

NON-EXHAUST PARTICULATE MATTER EMISSIONS DURING VEHICLE BRAKING: INFLUENCE OF DYNAMICS AND MITIGATION STRATEGIES

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Particulate matter (PM) is among the most serious environmental pollutants, posing significant threats to human health and air quality. The transport sector plays a key role in the formation of PM emissions, originating from both exhaust and non-exhaust sources. Ultrafine particles (UFP) and PM_{2.5} are of particular concern, as they can easily penetrate the respiratory system and cause cardiovascular diseases [1, 5].

Given the scale of the problem, environmental legislation in the European Union and the United States is continuously being improved to reduce particle emissions. Research shows that a significant share of PM pollution originates not only from exhaust gases but also from non-exhaust sources, especially particles generated by brake system wear [2, 3, 6].

In modern urban transport conditions, particles generated from the friction between brake discs and pads can account for up to 85% of PM₁₀ in traffic flows in European cities [4]. Since the braking process is closely linked to the mechanical characteristics of the vehicle, its kinetics, and road surface conditions, studying the impact of braking dynamics on PM formation is highly relevant.

Fine and ultrafine particles produced by brake wear are highly bioreactive and can enter the human respiratory and circulatory systems, leading to serious health effects [5]. Given the increasing environmental challenges—such as higher traffic volumes in large cities and climate change—effective measures must be developed to reduce non-exhaust emissions.

For example, the European Union is implementing regulations to control brake-related emissions under the EURO 7 standard, which envisages a gradual reduction of the PM₁₀ limit for vehicles from 7 mg/km in 2025 to 3 mg/km by 2035 [6].

The aim of this article is to analyse the mechanisms of non-exhaust PM formation during braking, to examine the factors influencing emission levels, and to review current mitigation strategies within regulatory policies and engineering solutions.

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