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WEAR EVALUATION OF THE FRICTION MATERIAL OF DISC BRAKE PADS

Non-exhaust (airborne) particulate matter PM10 and PM2.5 (with references to their sizes – smaller than 10 and 2.5 microns in diameter respectively), account to almost a halve of the overall PM emissions in Europe [1]. Mostly generated from braking elements and tyres in vehicles, as well as the road decomposition, non-exhaust PM are significantly hazardous not only for the human health, but also for the well-being of other species and the soil. The European Commission has adopted a plan for transitioning to zero on-board emissions for a large amount of the future vehicle fleet, yet there is no concrete plan for the dealing with the emissions of airborne PM, which gradually grow with the increase of the vehicle fleet in use and amount to as much as 30mg/km, depending on the vehicle type (light-duty, heavy-duty), the road type (urban, rural, highway) and many other factors.

Many laboratory studies have analysed the chemical composition of friction layers on brake pads in regards to the PM, in order to create a methodology for lowering of their emittance [2-5]. Simultaneously, these same metallic elements act for the most serious threat to human health and the environment when considering airborne PM. Analysis that are based on practical statistical data of two Ukrainian transport enterprises – LAA TRANS and TRANSPELE taken for the period 1999-2005 on all kinds of routes around Europe, show that the truck brake system is most likely to malfunction or failure averagely every 188 thousand km [6].

The presented results are on the amount of produced friction material per millimeter of worn-out brake pad friction layer and per km mileage of the pad.

The measuring of each sample brake pad was done by estimating with a calliper the existing friction material amount and also by measuring the weight of the pad with an electronic scale. The weight and thickness of the used friction material were then calculated by subtracting the measured values from the standard values of a new pad. The measured braked pads are of two sizes – for discs with diameter φ370mm, used in trailers, and for discs with diameter φ430mm, used in trucks and semi-trailers. The pads are produced from a few different companies, which all use different chemical compositions of the friction material and a slightly different geometry of their pads, the pads could easily be distinguished by their form, weight and wear properties, which is also visible from the results.

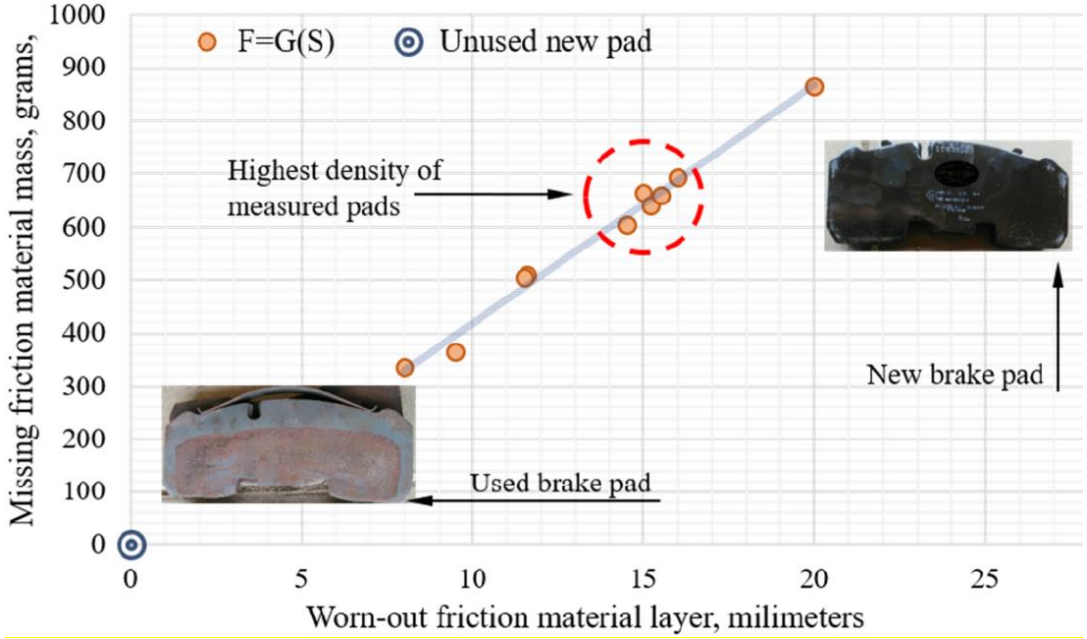

Figure 1. Missing friction material mass to worn out friction material layer, g/mm for Ø 370mm disc

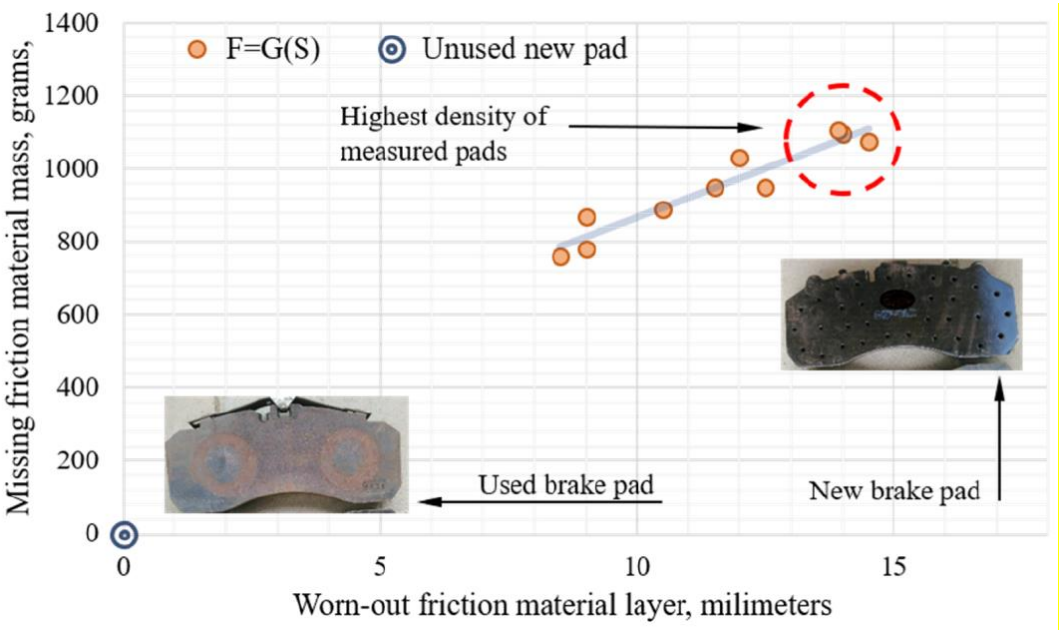

Figure 2. Missing friction material mass to worn out friction material layer, g/mm for Ø 430mm disc

On figures 1 and 2 is shown the measured data of 10 brake pads used for φ370mm discs in trailers and of 10 pads with φ430mm used in trucks and semi-trailers. The figures represent missing friction material in grams per missing friction material layer worn-out from the pad in milometers. At the left bottom corner of each graph is positioned a point representing an unused new pad with 0mm missing friction layer thickness and 0g missing friction material mass. Additionally, in each of the figures are shown images of a new and a used brake pad for each of the discs. A trendline is projected in order to show the average tendency g/mm of friction material wear. The bubble indicates the highest density in terms of measured braking pads, showing that most of them were measured at the theoretical end of their operational period.

The results show that brake pads of φ370mm discs produce about 38.42-44.34 g of particles per each mm of friction material used, while the larger brake pads with φ430mm discs produce 74.14-96.67 g of particles per each mm of friction material.

The values of brake pads wear in g/mm could easily be calculated in mg/km. However, it is very important to properly set the average mileage of the pads as it depends on many factors, such as the route of the vehicle fleet, the average gross mass of the goods transported, and many others. According to the statistical data of the enterprise which supplied us with pads, the average pad mileage of their fleet is about 150-200 thousand km. In this case, the pads generate about 3.37-3.90 mg/km of PM for the φ370mm discs, while the values of the larger brake pads correspond to 6.56- 8.56 mg of particles per km.

Such wide ranges of g/mm are due to the different chemical composition of the friction material on the pad, since the pads are produced by various companies.

In order to somewhat eliminate the problem of pollution from PM and also lower the significance of their generation process, various active and passive solutions for decreasing of the amount of PM, have been developed.

Typical passive solutions are the electric and hybrid drives, retarders, intarders and motor brakes. They help in facilitation of the work of the main brake system and so reduce the amount of formed solid particles to the lowest possible level. Hybrid and electric drives allow for regenerative braking, while retarders, intarders and motor brakes aid the braking process by means of fluid circulation. Active solutions, on the other hand, are focused on the direct capture of PM which is normally released during braking into the atmosphere. They are not commonly used yet, but there are several prototypes being developed by some automotive suppliers.

CONCLUSION. There are many factors affecting the amount of PM from brake pads, especially in the case of heavy-duty vehicles. According to the assessment in the study, the gross vehicle weight plays the biggest role in PM generation from braking in heavy-duty vehicles. The results estimated from vehicles operating on standard routes in Europe with an abundance of different road types and road profiles, that on average 3.37-3.90 mg/km of PM from braked pads with brake disc diameter φ370mm and 6.56-8.56 mg/km with brake disc diameter φ430mm, is produced. These values are significantly lower than the publicly presented data of up 30 mg / km and show how significant is the influence of the already mention factors on production of PM from disc brake pads.

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