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INVESTIGATION OF THE CONTACT RESISTANCE IN CONTACT MICROWELDING BY THE NON-DISCRETE LOGICAL MODELLING

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ABSTRACT

This article is devoted to investigation of the surface conditions for welding joints and contact resistance in contact microwelding by the method of the non-discrete logical modeling. The main advantage of this method is that the application of logical functions in system analysis allows describing the casual and effect relationships between large numbers of parameters of the welding technological process.

The non-discrete logical (NL) models of the surface conditions and the static characteristic of the contact resistance are offered. It is shown, that the static characteristic depends on the surface quality parameters, the physical properties of welded material and the welding conditions as well.

The acquired NL-models can be used as separate models to qualitative a priori analyzing the changes of the characteristic of surface conditions and of the static characteristic of contact resistance. On the basis of these NL-models the summarized solution that will provide the welds of high quality can be developed.

Keywords: microwelding, contact resistance**,** surface, logical modeling

1. INTRODUCTION

The contact welding belongs to thermo-mechanical class of welding processes. Thereby the mechanical effort (compression of welded details) is used for the thermal effect amplification.

The investigation of the characteristics of contact welding can be carried out by several ways: an intuitive method, statistical approach, fragmentary logic analysis, and optimization on the basis of the system analysis. At the resent years the method of non-discrete (NL) modeling, which was proposed by R.B.Rudzit [1], was successfully used by researches [2-4] and not only in welding field, but also, for example, in metallurgical science [5]. The main advantage of this method is that the application of system analysis by logical functions allows describing the causal and effect relationships between large numbers of parameters of the welding technological process. The process of contact welding is a very complicated object to research, that's why integrated investigation and description of contact welding by existing mathematical methods is quite complicated and not achieved at this time. The intuitive searches of the solution of different technical problems usually were unsuccessful or took much time and consumption of materials. That's why it was decided to try describing contact welding process by the method of the NL-modeling.

One of the main factors in the formation of the weld is the contact resistance, that directly influences on thermal field. If the thickness of details is smaller then the contact resistance significantly influences on welding process (especially in microwelding). The mechanical parameter (compression force) effects by means of contact resistance too. Therefore it is preferable to start the investigation of the characteristics of contact microwelding with investigation of contact resistance. However, at first, any investigation of contact resistance requires investigating of the surface conditions of welded details before welding. As it known, exactly surface conditions play the main role in determination of contact resistance value.

2. NON-DISCRETE LOGICAL MODEL OF SURFACE CONDITIONS

So, at the first step of analysis the characteristic of surface's conditions is described as NL-function of two nearest common parameters: parameter of form of surface S_f and parameter of surface chemical activity S_{ch}. Then the parameter of form of surface is represented as NL-function of surface roughness parameters: roughness average volume R_a and roughness step parameters S (step by roughness maximums) and S_m (step by roughness center line). On the other hand, the parameter of surface chemical activity is described as adsorbed coat thickness h_a. The scheme of the analysis and synthesis of NL-model you can see on Figure 1.

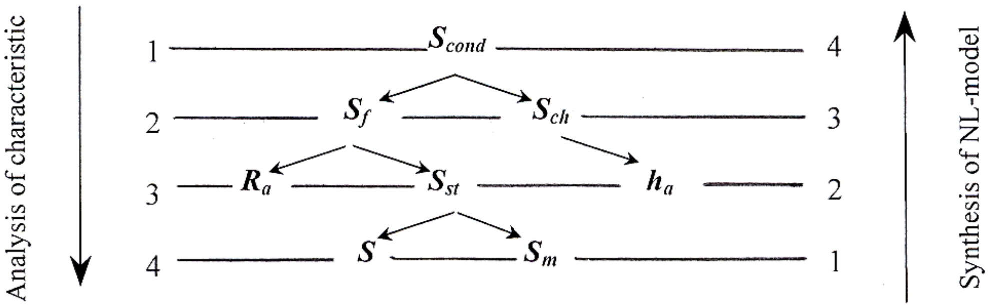

Figure 1. The scheme of the analysis of surface condition's characteristic S_{cond} and synthesis of its NL-model

After the analysis of the characteristic of surface conditions the NL-model synthesis is executed by consecutive substitutions of parameters-arguments of the subsequent step of analysis in directly determinated by them parameters-functions of the previous step of analysis. The kind of NL-function is defined by tabulation and analysis of the truth-value tables.

So, roughness step parameters are related to each other by nondiscrete (N)-conjunction:

$$S_{st} = f\left(S \;, \overline{S_m}\right).$$

1 =	1	1	
0 =	0	1	(1)
0 =	1	0	
0 =	0	0	

Where symbol 0 interpreted not as "no", but as "remote maximally small value" and symbol 1 interpreted not as "yes", but as "remote maximally big value". By this way it is possible to describe nondiscrete process with logical functions [1]. Symbol $\overline{S_m}$ indicates one of the NL-functions: N-negation. When level of parameter S_m increases the level of NL-function decreases and on the contrary, if level of parameter S_m decreases the level of NL-function increases.

$$S_{st} = \left| S \;/\cdot/\; \overline{S_m} \right| \;. \tag{2}$$

The parameter of form of surface was represented as N-conjunction of roughness average volume R_a and roughness step parameters:

$$S_f = \Big|_{2}^{1} R_a /\cdot/ \Big|_{1}^{1} S \;/\cdot/\; \overline{S_m} \Big|_{1} \Big|_{2} . \tag{3}$$

As a result of all substitutions, which recording in logical relationships is the nondiscrete-logical model, the NL-formula of surface conditions characteristic is determined. We can define the characteristic of surface's conditions as N-disjunction of parameter of form of surface and parameter of surface chemical activity:

$$S_{cond} = \Big|_{3}^{1}\Big|_{2}^{1} R_a /\cdot/ \Big|_{1}^{1} S \;/\cdot/\; \overline{S_m} \Big|\Big|_{1\,2} /+/ \Big|_{2}^{2} h_a \Big|\Big|_{2\,3} . \qquad (4)$$

As a result of the analysis of the received NL–model has been established, that the level of characteristic of surface's conditions will increase when the level of parameter of form of surface or level of parameter of surface chemical activity increases. In other words, level of characteristic of surface's conditions will increase with increasing of R_a, S, h_a and will decrease with increasing of S_m.

3. NON-DISCRETE LOGICAL MODEL OF THE STATIC CONTACT RESISTANCE

By static characteristic of contact resistance the fractional increase of resistance in contact is implied in comparison of intrinsic resistivity of conductor. At the first step of analysis the static characteristic of contact resistance R_{static} is described as NL-function of three nearest common parameters: parameter of form of contact F_C, parameter of adsorbed coat resistance R_{ad} and parameter of relative plastic deformation of surface ε:

$$R_{static} = \left| F_c \;/+/\; R_{ad} \;/+/\; \varepsilon \right| . \qquad (5)$$

Then the parameter of adsorbed coat resistance R_{ad} is represented as NL-function (6) of adsorbed coat thickness h_a and resistivity ρ_{ad}, resistance to deformation of coat material σ_{ad} and static pressure P_{st}. The scheme of the analysis and synthesis of NL-model of the adsorbed coat resistance R_{ad} is shown on Figure 2.

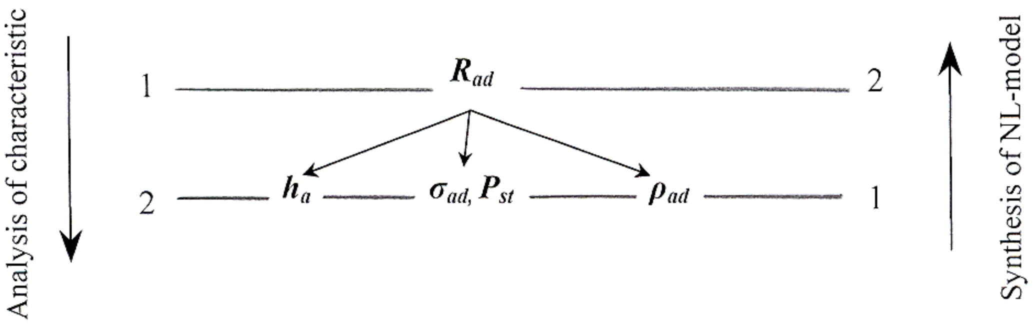

Figure 2. The scheme of the analysis of charactrictic of adsorbed coat resistance R_{ad} and synthesis of its NL-model

$$R_{ad} = \Big|_{2}^{1}\Big|_{1}^{1} h_a /\cdot/ \Big|_{1}\Big|_{1}^{2} \overline{P}_{st} \;/\cdot/\; \sigma_{ad} \Big|_{1} /\cdot/ \Big|_{1}^{3} \rho_{ad} \Big|\Big|_{1\,2} \cdot$$

(6)

The scheme of the analysis and synthesis of NL-model of the parameter of form of contact F_C (7) is shown on Figure 3, where F_{geom} – geometrical parameter, which reflecting character of distribution of the real contact areas; S_f – parameter of form of surface; $S_{concentr}$ – paramater, which reflecting degree of real contact areas concentration; σ_{cond} – resistance to deformation of conductor material; P_{st} – static pressure; L – length of contact; R – radiuss of conductor; φ – relative level of deformation of surface irregularities.

$$F_c = \Big|_{5}^{1}\Big|_{4}^{1}\Big|_{3}^{1}\Big|_{2}^{1} R_a /\cdot/ \Big|_{1}^{1} S /\cdot/ \overline{S}_m \Big|\Big|_{1\,2} /+/ \Big|_{2}^{2} L /\cdot/ R /\cdot/ R_a /\cdot/ \overline{\gamma} \Big|\Big|\Big|_{2\,3\,4} /\cdot/ \Big|_{4}^{2} \overline{P}_{st} /\cdot/ \sigma_{cond} \Big|\Big|_{4\,5} \cdot \qquad (7)$$

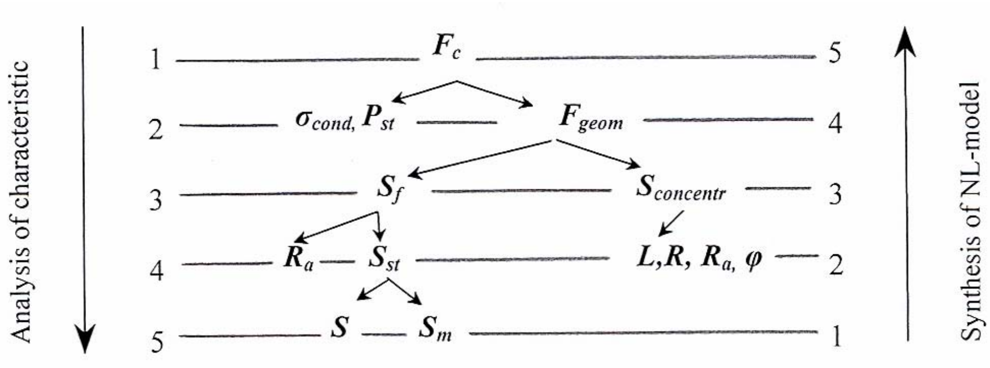

Figure 3. The scheme of the analysis of charactrictic of the parameter of form of contact F_C and synthesis of its NL-model

As a result of all substitutions, which recording in logical relationships is the nondiscrete-logical model, the NL-formula of static characteristic of contact resistance R_{static} is determined:

$$R_{static} = \Big|^{1}_{6} \Big|^{1}_{5} \Big|^{1}_{4} \Big|^{1}_{3} \Big|^{1}_{2} R_a /\cdot/ \Big|^{1}_{1} S /\cdot/ \overline{S}_m \Big|_{1} \Big|_{2} /+/ \Big|^{2}_{2} L /\cdot/ R /\cdot/ R_a /\cdot/ \overline{\gamma} \Big|_{2} \Big|_{3} \Big|_{4} /\cdot/ \Big|^{2}_{4} \overline{P}_{st} /\cdot/ \sigma_{cond} \Big|_{4} \Big|_{5} /+/$$
$$/+/ \Big|^{2}_{5} \Big|^{3}_{4} h_a \Big|_{4} /\cdot/ \Big|^{4}_{4} \overline{P}_{st} /\cdot/ \sigma_{ad} \Big|_{4} /\cdot/ \Big|^{5}_{4} \rho_{ad} \Big|_{4} \Big|_{5} /+/ \Big|^{3}_{5} \varepsilon \Big|_{5} \Big|_{6} \qquad (8)$$

4. CONCLUSIONS

1. The nondiscrete-logical (NL) models of surface condition's characteristic S_{cond} and of static characteristic of contact resistance R_{static} have been developed.
2. The NL-formulas of S_{cond} and R_{static} contain only standart roughness parameters (*Ra, S,* S_m) and easily determined parameters, such us physical properties of materials (σ_{cond}, σ_{ad}, ρ_{ad}), welding conditions (P_{st}), geometrical parameters (h_a, L, R).
3. The acquired NL-formulas can be used as separate models to qualitative a priori analyzing the changes of the characteristic of surface conditions and of the static characteristic of contact resistance or can be used in subsequent investigation of contact welding process. Finally, the summarized solution that will provide the welds of high quality will be developed.

5. ACKNOWLEDGEMENT

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