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Performance of laminated contact material Cu—Mo in open air ac low voltage contactors

B. Miedzinski, P. Wojtas, A. Kozłowski, J. Wosik,
A. Grodzinski *, M. Habrych **, N. Grechanyuk ***

Institute of Innovative Technologies, Poland
* Tele and Radio Research Institute, Warszawa, Poland
** Wroclaw University of Technology, Wroclaw, Poland
*** Institute of Material Science, UAS, Kiev, Ukraine

In the paper performance of laminated contact material Cu—Mo when use in open air ac low voltage contactors is presented and discussed. On the basis of the investigated results conclusions on effective application of such material to replace silver based compositions are formulated.

***Keywords**: contacts material Cu—Mo, low voltage contactor, performance.*

Introduction

The high price of silver that still is being used as the main component of contact material in various structures of switching equipment forces engineers and scientists to look for equivalent much cheaper materials as well as for less sophisticated manufacturing technologies that could meet the relevant requirements of a modern low voltage relays and switches[1—3]. One of alternative way might be replacement of noble metals by newly developed laminated composites materials manufactured by means by of a high power electrons beam technology [4]. Preliminary successful application in sliding contacts [5] and respective studies have found that such material could be copper molybdenum composition of a carefully selected composition and adapted structure to replace Ag based alloy in contacts of low voltage power contactors operating in air. Therefore respective investigations were carried out for selected contactors structure and conclusions basing on the investigated results were formulated for use in practice.

Investigation procedure

For testing 3 phase, double contact gap Chinese contactors type CJ20 of rated voltage 400/230 V and current of 160 A, 250 rms operated in air were selected (fig. 1).

View of both movable and stationary contact members, both made of Ag based alloy is presented in fig. 2.

The switching performance according to AC3 category of utilization was investigated under doubled rated current value ($2I_r$ = 320 A rms) at equal to 0,35 for limited number of switching cycles to 6000 in testing system as in fig. 3. After each 1000 cycles the contacts resistance value was controlled under DC current of 100 A using 4-point method as in fig. 4.

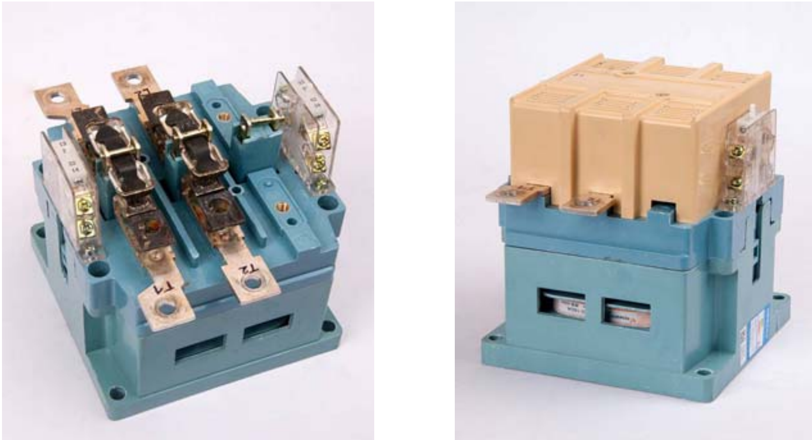


Fig. 1. View of contactors for testing.

Fig. 2. View of contacts before test.

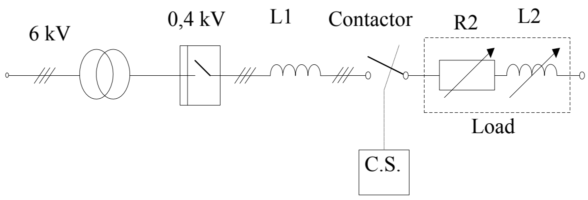


Fig. 3. Schematic diagram of switching test system; c.s-control and measuring-recording system.

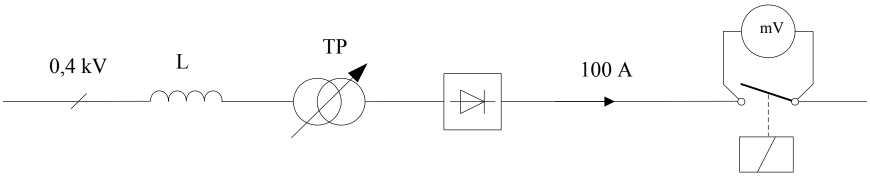


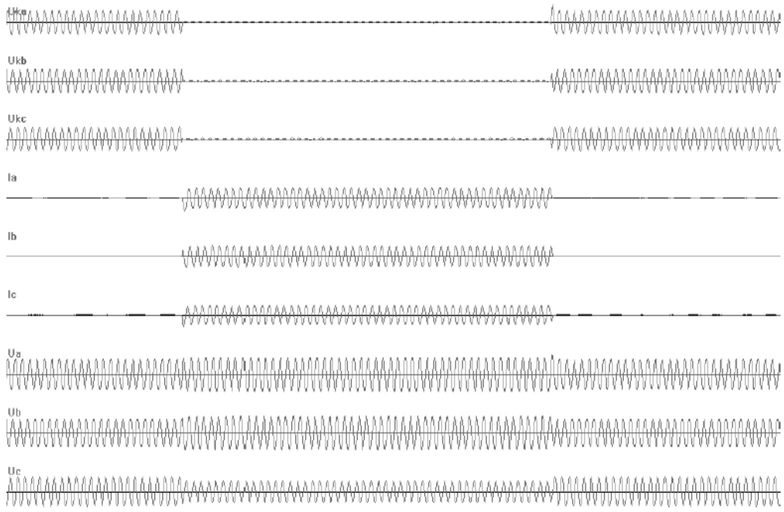
Fig. 4. Schematic diagram of system for measuring contact resistance 4-points method for 100 A DC.

Under the switching test both voltage across contacts, load current and supplying voltage value and waveforms were measured and recorded at the beginning of test and after each 1000 switching. The closed contacts had to pass the load current for 1s as illustrated in fig. 5.

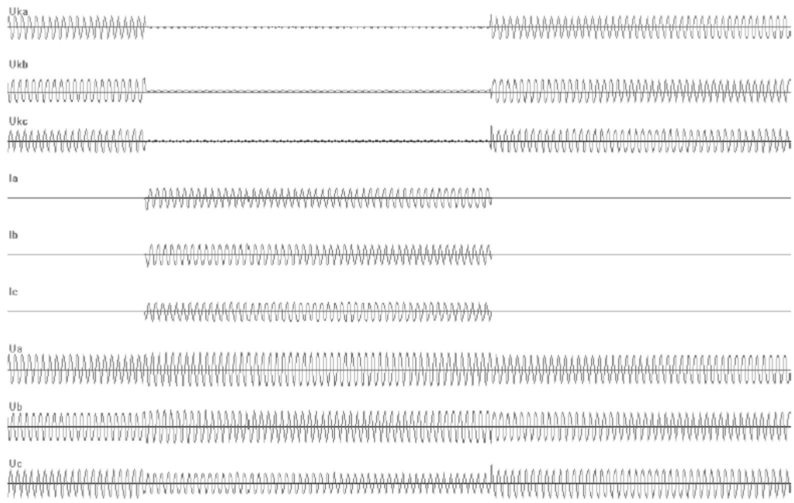
Performance of contactors with silver based contacts

Before the test both contact surface and material morphology was inspected and controlled. It was found that main components of contact material is silver and nickel (fig. 6.)

Under both closure (fig. 7) and opening (fig. 8, 9) electrical arc discharge is evident together with contact instability in transient and slight overvoltage values particularly at closure. The opening procedure is more effective than closure and its time does not exceed 20 ms. Contacts load current may decay rapidly at zero instantaneous value and/or at its maximum as well.

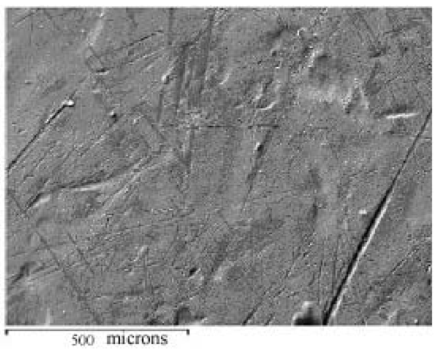


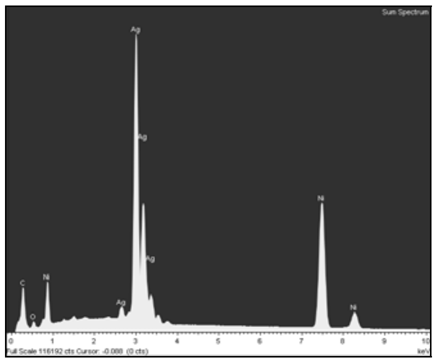
after 1000 switching cycles



after 6000 switching cycles

Fig. 5. Voltage across contacts, load current (1s) and supplying voltage respectively under test.





a *b*

Fig. 6. Contact Ag surface morphology — before test: electron-microscopic (*a*) and spectroscopic (*b*) pictures.

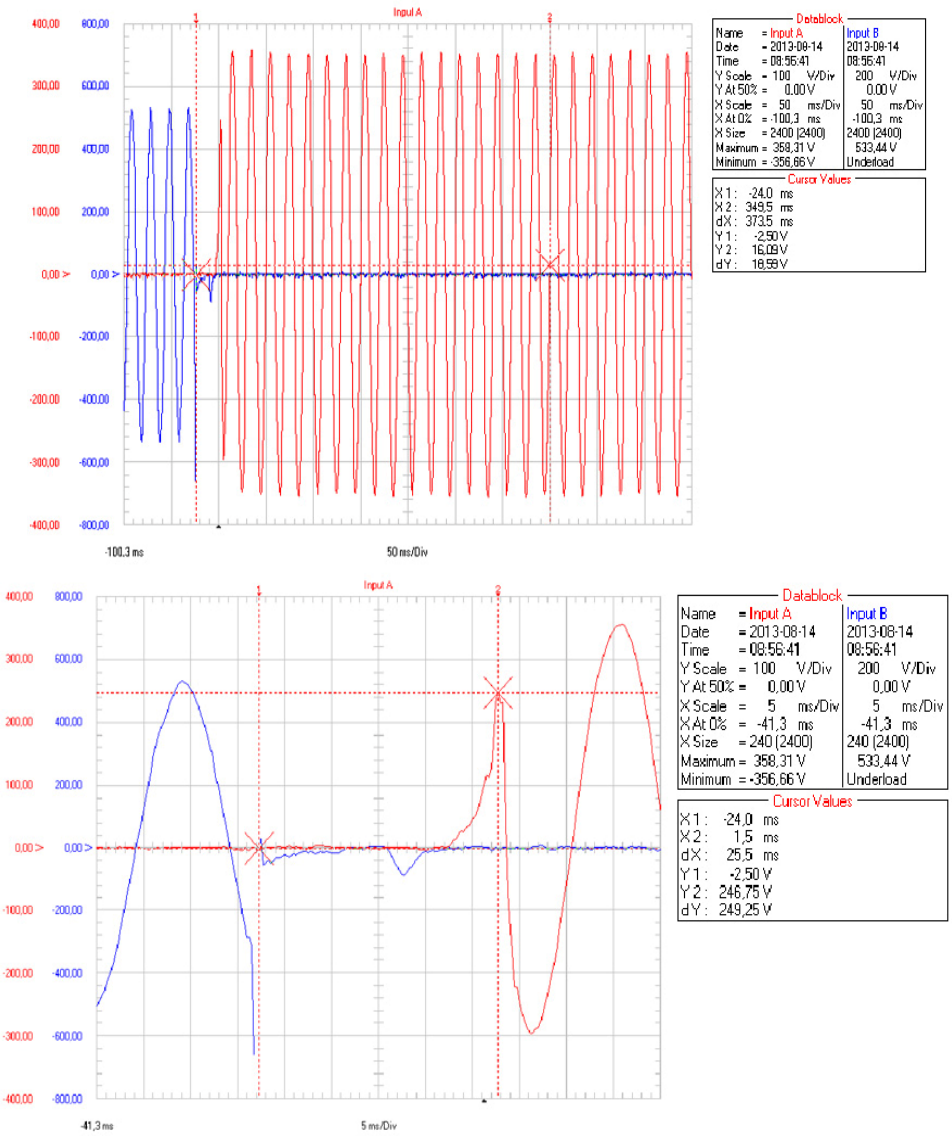


Fig. 7. Voltage across contact and current waveform at closure in one phase.

Contacts resistance value under operation was relatively stable at about 0,5 mΩ during first switching cycles indicating rapid increase, by about 100%, after 4000 operations. It results from relatively high contact surface wear under operation what can be compared from fig. 10. Contacts surface investigations confirmed high erosion rate due to electric arc not only of contacts material but also erosion of clamping parts of contacts sets structure (fig. 11).

As a result such elements like Cd, Sn and Fe were found to get out from volume onto the surface. Particularly undesirable is cadmium used as a silver alloy composition that is harmful for environment and is strictly forbidden for use in European Community countries.

After the test for silver alloy was completed the used contacts material was removed and replaced by composition Cu—Mo samples (fig. 12).

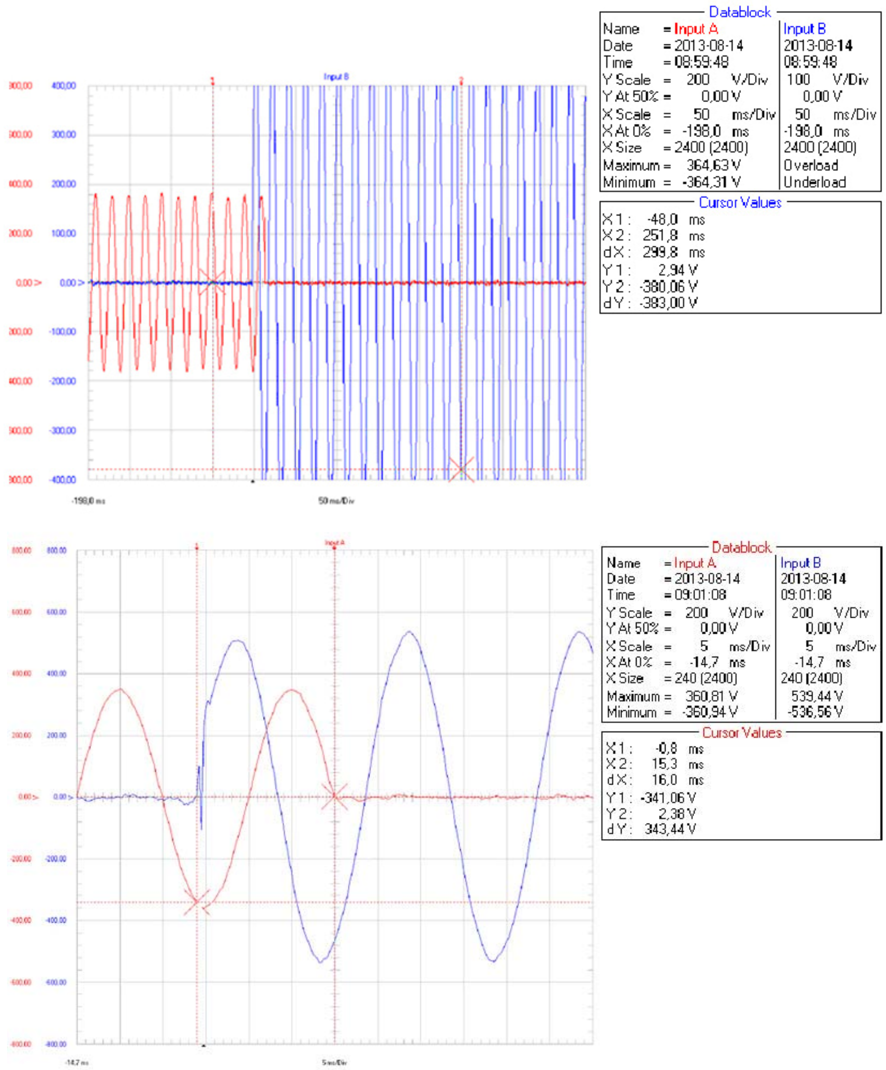


Fig. 8. Voltage and current waveform at breaking (at zero current) in one phase.

Performance of contactors with contacts Cu—Mo

The contactors with new contact material passed successfully the switching test under the same conditions of operation. Duration of both making and switching is much shorter in time (fig. 13, 14) however at the cost of higher overvoltage value. The contact resistance value is also higher as compared to silver based alloy of approximately by about 2—3 times and is less stable (fig. 15). However, its maximum value does not exceed 3 mohms what is not critical for the contactor operation. Contact surface erosion due to electrical switching arc does not seem to be vast (fig. 16). But to specify right conclusions further detailed surface investigations are required. They are already continued.

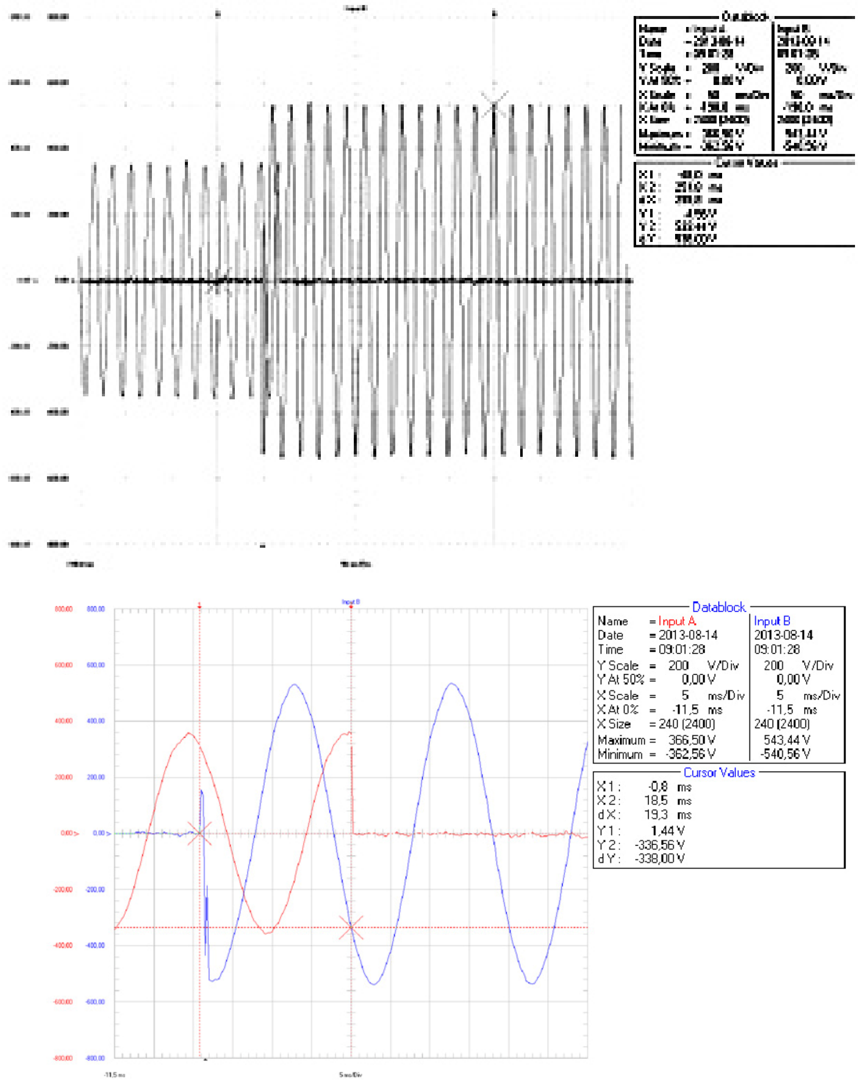


Fig. 9. Voltage and current waveform at breaking (at maximum current) in one phase.

Fig. 10. View of used silver based contacts after 6000 switching cycles.

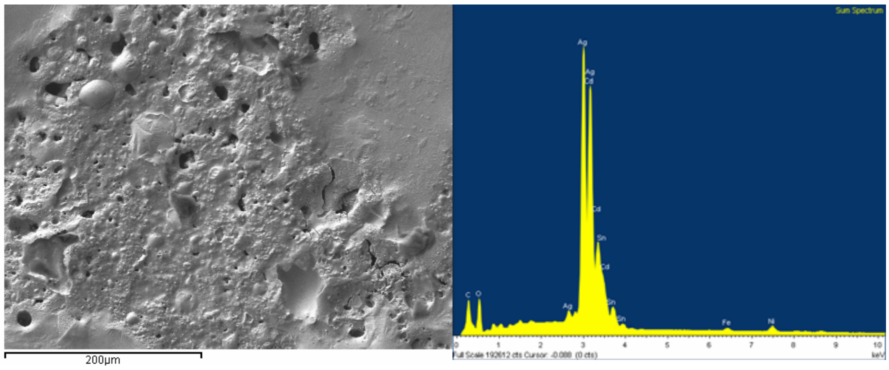


Fig. 11. Contact (Ag) surface morphology after test.

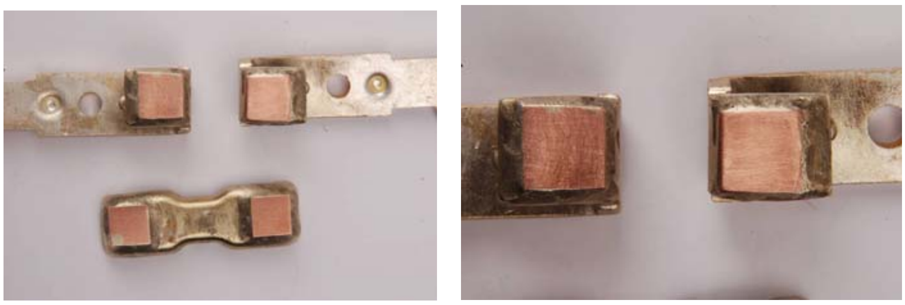


Fig. 12. View of new contacts made of composition Cu—Mo.

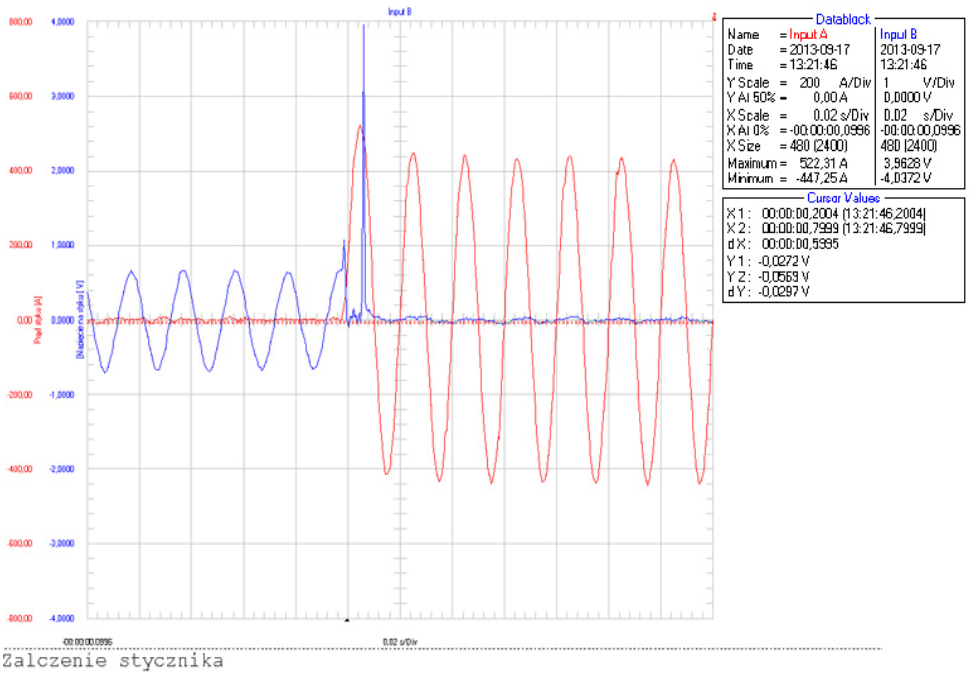


Fig. 13. Voltage across contact and current waveform at closure in one phase (Cu—Mo).

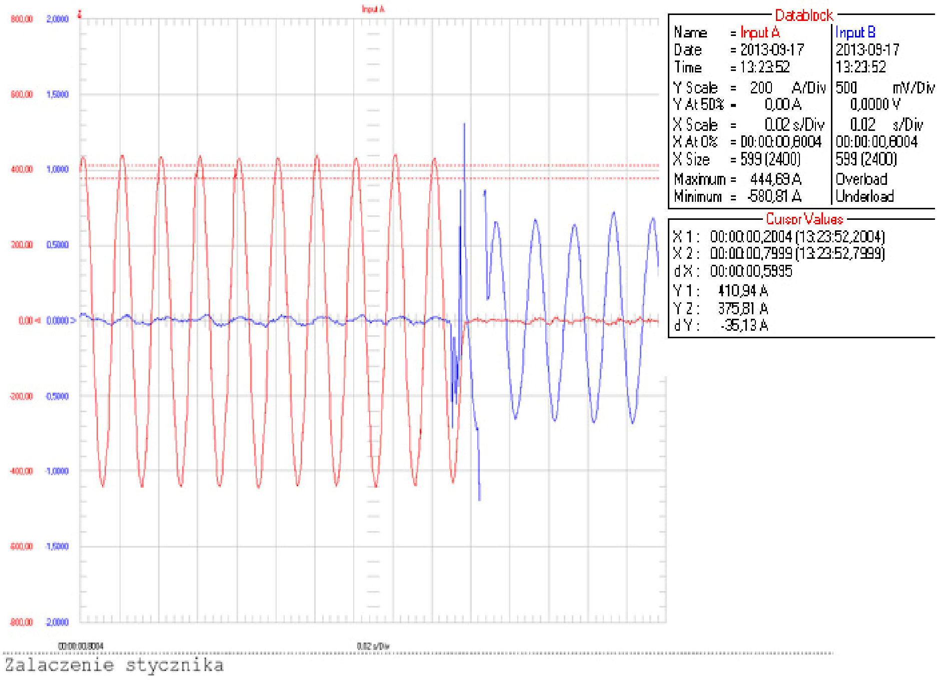


Fig. 14. Voltage and current waveform at breaking in one phase (Cu—Mo).

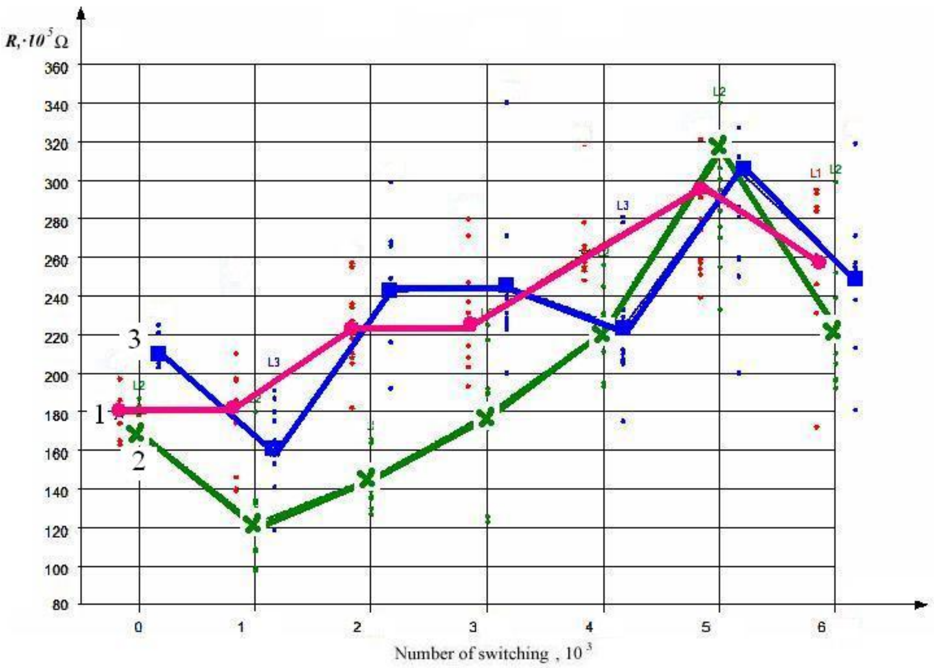


Fig. 15. Contact resistance value (for composition Cu—Mo) versus number of switching (320 A rms, cos fi = 0,35): 1 — L_1; 2 — L_2; 3 — L_3.

Fig. 16. View of used contacts Cu—Mo after 6000 switching cycles.

Conclusions

Under operation of selected Chinese LV air contactors with contacts made of silver based material, cadmium pollution was found to be released into the environment what is strictly forbidden by the European Community regulations.

Arc erosion of contacts made of silver based material, under operation, is relatively large what is also reflected in a sudden increase in the contact resistance value after around 5000 switching cycles under test.

The use of laminated composite material Cu—W makes duration of both breaking and making process shorter but at the cost of generating overvoltage, higher with compare to silver application.

T-contact resistance value is also higher as compared to silver based alloy of approximately 2—3 times and is changed with number of switching however, it does not exceed 3 mohm what is not critical for the contactor operation.

Contact surface erosion due to electrical arc discharge does not seem to be larger (however, requires further more detailed careful surface investigations).

The study shows that the laminated composite material Cu—Mo made by means of a high power electron beam technology is able to replace successfully silver based expensive contact material in Chinese LV power contactors operating under open air conditions. However, switching overvoltage values should be reduced, to acceptable in practice level, by careful selection of both molybdenum content and structure of the layers under processing.

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Эксплуатационные характеристики слоистого контактного материала Cu—Mo в воздушных АС низковольтных контакторах

Б. Медзинский, П. Войтас, А. Козловский, Д. Восик, А. Гродзинский, М. Хабрич, Н. Гречанюк

Представлены и обсуждаются эксплуатационные качества слоистого контактного материала Cu—Mo, используемого в низковольтных контакторах на открытом воздухе. По результатам исследований сформулированы рекомендации по эффективному применению такого материала взамен серебросодержащего.

Ключевые слова: *контактный материал Cu—Mo, низковольтные контакторы, характеристики.*

Експлутаційні характеристики шаруватого контактного матеріалу Cu—Mo в повітряних АС низковольтних контакторах

Б. Медзинський, П. Войтас, А. Козловський, Д. Восік, А. Гродзинський, М. Хабрич, М. Гречанюк

Представлено і обговорюються експлуатаційні властивості шаруватого контактного матеріалу Cu—Mo, який використовується в низьковольтних контакторах на відкритому повітрі. За результатами досліджень сформульовано рекомендації щодо ефективного застосування такого матеріалу замість срібловміщуючого.

Ключові слова: *контактний матеріал Cu—Mo, низьковольтні контактори, характеристики.*