Study on the classification of actions aimed to reduce the fuel consumption of road vehicles in service

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Abstract: This paper addresses the major global problem of reducing fuel consumption in the transport sector. The authors present the results of a study on the use of a quality management tool - tree diagram. The actions aimed at reducing the fuel consumption of the road vehicles in operation have been identified and classified. A three-level tree diagram was developed to answer the question: How can fuel consumption be reduced? The chart provides a complete and suggestive picture of the actions to be taken to solve the proposed problem. The actions have been grouped into three corresponding categories for three specific objectives: the acquisition of a vehicle suitable for the needs; proper use of the vehicle (eco-driving); proper maintenance. The authors of the paper believe that the tree diagram obtained is a good tool for informing and raising the driver's awareness of his role in reducing fuel consumption.

1. Introduction

Nowadays, automobiles are a very useful means of transport for comfortable transport and offer freedom of movement over short or long distances to solve work problems or for leisure travelers. The road transport sector has an upward trend influenced by human society which is in continuous development. This has led to an increase in the total number of means of transport and the increase in the total distance covered by motor vehicles. The final effect is also a negative one due to the excessive increase in fuel consumption. Big fuel consumption is a topical issue, as oil reserves are exhaustible within a relatively short period of time. Also, the automobiles by pollutant emissions have negative effects on the environment and human health. Carbon dioxide, emitted by cars in a quantity proportional to fuel consumption, is responsible for the global warming of the planet and negatively affects sustainable development. Another issue for transport companies is related to the cost of purchasing fuel that has increased much in recent years. They are directly interested in reducing fuel consumption.

Reduce fuel consumption is a research theme at world level, which concerns in particular the engineers in the field of construction of cars. Their attention was heading toward more and more constructive variants with low power consumption of fuel.
In the first part of the 21st century, there was an increased concern for the construction of new hybrid and electric road vehicles. The number of new hybrid cars and electric vehicles is growing, but the infrastructure for electric vehicles is still underdeveloped. Therefore, reducing the fuel consumption of road vehicles in service remains a major concern.

Specialty literature offers a lot of papers dealing with fuel consumption. In the following, we present for examples, only a few of the papers dealing with this issue. The paper [1] presents a study on the use of a new device attached to the engine to reduce fuel consumption. In the papers [2, 3] are proposed models based on the Genetic Algorithm (GA), to reduce and estimate the fuel consumption based on the optimization of transport parameters. Also based on the Genetic Algorithm, a management scheme for efficient fuel consumption was established [4]. The paper [5] presents an analysis of the influence of driver training programs on reducing fuel consumption. The paper [6] presents a study on improving driver behavior in the sense of reducing fuel consumption, based on feedback from some data recorders. Studies have also been carried out to determine a customized route search method based on vehicle behavior recognition, [7]. Research has also been carried out on the influence of vehicle design and traffic simulation, on reducing fuel consumption, [8]. More articles on Eco-driving and eco-driving effectiveness have been published. Some experiments were carried out by integrating a driving simulator and a traffic simulator [9, 10, 11, 12].

This paper presents the results of a study on the use of a quality management tool - tree diagram, to solve the problem of reducing fuel consumption in vehicles in operation.

Quality management tools are techniques that apply to different areas of activity. Most techniques are graphical methods, which, in their clear and explicit form, form a graphic image suggestive to solve a problem or a nonconformity. Applications of quality management tools are found in several studies and research on solving some quality problems. The authors of this paper (unique authors or research teams) have published other studies on the use of fishbone diagram and tree diagram [13, 14, 15, 16, 17, 18, 19]. In the Specialty literature are studies which use the tree diagram to solve some quality problems in various fields, such as: machine tool manufacturing [20,21], the design of the services of medical assistance [22], waters quality [23], quality products according to customer needs [24], program management in different organizations [25], etc.

2. Classification of actions to reduce fuel consumption in road vehicles in service

We studied the main factors that determine the fuel consumption of road vehicles in operation: the purchased vehicle model, driving style and maintenance. This has identified the actions needed to reduce fuel consumption. The actions have been grouped into 3 corresponding categories for the following three specific objectives: the acquisition of an automobile appropriate to the needs; the proper use of the vehicle (eco-driving); proper maintenance.

The study was based on a Brainstorming session with specialists in the field of motor vehicle engineering. Several papers in the literature were also consulted. The study was completed by drawing up a list of actions, presented in Table 1.

| Specific Objective | Actions |
|--------------------|---------|
| 1. Acquisition of a vehicle suitable for the needs | Avoiding the option for the automatic gearbox; For city journeys, "4 x 4" vehicles are not recommended; Choosing aluminum rims that reduce the weight of the car and contribute to fuel economy; Rationalization of facilities offered by electrical accessories; Choosing a diesel engine is recommended at a |
| 2. Appropriate use of the vehicle (eco-driving) |
|---------------------------------------------|
| yearly run higher than the usual one (10 ÷ 15 thousand km / year). |
| Choosing shorter and less crowded routes; |
| Choosing good quality roads; |
| Adopt a preventative and continuous driving style with avoiding brakes / accelerators and unnecessary speed changes (no starting, accelerating and sudden braking); |
| Avoiding left-right maneuvers through the strips, turns standing on the spot; |
| Using the motor brake as much as possible (speed reduction to be done gradually) |
| No long stops (more than one minute) with the engine running; |
| Avoiding the initial engine heating for too long; |
| Observing speed limits and moderate speed travel; |
| Rational use of air conditioning only when strictly necessary; |
| Using a GPS navigation system (the system offers information to the driver and helps in vehicle fleet management at auto monitoring); |
| Do not place unnecessary luggage (especially heavy) in the vehicle; |
| Periodic checking of the tire pressure (suitably inflated tires); |
| Do not use in the summer, winter tires that have increased consumption; |
| Using proper fuel; |
| Using the control system of cruising speed. |
| 3. Proper maintenance |
| Maintaining an optimal state of operation of the car through regular maintenance by the specialist; |
| Performing the periodic review according to the manufacturer's recommendations; |
| Comply with the instructions in the vehicle's manual on changing the air filter, spark plugs, engine oil, other fluids, etc.; |
| Dealing with deficiencies is done by professionals; |
| Checking and adjusting the engine is done by the professional mechanic. |
3. Tree Diagram for reducing fuel consumption

A tree diagram is proposed on 3 levels: the general objective, three specific objectives and the actions corresponding to each specific objective. The diagram is shown in Figure 1.

![Tree Diagram for reducing fuel consumption](image)

**Figure 1.** Tree Diagram of reducing fuel consumption

The general objective forms the level I and is given by the problem to be analyzed: reducing fuel consumption. The second level of the diagram is given by the three specific objectives: the acquisition of a vehicle suitable for the needs; proper use of the vehicle (eco-driving); proper maintenance. The actions proposed to solve the problem and the fulfillment of the three specific objectives are the third level of the tree diagram.

4. Conclusion

The tree diagram presented in this paper is used to answer the question: How can fuel consumption be reduced? The chart provides the optimal solutions to solve a major problem that concerns all of the world, reducing fuel consumption.

The specified tree diagram can be used in service and showroom of vehicles. The diagram can be displayed as a poster, at a visible place, to be read by drivers who go to buy a car or to perform service...
operations. The diagram provides a complete and suggestive picture of the actions to be taken to reduce fuel consumption. Some economic driving tips are needed and the probability of being applied increases because the solutions come from some specialists in the automotive industry.

The authors of the paper believe that the tree diagram obtained is a good tool for informing and raising the driver's awareness of his role in reducing fuel consumption.

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References
[1] Al-Rousan A A 2010 Reduction of fuel consumption in gasoline engines by introducing HHO gas into intake manifold Fuel and Energy Abstracts 35(23) pp 12930-35.
[2] Soofastaei A, Aminossadati S, Kizil M S and Knights P 2016 Reducing Fuel Consumption of Haul Trucks in Surface Mines Using Artificial Intelligence Models, Conference: Coal Operators’ Conference (At University of Wollongong) Vol. 1.
[3] Lo C , Chen C , Kuan T , Lo K and Cho H, Fuel Consumption Estimation System and Method with Lower Cost 2017 Symmetry 9 p 105.
[4] Lee W C , Tsang K F, Chi H R, Hung F H, Wu C K, Chui K T, Lau W H and Leung Y W 2015A high fuel consumption efficiency management scheme for PHEVs using an adaptive genetic algorithm Sensors 15 pp 1245–51.
[5] Haworth N and Symmons M Driving to reduce fuel consumption and improve road. http://acrs.org.au/files/arpr/RS010036.pdf.
[6] Toledo G and Shiftan Y 2016 Can feedback from in-vehicle data recorders improve driver behavior and reduce fuel consumption Transp. Res. Part A Policy Pract. 94 pp 194–204.
[7] Bao Y and Chen W 2016 A personalized route search method based on joint driving and vehicular behavior recognition Proc. of the IEEE MTT-S International Wireless Symposium, (Shanghai, China).
[8] Lin Y, Chen P and Chan K 2017 A method for reducing fuel consumption of urban scooters using vehicle design and traffic simulation, Proc. of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, Vol.231 issue: 7 pp: 1252-71
[9] Matsumoto S , Park T and Kawashima H 2014 A Comparative Study on Fuel Consumption Reduction Effects of Eco-Driving Instructions Strategies International Journal of Intelligent Transportation Systems Research 12-1 pp 1–8.
[10] Saito A and Takada H 2008 The relationship between eco-driving patterns of light duty freight vehicles and the improvement of fuel economy in real traffic conditions. Proc. of JSAE before lecture presentation 99–08 pp 27–30.
[11] Hiraoka T, Terakado Y, Matsumoto S and Yamabe S 2008 Quantitative evaluation of eco-driving on fuel consumption based on driving simulator experiments Proc. of 7th World Congress on Intelligent Transport Systems pp 163–68.
[12] Hiraoka T, Terakado Y, Matsumoto S and Yamabe S 2011 Effect of eco-driving instruction and fuel consumption meter on fuel consumption reduction, Hum. Interf. Soc. J., 12(1) pp 71–78
[13] Luca L and Filip CP 2011 On the assessment of the public order services quality by using classic instruments of quality management, Proc. Int. Conf. The Knowledge- Based Organization (Sibiu) pp 691-6.
[14] Luca L 2015 The Study of Applying a Quality Management Tool for Solving Non-Conformities in an Automotive, Applied Mechanics and Materials Trans Tech Publications, vol 809-810 pp 1257-62.
[15] Luca L, Todorut A V and Luca T O 2018 Quality management applied to analyze the reduction of the pollution which is generated from road transportation in agglomerated urban areas Scientific Bulletin of Naval Academy (SBNA) vol. XXI, Issue no.1, (MBNA Publishing
House Constanta) pp 116-22.

[16] Cirtina L M, Cirtina D and Luca 2014 Quality Management in Projects - QualityPlanning, Applied Mechanics and Materials 657 pp 891-5.

[17] Luca L 2016 A study on quality analysis measuring process Fiability & Durability 2 pp 68-72.

[18] Luca L , Pasare M and Stancioiu A 2017 Study to determine a new model of the Ishikawa diagram for quality improvement Fiability & Durability 1 pp 249-54.

[19] Pasare M 2016 On the mitigation actions of defects for plastical deformed parts Fiability & Durability 2 pp 114-7.

[20] Ghimisi S and Nicula D 2018 Actions to increase the reliability of chain transmissions 22nd International Conference on Innovative Manufacturing Engineering and Energy - IManE&E. Issue MATEC Web Conf. Vol.178, article number 06002 DOI: https://doi.org/10.1051/matecconf/201817806002

[21] Ghimisi S 2018 Measures for correct design, manufacturing and exploitation of gear transmissions to increase the reliability, Scientific Bulletin of Naval Academy Vol.21 (Constanta) pp 103-8.

[22] Despotou G, Jones RW and Arvanitis TN 2016 Using Event Trees to Inform Quantitative Analysis of Healthcare Services Unifying the applications and foundations of biomedical and health informatics. Book Series: Studies in Health Technology and Informatics Vol.226 pp 119-122.

[23] Saghebian S M, Sattari M T, Mirabbsi R and Pal M 2014 Ground water quality classification by decision tree method in Ardebil region, Iran. Arabian Journal of Geosciences 7 – 11 pp 4767-77.

[24] Islam M N 2004 A methodology for extracting dimensional requirements for a product from customer needs Int.J.of Advanced Manufacturing Technology 23 Issue: 7-8 pp 489-94.

[25] Li SS , Lee LC 2011 Using fishbone analysis to improve the quality of proposals for science and technology programs Research Evaluation 20-4 pp 275-82.

[26] Ionita I 2008 Managementul calității si ingineria valorii. (Editura ASE Bucuresti).