15th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2011, Prague, Czech Republic, 12-18 September 2011

PRODUCTION THE HIGH ELECTRIC CONDUCTIVE MATERIALS FOR CONTACTS BASED ON SILVER BY THE USE OF SINTERMETALLURGICAL METHOD

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ABSTRACT
The aim of this work was to find out the most suitable technological model , based on laboratory investigations, for production the contact materials as well as to realize this program, i.e. to start the industrial production of contact materials by market analyzing.
It is a suitable opportunity to point out that the program is high accumulative and that contact materials are three or more times expensive than starting raw materials.Experimental work included a selection of conditions for obtaining maximum density of starting blanks of AgNi (10-40%Ni) composite and its further plastic treatment into wire of certain sizes and later a detail characterization of the obtained material.Modern commercial material production for electrical contacts in the world has introduced in a large part the producer secret, although many works were written and published from this field of science.
It is completely understandable if we have in a mind the factors that have influence on contact features, and what are the results of their suitable use and given working conditions.
Key words: silver, contact materials, sintermetallurgical

1. UVOD

Electrical contacts exist in all electrical devices, switchers, relays and other electrical appliances. Reliable operation of complete devices depends mainly on their reliable operation. Therefore a special care is given to the electrical contacts and materials for electrical contacts [1].

Electrical contacts are divided to break and slide ones. Break contacts interrupt and connect electric circuit until contact parts of slide contacts slide one towards the other without separation. Depending on current intensity that is interrupted, there are mainly two types of breakdowns at contacts. Those are corrosion (oxidation and other reactions with surroundings) and erosion (melting, evaporation, dispersion) of operating surfaces of contacts. Erosion is usually connected to material transfer from one contact to the other what are especially expressed in contacts for direct current interruption. The grows are formed on one contact until the craters on the other under the influence of erosion and material transfer.Welding of contacts is possible at very high currents. Based on current intensity, the contacts should be divided into contacts for low loads (for current under 1 A) and contacts for higher loads, i.e. very high loads[2].It is important for first group of contacts that oxide and sulphide layers are not formed on contact surface because they increase contact resistance. There is no appearance of spark or electric arc. The used materials for those contacts are precious metals and their alloys.Electric arc and contact destruction with increase contact temperature appear at contacts for high load during interruption. Materials for those contacts should be resistant to arc effect, with high melting temperature and good thermal conductivity (to remove produced heat).
Forms of contact ends and pressure between them have a large influence on contact quality.

1.1. Materials for electric contacts obtained by the use of SM methods

Non-oxidized pure precious metals: platinum, palladium, silver, gold, and also high-melting metals: tungsten and molybdenum are used for contact for small loads.
Platinum does not oxidize in the air and does not form arc. It is used in alloys with other metals as well as iridium, for manufacturing the most precise contacts.
Palladium as contact material is very similar to platinum by its characteristics. Palladium is very often used instead of platinum because it is much more cheaper. Palladium alloys with silver are also used as contact materials.
Gold also has a tendency of arc and erosion formation so it is often used as contact material in the alloys with platinum, silver and nickel.
The care must be taken on silver tendency to arc formation when pure silver is used as contact material. Material transfer on silver contacts is lower than with platinum and gold, what is connected with silver oxidation in the air under the influence of electric discharge. Silver and copper alloys are also used as contact materials.
Tungsten is one of the most spread contact material. It is resistant to arc formation as platinum, it has high hardness and high melting temperature and it does not weld in contact operation. Disadvantage of tungsten is its oxidation in the air. Copper-tungsten-nickel and silver-tungsten-nickel alloys are used as contact materials. When molybdenum is used as contact material, the erosion is the more distinct than in tungsten. Molybdenum is also susceptible to the atmospheric corrosion.
Many materials are used for electric contacts of high loads (1A) as well as contacts of low loads, except pure platinum, palladium and gold alloys. That means, silver, silver-palladium, silver-copper, silver-cadmium, copper-cadmium and others belong to this group of contact materials. Besides metal alloys, metallic-ceramic materials are used as contact materials for various loads. Contacts of those materials are mainly used for high loads. Obtaining of this type contact materials is carried out by sintering, where pressed samples of mixture the metal powders are heated at high temperatures. Table 1 gives an overview of the application of contact materials. Metals that do not mutually form solid solutions are used as metallic-ceramic contact materials. In selection of components for metallic-ceramic contact, the following conditions have to be satisfied: one of the components has to have good electric conductivity, and the other good mechanical strength and high melting temperature regarding to the first one. Both components in operation conditions need not be mutually alloyed. Metallic-ceramic contacts, in comparison with metal contacts, have advantages in stability according to melting and welding and duration time of contacts.
For contacts of higher loads, the following metallic-ceramic compositions are use: silver-cadmium oxide, silver-nickel, silver-graphite, silver-tungsten, silver-molybdenum, silver-carbide tungsten, silver-zinc oxide, silver-cadmium-nickel, copper-tungsten, copper-graphite, and others.
Contact materials produced by sinter-metallurgy have the following characteristics:

- High resistance to arc erosion for current to approx. 100A
- Resistance to welding for high current peak during switching on to approx. 100A
- Low contact resistance
- Stability of contact resistance
- High electric and thermal conductivity
- Good mechanical characteristics
- Good machinability
- Good capability for soldering and welding

Some basic facts about contact materials are provided in Table 1.
In this paper, we used composite materials of Ag-Ni, whose properties are given in Table 2.

2. EXPERIMENTAL PART

For the needs of production the contact materials Ag-Ni, the following raw materials are used:

- silver in powder with granulometric content to10 μm produced by electrolytic method or precipitation
- nickel in powder with same granulometric content

Silver-nickel materials with contents of 10-40 wgt. % Ni are produced by the use of classic sinter-metallurgical method: pressing, sintering and extruding pressing.

Table 1. Contact material usage

BREAK SWITCHES	CURRENT INTENSITY	CONTACT MATERIALS
Relays - Low current relays - Power relays - Relays for motorcar industry * low current * blinking lights * thermal consumers * motors * lights	µA...10A 0.1A...50A 0.1....10A 1A...10A >10A >10A >50A	Au,AuAg20,Ag,Ag+AuCo0.3,AgNi0.15,AgPd30,AgPd30+AuCo0.3 Ag, AgNi0.15, AgCu3, $AgSnO_2$12, AgCdO10..15 Ag, AgNi0.15 PdCu15 AgNi0.15, AgNi10 AgNi0.15, AgNi10 $AgSnO_2$12
Break switches for household appliances	<10A ≤50A >50A	AgNi0.15, AgCu3 AgNi10....20, $AgSnO_2$2 $AgSnO_2$8..12, AgCdO10
Contact control switches	≤10A >10A	AgNi0.15 AgNi10....20
Light switches	≤20A >20A	AgNi0.15, AgCu3, AgNi10 $AgSnO_2$12, AgCdO10...15
Main switches	≤100A	AgNi10, $AgSnO_2$12, AgCdO10..15
Auxiliary switches	≤10A ≤100A	Ag, AgNi0.15, AgCu3, AgNi10 AgNi10...20
Motor switches	<10A ≤100A >100A	Ag, AgNi0.15, AgCu3 AgNi10...20, $AgSnO_2$8..12, AgCdO10 $AgSnO_2$8...14, AgCdO10...15
Motor current switches	≤50A >50A	AgC2...5, AgC AgC3...5,AgCu3, AgNi10...20
Protective switches	≤100A	AgCd4...5, AgNi20...40, AgZnO8, $AgSnO_2$12, AgW50...60, AgCd10...15
Motor protective switches	≤4A ≤25A ≥40A	AgNi10, AgZnO8, AgC3, AgC4 AgZnO8, AgC4, $AgSnO_2$12 AgC2...4, $AgSnO_2$12
Power switches *without pre-contact *with main pre-contact	≥63A 100A...250A >250A >250A	$AgSnO_2$12, AgC3, AgCdO10...15, AgZnO8 AgC4...5 AgC5 Main contact: Ag, AgNi0.15, $AgSnO_2$12, AgW50 Previous contacts: AgW70...80, CuW70...80

Table 2. Mechanical characteristics, density and electric conductivity of AgNi materials

Material	Tensile strength Rm, N/mm^2	Elongation A, %	Hardness HV 10	Density ρ, g/cm^3	Electric conductivity $m/\Omega mm^2$
AgNi10	220-400	20	50-110	10.2	50
AgNi20	280-450	15	60-120	10.0	46
AgNi30	330-530	8	80-135	9.8	41
AgNi40	370-580	6	82-150	9.7	37

Due to a fact that those pseudo-alloys have high plasticity, and only production of wire and strips is possible from them, what are necessary for manufacturing the miniature contacts, we thought that it was possible to realize this in given conditions, experimental production of AgNi wire.
Activities for this project realization were the following: selection of granulometric powder content, mixing of certain content powders, pressing, determination of thermo mechanical regime for plastic treatment, plastic processing, required analysis.
We have produced this composite such as we have mixed powders in certain ratio. Homogenized powder was pressed and sinterized due to realization certain physical-mechanical characteristics. Pressing pressure and sintering regime were also adjusted to obtain the most optimum material characteristics [3,4]. Due to increase of density, we have also done double pressing and sintering.
The obtained blanks were later plastic processed by the use of rolling and drawing. Various sizes wires were obtained in composites with good characteristics, first of all maximum density.

For the aim of obtaining the material with the most optimum characteristics, the composites of various contents were produced. The obtained results from analysis electrical conductivity and results of mechanical analysis for wire Ø3 mm (*- non-annealed; **-annealed) are presented in table 3.

Table 3. The results of mechanical tests and electroconductivity

Sample	Rm, MPa	ρ, g/cm^3	HV 10	Electric conductivity, S
AgNi14*	344.82	10.05	68	39
AgNi14**	192	9.98	51	40
AgNi40*	278.51	9.53	71	34
AgNi40**	270	10.03	59	42.57

3. CONCLUSION

- Production of electro contact materials was developed according to the original technology, AgNi 10-40 % Ni in laboratory conditions by the use of sinter metallurgy and plastic deformation processes.
- Characterization of the obtained materials was carried out.
- The obtained mechanical and electrical characteristics are approximate to those ones in world known producers of electro contact materials

4. REFERENCES

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