# Study on friction and wear in three-body systems with a limited number of abrasive particles

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**Abstract**

In many industrial processes and applications, contact of two bodies with an intermediate layer of loose, abrasive particles occur. The loose intermediate layer is undesirable in machine elements such as seals, bearings, gears or in applications such as tires on dirty roads and construction machinery due to their life-reducing friction and wear behavior. On the other hand, increased material removal is desired in manufacturing processes such as lapping.

During lapping, abrasive particles are mixed into a lapping fluid and applied to a rotating disc. The workpiece, which is pressed onto this lapping wheel by weights, undergoes a surface modification due to the irregular grain engagement. Depending on the material behavior of the workpiece, the grain size, shape and material, and the process parameters, a different surface is generated.

Knowledge of the contact mechanisms and the influence of particle characteristics on friction and wear helps to optimize the desired material removal and surface quality of the manufacturing processes. On the other hand, the tribological systems can be modified to reduce undesirable friction effects in applications and machine elements and to explain dynamic effects.

The relationship between particle shape, particle kinematics and material removal on samples was therefore experimentally investigated on a linear guide test rig. For this purpose, individual particles were placed on a plate which moves at a constant speed and glass samples with different weights were pressed onto the particles. The movement of the particles in contact was recorded with a high-speed camera. The cracks created on the glass samples could then be assigned to individual particles so that a connection could be established between kinematics and scratch.

This study investigated the influence of plate speed, sample loading and particle shape on kinematics and material damage for samples with and without applied liquid. To relate the kinematics to the coefficient of friction, a three-axis force sensor measures the normal and tangential forces during experiments. In addition, material damage and coefficient of friction were compared with single scratch tests with fixed particles.

As a first result, no direct relationship was found between the speed of the plate and the load of the samples on the kinematics of the loose particles. In contrast, the particle shape had the most dominant effect on the motion behavior. Particles with a rounder shape mostly roll, whereas rectangular shaped particles tend to slide.

The kinematics of loose particles under the influence of applied or no liquid has also been investigated using the discrete element method. The test setup and the particles were modeled in the open source DEM program “liggghts” and the particle kinematics were compared with measurements. Good qualitative comparability has already been achieved, whereby the simulation is to be extended by measured friction values and applied loads.

With these initial results, statements can already be made about the influence of the particle shape on the damaging behavior of the sample. For statements about the generated surface, investigations are carried out with a covering particle layer so that the entire sample surface is processed.