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# Dry-running Braking Systems in Tractors and Mobile Machines

*Increasing the maximum driving speed of tractor and agricultural machinery requires appropriate and efficient braking systems. Regarding the choice and dimensioning of braking systems, engineers will also have to sufficiently plan applicational and constructional features, as well as technical safety requirements. This paper describes the mechanisms of regular dry braking systems, since these have especially been used in commercial vehicles and heavy goods vehicles at driving speeds above 60 km/h.*

There is a variety of differently working braking systems being used in mobile work machines, be it dry or wet working, one disk or multiple disk brake, or drum brakes.

There are three rough categories of requirements made to brakes: the application oriented requirements, the technological ones and the legal requirements.

The legal requirements are of special importance since they are defining the design and interpretation of the components as well as the complete system. The rules to be adhered to for this are:

- in e.g. Germany the traffic admittance order (StVZO) with the § 41
- the directives of the European community 71/320/ EEC and the directives 76/432/EEC
- the ECE regulations 13 and 78

With the exception of special vehicles, the §41 of the StVZO dictates the introduction of the EC directives or the ECE regulation, with their largely agreeing [1].

The maximum mass and the driving speed are striking criteria for the division of tractors and work machines. In case of speeds above 40 km/h, the stricter requirements following the guideline 71/320/EEC (commercial vehicles) have to be considered [2].

This guideline divide commercial vehicles in three groups: N1 (maximum mass < 3,5 t), N2 (maximum mass between 3,5 t and 12 t) and N3 (maximum mass > 12 t). For all vehicles of N1, N2 and N3 the service braking system shall act on all the wheels on the vehicle and the action of the service braking system shall be appropriately distributed among the axles.

Due to the higher requirements on brake systems in vehicles with higher driving speeds and the meaning of disk braking systems in commercial vehicles, it is obviously reasonable to study the mechanisms of dry running disk braking systems. The research area of "Machinery Systems Design" of the Technical University of Berlin has done several research studies on the mechanisms of dry running brakes, the results of which shall be considered in the following [3].

When developing brakes and their choice for the application of suitable friction partners, engineers have to consider a variety of parameters influencing the friction process, acting more or less intensively in the contact surface between the friction partners. The most important parameters are shown in *Figure 1*. It is usual in practice to deal with the global friction qualities, i.e. engineers as-

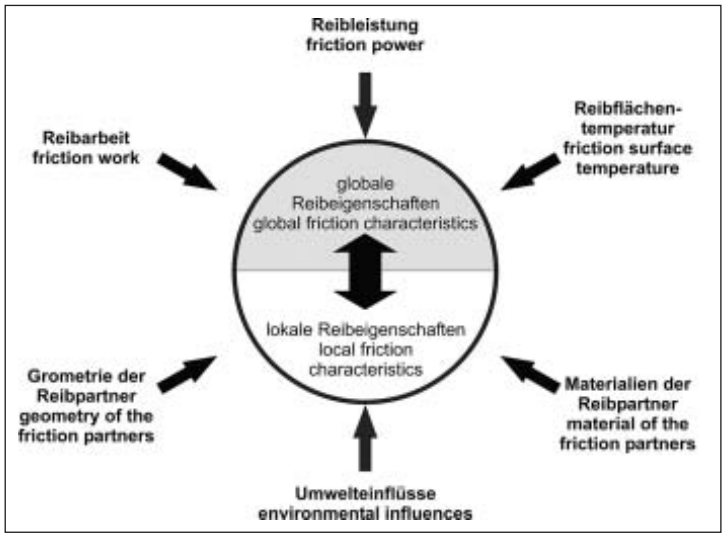


*Fig. 1: Important factors of influence on the friction process*

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**Keywords**

Tractor, brake, friction mechanism, friction temperature

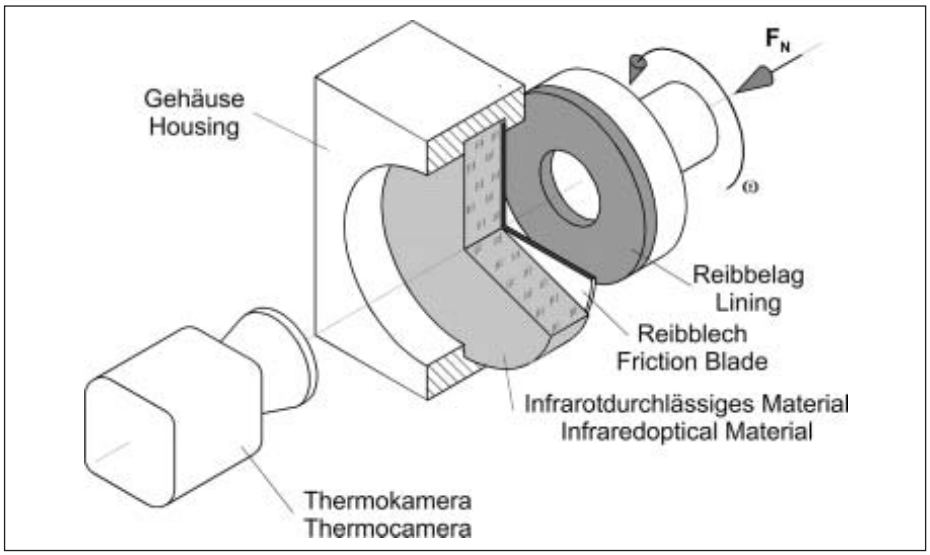


*Fig. 2: Measuring system for observation of temperature distribution in the contact area*

sume middle friction coefficients and wear indicators and, furthermore, state that the friction qualities are constant over the friction area. However, examinations of the local friction qualities have shown that this is not the case in reality. In the contact surface, there are spots of higher thermal load alternating with those of lower thermal load, from the point of view of the friction area breadth. There are concentric friction rings of differing friction intensity emerging on the disks of brakes and clutches. The thermal load in a friction ring is almost the same and changes during the process of friction periodically.

Examinations of the temporal changes of local friction qualities clearly show connections between local and global friction sizes. The research area of "Machinery Systems Design" developed a measuring system used to observe the local friction intensity. This system (*Fig. 2*), together with additional measuring components, like a laser aerosol particle size spectrometer, have been used to thoroughly examine the connections between the local and global friction qualities.

*Figure 3* shows that there are approximately the same temperatures in the individual friction ring segments, yet differing from one friction ring to another and shifting periodically. This characteristic is shown in the upper part of the figure by means of infrared pictures. In addition, the lower part of the figure shows an increasing friction moment and acoustic emissions with the friction zone being shifted. You will also notice a maximum wear in the most strongly loaded zones. Measuring the local particle concentration can help to prove this fact. Furthermore, the speed of the friction ring change obviously has an effect on the friction and wear qualities. These phenomena appear, more or less strongly, among different friction partners.

An other important aspect is the deformation and unevenness of brake disks. The deformation caused by temperature and the manufacturing faults are reasons for vibrations the driver can feel when driving the vehicle. The aim of the design must be an optimum construction of the disk. The design has to consider the temperature deformation behaviour e. g. with FEM-tools and the manufacturing process to reduce the negative influences of disks deformation on the vibration effects.

### Constructive aspects

The relationships between the local and global friction qualities can be useful for technical applications in various ways. Metrological recording of local friction sizes can help to get statements on their global qualities. The examination of the local friction qualities will optimise the application oriented choice of friction materials with the following aims:

- reduction of wear
- reduction of noise
- reduction of brake vibration
- increasing of life time
- brake effect optimisation

Measurement of local friction parameters will be helpful in brake management systems of tractors and mobile working machines as a part of a higher tractor management and suspension control system and in brake diagnostic systems.

This will help to increase the safety and comfort of fast tractors and mobile working machines.

## Literature

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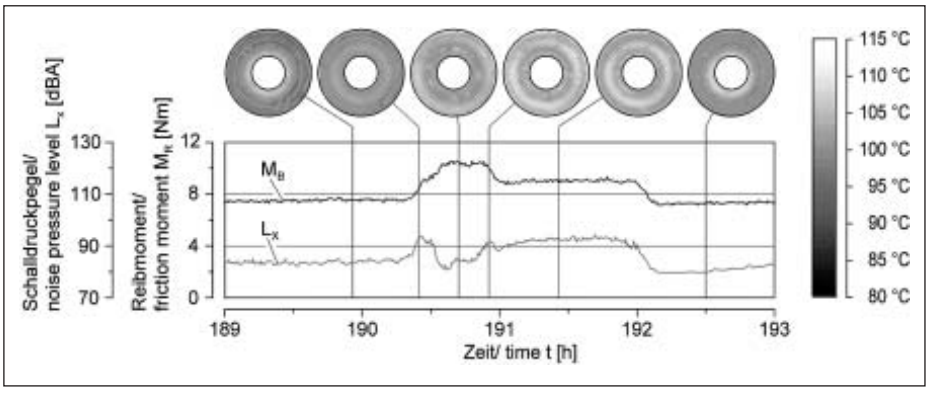


*Fig. 3: Relationship between temperature distribution, friction moment and noise emission over time [4]*