OVERVIEW OF RECENT DISSERTATIONS IN THE FIELD IN FINLAND

How Road's Roughness Affect Tyre/Road Friction?

The research on tyre/road friction is of huge importance due to its direct link to the road safety. The roughness of the road surface plays a major role in the tyre/road friction. In this dissertation, laboratory and field experiments along with the comparison of the experiments with theory predictions were utilised to advance the current understanding about surface roughness impacts on tyre rubber friction.

By monitoring the friction and the roughness of Finnish roads for nine months, it was shown that traditional surface roughness characterisations cannot narrate the actual link that exists between road roughness and friction. However, when surface roughness was characterised at multi-scale and only on the top portion of the road surface profile (where tyre meets the road), a strong correlation was achieved between friction and road roughness. Therefore, road surface roughness analysis for tyre/road friction must be carried out only on the relevant portion of the surface roughness profile.

A big challenge in rubber friction experiments is the reproducibility of the measurements itself, since the surface roughness of the roads are constantly changing during the sliding friction experiments. In this research work, for the first time, the application of 3D printing technology in tyre/road friction studies was introduced. This technology is a powerful tool for creating customised and reproducible surfaces for controlled laboratory rubber friction experiments. With the aid of a high resolution 3D-printer, hard polymer blocks were printed that looked like the surface of road surfaces. By controlling the surface roughness of these prints, polymer blocks with different stone size (macro-roughness) on their surfaces were produced.

Laboratory tyre rubber friction experiments on these surfaces, for the first time, have shown that increasing the size of the stones tend to decrease tyre rubber friction. The results open the path for controlled studies about the surface roughness impacts on tyre rubber friction. In the future, it is desirable that an optimum road surface roughness would be achieved for tyre/road friction, rolling resistance, noise, wear, etc.

The public examination of the doctoral dissertation of **Mona Mahboob Kanafi**, M.Sc. (Eng.), *Rocky road – surface roughness impacts on rubber friction,* was held on 7 April 2017 at the Aalto University School of Engineering.

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Proper consideration of fretting fatigue will increase the lifetime of machines

The reason for machine failure is often fatigue. Fretting fatigue that may occur in connected parts is a particularly harmful failure mechanism and can significantly decrease the lifetime of machines.

Machine components are joined together using, for example, bolted joints and interference fits. The connected parts should not have any movement relative to each other. However, due to dynamic loadings and vibration, very small-amplitude relative movement may develop between the joined components. High local stresses can be developed, which can lead to fatigue cracking. In his doctoral dissertation, MSc **Janne Juoksukangas** studied fretting fatigue in press fits and bolted contacts.

“Nowadays the trend is to increase power density while building lighter and more energy efficient machines. This sets challenges to machine durability. Better understanding and consideration of fretting fatigue will increase the reliability of machines”, Juoksukangas explains and continues:

“Taking fretting into consideration at the design stage of machine components can be difficult as the phenomenon is not fully understood and many aspects and parameters affect it. However, using modern modelling and measurement tools, the control of fretting fatigue can be improved and the lifetime of machines increased.”

Juoksukangas studied fretting fatigue using experimental and numerical methods. He explored the effect of different parameters used in machine design, such as joint preload.

“Fretting fatigue can dramatically decrease the fatigue life. Thus, consideration of fretting is important”, Juoksukangas emphasizes.

Juoksukangas developed a method based on the digital image correlation to measure the relative movement between contacting surfaces.

“The relative movement can be measured more comprehensively, which is helpful when analyzing fretting fatigue”, says Juoksukangas.

MSc Janne Juoksukangas’s doctoral dissertation *Modelling and Experimental Analysis of Fretting Fatigue in Complete and Bolted Contacts* was publicly examined at the Faculty of Engineering Sciences of Tampere University of Technology (TUT) on Wednesday, 24 May 2017.

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Janne Juoksukangas currently works in the Tribology and Machine Elements research group at the Department of Materials Science at TUT.

What affects rubber frictional performance on ice?

The good frictional performance of rubber on ice heavily influences vehicles’ mobility at winter conditions. In this dissertation, a methodology chain was developed using various microscopical imaging techniques in order the reveal the main frictional mechanisms when tire tread rubber slides on ice. The studies presented in this thesis help to broaden our understanding in the physics of tire-ice contact.

By analyzing the ice surface at its post-sliding state, different kind of contact marks can be observed depending on simulated traffic conditions (i.e. ice surface contamination), rubber hardness and rubber surface roughness. The results showed that it is not possible to single out one specific frictional mechanism due to the complexity of the tribosystem. The friction can be low when the rubber compound is harder, or the ice surface temperature is higher resulting local melting spots, leading to more hydrodynamic friction. Contrary, when the rubber compound is soft enough, or the ice surface temperature is colder, the likelihood of melting is low thus other mechanisms like deforming ice surface asperities and ploughing by hard fillers in rubber are more dominant. Interestingly, it was observed that pre-melted ice layer always lubricates the contact surface.

To overcome on the difficulties of observing three-dimensional micro contact state when rubber is squeezed against different type of road surfaces, a new, micro-computed-tomography based method was proposed. As a result, it was seen that the contact area on ice-like flat road surface is governed by the deformation of the rubber surface asperities, while on a rough road surface the contact is driven by the bulk deformation of the rubber. The nature of the contact state influences the frictional mechanisms of rubber on road surfaces. The large variety of observed frictional and contact mechanisms indicates that all modern tire compound development needs to fulfil multiplicity of requirements. Optimizing dynamic stiffness of the rubber, a good control over the rubber surface roughness and improving the molecular level interactions, like adhesion, can improve the performance of tires on icy surfaces.

The public examination of the doctoral dissertation of **András Kriston**, M.Sc. (Eng.), *Micro contact analysis of rubber-ice interaction during frictional processes*, was held on 30 June 2017 at the Aalto University School of Engineering.

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