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# MSM 2011

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## MECHATRONIC SYSTEMS AND MATERIALS

### ABSTRACTS

7-9 July, Kaunas

**7<sup>th</sup> International Conference**

**MECHATRONIC SYSTEMS AND MATERIALS**

**MSM 2011**

**ABSTRACTS**

**7 – 9 JULY 2011  
KAUNAS (LITHUANIA)**

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## PREFACE

In October 2005, the 1<sup>st</sup> International Conference Mechatronic Systems and Materials (MSM) was held in Vilnius, Lithuania. The successful first conference developed into the annual scientific event. Vilnius Gediminas Technical University, Kaunas University of Technology, Opole University of Technology and Białystok Technical University are the organizers and hosts of the MSM conferences arranged in a different city each year:

- 2005, Vilnius, Lithuania, (1<sup>st</sup>);
- 2006, Cracow, Poland, (2<sup>nd</sup>);
- 2007, Kaunas, Lithuania, (3<sup>rd</sup>);
- 2008, Białystok, Poland, (4<sup>th</sup>);
- 2009, Vilnius, Lithuania, (5<sup>th</sup>);
- 2010, Opole, Poland, (6<sup>th</sup>);
- 2011, Kaunas, Lithuania, (7<sup>th</sup>).

## AIM OF THE CONFERENCE

The aim of the conference is to provide an opportunity to share information and facilitate co-operation in mechatronics and new materials and dissemination of current research results in this multidisciplinary field.

## CONFERENCE VENUE

### City of Kaunas

MSM 2011 is organized in Kaunas. Kaunas with nearly 350 000 inhabitants is one of the most significant cities of Lithuania. It is not only a city of old traditions, but also large centre of business and industry. It can also claim to be a city of young people with over 39,000 students studying at 5 state universities. Hundreds of years of cultural heritage are preserved in the historical and architectural monuments, museums, theatres, art galleries and churches of Kaunas.

### Kaunas University of Technology

Kaunas University of Technology is the largest technological University in the Baltic States. The University shares the best traditions of classical Universities, offering almost all fields of technological studies and research. The Social and Physical Sciences are being particularly emphasized at the University, as a modern University graduate is expected to bear much more beyond the knowledge of his profession. Meanwhile the studies and research in the fields of Humanities and Biomedicine, as well as in the interdisciplinary fields, recently have been very successfully launched. New study programmes in Mechatronics, Sport Engineering, Musical Engineering, and Biomedical Engineering appeared to be very popular among the students.

## ABOUT MSM 2011

The Program Committee of MSM 2011 has accepted 146 papers by authors coming from 15 countries. We would like to express our gratitude to the Scientific Editorial Committee members and reviewers for discussing and reviewing the papers, as well as for their contribution to the quality and success of the Conference.

Selected papers will be proposed for publication in a special issues of the International Journals: "*Journal of Vibroengineering*", "*Elektronika ir elektrotechnika (Electronics and Electrical Engineering)*", "*Mechanika*" and in other scientific journals of the Kaunas University of Technology.

Presentations will be discussed in the following sections:

- i. Mechatronic Systems;
- ii. Materials (properties, modeling, manufacturing and processing);
- iii. Education in the Fields of Mechatronic and Material Science.

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## Investigation of wear of pneumatic elements in mechatronic systems

**Keywords:** pneumatic element, friction pair, friction coefficient

This paper is devoted to solving problems related to calculation of friction coefficient in friction pair of pneumatic elements in mechatronic systems, by taking into account adhesion forces and verification of theoretical expressions with experimental results.

The most important factor, which influences the wear behaviour of these friction pairs, is surface roughness of friction surfaces. A theoretical calculation of friction coefficient allows us to find the optimal surface roughness parameters, which will suite the requirements of service life of pneumatic cylinders used in factory automation applications.

### Components of friction force

In this article we present our approach to friction force investigation in relation to surface roughness. We first discuss components of friction force, where we indicate points, where these components can appear in pneumatic elements. Later we show some results of our tests, where we simulated different surfaces roughness influence on wear rate. The aim of this work is to achieve more precise wear rate calculations.

There are a lot of researches regarding adhesion force, where adhesion forces is calculated like mentioned below:

$$F_{ad} = F_c + F_w + F_{es}. \quad (3)$$

As we can see from Eq.(3), adhesion forces consist from three major components, capillary, van der Waals and electrostatic. During research of pneumatic elements, we can point out sources of these forces.

Capillary force usually occurs in humid environments. In Eq.(4) you can see approximate calculation of capillary force. As we can see from formula there are some parameters, which can be influenced by surface roughness.

$$F_c = \pi \cdot \gamma \cdot a \cdot \left( -\sin \alpha + \frac{\cos(\Theta_1 + \alpha) + \cos \Theta_2}{\frac{h}{a} + 1 - \cos \alpha} \cdot \sin^2 \alpha \right). \quad (4)$$

So if we speak about capillary forces in pneumatics, then there are usually two causes of these capillary forces, firstly like it's mentioned about from humidity, mainly in compressed air, and secondly from greases, which are used for lubrication of pneumatic elements. Both sources are persistent almost in all pneumatic systems, but it doesn't mean that we can't avoid them at all. Against humidity in air, we can use appropriate compressed air preparation units. There are more issues regarding lubrication, because without lubrication, friction pair will be influenced by dry friction, but there are some industries where we can't use any greases (like food, pharmacy industries). Nowadays this issue can be solved by using materials which do not requires lubrication, its mean that these materials can have the same service life, like conventional materials.

Van der Waals forces are caused by attractions between molecules, surfaces and atoms in friction pairs.

$$F_{vdw} = \frac{H \cdot d_s}{12 \cdot Z_0^2}. \quad (5)$$

As we can see from Eq.(5), van der Waals forces are greatly influenced by distance  $z_0$  between surfaces, so if we can calculate the optimum distance, which is depend from surface roughness, then we can lower effect of this force. Again, if we look from pneumatic point of view, these forces occur

when different parts of pneumatic elements come into close contact. There already are a lot of researches [1 - 4] on this topic, so there are a lot of theories, but some of them are against each other.

Electrostatic forces [1] may occur, if pneumatic elements are used in areas which are surrounded by intense electrostatic fields, or due to inappropriate selection of friction materials.

$$F_{es} = k \cdot \frac{|q_1| \cdot |q_2|}{s \cdot r^2}. \quad (6)$$

This component, which is shown in Eq.(6), is hard to be calculated, so we can use only approximate estimations of this component. There is a possibility to use probability theories, where we can calculate amount of electric charges on peaks of surface roughnesses.

All above mention components of adhesion force are dependent not only from material, but also from physical parameters of elements, like surface roughness. During research we found out that by using surface roughness parameters, we can more precisely determine friction forces, and thus also a wear rate. By combining our previous researches and theories, together with researches in adhesion forces, we can now more precisely calculate wear rate, and thus determine potential service life of pneumatic elements.

### Experimental analysis

To verify our proposed wear rate calculation formulas and to insure, that it's possible to calculate friction force in relation to surface roughness parameters, there were started a practical experiments for analysis of wear in pneumatic elements. Idea of experiment is to check how wear rate is changing under the same physical conditions (same load, same temperature of environment etc.), but with different surface roughness of one friction pair material (in this case pneumatic seal). Investigation will be continued in order to get more precise dependencies which describe the wear of pneumatic elements in mechatronics systems.

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