WELDING TENDENCY FOR SELECTED CONTACT MATERIALS UNDER DIFFERENT SWITCHING CONDITIONS

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Abstract:
The flow of significant current through electric contacts may lead to contact welding. In a.c. circuits this phenomena is not only dependent on properties of contact material (i.e. resistance to welding) but on the phase in which current is switched on. Welding tendency for contact materials made from AgNi, AgCdO and AgSnO2 was evaluated based on selected phase at which make operation took place.

Keywords
Relays, contact materials, contact welding, surface erosion.

Introduction

The relays which are intended for connecting the electrical load are prone to some disadvantageous phenomena. These may include making of overload currents and short-circuit currents, which may lead to shortening the time of maintenance of relays or, in extreme cases, to their complete destruction. Long term exposure to higher temperature may lead to relays degradation, for example change of its contact resistance and opening and closing times [18, 19]. The research already performed by Morin [12], Neuhaus [13] and Doublet [4], who independently undertook work for similar contact materials, concentrate on low-current circuits of direct current and small amperage. There are also articles related to the processes of making circuits of alternating current of average voltage and amperage of several kA [1, 6, 14].

MATERIALS AND METHODS

Contact welding can occur inside the contact areas of the contact surface A_S. When the switching arc is present, it is assumed that the welding takes place inside the area where the A_m surfaces, melted due to the electric arc, meet. Each arc root spot is surrounded by a molten contact material, located completely or partially inside or outside of the contact surface. The pinching force of the contacts depends on the size of area A_0 [13, 16].

The welding force of the contacts also depends on the contact material used. Some contact materials show a higher tendency to welding than others [12]. If the contact material is characterized by a high welding tendency, also the resulting welds will form as strong. Pure silver has the worst properties in this respect, it has a higher tendency for welding [8] and this is one of the reasons why it is not used as a contact material. AgCdO is characterized by slightly better parameters. It has a lower tendency for welding, but they create welds with higher strength.

RESULTS AND DISCUSSION

The most difficult working conditions for electromagnetic relays can occur at the moment of closing the damaged circuit in which a short-circuit current occurs. With significant short-circuit currents, processes such as contact heating above the melting point of the material, contact bounces and also welding may occur. Attempts have been made to connect a short circuit with the expected short-circuit current of 320 A. Contact materials that were tested are: AgNi, AgCdO and $AgSnO_2$. Each of them was composed of 90 % silver and a 10 % addition of nickel, cadmium-oxide and tin-oxide respectively. The $AgSnO_2$ was tested in two variations. For the first one contact rivets were made in the process of internal oxidation and refereed in the article simply as $AgSnO_2$. For the second one the rivet was designed to withstand higher inrush currents (up to 80 A for 20 ms) and refereed in the article as $AgSnO_2$ P. The system is designed to test short-circuit currents with prospective values up to $20I_n$ in circuits equipped with typical overcurrent protection apparatus, used in low voltage electrical installations, with rated current 16 A. In addition, the system is equipped with an external device synchronizing the moment of relay activation with the phase of the supply voltage. This system is intended for switching the relay contacts in the selected phase of the mains voltage. Measurements were carried out for two switching on currents:

- switching on the short-circuit current occurs at the moment when the voltage between the contacts reaches zero (case A),
- switching on short-circuit current occurs at the moment when the voltage between the reaches the maximum value (case B).

For case A short-circuit current increases from zero, and in case B shortcircuit current starts from the maximum value. The effects of such switching on the short-circuit current will have an impact on the electrode processes occurring in the contacts during the short-circuit. Switching on the circuit at the moment when both current and voltage reach zero, puts milder conditions for the operation of the relay. There shouldn't be a preliminary electric discharge between the contacts, thus the contact surface may undergo less erosion.

Eight attempts were made for each contact material. The current and voltage between the relay contacts were recorded. After each test, the contacts were checked for welding. On the basis of the oscilloscope recording, it was determined whether in the given test a contact bounce occurred. A summary of the results obtained are presented in table 1. It can be seen that for none of the attempts contact bounce b or welding s was observed. This leads to the conclusion that for switching the circuit at the moment when the current increases from zero value does not cause negative effects related to the relay rivets.

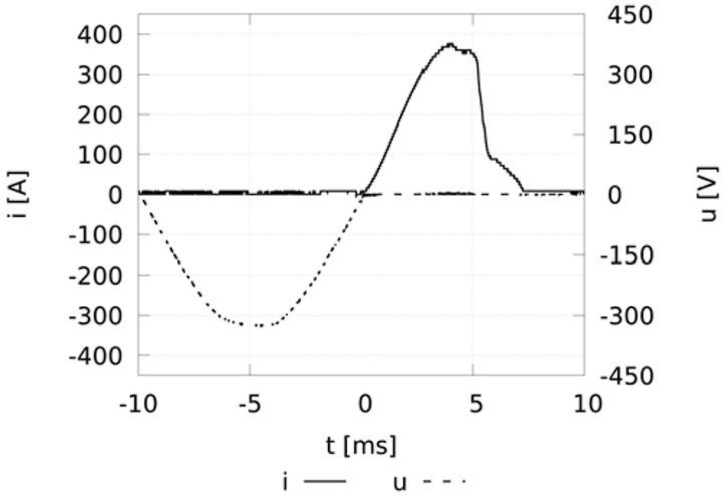

Fig. 1. An exemplary oscillogram of current and voltage waveform between the relay contacts when the circuit is closed when voltage between contacts reaches zero (case A); contact material – AgNi

CONCLUSION

Based on these results, it can be concluded that the most resistantto welding ($AgSnO_2$) [12] was characterized by the smallest deformation of the contact surface. In the next order is AgNi, and the biggest changes are observed for AgCdO. The melting point of these materials, according to the manufacturer's data, is identical (961 °C). The differences occur in the case of thermal conductivity. For $AgSnO_2$ thecoefficient of thermal conductivity is not described by the manufacturer, but for AgCdO it is by 12 % smaller than for AgNi, hence the susceptibility of this material to the effects of thermal interactions canbe greater. This may justify the observed increase in surface degradation at the AgCdO contacts.

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