Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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Annals of DAAAM International

EXPERIMENTAL TEMPERATURE MEASUREMENT OFOXY-ACETYLENE CUTTING PROCESS

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Abstract: *This article deals with temperature measurement of oxy-acetylene cutting. A direct path was carried out on a low carbon steel plate of 25 mm in thickness. The temperature was measured with four K-type thermocouples by digital converter NI USB 9211. Perfect thermal contact of the thermocouples and cut material was provided by a micro-weld. The thermocouples monitored the temperature dependence along thickness plate. The obtained temperature dependences will be used for numerical simulation of material heat load by ANSYS software.*
Key words: *measuring, temperature, oxy-acetylene cutting, thermocouple*

1. INTRODUCTION

Oxygen cutting is cutting technology with a wide range of applications. It is applied in different sectors of production, e. g. repairs, demolition of steel constructions, preparation of parent material for welding etc. Maximum thickness of materials being cut can reach several hundreds of millimeter. This is not possible by plasma and laser beam cutting methods, (Cary et al., 2005, ***, 2010). The principle of oxygen cutting is based on combustion of steel in oxygen. At first, material is heated to the temperature of ignition (for low carbon steel approximately 1350 °C). Then, the flow of oxygen is applied and the highly exothermic combustion process creates a liquid slug being blown out by the oxygen flow (Vasilko et al., 2003). As a result, the kerf in cutting material is formed.

2. OBJECTIVES

The aim of the work was to measure temperatures during oxy-acetylene cutting of low carbon steel plate of 25 mm in thickness. The obtained temperature relationship will be used for numerical simulation of the heat load prediction by ANSYS software.

3. EXPERIMENTAL PROCEDURE

Oxygen cutting experiments were carried out using steel plate S355J0 (DIN 1.0570). Steel S355J0 is structural steel for welding constructions with guaranteed weldability. The size of the samples was 300x120x25 mm.

3.1 The samples

There were prepared two groups of samples. The first one was made for searching of vertical temperature distribution (A series). The second one was dedicated for transverse temperature measurements (B series). The number of thermocouples was chosen with regard to measurement setup properties. Each sample had attached four thermocouples by a micro-weld.

Geometry of A series of sample was designed for location of all thermocouples at 5, 10, 15, 20 mm from the surface top of the material. The vertical thermocouples distribution is shown in Fig. 1.

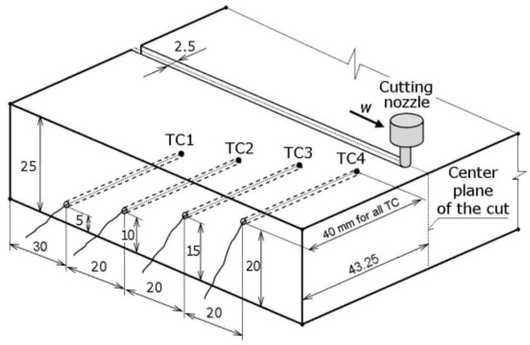

Fig. 1. The placement of thermocouples for vertical temperature measurement, A sample

Samples of B series were prepared for transverse temperature measurements. The thermocouples were located TC1: 14.25, TC2: 6.25, TC3: 4.25 and TC4: 2.75 mm from the central plane of the cut respectively. All thermocouples were located 5 mm from the top surface of the material. The transverse placement of the thermocouples is shown in Fig. 2.

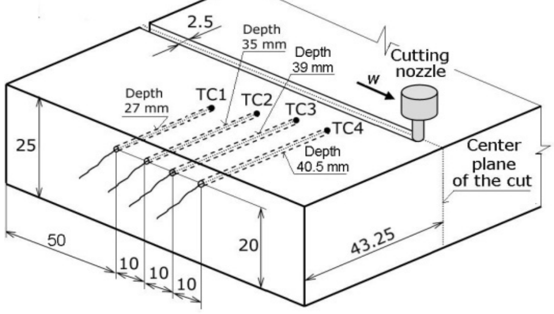

Fig. 2. The placement of thermocouples for transverse temperature measurement, B sample

3.2 Temperature sensors

A thermoelectric temperature measurement was chosen for temperature detection in several locations of sample during cutting process. Chromel-alumel "K" type thermocouples were used which are applicable within the temperature range up to 1250°C. It was necessary to place the thermocouples at the exact location and the exact depth. In order to provide this, there was necessary to drill holes in the samples and to micro-weld the thermocouples. The drill diameter was 2.5 mm.

3.3 Recording of measured temperatures

The measuring system consisted of a cutting machine RS 13, sample, connecting cables, module NI USB9211 and personal computer. There was used an electronic recording method for temperature measurement. The system of thermocouples was connected through input module NI USB9211 to the portable personal computer (***, 2009).

Temperatures were recorded 3 times per second. The obtained temperatures were transferred to the Origin 11 software and the temperature vs. time relationships were created.

3.4 The cutting device and cutting parameters

The horizontal oxygen cutting machine RS 13 was used. A several testing cuts with different cutting parameters were carried out before temperature measurement in order to determine the optimal cutting parameters. During this process the visual inspection of cutting edges was accomplished. The optimal cutting parameters were as follows: the pressure of preheat flame was 110 kPa, the pressure of cutting oxygen was 0.35 MPa. Cutting speed was 4.17 $mm.s^{-1}$ (250 $mm.min^{-1}$) and nozzle to material distance was 8 mm. There was necessary to keep the same cutting parameters for all samples. The measured results were recorded by computer. The cutting device and measuring setup are shown in Fig. 3.

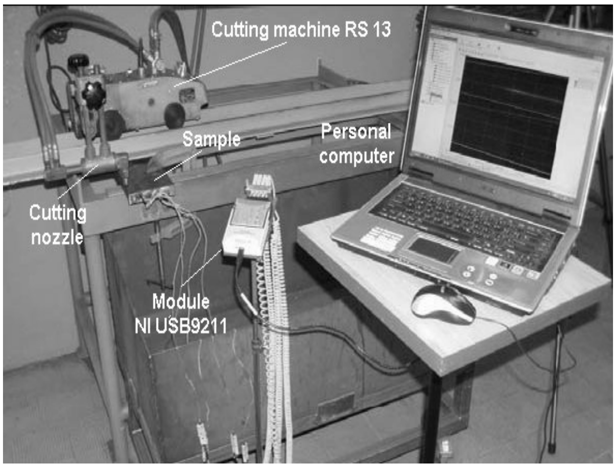

Fig. 3. The cutting device and measuring setup

4. OBTAINED RESULTS

Temperature distributions in the test samples as dependence on the material thickness (A series, Fig. 4) and plane cut distance (B series, Fig. 5) were obtained.

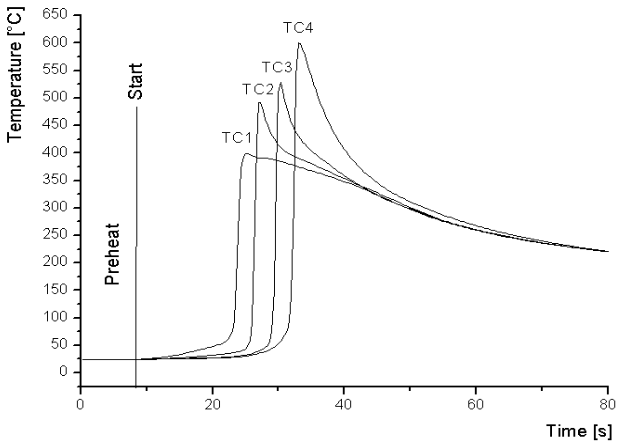

Fig. 4. Measured temperatures for A sample

Thermocouple	Distance from the top of surface	Maximum temperature
TC1	20 mm	399 °C
TC2	15 mm	492 °C
TC3	10 mm	528 °C
TC4	5 mm	600 °C

Tab. 1. The maximum temperatures for A sample

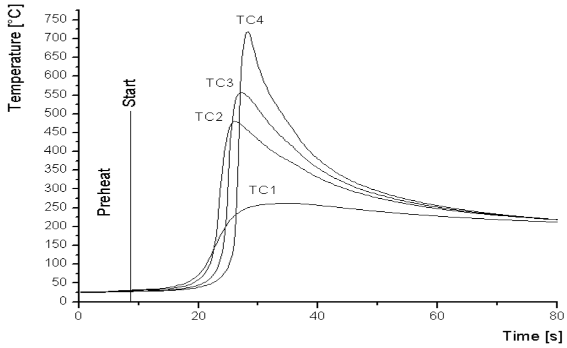

Fig. 5. Measured temperatures for B sample

Thermocouple	Distance from the center cutting plane	Maximum temperature
TC1	14.25 mm	262 °C
TC2	6.25 mm	480 °C
TC3	5.25 mm	556 °C
TC4	4.25 mm	719 °C

Tab. 2. The maximum temperatures for B sample

5. CONCLUSION

There were obtained eight temperature courses from eight points of cut sample. The measured data will be used in the next step of cutting process analysis - numerical simulation. Temperature of all thermocouples converged in the long run to the same temperature. This confirms, that all temperature measurements were correct. Analysis of temperature fall-off of TC1 and TC2 (Fig. 4) lead to assumption that these thermocouples were affected probably by the cutting nozzle heat source – temperature fall-off of TC1 and TC2 is slower and does not correspond to the TC3 and TC4 fall-off. There is also acceptable temperature course of B sample for numerical analysis (Fig. 5) Temperature gradient represented temperature difference of 457 °C at perpendicular distance 12 mm from cut plane. The numerical simulation will use inverse heat transfer problem. The inverse-numerical-correlation (INC) method will be taken into account (Alifanov, 1994). The objective of numerical simulation will be solution of transient thermal fields, thermal fluxes fields and values of volumetric rate of thermal energy generation from steel combustion during cutting. The simulation model will include nonlinear thermo-physical material properties and boundary conditions. The speciality of solving procedure will be change of steel to air elements of cut volume.

6. ACKNOWLEDGEMENT

This paper was realised with the support of grants: APVV 0057-07 and VEGA 1/0721/08.

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