Stark broadening of multiple Ar I lines as a diagnostics tool for transient welding arcs containing metal vapor

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The aim of this work is to determine plasma parameters in Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW) processes by using a combination of Stark broadened 696.54 nm, 738.40 nm, 763.51 nm and 794.8 nm Ar I lines. The line widths obtained from the measurements are correlated with results of other emission spectroscopy measurement techniques and Thomson Scattering carried out in the same processes [3]. Theoretical data available in the literature is compared to the obtained dataset for Ar I lines. It is used to discuss properties of the plasma and the influence of the metal vapor in the investigated processes. Moreover the usability of these lines as a diagnostic tool for simultaneous determination of electron densities and electron temperatures with current theoretical approaches is discussed.

1. Introduction

One of the most common industrial welding processes is GMAW. Due to a good process control in particular the *pulsed* GMAW process is interesting for industrial application. However it is not fully understood how the metal droplets and the resulting metal vapor interact in the plasma and thus influence the quality of the final join. Despite of a number of experimental investigations and modelling of the process that have been carried out so far, there is still a need for further experimental data in order to understand the physical processes within the arc and to obtain a reliable verification of its model [4]. Especially for aluminum as wire electrode only few emission spectroscopy investigations of electron temperature and density in the arc plasma have been carried out so far [1].

Stark broadening technique has been widely used to determine electron densities and temperatures in welding applications. Since species typically present in a welding process underlie to a quadratic Stark effect, line profiles have a temperature and electron density dependence. Thus several Stark broadened lines can be combined in order to determine temperature and density simultaneously. This method was applied in [8] using Ar I and Fe I lines.

However for welding processes, where Fe is not present, this method is not applicable. Theoretical data for broadening of different Ar I lines is available in the literature [6, 5, 2]. Thus it is desirable to develop a two line Stark broadening measurement method which uses Ar lines – a shielding gas typically used in many types of welding processes. Similar approach, which uses different line of the same element, was used to determine plasma parameters in a microwave discharge by [7]. The aim of this work is to evaluate the usability of multiple Ar I lies as a diagnostic tool for plasma parameter determination in GMAW processes.

2. Experimental setup

Stark broadening measurements were performed on two welding processes: GTAW with Argon and GMAW aluminum. For the simultaneous fine spectral resolution of a wide spectral range an Echelle spectrometer supplied with a CCD detector (Aryelle Butterfly 400, LTB Lasertechnik Berlin) was used. The light from the plasma volume with a cross section of 1 mm is collected by a fiber optic. In order to obtain a two dimensional signal different points of the plasma column are scanned along the horizontal arc axis.

3. References

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