



# OPTIMIZATION OF MODES OF SUBMERGED ARC SURFACING OVER THE LAYER OF ALLOYING CHARGE OF CATERPILLAR MACHINE RUNNING GEAR PARTS

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The optimization of modes of submerged arc surfacing with application of external magnetic field over the layer of alloying charge of caterpillar machine running gear parts was carried out. The influence of external axial magnetic field parameters and powders of silicon carbide SiC and aerosil SiO<sub>2</sub>, introduced with the charge, on hardness and microhardness of the deposited metal was studied. During experiments the concentration of silicon compounds in alloying charge, number of deposited layers, deviation in the arrangement of the latter relatively to the arc axis as well as induction of the external magnetic field were changed. The regression dependence of hardness on surfacing mode parameters for two types of charge is presented. The software complex was designed intended to determine the parameters of arc surfacing mode according to the proposed scheme to provide the maximum effect of using external influences. 11 Ref., 1 Table, 3 Figures.

**Keywords:** *arc surfacing, alloying charge, external magnetic field, powders SiC and SiO<sub>2</sub>, regression dependences, designing of surfacing technology*

Analysis of organization and carrying out of surfacing works shows that for restoration of parts, which at first sight operate approximately under the same conditions, a rather wide range of surfacing materials is commonly proposed differing by degree, and sometimes by alloying system which is not always justified [1–4]. In particular, it is well known from the experience of restoration of running gear parts of caterpillar machines that the requirements to deposited metal depending on conditions of the further operation (operation mode, hardness and granulometric composition of abrasive particles getting to the pairs of friction, etc.) can vary considerably [5].

As a result, for surfacing of the same running gear parts of caterpillar machines (conveyor rollers, rollers, tracks) it becomes necessary to use surfacing materials differing, in the first turn, by hardness, chemical composition and structure. It was established [6] that depending on the mentioned operation conditions the hardness of metal deposited on running gear parts of caterpillar machines should vary in the range of HV 285–435 (HB 283–413), which almost can not be achieved using only one grade of surfacing wire.

It has been shown [7] that changing of hardness of deposited metal in a rather wide range is possible in arc surfacing over the layer of alloying charge previously clad on the surface to be deposited. However, this method has a significant dis-

advantage, i.e. during its use the specified composition and good formation of deposited metal can be achieved only in a narrow range of surfacing modes [1]. Improving these parameters is possible due to application of external magnetic field, which, according to some information, has a positive influence on formation of deposited beads and properties of the deposited layers [8, 9].

The aim of these investigations was in optimization of modes of submerged arc surfacing with application of external magnetic field over the layer of alloying charge of running gear parts of caterpillar machines providing a specified hardness of the deposited layer.

To achieve this aim, the experiments on arc surfacing over the layer of alloying charge deposited on the surface of specimens of steel St3 with hardness HB 197–207 were conducted. During surfacing the external axial magnetic field was imposed on welding arc, thus increasing the width of weld pool. This allowed applying filler charge with displacement from the axis of the arc and made it possible to control the process of its melting. As the filler charge the powders of silicon carbides (SiC) and aerosil (SiO<sub>2</sub>) were used mixed with iron powders and binding substances.

Surfacing of specimens was performed using wire Sv-08A of 3 mm diameter under flux AN-348A in installation UD-209. The surfacing conditions are the following: current 400 A, voltage 32–36 V, wire feed rate 160 m/h, deposition rate 12–16 m/h, step of surfacing 6–8 mm, electrode stick-out 30 mm, current was direct, polarity – reversed. The coil, providing axial mag-



Proportions of mixtures and their consumption per unit of a weld length

Scheme of layers deposition	Hardness <i>HB</i>	
	Deposited layer	HAZ
Without additional effects	243	220
With imposition of constant magnetic field, $B_z = 20$ mT	248	229
With imposition of alternating magnetic field, $f = 50$ Hz, $B_z = 20$ mT	277	239
With imposition of alternating magnetic field, surfacing along the charge with SiC powder	452	227
With imposition of alternating magnetic field, surfacing along the charge with SiO <sub>2</sub> powder	512	245

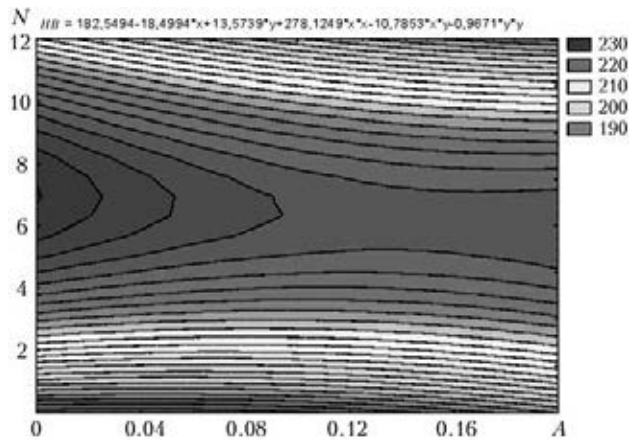
netic field, was attached to the torch so that the nozzle and electrode wire passing through it could serve as an additional ferromagnetic core. The coil was supplied with alternating or direct current. During experiments, the filler charge layers were placed at different distance from the axis of electrode wire, and their width was in the range of 8–10 mm.

To reduce the number of experiments a central planning of decomposition of the second order for the four factors (mixture composition; number of deposited layers of the mixture; eccentricity in the arrangement of alloying charge layer relatively to the axis of electrode wire; induction of external magnetic field) was performed. The experimental data processing was carried out with mathematical package STATISTICA 6.0.

To measure hardness on device TK-2, the plane specimens of 15 mm thickness were cut out of the deposited plates. The results of hardness measurement show that the effectiveness of supplying alternating magnetic field to the coil is higher than that of the constant one (see the Table).

The regression equation of hardness of deposited metal has the following form:

$$\begin{aligned}
 HB = & -19.8459 - 894.036A - 90.713N + \\
 & + 354.479n + 162.6051B + 695.3873A^2 - \\
 & - 110.68N^2 - 975.169n^2 - 1.08627B^2 - \\
 & - 17.2259AN + 286.0339An + 3.448646AB + \\
 & + 958.2996Nn + 10.45245NB - 63.9323nB,
 \end{aligned}$$



**Figure 1.** Dependence of hardness *HB* of deposited metal on distance *N* between the axis of electrode and layer of charge and concentration *A* (mass share) of aerosil SiO<sub>2</sub> in charge

where *N* is the distance from the axis of electrode to the layer of charge, mm; *A* is the concentration (mass share) of SiC (up to 0.15) or SiO<sub>2</sub> (over 0.15) in charge; *n* is the number of layers; *B* is the magnetic field induction, mT.

As it follows from the obtained data (Figure 1), the optimal is the arrangement of charge layer at 4–10 mm distance from the axis to the electrode. If the layer is located closer then it melts completely together with refractory particles, if it locates farther, it falls outside the melting zone.

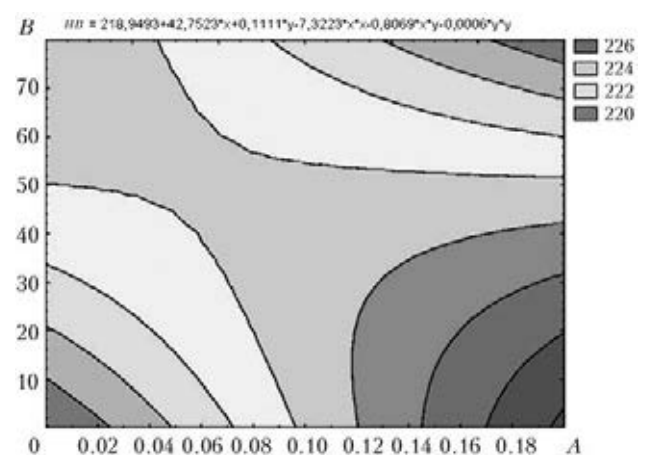
With increase in external magnetic field induction the width of weld pool increases causing a complete remelting of charge and, as a result, a complete melting of dispersed material. As a result, a decrease in hardness (Figure 2, zone *B* = 60–80 mT) is observed.

To determine the optimum parameters of arc surfacing mode with simultaneous application of external magnetic field providing a maximum benefit from dispersed material introduced in arc surfacing, a software complex was designed (Figure 3).

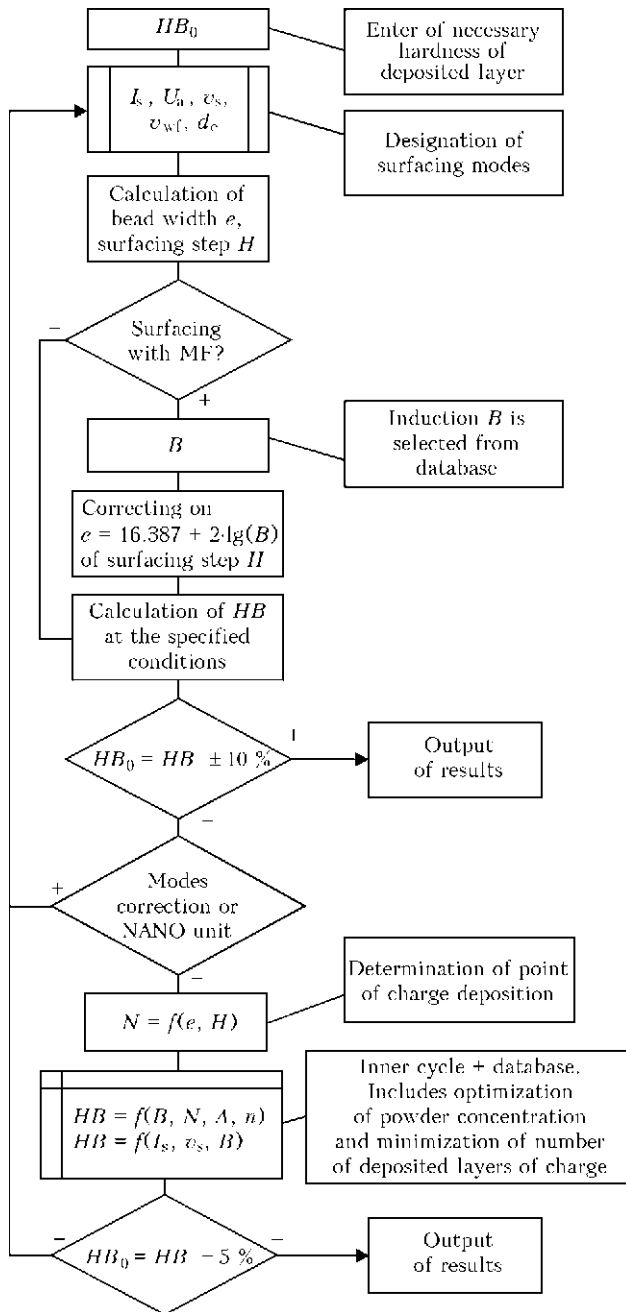
The parameters of surfacing mode, at which the desired hardness of deposited layer is achieved, are determined in the following sequence.

*Stage 1.* The user enters the value of necessary hardness *HB* of deposited layer.

*Stage 2.* The diameter of electrode wire *d<sub>e</sub>* (mm) is specified and either self entering of basic surfacing modes (current *I<sub>s</sub>* (A), deposition rate



**Figure 2.** Dependence of hardness *HB* of deposited metal on magnetic induction *B* (mT) of external axial field and concentration *A* (mass share) of aerosil SiO<sub>2</sub> in charge



**Figure 3.** Algorithm for determination of optimum parameters of surfacing mode

$v_s$  and wire feed rate  $v_{wf}$  (m/h)) from the software database or manual entering of the specified modes are offered. The user specifies conditions for the further calculation of surfacing parameters: with use of additional magnetic field (MF) or without it.

**Stage 3.** Calculation of the width of single deposited bead  $e$  (mm), which is formed under the conditions of surfacing at specified modes and surfacing step  $H$ . If the surfacing mode with MF was selected, then the program selects MF induction values from the database, correction of width and step of surfacing is performed.

**Stage 4.** Calculation of hardness of the deposited layer  $HB$  in surfacing without use of charge.

**Stage 5.** Determination of coordinates of charge layer arrangement as function  $N = f(e, H)$ .

**Stage 6.** Determination of hardness of deposited metal using available database. It includes optimization of concentration of powder material and minimization of number of deposited layers of charge.

Complex data processing with application of algorithms and models, published in [10, 11], is performed.

As the practice of using the program shows, in case of applying automatic correction of surfacing modes, return to the initial unit in manual mode in 95 % of cases is not required.

## Conclusions

1. It was determined that use of alternating magnetic field, imposed on welding arc, causes a greater increase in hardness of the deposited metal than use of constant magnetic field.

2. Analytical dependence for determination of hardness of the deposited layers is offered, which is achieved by additional supply of alloying charge with carbides or oxides of silicon and imposition of external magnetic field.

3. Software complex was developed intended to determine the parameters of arc surfacing providing maximum benefit from the introduced dispersed material and imposition of external magnetic field.

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