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# New welding technologies for car body frame welding

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## ABSTRACT

**Purpose:** of that paper was analysing main welding process for car body welding. The main reason of it was investigate possibilities of getting varied amount of acicular ferrite (AF) in WMD (weld metal deposit). High amount of acicular ferrite influences positively impact toughness of weld. For optimal amount of AF it is necessary to have optimal chemical composition in WMD. Important role plays especially Ni. There were also tested new welding technology: welding with micro-jet cooling.

**Design/methodology/approach:** During research with varied micro-jet parameters the chemical analysis, micrograph tests and Charpy V impact test of the metal weld deposit on pendulum machine were carried out. The Charpy V impact test was prepared according to standard ISO EN 148-1 Metallic materials - Charpy pendulum impact test - Part 1: Test method. Samples for impact testing were prepared according to standard ASTM A370.

**Findings:** Varied amount of acicular ferrite in weld metal deposit (in range 55-75%) in terms of micro-jet cooling parameters (numbers of jet, gas pressure). This high amount of acicular ferrite is unheard in weld metal deposit in another way or other methods of welding like MAG or TIG.

**Research limitations/implications:** That research was made for MIG method (according to PN-EN ISO 4063:2009) only. Another method of welding in this article was not tested. Other methods (for eg. MAG, TIG) have not been tested, but it is suspected that similar phenomena are taking place.

**Originality/value:** In this research new method of cooling weld joint during welding was used. At the present time use of micro-jet cooling while MIG is in the testing phase and requires an accurate diagnosis.This method is very promising and capable of industrial application, mainly due to the significant improvement of weld quality and reduces costs.

**Keywords:** Alloy elements; Welding; Nickel; Micro-jet cooling parameters; Weld metal deposit

**Reference to this paper should be given in the following way:**

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MATERIALS MANUFACTURING AND PROCESSING

## 1. Introduction

This paper studies safety and exploitation of weld steel structure of car body frames. The most important factors influencing that conditions are connected with material choice and welding technology. Because of that a good selection of steel and welding method is crucial to obtain proper steel structure. There are numerous tasks for car body frames. One from those, very important to vehicle safety, is vibration propagation [19,20]. Car body elements of higher durability are made from new materials, such as BH, TRIP, DP, IF, CP steels, nevertheless the most important material for car body frame is connected with low carbon and low alloy steel. That material is very often depended of small amount of carbon and the amount of main alloy elements such as Ni, Mn, Mo, Cr and V in low alloy steel and their welds [1-15]. Exploitation conditions of steel weld structure depends on many factors. The main role of that conditions is connected with material, welding technology, also state of stress and temperature. The material properties achieved by metallurgical methods are very important. So the novel metallurgical technologies are investigated [21-23]. Because of that very important is select steel and welding method for proper steel structure [11-18]. In the terms of the kind of steel it is used a proper welding method and adequate filler materials. In the present paper it was tested and optimized the chemical composition of metal weld deposit on the operational properties of steel welded structures. It was presented also new technology based on micro-jet cooling.

Chemical composition of steel and filer materials could be regarded as a very important factor influencing properties of metal weld deposit (WMD). Especially manganese, nickel, molybdenum are regarded as the main factors effecting metallographic structure of low alloy welds. In the paper only influence of the variable amounts of nickel on impact properties of low alloy metal weld deposit was tested. It was made in comparison with possibilities of new technology: welding with micro-jet cooling, that could be treated as future of car body welding. Nickel is regarded as the most beneficial element on impact toughness properties of low alloy basic electrode steel welds in sub-zero temperature. Authors of the main publications [3-6] present that also nitrogen and oxygen have great influence on impact toughness of WMD. The content of nitrogen in low alloy weld metal deposit should not be greater than 80 ppm, and that oxygen content should not exceed 500 ppm. It was observed that nickel (from 1% to 3%) in metal weld deposit gives good impact toughness properties of welds.

## 2. Experimental procedure

Firstly nickel as a main element influencing impact toughness of weld was tested. To assess the effect of nickel on mechanical properties of deposited metal weld deposit there were used basic electrodes prepared in experimental way. The electrode contained constant or variable proportions of the following components in powder form:

- technical grade chalk 30%,
- fluorite 20%,
- rutile 4%,
- quartzite 3%,
- ferrosilicon (45%Si) 6%,
- ferromanganese (80%Mn) 4%,
- ferrotitanium (20%Ti) 2%,
- iron powder 31%.

The principal diameter of the electrodes was 4 mm. The standard current was 180A, and the voltage was 22V. A typical weld metal deposited had following chemical composition:

- 0.08% C,
- 0.8% Mn,
- 0.37% Si,
- 0.013% P,
- 0.012% S.

The oxygen content was in range from 340 to 470 ppm, and the nitrogen content was in range from 70 up to 85 ppm. The acicular ferrite content in weld metal deposit was on the level of 50%. This principal composition was modified by separate additions of ferronickel powder up to 6.5% (at the expense of iron powder). A variation in the nickel amount in the deposited metal was analysed from 0 up to3 Ni%. Secondly micro-jet technology was adopted to welding process. Argon was used both as welding shield gas and as a micro-jet gas. Diameter of micro-jet stream was equal 40 µm, 50 µm or 60 µm. Montage of welding head and micro-jet injector illustrates Figure 1.

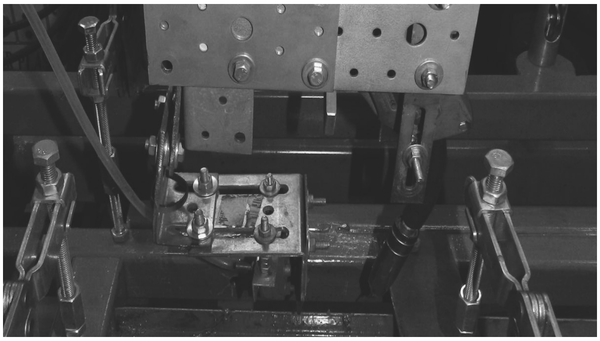


Fig. 1. Montage of welding head and micro-jet injector

Weld metal deposit was prepared by MIG welding with micro-jet cooling with standard parameters (Table 1).

Table 1.
Parameters of welding process with micro-jet cooling

| No | Parameter | Value |
|---|---|---|
| 1. | Principal diameter of welding wire | 1.2 mm |
| 2. | Standard current | 200 A |
| 3. | Voltage | 22 V |
| 4. | Shielding welding gas | Ar |
| 5. | Kind of tested micro-jet cooling gas | Ar |
| 6. | Number of streams in injector | always 1 |
| 7. | Standard of welding wire | EN 440: G4S:1 |
| 8. | micro-jet gas pressure | 0.4 MPa |
| 9. | diameter of micro-jet stream | 40 µm, 50 µm, 60 µm |

## 3. Results and discussion

After the welding process (firstly) using basic coated electrodes there were gettable metal weld deposits with the variable amounts of nickel. After that the chemical analysis, micrograph tests, and Charpy notch impact toughness tests of the deposited metal were carried out. The Charpy tests were done mainly at +20°C and -40°C with 5 specimens having been tested from each weld metal. The impact toughness results are given in Fig. 2.

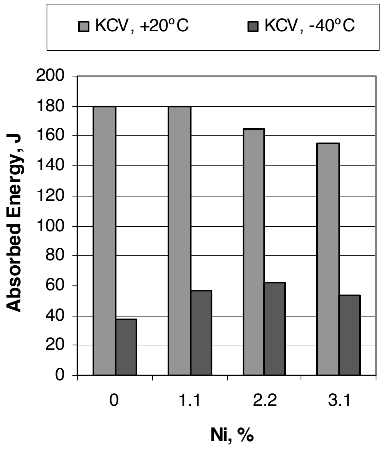
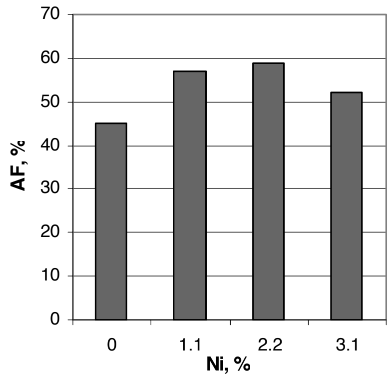



Fig. 2. Relations between the amount of Ni in MWD and the impact toughness of MWD

The microstructure of metal weld deposit having various amount of nickel was also analysed. Acicular ferrite and MAC phases (self-tempered martensite, upper and lower bainite, rest austenite, carbides) were analysed and counted for each weld metal deposit. Results of deposits with various structure are shown in Figure 3.

a)




b)

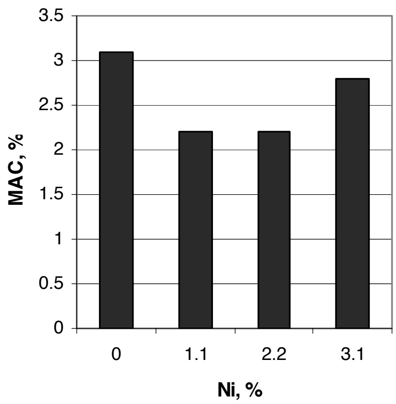



Fig. 3. Metallographic structure with Ni in MWD

It was easy to deduce that nickel has positive influence on the metallographic structure. That relation was also observed in impact toughness tests. Nickel is as the most positive elements influencing impact toughness and structure of MWD because of highest amount of acicular ferrite and lowest amount of MAC in comparison with other structures (having Mo, Mn, V, Cr, etc). Fracture surface of WMD with 1.1% of Ni is presented on Figure 4.

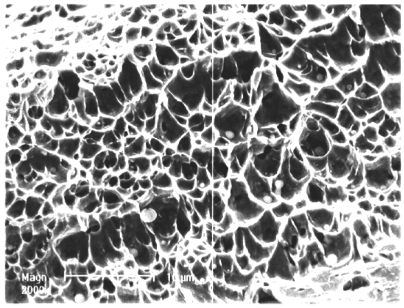
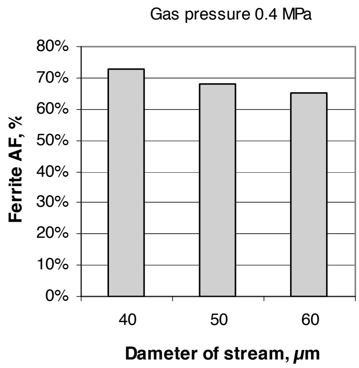


Fig. 4. Fracture surface of WMD with 1.1% Ni (2000×)

The surface is ductile, because of the beneficial influence of nickel on the deposit structure.

Secondly it was tested influence of micro-jet cooling just after MIG welding. There was tested injector with various diameters of micro-jet steams: 40 µm, 50 µm or 60 µm. Argon was chosen for the micro-jet gas. Example of metallographic structure in terms of argon pressure was shown in Figure 5.

a)




b)

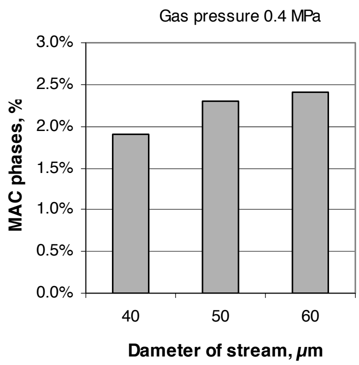



Fig. 5. Example of metallographic structure in terms of argon pressure

It was also observed that diameter of stream on the level of 40 μm could be treated as optimal one. Acicular ferrite was on the very high level, and respectively MAC phases on a very low level. Impact toughness of WMD is presented of Figure 6.

In standard MIG welding process (without micro-jet cooling) there are always gettable higher amounts of GBF (course ferrite) fraction. High percentage of AF ferrite is gettable only for welding with micro-jet cooling. Acicular ferrite with percentage above 70% was gettable only after micro-jet cooling.

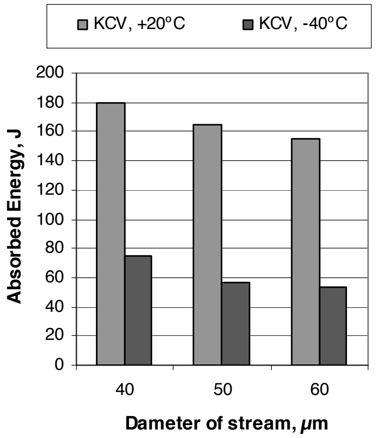



Fig. 6. Impact toughness for metal weld deposit after micro-jet welding

## 4. Conclusions

1. Nickel must be treated as the elements strongly influencing impact toughness properties of low alloy MWD.
2. Metal weld deposit with 2% of Ni could be treated as optimal, because of high amount of acicular ferrite.
3. Micro-jet technology is the future in low alloy welding.
4. After micro-jet cooling it is possible get more than 70% of acicular ferrite, that is impossible to get in another welding method (even with optimal Ni amount in MWD).

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