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EXPERIMENTAL CONTRIBUTIONS REGARDING THE INFLUENCE OF PRESSURE ON THE ELECTRIC PARAMETERS FOR SLIDING ELECTRIC CONTACTS

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Abstract. *The performed study contributes to the optimization of some functional aspects of sliding electric contacts, by means of a program of experimental proofing, to achieve a working improvement, from tribological and electrical point of view. Achieving this task has necessitate the design and construction of proofing stands, equipped for measuring operations and automated processing of information, for adjustment and control of the main parameters that intervene under these circumstances in working conditions. The experimental equipment has been conceived, to cover the entire value field, according to the program established for the main parameters: the interaction force on the contact level, implicit the medium pressure, the relative velocity (controlled in a very wide field of values), the electric sliding contact solicitation, by modifying widely the current density.*

1. INTRODUCTION

The advantages of constructive simplicity, the safe functioning, the facile sustenance and the relative low cost represent solid arguments for the implementation of sliding electric contacts in many applications, based on the energy transfer or the information carrying signal transfer.

The brush works within a range of mechanical and electrical loads. Therefore the assembly and the material are most important. The sliding contact voltage drop forms a resistance to the passage of commutation currents. The voltage drop depends basically on the applied pressure, the speed, the brush material, the contact surfaces, the current density and the temperature. Even if the brush materials have physical-mechanical properties, that have a wide range of values (such as the electric resistivity $\rho_e \in [0.1 \div 200]$ μΩ.m, the density $\rho \in [1,18 \div 7,7]$ kg/dm^3 or the hardness HB$\in$[10/20-60÷10/100-100]), the functional parameters have a narrow range of values. That's why the admissible current density varies on at most j ϵ (0,1÷0,2) A/mm^2, the medium pressure

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brush-ring varies on to $p_{med} \in [15 \div 40]$ kPa and the relative velocity exceeds exceptionally the limit values of $v \in [30 \div 40]$ m/s. Significant is that the voltage drop on the sliding contact has a relatively narrow range of values: $\Delta U \in [0,2 \div 1,5(2)]$ V.

The technical literature does not offer systematically studies on sliding electric contacts, on account of the preservation of some research results. Most information have general character and are described in prospects of producing companies, where constructive solutions are presented, followed by advices, related to a correct exploitation of sliding contacts. The offers are based on selected data, regarding physical-mechanical, tribological and chemical properties of the used materials for brushes and rings [3], [4]. These recommendations have general character, because they are relegated to a immovable value of the contact pressure, to a utmost value of the current density, to a limit of the working relative velocity, as well as to the maximal temperature value, which must not be exceeded by the contact components, regardless of the transmitted current density, of the peculiarities of the working surrounding and other influencing factors.

For the purpose of solving some of those problems enumerated below, the experimental program proposes the basic task of analyzing with priority the behavior of sliding electric contacts, consisting of common brushes used on contacts of generators and electric motors, working also in automotive construction and other automated equipments.

2. EXPERIMENTAL RESEARCH OBJECTIVES

The analyze of the main factors that influence the passing electric resistance of sliding electric contacts necessitate the conception of a vide systematic testing program. The designed and conceived equipment permitted the modification, adjustment and measuring of kinematical, mechanical and electrical parameters that intervene under testing conditions, for a most truthful simulation of real working conditions. The experiments were based on stabile control and adjustment methods, on means and measuring methods, registration and information processing, with performing programs and PC equipment, which ensured a very high investigation precision [2].

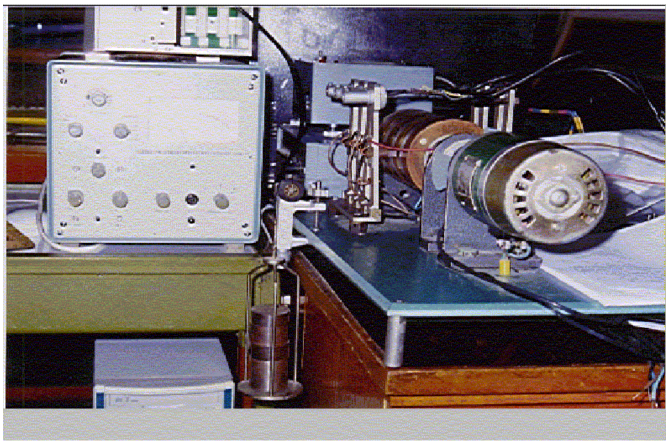


Fig. 1. Gauging assembly of the tensometric dynamometric transducer

3. GAUGING OF DYNAMOMETERS, BELONGING TO THE PROOFING STAND AND MEASURING OF INTERACTION FORCE BRUSH - RING

The gauging of the four tensometric dynamometers, coupled to the measuring bridge has been made with calibrated weights, applied on the plate of the gauging equipment, presented in fig.1. For an increased precision, the gauging system has been charged with successive loading and discharging. The variation area of the loading force has been accepted in a manner, that through the gauging of the measuring system can make several proofing for contact pressures, that exceed (2÷2,5) times the usual values. An important issue was the achievement of results under working simulation circumstances, with low values of medium contact pressure, to analyze the behavior of sliding contacts outside the recommended limits of the working regimes.

The pair of identical brushes was positioned diametrical opposite in outlying contact with the ring. To create similar conditions to the signal input and to the signal output of the sliding contact, the main imposed condition is, that the interaction forces, respectively the medium pressures applied to both contacts should be equal. The interaction force has been created by a screw mechanism and the pressure transmission has been made by using a compressing spring, which permitted a fine adjustment and a reduced variation of the pressure value.

The pressure measurement was made by means of a tensometric resistive method. The electric measuring scheme is in half - bridge construction, with an active transducer, running lengthwise on the spangle, made of spring steel and the temperature compensation transducer is glued transversal on the same spangle. The amplification factor of the assembly is in this case $1+\upsilon$ (Poisson factor υ =1,3).

4. RESEARCH METHODS

The behavior investigation of sliding electric contacts supposes the modification possibility of:

– the pressure p. The force or contact pressure control is made with the help of the dynamometric transducer, which consists of the preformed curved gilled spring, with two tensometric marks of 120 Ohm, produced by the German Company Hottinger Baldwin Messtechnik. The gauging operation of the dynamometer was presented above (Fig.1). After the gauging operation, the applied force and pressure on the sliding electric contact must be continuously modified and measured. The charging system can develop the value of the force of [0÷12,8] N, respectively a medium pressure of [0÷0,2] MPa. The investigation can be extended also for the study of the behavior under special tough conditions, regarding contact loadings, because of the limit upper values that exceed [5÷6] times the usual average working values. The average contact pressure has preestablished values of 10, 20, 30 and 40 kPa, obtained through the charging system (charging screw), assisted by gauging dynamometric transducers. The proofing tests have marked out that at lower values than 10 kPa of the pressure, the sliding electric contact becomes insecure, because of the very high variations of the ohm resistance and at values upper than 40 kPa, the contact resistance decreases insignificantly, but the wearing out increases a lot.

– the current density j. The measuring of the contact resistance is made indirect by means of referencing the voltage to the current intensity of the sliding contact. The measuring of the parameters voltage – current is insured by electronic measuring equipment and the computerized equipment registers the information. The current density results as a ratio of the current intensity, referred to the contact area (practically the brush area). The modification of the current density is obtained by two means:

- the source voltage is modified when a constant load resistance is fixed on to the switch of the output powermeter or
- through a modification of the value of the output powermeter load resistance or of the value change using resistance decades, in case of constant AC or DC voltage feeding (at 50 Hz, respectively 5 kHz). This electric scheme assures the current density increase up to $2 \cdot 10^6$ A/m^2 , value that exceeds up to [5÷15] times the normal working current density values. The current density has been modified stepwise, reaching a maximal value of 0,1875 A/mm^2 . This has been achieved by changing of the load value in the circuit in which the ring and two brushes were inseried (one current input brush and the other current output brush). The feeding has been made in circumstances of constant DC voltage of 12 V. In this case is used as the source a stabilized stepwise adjustable redresser or an automotive 12 V DC accumulator (with I_{max} = 210 A and capacity of 44 Ah). The preestablished current densities have been achieved by an appropriate modification and by the measurement of the current intensity, considering the effective contact area brush - ring.

5. MEASURING AND ANALYZE OF THE VOLTAGE DROP ON SLIDING ELECTRIC CONTACTS

The analyze of the graphic data dependence of the measuring notice, marks out that regardless the value of the force or medium contact pressure, the voltage drop on the conjunction of the sliding contact increases with the augmentation of the current density through the couple of the sliding contact. For predefined values of the relative velocity and current density, the voltage drop decreases always, when the average contact pressure increases. A favorable influence is observed until a certain limit, determined by the energy loss process and by the increase of the current density. The temperature of the brush increases with the augmentation of the contact pressure at constant current density (Fig. 2).

The specific wear depends on the mechanical losses (caused by the friction factor, the applied pressure and the speed) and on the electrical losses (caused by the voltage drop and by the current density) (Fig. 3).

The eq. (1) expresses the specific wear p^*:

$$p^* = f \cdot p \cdot v + j \cdot \Delta U \qquad (1)$$

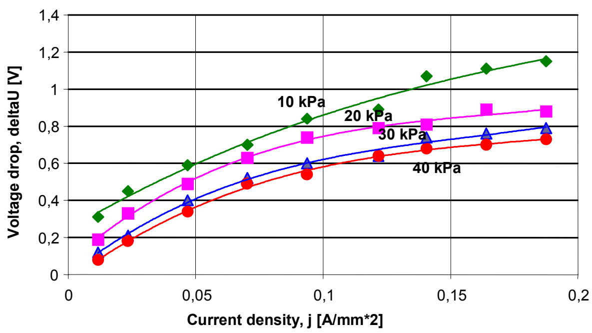
f – represents the friction factor, p – the contact pressure (as average value), v – the relative velocity brush - ring, j – the brush current density, ΔU – the voltage drop on one sliding contact.

6. CONCLUSIONS

The suitable pressure results as a compromise from electrical and mechanical considerations, sufficient to ensure a continuous contact brush – slip ring. The break of this contact may cause sparking and damage of the contact surfaces. With increased pressure rise the temperature and wear and decreases the voltage drop (for example ΔU decreases by 30% with an increase of the pressure from 15 to 55 kPa).

The high precision measurement operations are determined by the used tensometric transducers (interaction force measurement). The digital transducers were used for measuring current and voltage drop values. The performant Virtual Bench equipment, produced by the National Instruments company, based on a Multichannel Soft Data Logger offered the necessary imposed precision. The main conclusion of the experimental research is that a correct functionning of sliding contacts takes place only if the averige contact pressure is chosen as an optimal value $p_{optim} \in [p_{min} \div p_{max}]$. At lower values increases the contact resistance, respectively the voltage drop.

VOLTAGE DROP AND CURRENT IN FUNCTION OF THE PRESSURE DENSITY



METAL-GRAPHITE COLLECTOR BRUSHES "ROFEP URZICENI" ROMANIA STR 1570/1/7-89
Cu Sn 10 ring, dimensions: diameter / width 96 /10 mm; brushes, dimensions: 8x8x16 mm
Contact pressure: case a) 10 kPa, b) 20 kPa, c) 30 kPa, d) 40 kPa
Maximal brush temperature: case a) 47 ˚C, b) 59 ˚C, c) 68 ˚C, d) 74 ˚C
Velocity: 5 m/s (104 rad/s)

	Medium processed values				
Current density	Voltage drop ΔU [V]				Current intensity
j [A/mm^2]	a.) 10 [kPa]	b.) 20 [kPa]	c.) 30 [kPa]	d.) 40 [kPa]	I [A]
0.011718	0.31	0.19	0.12	0.08	0.75
0.023437	0.45	0.33	0.21	0.18	1.5
0.046875	0.59	0.49	0.4	0.34	3
0.070312	0.7	0.63	0.52	0.49	4.5
0.09375	0.84	0.74	0.6	0.54	6
0.121719	0.89	0.79	0.64	0.64	7.5
0.140625	1.07	0.81	0.74	0.68	9
0.164062	1.11	0.89	0.76	0.7	10.5
0.1875	1.15	0.88	0.79	0.73	12

Fig. 2. Voltage drop on the sliding contact on the velocity of 5 m/s

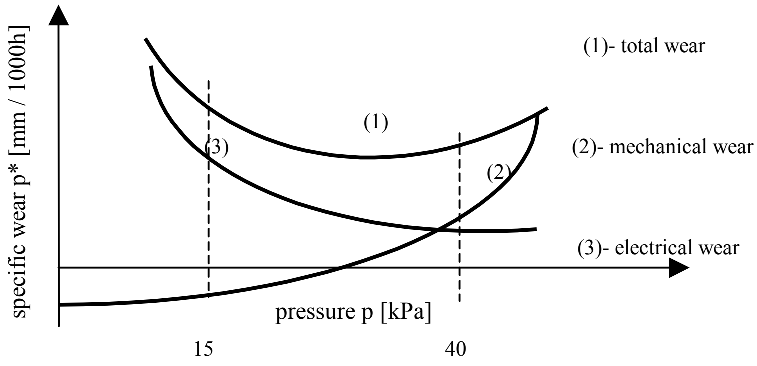


Fig. 3. The influence of the mechanical and electrical losses on the specific wear

If the contact pressure exceedes the maximal prescibed value, the functionning remaines from electrical point of view favourable but dangerous from tribologic – mechanical point of view. The inadmissible increasing of the active surface wear out and the rising temperature by overheating can damage the isolation of electric wires.

As a consequence, in correlation to the value of the current density, to limit the wear out process in case of very high velocity, the optimal values of the pressure can be chosen from the admissible inferior limit of the pressure values. At lower speed values, the pressure can be maintained to the upper limit of the admissible pressure values. The research results emphasized that in case of metal- graphite / bronze brushes, the rapport of admissible limit pressure values is approximatively four, that means that the pressure value adjustment intervall is large enough, to reach increased working safety and durability of the sliding electric contact, by the correct establishment of the tension regime [2].

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EKSPERIMENTALNI DOPRINOSI O UTICAJU PRITISKA NA ELEKTRIČNE PARAMETRE KLIZEĆIH ELEKTROKONTAKTA

Anca Popa, Rodica Militaru

Ovaj rad doprinosi optimizaciji nekih funkcionalnih aspekata kliznih električnih kontakta, pomoću eksperimentalnog istraživanja kako bi se ostvarilo funkcionalno poboljšanje sa tribološkog i električnog aspekta. Da bi se ostvario ovaj zadatak neophodna je izgradnja ispitnih štandova opremljenih za merenja i automatsku obradu podataka, za podešavanje i upravljanje glavnim parametrima koji utiču na radne uslove. Eksperimentalna oprema je dizajnirana tako da pokrije cele merne opsege glavnih procesnih parametara: sila interakcije na kontaktu, implicitni pritisak medijuma, relativna brzina itd.