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TRUCK FRAME WELDING REPARATION BY STEEL COVERED ELECTRODES WITH VARIED AMOUNT OF NI AND MO

Summary. This paper attempts to study safety and exploitation conditions of weld steel structure reparation of car body truck frames. Car (auto) body is the name given to the portion of an automobile which gives it shape. The work is a theoretical investigation and concentrates on structural integrity and vehicle safety after the reparation welding of truck frames. To study the effects of the frame flexibility and resistance, the truck frame has been welded by steel electrodes with varied amount of Ni and Mo. The most significant of factors influencing that conditions are connected with material choice, welding technology, state of stress and temperature. Because of that a good selection of steel and welding method is crucial to obtain proper steel structure. Shielded metal arc welding (SMAW) is a very popular method of welding used for car body reparation. Car body elements of higher durability are made of low carbon and low alloy steel, very often with small amount of carbon and the amount of alloy elements such as Ni, Mn, Mo, Cr, Ti, Al, V in low alloy steel and their welds. In the paper only the influence of the variable amounts of nickel, molybdenum on impact and fatigue properties of low alloy metal weld deposit was tested. The results show that there is good agreement between proper chemical composition of weld metal deposit (WMD) and truck structure properties.

SPAWALNICZE NAPRAWY RAM Z UŻYCIEM STALOWYCH ELEKTROD ZE ZMIENNĄ ZAWARTOSCIĄ NI ORAZ MO

Streszczenie. Artykuł jest próbą analizy bezpieczeństwa eksploatacji naprawianych metodami spawalniczymi konstrukcji ram pojazdów ciężarowych. Praca jest teoretycznym badaniem bezpieczeństwa naprawianej ramy pojazdów ciężarowych metodami spawalniczymi. Dla prześledzenia zmian plastyczności oraz wytrzymałości połączeń spawanych w ramach pojazdów ciężarowych, ramy spawano elektrodami otulonymi z różną, zmienną zawartością Ni oraz Mo. Najistotniejszymi czynnikami wpływającymi na plastyczność oraz wytrzymałość złącza jest wybór metody spawalniczej, stan naprężeń oraz temperatura. Odpowiedni dobór gatunku stali oraz metod spawalniczych do wykonania połączeń jest decydującym dla odpowiednich własności ramy nośnej. Elementy ramy nośnej wykonywane są ze stali o wysokiej wytrzymałości, są to stale nisko-węglowe oraz nisko-stopowe często z małymi domieszkami Ni, Mn, Mo, Cr, Ti, Al., V w stali oraz połączeniach spawanych. W artykule omówiono wpływ zmiennej zawartości niklu oraz molibdenu na udarność oraz wytrzymałość zmęczeniową niskostopowego stopiwa elektrodowego. Wyniki wykazały dużą zależność pomiędzy odpowiednim składem chemicznym a właściwościami stopiwa elektrodowego.

1. INTRODUCTION

"Love can last forever, but a truck frame most definitely will not" [8]. Properties of steel welded structures depend on many factors such as welding technology, filler materials, state of stress. The main role of that condition is also connected with materials, chemical composition of steel and metal weld deposit. Chemical composition of metal weld deposit could be regarded as a very important factor influencing properties of weld metal deposit (WMD). Especially nickel and molybdenum, are regarded as the main elements positively effecting on mechanical properties and metallographic structure of low alloy welds. The influence of nickel, molybdenum (and also other elements such as chromium, vanadium) contents in weld metal deposit on impact and fatigue properties was well analysed in the last 15 years [1-9]. 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 a positive influence on impact properties. The lowest amount of nitrogen in all weld metal gives the best impact results of metal weld deposit. However some authors [2, 3, 7] assume that some nitride inclusions such as TiN, BN, AlN could have a positive influence on the formation of acicular ferrite in welds. Because of that nitrogen might not be treated only as a negative element in steel and welds. Welding parameters, metallographic structure and chemical composition of metal weld deposit are regarded as important factors influencing the impact toughness properties of deposits [7-8]. In the paper only the influence of the variable amounts of nickel, molybdenum on impact and fatigue properties of low alloy metal weld deposit was tested.

2. EXPERIMENTAL PROCEDURE

Shielded metal arc welding (**SMAW**) is a very popular method of welding used for car body reparation. To assess the effect of nickel 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 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 nickel and molybdenum 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 were gettable metal weld deposits with the variable amounts of tested elements (Mo, Ni) 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, 2. The samples were prepared according to Polish Standards.

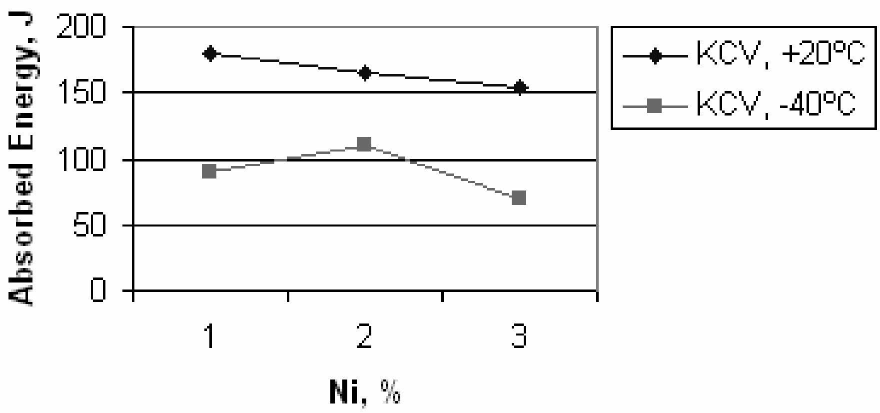

Fig. 1. Relations between the amount of Ni in WMD and the impact toughness of WMD
Rys. 1. Zależność pomiędzy zawartością Ni w stopiwie i jego udarnością

Analysing figure 1 it is possible to deduce that impact toughness of weld metal deposit is very positively affected by the amount of nickel. Amount of 2% Ni could be treated as optimal. Absorbed energy in terms of the amount of molybdenum in metal weld deposit is shown in figure 2.

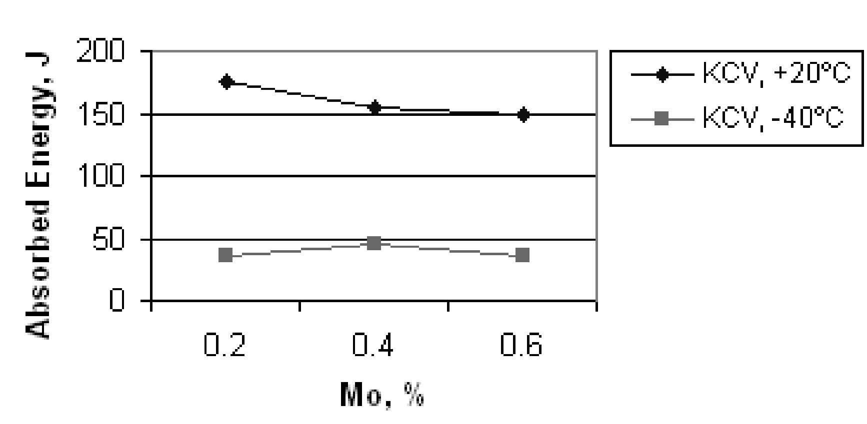

Fig. 2. Relations between the amount of Mo in WMD in WMD and the impact toughness of WMD
Rys. 2. Zależność pomiędzy zawartością Mo w stopiwie i jego udarnością

Analysing figure 2 it is possible to observe 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.

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 2% Ni and 0.4% Mo. Both of them are very similar, thus figure 3 shows fatigue value only for WMD with 0.4% Mo. The samples were prepared according to Polish Standards.

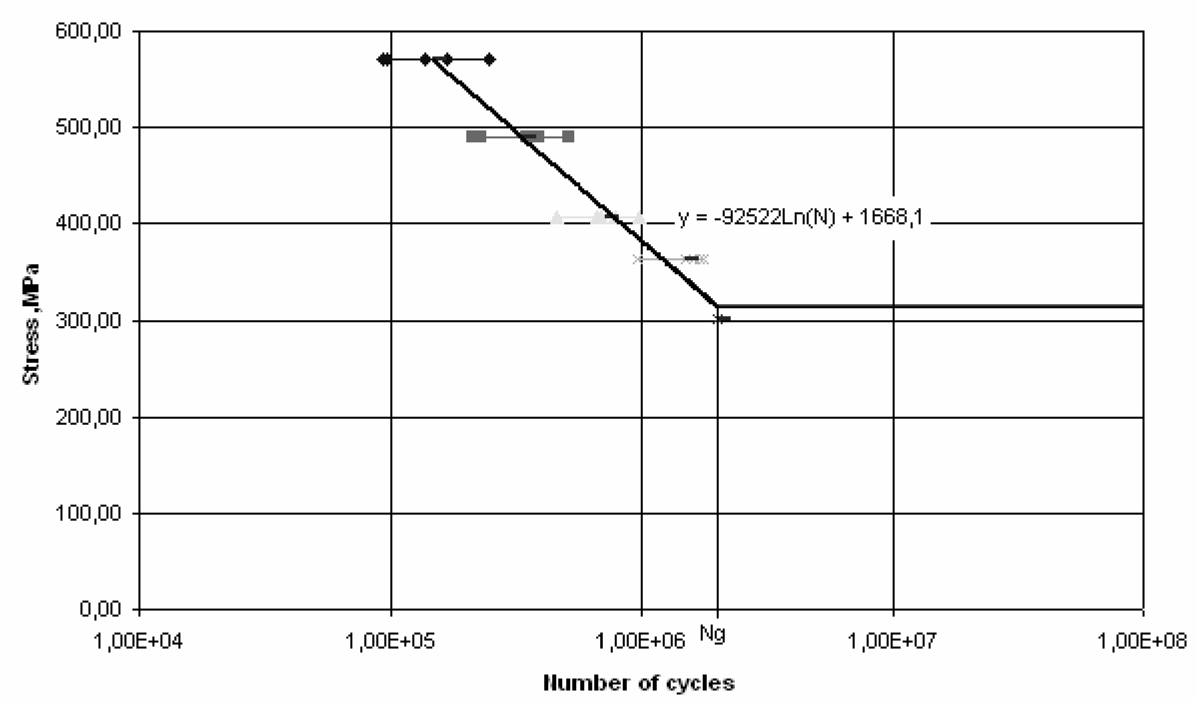

Fig. 3. S-N Fatigue properties for WMD with 0.4%Mo
Rys. 3. Wykres zmęczeniowy stopiwa z 0,4 % Mo

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 Ni or Mo could be treated as beneficial (comparison with figure 4, WMD without Mo, Ni).δ

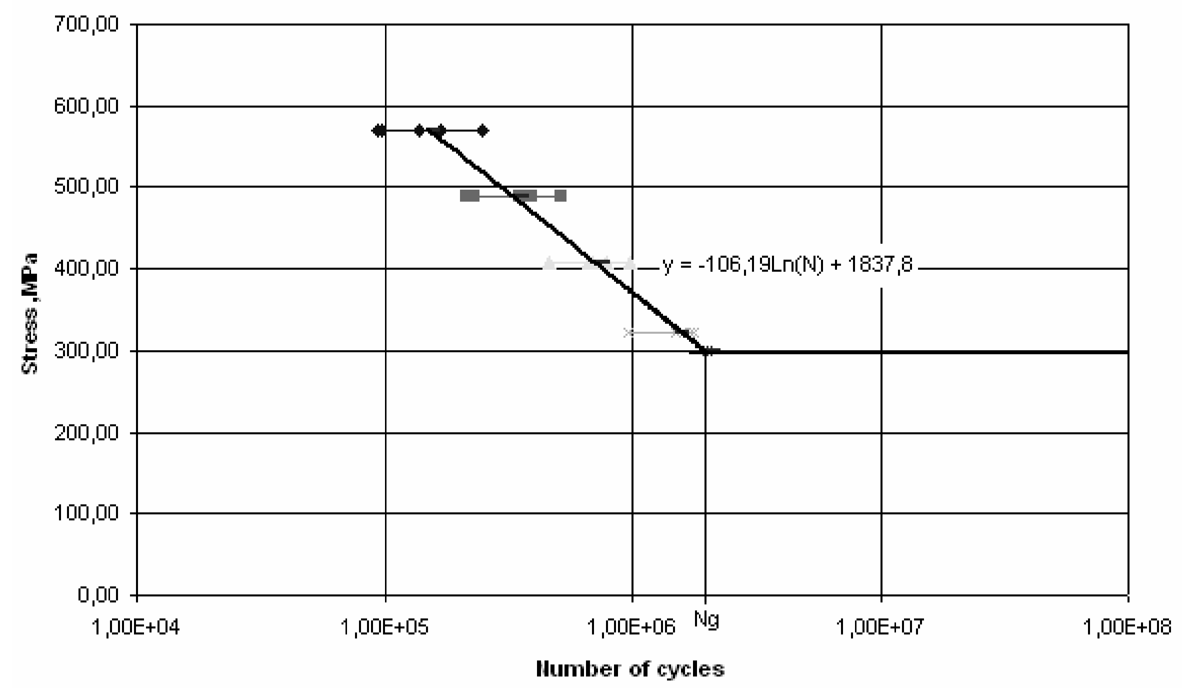

Fig. 4. S-N Fatigue properties for WMD with out Ni or Mo
Rys. 4. Wykres zmęczeniowy stopiwa bez Ni oraz Mo

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. I was able to compare the fatigue values for those deposits.

The microstructure and fracture surface of metal weld deposit having various amount of nickel and molybdenum 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. Amount of AF and MAC were on the similar level in deposits with Ni and Mo, also for Results of deposits with various structure (percentage of AF and MAC) are shown in figures 5 and 6.

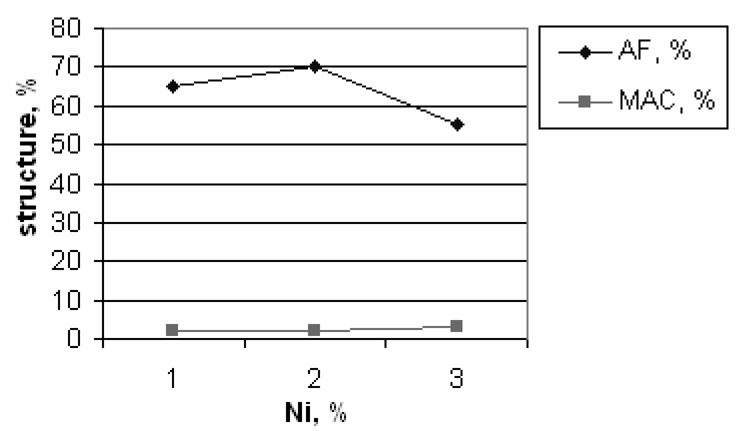

Fig. 5. Metallographic structure with Ni in WMD
Rys. 5. Struktura metalograficzna stopiwa z Ni

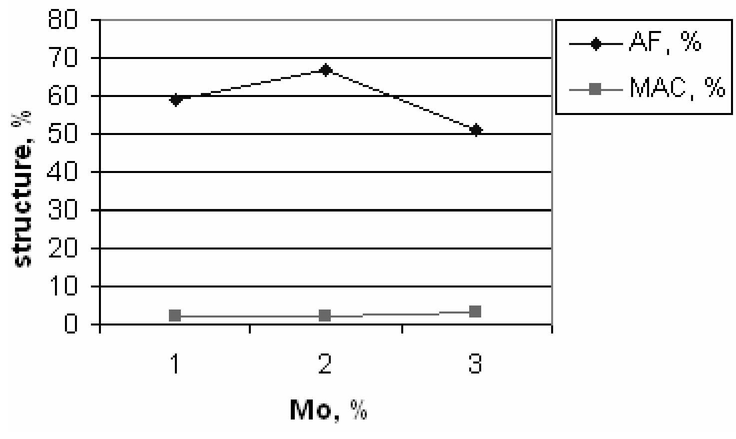

Fig. 6. Metallographic structure with Mo in WMD
Rys. 6. Struktura metalograficzna stopiwa z Mo

It was easy to deduce that nickel and molybdenum have positive influence on the structure. That relation was firstly observed in impact toughness tests, and further in fatigue tests. Thus nickel and 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 fig. 7.

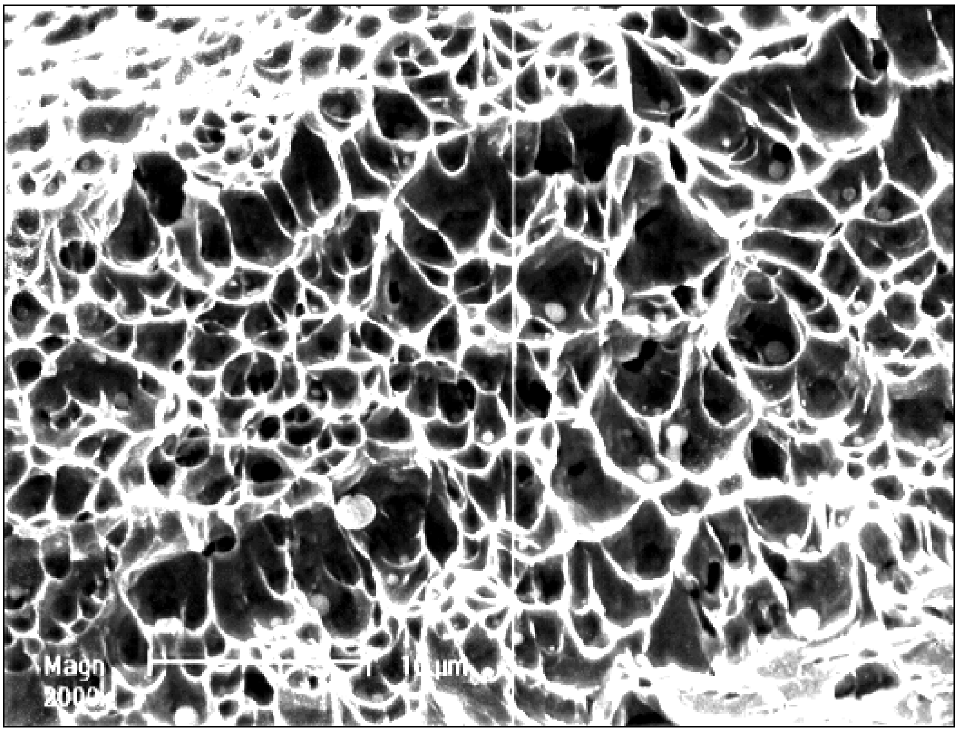

Fig. 7. Fracture surface of metal weld deposit with 0.4%Mo
Rys. 7. Powierzchnia przełomu stopiwa z 0,4 Mo

The surface is ductile, because of the beneficial influence of molybdenum (or nickel) on the deposit structure. After microscope observations it was determined that the amount of nickel (or molybdenum) has a great influence on the character of fracture surface. The surface was similar ductile for WMD having Ni in it.

4. CONCLUSIONS

1. Optimization of operational properties of steel welded structures might be done in terms of the chemical composition (amount of Ni or Mo) of WMD.
2. Nickel and molybdenum should be treated as the elements 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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