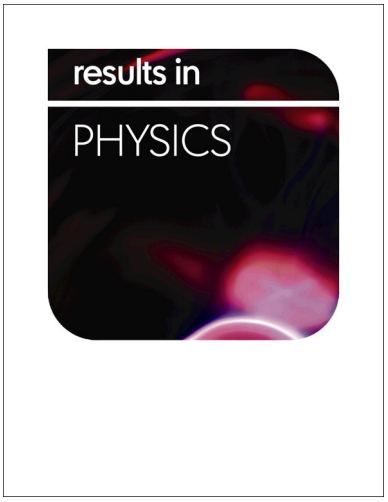

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Formability Analysis of Aluminum Double-layer Sheets Using a Magnetorheological Fluid

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Abstract: Bulging with overlapping metal sheet is one of the important ways to improve the forming performance of light alloy sheet. In order to investigate the bulging performance of aluminium double-layer sheets, this paper uses intelligent materials magnetorheological fluid (MRF) as a force medium for the first time, and also develops a exclusive device structure for it. The results show that: With the increase of magnetic field strength or mass fraction of MRF, the expansion bulging limit of the inner layer of pure aluminium sheets is significantly increased when the double-layer sheets reach the bulging limit, and the size of the location where the cracking length occurs produces an inverse trend change is decreased of size of the cracking portion. As the mass fraction of the magnetron fluid increases from 56% to 80% with 3A field coil current, the rate of decrease of the ultimate wall thickness variation rate of the inner layer aluminium sheet reached decreases by 15.75%, and expansion bulging limit height has increases by 8.74%. It can be seen that with stronger magnetic field or higher mass fraction of the MRF, it improves the uniformity of deformation coordination at various parts of the sheet. the improvement of the uniformity and coordination of the deformation of each part of the sheet is promoted. This study provides a scientific basis for improving the forming performance and comprehensive quality of low-plastic lightweight sheet.

Keywords: Double-layer sheets; Aluminium ; Magnetorheological fluid (MRF); Formability

Introduction

Lightweight alloy sheets including aluminum and magnesium are ideal materials to achieve lightweight in aerospace and automotive [1-2], but some problems, such as poor performance of plastic forming in the room temperature, result in the difficulty to form a complex structure or large deformation of the sheet with the traditional stamping process. Improving the plastic forming ability of light alloy sheets has become the key to solve such problems [3-6].

The results of the related studies show that if the experiment changes the pressure on both sides of the sheet which is puts load pressure on them [7], it can improve the hydrostatic pressure of deformation area but simultaneously inhibit the generation and expansion of internal cracks in the material, thereby it is necessary to enhance the plasticity of the material. Tiejun Gao et al [8] selects different thickness and performances of the sheets to make the experiment on pressure bulging of the aluminum alloy LF21 in viscous media pressure bulging experimental and the result shows that when the sheet is formed, the sheet with higher strength coefficient K , larger work hardening index n and appropriate thickness is helpful to improve the forming performance of the sheet. The study of 5A06 aluminum alloy sheet under different conditions of hydraulic forming by Xu et al [9] indicates that the thinning rate of thinnest wall is 13.6% while the single layer sheet is hydroforming with an internal pressure of 30MPa hydraulic forming was conducted on single-layer , and the sheet thinning rate is only 8.7% when it is a the double sheets are hydroforming with only 15MPa an internal pressure of only 15MPa , it can be seen that the double-layer sheet makes the distribution of wall thickness more evenly and a reasonable upper layer auxiliary sheet to the lower sheet can also inhibit wrinkling and the lower sheet wrinkles and excessive thinning of the lower sheet. Through The liquid-filled bending experiments of double tubes of low carbon steel/ aluminum alloy double tube show that the application of the cladding tube changes the thickness ratio and the stress state [10], and the outer maximum thinning point is not located at the center but at a certain angle with the central section. Thus it provides the theoretical basis for the forming and processing of the large slender pipe.

Then the new intelligent materials MRF has been introduced as a medium to the sheet metal forming field [11], and its rheological properties under the action of the magnetic field can be changed to achieve the effect of quantitative control to required parts of the sheet. After the preliminary attempt for applying both MRF pressure on both sides of the sheet It makes initial attempts by simultaneously applying magnetic media pressure on both sides of the sheet, the distribution of wall thickness and the uniformity of deformation have been improved [12].

It is a meaningful attempt to study the bulging behavior of aluminum double-layer sheets by using MRF as force-transmitting medium. As the magnetic fluid force and the mode of action of the hydraulic force medium are different from the conventional mediums, comparing to the hydraulic force medium, the deformation behavior and coordination order are very different. At the same time, the magnetic field and the rheological properties of the magnetic particles are change with different magnetic field

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