Fuel Consumption Tabulation in Laboratory Conditions

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***Abstract*— Environmental degradation has come about for a number of factors including the use of fossil fuels in vehicles for everyday use. This paper attempts to understand the relationship between fuel consumption and various engine performance parameters under laboratory conditions in order to see how various factors contribute to the overall fuel consumption. The framework for testing has been decided as the New European Drive Cycle (NEDC) given its various testing advantages against other driving cycles. A test rig was applied to simulate the NEDC under laboratory conditions. The findings from this study provide information how vehicular fuel consumption varies with such driving parameters as vehicle speed, acceleration, and throttle position. They can be used to predict fuel consumption under any real life driving conditions, which will contribute to reducing fuel consumption in future vehicle design..** *(Abstract)*

***Index Terms*— NEDC, standard driving cycle, mathematical model, real life driving, testing.** *(key words)*

I. Introduction

Rising strain on the natural environment has emerged as a major challenge to sustainable human existence on Earth. Human activities have added value to economic processes but have abraded the environment just as well. There has emerged the need for a way to deal with the increased production of waste by the anthropic development of human societies with special care not to impact negatively on the biosphere of Earth. Creative problem solving is a core component in finding solutions to the vast wastes by human growth and development that are compatible with the environment. Half of the current world population lives in urban centres and the rapid urbanisation has been a major challenge to scientists on how to maintain this population's health without affecting the environment (Morrison & Rauch, 2007). In a forum for research on the management and the effect that transportation has on the environment, some of the issues addressed included the traffic management, treatment, sustainable transport strategies, and increase on vehicle emissions, reduced air quality, and the quality of water (Morrison & Rauch, 2007).

Environment issues at both local and international levels such as global warming, the effects of acid rain, ozone depletion, water pollution and air pollution from industrial sources and automobile exhausts (Beychok, 2005). Environment engineers work with various environment protection agencies around the world that serve to protect and better the quality of water, air and the environment as a whole in order to prevent or reduce the effects of hazardous wastes on the environment.

This paper aims to discuss some development and steps taken to reduce the impact of human activity on the environment. An important aspect is to improve fuel economy of vehicles and reduce carbon emission. Fuel economy is enforced by the use of drive cycles. In the present study, an experimental setup is used to simulate drive cycles, measure fuel consumption and several of the parameters influencing it. This in turn has been applied to simulate the New European Drive Cycle (NEDC) to observe which factors influence fuel consumption and hence vehicle emissions.

II. Development

According to Article 25(1) of the Universal Declaration of Human Rights (UDHR, 2014):

> *"Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control."*

A number of factors, including burgeoning pollution and degradation of the human environment, have not allowed the achievement of basic human rights. Economic activities such as the use of vehicles, have led to some growth on one hand and have contributed to environmental degradation on the other hand in the longer run. There has been a development of dispersion models by scientists on air pollution to determine the effect of vehicle exhaust and industrial gas emissions on the quality of air, or the concentration of a pollutant at a receptor. The development of these models coincides to some extent with the desire to eradicate greenhouse gas emissions and especially carbon dioxide from the combustion process. Scientists apply engineering as well as scientific principles to determine the effect these pollutants will have on the quality of air, water and habitat; plant and animal life, capacity of agriculture, social impacts, traffic impacts, bionomic impacts, noise and effects on the landscape (Harrop, 2002). If results

Table 1 - Basic data used to build an environmental supply and monetary supply table sourced from (SYKE, 2013)

	Supply table	**Export table**	**Use table**	**Import table**
Economic data: flows of products, (products in monetary terms	Output by product and by sector	Products by exporting sectors	(Intermediate) consumption by product and by sector	Products by importing sectors
Idem but additionally (kg, numbers)	Products specified in physical units	Products specified in physical units	Products specified in physical units	Products specified in physical units
Environmental data: emissions and extractions (flows of compounds)	Emission by compound and by sector	Outflow by compound	Extraction or reabsorption by compound and by sector	Inflow by compound
Materials and substance flows (possibly also energy)	Materials / substances per product	Materials / substances per product	Materials / substances per product	Materials / substances per product

are positive for the risk of impacts then measures to mitigate the impacts are developed to prevent or limit the impacts.

III. Enviromental Impact Assessment

An environmental impact assessment (EIA) is one which involves evaluation of probable impacts of a project in the environment on human health, the risk to the ecology, and changes the project might have on services of nature (Glasson, Therivel, & Chadwick, 2013). This ensures developers and decision makers take into consideration the impact their projects have on the environment before making decisions on whether to proceed with the undertaking of these projects. A technology by the US Environmental Protection Agency (EPA) labelled environmental science uses the pathway analysis to determine the probable impact of environmental factors on human health (McMahon, 2006). In a report released by the EPA in 2008, potential impacts of climate change on human welfare and health as well as the communities are discussed. The challenges and potential effects of climate change and its possible effects on some communities and individuals like the elderly, children and people with chronic medical conditions (EPA, 2008). The development of public health infrastructures and environmental programs to protect water and air are possible ways of reducing these impacts.

Contrary to popular belief, reduction in environmental effects does not strain the economy of a country. The gross domestic product and the ecological footprint are products of different parts of the economy. For example, in a typical country's economy, the ecological footprint is derived from the primary production of energy, wood, fish and crops while the highest value added is obtained from the sale of apartments, public services and profits from retail trade.

In a research by the Aalto University in which environment extended input-output models (EEIO) were used to identify the most fundamental economic interactions out of a set of 23000 model parameters on the Finnish economy. EEIO combines the consumption, production and impacts of the environment into a clear scheme of equations in order to examine the origin of the gross domestic product (GDP) and the sectors of the economy which cause the most impact on the environment and loss in biodiversity. It involves the use of life cycle assessment (LCA) to examine raw materials and the methods required to manufacture a product (SYKE, 2013).

The models evaluated the environmental impacts including loss of biodiversity, Eco toxicity and land use and were used in conjunction with life cycle assessment impact tests to evaluate the footprint of carbon and other greenhouse gas emissions from products and services. The results of these tests showed that out of the thousands of various production paths tested, only a few of them had profound impact on the environment. As such it is only necessary to focus on these few important factors when addressing the issue of environmental impact on the global economy (SYKE, 2013). A global model like the Finland model is already being developed to examine the proportion of the value added produced by developed countries and the developing countries and where the work is carried out (SYKE, 2013).

IV. Drive Cycle

Gas emission from vehicles is a big contributor to the overall concentration of greenhouse gases in the atmosphere and especially carbon dioxide. As a response to this threat to the environment, major vehicle markets are introducing standards to ensure fuel economy in their countries with the main aim of reducing the emission of greenhouse gases from vehicles. Fuel economy which is measured by the amount of fuel consumed per unit distance by an automotive is enforced by the use of drive cycles. Factors that would result in differing observations in the same vehicle are noted and the vehicle is tested in different environments such as on a highway, an urban region or a combination of both. Several factors that influence the fuel economy of a vehicle include the engine characteristics, gear train characteristics, weight and aerodynamics, rolling resistance, driving cycle and driver habits (GFEI, 2013).

V. Experimental Simulation of Drive Cycles

A test rig was utilised to test vehicles which is located in the advanced Automotive Laboratory at University of Huddersfield. The test rig is equipped with two AAB 132Kw AC Dynamometers, with a 4 axis robot gear shift all controlled by sierra CP Engineering's V14 software.

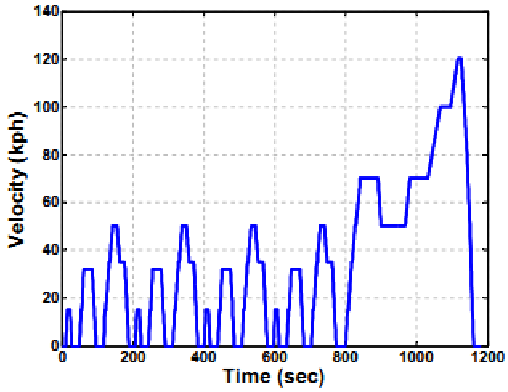
In order for the correct load to be applied to the engine as if it were in the vehicle, the system runs in Road law which enables the dynamometers to change depending on the aerodynamic load and tyre frictional forces that would be experienced. The system is integrated with speed, pressure, fuel and temperature transducers to enable all aspects of the power train to be measured accurately. The engine utilised in the testing is a 2005 Nissan Micra 4 cylinder 1.4L16v engine that is attached to a standard 5 speed manual gearbox. The engine and its drivetrain is instrumented with various sensors and the required drive cycles were programmed using the Cadet V14 software.

Figure 1 – Testing rig used for current study showing the generator type dynamometer (top) as well as the software interface (bottom).

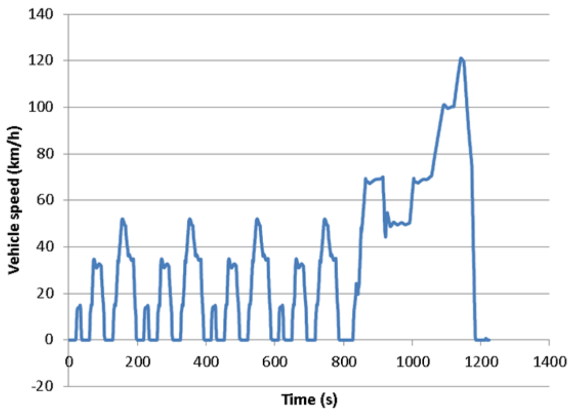
VI. Application for the New European Drive Cycle

A. New European Drive Cycle (NEDC)

The NEDC consists of four differentiated cycles of urban driving and one cycle of extra urban driving. The urban driving cycle is composed of consecutive accelerations, steady speed patches, decelerations as well as idling patches. In contrast, the extra urban driving cycle is composed of steady speed testing between 75 km/hr and 120 km/hr. Figure presented below present



(a)

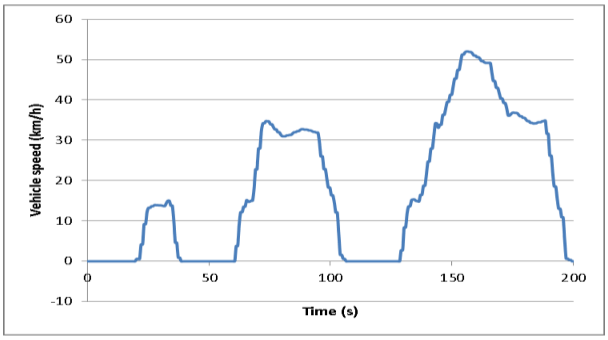


(b)

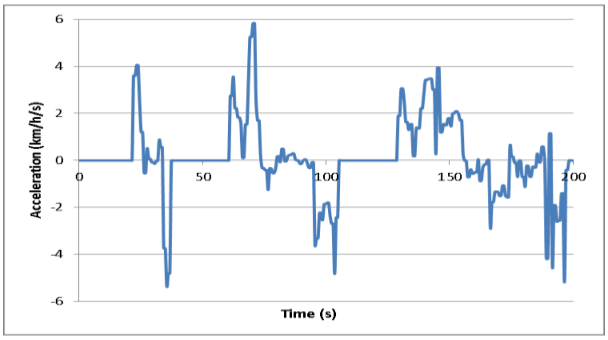
Figure 2 – The New European Drive Cycle (a) as defined from (Berry, 2007, p. 132), (b) as simulated experimentally

B. Experimental simulation of New European Drive Cycle

The entire NEDC was simulated in laboratory conditions in order to extract quantifiable results for prediction of fuel consumption. The resulting vehicle speed time history is plotted in Figure 1(b), and compared to the defined drive cycle that is shown in Figure 1(a). More details about the first urban driving cycle, i.e. approximately the first 200 s in the NEDC, are provided in Figure 2 showing time histories of drive-cycle parameters that are the most influencing on fuel consumption, i.e. vehicle speed, acceleration, and throttle position, together with fuel consumption (or more precisely, the fuel mass flow rate in g/s). The average fuel mass flow rate during this cycle is 0.34 g/s. The fuel density is 800 g/l; thus, the consumption is 8.5 l / 100 km. The consumption in the further three urban cycles and the last extra-urban cycles are 8.3, 8.2, 8.2 and 5.5 l / 100 km, respectively. The average consumption in the entire NEDC is 6.5 l / 100 km.



(a)



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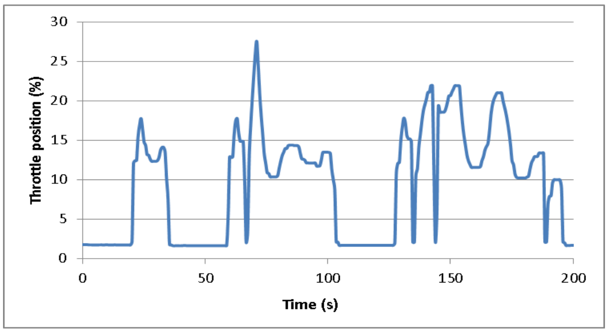
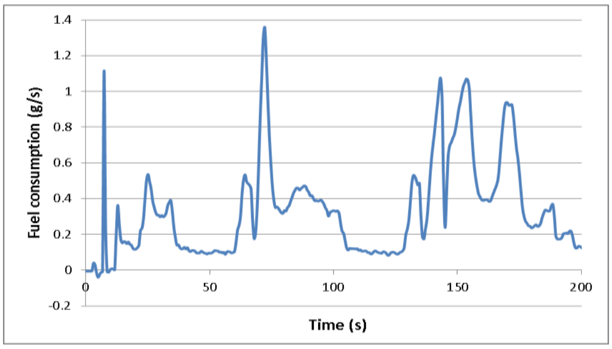


(c)



(d)

Figure 3 – Time history of the drive-cycle parameters during a drive cycle, (a) vehicle speed, (b) acceleration, (c) throttle position, (d) fuel consumption

VII. Conclusion

Management of the environment is usually coordinated poorly at the different levels of government which reduces the effectiveness of efforts applied to improve the quality of the environment. Further engagement of citizens through mechanisms of participation has not been effectively institutionalized in most local governments. As such there is need to institutionalize the management of the environment to ensure sustainable development with minimal effect on the environment and to promote participation as well as training of the communities on the important ways the environment could be sustained. The natural environment might be better protected by engaging in environment friendly activities since by conservation of these resources we do not lose in the economy and the effects of degradation of the environment are avoided. Such activities involve introducing and respecting standards to ensure fuel economy of vehicles, which is enforced by using drive cycles. The present study showed that drive cycles might be successfully simulated under laboratory conditions. Experimental simulations made it possible to measure time histories of drive cycle parameters including fuel consumption. The NEDC was simulated applying a 2005 Nissan Micra 4 cylinder 1.4L16v engine that is attached to a standard 5 speed manual gearbox. Results showed that the average consumption during this specific drive cycle is 6.5 l / 100 km, which is above the fuel consumption of 4 l / 100 km aimed by GFEI. However, it must be kept in mind that real life driving conditions would tend to vary since the current study occurred under laboratory conditions and failed to account for factors such as air drag. Further experimentation using actual vehicles on roads is required to realize how fuel consumption is connected to various real life parameters.

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