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The analysis of lock forming mechanism in the clinching joint

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ABSTRACT

In this study, the effect of the process parameters of the clinching process on the joinability of advanced high-strength steel was investigated using finite element analysis (FEA). The effect of die geometrical parameters on the achieved joint lock size and maximum forming force has been determined. It has been determined that the die groove width is the most important parameter affecting the material flow effect and energy consumption of the joining process. From the result, the die radius, die depth, and die groove shape were mainly affected by the joinability of advanced high-strength steel H320LA.

The results of experiments and numerical tests enable determining the effective process parameters of H320LA sheet metal joining process.

1. Introduction

Joining of metallic sheets is fundamental in the manufacturing of thin walled structures. Some mechanical joining techniques have been developed for joining advanced lightweight materials that are dissimilar, coated, and hard to weld [1–5]. An alternate method for the joining of sheets is known as clinching. Clinching has also been developed rapidly into relatively a new branch of mechanical joining techniques [6,7]. Consequently, the knowledge of the clinched joints has been the subject of a considerable amount of experimental and numerical studies [3,8–18].

In the design of mechanical structures which contain clinched joints, the information of these joints is essential. The quality of a joint made with a fixed die is evaluated by measuring the bottom thickness (X) (see Fig. 1a) in the middle of the base of the joint [12].

In clinching the tool design, the die cavity volume, including the die groove, is slightly larger than the punch penetration volume. The tools are designed in order to create an undercut which guarantees the mechanical interlock between the sheets [18]. The backward metal flow of the upper sheet would occur with the unfilling of die groove [13]. It is well known that for a given tool geometry, the clinch joint is characterized by the following parameters: the axial thickness of the sheets denoted by "X", the thinning of the upper sheet denoted by "t_n" (also called the nick thickness) and the clinch lock denoted by "t_s" (Fig. 1a).

The joint rigidity and load capability depends both on the joint loading method, and size and shape of the lock created in the joint. Depending on joint loading method, corresponding surfaces carry the pressure, and certain material surfaces are subject to tension and shearing. Generally, the size of cross section involved in carrying specified load depends on t_n or t_s value and the joint diameter (d_j).

For tearing load, the joint is loaded symmetrically (Fig. 1b), whereas for shearing the internal force distribution is different (Fig. 1c).

The trends, especially in the transport industry, towards reduced weight, increased performance and safety as well as a more rational and cost effective manufacturing have broadened the interest in high strength steels of good formability and weldability. High-strength steels can bear higher stresses than normal strength steels.

For a given load respectively a fixed stress in the component high-strength steels leads to smaller cross-sections and therefore also to reduced weight which results in decreasing costs. Typical fields of application: production of pressed parts (automotive industry), special sections and tubes of specified strength [19–21].

To design mechanical clinching tools that can give higher strength of the mechanical clinched joint, many researchers have investigated the relationship between the geometry of clinching tools and the strength of the mechanical, clinched joint [13–17].

The production of high quality joints with high resistance is the ultimate goal of the manufacturing industry. During the last years, experimental has been studied and used widely to examine the clinching parameters as well as their basic mechanisms.

Experimental and numerical studies of the clinching process are available in the literature. The comparison studies between round and square clinching tools for high-strength sheet metals, with various thicknesses, have been conducted by Varis [8,18]. The effects of tools geometry on both the nick thickness and the clinch lock were studied by De Paula et al. [22], by making some geometry modifications.

Lee et al. [17] has referred to 6063 aluminum sheet plate clinching, and at [13] has presented the results of DP780 and 5052 sheet

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