LAYER NUMBER INFLUENCE ON WELD DEPOSIT CHEMICAL COMPOSITION

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Abstract. At surfacing using the material of special properties the mixing of the surfaced material with the basic material, the metal loss of single chemical elements and next effects occur. The different chemical composition and properties of the surfaced material and the deposit layer are the result of these complicated processes. For the wear resistant weld deposits the surfacing in two, at most in three layers is in practice recommended. The paper contains results of experiments carried out by use of three different surfaced materials. The weld deposits were made by use of the manual metal arc welding (MMAW) and coated electrodes. At the tests the chemical composition of single layers and of the electrode material were compared.

Keywords: chemical composition, electrode, surfacing, mixing of materials at surfacing.

Introduction

From the merit of the welding technology it is evident that in the slag bath always the major or minor mixing of the surfaced or welded metal with the basic material, metal loss of chemical elements and next effects occur. This fact can lead, e.g., at welding of stainless steels to the corrosion resistance decrease in the weld bead field. At surfacing by use of mostly costly electrodes the mixing induces the lowering of the alloying elements in the deposit and in this way the wear or corrosion resistance decrease. Therefore, the deposit is mostly made in two or three layers.

Materials and methods

Analogical situation is at the surfacing of wear resistant deposits, made by manual arc welding using coated electrodes. In practice this method is often used at worn out functional surfaces at their renovation, eventually at their manufacturing as so-called preventive deposits [1-6].

But the available literature is not bringing sufficiency of documentation for the documentation of the built-up deposit. In practice this is usually found out empirically according to following consideration:

- the first layer chemical composition is thought as the arithmetic mean of the chemical elements content of the deposited and basic materials;
- the second layer composition is thought as the 2/3 to 3/4 of the deposited material chemical elements content (the share of the basic material content is the rest, then 1/3 to 1/4) of the basic material;
- the chemical composition of the third layer is thought as the same as the composition of the deposited material [7-9].

From the above mentioned empirical consideration it follows that the demanded chemical composition should be reached in the third layer of the deposit. If we perform definite simplification and if we think only of the influence of materials mixing, the chemical composition of the nth layer is possible to be expressed by the following equations:

- first layer

$$\frac{A+B}{2}, \tag{1}$$

- second layer

$$\frac{A+\frac{A+B}{2}}{2}, \tag{2}$$

- third layer

$$\frac{A+\dfrac{A+\dfrac{A+B}{2}}{2}}{2}, \tag{3}$$

- n^{th} layer

$$\frac{1}{2^n}\left[\left(2^n-1\right)A+B\right], \tag{4}$$

where: *A* – Composition of the electrode (or the watched element content), %;
B – Composition of the basic material (or the watched element content), %.

For this theory validation as the basic material the steel 11 373 according to CSN 41 1373 (S235JRG1) [10] was chosen. For the manual arc welding the electrodes of the types E-B 508, E-B 518 and E-B 519 of the firm ESAB [11] were chosen. The nominal chemical composition of the basic material according to the standard [10] is presented in Table 1; the chemical composition of used electrodes according to the producer catalogue [11] is presented in Table 2.

Table 1

Chemical composition of the basic material [10], % wt.

Chemical composition	**C**	**P**	**S**	**N**
11 373	Max. 0.17	Max. 0.45	Max. 0.45	Max. 0.07

Table 2

Nominal chemical composition of electrodes [12], % wt.

Nominal chemical composition	**C**	**Si**	**Mn**	**Cr**	**Mo**	**B**
E-B 508	0.5	0.5	0.7	6.0	0.6	x
E-B 518	3.4	0.8	0.5	29.0	x	x
E-B 519	3.5	2.0	0.9	24.0	x	0.2

The test specimens were made in the laboratory of the Department of Material Science and Engineering Technology TF CUA in Prague. From steel trip of the steel 11373 the specimens of the basic material were cut out and milled to the form of plates of 100 x 100 x 20 mm size. The specimens were marked, carefully cleaned and degreased. Then according to the electrodes producer recommended surfacing parameters using the method MMAW (method 111 according to the standard ČSN EN ISO 4063) [12] the deposits of dimensions about 80 x 80 mm were surfaced. Using the electrodes E-B 518, E-B 519 and E-B 508 one layer, two layers and three layers deposits were made, using the electrode E-B 508 also the specimen of five layers. The next layer was made always after the perfect slag removing using the steel brush. The next passes were laid across the direction of the foregoing passes. Then the deposit surface was grinded using the minimum allowance so that the chemical composition analysis could be carried out.

Results and discussion

The analysis results of the basic material chemical composition are presented in Table 3, of the electrode E-B 508 in Table 4, of the electrode E-B 518 in Table 5 and of the electrode E-B 519 in Table 6.

Table 3

Actual chemical composition of the basic material, % wt.

Chemical composition	C	Si	Mn	Cr	Mo
11 173	0.085	0.22	0.42	0.14	0.017

Table 4

Actual chemical composition of the electrode E-B 508, % wt.

Chemical composition	C	Si	Mn	Cr	Mo
1st layer	0.56	0.49	0.73	4.39	0.35
2nd layer	0.64	0.48	0.80	5.86	0.43
3rd layer	0.63	0.51	0.84	6.29	0.44
5th layer	0.60	0.39	0.82	6.81	0.48

Table 5

Actual chemical composition of the electrode E-B 518, % wt.

Chemical composition	**C**	**Si**	**Mn**	**Cr**
1st layer	3.50	0.64	0.52	24.72
2nd layer	3.70	0.67	0.49	25.68
3rd layer	3.68	0.74	0.55	26.02

Table 6

Actual chemical composition of the electrode E-B 519, % wt.

Chemical composition	**C**	**Si**	**Mn**	**Cr**
1st layer	2.61	1.15	0.64	17.64
2nd layer	3.35	1.32	0.65	20.98
3rd layer	3.11	1.40	0.66	22.97

The results presented in the foregoing tables are collectively presented for the electrode E-B 508 in Fig. 1, for the electrode E-B 518 in Fig. 2 and for the electrode E-B 519 in Fig. 3.

From the results of the carried out tests which are presented in Tabs. 1 to 6 and in Figs. 1 to 3 it is evident that the actual chemical composition determined by the laboratory analysis differs expressively from the chemical composition calculated according to the equations (1) to (4). The value of this deviation is different not only for single tested electrodes but for different monitored elements, too.

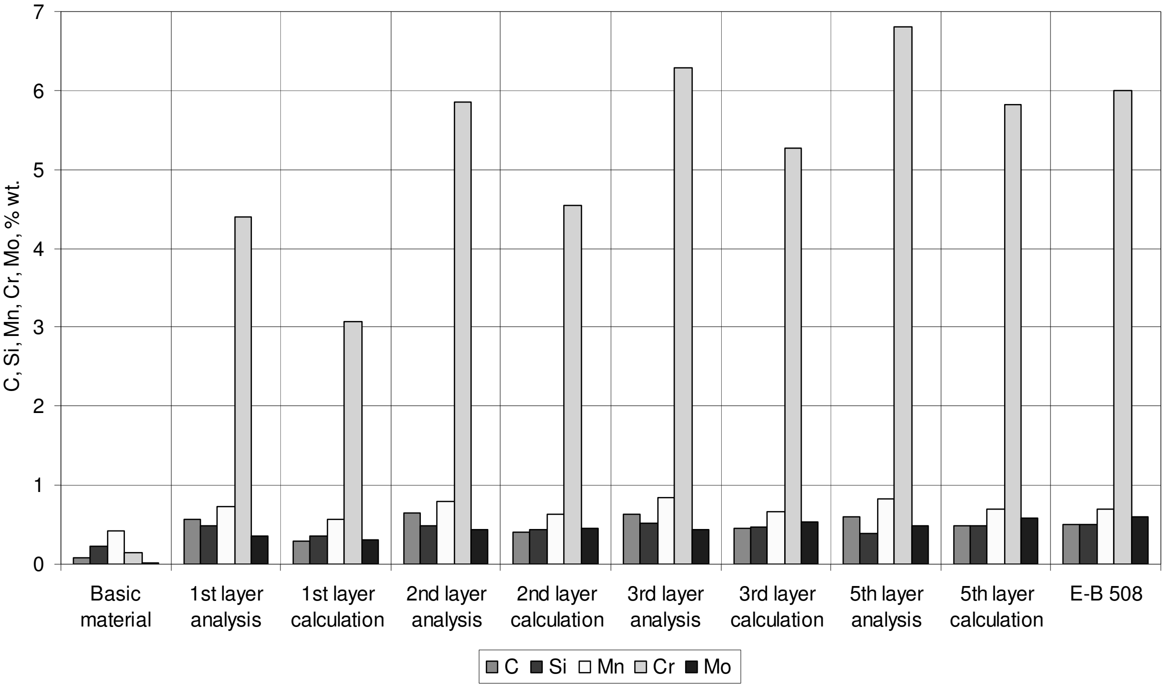

Fig. 1. **Results of the weld deposit from E-B 508**

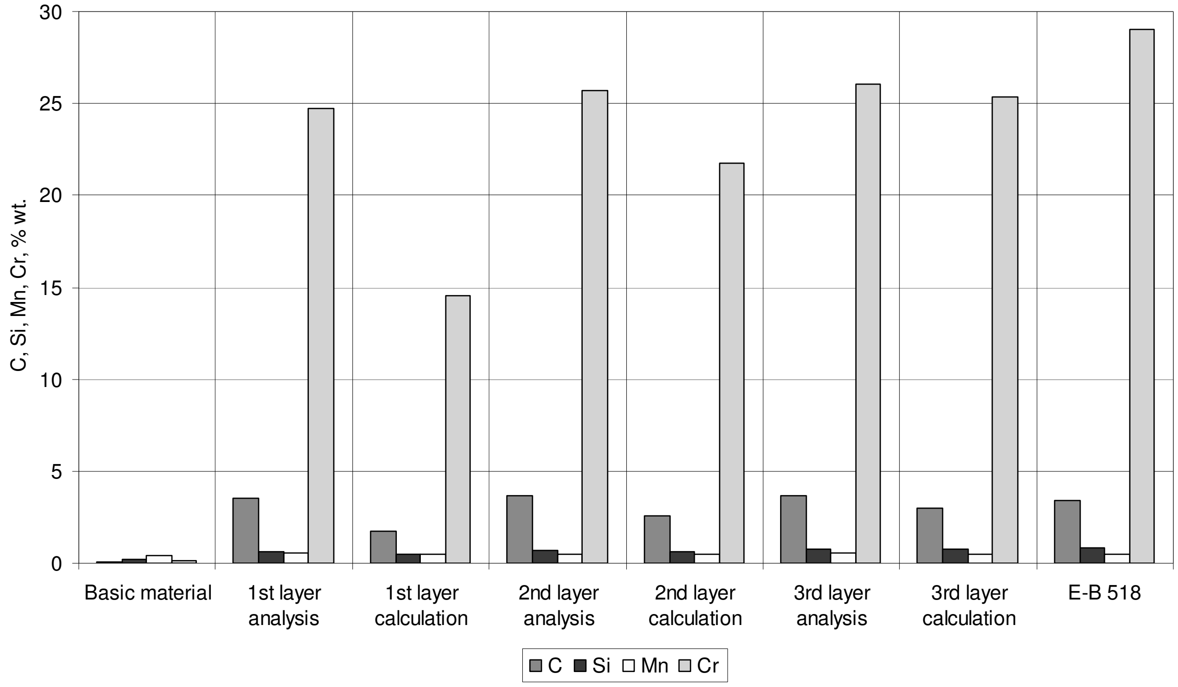

Fig. 2. **Results of the weld deposit from E-B 518**

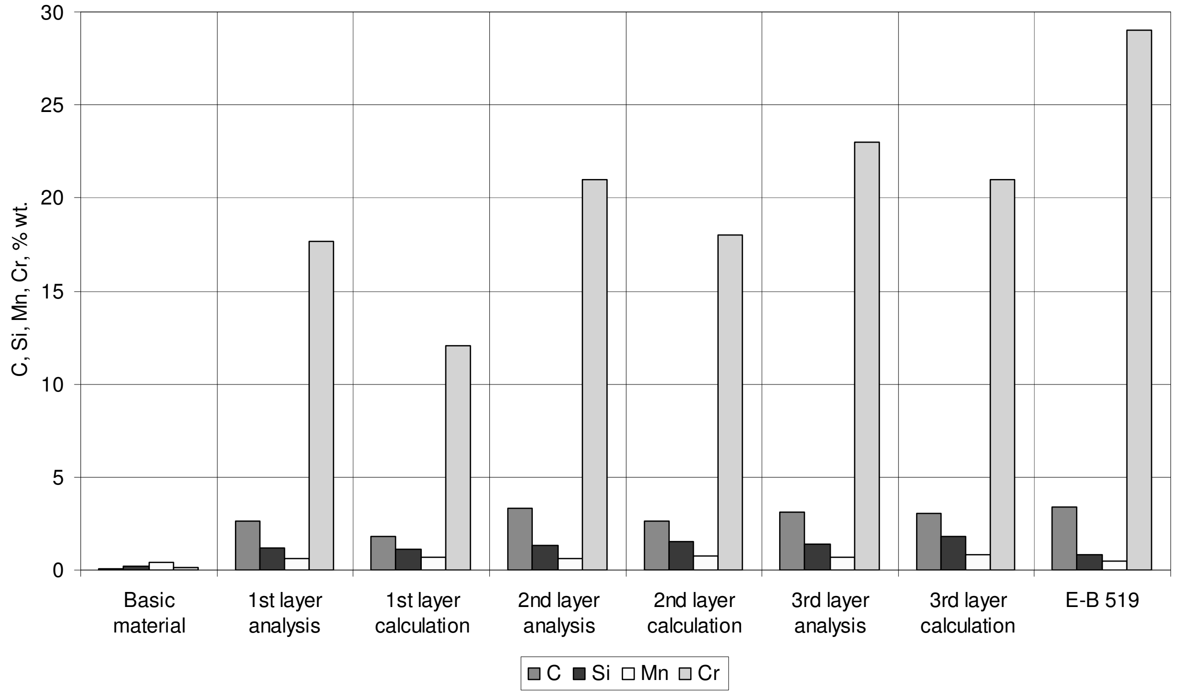

Fig. 3. **Results of the weld deposit from E-B 519**

The differences between the actual content of the concrete chemical element determined by the analysis and the assumed content determined by the calculation can be evaluated by the mutual share of these two values. At the same time we find that the greatest differences are at carbon (difference +1 to +101 %). Relatively great differences are also at chromium (difference +2 to +70 %), minor at silicon (difference -21 to +36 %) and manganese (difference -21 to +30 %), the minimum at molybdenum (difference -18 to +13 %). It is interesting that mostly (79.5 %) the actual content of the given element is higher than the calculated one.

From above mentioned it follows that the calculation used sometimes in practice can be only orientation for the chemical composition of the deposit. For more precise composition determination it is unusable. Always it is necessary to carry out the analysis of the chemical composition.

From the results it is also evident that in conformity with the presumption that with a higher number of layers the actual chemical composition of the deposit nears the nominal chemical composition of the electrode presented by the producer.

Conclusions

In the framework of experiments the 1-, 2-, 3- and 5 layers deposits were surfaced using the electrodes for manual arc welding of types E-B 508, E-B 518 and E-B 519 and the basic material steel 11 373. In consequence their chemical composition was studied. The composition was also computed using the mathematic model sometimes used in practice.

The differences between the actual and calculated chemical compositions differ according to the electrode material and they are different for concrete chemical elements (C, Si, Mn, Cr, Mo), too. It was proved that the mathematical method of the deposit chemical composition calculation is indeed simple, but at the same time very inaccurate. Therefore, its use is very limited, e.g., for the orientation chemical composition of the deposit. But for more exact study of deposits it is unusable. In these cases it is always necessary to determine the chemical composition of the deposit using some of suitable analytic methods.

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