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CONTENTS

SCIENTIFIC AND TECHNICAL

Egerland S., Zimmer J., Brunmaier R., Nussbaumer R.,  
Posch G. and Rutzinger B. Advanced gas tungsten arc welding  
(surfacing) current status and application ..... 2

Knysh V.V., Solovej S.A., Nyrkova L.I., Shitova L.G. and  
Rybakov A.A. Improvement of cyclic fatigue life of tee welded  
joints by high-frequency mechanical peening under the  
conditions of higher humidity and temperature ..... 12

Lebedev V.A., Lendel I.V., Yarovitsyn A.V., Los E.I. and  
Dragan S.V. Peculiarities of formation of structure of welded  
joints in arc surfacing with pulse feed of electrode wire ..... 18

Lukashevich A.A. Calculation-experimental method for  
determination of spectrum components of non-stationary  
loading of carbon steel welded joint ..... 24

INDUSTRIAL

Tsaryuk A.K., Skulsky V.Yu., Nimko M.A., Gubsky A.N.,  
Vavilov A.V. and Kantor A.G. Improvement of the technology of  
welding high-temperature diaphragms in steam turbine flow  
section ..... 28

Kulik V.M., Osadchuk S.A., Nyrkova L.I., Elagin V.P. and  
Melnichuk S.L. Extension of service life of welded tanks of  
stainless steel by increasing pitting resistance ..... 37

Olejnik O.I., Maksimov S.Yu., Paltsevich A.P. and  
Goncharenko E.I. Development of technology of mechanized  
arc welding in repair of pressurized main gas pipeline ..... 42

Vasilev Yu.S., Olejnik N.I. and Parshutina L.S. Development of  
adhesion and adhesion-welding technology for repair of bearing  
seats for extension of service life of casing parts of power  
equipment ..... 49

INFORMATION

On the 100<sup>th</sup> anniversary of Boris I. Medovar ..... 54

# ADVANCED GAS TUNGSTEN ARC WELDING (SURFACING) CURRENT STATUS AND APPLICATION

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Gas Shielded Tungsten Arc Welding (GTAW) — a process well-known providing highest quality weld results joined though by lower performance. Gas metal arc welding is frequently chosen to increase productivity along with broadly accepted quality. Those industry segments, especially required to produce high quality corrosion-resistant surfacing, e.g. applying nickel-based filler materials, are regularly in consistent demand to comply with «zero defect» criteria. In this conjunction weld performance limitations are overcome employing advanced «hot-wire» GTAW systems. This paper, from a welding automation perspective, describes the technology of such devices and deals with the current status in this field, namely the application of dual-cathode hot-wire electrode GTAW cladding, considerably broadening achievable limits. 27 Ref., 2 Tables, 14 Figures.

**Keywords:** GTAW (cladding), single-cathode GTAW, hot-wire welding, dual-cathode GTAW

Arc welding, to the widest extent, is suggested utilised for fusion welding. The major remainder, i.e. weld surfacing, is supposed reasonably split into «hardfacing» and «corrosion-resistant» weld overlay [1, 2]. Economic considerations drive manufacturers to apply high performance surfacing processes, such as submerged-arc welding or resistance electroslag welding. Although producing broadly acceptable quality, these processes are specifically limited respectively due to compulsory use of flux (limited out-of-position capabilities), high dilution, or undesirable aspect ratios.

Controlled gas metal arc welding processes (e.g. CMT method) have been introduced to the industry coping with dilution related issues, e.g. corrosion [3], and thereby partially replacing submerged-arc and resistance electroslag welding. Surfacing applications exist, however, defining «zero defect» criteria paramount to prevent complicated rework, sustainably assure highest surfacing performance and maintaining long-term component durability. Though joined by limited performance in arc efficiency and weld deposition rate, gas shielded tungsten arc welding (GTAW)

is frequently applied in such cases. To overcome lack of performance, systems have been developed modifying the wire feeding process hereby leading to either «cold-wire» or «hot-wire» GTAW. While the former was early revealing process instabilities and noticeably rather difficult deployable [4, 5], the latter appeared capable of tackling inconsistencies, mainly, by preheating the wire.

Manz [6] early described the advantages, e.g. a significant increase in weld deposition rate through beneficially using the resistive wire heating and, compared with cold-wire GTAW, hereby achieving wire feed rates 3 to 10 times faster into the weld pool [4]. Hot-wire GTAW systems continuously advanced are nowadays well-accepted because of providing user benefits [2, 7, 8]. Information on the operational relationship applying hot-wire and cold-wire GTAW is given in [6] and according to this author proper parameter set up would even allow the deposition of wire without any additional arc. This is due to electrical resistive heating of the wire of a specific composition and diameter according to [6]

$$PR = PL\rho/d^2(\pi/4), \quad (1)$$

where  $\rho$  is the apparent resistivity of the wire material;  $L$  is the effective wire extension length; and  $d$  is the wire diameter. The energy required for melting the wire can be expressed as

$$E_{\text{melt}} = HF\delta d^2(\pi/4), \quad (2)$$

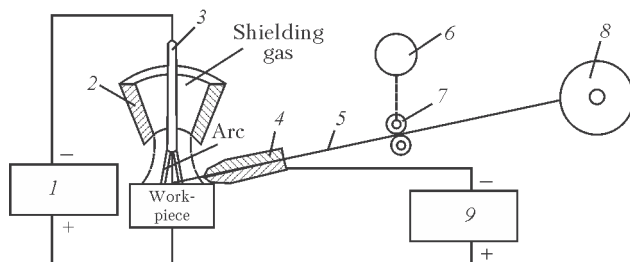
where  $H$  is the heat content of the liquid wire volume;  $F$  is the wire feed rate; and  $\delta$  is the apparent wire density.

Figure 1 adopted from [6] schematically depicts the hot-wire GTAW principle.

Wire feed rate can be computed as

$$F = PL(ES)/(\pi d^2/4). \quad (3)$$

$ES$  is here referred to as the «extension sensitivity constant» [6] dependent only on the wire material



**Figure 1.** Schematic of hot-wire GTAW system [6]: 1 — GTAW power supply (CC mode); 2 — nozzle; 3 — tungsten electrode; 4 — contact tube; 5 — filler wire; 6 — wire feeder; 7 — feed rolls; 8 — wire reel; 9 — hot wire power supply (CV mode)