The Motorcycle Driving Behaviors on Heterogeneous Traffic: The Real World Driving Cycle on the Urban Roads in Makassar

Muhammad Andry AZIS [a], Muhammad Isran RAMLI [b], Sumarni Hamid ALY [c], Muralia HUSTIM [d]

[a,b,c,d] *Civil Engineering Department, Engineering Faculty, Hasanuddin University, Makassar, 90-245, Indonesia*
[a] *E-mail: muhammadandryazis@gmail.com*
[b] *E-mail: muhisran@yahoo.com*
[c] *E-mail:marni_hamidaly@yahoo.com*
[d] *E-mail:muraliahustim@gmail.com*

Abstract: The present paper attempts to understand the real world driving cycle of motorcycle on an arterial urban route in Makassar City, Indonesia. This study carried out a survey to describe the motorcycle driving cycle on the route for each traffic direction in the three peak-hour periods of the traffic condition, i.e. morning peak, noon peak, and evening peak periods. The survey used a GPS equipment to capture the motorcycle travel speed second by second. We analyzed eight parameters of the motorcycle driving behavior. The analysis results show that the driving cycle of the motorcycle is dominated by the acceleration and the deceleration behavior mode, while the cruise mode is superior to the idling mode. The results indicate that the motorcycle behavior could be categorized as the steady flow on the low average speeds. We expect that the results are useful in development prediction models for motorcycle emission in further studies.

Key Words: Motorcycle, driving cycle, heterogeneous traffic, urban roads, Makassar.

1. INTRODUCTION

The vehicle driving cycle is an important micro traffic behavior, which represent a speed–time sequenced profile developed for a certain road, route, specific area or city. In other words, the driving cycle is a sequence of vehicle operating conditions (idle, acceleration, steady state and deceleration) developed to represent typical pattern in an urban area. It is widely used to estimation transport air pollutant emissions and in the building of databases for building emission inventories (Aly et al., 2012; Saleh et al., 2009). For instance, driving cycles for light vehicle (LGV) are to enhance traffic management systems, estimating fuel consumption patterns and reduce transport impacts on health and environment (Tzirakis et al., 2006; Saleh, 2007; Hung et al., 2007; Aly et al., 2012).

Regarding the major composition of motorcycle in Makassar City, Indonesia, approximately 70% - 80% (Zakaria et al., 2011; Henny et al., 2012; Hustim et al., 2012), the motorcycle driving cycle seems important to be grasp in order to improve traffic management systems and to estimate the motorcycle emission in the city.

There are some previous researches addressed to the driving cycle of motorcycle. For example, Saleh et al. have developed the motorcycle driving cycle for Edinburg (2009), and Delhi (2010). As well as, Oanh et al. (2012) evaluated driving cycle of motorcycle in Hanoi. Furthermore, Kumar et al. (2011) and Oanh et al. (2012) estimated motorcycle emission based on the motorcycle driving cycle for Edinburg and Hanoi, respectively.

According to the above background and the insight from the previous researches, this paper purposes to understand and to analyze the real world driving cycle of motorcycle on an urban arterial route in Makassar City, Indonesia.

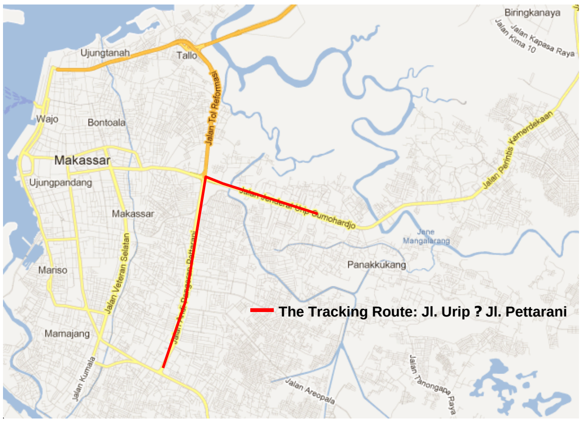
The rest of this paper is organized as follows. Section 2 describes the study methods such the route location, the equipment survey, and survey method of driving cycle, and the analysis method. Section 3 presents the results of the survey and of the parameters of the motorcycle driving cycle. The final section, Section 4 provides discussion related to the result and concludes.

2. THE STUDY METHODS

The study methods consist of the route location, the equipment survey, the survey method of driving cycle, and the analysis method. We will explain these methods in the following sub sections.

2.1 The Route Location of the Driving Cycle Survey

The study has chosen one of the important urban arterial routes in Makassar City, Indonesia as target of the survey location. The route, the red line as shown in Fig. 1, is the main corridor which connected western part and eastern part of the city. The route consists of two urban arterial roads, i.e. Jl. Urip and Jl. Pettarani. The length of each road is 2.5 km and 4.2 km respectively. Both roads are categorized as six lanes and two direction road type, which each direction is separated by physical median in the middle of the roads. In the route, there is a fly over facility that connect both roads each other and also with two others roads.



a. GPS (Etrex 30) b. Motorcycle (Yamaha)

Figure 2 Equipments driving cycle survey

Figure 1 Route of the driving cycle survey

2.2 The Equipments of the Driving Cycle Survey

The driving cycle survey uses a global position system (GPS) equipment to track the driving behavior of motorcycle along through the route. The GPS type which used in this survey is Garmin Etrex 30 as shown in Fig. 21. This GPS is suitable to record the motorcycle speed second by second in order to describe the driving cycle.

The other one of the main equipments for driving cycle survey in this study is a motorcycle. The type of the motorcycle which used in this study is Yamaha Jupiter which has engine size 110 cc and year production 2011. Fig. 2b shows the visual of the motorcycle type. The main reason in choosing the motorcycle type as the vehicle test in this study is that the type is one of major type motorcycles available in Makassar City.

2.3 The Survey Method for the Motorcycle Driving Cycle

The present study adopts a floating car survey method using a vehicle test in order to capture the nature of the traffic flow situation on the route. The method results a floating car data (FCD), also known as floating mobile data, is a method to determine the traffic speed on the road network. It is based on the collection of localization data, speed, directions of travel and time information from mobile source in vehicles that are being driven. These data are the essential source for traffic information and for most intelligent transportation systems (ITS). This means that every vehicle with an active mobile source (such as GPS or hand-phone) acts as a sensor for the road network. Based on these data, traffic congestion can be identified, travel times, speed second by second can be calculated, and traffic reports can be rapidly generated.

By using the GPS and the motorcycle as the vehicle test, we conducted the survey of the motorcycle driving cycle on the route in October, 16th, 2012. The tracking survey is started from the starting point and finished at the end point of the route location. The motorcyclist drives the route at the natural speed of the surrounding traffic, while at the same time the motorcyclist sets the GPS to record the motorcycle speed second by second and the travel time over the route. The driver drives at the ambient speed which the driver did not travel faster, (overtaking more vehicles than overtook the test car), or slower (being overtaken by more vehicles than were overtaken by the test car) than the surrounding traffic.

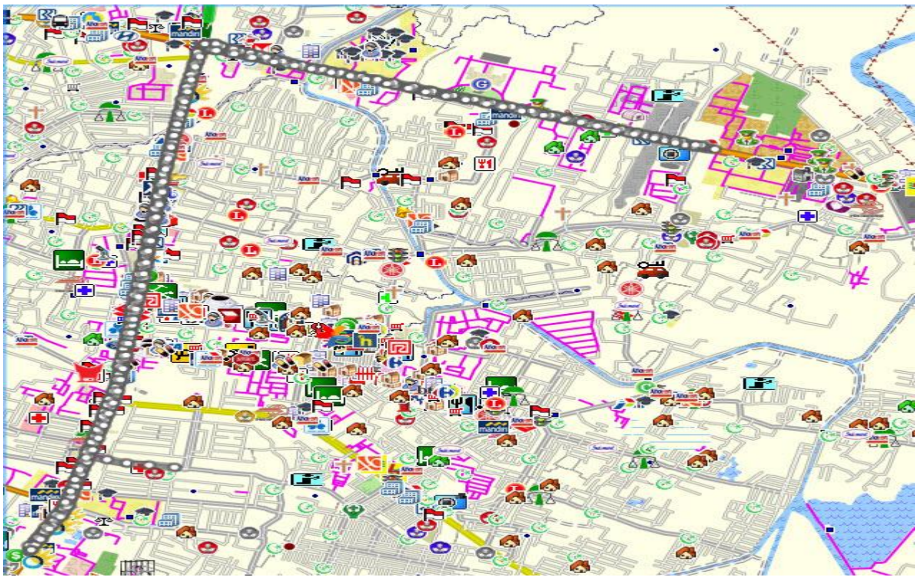


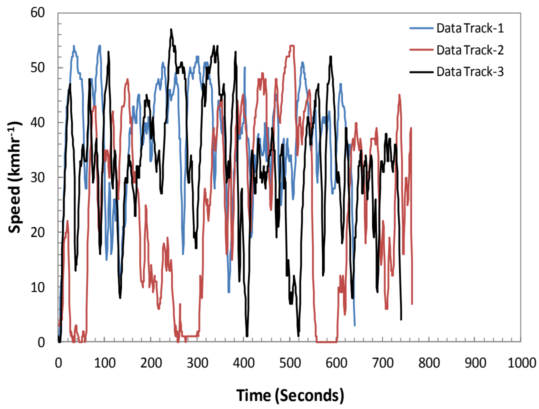
Figure 3 Tracking Results using GPS

The survey was repeated three times using the same vehicle test for each traffic direction and for each peak hour period of the traffic. We considered three peak hour periods, i.e. morning peak, noon peak, and evening peak periods to capture variation of the traffic situation.

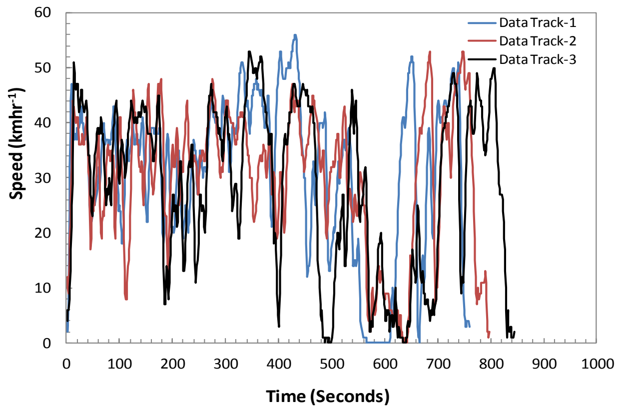
3. THE STUDY RESULTS

3.1 The Driving Cycle of Motorcycles

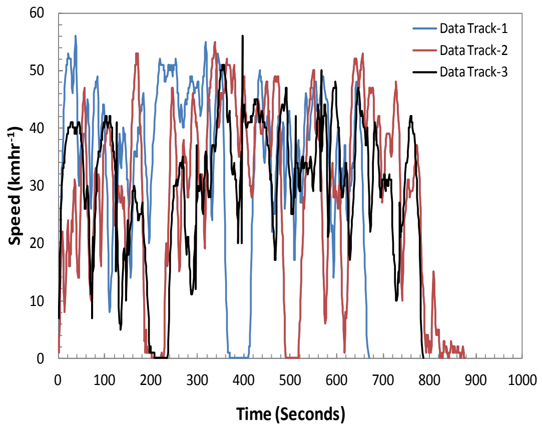
By using the data tracking as in Figure 3, the figures of the motorcycle driving cycles for each traffic direction and each peak hour period were plotted as shown in Figure 4. The driving cycle figures of the motorcycle show the fluctuation of the motorcycle travel speed in second by second along the route. Figures 4 shows that mostly driving cycle on the route are around 800 seconds until 900 seconds, except the noon peak period for direction-B which achieved around 1,000 seconds, due to there are differences of intersection number for the direction-B.



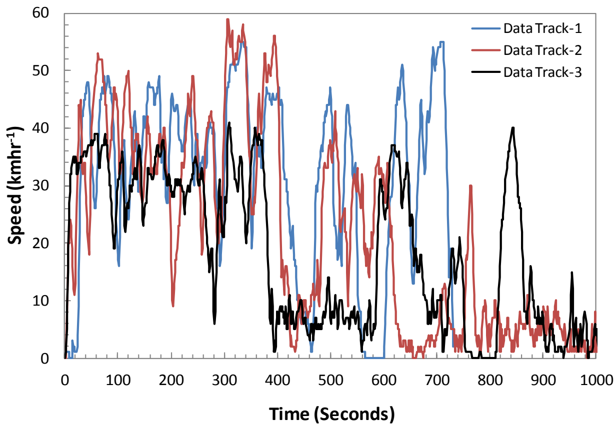
a. Morning peak period for direction-A



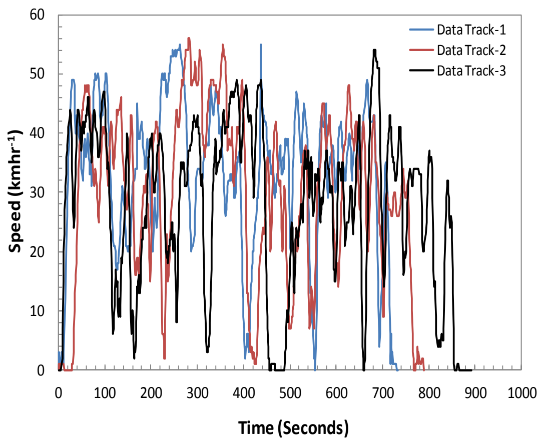
b. Morning peak period for direction-B



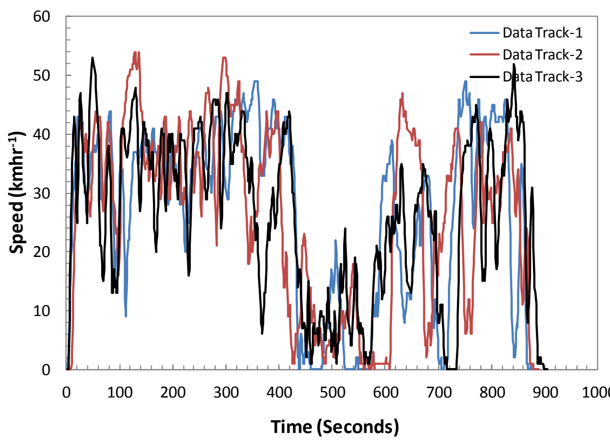
c. Noon peak period for direction-A



d. Noon peak period for direction-B



e. Evening peak period for direction-A



f. Evening peak period for direction-B

Fig. 4 The Driving cycle of motorcycle

3.2 The Parameters of the Motorcycle Driving Cycle

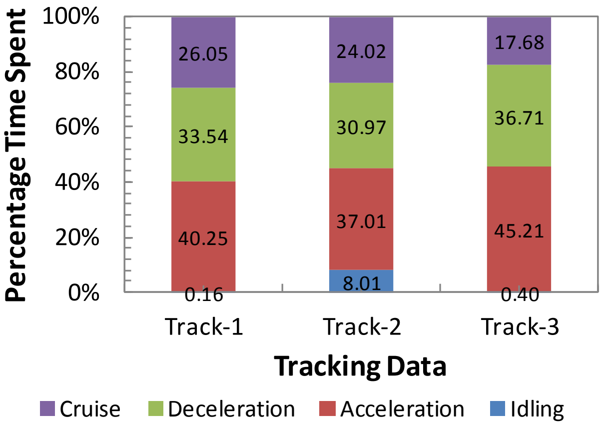
In order to understand the behavior of the motorcycle driving cycle, we have analyzed the eight parameters of the motorcycle patterns. The analysis results are presented in Table 1 and Fig. 5.

Table 1 shows that the average speed including all motorcycle behavior mode (V1) and the average speed without idling mode (V2) are around 24 kmhr^{-1} until 38 kmhr^{-1}. Both speeds mostly similar due to the percentage in the survey of idling (Pi) of the driving cycle is very small as shown in Fig. 5. In addition, the acceleration (A) and the deceleration (D) are around 0.4 ms-2 until 0.6 ms^{-2}, while the motorcycle spent time for cruise (C) for each period and traffic direction have 140 seconds for the smallest value and 402 seconds for the largest value.

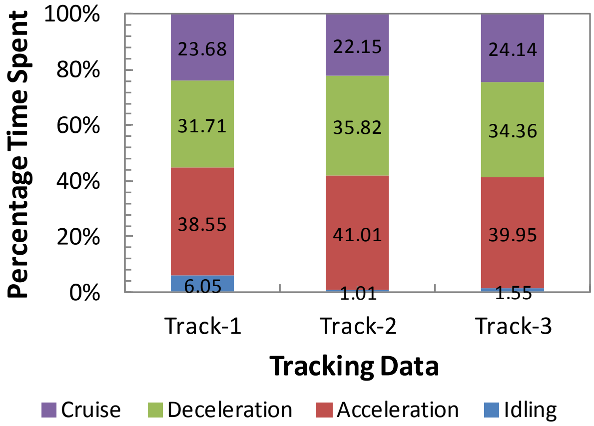
Furthermore, Fig. 5 shows that the percentage of acceleration (Pa) and percentage of deceleration (Pd) are the two largest fractions on the driving cycle mode. Both parameters have values from 30% until 40%, where the percentage of acceleration (Pa) a slightly larger than the percentage of deceleration (Pd). Meanwhile, the percentage of cruise (Pc) has fraction about 20% until 30%. However, the percentage of idling (Pi) is very small in all the motorcycle driving cycle. Regarding the percentage of each driving cycle mode, the traffic flow of the motorcycle in the route is steady, eventhough its speed is low.

Table 1 Parameters of the motorcycle driving cycle on the arterial urban road in Makassar

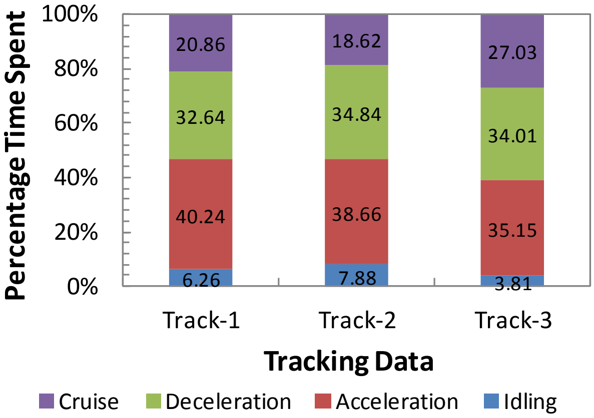
Data Track	V_1 (Kmhr^{-1})	V_2 (Kmhr^{-1})	D (ms^{-2})	A (ms^{-2})	C (Sec)	P_i (%)	P_d (%)	P_a (%)	P_c (%)
Morning peak period for direction-A									
Track-1	27.75	27.88	0.63	0.58	145.0	0.17	35.75	39.03	25.04
Track-2	28.17	28.49	0.56	0.50	128.0	0.00	36.25	40.44	23.32
Track-3	29.66	29.90	0.60	0.56	98.0	0.38	38.51	42.34	18.77
Morning peak period for direction-B									
Track-1	13.43	14.02	0.48	0.48	292.0	4.72	32.97	33.56	28.74
Track-2	17.22	17.39	0.51	0.46	173.0	1.24	35.08	39.89	23.80
Track-3	18.13	18.06	0.61	0.56	116.0	1.15	39.11	43.12	16.62
Noon peak period for direction-A									
Track-1	27.92	28.43	0.54	0.51	138.0	0.91	35.52	38.43	25.14
Track-2	29.08	29.21	0.56	0.60	98.0	0.00	41.52	39.81	18.67
Track-3	26.86	27.00	0.61	0.57	123.0	1.20	37.35	40.28	21.17
Noon peak period for direction-B									
Track-1	26.93	28.00	0.55	0.52	105.0	2.33	36.58	38.90	22.20
Track-2	29.08	29.25	0.52	0.50	76.0	0.00	40.14	42.02	17.84
Track-3	27.06	27.53	0.66	0.57	108.0	0.42	35.67	40.98	22.93
Evening peak period for direction-A									
Track-1	24.63	24.71	1.20	1.32	125.0	1.49	40.73	37.09	20.70
Track-2	24.54	24.22	0.70	0.73	104.0	1.59	41.47	40.35	16.59
Track-3	22.02	21.40	0.80	0.78	129.0	0.42	40.33	41.31	17.94
Evening peak period for direction-B									
Track-1	28.71	28.76	0.81	0.83	66.0	0.00	42.96	41.80	15.24
Track-2	24.64	23.47	0.64	0.66	89.0	0.00	41.36	40.33	18.31
Track-3	27.29	26.76	0.71	0.70	73.0	0.00	41.61	42.48	15.90



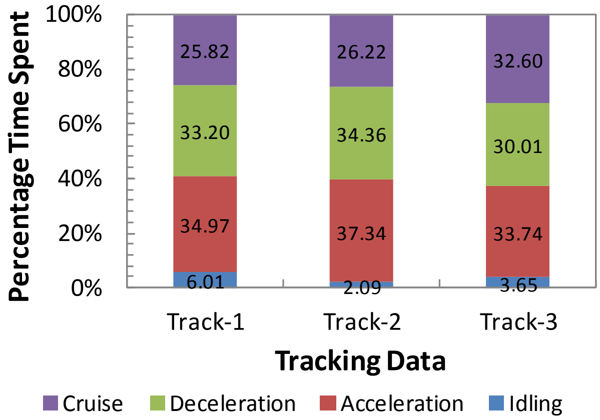
a. Morning peak period for direction-A



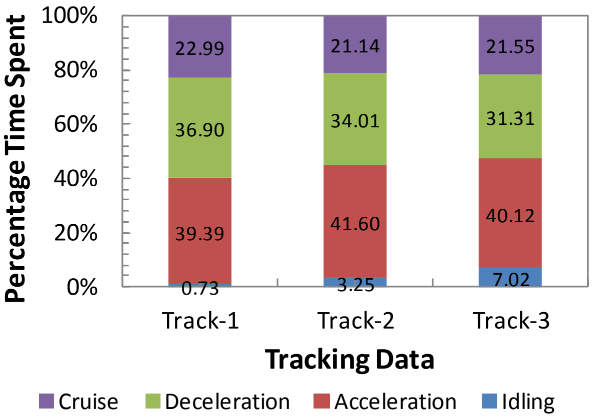
b. Morning peak period for direction-B



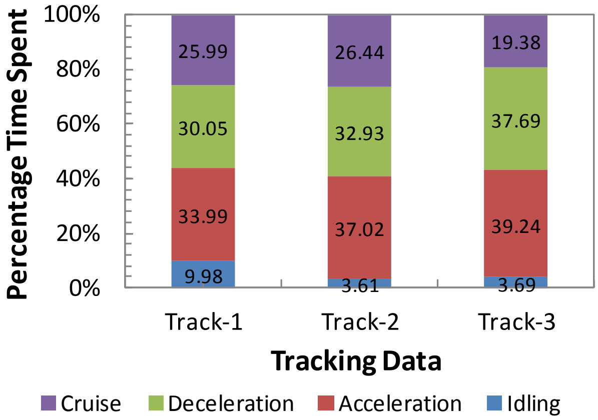
c. Noon peak period for direction-A



d. Noon peak period for direction-B



e. Evening peak period for direction-A

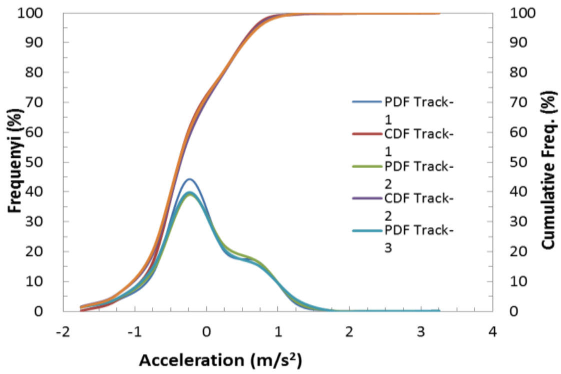


f. Evening peak period for direction-B

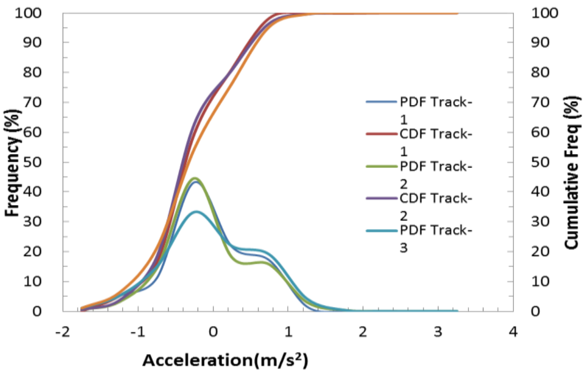
Fig. 5 The driving cycle of motorcycle

3.3 The acceleration and deceleration of the motorcycles

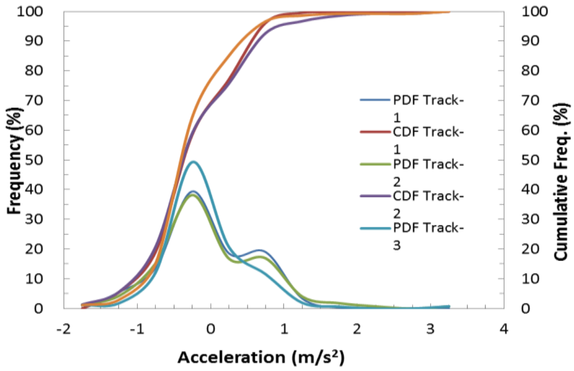
This study continues to analyze the acceleration and deceleration parameters of the motorcycle as the dominant behavior on the motorcycle driving cycles. In this regard, the probability density function (PDF) and cumulative density function (CDF) of both parameters are analyzed. The analysis results are presented in Figure 6. Figure 6 shows that the motorcycle acceleration and deceleration values are generally in interval of -1.0 ms^{-2} until 1.0 ms^{-2}. The figure also shows that there is no difference acceleration and deceleration among the time period variations.



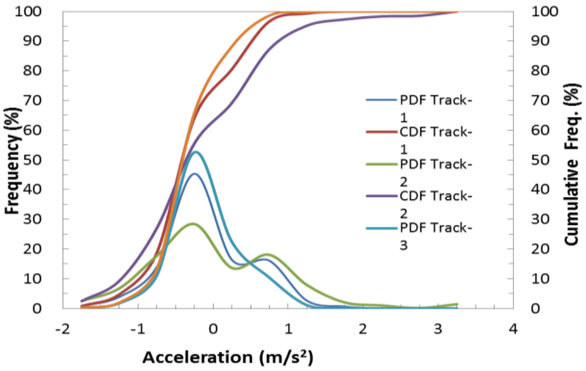
a. Morning peak period for direction-A



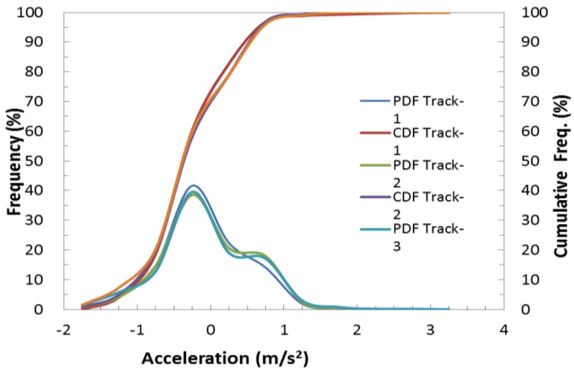
b. Morning peak period for direction-B



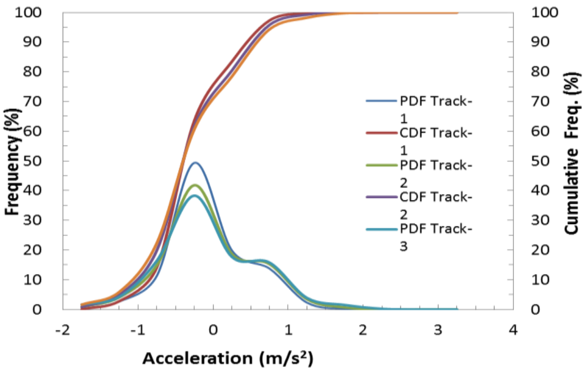
a. Noon peak period for direction-A



b. Noon peak period for direction-B



a. Evening peak period for direction-A



b. Evening peak period for direction-B

Figure 6 PDFs and CDFs of the motorcycle acceleration and deceleration.

3.4 The comparison of the motorcycle acceleration and deceleration among time period

Regarding the *F-test* and *t-test*, we present the comparison results of the motorcycle acceleration and deceleration among time periods as shown in Table 2 and Table 3 for both tests respectively. Both tables show that the motorcycle acceleration and deceleration among the time periods are similar.

4. CONCLUSSION

The real world driving cycle of motorcycle on an arterial urban route in Makassar City, Indonesia has been analyzed in this study. By using GPS equipment and floating car survey method, the driving cycle was described the fluctuation of motorcycle speed in second by second. Then, eight parameters of the driving cycle i.e. the average speed including all motorcycle behavior mode (V1), the average speed without idling mode (V2), the acceleration (A), the deceleration (D), the motorcycle spent time for cruise (C), the percentage of acceleration (Pa), the percentage of deceleration (Pd), the percentage of cruise (Pc), and the percentage of idling (Pi) were analyzed.

Table 2 The results of F-test for the motorcycle acceleration and deceleration varians

Time Periods	Data Types	Track-1	Track-2	Track-3	
Morning Peak	Track-1		0.0057	0.0000	Values of $F_{statist.}$
	Track-2	1.1325		0.0267	
	Track-3	1.1338	1.1280		
	Values of $F_{critical}$				
	Data Types	Track-1	Track-2	Track-3	
Noon Peak	Track-1		0.7918	0.9966	Values of $F_{statist.}$
	Track-2	1.1253		0.7901	
	Track-3	1.1234	1.1220		
	Values of $F_{critical}$				
	Data Types	Track-1	Track-2	Track-3	
Evening Peak	Track-1		0.1978	0.9602	Values of $F_{statist.}$
	Track-2	1.2081		0.1713	
	Track-3	1.2062	1.2028		
	Values of $F_{critical}$				

Table 3 The results of F-test for the motorcycle acceleration and deceleration means

Time Periods	Data Types	Track-1	Track-2	Track-3	
Morning Peak	Track-1		0.9666	0.9947	Values $t_{statist.}$
	Track-2	1.9631		0.4868	
	Track-3	1.9632	1.9632		
	Values of $t_{critical}$				
	Data Types	Track-1	Track-2	Track-3	
Noon Peak	Track-1		0.9892	0.9701	Values $t_{statist.}$
	Track-2	1.9630		0.4903	
	Track-3	1.9628	1.9628		
	Values of $t_{critical}$				
	Data Types	Track-1	Track-2	Track-3	
Evening Peak	Track-1		0.9157	0.9648	Values $t_{statist.}$
	Track-2	1.9639		0.4759	
	Track-3	1.9638	1.9637		
	Values of $t_{critical}$				

The analysis on data survey of the eight parameters of the motorcycle driving cycle behavior shows that the motorcycle has the average vehicle speed below 40 kmhr-1, however the fraction of acceleration, deceleration and cruise parameters dominated the driving cycle.

The motorcycle acceleration and deceleration values are generally in interval of -1.0 ms^{-2} until 1.0 ms^{-2}. However, there is no difference acceleration and deceleration among the time period variations. Overall, the phenomena of the motorcycle driving cycle in the route could be categorized as steady flow on the low average speeds. These results confirmed the Hustim et al. (2012) research about the characteristic of the heterogeneous traffic condition in Makassar City, as well as Aly et al. (2012) research for the driving cycle of passenger cars on an arterial road in the city.

In conclusion, the motorcycle driving cycle on the route provide a basis for an extension survey of the motorcycle driving behavior in all urban arterial routes in Makassar city. We also expect that the results are useful in development a prediction model for motorcycle emission in further studies.

REFERENCES

Abulebu, H., Ramli, M.I., dan Harianto, T., (2012), A Study on the Motorcycle Speed of One-Directional Urban Roads in Makassar. Proceeding of the 15th FSTPT International Symposium.

Aly, S.H., Selintung, M., Wunas, S., Sasmita, S.A., dan Ramli, M.I., (2012), Running Vehicle Emission Factors of Vehicle Fleet in Makassar, Indonesia. Proceeding of the 8th International Symposium on Lowland Technology.

Asri, A., Ramli, M.I., dan Samang, L., (2011) Motorcyclist acceptability on road safety policy: Motorcycle exclusive lane in Makassar. Proceeding of the 14th FSTPT International Symposium, Pekanbaru, Riau, November 11-12, 2011.

Asri, A., Ramli, M.I., Ali, N., dan Samang, L., (2012) A study on motorcycle ownership of residential households in Makassar. Proceeding of the 15th FSTPT International Symposium, STTD Bekasi, November 23-24, 2012.

Azis, M.A., Ramli, M.I., dan Aly, S.H., (2012) The real world driving cycle of motorcycle on an arterial urban route in Makassar - Indonesia. Proceeding of the International Seminar On Infrastructure Development In Cluster Island Eastern Part of Indonesia, Bau-Bau, January 19th, 2013.

Chandra, S., and Kumar, U., (2003) Effect of Lane Width on Capacity under Mixed Traffic Condition in India. Journal of Transportation Engineering, Mar. Apr., 155-160.

Hustim, M., Anai, K., dan Fujimoto, K., (2011) Survey on Road Traffic Noise in Makassar City in Indonesia: Effect of Horn on Noise Level. Proceeding of the 40th Conference of Architectural Institute of Japan, Kyushu Branch.

Hustim, M., dan Fujimoto, K., (2012), Road Traffic Noise under Heterogeneous Traffic Condition in Makassar City, Indonesia. Journal of Habitat Engineering and Design, Vol. 4, No. 1, pp. 109 – 118.

Minh, C.C., Sano, K., dan Matsumoto, S., (2005) The Speed, Flow and Headway Analyses of Motorcycle Traffic. Journal of the Eastern Asia Society for Transportation Studies, Vol.6, pp. 1496-1508.

Minh, C.C., Sano, K., Mai, T.T., and Matsumoto, S. 2010. Development of Motorcycle Unit for Motorcycle-Dominated Traffic. Journal of the Eastern Asia Society for Transportation Studies, Vol.8, pp. 1596-1608.

Nakatsuji, T., Hai, N.G., Taweesilp, S., and Tanaboriboon, T. 2001. Effect of Motorcycle on Capacity of Signalized Intersections. Infrastructure Planning Review, Sep., 935-

942.
Pemerintah Provinsi Sulawesi Selatan, (2012) Sulawesi Selatan dalam Angka, Badan Pusat Satistik, Pemerintah Provinsi Sulawesi Selatan.
Putranto, L.S., Suardika, G.P., Sunggiardi, R., Munandar, A.S., and Lutfi, I. 2011. The Performance of Motorcycle Lanes in Jakarta and Sragen. Proceeding of the 9th Conference of the Eastern Asia Society for Transportation Studies.
Zakaria, A., Aly, S.H., Ramli, M.I. 2011. Distribution Model of Motorcycle Speed on Divided Roadway in Makassar. Proceeding of the 14th FSTPT International Symposium.