



Controlled bending of metal sheets using tungsten inert gas arc

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Abstract. This work proposes to impart controlled bending of metal sheets by localized heating using tungsten inert gas (TIG) arc. AISI 304 steel sheet was formed varying arc current (I), scan speed of the TIG torch (v_s), dwell time between successive scans (t_d), number of the scan passes (n) and distance of the bending edge (i.e. scan path) from the free edge (a). The bending angle was achieved, increased with increase in I and n but reduced with v_s , t_d and a . Such thermal forming by TIG has not been reported before. This is inspired by the other two thermal forming processes, namely *Laser forming* and *Line heating* or *Flame forming* which use laser and oxy-acetylene gas flame respectively. In both the processes, high bending angle per scan pass necessitated surface melting (up to 46.4% in laser forming). In the current experiments on the proposed method which is cheaper than laser forming and more precise than flame forming, maximum melting remained within 32.15% of the sheet thickness. Bending angle per scan pass ($0.7 - 1^\circ$) and edge effect (i.e. variation of bending angle along the scan path) both comparable to laser forming could be achieved at a scan speed in the range of 15 – 21 mm/s.

Keywords. Thermal forming; TIG forming; die-less forming; flexible forming.

1. Introduction

In today's era of flexible automation to produce customized parts, flexible sheet metal forming processes like single point incremental forming (SPIF) [1] and thermal forming [2, 3] have drawn significant research attention. They can produce a wide variety of formed parts without requiring dedicated tool-die. SPIF utilizes localized contact force on the sheet being formed by a usually hemispherical tool tip, having translating motion along a planned tool path, assisted by lubrication with/without rolling of the tip end. The thermal forming mechanism is different. Localized heating of a material causes non-uniform temperature distribution within it. The region with a higher temperature tries to expand more which is resisted/compressed by the cooler surroundings. Usually temperature dependent flow

stress being lower in the high temperature region, such compression may go into the plastic regime and cause permanent deformation. This is the primary reason for weld distortion, where the expansion of the hot region surrounding the weld pool do not conform to that of the cooler adjacent region, leading to evolution of internal tensile-compressive stresses [4]. On the other hand, localized heating with a laser beam [2] or a gas flame [3] can impart controlled deformation to the materials. According to the used heat sources mentioned, the process is termed as *Laser forming* and *Line heating* or *Flame forming* respectively. Together they constitute the forming method named Thermal forming which can complement the commonly used Mechanical forming techniques involving external force. Mechanical forming suffers from the disadvantage that even after using in-process control, spring back cannot be eliminated completely, which is of significant concern for near net shape forming [5]. Some inaccuracies are often left

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