



Determine the Useful Life of Catalytic Converter and Standard Revision of Technical Inspection Centers

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ARTICLE INFO

Article history:

Received : 2 June 2021

Accepted:30 Aug 2021

Published:1 Sep 2021

Keywords:

Catalytic Converters

Pollutants

Pollution standard

Technical Inspection

ABSTRACT

Today, many car manufacturers can achieve emission standards through catalytic converters. The goals of this research was in tow sections. Initially, the amount of pollutants was measured to determine the role of the catalytic converters in the reduction of pollutants for 3 types of vehicles and in 50 cases, in the two stages before and after the catalytic converter. Then, to achieve the useful life of the catalytic converter, out of 750 test vehicle emissions were tested. Data analysis was done by SPSS software, which shows that catalytic converters can reduce up to 80% of exhaust emissions. This is independent of the type of vehicle. The useful life of the catalytic converters is up to 36 months, so they should be replaced at least every three years. Also, the pollutant standards of the technical examination centers are reviewed. For this purpose, the pollutants have been measured in 2200 vehicles. Due to the huge difference in technology, cars are divided into two main categories of carburetor and injector and are analyzed statistically. Eventually, for each group of these vehicles, the values of HC, CO and O₂ are obtained.

1. Introduction

Due to the increasing production of cars in the world, the biggest danger that threatens the human environment is polluting gases that emitted from cars. Most countries in the world deal with the problem of car pollution and the enactment of laws to prevent the movement of polluting vehicles in the environment, as well as the application of pollution standards by car manufacturers [1].

Catalytic converter is one of the solutions to reduce car pollution. These converters effectively prevent air pollution by chemically purifying pollutant gases. The main pollutants produced by engines such as; nitrogen oxide (NO_x), carbon monoxide (CO), unburned hydrocarbons (HC) and other suspended particles. Figure 1 shows the contamination of these three main pollutants as a function of the dimensionless compression ratio for

a conventional spark ignition motor in steady state situation. Contamination of nitrogen oxides and carbon monoxide, as well as half of all hydrocarbon pollution, is caused by engine exhaust gases. In addition, all fuel-consuming systems produce large amounts of carbon dioxide, which is the most important greenhouse gas [2].

If combustion occurs complete, the gases from the exhaust are only CO₂ and water's vapor. But when the rich mixture is burned, there is not enough oxygen for complete combustion and some of the carbon is converted to CO. In contrast, when lean mixture is burned, NO is produced due to the presence of excess oxygen to combine with N₂, especially at high temperatures. Pollution of spark ignition engines is divided into three categories: exhaust emissions, evaporative pollution, and crankshaft contamination. The most important

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<https://doi.org/10.22068/ase.2021.590>

components of NO_x, CO and HC pollution are exhaust emissions [3].

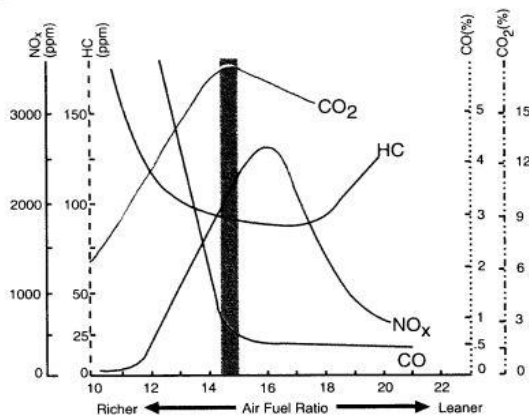


Figure 1: Concentrations of different pollutants and fuel consumption based on relative air-fuel ratio [4]

Some paper aims at reviewing the present development and improvement on the catalytic converter used on the reduction of exhaust emission in order to meet the regulations and market demand [5].

Technical inspection has also been introduced and expanded as a set of test rules and procedures by using specific equipment for each test, and more than half a century has passed since the introduction of the technical inspection plan in developed countries [6]. With the increasing number of cars and air pollution problems, the fight against pollutants has been seriously pursued, and the Environmental Protection Agency has implemented pollution standards in Iran according to European standards.

Li etc. observed whether air pollution affects analyst information production by exploiting variation in air quality. In comparison with other analysts, analysts exposed to air pollution are less likely to issue timely or accurate forecasts. The evidence recommended that air pollution jeopardizes analysts' ability to make available information to the capital market [7].

the causal relationship between China's fuel standards, which specify lower sulfur content, and air pollution was considered. They exploit a difference-in-differences design and regression discontinuity analyses. Evidence proposed the enforcement of high-quality gasoline standards significantly improved air quality. The outcomes confirmed the efficiency of precise standards in reducing air pollution in a developing country setting [8].

Today, due to the diversity in the production of domestic cars in terms of manufacturing technology (production of cars with 1950 technology) and the production of all kinds of modern cars in the world, the way of conducting examinations and issuing technical inspection cards is currently facing shortcomings. For example, the acceptable range of HC and CO pollutants, which are the most important pollutants, is $CO < 5\%$ and $HC < 500$ ppm. In many modern cars (injectors), the HC and CO are below 0.5% and 100ppm, respectively. However, many modern cars in our country, in the worst case of engine operation, also manage to receive a technical inspection of the car. In this study, the role of catalytic converter in reducing emissions from gasoline car exhaust and determining the useful life of converters has been investigated. Also, the pollution standard of car technical inspection centers is examined and the standard values of HC, CO and O₂ are proposed to create more suitable conditions for the pollution test in car technical inspection centers.

2. Research data collection method

The required data of this study were obtained in Kerman Technical Inspection Center No. 3 by random sampling of 3000 vehicles referred to the Technical Inspection Center in a one-year period. This is while the total number of passenger cars in the country is 18370000. The sample size was selected using simple random sampling and Cochran's formula and 90% accuracy of 3000 vehicles. In this study, the statistical population under study, passenger cars that refer to technical inspection and measured variables, type and model of vehicles and items measured by the test device, vehicle exhaust pollutants (HC, CO, O₂, CO₂ and λ). In this center, uses the MGT5 (figure 2) exhaust smoke analysis device and complies with the zero class OIML standard, which has the highest measurement and display accuracy. It is worth noting that CO, CO₂ and O₂ are measured in terms of the percentage of volume in the exhaust gases from the exhaust and HC in terms of parts per million (ppm). The value of λ is also determined numerically.

2.1 The role of catalytic converter in reducing pollutants

Among the cars, Pride, Peugeot 405 and Peugeot 206 have been selected due to their multiplicity, as well as the high percentage of pollutant production compared to other cars [9]. First, the available data

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were statistically analyzed with SPSS and Excel software. Then the output variables of the pollution test device (HC, CO) are described separately. The contour box diagrams for these cars, measured before and after the catalyst, that are shown in Figures 3. It should be noted that in this category, only examples of the obtained graphs are presented. The amount of contaminant is indicated before the catalyst by the letter B and then by the letter A.



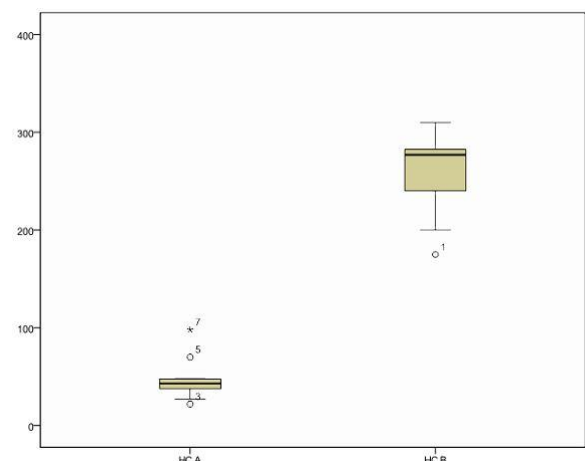
Figure 2: The device used in the current study

It should be noted that the box diagrams contain complete information of the minimum, maximum, first and second quarters. In this study, HC and CO pollutants will be investigated and NOx contaminants will be investigated in the next steps. Studies have shown that the performance of the catalytic converter is acts to reduce the amount of pollutants independent of the type of vehicle, and reduces CO by about 80% and HC by 78%. Examination of the charts shows that catalytic converters in ideal conditions can reduce the amount of unburned HCs by 83.9% and CO by 79.9%.

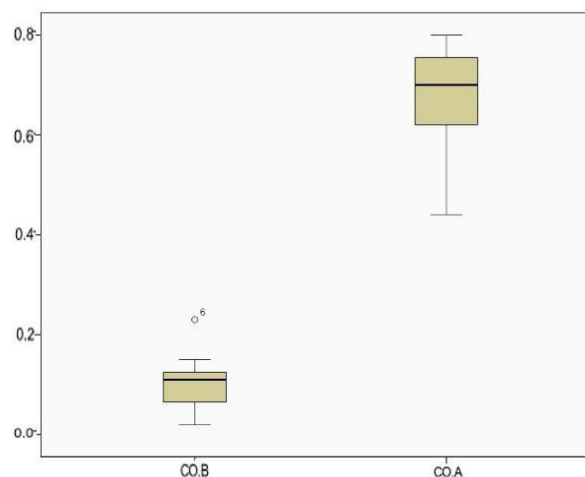
2.2 Investigation of catalytic converter life

In order to obtain the useful life of the catalytic converter, 750 vehicles have been tested for pollution in three consecutive years, and the variables HC, CO, O₂, CO₂ and λ have been measured and the obtained results were presented as box diagrams (figure 4). These diagrams show the amount of HC and CO for each car according to the year of production (first, second and third year after production), which is equal to the year of production of the catalytic converter. Along with

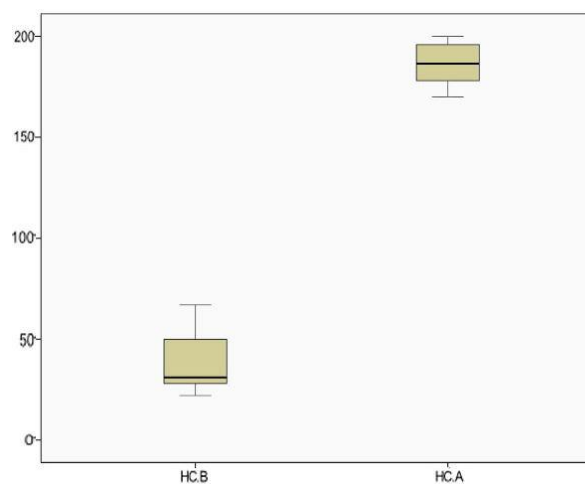
the operation of the car, the efficiency of catalytic converters also decreases.



(a)

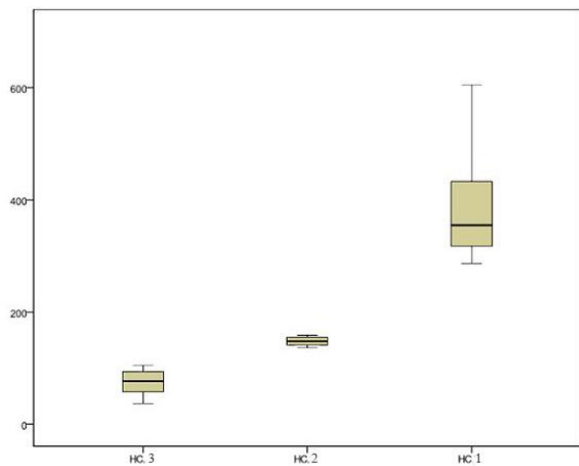


(b)

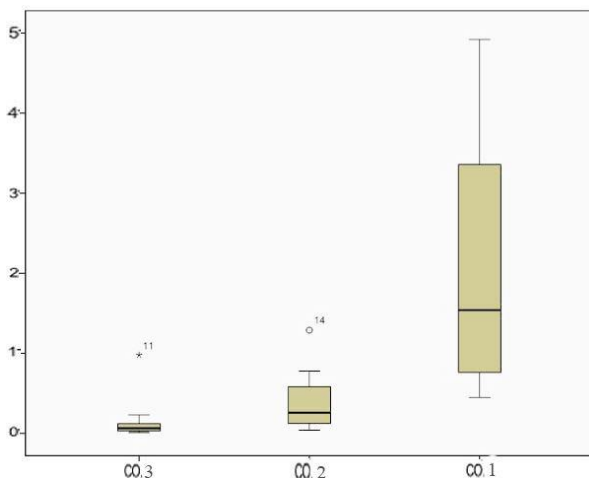


(c)

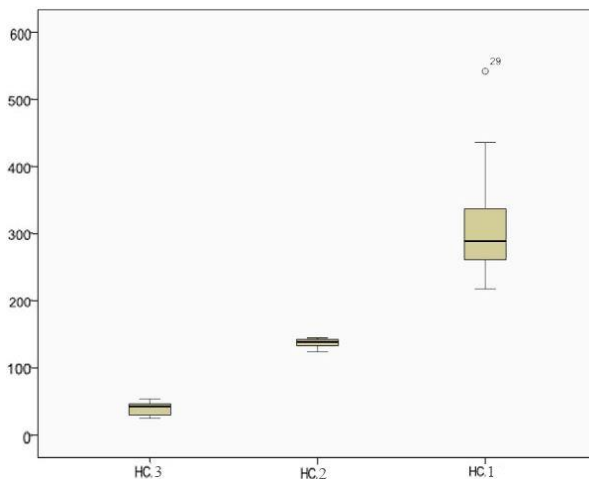
Figure 3: a) HC level in Pride before and after catalytic converter, b) CO level in the Peugeot 206 before and after the catalytic converter, c) HC level in the Peugeot 405 before and after the catalytic converter



(a)



(b)



(c)

Figure 4: Parameters rate according to the life of the catalytic converter: a) HC in the Pride, b) CO in the Peugeot 206, c) HC in the Peugeot 405

Examination of the charts showed that after two years of catalytic converter operation, the average HC output was 55% and after three years it was 80%, and CO was 62.5% after one year and after

two years 88% will increase. With this description, the useful life of the converters is a maximum of three years and they need to be replaced after this period.

2.3 Checking the pollution standard of car technical inspection centers

Due to the great difference in the technology of making different types of carburetor and injector cars, the amount of exhaust emissions from these cars is very different. Thus, carburetor and injector vehicles are divided into two separate categories, and each category is analyzed separately to obtain statistical values for the three CO, HC, and O₂ gases for each group. The available data are categorized and statistically analyzed by using SPSS and Excel software. Figure 5 shows the description of these variables among the subjects.

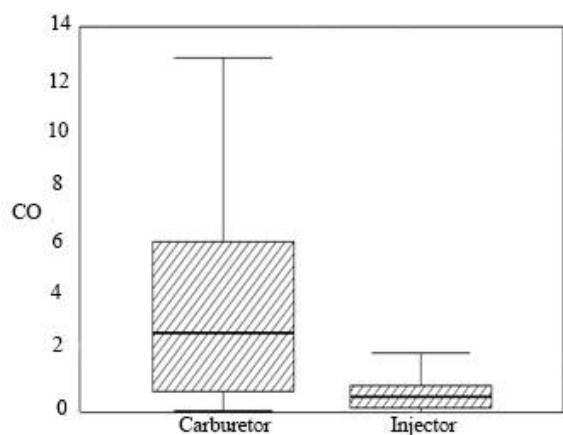
2.4 Calculation of pollution values of technical inspection centers

Currently, all cars are tested under the same conditions, while there is a great variety in terms of quality between these cars. For the three gases HC, CO, O₂, the acceptable range is currently specified. At this stage, according to the available data, the aim is to introduce new ranges for each of these three gases. To achieve this goal, the data for each gas is sorted upwards and then the vehicles that are outside the acceptable range are removed (For the three HC, CO, and O₂ gases, larger or equal values of 500, 5, and 4 were removed, respectively). Then, for the remaining data, the mean and standard deviation values are calculated and the sum of these two values is introduced as a new range for each gas that can be prepared and presented to the Environmental Organization for proposal (Table 1).

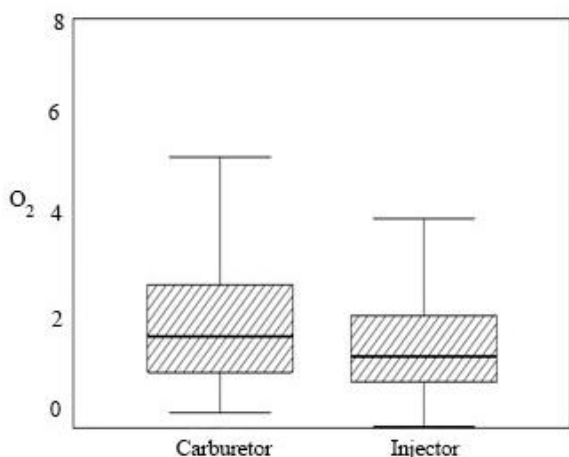
Among the vehicles tested to obtain the index values, it is observed that in carburetor vehicles, the average amount of O₂ is 1.75 with a standard deviation of 0.9, the average of CO is 1.78 with a standard deviation of 1.5, the average of HC is 243.71 is obtained by standard deviation 118.89. Average values were obtained by calculating a standard deviation for O₂, CO and HC was 2.65, 3.28 and 362.6, respectively. Similarly, in injector vehicles, the average amount of O₂ was 1.47 with a standard deviation of 0.86, the average of CO was 0.81 with a standard deviation of 0.96, and the average of HC was 144.87 with a standard deviation of 95.98. Average values were obtained

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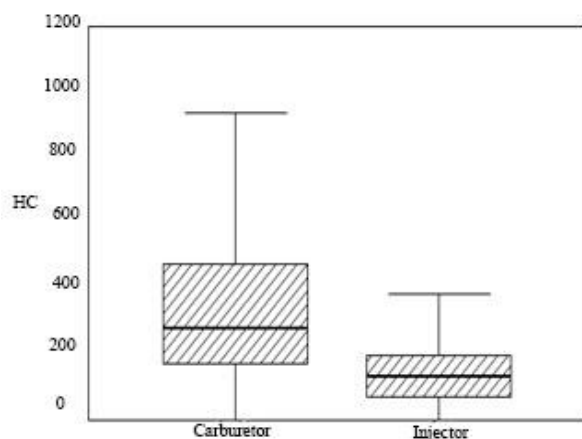
by calculating a standard deviation for O₂, CO and HC was 2.33, 1.77 and 240.85, respectively.



(a)



(b)



(c)

Figure 5: Diagram of variables boxes: a) CO, b) O₂, c) HC

Table 1: Describes the variables

| Engine type | Variable | Average | Standard deviation | Acceptable range |
|-------------|----------------|---------|--------------------|------------------|
| Carburetor | O ₂ | 1.75 | 0.9 | 2.65 |
| | CO | 1.78 | 1.5 | 3.28 |
| | HC | 243.71 | 118.89 | 362.6 |
| Injector | O ₂ | 1.47 | 0.86 | 2.33 |
| | CO | 0.81 | 0.96 | 1.77 |
| | HC | 144.87 | 95.98 | 240.85 |

3. Conclusions

In the present study, the role of catalytic converter in reducing pollutants and determining its useful life in gasoline vehicles, as well as reviewing and modifying the pollution standard of vehicle technical inspection centers have been studied. The results are:

- Catalytic converter performance reduces the amount of pollutants independent of the type of vehicle and reduces the amount of CO by about 80% and the amount of unburned HCs by 78%.

- The useful life of catalytic converters is a maximum of three years, after which the amount of emissions increases by more than 80%. Therefore, conditions must be provided to replace catalytic converters at most once every three years.

- Carburetor cars are much worse in terms of performance and emissions than injector cars, so that the average CO₂ in injector cars is 13.37 and in carburetor cars is 10.91, which indicates the quality of better combustion in it's an injector car. Also, the average CO in injector cars is 1, and in carburetor cars is 3.87, and the average HC is 165.41 and 368.81 in injector and carburetor car, respectively. Obviously, part of the difference observed in the results is due to the difference in car models, which on average carburetor cars have a lower average model than injector cars.

- The proposed acceptable range values were obtained by calculating a standard deviation for O₂, CO and HC was 2.65, 3.28 and 362.6, respectively for carburetor vehicles. Similarly, for injector vehicles the average values were obtained 2.33, 1.77 and 240.85 for O₂, CO and HC, respectively.

- Given the 27% share of carburetor cars in Iran, and the high levels of pollutant production in these cars (which is mostly due to design problems) and the high share of fuel consumption in these cars in the first priority, the government provided conditions for carburetor car owners to replace new and remove carburetor vehicles from the country's transport fleet.

- Since many drivers try to remove the catalyst in the car due to a decrease in power in their car (2 to

3%), it is recommended that the vehicles referring to the technical inspection centers be controlled in terms of having a catalyst and provided conditions. Catalysts should be replaced at most once every three years.

- The acceptable range must also be defined for λ . In some cases, car repairmen have to adjust the carburetor with a lot of air to minimize the amount of pollutants in order to get the car out of the pollution test, and after passing the test, they adjust the car with high fuel again. It should be noted that the best range of λ is between 1 to 1.1.

Engineering, Vol. 10, No. 2, (2020), pp. 3227-3232.

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