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# POSSIBILITIES OF JOINING TECHNIQUES APPLICATION AT RAILWAY LINES JOINING AND MAINTENANCE

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Preliminary Note – Prethodno priopćenje

This paper presents most important techniques which is possible to apply at joining of railway lines as well as maintenance procedure. Beside thermit welding as a older joint process for that job (since 1895.) it is mentioned flash welding as a modern joining technique interesting from the point of cost efficiency. In a case of maintance tasks it is necessary to caunt arc welding processes and thermit welding, too. Authors gave some experimental date collected during investigation on railway lines joining techniques application.

*Key words:* welding, railway lines, thermit welding, flash, arc welding, microstructure

**Mogućnosti primjene tehnika spajanja izgradnja i održavanje tračničkih linija.** U radu se opisuju najznačajniji postupci zavarivanja pogodni za spajanje i održavanje željezničkih tračnica. Pored aluminotermijskog postupka spajanja tračnica (u primjeni od 1895. god.), spominje se i elektrootporno zavarivanje iskrenjem kao suvremeni postupak spajanja sa stajališta tehnologičnosti. Kod održavanja željezničkih tračnica važno je računati i sa elektrolučnim zavarivanjem i sa aluminotermijskim zavarivanjem. Autori daju eksperimentalno dobivene podatke prikupljene tijekom ispitivanja mogućnosti primjene tehnika spajanja željezničkih tračnica.

*Ključne riječi:* zavarivanje, tračničke linije, aluminotermijsko zavarivanje, elektrolučno zavarivanje, mikrostruktura

## INTRODUCTION

Thermit welding was appeared in application at the end of XIX century. It is still in application with some improvements in relation to beginning of application. Beside that welding process, very important process in joining of railway lines is flash welding. It is modern high efficiency welding process suitable for workshop and on site application. The equipment for flash welding is not so simply as equipment for thermit or arc welding but it is reasonable to expect more better quality at flash welding due to more suitable performing of welding as well as control of welding parameters during welding process. All afore mentioned welding processes are still in application and play significant role in installation and maintenance of railway as well as streetcar lines. Beside short overview of thermit and flash welding processes authors give some results of quality investigation on welded joints performed bz these welding processes. The importance of joining and maintenance of railway lines is of national interest of each country because of fact that railway transport plays and will play very important role in goods transport. Especially today in the time of rational energy consumption and savings and environmental protection.

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## THERMIT AND FLASH WELDING FUNDAMENTALS

Thermit welding is a welding process which produces coalescence of metals by heating them with superheated liquid metal from a chemical reaction between a metal oxide and aluminium with or without the application of pressure. The heat for welding is obtained from an exothermic reaction between iron oxide and aluminium by the following formula: [1]

$$8\,Al + 3\,Fe_3O_3 = 9\,Fe + 4\,Al_2O_3 + Heat \qquad (1)$$

Figure 1 shows steps of thermit welding. Maximal temperature as a result of aforementioned reaction is approximately 2 500 $^oC$. Before railway lines welding by thermit welding process the preheating by gas flame is applied. The effective time of chemical reaction and welding is less than minute but whole procedure with preparing time and post processing time is over 30 minutes (depending on weather conditions, access to workpiece, shape and dimensions of workpiece etc.).

Cleanness is generally very important at welding. At thermit welding it is extremely important because of direct influence on weld joint quality and weldment properties.

Flash upset welding (Figure 2) is resistance welding process which produce coalescence simultaneously over the entire area of abutting surfaces or progressively along a joint, by the heating obtained from resistance to

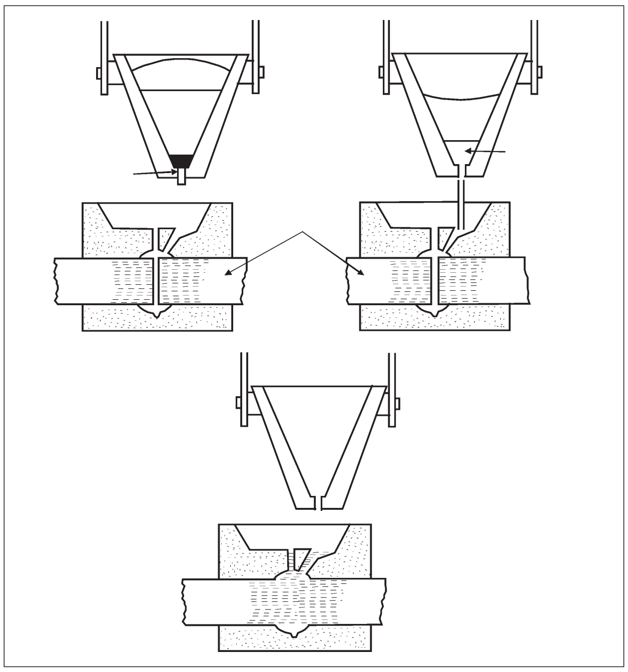


**Figure 1** The steeps of thermit welding [1]

electric current through the area where those surfaces are in contact. [1] For all resistance welding processes it is important Joule's low:

$$Q = I^2 \cdot R \cdot t, \text{J} \quad (2)$$

From this equation it is possible to detect main welding parameters: welding current (A), resistance (Ω) and time (s). Another one important parameter is pressure which is applied during whole welding cycle. The main influence on obtained heat quantity has current which is in function of time during the welding cycle (Figure 3).

## EXPERIMENTAL INVESTIGATION OF THERMIT WELD MICROSTRUCTURE

After application of thermit welding (Figure 4) on steel for railway lines (type 900 A according to UIC 860 V standard) it was prepared specimen for macro and microstructure analysis. Figure 5 shows macro section of welded joint based on which are made microstructure

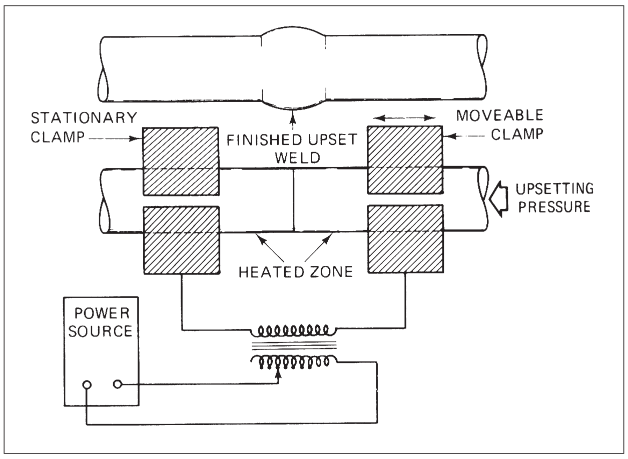
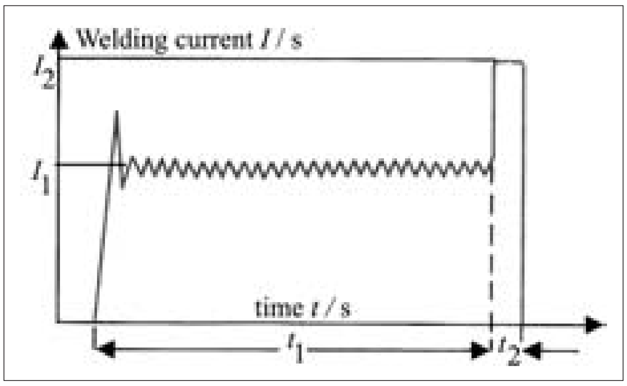



**Figure 2** Sketch of flash welding process [1]




$t_1$ = flashing time, s
$t_2$ = upset current time, s
$I_1$ = flashing current, A
$I_1$ = upset current, A

**Figure 3** An example of welding current (*I*) as a function of time during flash upset welding [2]

photographies of individual parts of welded joint (Figures 6 to 9).

Figure 7 shows „border line" or „fusion line" between weld metal and heat affected zone.

**Figure 4** Location of specimen for metalographical and hardness examinations

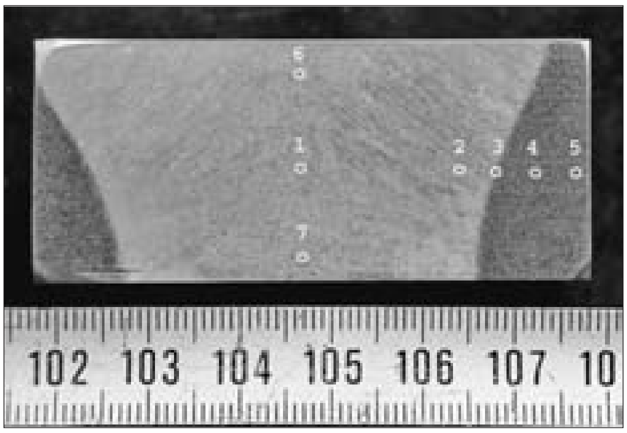



**Figure 5** Macro section of thermit welded joint on railway line

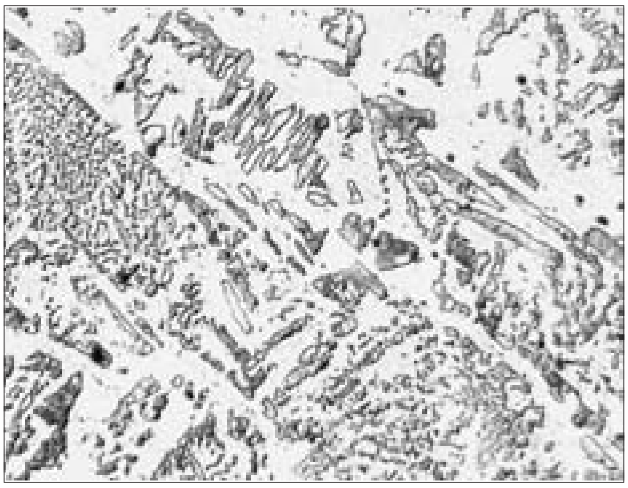


**Figure 6** Microstructure of weld metal (Figure 5, location 1)

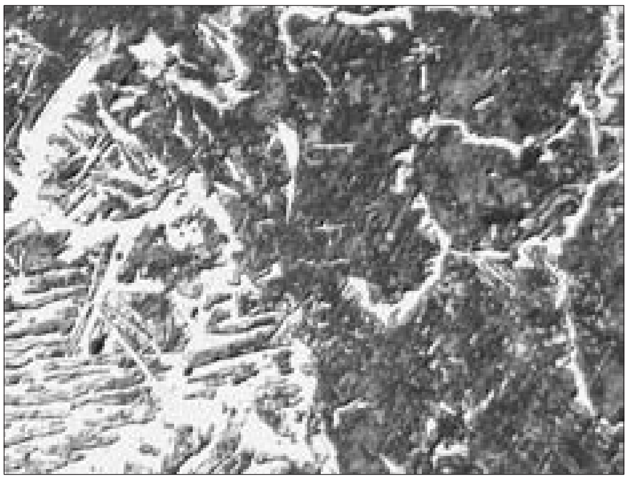


**Figure 7** Microstructure zone between weld metal and heat affected zone (Figure 5, location 3)

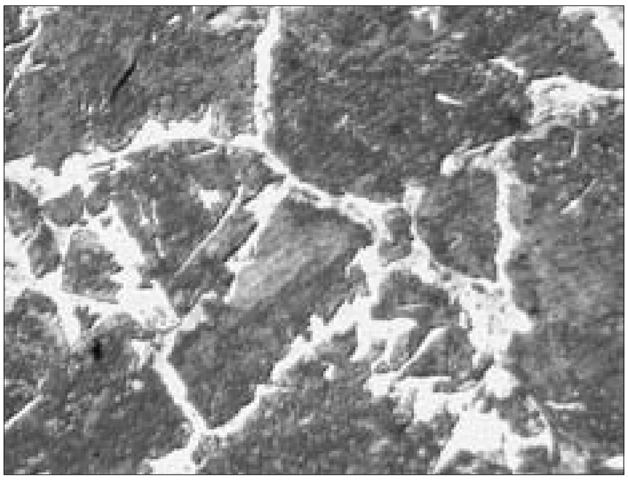


**Figure 8** Microstructure of heat affected zone (Figure 5, location 4)

Hardness *HV* 1 distribution on weld joint specimen is shown on Figure 10. It is evident not high hardness value in weld metal (average value 150 *HV* 1), but it is increased in heat affected zone on bit over 250 *HV* 1.

After flash upset welding it is prepared macro section of welded joint (Figure 11 a and b). Weld joint is performed on professional welding machine by the same welding parameters as production welding. After that it is prepared micro photographies of individual zones of welded joint shown at Figure 11 a and b. Microstructures of weld metal and heat affected zone are presented on Figures 12 and 13. Figure 14 shows hardness distribution in welded joint.

Welding technologies for railway lines setting are still in progress [3]. There are wide range of welding processes with strong stress on productivity and safety. Inspection of rail welds [4] is important due to fact that there are huge number of risks at railway lines transport. New and modern technologies are very important in that

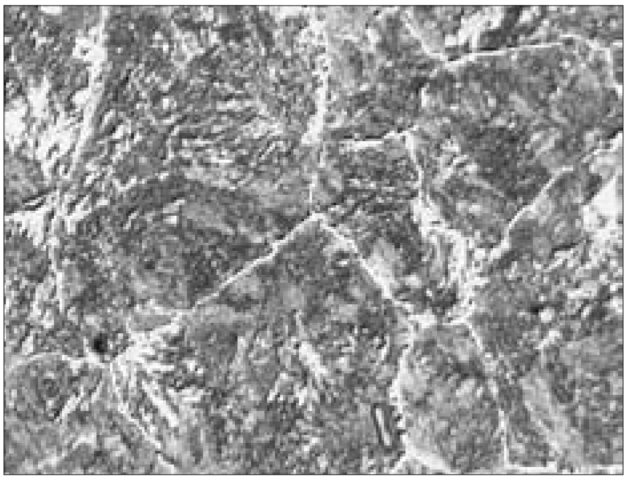


**Figure 9** Microstructure of heat affected zone (Figure 5, location 5)

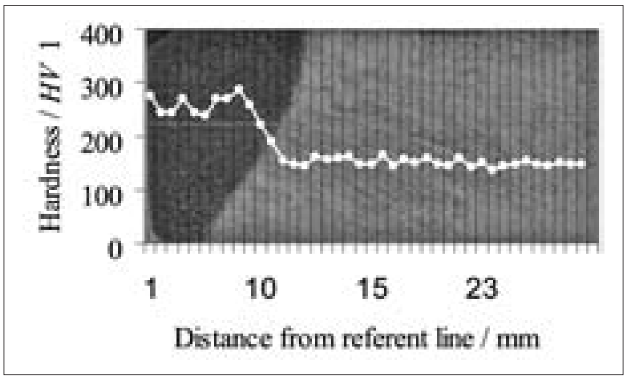
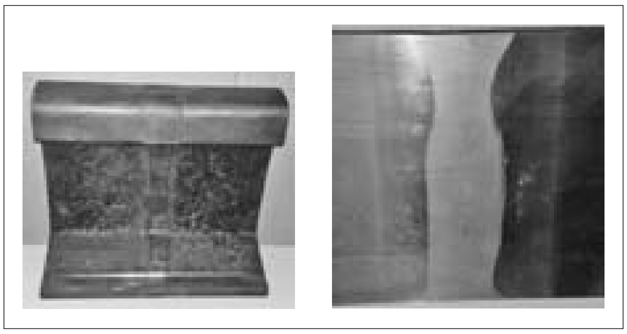



**Figure 10** Hardness *HV* 1 in heat affected zone (darker, left area on Figure) and weld metal



a) b)

**Figure 11** Front view and lomgitudinal cross section of flash resistance upset welded joint

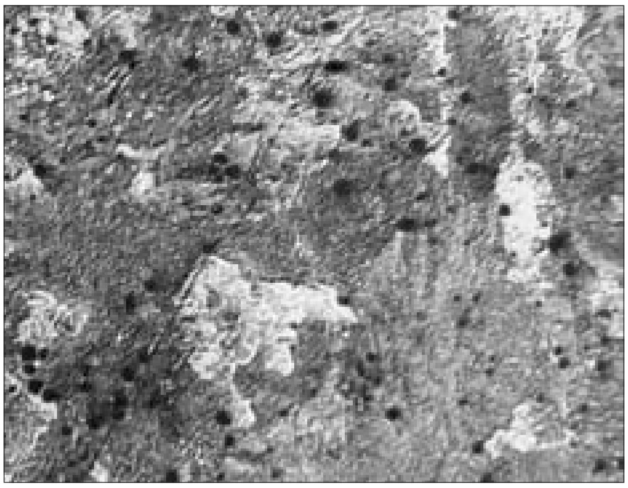


**Figure 12** Microstructure of middle of weld joint from Figure 11.

**Figure 13** Microstructure of heat affected zone of weld joint from Figure 11.

sense for productivity and cost efficiency as well as quality and safety.

## CONCLUSION

Application of welding processes is still important for building and maintenance of railway lines due to fact that railway traffic will play very important role in global traffic of people and goods. Thermit welding and flash welding are processes used in construction of railway lines. They are cost effective and reliable if they are performed under strict conditions and welding parameters in workshop as well as on site. Beside short fundamentals of those welding processes authors gave experimental results of microstructure examinations of individual zones in welded joint (weld metal and heat affected zone) and hardness distribution in welded joints. Presented results confirmated satisfactory quality of welded joints performed by both aforementioned welding processe. Presented results are base for the next investigations relating to reliability and safety of welded joint at railway lines as well as investigations of repair procedure influence on quality of these weldments.

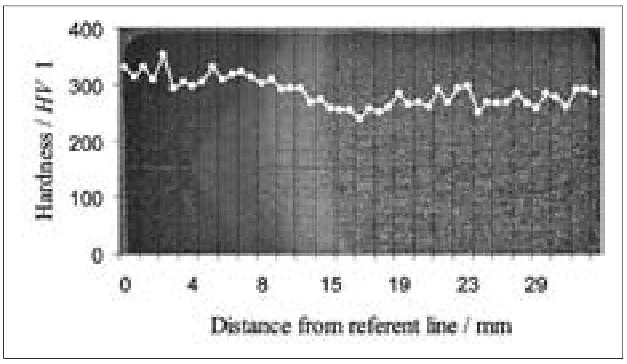



**Figure 14** Hardness *HV* 1 distribution heat affected zone (darker, left area) to middle of the welded joint (right area)

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**Note:** Responsible translator: Željka Rosandić, Faculty of Mechanical Engineering, University of Osijek, Slavonski Brod, Croatia