

# INFLUENCE OF LUBRICATED SLIDING COUPLE STRUCTURAL MATERIAL TYPE ON GENERATED POTENTIAL DIFFERENCE VALUE

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## Abstract

In earlier investigations it found that in lubricated sliding couples is generated electrical potential difference (GPD). The sensitivity of this tribological index and information quantity contained in it far exceeds than previously used (classical) indicators, like coefficient of friction or temperature. Previous investigations do not allow to draw generalizing conclusions, how the force of the tribological parameters affect the GPD signal value. Selected materials of samples and counter-sample were grouped in pairs, forming various combinations I - the same name materials couple, in which the sample and counter-sample were made of the same material; II - the various name materials couple, in change places pairs, in which the two different materials interchangeably in one case are the samples and the second - counter-samples; III - the various name materials couple, in change places pairs, in which the sample from one material was mated with counter-samples from different materials. The testing materials were selected associations represented by a series of metal lying in the Volta electropotential (galvanic) series, both relatively close to each other, as well as a considerable distance and some of the same metal alloys. In presented investigations it was state that there was no clear relationship between the recorded GPD signal effective potential value and the values of the electropotential (galvanic) series. The GPD signal value is individual feature of the each couple and depends on the type of construction materials each pairs of elements forming the each couple. The GPD signal value is lower for the same name materials couple, in which the sample and counter-sample were made of the same material, than for various materials couple. It was found that in the various name materials couple, in which the two different materials interchangeably in one case are the samples and the second - counter-samples, GPD signal value is different.

**Keywords:** tribology, indexes of tribological process course, generated potential difference, wear, structure of superficial layer

## 1. Introduction

Trend of machine construction evolution progress in direction continuous growth of mating elements load enforces the use of new materials for elements or the formation of the respective properties of these elements surface layers. Therefore required is a precise analysis of the tribological process, taking place between couple elements.

In lubricated sliding couple there is generated electric potential difference (GPD). The sensitivity of this tribological index and information quantity contained in it far exceeds than previously used (classical) indicators, like coefficient of friction or temperature. It was also found to achieve a sensitivity limit of the wear assessment methods, which is the measurement of weight loss of mated elements. In such cases it is possible to assess the mating based on the analysis of tribological process index, which is the GPD signal [7, 8, 9].

Analysis of changes in the value of the effective potential of generated potential difference GRP during mating, can estimate the time  $T_g$  from start-up to the beginning of the formation of lubricating wedge, i.e. the time indicating how long it took the elements mating under conditions of boundary friction, estimate the time  $T_s$  – says about stabilization tribological processes in

frictional contact (running-in process was finished) and estimate the time  $T_{max}$  indicating about that the intensity changes in the friction couple [2, 3, 4, 5, 6].

It was also found that the value of the recorded GPD signal depends not only on the parameters of the tribological force, such as unit pressure, the relative movement velocity, lubricant properties, but also on the physicochemical properties of elements surface layers, such as the material type or its structure.

Previous investigations do not allow to draw generalizing conclusions, how the force of the tribological parameters affect the GPD signal value [6]. Therefore, an attempt to determine the effects of elements construction material type of the generated GPD signal.

## 2. Object and and research range

Tribological researches were performed on KRWAT-1 stand, performing friction in the rotary motion. View of research couple elements are shown in Fig. 1. Geometric shapes and dimensions of samples (1) and counter-samples (2) reflect the typical association journal – slide bearing. The dimensions of counter-sample, which is a sector of slide bearing, ensures the adopted research conditions [1, 2, 7, 8] to obtain the lubricating wedge. The relative motion velocity of elements mating was 4,12 m/s (1000 rpm), mean unit pressure were 1.5 MPa. The GPD signal value was recorded by the measurement system, described in the works [1, 7].

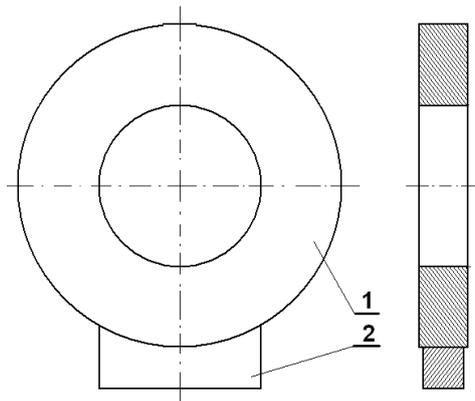


Fig. 1. The geometry of tested couple elements: 1 – sample, 2 – counter-sample

The lubrication of couple elements took place by drop-wick lubrication by synthetic engine oil. The duration of the test was 180 min. At that time, for assumed force parameters, obtained a guaranteed period of stabilized mating (GPD signal effective potential value), i.e. running-in process was finished [1, 7, 8].

The testing materials were selected associations represented by a series of metal lying in the Volta electropotential (galvanic) series, both relatively close to each other, as well as a considerable distance (Tab. 1) and some of the same metal alloys.

Table 1. Electropotential (galvanic) series and electron work functions

No.	Metal	Electropotential (galvanic) series [V]	Electron work functions [eV]
1.	Al	-1,66	4,28
2.	Cr	-0,71	4,5
3.	Fe	-0,44	4,7
4.	Cu	+0,37	4,65

Selected materials of samples and counter-sample were grouped in pairs, forming various combinations (Tab. 2):

I - the same name materials couple, in which the sample and counter-sample were made of the same material;

II - the various name materials couple, in change places pairs, in which the two different materials interchangeably in one case are the samples and the second - counter-samples;

III - the various name materials couple, in change places pairs, in which the sample from one material was mated with counter-samples from different materials.

Table 2. Investigated couple type

Couple type	Sample	Counter-sample
I	Al	Al
	Cu	Cu
	Cr	Cr
	45 steel	45 steel
	grey cast iron ZI200	grey cast iron ZI200
II	Al	Cu
	Cu	Al
	Al	45 steel
	45 steel	Al
III	45 steel	Cu
	45 steel	grey cast iron ZI200
	grey cast iron ZI200	Cu
	grey cast iron ZI200	Cr

### 3. Research results

Mean value of generated potential difference for the same name materials couple type I, in which the sample and counter-sample were made of the same material, are shown in Fig. 2.

The maximum  $U_{max}$  of GPD signal value as well as maximum stabilized  $U_s$  of GPD signal value showed ZI200-ZI200 couple. Significantly lower  $U_{max}$  i  $U_s$  of GPD signal value showed 45-45 i Cu-Cu couples. The lowest value stated for Cu-Cu i Al-Al couples.

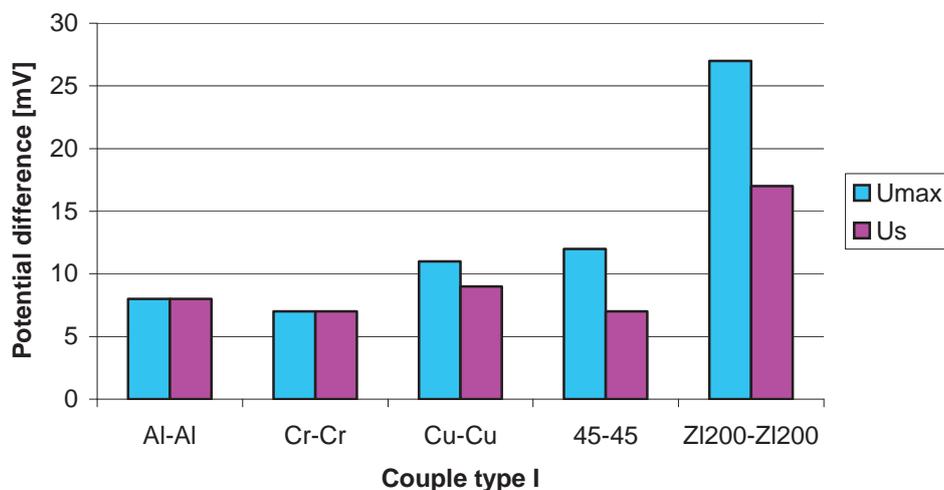


Fig. 2. Mean value of generated potential difference  $U_{max}$  and  $U_s$  for the same name materials couple type I

You can not to determine a clear relationship between the recorded GPD signal values and the values of electropotential (galvanic) series potentials of metals. Couples of metals with high potential (Al-Al, Cr-Cr) showed the lowest GPD values, but couple of metals with a relatively low absolute value of the potential (Cu-Cu) and iron-based alloys (45-45 i ZI200-ZI200) showed the lowest values showed the highest values.

You may also be noted that for 45-45, ZI200-ZI200 and Cu-Cu couple stabilized  $U_s$  of GPD signal value is lower than the maximum value of  $U_{max}$ . According to [7], it can say about high surface activity of the lubricant, intensely formative a new surface layer of mated couple elements, adequate for the assumed parameters to force.

For the Al-Al and Cr-Cr couple reached the maximum value  $U_{max}$  is also a stabled value  $U_s$ . This may mean that that in couple there is a continuous process of the new surface layer formation.

In the case of Al-Al and Cr-Cr couple it may be associated with the permanent restoration of oxides on the surface friction, because both Al and Cr actively react with atmospheric oxygen, undergoing passivation. Also Cr is relatively poorly wettable by the lubricant.

Mean value of generated potential difference  $U_{max}$  and  $U_s$  for the various name materials couple, in change places pairs, in which the two different materials interchangeably in one case are the samples and the second - counter-samples, are shown in Fig. 3.

It may be noted that both Al-Cu and Cu-Al couple and both Al-45 and 45-Al couple shown different  $U_{max}$  and  $U_s$  values, depending on which of the materials is the sample and which – the counter-sample.

The Cu-Al couple showed a higher maximum value  $U_{max}$  and higher maximum value  $U_s$  than change places Al-Cu couple. Analogously Al-45 couple showed a higher maximum value  $U_{max}$  and higher maximum value  $U_s$  than 45-Al couple. At the same time the Al-45 couple showed the higher difference between the values of  $U_{max}$  and  $U_s$ . It may be noted that in Al-Cu, Cu-Al and 45-Al couples reached the maximum value  $U_{max}$  are simultaneously practically stabilized values  $U_s$ .

You may also be noted that despite greater difference in the electrochemical series of potentials between Al and Cu than Al and Fe, generated potential difference  $U_{max}$  and  $U_s$  value were lower for Al-Cu couple than for Al-45 couple. In turn, for Cu-Al couple were higher than for 45-Al couple.

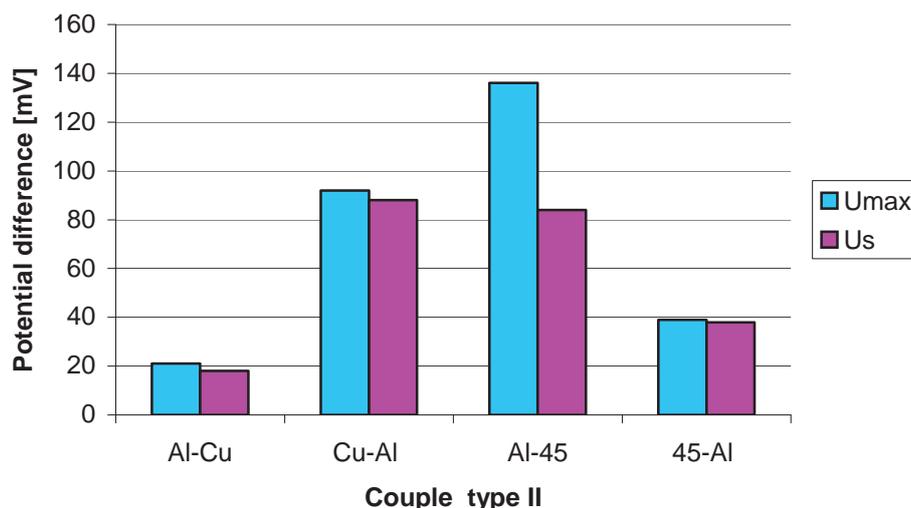
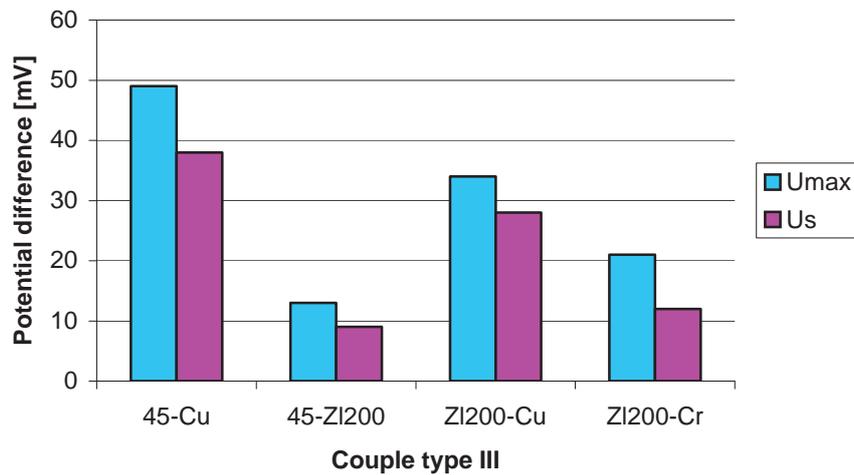


Fig. 3. Mean value of generated potential difference  $U_{max}$  and  $U_s$  for various materials couple type II

Stated relevant differences in the recorded GPD signal values for the same pairs of metals are probably as results of different mating conditions of surface friction. In the case of counter-sample,

all of its friction surface is constantly in contact with the surface friction of the sample and surface-active lubricant additives. But the sample friction surface contact with the counter-sample friction surface is temporary and variable over time. This surface only in a very short time remains in contact with the counter-sample friction surface, for a longer period of mating becoming into contact with atmospheric oxygen.

Mean value of generated potential difference  $U_{max}$  and  $U_s$  for the various name materials couple, in change places pairs, in which the sample from one material was mated with counter-samples from different materials, are shown in Fig. 4.



*Fig. 4. Mean value of generated potential difference  $U_{max}$  and  $U_s$  for various materials couple type III*

It can be concluded that for 45-Cu, 45-ZI200, ZI200-Cu and ZI200-Cr couples stabilized GPD signal effective potential  $U_s$  value is lower than the maximum  $U_{max}$  value. Undoubtedly, this confirms the fact that the lubricant surface activity in respect of such materials as 45 steel, grey ironcast ZI200 or Cu.

The maximum  $U_{max}$  and  $U_s$  of GPD signal value was found for 45-Cu and ZI200-Cu couples, some what lower for ZI200-Cr couple. The lowest  $U_{max}$  and  $U_s$  values was found for 45-ZI200 couple. This may indicate a high similarity of physicochemical properties of 45 steel and grey cast iron ZI200 and confirm the surface activity of the lubricant in respect of these materials.

#### 4. Conclusion

1. There was no clear relationship between the recorded GPD signal effective potential value and the values of the Electropotential (galvanic) series.
2. The GPD signal value is individual feature of the each couple and depends on the type of construction materials each pairs of elements forming the each couple.
3. The GPD signal value is lower for the same name materials couple, in which the sample and counter-sample were made of the same material, than for various materials couple.
4. It was found that in the various name materials couple, in which the two different materials interchangeably in one case are the samples and the second - counter-samples, GPD signal value is different.

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