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Effect of Mn and Mo on the quality of welding trucks steel supporting structures

T. Węgrzyn*, R. Burdzik
Faculty of Transport, Silesian University of Technology,
ul. Krasińskiego 8, 40-019 Katowice, Poland
* Corresponding author: E-mail address: tomasz.wegrzyn@polsl.pl

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Properties

ABSTRACT

Purpose: The aims of the research are studies safety and exploitation conditions of weld structure reparation of car body truck frames.

Design/methodology/approach: Structure of car body truck frames are the main object of the research. Impact toughness, fatigue properties were measured, fractographic analyses were made. Subject scopes are experimental research about weld structure reparation of car body truck frames. Theoretical calculations should be used as the hint automotive welding reparations.

Findings: Optimization of operational properties of steel welded structures might be done in terms of the chemical composition (amount Mo, Mn) in WMD. Molybdenum should be treated as the element very positively influencing impact toughness and fatigue properties of low alloy WMD. The cause of damages and deformation of steel car body frame structures is often connected with no proper choice of welding materials, their joining technology, and chemical composition of WMD.

Research limitations/implications: Studies on the effect of other important alloying elements on the properties of the frame of a vehicle should be continued.

Practical implications: Practical implications might be improving of the passive safety of the vehicle by quality of the car structures reparations.

Originality/value: A novelty is the analysis of the impact of major alloying elements in the weld on the quality of repair structural components of the vehicle.

Keywords: Welding; Truck steel; Shielded metal arc welding

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1. Introduction

Properties of steel truck weld structures depend on many factors such as welding technology, filler materials, state of stress. The main role of that conditions is also connected with materials, chemical composition of steel and weld. Chemical composition of metal weld deposit (WMD) could be regarded as a very important factor influencing properties of weld. Manganese and molybdenum are regarded as the main elements positively effecting on mechanical properties and metallographic structure of low alloy welds. The influence of manganese, molybdenum (and also other elements such as nickel, chromium, vanadium) contents in weld metal deposit on impact and fatigue properties was well analysed in the last 15 years [1-10]. Chromium, vanadium, and especially nitrogen are regarded rather as the negative element on impact toughness properties of low alloy basic electrode steel welds in sub zero temperature, meanwhile nickel and molybdenum have the positive influence on impact properties. Welding parameters, metallographic structure and chemical composition of metal weld deposit are regarded as the important factors influencing the impact toughness properties of deposits [7-8]. In the paper only the influence of the variable amounts of manganese and molybdenum on impact and fatigue properties of steel truck weld structure and properties was tested.

2. Experimental procedure

Shielded metal arc welding (SMAW) is a very popular method of welding used for steel car body reparation. To assess the effect of manganese and molybdenum on mechanical properties of deposited metals there were used basic electrodes prepared in experimental way. The electrode contained constant or variable proportions of the following components in powder form, shown in Table 1:

Table 1.
Composition of electrode coat

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 180 A, and the voltage was 22 V. A typical weld metal deposited had following chemical composition (Table 2):

Table 2.
WMD chemical composition

C	0.08%
Mn	0.8%
Si	0.37%
P	0.018%
S	0.019%

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 mainly above 50%. This principal composition was modified by separate additions (Table 3).

Table 3.
Ferropowder in electrode coat

ferromolybdenum powder	up to 1.5% (at the expense of iron powder)
ferronickel powder	up to 6.5% (at the expense of iron powder)

A variation in the molybdenum and manganese amount in the deposited metal was analysed from (Table 4):

Table 4.
Mn, Ni, Mo in WMD

Mn%	0.8 up to 2.4
Ni%	1 up to 3
Mo%	0.2 up to 0.6

3. Results and discussion

After the welding process using basic coated electrodes there was gettable metal weld deposit with the variable amounts of tested elements (Mo, Mn) in it. After that the chemical analysis, micrograph tests, fatigue and Charpy notch impact toughness tests of the deposited metal were carried out. The impact toughness results are given in Figures 1 and 2. The samples were prepared according to Polish Standards.

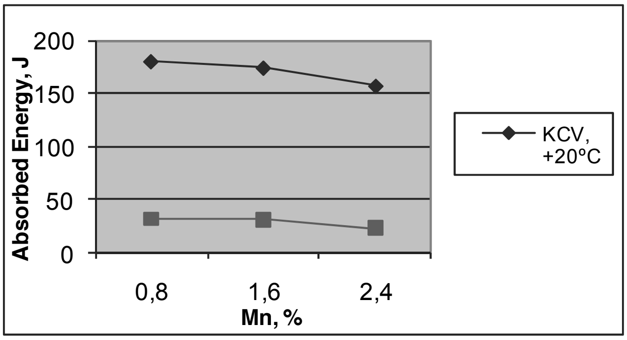

Fig. 1. Relations between the amount of Mo in WMD and the impact toughness of WMD

Analysing Figure 1 it is possible to observe that impact toughness of weld metal deposit is neutrally affected by the amount of manganese. Absorbed energy in terms of the amount of molybdenum in metal weld deposit is shown in Figure 2.

Analysing Figure 2 it is possible to deduce that impact toughness of metal weld deposit is also very positively affected by the amount of molybdenum. Amount of 0.4% Mo could be treated as optimal. In automotive weld structures there are two general types of tests conducted: impact toughness and fatigue tests.

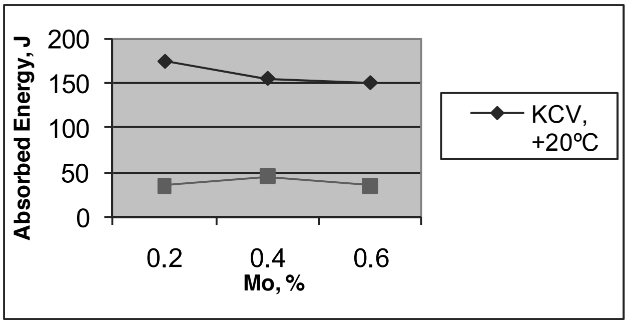

Fig. 2. Relations between the amount of Mo in WMD in WMD and the impact toughness of WMD

The second kind of mentioned tests focuses on the nominal stress required to cause a fatigue failure in some number of cycles. This test results in data presented as a plot of stress (S) against the number of cycles to failure (N), which is known as an S-N curve. Fatigue tests were generated for two deposits with amount of:

- 0.8%Mn and 0.4%Mo,
- 1.6%Mn and without Mo.

Figure 3 shows fatigue value for first tested deposit (0.8%Mn and 0.4%Mo). The samples were prepared according to Polish Standards.

It is important that more than 10^4 cycles to failure where stress is low and deformation primarily elastic were obtained. The figures present high-cycle fatigue situations of the magnitude of a cyclic stress (S) against the logarithmic scale of cycles to the failure.

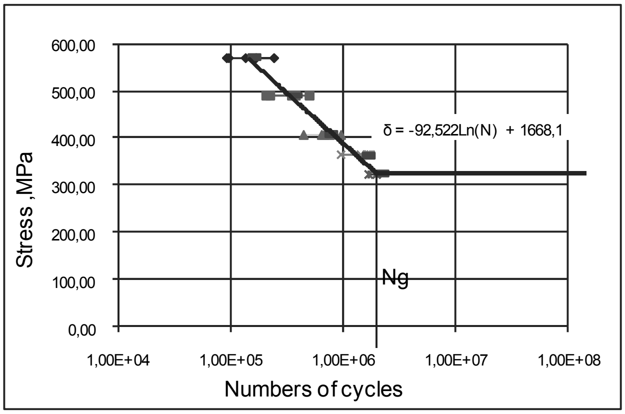

Fig. 3. S-N Fatigue properties for WMD with 0.4%, Mo, 0.8 Mn

Looking for the S-N curve for the 0.4%Mo deposit to make an estimate of its fatigue life it easy to deduce, that amount of 0.8% Mn and 0.4% Mo could be treated as beneficial (comparison with Figure 4, WMD without Mo).

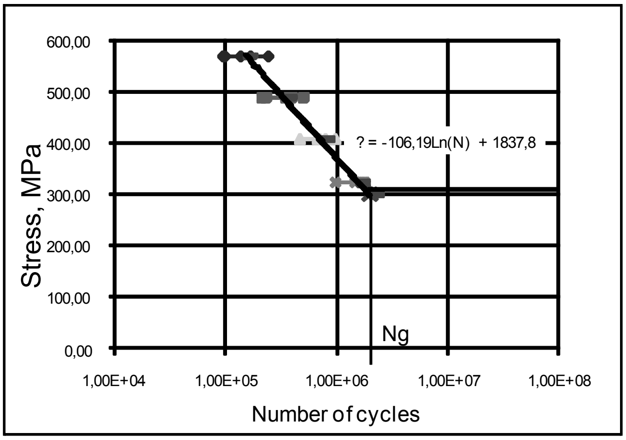

Fig. 4. S-N Fatigue properties for WMD without Ni or Mo

Thus fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The maximum stress values are less than the ultimate tensile stress limit, and may be below yield stress limit of the material.

The microstructure and fracture surface of metal weld deposit having various amount of manganese and molybdenum was analysed with special attention. Acicular ferrite and MAC phases (self-tempered martensite, upper and lower bainite, rest austenite, carbides) were analysed and counted for each weld metal deposit:

- 0.8%Mn and 0.4%Mo,
- 1.6%Mn and without Mo.

Amount of AF and MAC were not on the similar level in two tested deposits, results of deposits with various structure (percentage of AF) are shown in Table 5.

Table 5.
Results of deposits with various structure (percentage of AF)

Deposit 0.4% Mo, 0.8%Mn	Deposit 1.6% Mn
55 % AF	40%AF

Molybdenum has positive influence on the structure (55% AF). That relation was firstly observed in impact toughness tests, and further in fatigue tests. Because of that molybdenum could be treated as the positive elements influencing impact toughness and structure of WMD because of higher amount of acicular ferrite and lower amount of MAC. Additional fracture surface observation was done using a scanning electron microscope. The fracture of metal weld deposit having 0.4% Mo is presented in Figure 5.

The surface is generally ductile, because of the beneficial influence of molybdenum on the deposit structure. However it is still difficult to explain scientifically that phenomenon.

Nevertheless it is obvious (after microscope observations) that molybdenum has a great influence on the character of fracture surface.

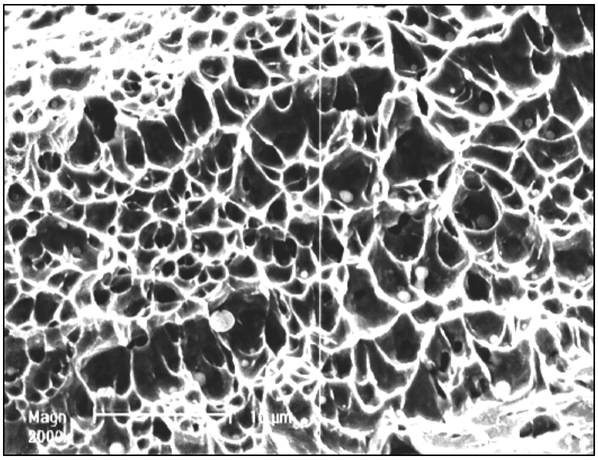

Fig. 5. Fracture surface of metal weld deposit with 0.4%Mo

In the present paper it was tested and optimized the chemical composition of WMD on the operational properties of car body frame steel weld structures. The influence of the variable amounts of manganese and molybdenum on impact properties of low alloy metal weld deposit properties was tested. Especially molybdenum has the positive influence on impact and fatigue properties.

4. Conclusions

1. Optimization of operational properties of steel welded structures might be done in terms of the chemical composition (amount Mo, Mn) in WMD.
2. Molybdenum should be treated as the element very positively influencing impact toughness and fatigue properties of low alloy WMD.
3. The cause of damages and deformation of steel car body frame structures is often connected with no proper choice of welding materials, their joining technology, and chemical composition of WMD.

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