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Original Research Article

New original method and device for testing aluminum alloys susceptibility for extrusion welding

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ABSTRACT

Common methods of weldability assessment of aluminium alloys do not fully reflect the welding conditions occurring during extrusion through the porthole dies, hence the obtained results are not much good for practical use. There are no weldability tests in which the temperature, unit pressure, welding time and deformations in the welding zone can be simultaneously controlled. It is necessary in the correct bonding test to provide the welding conditions without contact of air, which could oxidise of the metal streams. The paper presents the original device for the research of aluminium alloy weldability, reflecting the conditions of metal bonding (without air access), which occur in the welding chamber of porthole dies. This device is a modification of a previously patented device carried out in order to determine more precise basic welding parameters. The operation principle as well as the methodology for determination of susceptibility to welding of aluminum alloys has been presented, using the AlMgSi alloy as an example in the type of EN AW-6082. The welding conditions of the 6082 alloy were determined, which allowed for high quality bonding. A parameter describing the welding conditions was defined as the relationship of the normal welding stress to the yield stress (σ_n/k) and its values were determined at different temperatures. The obtained values of welding stress are the basis for the proper design of porthole dies.

1. Introduction

The known methods of metals weldability testing consist of the welding of the two starting materials with the use of hot plastic working processes, usually the swelling and rolling. Szczegoliewatych et al. [1] conducted tests of aluminum alloy weldability where the sample from the tested alloy is pressed at a certain temperature, resulting in an increase of the facing surface area of the bonded materials. In order to determine the alloy susceptibility to weldability, material samples with weld formed at different deformation grades and at different temperatures were stretched. The method of testing the

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weldability of aluminum alloys and magnesium alloys based on hot compression samples was patented by Cook et al. [2]. Similar tests of aluminum alloys weldability with hot compression were conducted by Sahin et al. [3]. However, the mentioned above the weldability tests are burdened with an error resulting from the oxidation of the welding surface due to air access.

Akeret [4] tested the ability to welding of the soft and hard deformable aluminum alloys using a hot rolling process of a flat ingot cut to half on its length. The samples welded in the rolling process were next submitted to mechanical tests. The assessment of the weldability of 6060 and 6082 alloys in the rolling process of the flat ingots of different thicknesses over a wide temperature range was conducted by Ceretti et al. [5] and D'Urso et al. [6]. The quality of bonding was assessed on the basis of structural tests of the welding areas. However, in the case of welding tests based on the rolling process, oxidation of the bonded surfaces also occurs.

There are also known methods of assessment the weldability of aluminum alloys using the hot extrusion process. Wantuchowski et al. [7] used a special die allowing extrusion of the three flat bars with a weld in the middle of the sample and due to this method it was possible to test the welding efficiency of a given alloy. The 6063, 6082, 6151 and 5052 alloys were tested in these investigations. The complete data, taking into account the effectiveness of welding over the entire length of the extruded profile, was included in the paper (Zasadziński et al. [8]). In the case of tests based on hot extrusion of the flat bars the problem of surface oxidation of welded samples was eliminated, but it was not possible to determine the unitary pressure under the web in the welding chamber. Akeret [9] analysed the weldability of various grades of aluminum alloys on the basis of hot extrusion of a flat bar through the test porthole die. He stated that proper metal bonding required an adequate size of the welding chamber. If the welding chamber is too small, it may be incompletely filled resulting in free space under the web, whereby the individual metal streams are too weakly compressed and permanent bonding of the metal does not occur. In the case of too large welding chamber under the web, a dead zone is created, which impedes the

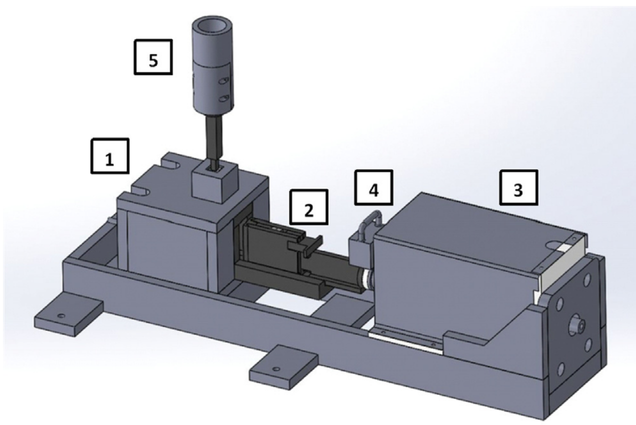

Fig. 1 – Model of the device for tests of metals and alloys welding: (1) heating chamber, (2) shearing and welding cartridge tool, (3) hydraulic cylinder, (4) adapter of hydraulic cylinder and tool assembly holder, (5) upper compressing punch.

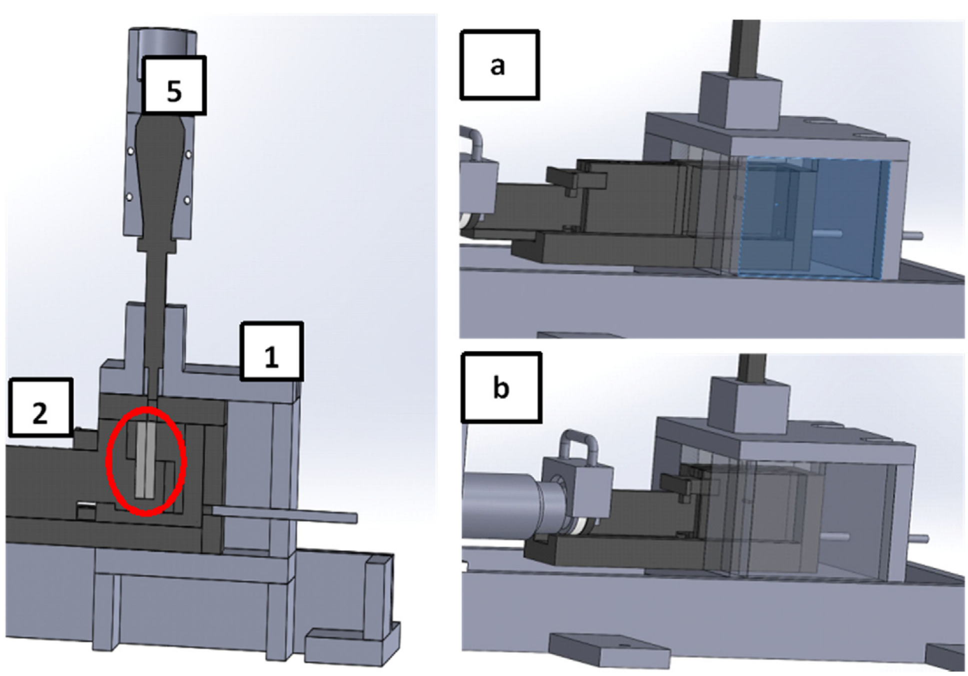

Fig. 2 – Interior view of heating chamber (1), shearing and welding cartridge (2) along with the welded samples and upper compressing punch (5) – on the left, and movement of shearing and welding cartridge assembly: (a) exerted cartridge assembly, (b) cartridge in heating system – on the right.