INVESTIGATION OF DRIVING CYCLE OF MOTORCYCLE FOR EDINBURGH (EMDC), UK -A COMPARISON

Ravindra Kumar, Wafaa Saleh, Howard Kirby
Napier University, Edinburgh, UK

ABSTRACT

Driving cycle has been always fascinating to environmentalists, traffic engineer, and automobile engineer for their different purpose of use. Edinburgh has been experiencing a 100 % growth of motorcycle in the last 10 years due to recent government promoting policies. Due to changes in traffic scenarios, different purpose of use, and their increasing share in the current fleet, there has been need to understand and investigate the driving cycle of motorcycle for Edinburgh both from the emission, fuel consumption and the impact of traffic management schemes point of view. In this study, an Edinburgh Motorcycle Driving Cycle (EMDC) has been developed based on data collected for home to work trips for Edinburgh and its surroundings. The data acquisition system was developed with the help of a GPS based Performance Box, which records the speed, acceleration, and distance data every 1/10 of the second. Driving data was colleted at five different routes and then segmented into two types of trips named; urban and rural trips based on speed limits of the different categories of the roads. Recruited volunteers performed a total of 44 urban and 44 rural trips on these routes. Finally, a true representative cycle was developed using the assessment parameters and then statistical significance for the total trips. The result obtained from the current analysis of the database indicates that EMDC has cycle length of 625 seconds for the urban part and 1120 seconds for the rural part. The time spent in acceleration and deceleration modes are significantly higher than any other driving cycle developed to date, which reflects the typical characteristics of the driving cycle for motorcycle in Edinburgh.

***Key Words**: Motorcycle, driving cycle, Edinburgh, rural, urban, emissions*

1. INTRODUCTION

European Commission Directive 97/24/EC, entered into force on 17th June 1999, which established limit values and procedures to evaluate motorcycles emissions in Europe. It was implemented into two phases: the first phase was named as Euro I, which was placed during a period of 24 months from the adoption of the Directive. The second phase, Euro II, which was placed at least three years after its entering into force. The Euro II phase introduced even stringent limits on emission standard. The limits and the classification for the Euro III stage (2006) have been introduced in the abovementioned Directive for the European driving cycles (ECE) as shown in the Figure 1[1].

These emission standards have been getting stricter continuously since their introduction. Nevertheless, these standards are based on driving data of motorcycle in different parts of the world, which does not reflect the Edinburgh motorcycle-driving pattern. Global technical regulation (GTR) developed a worldwide motorcycle emission test cycle for collecting data from different part of the world in more harmonical manner as shown in the Figure 2 [2]. In another study, Booth et al. [3] investigated the Edinburgh driving cycle (EDC) for cars and buses to develop an air quality forecast tools as shown in the Figure 3, which predict both future level of vehicular emission within the Edinburgh city centre and measure the effect of different levels of traffic control scenarios. This driving cycle did not consider motorcycles exhaust into account, as they do not represent a large number of market shares.

Investigation of driving characteristics of motorcycle are significantly different than those of private cars due to its filtering ability, moving ahead of queues, progressing parallel to other vehicles in same lane, different driving nature and purpose of use (recreational, sporting, etc.) hence it share has been double since last 10 years in Edinburgh fleet [4]. In reality, the different types of vehicles are driven in different manners, and should be therefore tested according to their performance levels and uses. The aim of this poster is to demonstrate the investigation of the real world driving cycle for motorcycles in Edinburgh and comparing it with existing driving cycle

1.1. Existing driving cycle in UK

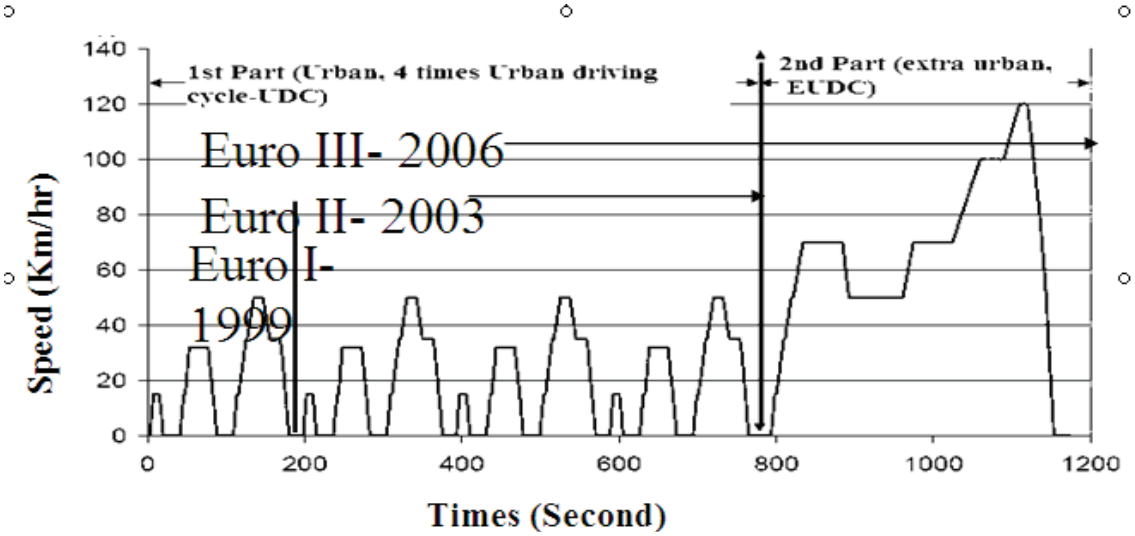

Figure 1: European driving cycle

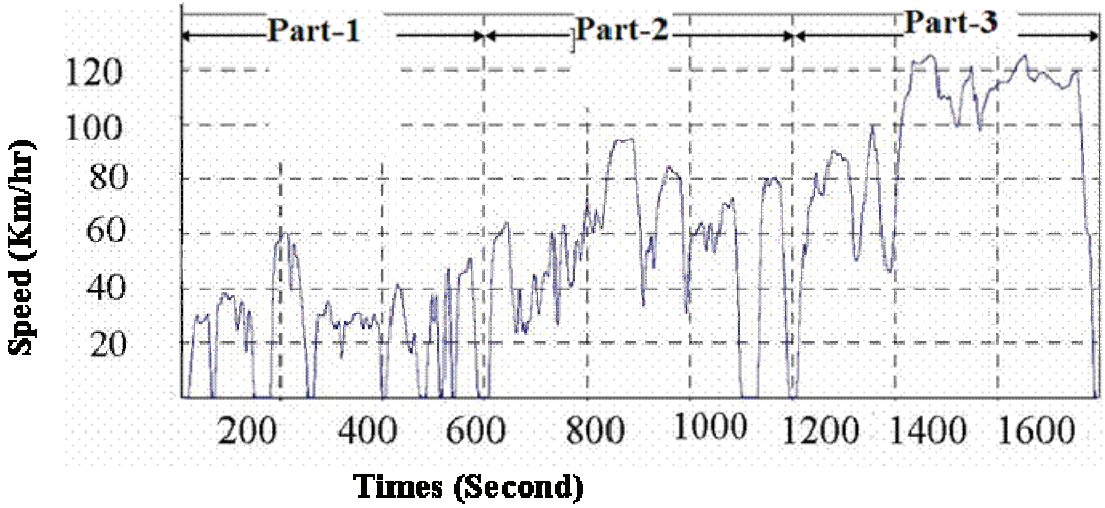

Figure 2: Worldwide motorcycle Test Cycle

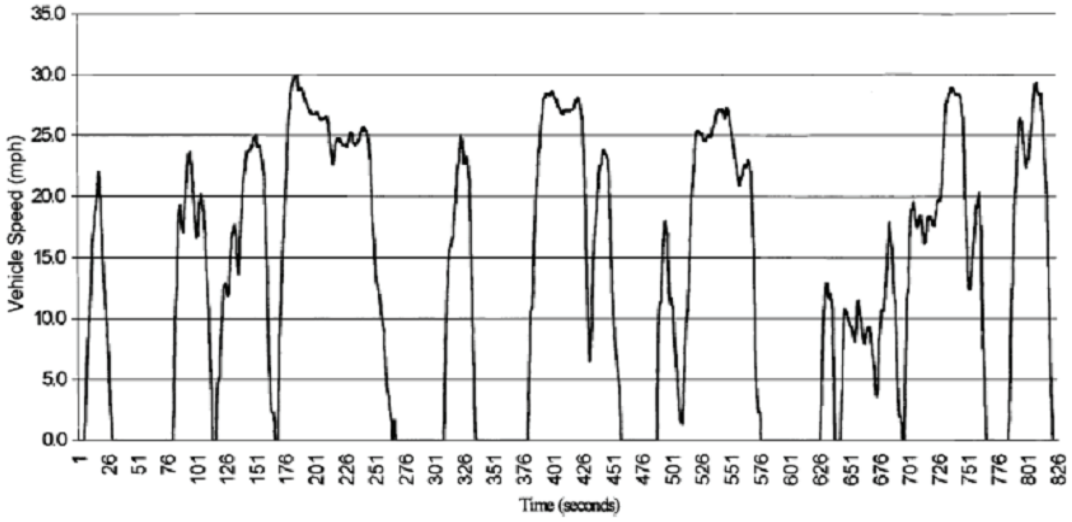

Figure 3: Edinburgh Driving Cycle [2]

1.2. Emission factor comparison- Car and Motorcycles

- Primary means of transportation in Europe - Cars (highly efficient and reduced emission)
- Motorcycles - In their subordinate role logs lower yearly mileage per vehicle- higher contribution to traffic emissions per km
- Comparison of mean unit emissions shows that motorcycles exceed cars in NOx emissions as shown in the Figure 4.

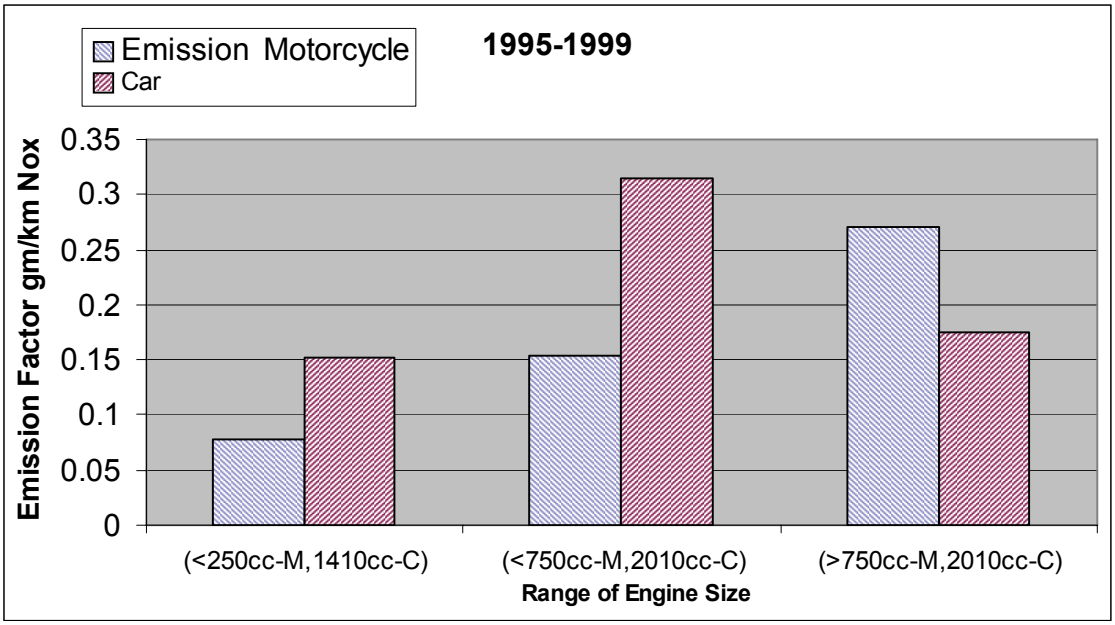

Figure 4: Emission factor comparison between motorcycles (M) and cars (C)

2. RESEARCH GOAL & APPROACH

2.1. Motivations

The motivation of this research was complexity and variations in driving cycle due to city to city, vehicle to vehicle, area to area, and road to road. Also driving cycle based on recording real world driving test (complex transient in nature) has different effect on the emission than standard driving cycle.

2.2. Aim of this research

To investigate the driving cycles of motorcycles for Edinburgh (EMDC), which consist of urban and rural, rush hour, non rush hour, and different engine sizes.

2.3. Methodology

Data acquisition system was developed with help of GPS, motorcycle, battery and software as shown in the Figure 6

- Route characterisations was done by dividing the city into north south and east west corridor as shown in Figure 5
- Real world driving recording of driving data was done at different routes by different drivers and detailed in the Table 1.
- Statistical validation of assessment parameter and synthesis of the data was done to develop the Edinburgh motorcycle driving cycles.
- Finally, Edinburgh Motorcycle driving cycle (EMDC) was derived based on the assessment criteria and least sum of absolute error of coefficient of variations (CV) for both urban and rural. The derived EMDC for urban and rural have been shown in the Figure 7 and 8.
- The vehicle operating mode of EMDC was compared with different driving cycles as shown in Figure 9

3. PROGRESS & DEVELOPMENT

3.1. Route selection and data collection of speed –time

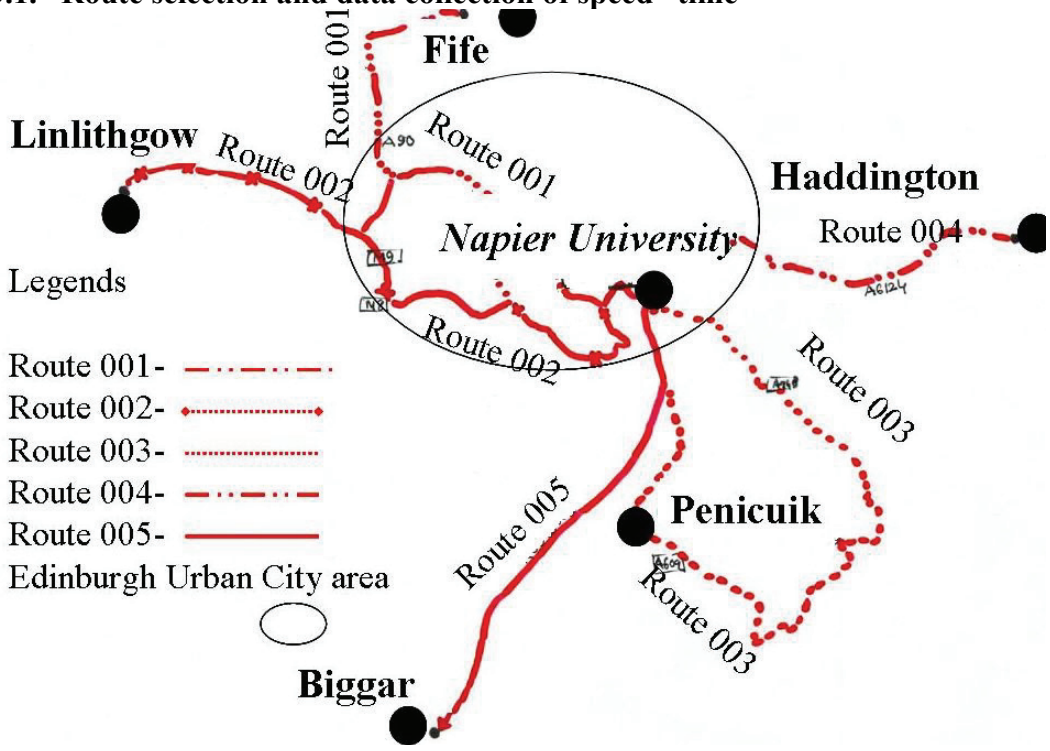

Figure 5: Selected routes for investigation of motorcycle driving cycles for Edinburgh and surroundings

Table 1: The routes names and description

Route description	Route nomenclature
Napier to Fife	001
Napier to Linlithgow	002
Napier to Penicuik	003
Napier to Hoddington	004
Napier to Beggar	005

3.2 Data acquisition system

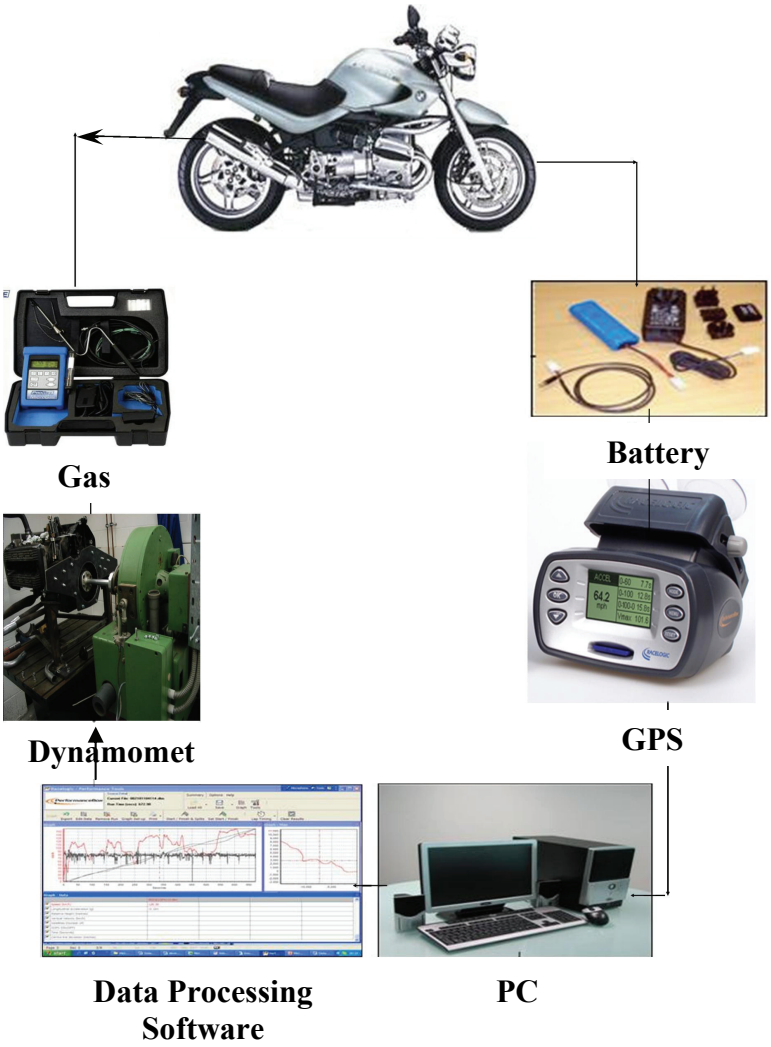

Figure 6: Data acquisition system and data processing

4. EDINBURGH MOTORCYCLE DRIVING CYCLE CONSTRUCTION MECHANISM (EMDC)

The data consolidation of huge amount of driving data is most important to derive a representative driving cycle. Two major aspects have been considered: (a) a more reasonable cycle length calculation based on the collected driving data and b) adopting more stringent assessment criteria for the selection of the best driving cycle.

- First, the collected trip data sets were classified according to the speed limit and road type (urban and rural).
- Total sums of absolute errors of each of the assessment parameters were calculated for each test run.
- Finally, a candidate cycle for urban and rural trip was chosen, which has got the least sum of absolute error
- From the data, test run 002 was selected with least sum of absolute error (8.2%) for urban trips. Route 001 was chosen a candidate cycle for rural trips with least sum of absolute error (8.34%).
- Another criterion was to set up least cycle duration within this test run. For test run 002 and route 001, least cycle duration length of found iteratively from each journey.
- This was set as a best representative driving cycles for urban and rural trips.
- The obtained driving cycles for the urban and the rural areas are presented in Figure 7 and 8 respectively.

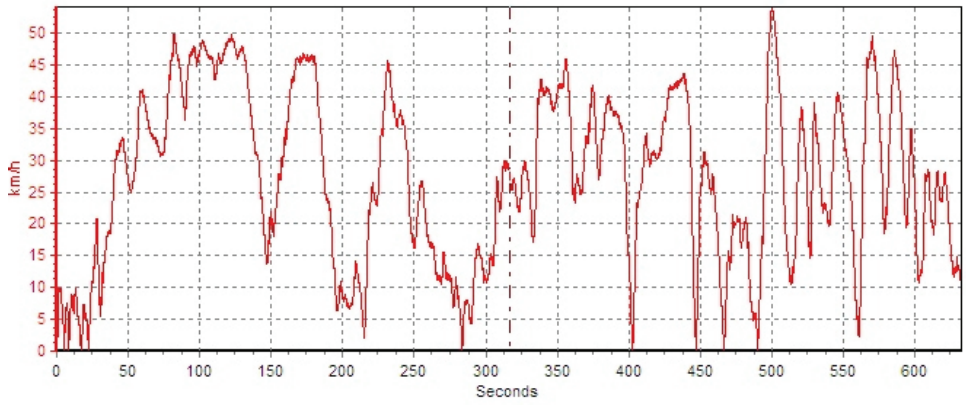

Figure 7: Typical Edinburgh motorcycle driving cycle (Urban)

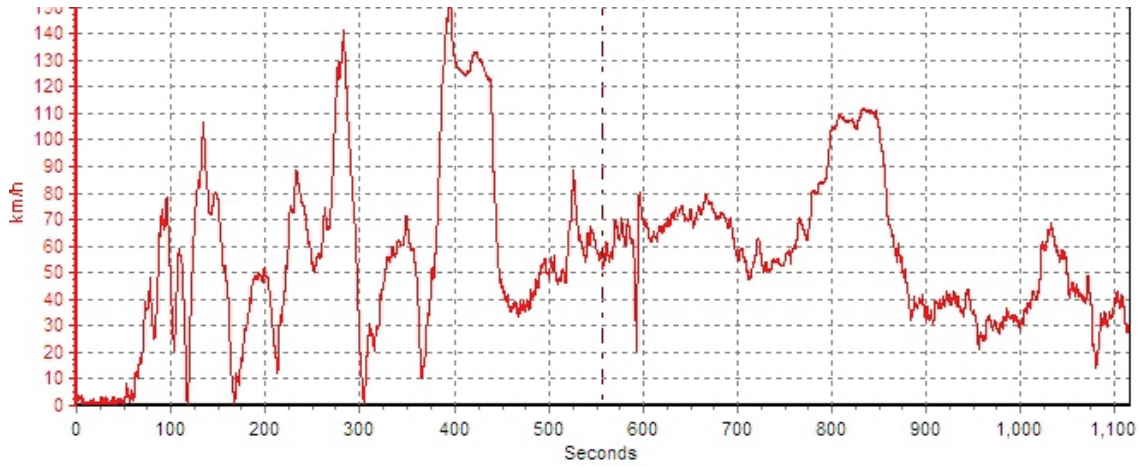

Figure 8: Typical Edinburgh motorcycle driving cycle (Rural)

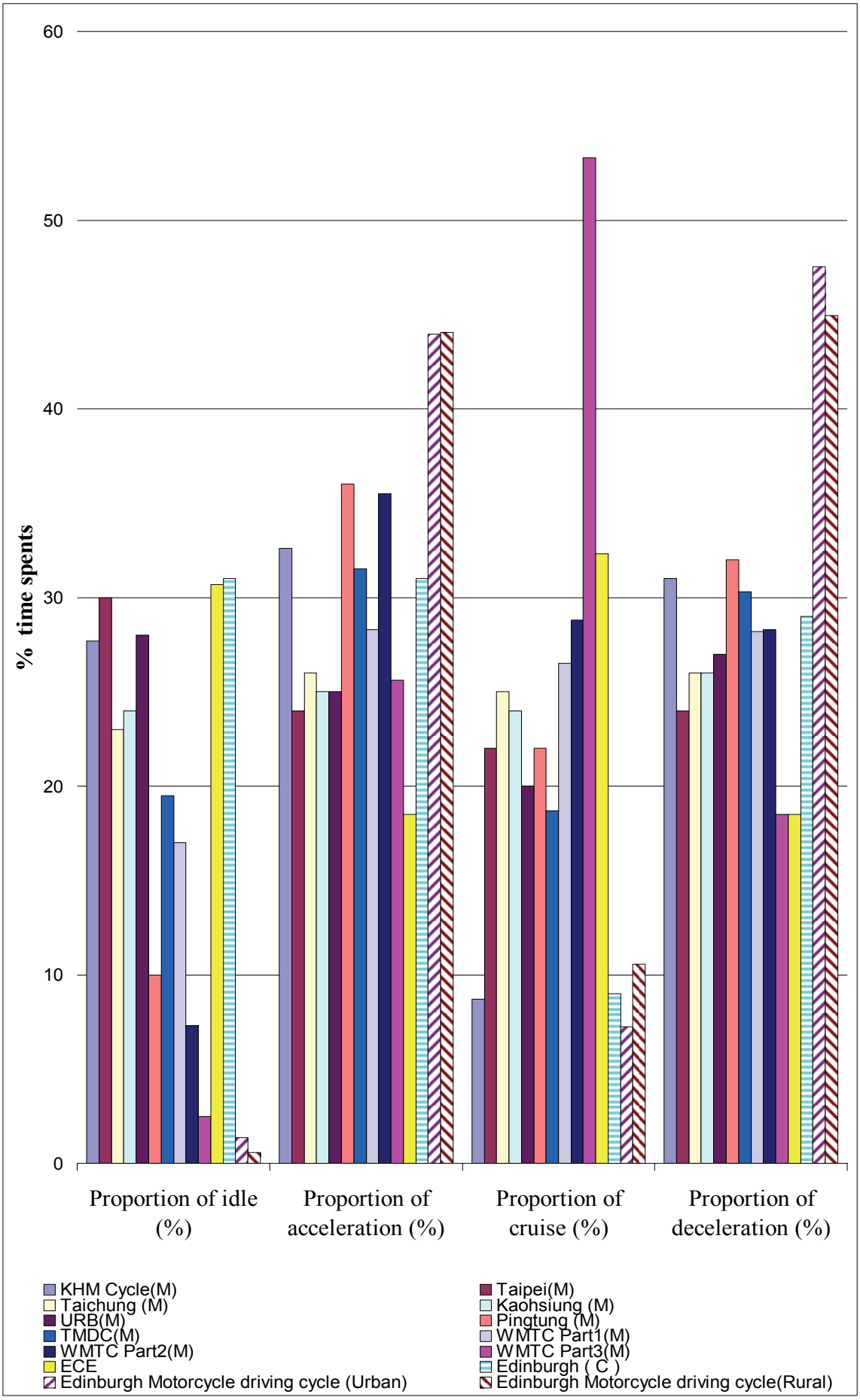

Figure 9: Percentage time spent in different vehicle operating mode and its comparison with other driving cycle

5. RESULTS AND CONCLUSIONS

European motorcycle has higher dynamic acceleration than cars due to higher mass power ratio. There was a large idle proportion and an extremely small cruise proportion in the urban areas. The discrepancies of the mean values drawn from the urban test runs and the rural test runs reflect a significant difference of the driving patterns of these categories of roads. The average cycle speed and the average running speed of rural highway were both higher than those of the urban roads. The idle proportion for the rural section was significantly smaller than the urban sections, while the cruise proportions for the rural trips were larger. Average cycle speed of Edinburgh motorcycle driving was higher than the existing European, WMTC and Edinburgh Driving Cycle. Average speed of existing Edinburgh driving cycle (urban), which is 20 kph lower than the derived Edinburgh driving cycle (urban) for motorcycle, which was 37.97 kph. Average running speed of Edinburgh motorcycle driving cycle for rural roads was found to be highest among all the driving cycle developed over the world. It means that Edinburgh motorcycle driving cycle has larger speed than other existing mandatory cycles. The idle proportion of the Edinburgh driving cycle, ECE, and WMTC are not similar to the mean value of the EMDC for the urban and rural roads. Percent idling time of EMDC is very close to WMTC part 3 for motorways. The percentage of cruise time for KHM cycle, Edinburgh driving cycle and Edinburgh motorcycle driving cycle (EMDC) for urban and rural roads are very similar as shown in Figure 9. The EMDC was found to be unique of those mentioned above (i.e. mandatory legislative cycles). It implies that the urban and rural areas of Edinburgh have their own typical driving characteristics.

6. ACKNOWLEDGEMENT

The author would like to thank volunteers for driving motorcycles, India government for provision of funding the study; technician Ron, Stephen and School administrative support staff, DVLA, Edinburgh Council for providing data; Professor. Peter Strum, Graz University of Technology, Austria for nice discussion on this research and my family and friends for all their unconditional support and love.

7. REFERENCE

[1] Directive 2002/51/EC of the European Parliament and of the Council of 19 July. (2002). " Reduction of the Level of Pollutant Emissions from Two- and Three wheel Motor Vehicles and Amending Directive 97/24/EC", Official Journal of the European Communities

[2] Global Technical Regulation TR No 2. WMTC, 2005

[3] Booth, A Esteves., Munner, T., Kirby, H., Kubie, J., Hunter, J. (2001). "The Measurement of Vehicular Driving Cycle within City of Edinburgh" Transportation Research Part D 6, 209-220.

[4] Kumar, Ravindra., Saleh, W., Kirby, Howard. (2007). "Development of driving cycle for motorcycle for Edinburgh", Managing Knowledge, Technology and Development in the Era of Information Revolution, Fifth International Conference, jointly organised by the World Association for Sustainable Development (WASD) and Griffith University (Australia) , ISBN (Print) 0-9551771-3-8 (Print).