Particle Emissions from Euro 6 Diesel Cars during Real World Driving Conditions

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Introduction

CO, NOx, HC and Particle mass have been monitored in different vehicle emission standards and Particle number (PN) has been added to standards recently. The EU has proposed a solid particle PN limit in Euro 5b and Euro 6. The PN limit for low duty vehicles (LDVs) is set to be 6.0×10^{11} (#/km). Within the recent decades of the European Union, there has been an overall reduction in emissions of air pollutants. It can however be reported that emissions of diesel engines that are measured within laboratory conditions are different from what is happening in real world driving condition. To combat this issue, a more realistic measurement method called Portable Emission Measurement System (PEMS) is recommended. There are very low amounts of real world emission data from PEMS for passenger cars [1]. Also, the available reports mostly concentrated on gaseous emissions such as NOx [2] and particle emissions from diesel passenger cars in real world is rarely studied. The aim of this research is to study particle numbers from diesel vehicles during the real world driving and compare it with recently introduced Euro 6 particle number limit. SAS regression tool was utilised to present trends within the vehicle speed and the particle number, while presenting interesting data on vehicle operation habits for speed.

Methodology

For the experiments, a Portable Emission Measurement System (PEMS) was used to record the real-world driving particle data of two different Euro 6 diesel passenger cars. Vehicle 1 has a 2 L diesel engine while the engine size of vehicle 2 is 1.6 L, tested vehicles are from two different manufacturers. The data were collected for more than two hours drive with varying speeds in urban, rural and motorway driving conditions. The designed route needs to cover certain speed, topography and human population parameters [3].

The data is analysed for complete journey as well as the cold start, urban, rural and motorway separately. The criterion for cold start condition was engine coolant temperature. The engine condition in which the coolant temperature is below 70º C was considered as cold start condition. SAS studios was also used to compile and outline trends of the data that was found, presenting the effect of certain factors on particle number.

Results

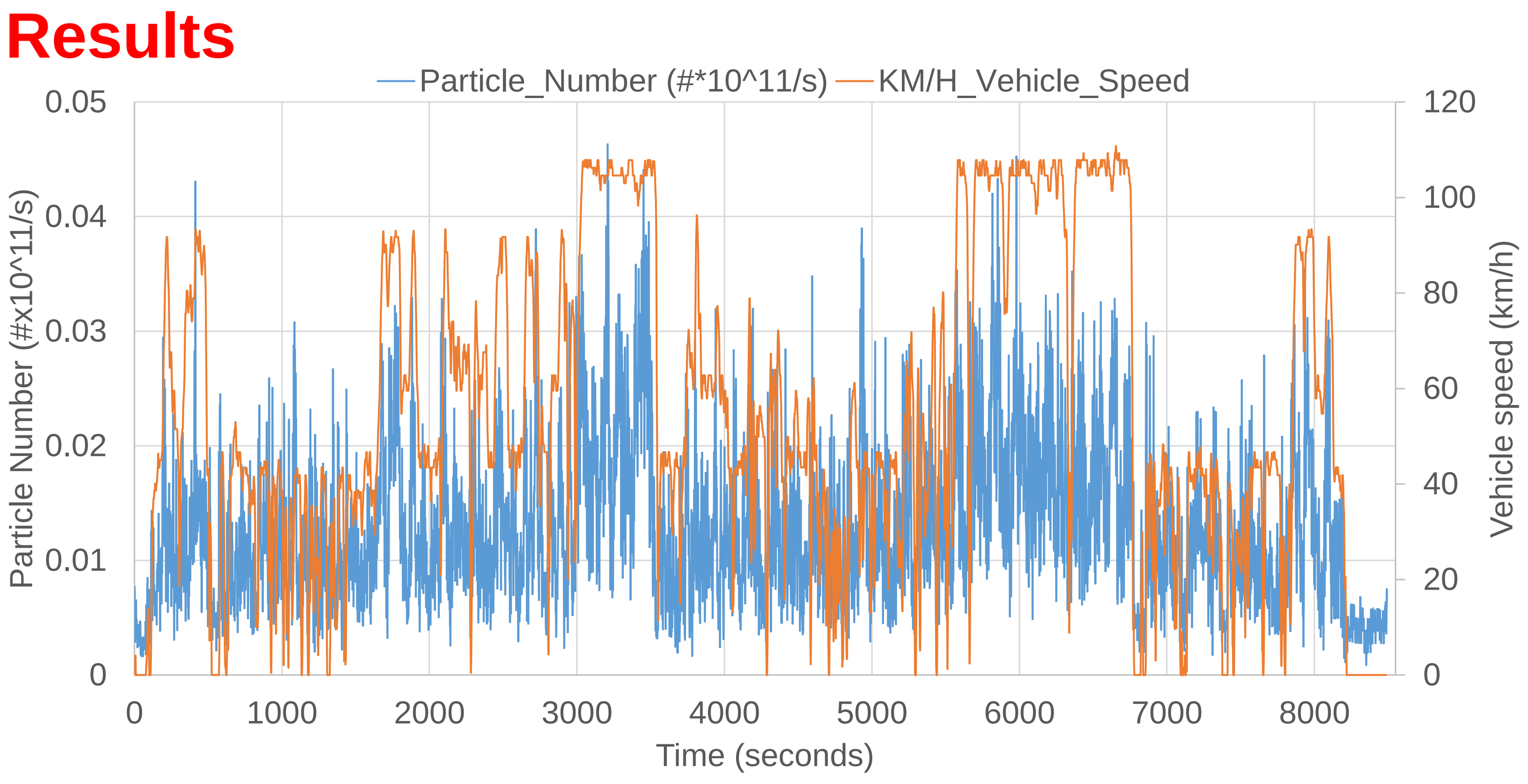

Figure 1: PN and vehicle speed for vehicle 1.

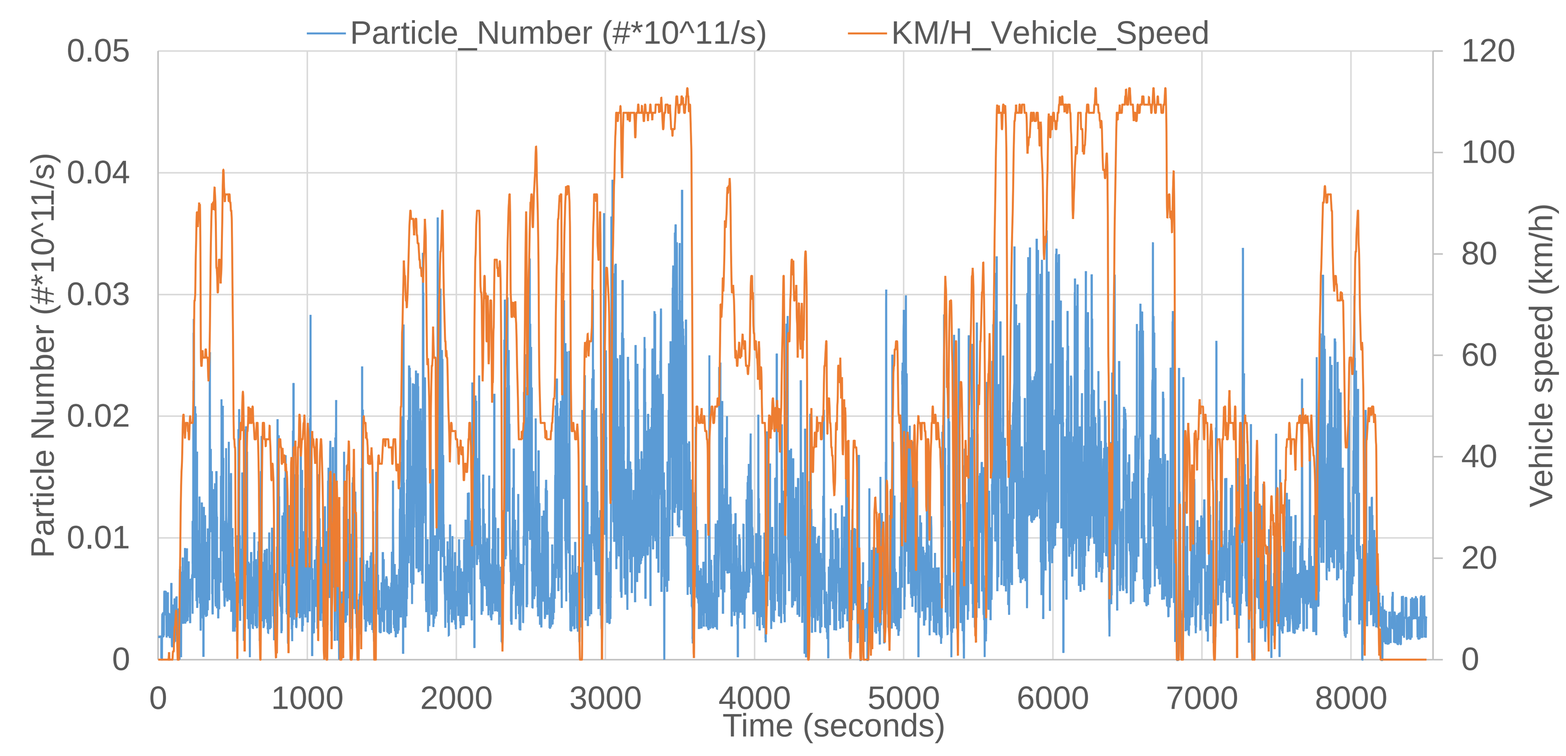

Figure 2: PN and vehicle speed for vehicle 2

Table 1: Particle number of each driving mode including cold start; in both #/km and #/s. Compared to limit

	Total Particle number: Cold start	Total Particle number: Urban	Total Particle number: Rural	Total Particle number: Motorway	Total Particle number: Overall	Euro 6 limit
Vehicle 1: Particle number (#/s)	1,009,329,155	988,116,937	1,235,719,402	1,857,164,159	1,266,973,629	-
Vehicle 1: Particle number (#/km)	0.954×10^{11}	1.20×10^{11}	0.705×10^{11}	0.667×10^{11}	0.828×10^{11}	6×10^{11}
Vehicle 2: Particle number (#/s)	686,335,925	649,652,121	946,186,595	1,467,657,699	935,232,138	-
Vehicle 2: Particle number (#/km)	0.535×10^{11}	0.784×10^{11}	0.538×10^{11}	0.522×10^{11}	0.596×10^{11}	6×10^{11}

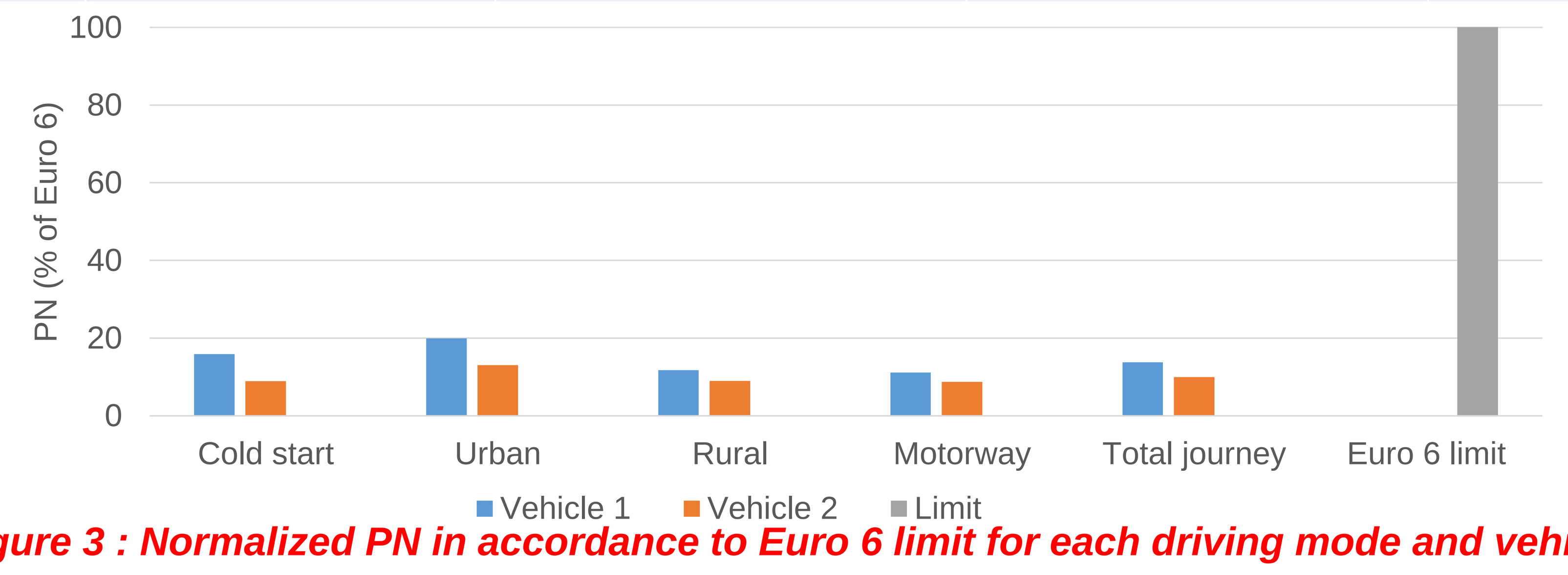

Figure 3 : Normalized PN in accordance to Euro 6 limit for each driving mode and vehicle

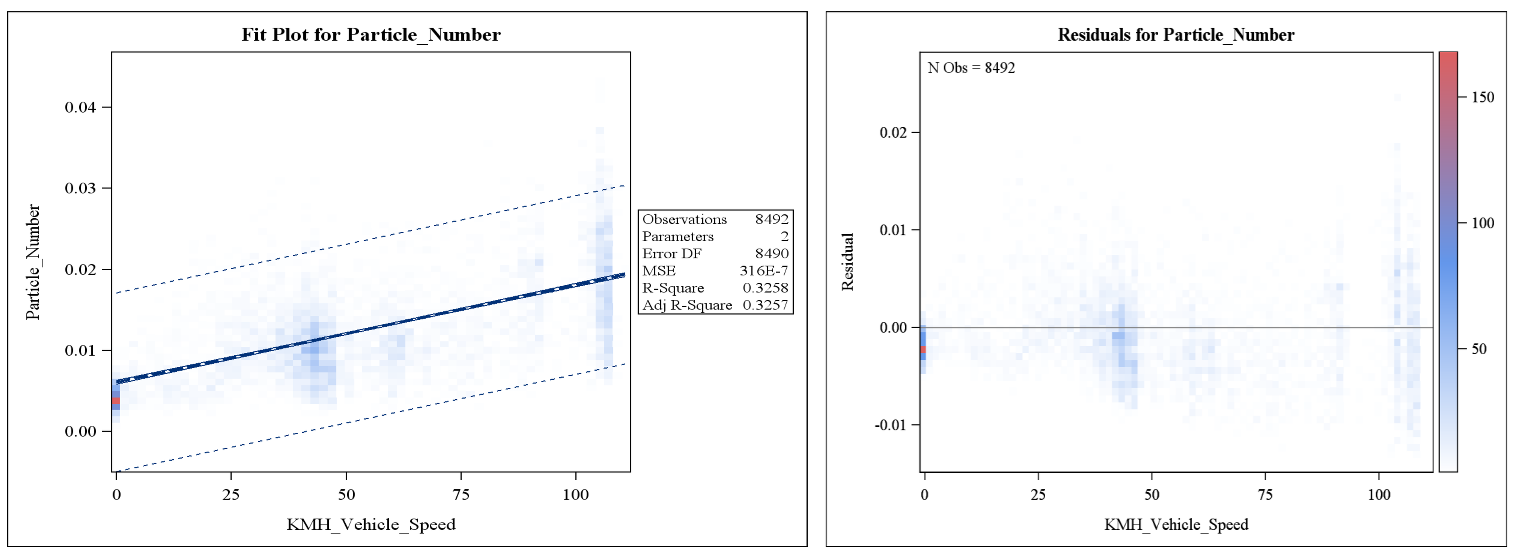

Figure 4: SAS data on particle number/vehicle speed using the regression function for vehicle 1.

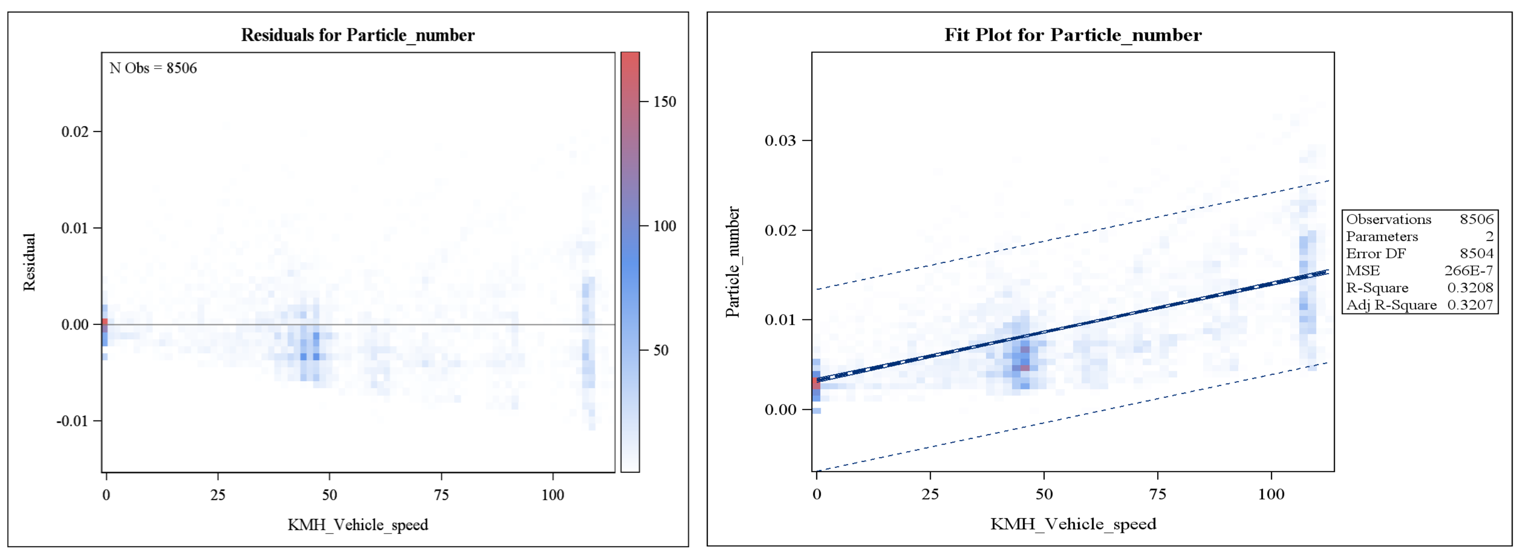

Figure 5: SAS data on particle number/vehicle speed using the regression function for vehicle 2.

Analysis

For both vehicles, PN (#/km) during the urban driving was higher compared to the rural and motorway while total number of PN for both vehicles remained well below the Euro 6 standard limit (6×10^{11} #/km). The engine size of the vehicle 1 is bigger than vehicle 2, it is one of reasons for the increase in total number of particles emitted from vehicle 1 compared to vehicle 2 in all driving modes (see Table 1). Cold start can be presented to effect particle emissions somewhat; results from these graphs presented here prove inconclusive however.

It can be seen that the most efficient way to drive for less particle number output in accordance to distance is at high speed.

Linear regression analysis was also developed using SAS software. From the results in Figure 4 and 5, a positive trend within the regression line is observed; it means PN is following the vehicle speed trend and an increase in vehicle speed corresponds to increase in PN emissions. This effect can be seen in Figure 1 and 2 from almost simultaneous peaks of PN and speed, however, the SAS model facilitates this observation. Additionally the SAS models presents interesting data on the vehicle habits of drivers, a high amount of data was found at three areas within the regression line; and having the most amount of data found when stationary. This presents the intermittent nature of UK roads, indirectly contributing to emissions. The SAS regression model for vehicle 2 suggests that this vehicle produced less emissions than vehicle 1 considering its smaller regression line slope.

Conclusion

Investigations were made into the study of real driving emissions for two different Euro 6 passenger cars from two manufacturers. In summary, this study found that the particle number (PN) emission remains below standard limit for both vehicles. It can be outlined that at higher speeds there is a higher amount of particle number. Additionally, the report highlighted the driving conditions effects on the emitted particles.

Investigations were made into the effect of vehicle speed on particle number for two types of vehicle. The greater the vehicle speed, the higher the particle number output when distance is not taken into consideration.

The research also outlined the overall driving habits of drivers and its contribution to emissions.

Research presented how the most efficient way to drive for lower particle number output in accordance to distance is at high speed

References

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