COVERED ELECTRODES WITH VARIED AMOUNT OF MO FOR LONG STRUCTURES

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Abstract

This paper attempts to study safety and exploitation conditions of long weld steel structures. To study the effects of the long structure flexibility and resistance, the structure been welded by steel covered electrodes with varied amount of 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) also known as manual metal arc welding (MMA) is a very popular method of welding used for structure reparation. Very often SMAW could be also treated as main montage process.

Keywords: Long weld steel structures, steel covered electrodes with varied amount of Mo, Shielded metal arc welding (SMAW)

1. INTRODUCTION

Properties of long welded structures depend on many factors such as welding technology, filler materials, on level of stress. The main role of those conditions is also connected with materials, chemical composition of steel and metal weld deposit [1-8]. Chemical composition of metal weld deposit could be regarded as a very important factor influencing properties of weld metal deposit (WMD). Molybdenum and nickel are regarded as the main element positively effecting on mechanical properties and metallographic structure of low alloy welds. Molybdenum improves the impact strength of the alloy having an increased content of vanadium and nitrogen [1]. 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. 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 molybdenum and nickel have the positive influence on impact toughness properties. First of all welding parameters, metallographic structure and chemical composition of metal weld deposit are regarded as the important factors influencing the impact toughness and fatigue properties of long weld structures [1]. In the paper only the influence of the variable amounts molybdenum on impact and fatigue properties of low alloy metal weld deposit (additionally having various amount of vanadium and nitrogen) was tested.

2. EXPERIMENTAL PROCEDURE

To assess the effect of 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	25 %
fluorite	21 %
rutile	5 %
quartzite	4 %
ferrosilicon (45 % Si)	7 %
ferromanganese (80 % Mn)	5%
ferrotitanium (20 % Ti)	2 %
nitrited vanadium	0-3 %
Ferromolybdenum (20 %Mo)	0-6 %
iron powder	22-31 %

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 %
O	400ppm
N	55ppm

This principal composition was modified by separate additions of ferromolybdenum powder up to 6 % and nitrited vanadium up to 3 % at the expense of iron powder. As a result, three deposits were received with different portion of molybdenum and nitrogen (however it was not intended to change the nitrogen content). A variation in the molybdenum (and nitrogen) amount in the deposited metal is shown in **Table 3**.

Table 3 Mo and N amount in WMD

Deposit	Mo amount in WMD, %	N amount in WMD, ppm	V amount in WMD, %
A	0	55	0
B	0.18	55	0.05
C	0.42	55	0.04
D	0.63	55	0.05
E	0.19	60	0.11
F	0.44	60	0.12
G	0.65	60	0.10

Amount of nitrogen was rather on the same level in all tested deposits. Because of it influence of nitrogen on metallographic structure and mechanical properties of weld structure further was not analysed.

3. RESULTS AND DISCUSSION

After the welding process using basic coated electrodes there were gettable metal weld deposits with the variable amounts of molybdenum in it. The molybdenum content could be approximated to a value of 0.2; 0.4 and 0.6 % for easier interpretation of results. The vanadium content could be approximated to a value of 0.05 and 0.1 for easier interpretation of results. In all deposits carefully was counted amount of acicular ferrite, the most beneficial phase in weld metal deposit. MAC phases (self-tempered martensite, retained austenite, carbide) were on the same level of 2.5 % in all tested deposits. Amount of acicular ferrite in various deposits is shown in **Table 4**.

Table 4 AF in WMD having different portion of Mo and V

Mo in MWD,%	V in MWD, %	AF in WMD, %
0	0	40
0.05	0.2	47
0.05	0.4	52
0.05	0.6	44
0.1	0.2	43
0.1	0.4	49
0.1	0.6	41

It is easy to deduce that amount of 0.4 % Mo in weld could be treated as optimal for WMD especially having lower amount of vanadium. Metallographic images of typical deposits are shown in **Figure 1**.

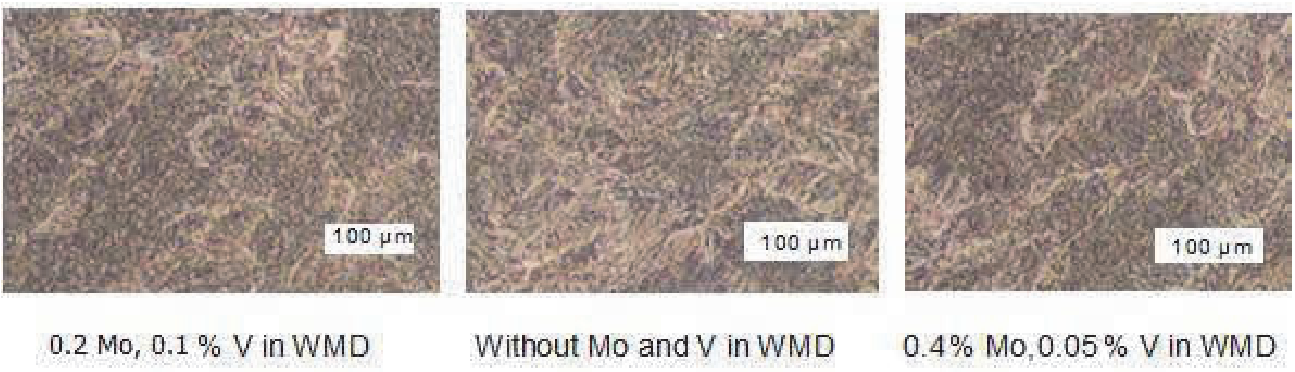

Figure 1 Weld metal deposits with various amount of Mo and V

It is easy to observe that amount of 0.4 % Mo in weld could be treated as optimal value because of AF amount in weld metal deposit having smaller amount of vanadium (0.05 %). After that observation the chemical analysis, micrograph tests, fatigue and Charpy notch impact toughness tests of the deposited metal were carried out. Absorbed energy in terms of the various amount of molybdenum and vanadium in metal weld deposit are shown in **Tables 5, 6**.

Table 5 Impact toughness for SMAW welding with varied amount of Mo in WMD having 0.05 % V

Mo amount, %	Temp., °C	Impact toughness,[KV, J]
0	- 40	below 47
0.2	- 40	below 47
0.4	- 40	57
0.6	- 40	below 47
0	-20	below 47
0.2	-20	53
0.4	-20	64
0.6	-20	49
0	0	61
0.2	0	79
0.4	0	84
0.6	0	65
0	+20	171
0.2	+20	183
0.4	+20	187
0.6	+20	173

Table 6 Impact toughness for SMAW welding with varied amount of Mo in WMD having 0.1 % V

Mo amount, %	Temp., °C	Impact toughness, J
0	- 40	below 47
0.2	- 40	below 47
0.4	- 40	51
0.6	- 40	below 47
0	-20	below 47
0.2	-20	48
0.4	-20	52
0.6	-20	below 47
0	0	54
0.2	0	63
0.4	0	76
0.6	0	58
0	+20	170
0.2	+20	181
0.4	+20	182
0.6	+20	176

Analysing results of **Tables 5** and **6** it is possible to observe that impact toughness of metal weld deposit is also positively affected by the amount of molybdenum. Amount of 0.4% Mo could be treated as optimal in both tested deposits (with higher and lower amount of vanadium). Four class of impact toughness (minimum 47J at

-40 °C) is preserved only for deposit having 0.4 % Mo and both levels of vanadium. Second class of impact toughness (minimum 47 J at -20 °C) is preserved only for one deposit having Mo in it (all tested levels). Analysing **Tables 3** and **5** it is possible to deduce that impact toughness of metal weld deposit is affected by the amount of molybdenum and partly is dependent on nitrogen amount. In long 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 0.4 % Mo, 0.05 %V and for deposit without Mo and V in it. **Figure 2** shows fatigue value for WMD with 0.4% Mo and 0.05% V.

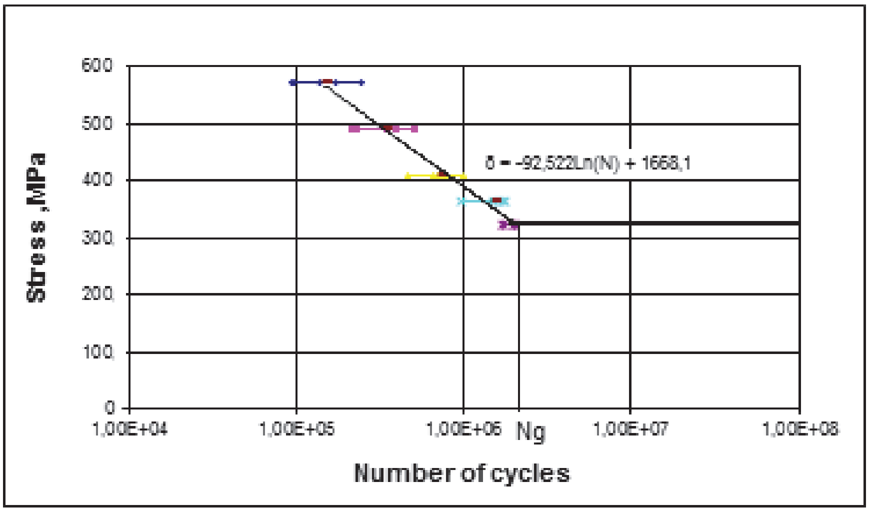

Figure 2 S-N Fatigue properties for WMD with 0.4 % Mo, 0.05 % V [1]

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 0.4 % Mo could be treated as beneficial (comparison with **Figure 3**, WMD without Mo).

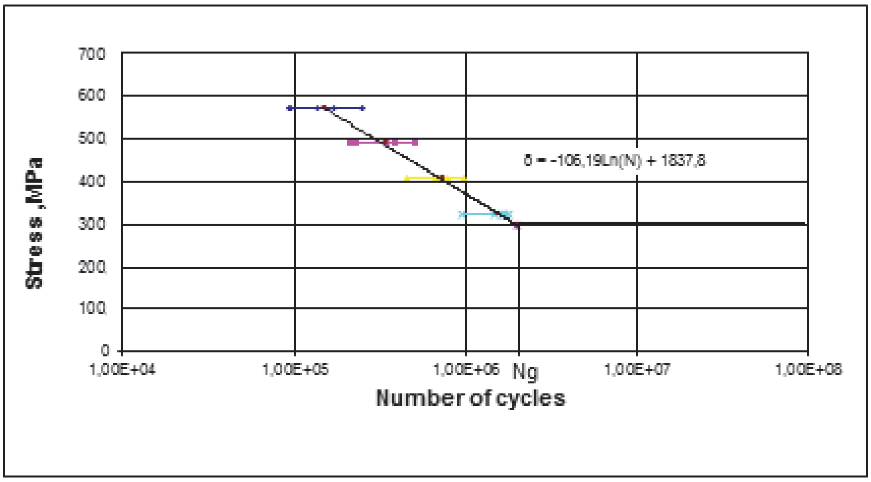

Figure 3 S-N Fatigue properties for WMD without Mo

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 last part of the research was concentrated on deflection tests of long structures (16 m in length). Results are shown in **Table 7**.

Table 7 Deflection of (16 m) long structure corresponding with deposits with different portion of Mo and V

V in WMD, %	Mo in WMD, %	Deflection, mm
0	0	70
0.05	0.2	34
0.05	0.4	27
0.05	0.6	45
0.1	0.2	32
0.1	0.4	29
0.1	0.6	41

It is easy to deduce that deflection of long weld structures depends on Mo amount in weld metal deposit having two various levels of vanadium. Amount of 0.2 % Mo could be treated as optimal. Vanadium could be treated as a neutral element influencing structure deflection.

4. SUMMARY

In the present paper it was optimized the chemical composition of Mo portion in WMD of long weld structures. The influence of the variable amount molybdenum on impact properties of low alloy metal weld deposit properties was carefully tested. Molybdenum have the positive influence on impact and fatigue properties. Design engineers of long structures should base on actual welding technology. The main role of those conditions is connected with welding technology. Summing up the paper it has been concluded, that especially important is a good selection of welding method for proper steel structure cconclusions.

- Optimization of operational properties of steel welded structures might be done in terms of the chemical composition (amount of Mo) of WMD.
- Molybdenum should be treated as the element positively influencing impact toughness and fatigue properties of low alloy WMD.
- Molybdenum has influence on acicular ferrite amount in WMD having various amount of vanadium.

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