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Thin-Walled Structures 43 (2005) 826–844
THIN-WALLED STRUCTURES
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Design of axial/torque joint made by electromagnetic forming

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Received 28 August 2003; received in revised form 14 October 2004; accepted 15 October 2004
Available online 8 December 2004

Abstract

Recently, weight reduction of vehicles has been of great interest, and consequently, the use of low-density materials in the automotive industry is increasing every year. However, the substitution of one material for another is not simple work. Simple substitution of material cannot achieve stiffness and strength, so that the structure of the automobile should be redesigned totally. Spaceframe is rapidly being adopted as a body structure for accommodating lightness, stiffness and strength requirement. In spaceframe manufacturing, it is often required to join tubular parts with different cross sectional shapes and different materials. But there are few suitable methods for satisfying these requirements, so that much interest has been focused on testing suitable joining methods. Joining by electromagnetic forming (EMF) can be useful method in constructing spaceframe. It offers some advantages compared with the conventional joining method such as welding. In this paper, joining by EMF was investigated as a pre-study for application to an automotive spaceframe. Finite element simulations and strength tests were performed to analyze the influence of geometric parameters on the joint strength. Based on these results, axial joint and torque joint were designed and guidelines for designing EMF joint were established.

Keywords: Electromagnetic forming (EMF); Joining; Joints; Spaceframe

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doi:10.1016/j.tws.2004.10.009

1. Introduction

Vehicle weight reduction is one of the major methods for improving automotive fuel efficiency. The substitution of low-density materials such as aluminum, magnesium, plastics, etc. for steel is a good example for vehicle weight reduction [6,7]. Among lightweight materials, the use of high-strength aluminum alloy in the automotive industry is increasing every year. However, the substitution of one material for another is not simple work. Simple substitution of material cannot achieve stiffness and strength, so that the structure of the automobile should be redesigned totally. Spaceframe, or structural frame consisting of closed section members that can be extruded or hydroformed is rapidly becoming the chosen body structure for accommodating lightness, stiffness and strength requirements as an alternative to conventional monocoque. Fig. 1 shows a layout of an automotive spaceframe.

In spaceframe manufacturing, it is often required to join tubular parts with different cross sectional shapes and different materials [1–3]. But there are few suitable methods for satisfying these requirements, so that many researchers have focused their interest mainly on testing suitable joining methods [8]. For example, resistance spot welding, which has been used for constructing conventional monocoque, has difficulties in joining dissimilar materials and tubular members. Several other joining methods have been considered in the construction of a spaceframe. For instance, the Audi A2 spaceframe, which was evaluated for successful body design, was constructed via laser welding, metal insert gas (MIG) welding and self-piercing rivet [4,5,9,10].

Joining by EMF can be useful method in overcoming the limitations. It can be applied to join dissimilar materials and tubular members. Further, there is no heat involved in the EMF process, significant problems associated with welding, for example distortion and weakening, are eliminated. Low tooling cost and rapid joining time are other benefits of this process.

In the present paper, joining by EMF was investigated as a pre-study for application to an automotive spaceframe. Finite element simulations and strength tests were performed to analyze the influence of geometric parameters on joint strength. Based on these results, axial joint and torque joint were designed and guidelines for designing EMF joint were established.

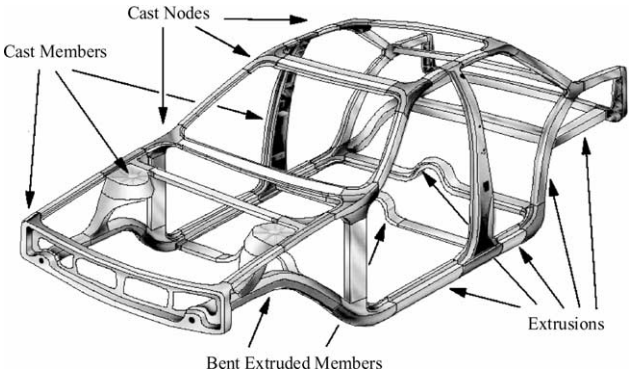

Fig. 1. Layout of automotive spaceframe.