AiF Project 17616 N

Sole Design Guidelines for Optimum Slip and Rupture Resistance

The goal of this AiF project was to develop guidelines for slip-resistance optimised sole design for prevention of slip, trip, and fall accidents. As a first step, the soles of modern shoes, sole materials, and sole test specimens produced in-house were tested and evaluated with the aid of specially developed methods and tools on existing test equipment. In addition, the sliding properties of soles on a slab of glass were recorded with a video camera and analysed by image processing techniques in order to draw conclusions about the underlying frictional mechanisms. These systematic studies permitted determination of the influence of individual design parameters on slip resistance and rupture resistance. A catalogue of guidelines with design examples was drawn up on the basis of the results obtained.

Some 185,000 slip, trip, and fall accidents were recorded by the German occupational insurance associations in 2013. A significant risk factor for such accidents: inadequate slip resistance of shoe soles. However, the design of slip-resistant soles is largely empirical and suffers from a lack of generally accessible design guidelines. By identifying and evaluating the factors influencing slip resistance and summarising them as a set of readily applicable rules, Project 17616 N aims to remedy this situation. The project focuses on shoe-floor systems; the floor surface is presumed to be non-distorting and the shoe is presumed to have a flat heel. The information gained is particularly valuable in the safety shoe sector, but also has applications in other areas.

In order to identify the parameters affecting slip and rupture resistance, PFI has tested currently available soles and sole materials from various suppliers on slip resistance and flexing endurance test equipment with the aid of new tools specially developed for this purpose.

The new tools include a device and appropriate software for contact surface visualisation and determination, a modular system for combined measurement of sole components, and finally a purely mechanical measuring device for determination of the coefficient of friction of soles and sole components. The parameters considered are typically contact area, edge length, tread depth, as well as the nature and hardness of the material. Measurements performed on specially produced sole specimens, during which individual parameters were altered in a controlled manner, permitted quantitative description of the influence of these parameters.

The contact surface measuring device determines surface areas subjected to a static load and also permits conclusions to be drawn by means of video analysis about the behaviour of the sole during the gliding process and thus about the underlying frictional mechanisms. This is demonstrated by the example shown in Figure 1.

The equipment and tools developed in the course of the project, especially the modular sole testing system and the straightforward rubbing device, facilitate rapid referencing of soles in the development process and thus help to save time and money.

A catalogue of guidelines was subsequently formulated which provides guide values for characteristic properties and, in some cases, information about the improvements in the coefficient of friction to be expected on changing the characteristic values. In addition, the catalogue also contains readily understandable examples of positive and negative designs.

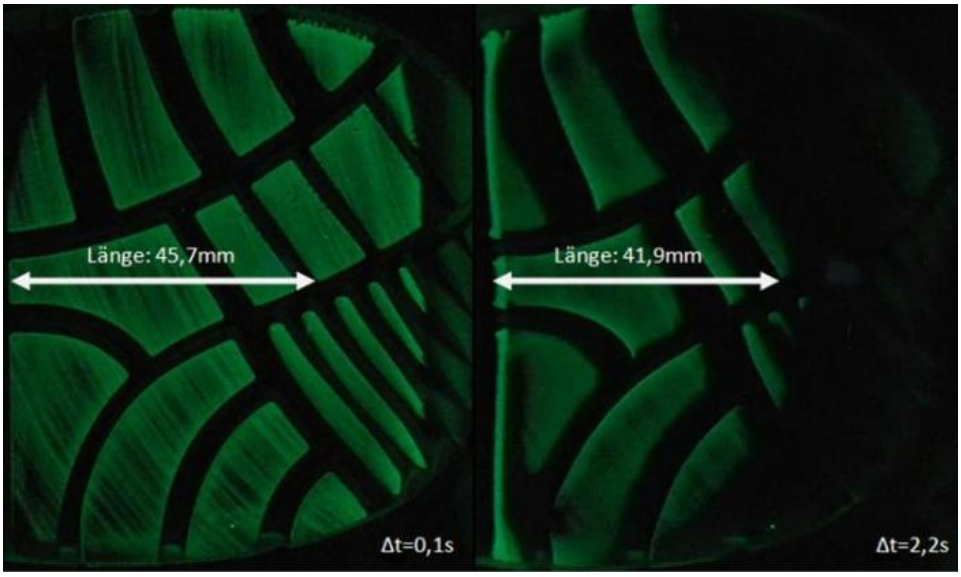

Fig. 1: Snapshot of a shoe sole sliding over a glass plate on application of a normal force of 500 N. Left: Start of sliding motion. Right: During sliding, in this case from left to right. The high load on the edges of the tread, particularly on the leading edge, and the compression of the sole are clearly recognisable.

IGF Project 17616 N of the Test and Research Institute Pirmasens was funded by the Federal German Ministry of Economics and Energy through the German Federation of Industrial Research Associations ("Arbeitsgemeinschaft industrieller Forschungsvereinigungen"– AiF) within the IGF programme for promoting industrial cooperative research in accordance with a resolution adopted by the German Parliament. We wish to take this opportunity express our gratitude for this funding.

The complete final report can be ordered from:

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Gefördert durch:

Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages