Reducing Harmful Effects of ICE Using EV in Metropolitan Cities

Arif Senol Sener

***Abstract*—Rapid increase in world population cause many problems such as air pollution due to usage of fossil fuel. In this article, effects of internal combustion engine (ICE) light commercial vehicle (LCV) to air pollution is investigated considering the Turkish customer profile in a metropolitian city Istanbul. This paper also presents a comparison of air pollution effects of vehicles between European Metropolitian cities and Istanbul in terms of number of breaking, loss of energy due to waiting time in heavy traffic as well as health and economic effects. The benefit of using electrical vehicles (EV) are suggested as an alternative to reduce air pollutions in metropolitian cities.**

***Index Terms*—Air pollution, braking, disperced energy, electrical vehicle , emission.**

I. Introduction

As it is known that air pollution is very harmful effects on human health, environment and economy. Pollutants in the air is produced by industry, transport and residential heating. As a result of dirty air leads to respiratory and cardiovascular diseases in everyday. It also harms ecosystems and biodiversity and cause to a decrease in agricultural crop and commercial forest yields [1]. It is therefore paramount that we take necessary step along the sectors and national borders. Each year millions be wronged poor health as a result of bad air quality, both inside and outside. Mainly the sources of air pollution are industry, residential heating and especially the most one from traffic. Conventional ICE cars with internal combustion engines (ICE) have many disadvantages in respect to air pollution that is harmful effects on living creature due to the vehicle exhaust gas, low efficiency, nongained regenerative brake force energy, noise pollution and fuel dependence of improving countries. In Fig. 1, one of the conventional ICE vehicle's inlet and outlet gasses are presented. After combustion of fossils fuels cases, gases written at the right side of the figure is generated.

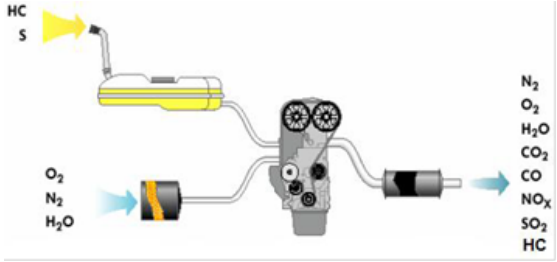

Fig. 1. Gases generated by combustion of fossil fuels in ICE vehicles [2].

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The exhaust gases produced by ICE vehicles are one of the major factors that lead to air pollution in recent years. The main pollution sources of a vehicle; exhaust pipe, fuel tank, ventilation cartel, carburetors, brake pads and tire [2].

World Health Organization (WHO) announced in their reports 1.4 percent of deaths caused by the air pollution [3]. Moreover, 50 percent of these deaths that is caused by road traffic pollution are expected in Europe [3]. Furthermore many kinds of diseases such as asthma, allergic reactions, bronchitis, upper respiratory tract infection or, in large part, cardiovascular disease is contribuited by road traffic pollution. Inhaling polluted air makes the blood coagulate has been proved [3]. When the level of PM particles exceeds the WHO limit standard of 25 mg/m3 Deaths are increased [3].

To eliminate harmfull effect of ICE's emission, many countries in the world have started working on new alternative energy sources that has zero emission for using in all areas. In Fig. 2 CO2 emmison target setted by different coutries for all type of light commercial is demonstrated. When the EU Co2 target is compared to US, China and Japan is ambitious. And It is aimed for a 95 g CO2/km by 2020; and regulations are likely to further tighten beyond 2020. For example, in 2013, a target of 68-78 g CO2/km was planned for 2025, with the final decision on post-2020 targets likely to be reached in by 2016 [3].

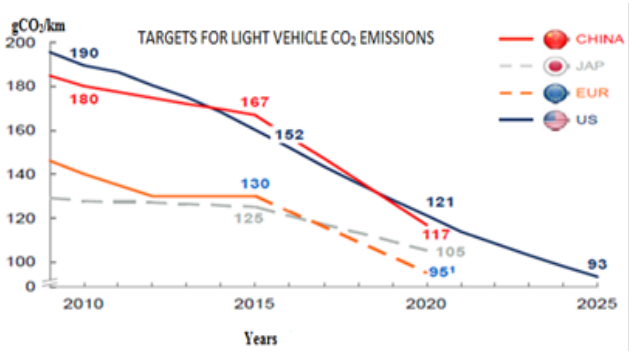

Fig. 2. Planned emission standards in select region gCO2/km normalized to New European Driving Cycle [3].

These tightening regulations are pressuring automotive original equipment manufacturer (OEMs) to reduce their fleet emissions. Achieving the emission reduction targets beyond 2020 will require some form of electrification [3]. In last 5 years in EU many governments have setted EV adaptation target in order to accomplish the goals of emissions reduction, energy independence, and technology ownership. It is aimed that approximately 8-9 million EVs will be on the road by 2020.

Especially, in last two decade some of the automotive manufacturers in Turkey have started R&D research so as to

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satisfy their customers expectation in terms of vehicle performance aqusitic, fatigue test etc. according to Turkish customer profile. There are two popular method is being used in the world for determining customer usage profile; one is questionnary and second is black box method which are used for determination of load spectrum for the whole life of vehicle is very important [4]-[8].

One example of a customer usage study which includes dry and wet ground usage of tractor and agriculture as well as non-agriculture tractor usage and also regional tractor usage examination is a study on a tractor usage in India, which was performed by ETEC (Eicher Tractors Engineering Centre) and ARIA (Automotive Research Association of India [9]. Another example is a customer usage study performed by FIAT Co. for Brazilian and Italian markets [10]. And one of the other example is of customer usage study was performed by FIAT Co. for defining Turkish customer vehicle usage profile and fatigue characteristics effect of Turkey's road profiles on a segment B vehicle produced in EU [11]. Iveco and nCode Co. realized one study in 1999 in Australia [12]. During this study they acquired 28 load measurements, 12 micro-strains, 2 weight conditions, 16 test track surfaces revealing 1280 signals with approx. 1.5 gigabyets and 26 road route surfaces revealing 280 signals with approx. 4 gigabytes. But in this study on 50 roads, approx. 45 gigabytes raw data were acquired and after processing the raw data, the total data file size was increased from 45 gigabytes to approx. 200 gigabyets [4].

In this study, the road fatigue characteristics are totally measured from one city to another city to find out fatigue effect of different roads and to form new reliability roads that are necessary during the process and pre-series production around the interested factory. During the research it is observed that large cities especially Istanbul in Turkey have traffic jam very heavy is subjected to vehicles to start-stop, waiting in traffic very long time consequently made a lot of brake which lead to great loss of energy. Moreover, by referencing this measurements the braking quantity and pressure in normal driving conditions in Istanbul traffics is measured consequently and then the amount of energy lost during braking is calculated [4],[11].

II. Air Quality and Vehicle Fleet in Turkey

In every country, the energy sector (residential heating, traffic, industry) originated from fuel consumption that has been increasing as well as greenhouse gas emission [13]. The main factors that determine the air quality in the past; industrial activities and heating fuel consumption but especially nowadays it has become one of the main factors of traffic as a result of the rapid increase in transport networks. In Fig. 3 the total number of vehicles evaluation between 2000 and 2014 in Turkey is presented [14]. As it can be seen from the graphic, the total vehicle quantity has been increased gradually year by year.

A. The Case of Istanbul

Istanbul has a surface area of 5343 km square with 39 districts. In addition, Istanbul has been considered as the industrial, economic and financial center of Turkey with 55% of trade and 27.5% of the national production in Turkey. The emission sources in Istanbul have changed significantly. Twenty years ago, anthropogenic emissions are mainly produced by residential heating and industrial sources, today the most important anthropogenic sources are industrial sources as well as vehicle traffic and has been re-aired collapsed powders resulting traffic [15].

Quantity of vehicles fleet in Istanbul, being a metropolitan city, are so huge due to the immigration from all over the Turkey. This heavy traffic in Istanbul causes air pollution and increased CO2 emission by giving harm for human beings. In Fig. 5, the percentage of vehicle fleet of Istanbul and Turkey is showed [14]. 20% of PM, 1% of SO2 ,68% of CO , 89% of NOx, 68% of NMVOC emissions are emitted by vehicles fleeted in Istanbul in year 2012 [16].

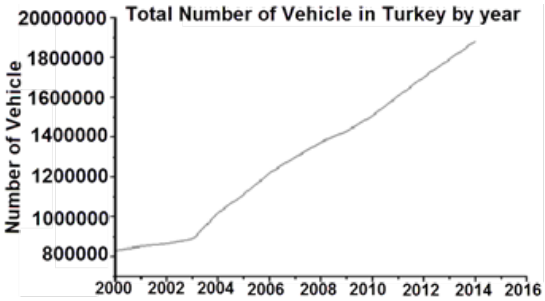

Fig. 3. Total number of vehicles in Turkey by year [14].

III. Implementation and Methodology

While Turkish Mission Profile was being searched with a LCV at variety of regions and cities in Turkey a lot of parameters such as; accelerometers, transducers, thermocouples etc. and their force, torque, displacement, temperature etc. signals were recorded in normal traffic conditions [4], [5], [17]. The datas were collected in six different region of Istanbul. Collected raw brake force and temperature data were processed with spike analysis, filtering analysis, arithmetic manipulation [8]. Immediately after proccesed datas is subjected to by statistical level crossing counting method [8], [18]. Then each brake force data are normalized to 1000 km for the comparison. After that the average of the 6 route were handled by applying arithmetic manipulation. en you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

A. Istanbul Brake Force Datas

In Fig. 4, the brake pressure transducer that is used for collecting brake data's quantity and pressure which has the range from 0 to 200 bars with voltage is presented.

Fig. 4. Brake disc transducer.

Fig. 5. Front left disc thermocouple.

In Fig. 4 and Fig. 5 subsequently, K type brake disc thermocouple, which has the range from -160...+ 1260, is used for collecting brake disc temperature and brake transducer fixed on the brake liquid pipe which has the range from 0 to 200 bar are presented.

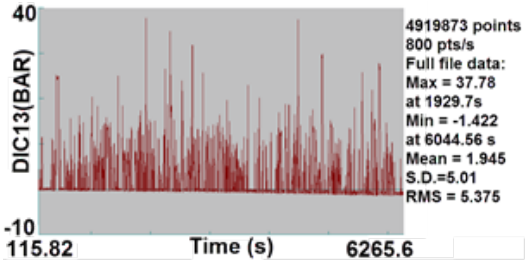

Fig. 6. Brake pressure test_301 in Istanbul.

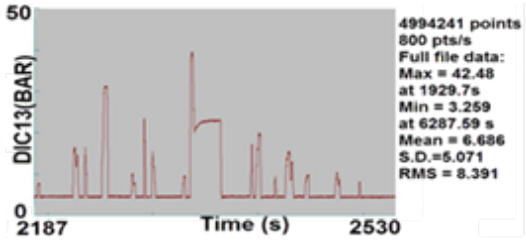

Fig. 7. A section of brake pressure test_301 in Istanbul.

Fig. 6 and Fig. 7 subsequently demostrade Istanbul test _301 brake test pressure and quantity in time domain totally and momently.

IV. Results and Discussion

A. Eloboration of Brake Force Quantity

In Fig. 8 elaboration of brake force quantity for 1000 km during normal driving condition in Istanbul is presented. These quantity of brake forces are provided from 6 different routes average of measured data in Istanbul. Before averaging each route distance signal is normalized to 1000 km [4], [11].

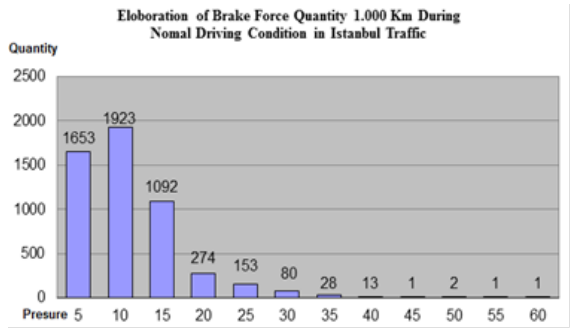

Fig. 8. Brake force quantity 1000 Km during normal driving condition in İstanbul Traffic.

B. Disperced Energy Calculation

In Fig. 9 front right brake disc temperature in time domain and level corssing counting graphics of test_301 in İstanbul is presented.

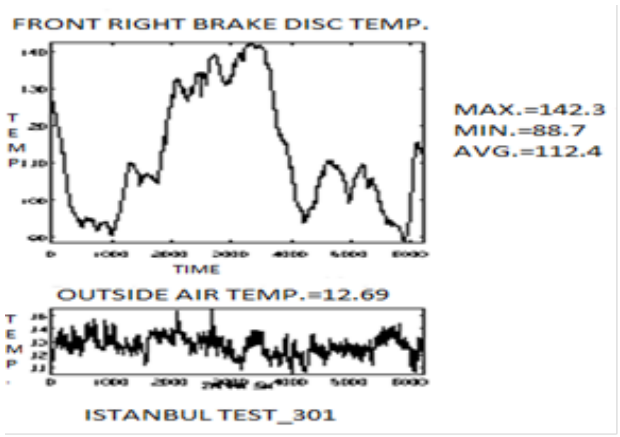

Fig. 9. Front brake disc temperature graphics during Istanbul test 301.

TABLE I: Disperced Energy Calculation

İSTANBUL (CITY USAGE)	$T_{1,max}$ (°C)	$T_{1,min}$ (°C)	$T_{1,0}$ (°C)	T_2 (°C)	Δ T ($T_{1,0}$- T_2)	t (s)	X (Km)	N 1000 Km	Disperced Energy DELE = ΔT*t*x*N
IST_ 101	188	59,3	118,8	13,8	105,0	7169	55	18,2	13683665
IST_ 201	246,8	40,3	119,8	10,1	109,6	6535	70	14,3	10235990
IST_ 301	196	89,3	136,2	12,7	123,5	6085	39	25,6	19270727
IST_ 401	279,8	29,4	125,2	13,8	111,4	5365	41	24,4	14579715
IST_501	277,7	44,4	112,3	13,3	99,0	11828	88	11,4	13302468
IST_601	268,8	39,7	110,9	14,4	96,5	7701	57	17,5	13037658
AVERAGE									14018371
AVER.*200									2803674113

In Table I the disperced energy calculation is presented where;

$T1$,max (oC) =Max front left brake disc temp.0 C

$T1$,min .(oC) = Min front left brake disc temp.0 C

$T1$,0 (oC) = Average front left brake disc temp.0 C

$T2$ (oC) = Average external air temperature Δ T

ΔT ($T1$,0- $T2$) = Average external air and front left brake disc temperature

t (s) = Test time(second)

X(Km) = Test distance

N 1000 Km = Normalized test distance to 1000 Km.

The formula for calculation of energy dispertion is presented as following [11];

$$DELE = \Delta T(T1,0- T2)* t(s)*X*N$$

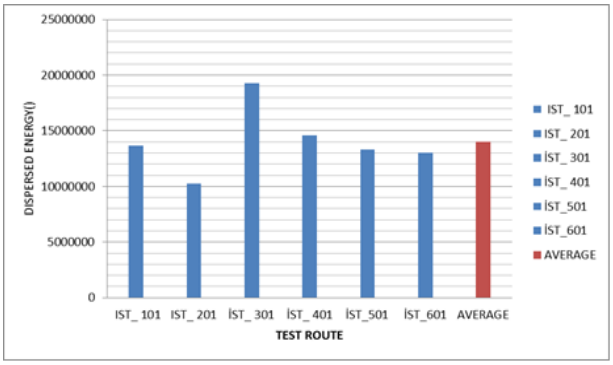

Fig. 10. Disperced energy distrubuition for different test route in Istanbul.

In Fig. 10, statistical data of the disperced energy quantity

for six routes and their average 1000 km normalized data are depicted. Recall that for photon of energy dissipated quantity is a quantity proportional to the total energy dissipated by radiation convection and conduction. By the sizes, it calculates the factor of energy dissipated by that important information about the capabilities worn (pads and discs) paths. They were not introduced the various coefficients as the data are used only to compare. From the graphs it is evident that the paths are more generous for braking system the sequentely IST_301, IST_401, IST_101, IST_501, IST_601, IST_201.

V. Conclusion

There is a significant share of ICE on air pollution causing to necessary the development of emission control technologies. Despite emission-reducing technology, it has not been reached the desired value. Istanbul is the largest city of Turkey that is ranked seventh out of 97 cities in terms of most air polluted cities in the world [19]. Air pollution in Istanbul exceeds the maximum tolerable limit set by WHO [20]. This has led to necessary the development of emission control technologies. Air pollution level in Istanbul effecting human healt is still above the critical value, altough the produced vehicles equppied with emssion control technologies from Euro 1 to Euro 6 have been used by customers since 2000 year [16], [19], [20]. In this study it is examined that the air pollution in major cities has reached alarming levels for the reasons explained above, therefore reducing air pollution studies should be performed by each country.

On the other hand, the use of electric vehicles is an alternative solution that could be applied to where a lot of work is done on this issue in the World and Europe. This study create awerness that there are many reasons for increasing the use of electric vehicles replacing by ICE vehicles. The first and most important ones that electric vehicles have low emission values which are not considered [21]. Otherwise the most significant element is the electric motor.

In addition, when the EV is stationary like in Metropollitan city (Istanbul) and at traffic lights. It is not consuming any energy, unlike an ICE, which is wasting 100% of its fuel energy. Similarly, an electric motor can use regenerative braking to recover energy when the driver brakes and at idle speed case. But a petrol engined car's braking energy is simply lost as heat by friction without any recover breake energy. More than this frequently braking and start and stoping can cause the wear of breaking components before the estimated life interval [4], [6].

With ICE vehicle is used in the metropolitan city like Istanbul, energy losses are at high level during stop and waiting times. Although new vehicles are equipped with the start and stop systems cannot be prevented enough energy loss.

As it can be seen from Fig. 11 that a B segment gasoline vehicles produced by European manufacturer that is used in Europe, dispersed energy calculation in Istanbul and various roads is illustrated in Fig. 11. This measurements were done by a segment B gasoline vehicle with 57 HP gasoline engine [11].

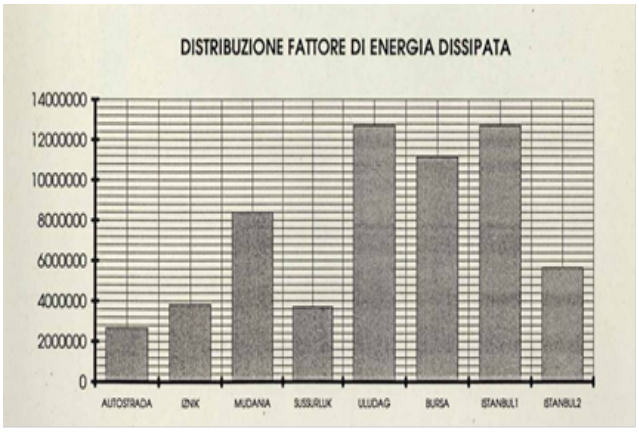

Fig. 11. Dispersed energy distribution of different test route [11].

In this study one LCV has 77 hp diesel engine is used for measurement [4]. When comparing amount of disperced energy of this vehcile is too close to segment B European vehicle energy lost. Fig. 10 and Fig. 11 illustrade that Istanbul_1 test route has the 13000000 KJ whereas Istanbul test_301 has 19271000 KJ energy disperced [11]. This difference is thought that due to the weight of the vehicle, the road route and dissimilar vehicle traffic between different years.

As it is clear that used fossil fuel in internal combustion engine force the countries to depend on petrol producing countries. Where as the electricity energy necessary for EV might be provided by different ways such as ; nuclear energy, solar energy, wind turbines, hydroelectric power plants, thermal power plants, wave generators, photovoltaic conversion thus the petrol energy dependency of the goverment can be reduced either air pollution, make better economy. In Europe, the deployment of reducing petroleum fuel use by the transition to electric vehicles is activated. However the concrete steps have not been taken in Turkey. Therefore Turkey should apply deployment policies of electric vehicles without any delay.

Acknowledgment

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