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A DRIVING CYCLE FOR VEHICULAR EMISSION ESTIMATION IN DHAKA CITY

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ABSTRACT

Traffic congestion is a serious concern for the city dwellers of Dhaka, the capital of Bangladesh. It results in commuter frustration, longer travel time, loss of productivity, high rate of accident, higher fuel consumption and deterioration of air quality. Driving cycle, a speed-time profile, can be used to estimate vehicle emission, computing fuel consumption and assessing traffic impact. Although such driving cycle both at legislative and non-legislative are used for exhaust emission specification and research level in developed countries, there is no known driving cycle developed for Dhaka city. To meet the necessity an elementary driving cycle for Dhaka city has been developed in this study. Three major motorways of Dhaka city were selected and a GPS system was employed to collect speed-time data at three different times during day by using two different types of vehicles. Both peak and non-peak traffic periods during weekdays when the congestion of traffic is higher were selected for the study. It is observed that about 57% of the vehicles driving time were spent at idling and moving at low speed. The driving cycle has a cycle time of 2050 seconds, distance of 7.2 km, and average velocity of 12.1 km/hr.

Keywords: Driving Cycle, Dhaka City, Emission Test Cycle.

1. INTRODUCTION

Dhaka burdened with a population over 15 million has been influenced by development processes and subjected to high rate of urbanization. Traffic congestion is an issue of great concern for the inhabitants of the city resulting in commuter's frustration, longer travel times, loss of productivity, increased accidents, higher fuel consumption, and deterioration in air quality. Air pollution in Dhaka is worsening due to increasing motorization. Although existing air quality monitoring data is limited, the ambient air quality measurements available indicate that the air pollution is deteriorating.

Visible signs of ambient air quality of Dhaka are indicating an upward trend in gross emissions in recent years. Emissions from vehicles are affected by the driving patterns which mainly depend on traffic conditions. *Driving Cycles* have been developed to provide a speed-time profile that is representative of urban driving [1-4]. In other words, it is a time series of vehicle speeds developed to represent typical driving patterns. Driving cycle is a dynamic entity which is continuously changing and evolving. Knowledge of driving cycle which describes the exact driving patterns of the city is of vital importance to its understanding and the role it will play in forecasting accurate vehicular emissions. They are used in estimating vehicle emissions, computing energy consumption, and assessing traffic impact.

There are two major categories of driving cycles: legislative and non-legislative. In legislative driving cycles, exhaust emission specifications are imposed by governments for the car emission certification, e.g. FTP75 (Federal Test Procedure) used in USA, NEDC (New European Driving Cycle) in Europe, and 10-15 Cycles used in Japan [3]. Non-legislative cycles, such as Hong Kong driving cycle and Sydney driving cycle, find broad application in research for energy conservation and pollution evaluation.

Moreover, standard cycles mostly smoothed out the vehicle operation modes (acceleration, deceleration, idling and cruising). Since most of the pollution is generated due to changes between the modes, output of this type of models are significantly compromised [5-6].

Driving cycles either legislative or non-legislative used frequently in emission models to assess the impact vehicular emission on environment [7-8]. However, most of the emission models have short-comings in describing actual driving behavior, local road conditions and maintenance practices [9]. Assumption of driving practices and vehicle conditions prevailing in USA or Japan while deriving emission factors for Dhaka city would result in inaccurate prediction of vehicular emissions. Standard driving cycles used in developed countries embodied the characters of their driving patterns probably are not ideal for cities of developing countries to evaluate emission factors [10-12].

To the best knowledge of the author, there is no existing driving cycle officially developed to represent the traffic in Dhaka or elsewhere in Bangladesh. Quantification of vehicle emissions for Dhaka is restricted by the lack of driving cycles. This study is intended to examine the characteristics of vehicle driving patterns in Dhaka and to improve the understanding of driving characteristics of Dhaka.

2. METHODOLOGY

To build a realistic driving cycle that would represent the true driving characteristics, it is necessary to collect speed data of various routes, times and vehicles. Two main methods commonly applied in measuring traffic data are [13]:

i. Chase-car technique to measure the speed of randomly targeted vehicles,
ii. Instrumented vehicle driven by professional drivers or private drivers or owners.

Chase-car method is most versatile. Chase-car is a vehicle that records relative distance between the car and randomly chosen target vehicle with a laser. In the other method, a vehicle equipped with either data logger with a speed measuring device or a global positioning system (GPS) is used collect the necessary data. Accuracy may vary among techniques for devices' sampling rate (data recorded per second).

Driving cycle can be prepared by dividing the data into segments of similar driving pattern and randomly selecting and linking segments on the basis of performance criteria that minimize the difference between the speed-acceleration frequency distribution exhibited by the cycle which uses only a portion of the data and the distribution using all data. Another way of developing driving cycle is to analyze the data and determine the percentage of operational modes (acceleration, deceleration, idling and cruising) of the total collected data and preparing a synthetic cycle with the same percentage of operational modes [1]. It smoothes out the transition phases between steady speed and acceleration.

The four standard operational modes are defined as: (a) *idling mode*: zero speed and acceleration, (b) *acceleration mode*: having positive speed change of more than 0.1 m/s^2, (c) *deceleration mode*: having negative speed change of more than 0.1 m/s^2, and (d) *cruising mode*: having absolute speed change of less than or equal to 0.1 m/s^2 [10].

In the present study, instrumented vehicle technique with private driver was used to collect data. A GPS system with a capacity to provide maximum one data per second was used. The information of two available vehicles engaged in the study is summarized in Table 1:

Three main motorways of Dhaka city were selected: i) Shahbag-Kakoli, ii) Nilkhet-Shyamoli, and iii) Shahbag-Tejgaon. The reason behind selecting these motorways is important to be acknowledged. Dhaka city typically not only supports medium and heavy weighted motor vehicles on its road, but also supports physically driven three wheelers, known as rickshaws. It is usually seen in city roads that when motor vehicles move behind these rickshaws, other vehicles cannot accelerate. In the above mentioned selected routes, physically driven two or three wheelers are not allowed. This implies that the data does not represent true driving characteristics of Dhaka. However, variation of data in arterials will be very high as there are no traffic signals in those roads. Moreover, the width of the road, presence of road separator, maintenance works, and presence of road side obstruction (e.g. shops, construction materials, and dustbins) will significantly influence the data. Considering all these factors only major motorways were taken into account for the study. In subsequent studies, other arterials will be accommodated.

Table 1: Characteristics of the vehicles

Maker	Model Year	Disp. (cc)	Fuel Supply System	Emission Control System	Odometer Reading (km)
Toyota Axio	2006	1500	VVTi	TWC	15,000
Jeep	2002	1800	EFI	TWC	90,000

As the traffic situations keep changing all through the day data was taken at three different times of the day: (a). 10 am, (b) 1 pm and (c) 3 pm. It should be noted that the time of maximum traffic congestion (8 am and 6 pm) occurring in Dhaka city was not considered in the current analysis. It avoids skewed representation of driving cycle. However, the importances of the times are unavoidable and in future those data will be collected and incorporated. All the data were collected in weekdays.

3. DRIVING CYCLE FOR DHAKA CITY

The present study analyzed the collected data and developed an elementary driving cycle for Dhaka. For this purpose, data of three routes (up and down), two vehicles and three time slots, a total of (3 x 2 x 2 x 3) 36 trips were collected. In each trip, average travel time and distance were 30.6 minutes and 7.2 km, respectively. Maximum and minimum times of trips were 55 minutes and 15.1 minutes, respectively. Among these 36 trips maximum and minimum average velocities of a trip were 25.5 km/hr and 7.4 km/hr, respectively.

Vehicle speed distribution was analyzed from the collected on-road speed time data. Fig.1 shows the percentage distribution of all vehicle speed data. The figure shows the distribution of percentage of time which a vehicle spent in each speed range. It can be observed that about 56.2% of travel time was spent at or below 10 km/hr speed. It indicates that vehicles spent a lot of time in idling and moving at low speed. It was also observed that only a fraction of time (0.7%) the vehicles can speed up above 60 km/hr.

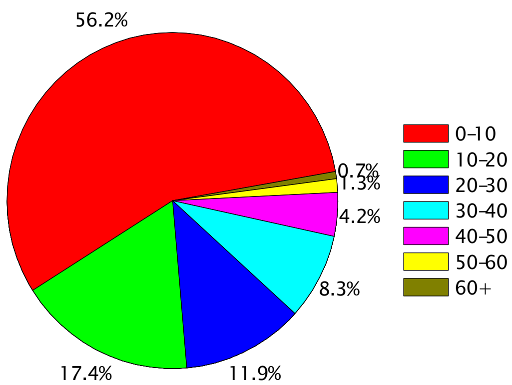

Fig 1. Speed distribution of vehicles in Dhaka city

The speed distribution of all data is used to develop the driving cycle of Dhaka as such that the ideal driving cycle would have approximately same speed distributions. Ideal driving cycle should have same percentage time of operation mode which cannot be ensured. One of the reasons why it could not be done is that number of acceleration and deceleration in each trip. So, a driving cycle which satisfies the average speed distribution of all cycles among 36 recorded cycles is selected and analyzed. Figure 2 shows the speed-time profile of such a selected cycle. The cycle is 2050 seconds long with a travel distance of 7.2 km/hr. It has an average speed of 12.7 km/hr which is a little below the combined average speed of 14.6 km/hr.

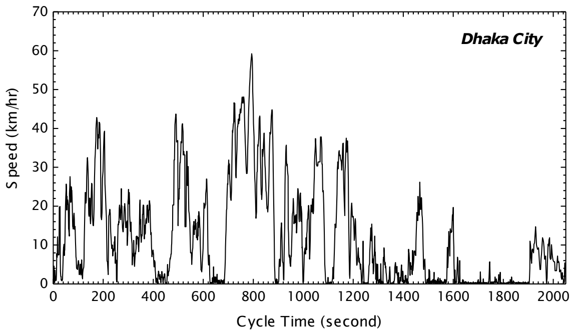

Fig 2. Speed-time profile of Dhaka city

Figure 3 shows the FTP75 cycle as developed in California and later used all across United States as standard and guidelines for developments of subsequent driving cycles. Comparing the FTP75 with our developed elementary cycle, it is evident that the number of spikes or the rapid changes in speed occurring in Dhaka cycle is more frequent than that of FTP75. It also shows regular intervals between short period of drives which are absent in our cycle. Average speed of US EPA city cycle LA4 is 31.2 km/hr as against our recorded average of 12.7 km/hr. This information gives us clear message that standard driving cycles e.g. FTP75 is not suitable to predict the emission standard of Dhaka or elsewhere in Bangladesh. The necessity to develop a complete and competent driving cycle to evaluate the emission condition of Dhaka city strongly felt.

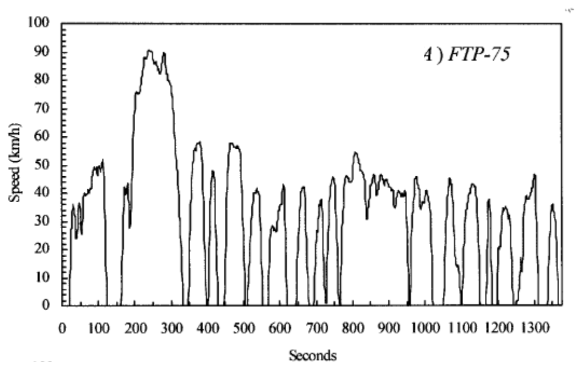

Fig 3. Speed-time profile of FTP75 [11]

Figure 4 shows the acceleration pattern of the elementary cycle developed for Dhaka. The number of acceleration value equal or higher than 3 (km/hr)/sec is more than 50. Such acceleration pattern is very alarming suggesting very high emission. It should be noted that here the acceleration value of 0.36 (km/hr)/sec or less is considered to be steady or zero acceleration and hence not shown in the figure. Actual number of observed smaller acceleration is much more.

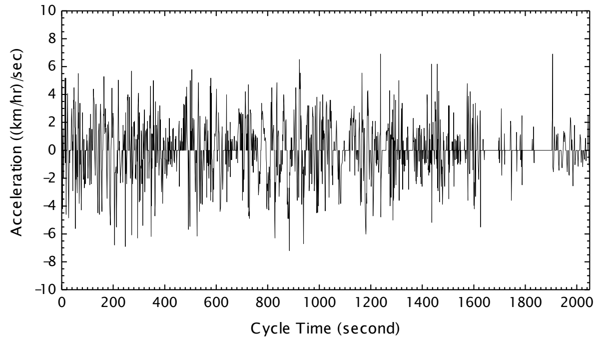

Fig 4. Acceleration-time profile of Dhaka city

Figure 5 shows the percentage of operational mode of the elementary driving cycle developed for Dhaka city. It shows a total 25.4% idling, 33.6% acceleration, 32.0% deceleration and 9.0 % cruising time.

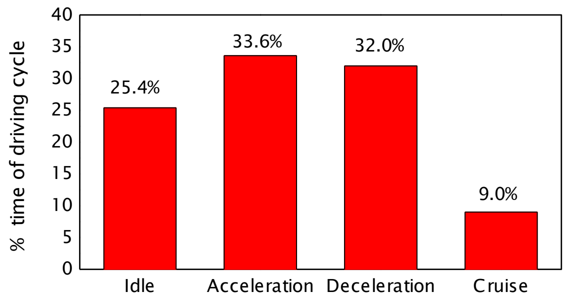

Fig 5. Percentage of time spent in different driving mode

4. CONCLUSIONS

Three major motorways of the Dhaka city were selected, covering different distances and geographical locations. Instrumented (with a GPS) vehicle was used to collect speed–time data at three different times during day time using two different vehicles. The times were selected so that traffic peak and non-peak periods were covered. The studies were carried out only on the weekdays when the congestion of traffic is higher.

From the results it can be concluded that the vehicles at Dhaka city remains idle or at very low velocity during 56.2% of the total cycle time and the value of acceleration changed very rapidly and frequently. From the collected data an elementary driving cycle for Dhaka city was developed. Its total cycle duration is 2050 seconds, average distance 7.2 km and average speed 12.7 km/hr.

5. REFERENCES

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