, respectively, when using a modified conical tractrix die (MCTD) which is introduced in this work. Moreover, finite element (FE) modeling of the LDR test was done and the developed model was validated with the experimental results. The FE model also revealed the strain evolution pattern at different parts of the blanks during drawing which confirmed the uniform flow of sheet metals in the MCTD and justified the improvements achieved in the LDR.

Keywords: Tailor friction stir welded blanks, Optimization, Limiting drawing ratio, Modified conical tractrix die, Finite element modeling.