FACULTY OF MECHANICAL AND CIVIL ENGINEERING
IN KRALJEVO
UNIVERSITY OF KRAGUJEVAC

The Eighth Triennial
International Conference

HEAVY MACHINERY HM 2014

Proceedings

ZLATIBOR, SERBIA
June 25 - June 28 2014

CONFERENCE CHAIRMAN

Prof. dr Milomir Gašić, FMCE Kraljevo

INTERNATIONAL SCIENTIFIC PROGRAM COMMITTEE

CHAIRMAN

Prof. Dr Mile Savković, FMCE Kraljevo

VICE-CHAIRMAN

Prof. Dr Milan Kolarević, FMCE Kraljevo, Serbia

MEMBERS

1. Prof. Dr M. Alamoreanu, TU Bucharest, Romania
2. Prof. Dr S. Arsovski, FME Kragujevac, Serbia
3. Prof. Dr D. Atmadzhova, VTU "Todor Kableshkov", Sofia, Bulgaria
4. Prof. Dr M. Berg, Royal Institut of Tecnology-KTH, Sweden
5. Prof. Dr H. Bogdevicius, Technical University, Vilnus, Lithuania
6. Prof. Dr S. Bošnjak, FME Belgrade, Serbia
7. Prof. Dr A. Bruja, TU Bucharest, Romanija
8. Prof. Dr Z. Bučevac, FME Belgrade, Serbia
9. Prof. Dr R.Bulatović, FMCE Kraljevo, Serbia
10. Prof. Dr A. Bukvić, FME East Sarajevo, Bosnia and Herzegovina
11. Prof. Dr M. Dedić, FMCE Kraljevo, Serbia
12. Prof. Dr A. I. Dotsenko, MGSU, Moscow, Russia
13. Prof. Dr R. Durković, FME Podgorica, Montenegro
14. Prof. Dr M. Đapić, FMCE Kraljevo, Serbia
15. Prof. Dr Z. Đinović, Integrated MicroSystem, Vienna, Austria
16. Prof. Dr K. Ehmann, Northwestern University, Chicago, USA
17. Prof. Dr A. Emeljanova, HGTUSA Harkov, Ukraine
18. Prof. Dr V. Filipović, FMCE Kraljevo, Serbia
19. Prof. Dr C. Fragassa, University of Bologna, Italy
20. Prof. Dr M. Gagl, Integrated MicroSystem, Vienna, Austria
21. Prof. Dr D. Golubović, FME East Sarajevo, Bosnia and Herzegovina
22. Prof. Dr V. Jovišević, FME Banja Luka, Bosnia and Herzegovina
23. Prof. Dr B. Jerman, FME Ljubljana, Slovenia
24. Prof. Dr Z. Jugović, Tehnical Faculty Čačak, Serbia
25. Prof. Dr V. Karamarković, FMCE Kraljevo, Serbia
26. Prof. Dr M. Karasahin, Demirel Univerity, Istanbul, Turkey
27. Prof. Dr I. Kiričenko, HNADU Kiev, Ukraine
28. Prof. Dr K. Kocman, Tecnical University of Brno, Czech Republic
29. Prof. Dr S. Kolaković, Faculty of Tehnical Sciences, Novi Sad, Serbia
30. Prof. Dr M. Kostic, Northern Illinois University, DeKalb, USA
31. Prof. Dr M. Králik, FME Bratislava, Slovakia
32. Prof. Dr E. Kudrjavcev, MGSU, Moskow, Russia
33. Prof. Dr Đ. Lađinović, Faculty of Tehnical Sciences, Novi Sad, Serbia
34. Prof. Dr LJ. Lukić, FMCE Kraljevo, Serbia
35. Prof. Dr Z. Marinković, FME Niš, Serbia
36. Prof. Dr N. Mešćerin, MGSU, Moskow, Russia
37. Prof. Dr I. I. Nazarenko, KNUBA Kiev, Ukraine

38. Prof. Dr N. Nedić, FMCE Kraljevo, Serbia
39. Prof. Dr N. Nenov, VTU "Todor Kableshkov", Sofia, Bulgaria
40. Prof. Dr V. Nikolić, FME Niš, Serbia
41. Prof. Dr E. Nikolov, Technical University, Sofia, Bulgaria
42. Prof. Dr M. Ognjanović, FME Belgrade, Serbia
43. Prof. Dr J. Peterka, FMS&T, Trnava, Slovakia
44. Prof. Dr D. Petrović, FMCE Kraljevo, Serbia
45. Prof. Dr Z. Petrović, FMCE Kraljevo, Serbia
46. Prof. Dr J. Polajnar, BC University, Prince George, Canada
47. Prof. Dr V. Radonjanin, Faculty of Tehnical Sciences, Novi Sad, Serbia
48. Prof. Dr V. Raičević, FME Kosovska Mitrovica, Serbia
49. Prof. Dr M. Rajović, FMCE Kraljevo, Serbia
50. Prof. Dr M. Stefanovć, FME Kragujevac, Serbia
51. Prof. Dr D. Sever, Maribor, Civil Engineering, Slovenia
52. Prof. Dr M. A. Stepanov, MGSU, Moskow, Russia
53. Prof. Dr I. S. Surovcev, VGSU, Voronezh, Russia
54. Prof. Dr Z. Šoškić, FMCE Kraljevo, Serbia
55. Prof. Dr LJ. Tanović, FME Belgrade, Serbia
56. Prof. Dr S. Trifunović, FMCE Kraljevo, Serbia
57. Prof. Dr J. Vladić, Faculty of Tehnical Sciences, Novi Sad, Serbia
58. Prof. Dr M. Vukićević, FMCE Kraljevo, Serbia
59. Prof. Dr K. Weinert, University of Dortmund, Germany
60. Prof. Dr N. Zrnić, FME Belgrade, Serbia

ORGANIZING COMMITTEE

CHAIRMAN:

Prof. Dr Ljubomir Lukić, FMCE Kraljevo

VICE-CHAIRMAN:

Prof. Dr Zlatan Šoškić, FMCE Kraljevo, Serbia

MEMBERS:

Doc. Dr S. Ćirić-Kostić, FMCE Kraljevo, Serbia
Doc. Dr Lj. Dubonjić, FMCE Kraljevo, Serbia
Doc. Dr O. Erić, FMCE Kraljevo, Serbia
Doc. Dr R. Karamarković, FMCE Kraljevo, Serbia
Doc. Dr M. Marašević, FMCE Kraljevo, Serbia
Doc. Dr D. Pršić, FMCE Kraljevo, Serbia
Doc. Dr S. Šalinić, FMCE Kraljevo, Serbia
M.Sc. M. Bjelić, FMCE Kraljevo, Serbia
M.Sc. N. Bogojević, FMCE Kraljevo, Serbia
M.Sc. Z. Glavčić, FMCE Kraljevo, Serbia
M.Sc. Lj. Lalović, FMCE Kraljevo, Serbia
M.Sc. G. Marković, FMCE Kraljevo, Serbia
M.A. N. Pavlović, FMCE Kraljevo, Serbia
M.Sc. B. Radičević, FMCE Kraljevo, Serbia
M.Sc. N. Zdravković, FMCE Kraljevo, Serbia

Dependence of Mechanical Properties of the Base Metal and Welded Joint of the High Strength Steel S690QL on Elevated Temperatures

Dušan Arsić[1*], Vukić Lazić[1], Andreja Ilić[1], Lozica Ivanović[1],
Srbislav Aleksandrović[1], Milan Đorđević[1]
[1] Faculty of Engineering, University of Kragujevac, 34000 Kragujevac (Serbia)

In this paper is analysed behaviour of mechanical properties of the welded joint and base material of high strength steel S690QL at elevated temperatures. The exposure to elevated temperatures could lead to deterioration of mechanical properties of steel as well as to decreasing of load bearing capacity. Since this steels belongs to a group of steels with exquisite mechanical properties, the aim of this work is to show which is the critical temperature when its mechanical properties are going to worsen. For that purpose, an experimental investigation has been carried out. The specimens were taken both from the welded plate and the base material. The welding was performed with GMAW procedure using two types of filler metals with different mechanical properties for root layer and cover ones. The experiment was performed within the temperature range 20°C to 550°C. The obtained results show the difference with respect to several references, including the European standards, steel producers recommendations and some other researches results. Therefore, studying of mechanical properties of this steel at elevated temperatures is of the utmost importance.

Keywords: High strength steel, S690QL, Welded joint, High temperature, Mechanical properties.

1. INTRODUCTION

With constant advancements in the field of welding technology, there is a growing need for high strength construction steels such as the steel grade S690QL which is analysed in this paper. In order to maintain good weldability, the carbon content in high strength steels has to be as low as possible (max 0.22%) and the steel should have good mechanical properties which would make the welded construction reliable and light. When complex welded constructions are made, especially the ones made of steels of wide cross-sections, the steel is often heated (preheated, additionally heated and tempered), and the process engineers and designers often find themselves in a dilemma concerning the maximum temperatures allowed for this process. In the literature, wide ranges of these temperatures can be found, depending on the thickness of the welded plates i.e., their thickness equivalents. The aim of this experimental paper is to determine the maximum working temperatures at which both base metal (BM) and weld metal (WM) keep thier high strength values.

Dependance of mechanical properties of the base material and welded joints on the temperature has been subject of numerous investigations [1-6]. Due to that, we want do give our contribution to understanding of influence of high temperatures on mechanical properties.

The results shown in the papers [1-4, 6-8] represent a good starting point to understanding the influence of temperature on the base material mechanical properties. However, this influence has not been analysed particularly for the welded joints of high strength steels, which are very sensitive not only to local input of heat that ocurrs during the welding process but also to elevated working temperatures. Due to these reasons we have chosen to perform complex experimental investigations both of the base material and the welded joints. Some of our published papers [9, 10, 11] studied the high steel grade S690QL and certain zones of welded joints from the aspect of mechanic and metallurgical properties. In these papers different welding methods and different filler materials were used in order to find the most suitable welding technology. In the present paper we have chosen the MAG welding method and two different filler materials. The root passage was done using austenitic filler material, and the passes were filled with the filler material of the strength similar to the base material strength. Thus, good ductility of the joint and the minimum stress concentration are achieved, while residual stresses in the welded joints are significantly decreased.

2. SELECTION OF THE MOST SUITABLE WELDING TECHNOLOGY

1.1. Base metal

Since behaviour of the steel S690QL is studied at elevated temperatures, the welded joints have to be welded using the most suitable welding technology. The steel S690QL is produced under special conditions by heating up to the austenite region, rolling and finally by controlled cooling. The steel produced in such a thermo-mechanical treatment process (Quenching + Tempering – Q + T steel) is highly resistant and has good toughness which is maintained even at low temperatures [12]. There are three modifications of this steel that differ only in the guaranteed impact toughness. In fact, all the modifications have the same guaranteed impact toughness of 27 J but different transient temperatures. For the steel grade S690QL it is 47 J at -40°C. The chemical composition and the most important mechanical properties of the steel S690QL are given in Tables 1 and 2 [9, 10, 11, 16].

1.2. Selection of the welding technology

The MAG/MAG method was proposed For welding of the steel grade S690QL the proposed method is MAG/MAG (GMAW/GMAW), and two different filler materials [11, 12] for the root pass and the cover welds were chosen (Tab. 3).

*Corresponding author: dusan.arsic@fink.rs; cmz@fink.rs