Determination of parameters influencing the vehicle emissions in Greece using a remote sensing system

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Abstract
A remote sensing system called FEAT was used to make over 10.000 valid motor vehicle CO and HC emissions measurements in the Thessaloniki area (Greece). FEAT is made up of three basic units : the IR source, an IR photovoltaic light detector and a computer. The data treatment of the passenger cars emissions in Thessaloniki show that only a small percentage (10-20%) of the cars produce the largest contribution to emissions. The CO and HC emissions data are correlated to the model year of the vehicles. The results indicated that the vehicles called "gross polluters" are not only old technology or old model vehicles.The results of Thessaloniki vehicles emissions measurements are compared with results of measurements in different cities in the world. The comparison demonstrate that maintenance is a very important factor in controlling car emissions.

Résumé
Le système de télédétection FEAT a été utilisé pour réaliser plus de 10.000 mesures de CO et HC aux émissions véhiculaires à la région de Thessaloniki (Grèce). Le système FEAT est constitué par trois unités fondamentales : une source IR, un détecteur photovoltaique IR et un microordinateur. Le traitement des données des émissions des véhicules passagers à Thessaloniki montre qu'une petite pourcentage (10-20%) des véhicules produit la plus large contribution aux émissions. Les données des CO et HC ont été correlées avec l'année du modèle des véhicules. Les résultats montrent que les véhicules les plus pollués ne sont pas seulement des véhicules de technologie vielle ou de modèle vieux. Les résultats des mesures des émissions véhiculaires de Thessaloniki ont été comparés avec les résultats des mesures des villes différentes du monde. La comparaison démontre que la maintenance est un facteur très important pour contrôller les émissions véhiculaires.

Introduction

Mobile sources are believed to contribute a significant portion to emissions of CO, HC and NOx. These pollutants are very determinant for formation of the photochemical smog in an urban area. [1] Air pollution control measures taken to mitigate mobile source emissions include inspection and maintenance programs (I+M). Nonetheless, despite two decades of air pollution control efforts, many people continue to live in areas where the air is unhealthy.

With initial support from the Colorado Office of Energy Conservation in 1987, the University of Denver developed an Infra-Red (IR) remote sensing system for vehicle carbon monoxide (CO) and hydrocarbons (HC) exhaust emissions, called FEAT for Fuel Efficiency Automobile Test [2,3].

Using this system, the CO and HC emissions of many thousands of vehicles have been measured in different cities in the world, such as : Los Angeles,USA [4], Denver,USA [5], Chicago,USA [6], Toronto,Canada [7], London,UK [8], Mexico City,Mexico [9], Gothenburg,Sweden [10], Thessaloniki,Greece [11,12].

In this paper the CO and HC emissions measurements of over 10.000 vehicles in the Thessaloniki area (Greece) are studied and these data are correlated to the model year of the vehicles. The results of Thessaloniki vehicles emissions measurements are compared with results of measurements in different cities in the world.

1.Methodology

The remote sensing system FEAT (Fuel Efficiency Automobile Test) is made up of three basic units : the IR source, an IR photovoltaic light detector and a computer. The IR source sends a horizontal beam of radiation across a single traffic lane and the beam is picked up by the detector on the opposite side and split into four wavelength channels : CO, CO_2, HC and reference.

The absorption of light by the molecules of interest reduces the signal, causing a reduction in the output voltage. The FEAT computer takes these measurements and determines the percentage of CO, CO_2 and HC in the exhaust plume. For every vehicle that passes through the IR beam, the computer freezes a videotaped picture of the rear end of the vehicle showing the license plate number and a read-out of the percentage of CO, CO_2 and HC in the exhaust plume. The results are stored on a digital computer data-base including the date, time and emissions, as well as on S-VHS videotapes.

The remote sensing system was used for the vehicle emissions measurements in a single-lane of a roadway (Mitropoleos Str.) in Thessaloniki. There was a statistical treatment of the data and the videotapes were read for licence plate identification. There was also, an analysis to correlate the emissions to the age, model and make of the vehicles.

2.Results and discussion

The results of the data first treatment of the overall sample fleet (10.000 vehicles measurements) in Thessaloniki are presented elsewhere [11,12]. In this paper we present a data treatment of the passenger cars (2.000 vehicles measurements) in Thessaloniki correlated with the Thessaloniki total sample fleet, the passenger cars model year and the data from other cities in the world.

The Figures 1 and 2 illustrate the Thessaloniki passenger cars CO and HC emissions respectively subdivided into tenths. The height of each bar represents the average emissions for that tenth of the sample fleet. The distribution of the data is that 70% of the cars are clean with CO emissions considerably less than the limit value : 3%. Only the 10% of the cars present CO emissions considerably higher than 3% (the mean value of this category is almost 6%). The results for HC are qualitatively similar with those for CO : only the 10% of the cars present HC emissions considerably higher than the limit value 0.3% (the mean value of this category is almost 0.5%).

The graphs show even more clearly the impact of the gross polluters representing the dirtiest 20% of the vehicles (the two highest bars in both Figures), which produce by far the largest contribution to CO and HC emissions. Removal or remediation of these vehicles would clearly provide considerable reduction in mobile emissions.

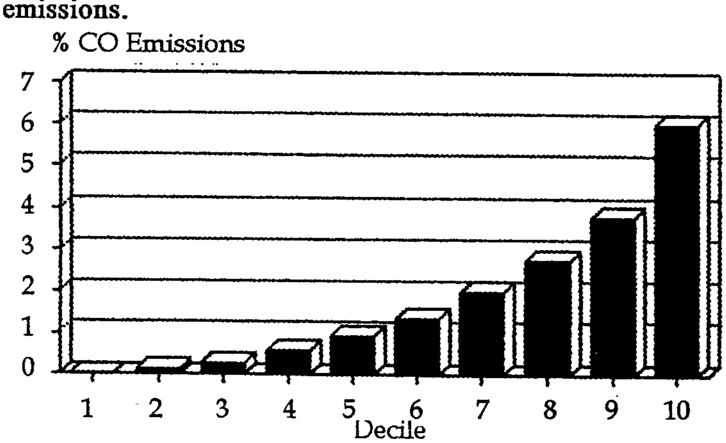

Figure 1 : Passenger cars CO emissions subdivided into tenths. Thessaloniki, Greece.
Figure 1 : Emissions en CO des véhicules passagers sous-divisés en dizaines.Thessaloniki, Grèce.

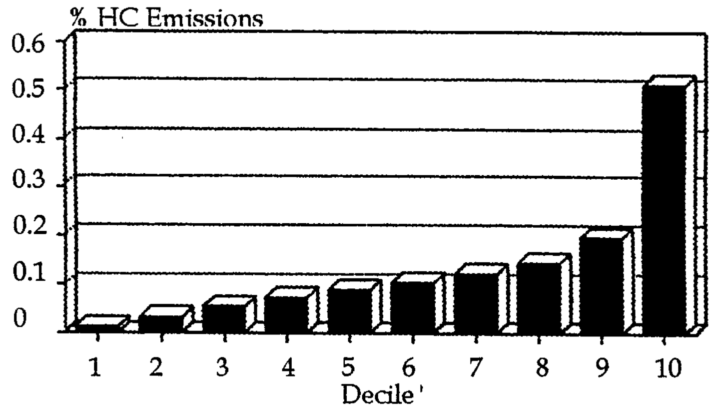

Figure 2 : Passenger cars HC emissions subdivided into tenths. Thessaloniki, Greece.
Figure 2 : Emissions en HC des véhicules passagers sous-divisés en dizaines. Thessaloniki, Grèce.

The results for CO and HC passenger cars emissions from Figures 1 and 2 are qualitatively similar with the results for the CO and HC total sample fleet emissions in Thessaloniki [11,12] and the results for the sample fleet emissions in different cities in the world : Los Angeles [4], Denver [5], Chicago [6], Toronto [7], London [8], Mexico City [9], Gothenburg [10].

The Figures 3 and 4 illustrate a separation of the Thessaloniki passenger cars CO and HC measurements for which registration data exists into groups by model year. Whithin each year the emissions are rank ordered by % CO emissions (Figure 3) and % HC emissions (Figure 4) and divided into five equal sized parts. The emissions of each part are averaged and presented as the height of the bar for that part.

From the Figures 3 and 4, it can be seen that the dirtiest parts of the newest passenger cars (1991-92, 5th parts in both Figures) have much higher CO and HC emissions than the cleanest parts of the oldest cars (1972-75, 1st,2nd and 3rd parts in both Figures). It can also be seen that the most rapid deterioration in CO and HC emissions occurs during the first five to six years of ownership. After that time the rate of increase of emissions slows down considerably.

The results for CO and HC passenger cars emissions in Thessaloniki related to the cars model year from Figures 3 and 4 are qualitatively similar with the results for the 200.000 cars emissions in different cities in the world : Los Angeles, London, Mexico City, Gothenburg [13].

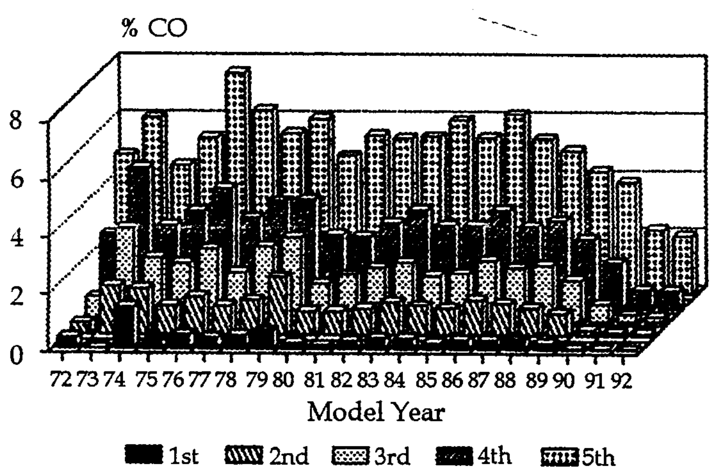

Figure 3 : Separation of Thessaloniki passenger cars measurements into groups by model year. Each model year is rank ordered by % CO emissions and divided into five equal size parts. The emissions of each part are averaged.

Figure 3 : Séparation des mesures des véhicules passagers à Thessaloniki en groups à rapport de l'année du modèle. Chaque année du modèle est à l'ordre de la pourcentage des émissions en CO et divisée à cinq parties égales à rapport de la taille. Le moyen des émissions de chaque partie a été consideré.

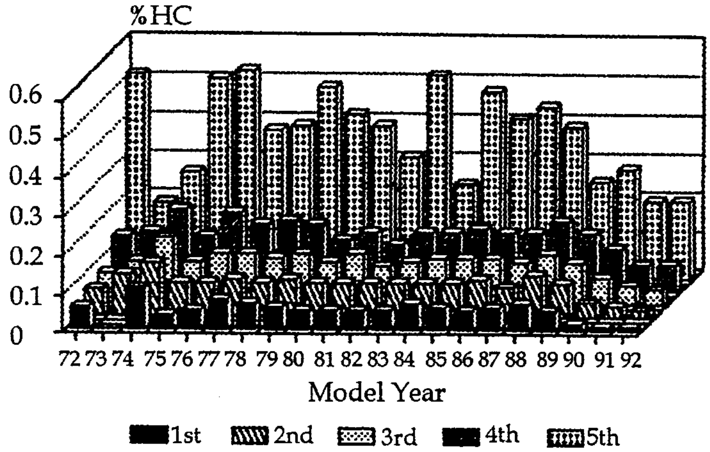

Figure 4 : Separation of Thessaloniki passenger cars measurements into groups by model year. Each model year is rank ordered by % HC emissions and divided into five equal size parts. The emissions of each part are averaged.

Figure 4 : Séparation des mesures des véhicules passagers à Thessaloniki en groups à rapport de l'année du modèle. Chaque année du modèle est à l'ordre de la pourcentage des émissions en HC et divisée à cinq parties égales à rapport de la taille. Le moyen des émissions de chaque partie a été consideré.

The Figures 5 and 6 show the emissions profile shown in Figures 3 and 4 respectively, multiplied by the number of passenger cars in each part (each bar of the Figures). Each bar of the Figures 5 and 6 now show its contribution to total passenger cars CO and HC emissions respectively. The more numerous newer, dirty cars dominate the CO and HC output. These Figures show that too much concern about the emissions of older vehicles is not warranted because there are so few of them out on the road. The emissions from the dirtiest part of the 1991-92 vehicles (5th parts in both figures) are much higher than the dirtiest parts of the 1972-75 vehicles (5th parts in both figures). Again this is due to the greater number of one or two years old vehicles in the fleet compared to those 17-20 years old.

The results for CO and HC passenger cars emissions in Thessaloniki related to the cars model year and their contribution to total fleet emissions from Figures 5 and 6 are qualitatively similar with those in different cities in the world [13], but there are some important differences which must be underlined and explained. The differences are the maxima of 1978-79 and 1983 model year cars and the minimum of 1987 model year cars (in both Figures). The '78-'79 maxima are due to the fact that this period was just before a considerable increase of cars prices. The '83 maximum is due to the fact that during this year there was a considerable increase of salaries. The '87 minimum is related to a considerable decrease of salaries during this year. It is also important to note that only the '91-'92 model year cars in Greece have an important fraction of catalyst equipped cars.

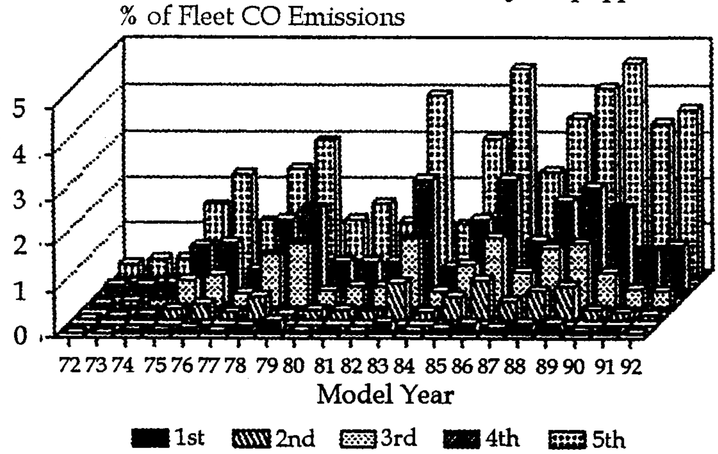

Figure 5 : Each part of Figure 3 is multiplied by the number of passenger cars in that part. Each part now shows its contribution to total passenger cars CO emissions in Thessaloniki.

Figure 5 : Chaque partie de la Figure 3 est multipliée par le nombre des véhicules passagers de cette partie. Chaque partie montre maintenant sa contribution aux émissions totales en CO des véhicules passagers à Thessaloniki.

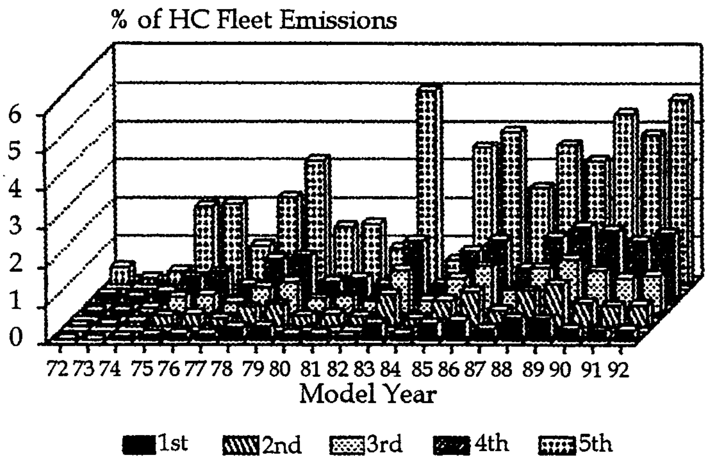

Figure 6 : Each part of Figure 4 is multiplied by the number of passenger cars in that part. Each part now shows its contribution to total passenger cars HC emissions in Thessaloniki.

Figure 6 : Chaque partie de la Figure 4 est multipliée par le nombre des véhicules passagers de cette partie. Chaque partie montre maintenant sa contribution aux émissions totales en HC des véhicules passagers à Thessaloniki.

These different maxima and minima for passenger cars model year contribution to total fleet CO and HC emissions show the impact of the governmental economic policy to increase or decrease cars emissions in combination with the consummers behaviour.

All the above mentioned figures demonstrate that vehicle maintenance is a more important factor than vehicle age in determining and controlling fleet emissions. Since the average emissions of all fleets are dominated by a small percentage of dirty vehicles, the differences over time are caused by maintenance factors.

Conclusions

The measurements of on-road vehicle emissions in Thessaloniki - Greece, using a remote sensing system, show that only a small percentage of passenger cars (10-20%) produce the largest contribution to CO and HC emissions.

These vehicles called "Gross Polluters" are not only old technology or old model vehicles.

The more numerous newer, dirty vehicles dominate the fleet emissions.

The governmental economic policy has considerable impacts to the cars model year contribution to total fleet CO and HC emissions in combination with the consummers behaviour.

The results from vehicle emissions measurements in Thessaloniki are qualitatively similar with those in other cities of the world (Los Angeles, London, Mexico City, Goethenburg) and demonstrate that maintenance is a more important factor than vehicle age and model in determining and controlling vehicles emissions.

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