TRANSPORT PROBLEMS 2016 Volume 11 Issue 4
PROBLEMY TRANSPORTU DOI: 10.20858/tp.2016.11.4.3

truck frames; exploitation and safety conditions;
welding; electrodes; alloy elements

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ELECTRODES WITH VARIOUS AMOUNT OF NICKEL FOR TRUCK FRAME REPAIRS

Summary. The goal of this paper is to analyze the exploitation and safety conditions of weld steel structure of car body truck frames after welding repairs made by covered electrodes. The main role of conditions in connected with materials, alloy elements in steel and filer materials, welding technology, state of stress and temperature. Because of that, good selection of steel and choice of welding method for proper steel structure repairs are very important. For responsible steel, structures like truck frames and low alloy steel are used, very often with small amounts of carbon and some amounts of alloy elements such as Ni and Mo in low alloy steel and their welds. To study the frame's flexibility and resistance, welded joints have been analyzed. Samples have been welded by steel electrodes with various amounts of Ni.

ELEKTRODY OTULONE DO NAPRAW RAM POJAZDÓW CIĘŻAROWYCH

Streszczenie. Celem artykułu jest analiza właściwości eksploatacyjnych oraz bezpieczeństwa naprawianych ram pojazdów ciężarowych z użyciem spawania. Ważną rolę odgrywają połączenia materiałów, pierwiastki stopowe, materiały dodatkowe, technologia spawania, stan naprężeń oraz temperatura. Bardzo istotne są odpowiedni dobór stali oraz metody spawalniczej. Na odpowiedzialne konstrukcje stalowe, jak np. ramy pojazdów ciężarowych, jest używana niskostopowa stal, często z niską zawartością węgla oraz dodatkiem pierwiastków stopowych, takich jak Ni oraz Mo. Do oceny elastyczności oraz wytrzymałości połączeń spawanych w ramach pojazdów ciężarowych, analizowano właściwości połączeń wykonanych elektrodami o różnej zawartości Ni.

1. INTRODUCTION

The frame of vehicles has a lot of impact on their safety in traffic. Safety and durability of vehicles largely depend on the fatigue strength of the framework that welded the joints within [8-11]. There are still tested new techniques and materials used for car body frames [4-10]. In the last 5 years, important publications were presented about welding with micro-jet cooling [3-4, 12] that could also be used in car body repairs. In the frame of truck vehicles in addition to major impulse forces during exploitation, they are stresses much smaller but very often repeated. Such forces may cause the occurrence of fatigue cracks [11-13]. This type of damage is considered to be common and to cause the transition of welded frame into a state of unfitness for operation. There are known cases of damage to the framework of trucks due to fatigue cracking [6, 10, 15].

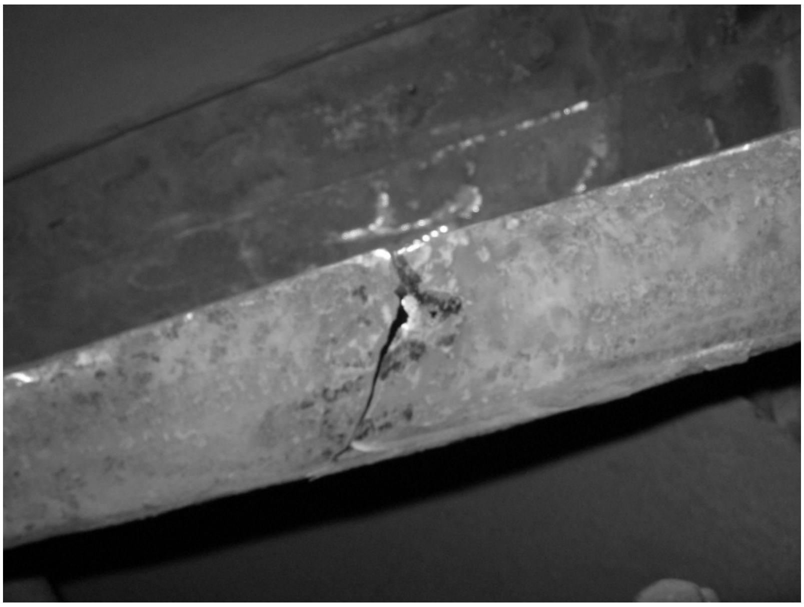

Fig. 1. Fatigue cracking in truck vehicle frame
Rys. 1. Pęknięcia zmęczeniowe w ramie pojazdu

Welded steel frame is still one of the most frequently encountered structures carrying truck vehicles. Properties of steel welded structures depend on many factors such as welding technology, filler materials and state of stress. The chemical composition of welded metal deposit could be regarded as a very important factor influencing properties of weld metal deposit (WMD). The influence of nickel content in weld metal deposit on plastic properties was well analysed by many researchers in the last 15 years [1-3, 11-15]. The influence of nickel on impact toughness of welds is presented below (fig. 2).

Analysing figure 2 it is possible to observe that impact toughness of weld metal deposit (WMD) is positively affected by the amount of nickel [1]. Frame vehicles are made of steel with good strength and plastic properties. Regardless of the analysis of the impact toughness properties, it is important to understand the characteristics of fatigue. These are usually constantly type S355J0 (EN). Welded joints are located in the framework of this type and should have the good strength and plastic properties too.

2. EXPERIMENTAL PROCEDURE

Truck during exploitation is subjected to considerable dynamic loads. These charges are the result of driving on uneven surfaces, sharp curves, hard braking. The size of the typical stresses during operation of the truck is shown in fig. 3. The stress value allows us to assess the fatigue strength of welded track frames. Examples of the stress value registered on the elements of the frame of the truck during unloading shows in fig. 3.

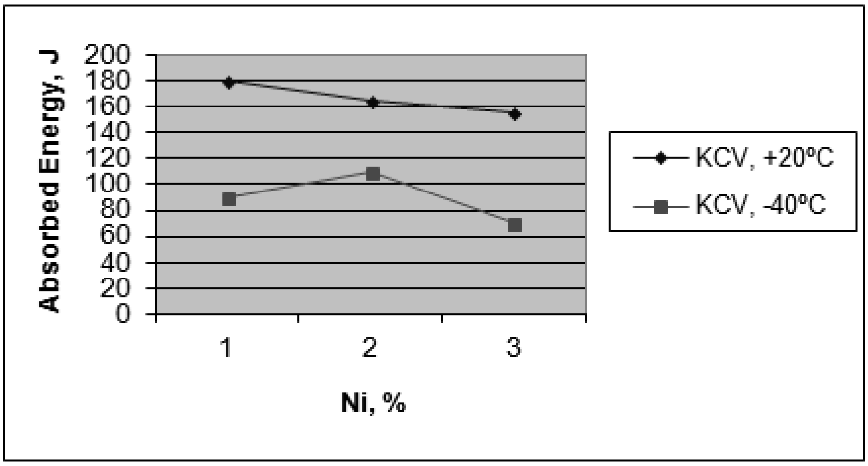

Fig. 2. Relations between the amount of Ni in MWD and the impact toughness of WMD [1]
Rys. 2. Wpływ niklu na udarność stopiwa MWD [1]

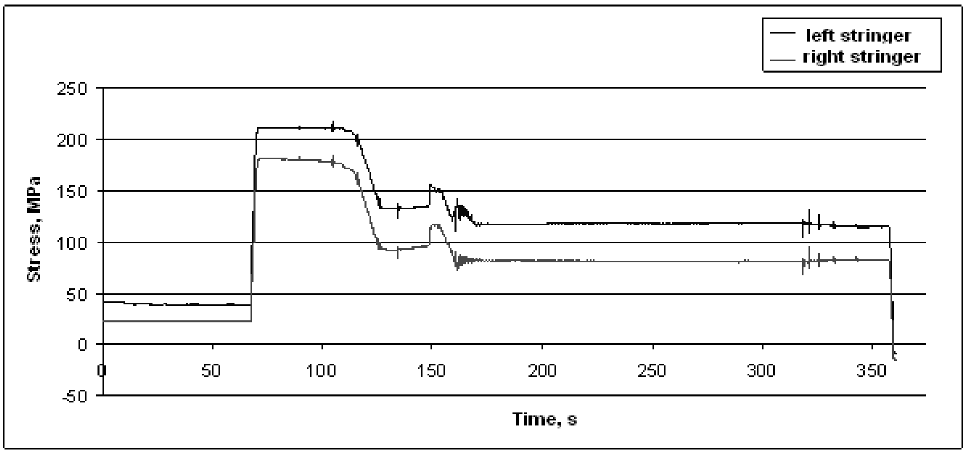

Fig. 3. Intensity of stresses in stringers of the frame while unloading
Rys. 3. Naprężenia w podłużnicach naczepy podczas rozładunku

At the same time welded connections located within the frame of the truck are periodically occurring strains that can cause damage in the form of fatigue cracks. It was decided to examine the effect of nickel (element strongly affecting the impact strength) on essential property connection vehicle frames. To assess the effect of nickel on mechanical properties of deposited metals, basic electrodes prepared in an experimental way were used. The electrode contained constant or variable proportions of the following components in powder form.

The oxygen content was in the range from 340 to 470 ppm, and the nitrogen content was in the range from 70 up to 85 ppm. The acicular ferrite content in weld metal deposit was above 45%. This principal composition was modified by separate additions of ferronickel (up to 8%, at the expense of iron powder). A variation in the nickel amount in the deposited metal was respectively tested from 1% up to 3% Ni.

Table 1

Composition of basic electrodes

technical grade chalk	30%
fluorite	20%
rutile	4%
quartzite	3%
ferrosilicon (45%Si)	6%
ferromanganese (80%Mn)	4%
ferronickel (20%Ti)	up to 8%
iron powder	up to24%

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 the following chemical composition.

Table 2

Composition of typical weld metal deposit

C	0.08%
Mn	0.8%
Si	0.37%
P	0.018%
S	0.019%
Ni	1-3%

3. RESULTS AND DISCUSSION

After the welding process using basic coated electrodes, there were gettable weld metal deposits with the variable amounts of tested elements (Ni) in it. After that procedure, the chemical analysis, micrograph tests, and fatigue strength tests were carried out. The tests were done at +20°C and 20 specimens having been tested from each weld metal. Fatigue strength was tested for four load constant levels (stress ratio R $\neq$0). The fatigue strength results are given in figures 4-6. Fatigue strength was tested in bending rotation (sinusoidal waves).

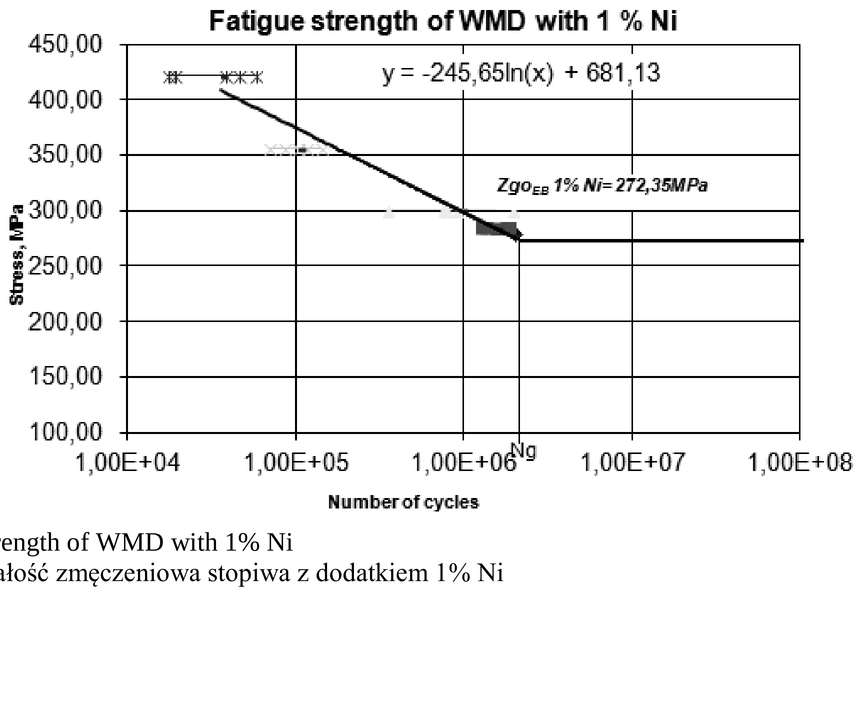

Fig. 4. Fatigue strength of WMD with 1% Ni

Rys. 4. Wytrzymałość zmęczeniowa stopiwa z dodatkiem 1% Ni

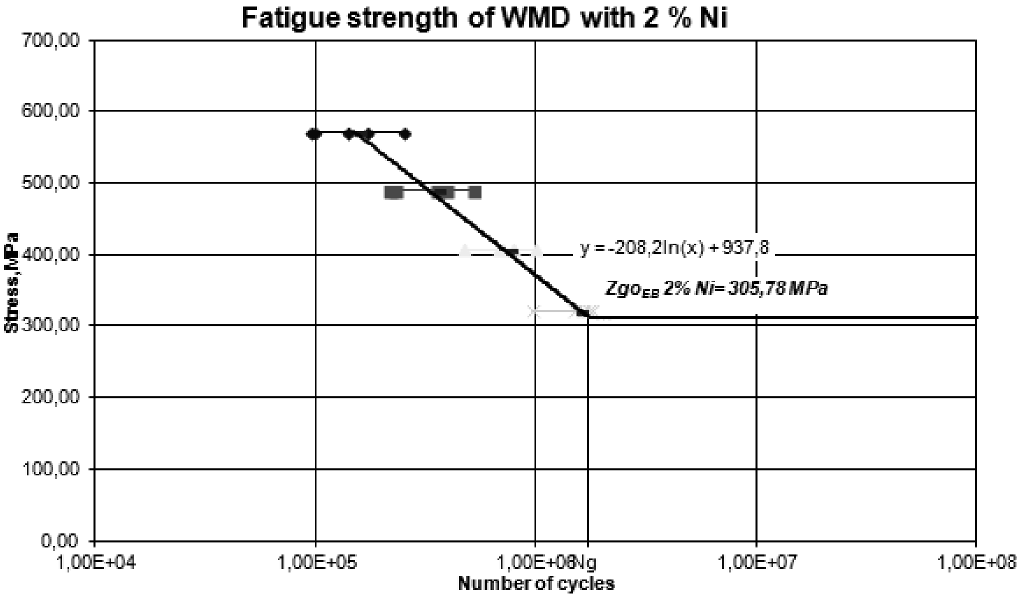

Fig. 5. Fatigue strength of WMD with 2 % Ni
Rys. 5. Wytrzymałość zmęczeniowa stopiwa z dodatkiem 2% Ni

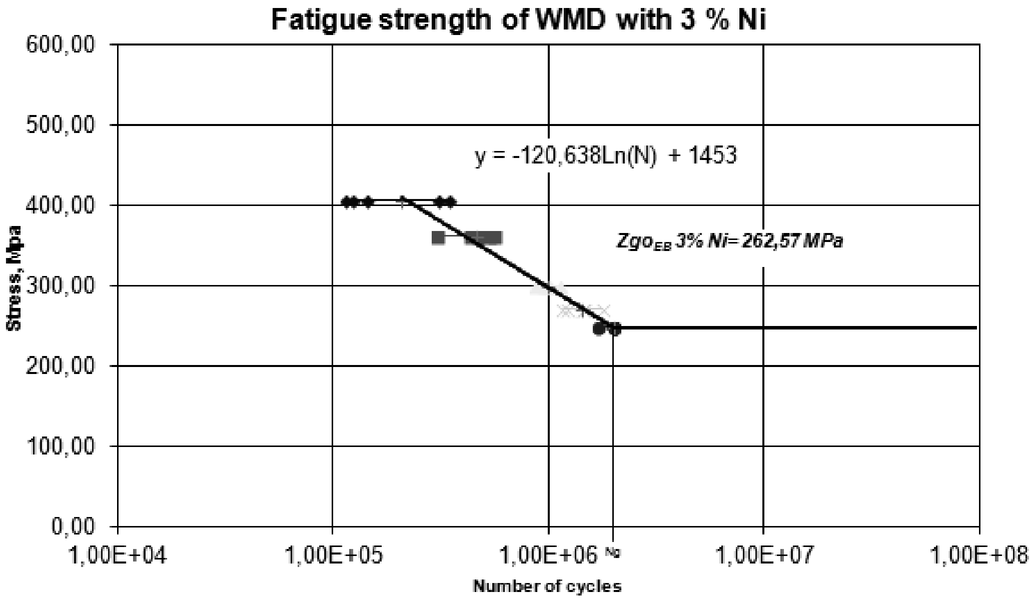

Fig. 6. Fatigue strength of WMD with 3% Ni
Rys. 6. Wytrzymałość zmęczeniowa stopiwa z dodatkiem 3% Ni

Analysing fig. 4-6, it is possible to deduce that fatigue strength of weld metal deposit is very positively affected by the amount of nickel. Nickel could be treated as a very important element influencing WMD fatigue strength properties. The amount of 2% Ni could be treated as optimal. The influence of nickel content in weld metal deposit on impact toughness was well analysed by many researchers [1-3, 11-15]. Literature data on the fatigue properties of frames after welding with various amounts of nickel were not given so explicitly [3, 12]. For a fuller explanation of the fatigue properties of frames after welding with various amounts of nickel it was decided to carry out observations of the microstructure. The microstructure of weld metal deposit having various amounts of nickel were precisely 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. The amount of AF and MAC phases were on the similar level in all tested deposits with various amounts of Ni (fig. 7).

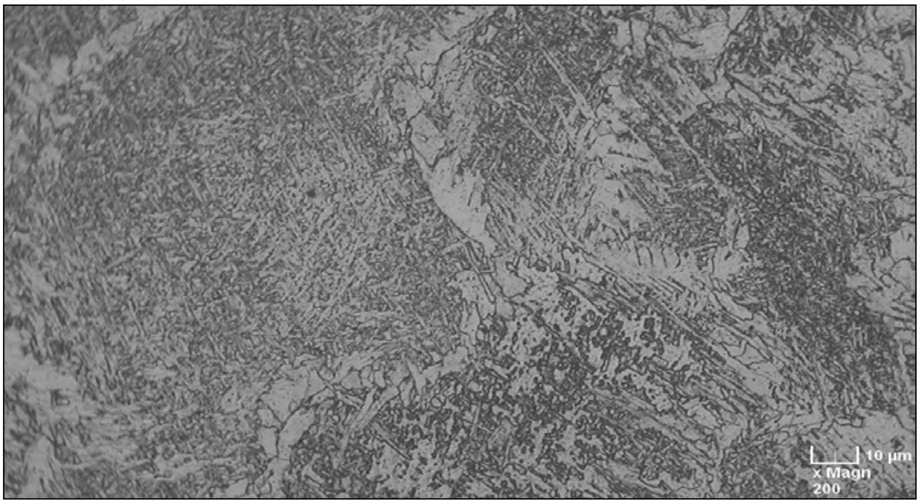

Fig. 7. Estimation of grain size in WMD with 2% Ni, 55% of acicular ferrite, 3% of MAC, 200×
Rys. 7. Szacowanie wielkości ziaren w stopiwie elektrodowym zawierającym 2% Ni, 55% drobnoziarnistego ferrytu, 3% faz MAC, 200×

Analysing figures regarding fatigue strength of WMD with various amounts of Ni and microstructure, it is possible to conclude that nickel could be treated as a very positive element in low alloy weld metal deposit. Good impact toughness and very good fatigue strength of car body frames correspond with the chemical composition of WMD (especially with the proper amount of Ni).

4. CONCLUSIONS

1. Nickel could be treated as a positive element in low alloy weld metal deposits.
2. Amount of 2% Ni could be treated as optimal.
3. Nickel should be added into car body frame WMD because of its good fatigue strength and impact toughness.
4. WMD with 2% Ni allows us to get high amounts of acicular ferrite that corresponds with good mechanical properties of truck frames after welding.

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Received 23.04.2015; accepted in revised form 18.10.2016