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Study of a Laser-enhanced welding arc using advanced split anode technique

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1. Introduction

In TIG (tungsten inert gas) welding the arc burns in a shielding atmosphere of an inert gas provided by a nozzle between a sharp pointed tungsten electrode and a workpiece. The energy produced is transferred into the surface of the anode workpiece acting as a heat source with a spatial intensity distribution according to the actual arc parameters. A new welding procedure based on the enhancement of the welding arc by a focused low power laser beam provides remarkable improvements of the welding seam by changing the arc behaviour [1,2] (fig. 1). This paper summarizes a measurement technique in order to analyse the change of the current density profile by the interaction of TIG welding arc and supporting laser beam.

2. Experimental set-up

In order to understand the energy transfer into the weld pool the current density distribution has to be determined at the surface of the workpiece. The experimental method consists of splitting the anode and measuring the current to both sections as a function of the arc position relative to the splitting plane at different angles with respect to the splitting gap (enhanced Nestor-split-anode technique, s. fig. 1). In contrast to former investigations [3], this procedure was used for real welding conditions for arcs moving with high speed relative to the anode surface (when using cooled copper anodes as is usual for the Nestor method, the arc is a different one because of the absence of evaporating material from the workpiece surface!). Applying the Radon transformation to the arc current curves measured, a reconstruction of real asymmetric current density profiles is possible.

3. Data inversion technique

For the computation of the current density distribution at the workpiece surface by the data inversion program radon, current scans for a number of angles Θ are needed at the same arc parameter set. Conventional techniques of measurement use the assumption of radial symmetry. Here, the radon algorithm (fig. 2, based on the radon equation [4,5]) is capable for every data inversion problem. Compared to tomographic image analysis algorithms, it allows to compute the exact values of the continous physical quantity to be determined.

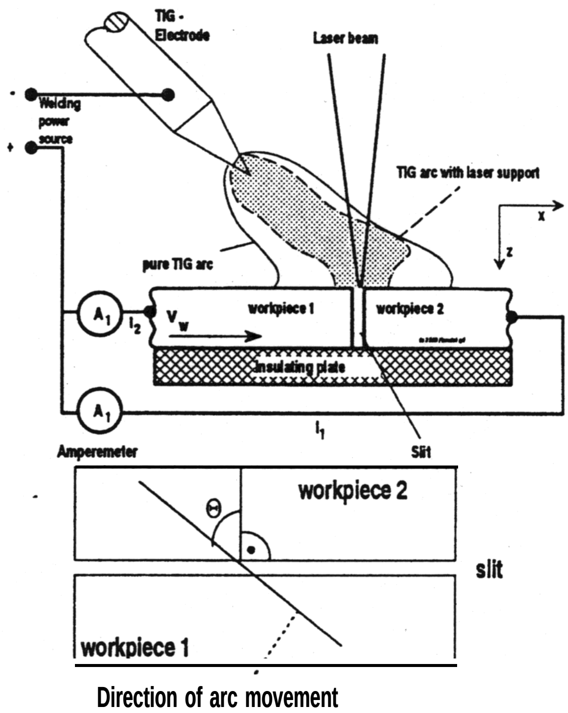


Figure 1: Experimental **set-up for split-anode measurements**

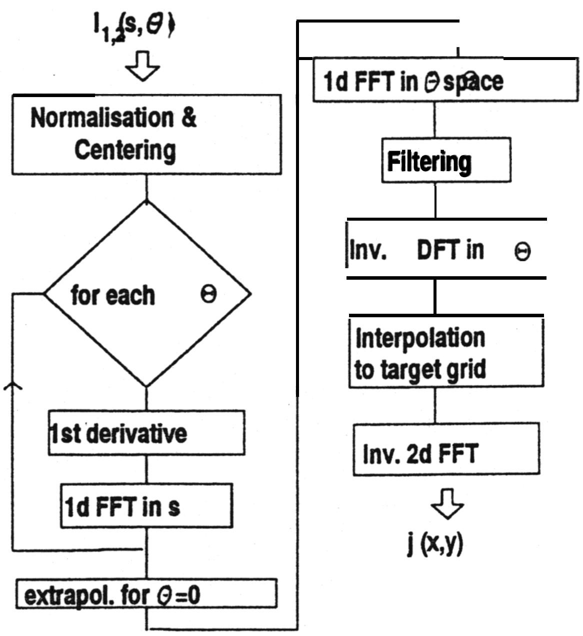


Figure 2: radon data inversion algorithm.

4. Results and Discussion

In figure 3 and 4 the effect of a focused laser beam on the current density of the TIG *arc* can be seen: The laser changes the arc operating mode and thus concentrates the arc current around the laser focal point. In addition, the maximum current density becomes nearly independent from arc length.

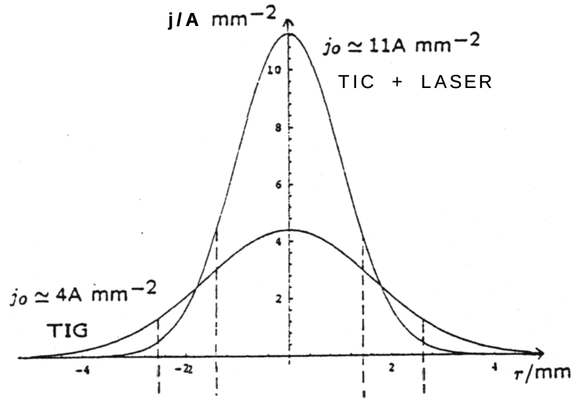
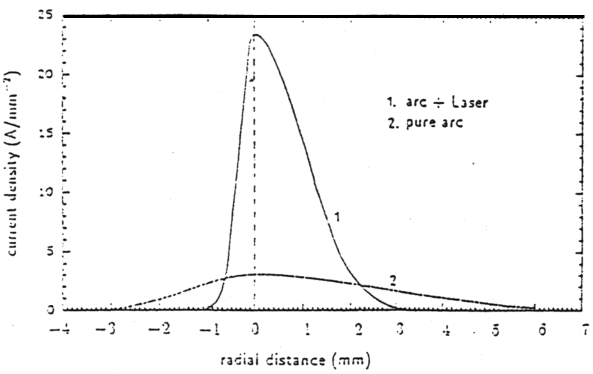


Figure *3:* **Current densities of the TIG and the LASER-TIG arc for comparatively low welding speed as calculated under the assumption of radial symmetry**



Fire 4: Current densities of the TIG and the LASER-TIG arc for higher welding speed, central cross section of the distribution in the plane of the arc movement

Figure 5 shows the complete distribution of the TIG arc current on the workpiece surface according to curve 2 in fig. 4., which is truly not radial symmetric.

The LASER-TIG arc current density distributions measured, turn out to be sharply peaked. An exact measurement, however, is still verydifficult, because for small arc radii the effect of the insulating slit width (0.2 mm air) becomes important and the welding process causes a short circuit betweenthe two anode parts for values of Θ above 30”. Therefore, additional refinement of the measurement technique is required.

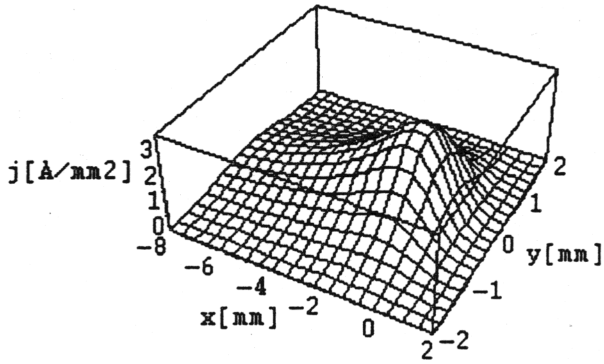


Figure 5: Complete current density distribution of a **TIG- arc at high welding speed.**

5. Conclusions

Developed in the early sixties by Nestor [3], the measurement of the welding arc current density by a split anode is used as a standard technique [e.g. 6]. However, *real* welding arcs are melting the anode workpiece and have a non radial symmetric current density distribution (fig. 5). Therefore, they are requiring measurements at different scanning angles Θ and a data inversion technique without the assumption of radial symmetry.

Such a data inversion technique was developed within this study and used to calculate the current density distribution of TIG and LASER-TIG welding arcs.

The results show the drastic effect of a supporting laser beam on the arc, where the maximum current density is increased by a factor of 2-4.

6. Acknowledgement

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7. References

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