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# Design of stamping processes of pinless FSWed thin sheets in AA1050 alloy for motomotive applications using FEM

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**Abstract**

In the present paper, the cold stamping of friction stir welded AA1050-O thin sheets, obtained using a pinless tool, was studied. A preliminary investigation allowed to define the weldability window, in terms of the rotational and welding speed values, leading to joints with the desired mechanical properties. Then, the constitutive behavior of both the parent material and welded zone was characterized by means of uniaxial tensile tests. The constitutive equations obtained by analyzing the experimental results were implemented into the FEM code used to simulate the cold stamping process of FSWed blanks. The virtual prototypes were validated by performing stamping experiments of the FSWed blanks and comparing the predicted and measured results in terms of sheet thickness, and major strain vs. minor strain data.


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*Keywords:* Aluminium alloys; Friction stir welding; Formability; Stamping; FEM

## 1. Introduction

In recent years, demand for lightweight structures has risen substantially in an effort to reduce weight, fuel consumption and environmental impact of vehicles such as cars, motorcycles and others. In the manufacturing of sheet metal assemblies, lightweight structures can be effectively obtained using Tailor Welded Blanks (TWBs) fabricated by joining together, from one side or double side, two or more sheets of different gages or grades [1]. The

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desired geometry can be obtained by stamping TWBs with an optimized thickness distribution. Among the welding technologies that can be used, friction stir welding (FSW) is characterized by several advantages over fusion welding techniques in terms of environmental impact, mechanical properties and post welding formability. However, the thickness reduction in butt joints, resulting from the forging effect of the tool shoulder, and the microstructural changes occurring during welding could limit the attitude of FSW blanks to be cold stamped. As a consequence, in order to achieve sound parts with the desired geometry, it is necessary to accurately design all the manufacturing phases, from FSW to stamping. To this end, the finite element method (FEM) can be used to optimize the entire manufacturing cycle. One of the aspects that critically affect the effectiveness of the FE simulations of the cold stamping phase is the precise characterization of the rheological behavior of the FSWed zone since it can be the weakest area of the assembled part [2]. As a matter of fact, depending on the initial temper state of the sheet material, the strain hardening and the microstructural transformations produced by friction stir welding can strongly affect the plastic flow behavior of the deforming material. If the strain hardening coefficient (n) of the welded material is higher to the one of the parent material, the sheet thinning in the FSWed zone will be less pronounced than that in the parent material and the cold stamping will be able to provide sound parts.

In this framework, the present work aims at investigating cold stamping of FSWed AA1050 aluminium sheets obtained using a pinless tool. A preliminary investigation allowed to define the rotational and welding speed values used in the FSW experiments. Then, the constitutive behavior of both parent material and welded zone was characterized by uniaxial tensile tests. The constitutive equations were implemented into the FEM code used to simulate the cold stamping process of FSWed blanks. Finally, the FE simulations were validated by comparing the predicted results with those measured on cold stamped parts.

## 2. Material and procedures

### *2.1. Material*

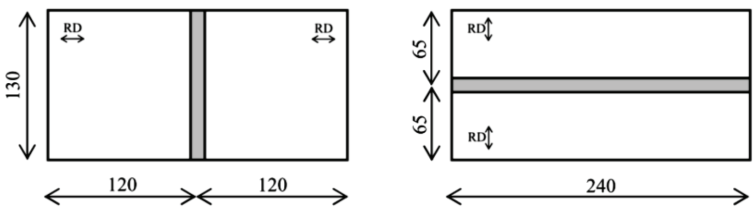
The material studied was the low strength AA1050 aluminium alloy characterized by excellent corrosion resistance, high ductility and highly reflective finish. The alloy was supplied in the annealed temper state (O) in order to take advantage of its high deep drawability [3].

### *2.2. Friction stir welding experiments*

Butt joints were obtained by means of friction stir welding of sheet blanks in AA1050-O using a CNC machining center. Owing to the small sheet thickness (1.57 mm), the FSW experiments were performed using a pinless tool, in H13 tool steel, with a shoulder diameter of 8 mm [4].

The rotational speed ($\omega$) and welding speed (v) were kept constant and equal to 800 rpm and 300 mm/min, respectively. Such values were obtained by analyzing the results shown in a previous work that has allowed the definition of the weldability window [3]. The tool plunging and nuting angle were imposed equal to 0.1mm and 2°, respectively.

In all the FSW experiments, the welding line was perpendicular to the rolling direction. Two different sheet assemblies, characterized by different welding line orientations, were produced (Fig. 1).




(a) (b)

Fig. 1. Friction stir welded sheet assemblies with different welding line orientations: (a) transversal and (b) longitudinal.