THE INFLUENCE OF TECHNICAL CONDITIONS AND THE AGE STRUCTURE OF VEHICLES ON TRAFFIC EMISSION

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Abstract

The article presents the results of the simulation of the traffic emission from vehicles for different type of roads. The calculations of emission have been made by using the methodology which is used in Europe. To register the number and the type of vehicles for each road a digital camera was used. The traffic stream has been recorded in the same length of time. The investigations have been made for different classes of roads with different types of vehicles. There was estimated number of the vehicles per vehicle category and the age structure of the vehicles for each type of road. The vehicles have been divided into different exhaust emission legislation classes. Additionally, measurements of the group of 300 different vehicle have been made. Those measurements provided information about the level of emission from each vehicle. The total vehicle emission was calculated depending on the type of road, the number of vehicles, the number of vehicles per vehicle category, the age structures, the average speed per vehicle type etc. At first, the simulation of the traffic emission from vehicles was made, taking into consideration the fact, that the vehicles are in good technical conditions. Next, the calculation was made for real technical conditions of vehicles. This investigation has shown that the technical conditions of the vehicles have an important influence on the estimated emission level.

Keywords: *Road transport, traffic emission, technical condition of the vehicles, the age structure of the vehicles, simulation*

1. Introduction

The motor vehicles are a significant source of air pollution. The total emission level is heavily dependent on the type of road, the number of vehicles, the type of vehicles and also their age structures, average speed per vehicle type and per road, the fuel type and the fuel consumption etc. The traffic emission is increasing all the time because the number of vehicles is also growing. It is a very important problem to determine emission from road transport thoroughly. In Europe, there are a lot of different methodologies to calculate emissions from road transport [1-3]. In these methodologies the calculations of vehicle emission are carried out with combination of data i.e. the type of road, the type of vehicles and their age structures for different types of road, the average speed of vehicles etc. In Europe, there are the reports about the calculations of vehicle emission [4].

The existing models are still extending. These models generate different components of exhaust emission [5], instantaneous traffic emission [6] and concentration of car exhaust pollutants in street canyons [7]. There are a lot of comparisons of different models, which has a positive effect on development of methodologies to calculate emissions from road transport [8, 9]. An influence of traffic produced turbulence on car exhaust pollutant concentration have also been determined [10]. The emission has been estimated taking into consideration the type of roads [11], driving patterns [12], the type of vehicles, different types of emission etc.

Present, the way of determination the effect of age and technological change on motor vehicle emissions have been developed. The important problem is also the influence of the engine construction and engine technical conditions on traffic emission.

2. Methodology

This article presents the results of simulation of the emission from the road transport. Total emission was calculated with combination of the investigation results i.e. the type of vehicles and their age structures for different types of roads. The investigations have been made for different classes of roads. Different classes of roads with different types of vehicles were chosen. To register the number and the type of vehicles for each road, a digital camera was used. The traffic stream has been recorded in the same length of time (15 minutes).

On the basis of the analysis of the recorded traffic stream, the number of vehicles per vehicle category and the age structure of vehicles for each type of road have been estimated. The vehicles have been classified into different exhaust emission legislation classes.

Firstly, the investigations have been made for the A4 motorway Katowice – Gliwice. Next, the investigations have been made for the DTS expressway Katowice – Zabrze and for the DK 79 road in Katowice. The A4 motorway is a type of transit road. The DTS expressway Katowice – Zabrze is a type of local road. The DK 79 road is a national road. The research for these roads has been made in Katowice. For each road there are different numbers of vehicles, different vehicle structures and their age structure. Additionally, the measurements of exhaust emission for 300 different vehicles have been made. The measurements have been made in accordance with ECE Regulations and methodology of periodical car inspection. Those measurements provided information about the level of emission from each vehicle and percentage of faulty vehicles of total number of cases. The total vehicle emission was calculated depending on the number of vehicles, the number of the vehicles per vehicle category, the age structures, the average speed per vehicle type. At first, the simulation of the traffic emission from vehicles was made taking into consideration the fact that the vehicles are in good technical condition. Those calculations were made for vehicles from each road and the results of simulation were compared. Additionally, the simulation was made for the test group of 300 vehicles. For the test group the calculations were made assuming that all cars were in good technical conditions and next taking into consideration the real results of tests.

Total traffic emission, for each road and for the test group, has been calculated using methodology from COPERT [1].

3. The results of the research

3.1. Vehicle structure in road traffic

Those investigations have been aimed at determining the vehicle structure for each road. During the investigations to register the traffic stream a digital camera was used. The traffic stream has been recorded in the same length of time – 15 minutes during 30 days, at different times of the day. On the basis of these analysis of the recorded traffic stream, the number of vehicles per vehicle category and the age structure of vehicles for each type of road have been estimated. For each category of vehicles, taking into consideration the exhaust emission legislation classes, the number of vehicles was estimated. The results of investigations for one case were shown in Tab. 1.

Tab. 1. The number of vehicles for chosen roads in the same length of time (15 minutes)

Name of road	The numer of vehicles						
	Gasoline passenger cars	Diesel passenger cars	Light duty vehicles	Heavy duty vehicles	Buses	Other	Total number of vehicles
A4 motorway	769	85	205	154	5	0	1218
DTS expressway Katowice – Zabrze	440	97	111	71	0	0	719
DK 79 road in Katowice	357	78	51	18	3	1	508

Figure 1 shows the vehicle structure for different roads. The real structure of vehicles was compared with the statistical structure of vehicles in Poland.

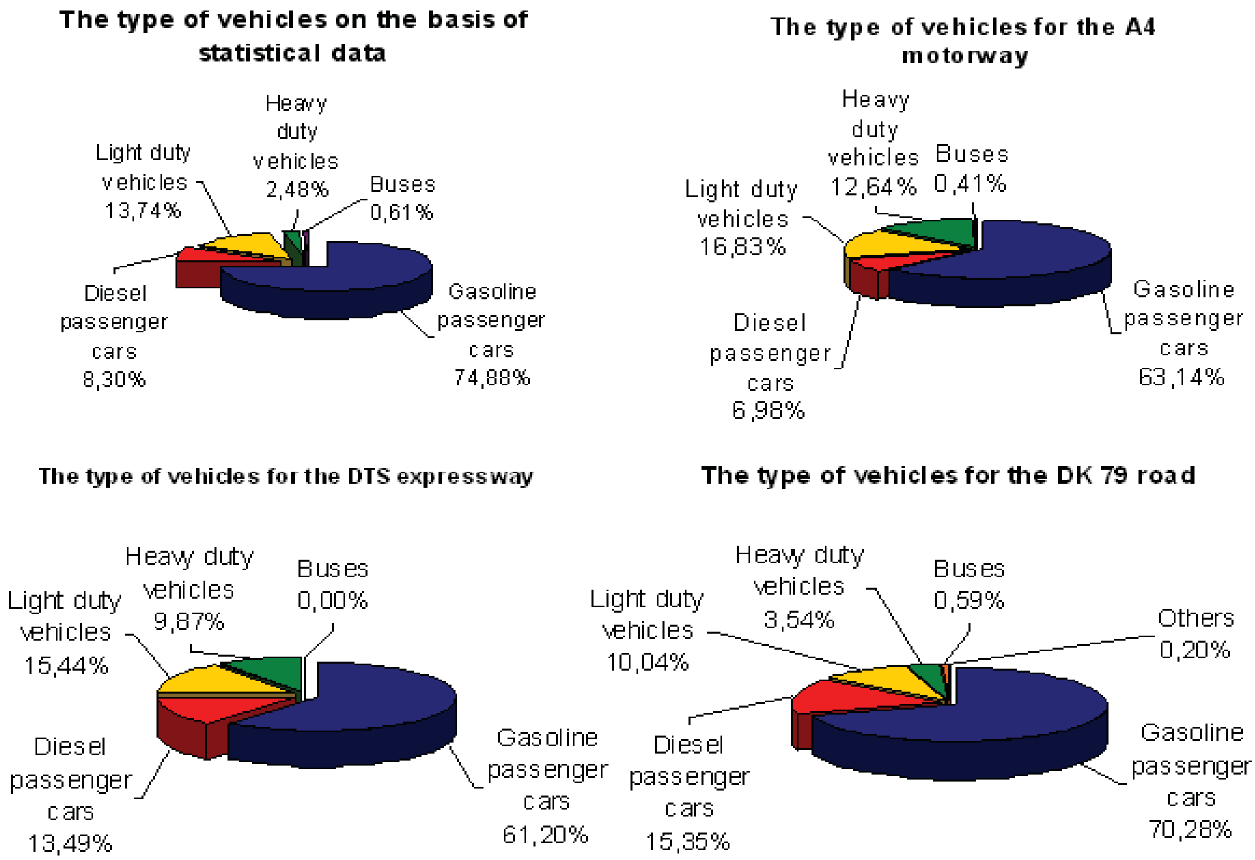

Fig. 1. The vehicle structure for different types of roads and those on the basis of statistical data

For all roads the passenger cars were divided into two groups: passenger cars with compression engine and passenger cars with spark ignition engine. That division was based on the statistical data.

There are huge differences between vehicle structures for each road. The traffic structure depends on the type of road. The biggest amount of passenger cars was for DK 79. For that road there was the smallest amount of heavy duty vehicles. The highest number of heavy duty and also light duty vehicles was for A4 motorway. High number of those types of vehicles was noticed for DTS expressway as well.

The DK 79 is a typical city road which connects the city centers with residential areas while the A4 motorway and DTS expressway are typical transit roads.

For each road the age structure of vehicles has been estimated. The results were compared with the age structure of the test group. The results of estimation for passenger cars were shown in Fig. 2 i 3. Fig. 2 shows the results of estimation for roads. Fig. 3 shows the results of estimation for passenger cars from test group. The cars have been classified into different exhaust emission legislation classes. The results of investigations were compared with statistical data.

The results of investigations have shown that there are different age structures of vehicles for each type of road, for the test group and for statistical data. For DK 79 road there was the largest amount of vehicles which meet the Euro III requirements. The similar situation was in case of DTS road. In case of A4 motorway there was the largest number of vehicles which meet the Euro II and also Euro III requirements.

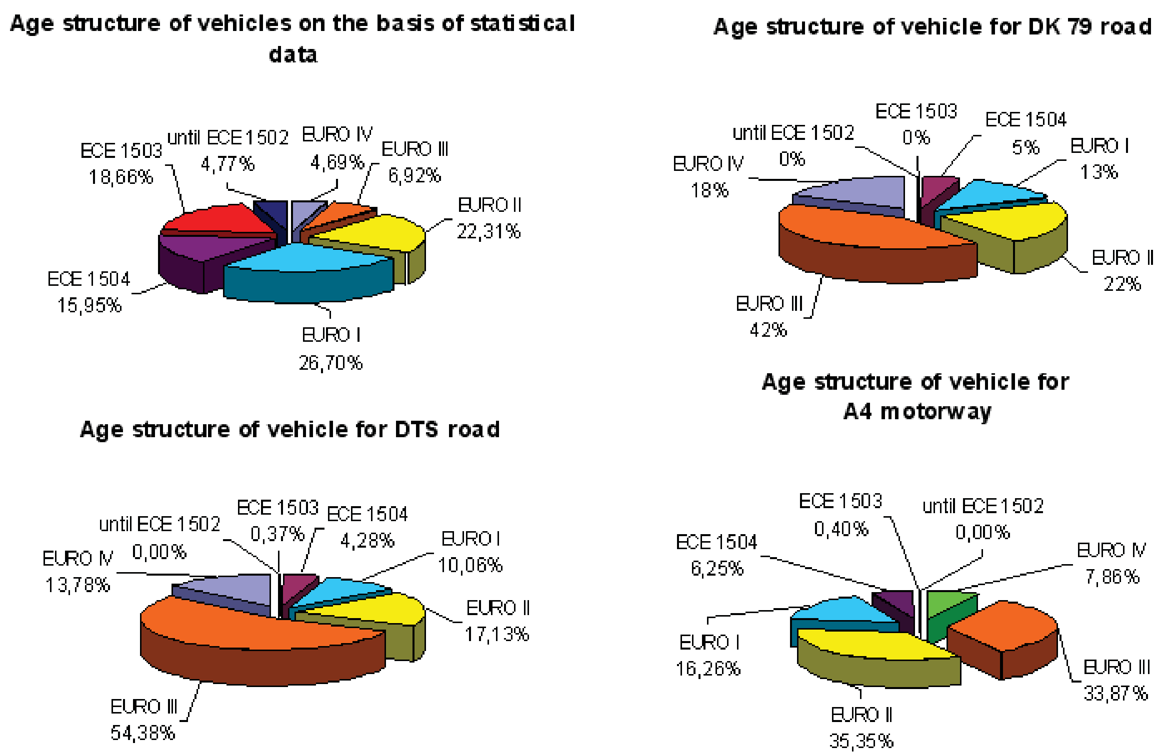

Fig. 2. The age structure of vehicles for all roads for passenger cars

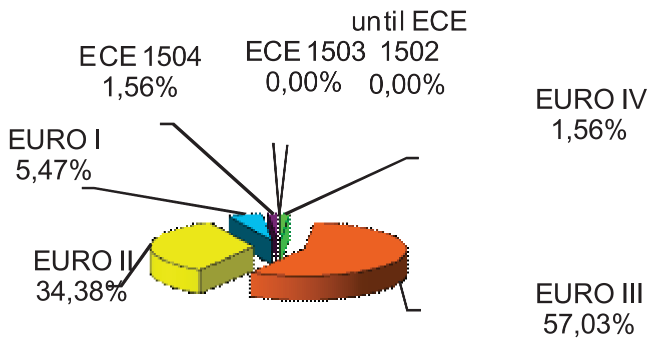

Fig. 3. The age structure of the test group

3.2. The technical conditions of vehicles

To determine the influence of technical conditions of vehicles on their emission, each vehicle of the test group was examined. During these examinations the exhaust emission of vehicles was measured and the type of engine faults and their influence on the level of exhaust emissions was estimated.

The damages can be classified in following groups:

- complete breakdown of the engine,
- increased fuel consumption and pollutants,
- more intensive wear of friction pair,
- hard warming up engine.

The Fig. 4 shows how many different damages have influenced the level of exhaust fumes.

About 42% different damages of engines had a significant influence on the level of exhaust pollutants. About 27% caused the damages which had the influence on more intensive wear of a friction pair. About 13% of damages caused complete breakdown of engine and about 5% of damages caused the problems with warming up the engine.

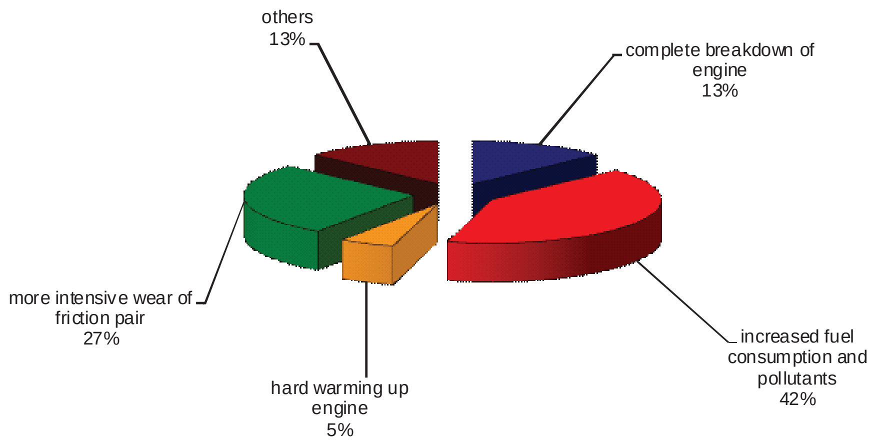

Fig. 4. The influence of different damages of engines on maintenance

The results of measurements of exhaust pollutants were compared with law regulations. Fig. 5 shows the results of comparison of CO and HC emission for passenger cars with spark ignition engine.

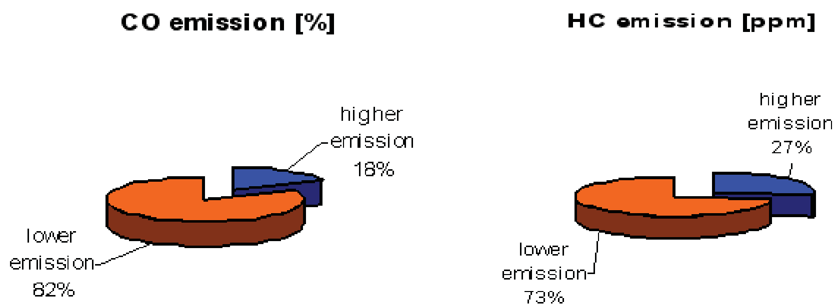

Fig. 5. The comparison between CO and HC emission and national requirements of emission for gasoline passenger cars; lower – emission lower then national permissible emission level, higher – emission higher then national permissible emission level

About 18% of gasoline passenger cars have exceeded the permissible CO emission level. In case of HC emission, there were about 27% of gasoline passenger cars which have exceeded the permissible HC emission level.

The results of measurements were compared with permissible emission level determined by car producers (Fig. 6).

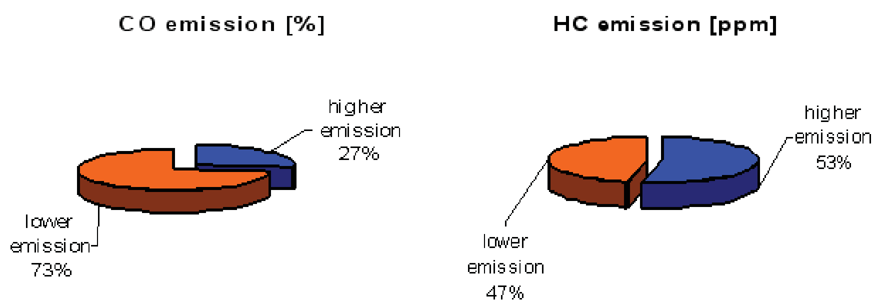

Fig. 6. The comparison between CO and HC emission and requirements of emission for gasoline passenger cars; lower – emission lower then permissible emission level determined by car producers, higher – emission higher then permissible emission level determined by car producers

In this case, about 27% of gasoline passenger cars have exceeded the permissible CO emission level determined by car producers. About 53% of gasoline passenger cars have exceeded the permissible HC emission level determined by car producers. There are vehicles which have not exceeded the permissible emission level determined by producers but have exceeded national permissible emission level. These vehicles are in bed technical conditions according to requirements of producers of those cars but in satisfactory technical conditions regarding national legislation. This could be a cause of high emission from those vehicles.

4. The results of the simulations

4.1. The influence of the age structure of vehicles on traffic emission

The calculations of exhaust emission for each category of road and estimated traffic stream were made. First the calculations were made for real traffic stream for each category of road. The results of calculations for passenger cars were shown in Fig. 7. The total level of exhaust emission depends on the age structure of vehicles and the real traffic stream.

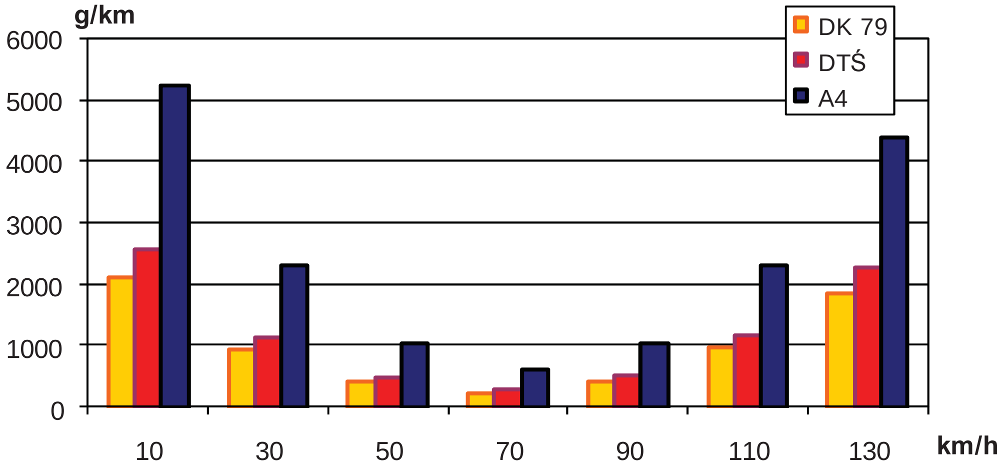

Fig. 7. The results of the calculations of the CO emission for gasoline passenger cars

In order to estimate the influence of age structure of vehicles on exhaust emission for each type of road the simulation for the same amount of cars (1000) was made. The age structure of vehicles was the same as in real traffic stream for each type of road. The results of the calculation have been presented in Fig. 8.

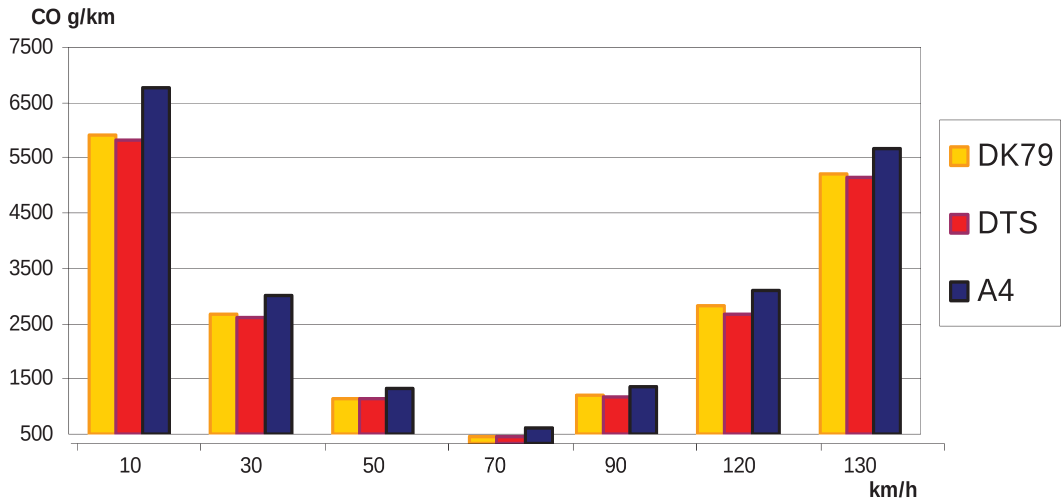

Fig. 8. The results of calculations of the CO emission for 1000 gasoline passenger cars

The results of calculations for real traffic stream show that the highest level of emission was for the A4 motorway but it is the result of higher number of vehicles during the time of recording. The age structure of cars has less influence on the results of calculations (Fig. 8) but it is important for correct results of exhaust emission estimation.

4.2. The influence of technical conditions on traffic emission

The same simulation as in the case of chosen roads was made for the test group of vehicles. The results of simulation for CO for passenger cars with spark ignition engine were shown in Fig. 9.

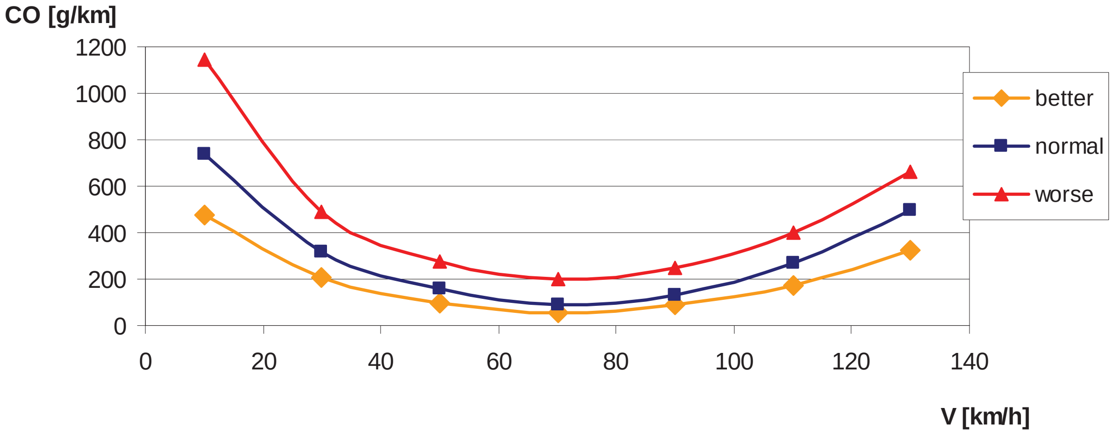

Fig. 9. The results of calculations of CO emission depending on the technical conditions of vehicles

The simulation was made for three cases. In one case the calculations have been made assuming that all vehicles of the test group meet the requirements of European emission standards (Fig. 9 - “normal” line).

Secondly, the calculations have been made for real technical conditions of cars. These vehicles which met the requirements of Polish legislation were categorized into the appropriate group of cars with European emission standards. These vehicles which did not meet the requirements were categorized into group of cars which met these requirements. These vehicles have been categorized into a group of European emission standards with higher level of emission (Fig. 9. “worse” line). The estimated emission in this case is much higher then emission in the first case.

In some instances, the vehicles met the appropriate emission standards, but also met the better (newer) emission standards. In these cases, the vehicles were categorized into better standards. The rest of vehicles were categorized into an appropriate group, connected with the date of production and European emission standards (Fig. 9 “better” line).

This simulation has shown that the results of the estimated level of exhaust emission depend on the correct classification of vehicles in each emission legislation classes. The calculated exhaust emission depends on vehicle age and the technical conditions of vehicles.

5. Conclusions

The total emission was calculated with combinations of different data. The results showed that a lot of vehicles have not met the requirements of national legislations. This investigation has shown that the technical conditions of vehicles have an important influence on the estimated emission level. The results of exhaust emission level depend on traffic stream, age structure of vehicles and correct classification of vehicles into appropriate emission legislation classes. It is possible to estimate the percentage of cars which have met the requirements for the appropriate emission legislation class for each category of cars. Therefore, the technical conditions should be taken into consideration while estimating traffic emission.

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