Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 28
ISSUE 1
May
2008

Thermovision researches of temperature fields distribution in GMA brazed joints of solar collectors

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Received 31.01.2008; published in revised form 01.05.2008

Manufacturing and processing

ABSTRACT

Purpose: of this study was to investigate of temperature fields distribution during GMA brazing of solar collectors.
Design/methodology/approach: IR-pictures were recorded with 50 Hz frequency. After recording, thermovision pictures were analyzed in Irbis software module. This software permit to matching recording parameters, identification of temperature values in arbitrary picture points, assign temperature profiles.
Findings: distribution of temperature fields in the GMA brazed joints in the function of GMA brazing parameters and brazing techniques was established.
Research limitations/implications: basic information about distribution of temperature fields in the GMA brazed joints is the background of the researches of GMA brazing parameters providing highest quality joints.
Practical implications: results of this paper are the data of the temperature fields distribution during GMA brazing of solar collectors joints recorded by IR-camera. This data are important to set an optimal brazing parameters.
Originality/value: the researches were provided using newest filler material for GMA brazing of solar collectors parts using IR recording equipment.
Keywords: GMA brazing; Robotized brazing; Solar collectors; Thermovision

1. Introduction

Intensive growth of alternative sources of energy now results in solar energy utilization. Modern projects of solar absorbers permits to using them to heating water and houses.

Growth of interesting of solar absorbers use is a result of consciousness of people that using alternative sources of energy is a best way to pollutions limitation, especially according to decreased coal, gas and oil world inventory [4,11-15].

Most important elements of solar absorbers are copper pipe-foil joints. In these pipes flows water which receive energy absorbed by copper foil with absorber layer. Main criteria of welding technology assessment is quality. Quality as a tensile strength not lower than base material and high thermal conductivity means as a accurately heat conduction by pipe and foil contact [1-7,9,10].

Significant, from technological view point, is also facility of joining and ability to practical implementation it means to industrial production of solar energy collectors according to PN-EN 12975-1:2000 standards. Used joining technologies must guarantee high quality of joints and high productivity with lower costs. These requirements must be connected with high level of knowledge and analysis of welding processes. Low costs of solar collectors production can be obtained by minimize a number of operation made by people and replace them by a machine in automated production cell. Automated production cells brings increase of productivity simultaneously with increase of precision and repeatability of process. But unfortunately automated production processes requires expensive, precise instrumentation to obtain high quality [11-18].

2. Main researches

GMA brazing process (Fig. 1) of copper thin foil-pipes joints was investigated with optimal parameters for two different types of joints:

- a plain cooper foil brazed with pipe using butt joint, Fig. 2 and 3, Table II,
- and two fillet joints of pipe and semicircular drawed canal foil, Fig. 4 and 5, Table III.
- EcoBraz 38102 brazing solder 1.0 [mm] wire was used as a filler material, Table I.

Table 1.
Chemical composition and properties of copper-phosphorus solder with silver additives (B Cu92PAg) EcoBraz 38102, according to EN 1044 standards

Alloying components contents, [%]								
Cu	P	Ag	Al	Bi	Cd	Pb	Zn	Zn+Cd
92.0	max 6.3	max 2.0	max. 0.01	max. 0.03	max. 0.01	max. 0.025	max. 0.05	max. 0.05

Properties:
Brazing temperature range: 645 – 825 [°C],
Optimal brazing temperature: 740 [°C],
Density: 8.1 [g/cm^3],
Tensile strength: 250 [MPa],
Elongation: 6.0 [%],
Work/operating temperature range: -50 – 150 [°C].

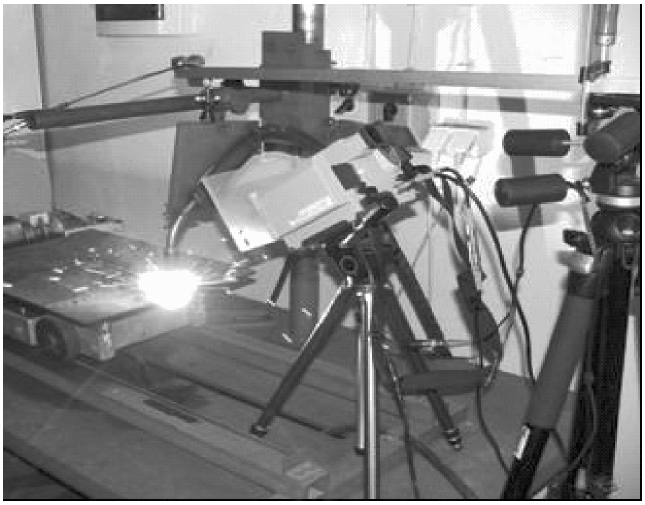

Fig. 1. A view of automated GMA stand for brazing copper thin foil-pipe joints of solar collectors parts (during thermovision pictures recording)

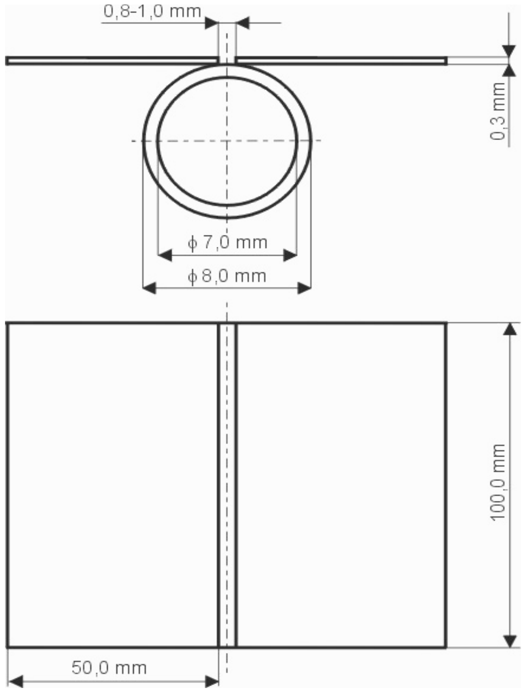

Fig. 2. Preparation directions of solar absorber parts for GMA brazing of copper pipe-plain foil joints

Table 2.
An influence of EcoBraz 1,0 [mm] 38102 wire GMA brazing parameters on quality of copper pipe-plain foil joints

Spec. designation	I [A]	v_l [cm/min]	Quality asessment
1PA	75	48	Low quality, irregular face
2PA	75	45	
3PA	75	40	
4PA	80	40	
5PA	85	40	High quality, wide bead
6PA	90	40	
7PA	95	40	
8PA	100	40	Low quality, high foil distorsions

Remarks: brazing with DC+ current. Shielding gas (argon) flow rate – 15 [l/min]. Electrode sitck-out – 18 [mm]. Brazing gap width: 0,5 – 2,0 [mm]. Designations: I – brazing current, v_l – brazing speed.

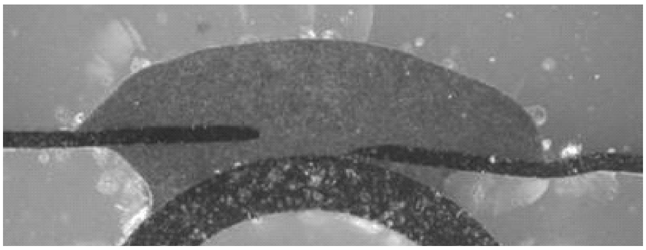

Fig. 3. Macrostructure of pipe-flat foil GMA brazed joints with EcoBraz 38102 1.0 [mm] wire, brazing parameters – Table II, spec. design. 7PA

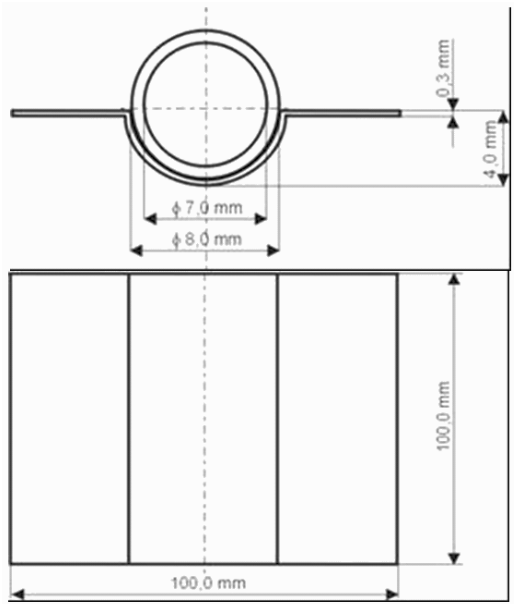

Fig. 4. Preparation directions of solar absorber parts for GMA brazing of copper pipe-semicircular drawed canal foil joints

Table 3.
An influence of EcoBraz 38102 1,0 [mm] wire GMA brazing parameters on quality of copper pipe-semicircular drawed canal foil joints

Spec. designation	I [A]	v_l [cm/min]	Quality assessment
1PB	75	70	Low quality, irregular face
2PB	75	50	
3PB	75	60	Low quality, bad positioning
4PB	75	60	Good quality
5PB	80	60	Irregular face width
6PB	80	60	

Remarks: brazing with DC+ current. Shielding gas (argon) flow rate – 15 [l/min]. Electrode sitck-out – 18 [mm]. Angle between torch and foil - 45[°]. Brazing gap width: 0.5 – 2.0 [mm]. Designations: I – brazing current, v_l – brazing speed.

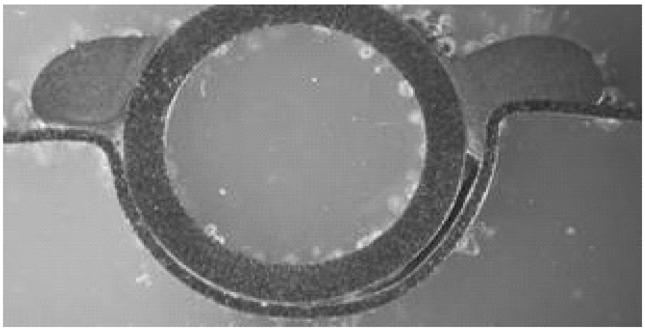

Fig. 5. Macrostructure of pipe-semicircular drawed canal foil GMA brazed joints with EcoBraz 38102 1,0 [mm] wire, brazing parameters – Table 3, 4PB

In order to define of temperatures distribution in pipe-foil joints of solar absorber parts during GMA brazing with EcoBraz 38102 1.0 [mm] wire, thermovision pictures were recorded by VarioCamirmy Infratec IR-camera, equipped in cooled microbolometer detector with max. resolution 320x240 pixel with 50 Hz frequency. To record thermovison pictures sequences on computer hard-drive Irbis on-line software was used.

IR-camera was placed 300 [mm] from GMA torch to provide observation in arc area, molten pool and also at the surface of brazed elements. Recorded pictures were analyzed in Irbis software module. This software permit to matching recording parameters, identification of temperature values in arbitrary picture points, assign temperature profiles etc. Examples of results of thermovision investigations illustrates Figures 6 and 7.

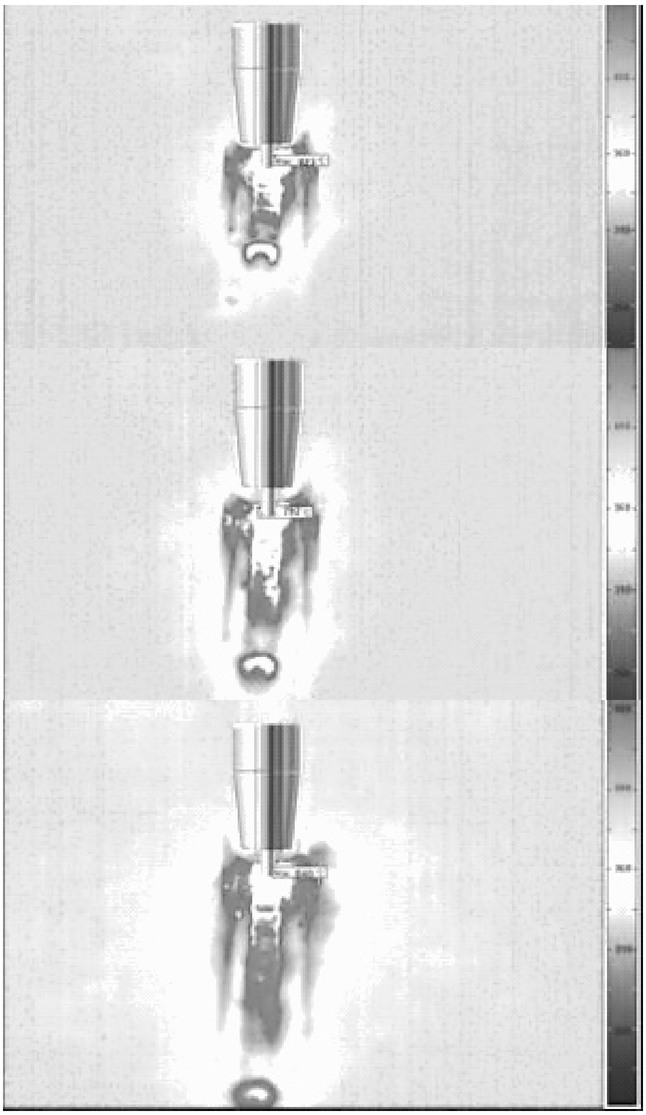

Fig. 6. Thermovision pictures (at the beginning, during and at the end) of plain foil-pipe GMA brazed joint with EcoBraz 38102 1.0 [mm] wire

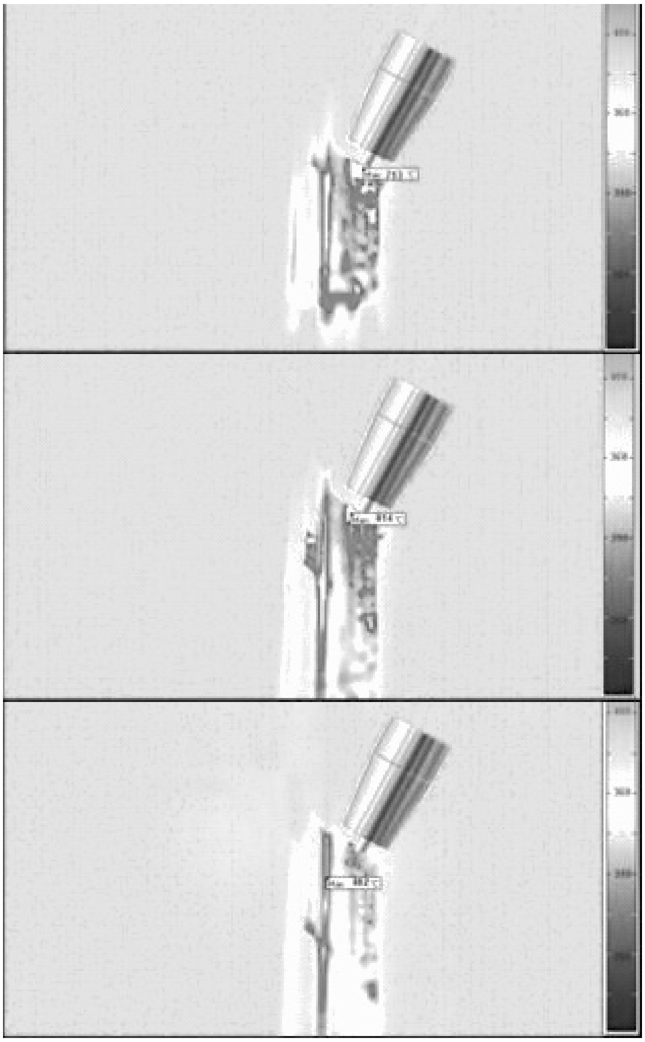

Fig. 7. Thermovision picture (at the beginning, during and at the end) of pipe-semicircular drawed canal foil GMA brazed joint with EcoBraz 38102 1.0 [mm] wire

3. Conclusions

Thermovision tests indicates, that GMA brazing process provide to beneficial temperatures distribution in brazed joints. Max. temperatures in brazing zone do not exceed copper melting temperature. GMA brazing tests of compared joints, indicate that more beneficial is technique of brazing with semicircular drawed canal foil thanks to better temperature distribution and smaller distortions of brazed elements.

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