SOLUTIONS CONCERNING THE INCREASE OF ROLLER-TYPE SIDING CONTACT'SRELIABLENESS TO VARIABLE TRANSFORMERS AND AUTOTRANSFORMERS

Elena-Daniela OLARIU and Dorel CERNOMAZU

"Stefan cel Mare" University of Suceava

elenao@eed.usv.ro

Abstract **– This work has for an object the perfecting the system of the contact roller in the aim how much safe in operation. In first part of this paper is presented an experimental study based on the utilization the physical model of the contact roller. Through the use of the methods: magneto-active powders, of the shields with ferrofluid and the thermo-signallizer layers with the cobalt chloride, is emphasized the spectrum of the lines of flow generated by the load current and the short-circuit current established through the contact roller.**

Keywords: *contact roller, coils, autotransformer, transformer .*

1. INTRODUCTION

The frequent method used for continuously adjustable output voltage below load is the transformers an autotransformers method with continuously variation of the coils number of winding through the sliding contact. In this category are include the transformers and the autotransformers whereat the windings variable part is executed in the likeness of coil with one or many more beginnings and where is removed the winding isolation of generetrix coil. On this part made is displaced a sliding contact. .

Autotransformers with the sliding contact are used in laboratory equipments. These were used and inside of for attempts for the realization automatic systems of stabilize the voltage. Although inside of the autotransformer theory is considered as the roll come in touch only with one an coil, in practice she he gets in touch almost always with tow neighbors coil. The contact from the figure 1 presents two possible cases: a) when the contact roller is in contact with just one conductor of coil; b) when the contact roller shorting a coil of winding. In case b) in the closed circuit formed by coil shorten from roll appears a flask current produced by induced electromotive force in the coils by the magnetic alternative field flux of transformer wanders through the magnetic iron core of transformer and produces appreciable local superheating mostly in the zone of the points of contact.

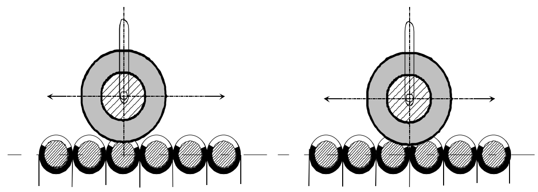

Figure: 1 Working variant of the roller-type sliding contact

a) Contact roller is in contact with just one conductor of coil; b) Contact roller shorting a coil

The continuously adjustable problem of voltage in some industrial sectors, which require the bigger adjustable powers, conducted to the mobile current tapping in the interest of an assurance a better working.

2. APPEARANCES CONCERNING THE HEAT

The heating of the contact between the roll and the winding is due to the resistance of the circuit, that is the contact resistance between the roll and the conductor, the route resistance between the contact point of the roll with the winding and the element central collector of roll and the route-closing resistance of short-circuit current in the case in which the roll shorting the extremities of coil.

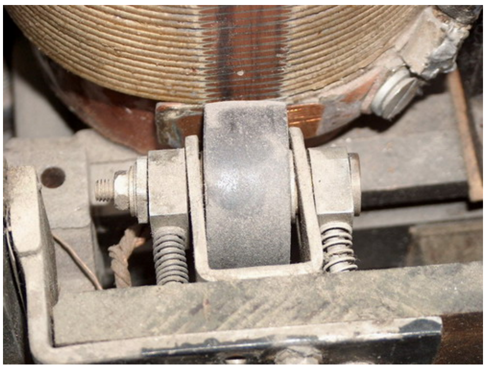

Figure 2: General view about roller-type sliding contact

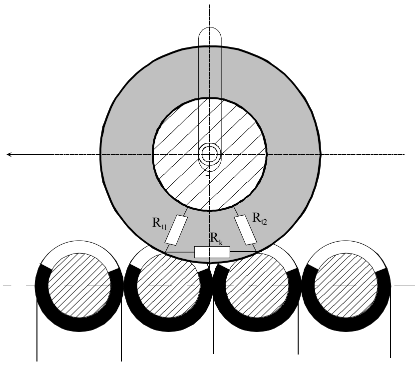

Figure 3: Explicative to the routes of currents established through roll

Analysis effectuated about the roller-type contact sliding distinguished following zones that conduct to the heat losses:

- the zone of the contact between the axle of the run system and bushed bearing of contact roller from graphite, characterized by contact resistance R_{c1}
- the zone of the contact between the contact roller and the conductor of winding, characterized by contact resistance R_{c2};
- the zone of the conductor route between two points which shorting a coil of winding, characterized by short-circuit resistance R_t;
- the zone of circuit, through the roll, between the contact point of windings conduct with roll and the contact point between the axle of the run system and bushed bearing of contact roller, characterized by transition resistance R_t .

The currents involved in the heat losses are: the load current I_s and the short-circuit current I_k .

The expression of the heat losses is:

$$p_T = p_{c1} + p_{c2} + p_t + p_k$$

where:

- $p_{c1} = R_{c1} \cdot I_s^{\,2}$ heat losses in the zone of the zone of the contact between the axle of the run system and bushed bearing of contact roller from graphite;

- $p_{c2} = R_{c2} \cdot I_s^{\,2}$ heat losses in the zone of the contact between the contact roller and the conductor of winding;

- $p_t = (R_{t1} + R_{t2}) \cdot \left(\frac{I_s}{2}\right)^2$ heat losses in zone of circuit, through the roll, between the contact point of windings conduct with roll and the contact point between the axle of the run system and bushed bearing of contact roller;

- $p_k = R_k \cdot I_k^{\,2}$ heat losses in the zone of conductor route between two points which shorting a coil of winding.

So that expression of the heat losses becomes:

$$p_T = R_{c1} I_s^{\,2} + R_{c1} I_s^{\,2} + (R_{t1} + R_{t2}) \left(\frac{I_s}{2}\right)^2 + R_k I_k^{\,2}$$

Report to first the source of heat losses in the figure 4 are presented the effects of superheating challenged of the improperly contact between the bushed bearing of the roller and the axle of the run system.Therefore the load current were obliged to is closed through the elements of the press system which in natural ways don't assist in the conduction of the load current. Is can remarked the change of color of bushed bearing pursuant to the superheating.

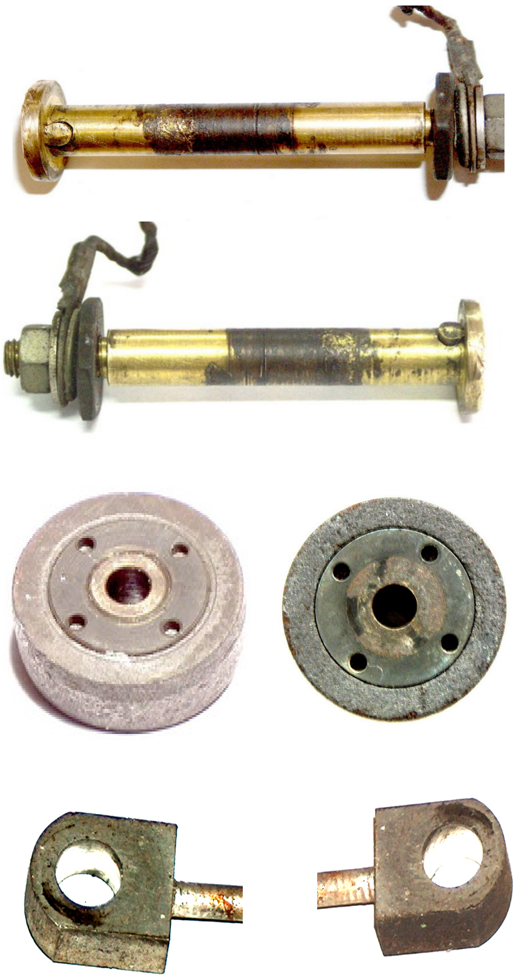

Figure 4: The effects of superheating on contact roller

3. CONTRIBUTION CONCERNING DECREASE OF THE HEAT LOSSES p_{c1} AND p_{c2}

Analysis effectuated about the roller-type sliding contact distinguished the importance of pressure force of what surfaces is touched. This force represents the topmost factor which influences the contact resistances R_{c1} and R_{c2}, fact pointed out of the evolution of the curves from figure 5.

For same appearance contact surface, the contact resistance is as much more little with how the pressure force these surfaces is bigger because of she depends the real contact surface. In the domain of little forces the increase of pressure force conduct to the suddenly decrease of transition resistance of contacts. The increases of pressure force don't produce an importance modification of the transition resistance. The curves that represent the dependency transition resistance by pressure force are generally hyperbolism primates by formal expression:

$$R_t \cdot F^m = K$$

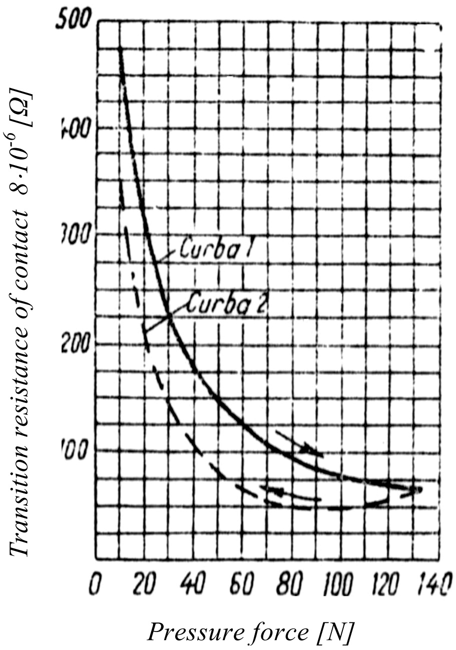

Figure 5: Dependency transition resistance by pressure force (copier from [1])

curve 1- the pressure force increase,

curve 2 –the pressure force decrease.

The values of coefficient k, obtained experimentally for different contacts are give in the table 1:

Tabel 1 (copie from [1])

The material from which is maked the contact	*K [Ω •N]*	*The state of contact surfaces*
copper- copper	$(0{,}08-0{,}14)\cdot 10^{-2}$	removed slag
copper- tinned copper	$(0{,}07-0{,}1)\cdot 10^{-2}$	removed slag
copper- tinned copper	$0{,}1 \cdot 10^{-2}$	in dry state
copper- tinned copper	$0{,}07 \cdot 10^{-2}$	oil lubricated
copper- tinned copper	$0{,}03 \cdot 10^{-2}$	in part oxidized
copper- copper (finger-type contact)	$0{,}28 \cdot 10^{-2}$	removed slag
copper- copper (brush-type contact)	$0{,}1 \cdot 10^{-2}$	removed slag
aluminum – aluminum	$0{,}127 \cdot 10^{-2}$	removed slag
aluminum - brass	$1{,}85 \cdot 10^{-2}$	removed slag
aluminum -copper	$0{,}38 \cdot 10^{-2}$	removed slag
aluminum -steel	$4{,}4 \cdot 10^{-2}$	removed slag
brass - brass	$0{,}67 \cdot 10^{-2}$	removed slag
steel - steel	$7{,}6 \cdot 10^{-2}$	removed slag
steel - copper	$3{,}1 \cdot 10^{-2}$	removed slag

The values of coefficient m, obtained experimentally for different contacts are give in the table 2:

Table2 (copie from [1])

The type of the contact	*m*
plane-plane or lamellar	1
peak-plane	0,5
sphere- plane	0,5
sphere- sphere	0,5
adaptable finger	0,5-0,65
contact of bar	0,5-0,2
tulip	0,75

In the case of the transformers and autotransformers with roller-type contact sliding, the contact conditions analyzed varied from a one contact point to other depending on the rate of wear, of the graphite roll, the state of contact surface of winding, of the rate of cleanness contact surfaces and of environment conditions. The adjustment of the pressure force depending on these conditions can be realized the solution conceived of authors of this paper an exposed in the figure 6. These solution offers the possibility check of the contact resistance between the brassy bushed bearing and the axle of the collector system with the roll, the respective zone thing present an importance source of increase of the contact temperature. The solution consist in the realization of the roller-type contact sliding equipped with a thermal detector place in the extension of the axle of contact roller. The thermal detector represents in fact an electromechanic actuator with the paraffin which to overtaking of the fusing temperature of paraffin act through of bar and of a flexible conductors, about the springs system which found the pressure force an the contact roller correlating thus the steady running conditions and contact conditions with the pressure force of the roll.

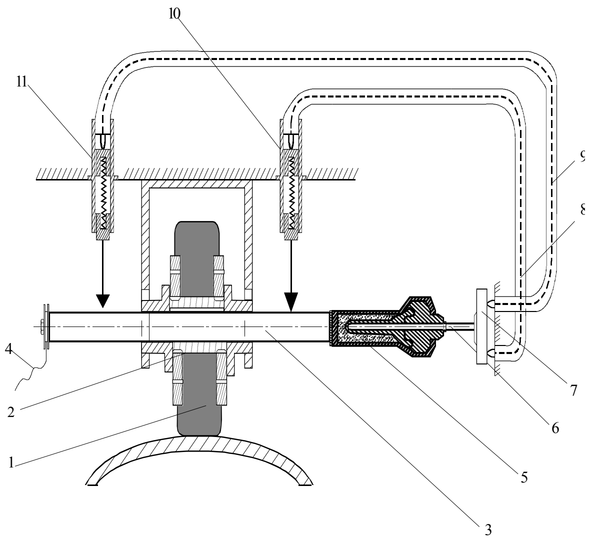

Figure 6: Automatic systems for check of the pressure force created on the contact roller

1-contact roller; 2- metallic bushed bear; 3-ax;

4- flexible cable; 5- thermal detector;

6- bar-piston; 7- taller; 8, 9- flexible cables of actuation; 10, 11- springs

4. CONTRIBUTION CONCERNING DECREASE OF THE HEAT LOSSES p_t AND p_k

The contact roller is composed from theological reason from two homogeneous, linear and isotope materials. For determined the spectrum of magnetic field established through the contact roller substituted he with a disk from rolled sheet-iron to cold. Decreased the losses p_t the authors of paper studied the possibility of geometric shape modification of the contact roller.

Reduce the loss p_t he realized through the decrease of resistance between the contact point of the conductor of the winding with the contact roller and the contact point between the axel of the run system and the bushed bear, respective resistance R_t.. Touch this objective of breadth of the contact roller just as is adequate in the figure 7.

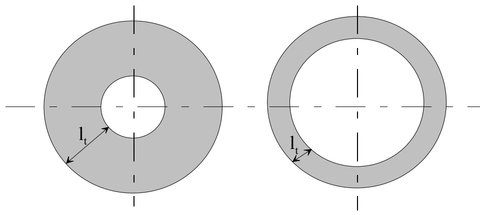

Figure 7: Geometric shape modification of the contact roller

Valorize this possibility were realized through an experimental study based on give-away the spectrum of the lines of current in the analyzed zone of the roller contact. In the mentioned aim were used-up: spectrum method of magnetic field generated of the lines of current (in the figure 8)and the thermal spectrum method generated of the lines of current (the figure 9)

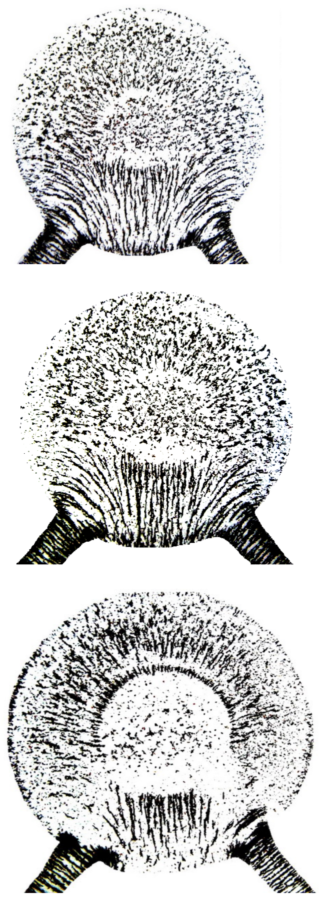

Figure 8: Spectrum method of magnetic field generated of the lines of current

Figure 9: Thermal spectrum method generated of the lines of current

Both methods showed as reduce of breadth of the contact roller just as is proper in the figure 7 affect in a low measure the spectrum of the lines of currents afferent to load current I_s (figure 10).

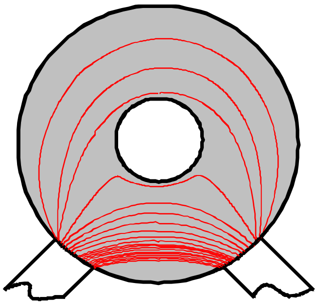

Figure 10: Spectrum of the lines of current

For the diminution of the losses p_k must interfered on short-circuit current I_k by:

- increase the electric material resistivity of the contact roller;
- increase of the impedance voltage of a transformer u_k;

Reduce of short-circuit current is achieved through the increase of electric material resistivity of the contact roller.

Dates selected in the table 3 illustrate the possibility finded out to the user within reach in the aim choose of a proper material for the contact roller.

Table 3

Material – type of contact roller		*Electric resistivity [μΩ·m]*
CDR	CDR – 4	25 –45
	CDR – 3	50 –95
	CDR - 1	60-400
BGR	BGR – 3	100 - 140
	BGR - 2	220 – 280
	BGR - 6	500 – 800
EGR	EGR –19	12 – 20
	EGR – 10	15 –28
	EGR - 5	45 - 60

A second measure for the diminution of the loss consists in the increase of the impedance voltage of a transformer u_k through the decrease of breadth of the magnetic system columns. This were theoretical proven used the expression of the short-circuit current I_k:

$$I_k = \frac{S_n}{U_n} \cdot \frac{100}{u_K},$$

where : S_n –rated output VA;
U_n – rated voltage of a transformer [V]
u_k – impedance voltage of a transformer [%]

For impedance voltage of a transformer u_k is used the expression:

$$u_k = \sqrt{u_{ka}^2 + u_{kr}^2}$$

where:

- u_{ka} active component of impedance voltage of a transformer determine with the relation:

$$u_{ka} = \frac{P_{kn}}{S_n} \cdot 100 \ [\%];$$

- u_{kr} reactive component of impedance voltage is determined with the relation:

$$u_{kr} = \frac{2\pi\mu_0 f w_1 I_1 l_m \delta' k_q}{e_1 H_B} \cdot k_R \cdot 100 \quad [\%];$$

in which :

- the equivalen width of the by-pass:

$$\delta' = a_{ij} + \frac{a_{ja} + a_{ia}}{4} + \frac{a_j + a_i}{3} \ [\text{mm}]$$

- a_{ja} and a_{ia} be the widths of the armature duct;
- the medium equivalence length of the coils of windings:

$$l_m = \pi \cdot \left[D_c + 2 \cdot a_{mj} + a_{ji} + \frac{a_i + a_{ia} + 3(a_j + a_{ja})}{2} \right] [\text{m}]$$

- H_B - the height of the windings;
- Rogowski's coefficient:

$$k_R = 1 - \frac{a_j + a_i + a_{ji}}{\pi \cdot H_B}$$

- the correlation factpr of unblances:

$$k_q = 1 + \frac{x^2 H_B}{r \delta' k_R}$$

Figure 11: Autotransformer with contact roller

a) autotransformer with high columns;

b) autotransformer with short columns

He consisted, as the reactive component of the impedance voltage of a transformer is dependency of the breadth of magnetic system columns, reason for which a solution for the diminution of heat losses is utilization of the transformers with short columns.

4. CONCLUSIONS

The servo-system with siding contact is affected of a series of losses challenged of the load current I_s and the short-circuit current I_k established on the material of the contact roller;

The load current *Is* conducts to the appearance of the next losses categories:

- heat losses to the contact between the axle of the run system and bushed bearing of contact roller from graphite(p_{c1});
- heat losses in zone of circuit, through the roll, between the contact point of windings conduct with roll and the contact point between the axle of the run system and bushed bearing of contact roller (p_t);
- heat losses to the contact between the contact roller and the conductor of winding(p_{c2});

Solutions proposed in the paper have direct objective the decrease of the loss p_{c2} trough the pressure force on the contact roller and the diminution of loss p_t through the diminution of the breadth of contact roller.

The short-circuit current I_k conducts to appearance of the short-circuit losses p_k. Solutions for the diminution of this losses are::

- selection of a material for the contact roller with great resistivity;
- decrease of short-circuit current through the increase of the impedance voltage of a transformer; in the aim showed is proposed the solutions of transformer and autotransformer with short columns.

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