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Characterization and Development of a KT River Driving Cycle for PHERB Powertrain

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Abstract-Unlike standard driving cycles, the novel driving cycle of a Kuala Terengganu (KT) river for plug-in hybrid electric recreational boat (PHERB) powertrain is presented in this paper. The real world data are obtained using on-board measurement techniques, which is global positioning system to collect boat speed-time data along the selected route. Route selection was based on the records of average daily traffic of the KT river cruise. Various variables were used in the characterization of KT river driving cycle development for PHERB powertrain. The developed driving cycle contains a 2058 s speed time series, with a distance of 8.5 km, and an average and a maximum speed of 14.88 km/h and 31.93 km/h, respectively. The results obtained from this analysis are within reasonable range and satisfactory.

Keywords – Driving Cycle. Plug-in hybrid electric recreational boat, Powertrain

I. INTRODUCTION

The drive cycle profile contains a time history data for a desired speed [1 – 4]. The drive cycles consist of multiple accelerations and braking events for a particular range of time depending on the type of the drive cycle profile. There is no existing driving cycle for river in Kuala Terengganu (KT). Therefore, the objective of this study is to construct and characterize the KT river driving cycle. Then, the characteristics of a developed KT river driving cycle for plug-in hybrid electric recreational boat (PHERB) powertrain is calculated.

II. DRIVING CYCLE DEVELOPMENT

In this study, on-board measurement method was implemented in developing the KT river driving cycle. Global positioning system (GPS) is used to collect the speed-time data along the selected route. For KT river drive cycle, the data was collected based on regularly route used by tourist. Based on the literature [5 – 6], 12 variables are used in KT river driving cycle construction as listed in Table I. The development of driving cycle involves three steps, which are route selection, data collection and drive cycle construction. The methodology of the KT river driving cycle development is illustrated in the form of flow chart in Fig 1. Fig 2 shows the selected route for KT river driving cycle development.

TABLE I. VARIABLES USED IN KT RIVER DRIVING CYCLE ANALYSIS

No	Variable	Unit	Formula
1	Average Speed , v_1	km/h	$v\_avg = 3.6 \frac{dist}{T_{total}}$
2	Average Running Speed, v_2	km/h	$v\_run = 3.6 \frac{dist}{T_{drive}}$
3	Average Acceleration, a	m/s²	$a\_avg = \left(\sum_{i=1}^{n} \begin{cases} 1\,(a_i > 0) \\ 0\ \text{(else)} \end{cases} \right)^{-1} \sum_{i=1}^{n} \begin{matrix} 1 & (a_i > 0) \\ 0 & \text{(else)} \end{matrix}$
4	Average Deceleration, d	m/s²	$d\_avg = \left(\sum_{i=1}^{n} \begin{cases} 1\,(a_i < 0) \\ 0\ \text{(else)} \end{cases} \right)^{-1} \sum_{i=1}^{n} \begin{matrix} 1 & (a_i < 0) \\ 0 & \text{(else)} \end{matrix}$
5	Mean Length of a driving period, c	s	$T_{total} = t_2 - t_1 + \sum_{i=2}^{n} (t_i - t_{i-1})$
6	Time Proportion of Idling, P_i	%	$\%drive = \frac{T_{drive}}{T_{total}}$

7	Time Proportion of Cruise, P_c	%	$\%cruise = \frac{T_{cruise}}{T_{total}}$
8	Time Proportion of Acceleration, p_a	%	$\%acc = \frac{T_{acc}}{T_{total}}$
9	Time Proportion of Deceleration, P_d	%	$\%dec = \frac{T_{dec}}{T_{total}}$
10	Average number of acceleration-deceleration changes within one driving period, M		-
11	Root Mean Square of Acceleration, RMS	m/s^2	$RMS = \sqrt{\frac{1}{T_{total}} \sum_{i=1}^{n} a_i^2}$
12	Acceleration Energy per Kilometer, KPE	m/s^2	$PKE = \frac{1}{dist} \sum_{i=2}^{n} \begin{cases} v_i^2 - v_{i-1}^2 & (v_i > v_{i-1}) \\ & (else) \end{cases}$

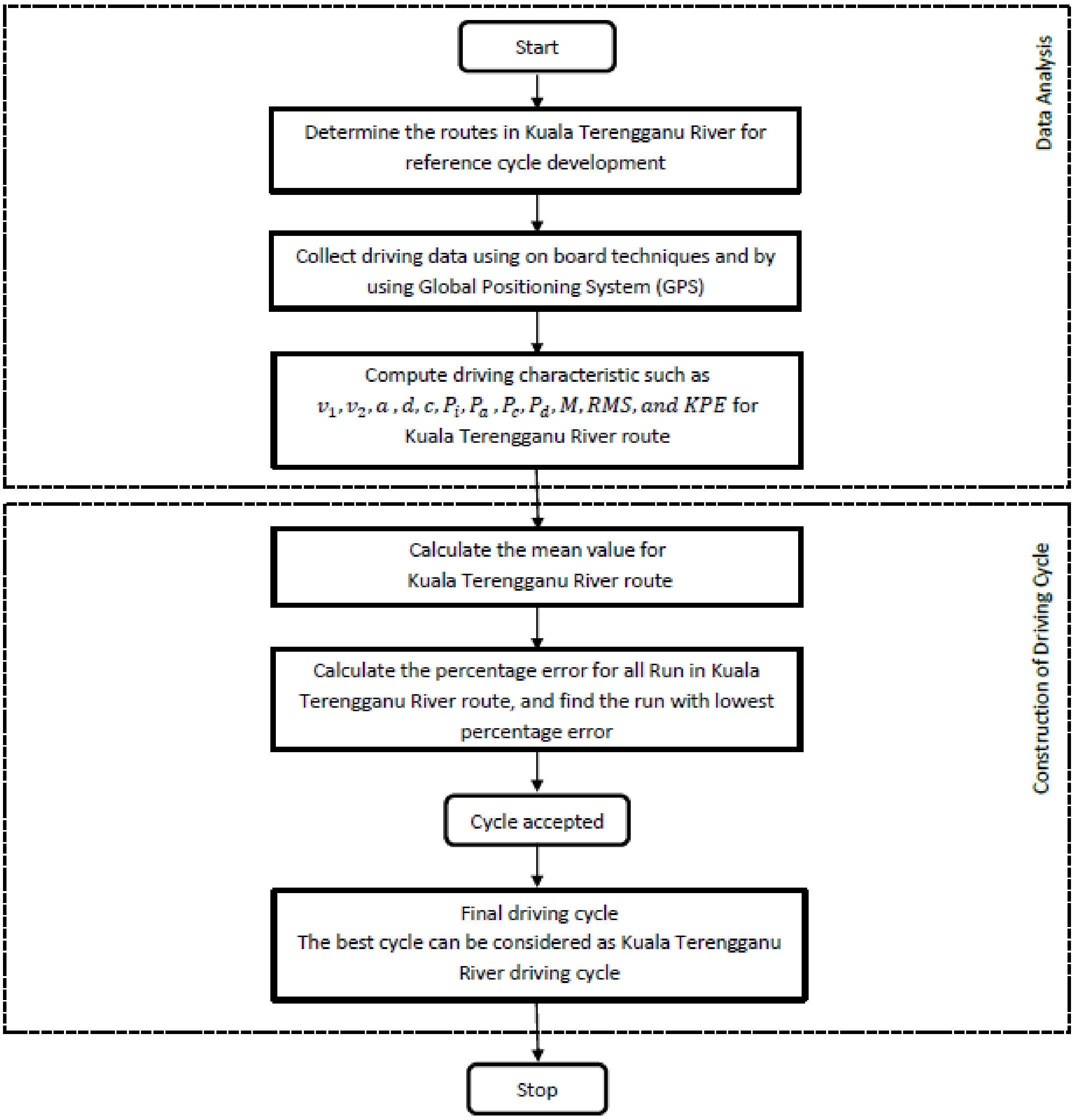

Fig 1. Flow chart of KT river driving cycle development

Fig 2. The selected route of KT river

III. DATA ANALYSIS

Speed-time data is collected by using GPS along the selected route around KT river. The data is collected during the period of 5:00 - 6:00 p.m. for 20 days on January 2015. During 20 days of collecting data, as many as 20 runs are recorded for 1 run per day. The value of 12 data variables are shown in Table II, then the mean values are calculated and listed in Table III. After that, the percentage error for all run is calculated as in Table IV. The lowest percentage error for run 4 is considered as the best KT river driving cycle. The most important factor influencing the emission of the boat and important criteria to measure the traffic quality is speed. The average speed for KT river driving cycle is 14.88 km/h and the average running speed is 14.99 km/h.

Based on the results, it can be concluded that the speed is low, as expected. During the test run, time proportion for four operating modes, which are idling, cruising, acceleration and deceleration are calculated. The time proportion of idling, cruising, acceleration and deceleration are 0.78, 33.97, 32.38 and 32.91, respectively. The rate for acceleration and deceleration are identical, which is 0.14 m/s^2. Therefore, it shows that the driving behavior in KT river is an aggressive type. The value of mean length of driving period is 2058 s. The mean length of driving period is high, this indicates that the path is good and clear without any obstacles. The root mean square for this run is 0.22 m/s^2 and the acceleration energy per kilometer is 0.08 m/s^2. The best KT river driving cycle is constructed as presented in Fig 3.

TABLE II. KT RIVER DRIVING CYCLE DATA ANALYSIS

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s^2)	d (m/s^2)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s^2)	KPE (m/s^2)
j	1	2	3	4	5	6	7	8	9	10	11	12
Run 1	14.51	14.60	0.11	0.11	2055	0.63	40.10	29.41	29.89	0.59	0.13	0.07
Run 2	14.54	14.69	0.14	0.14	2046	1.03	27.66	35.79	35.55	0.71	0.18	0.10
Run 3	14.64	14.82	0.27	0.26	2060	1.21	57.91	20.16	20.74	0.41	0.31	0.11
Run 4	14.88	14.99	0.14	0.14	2058	0.78	33.97	32.38	32.91	0.65	0.22	0.08
Run 5	14.74	14.82	0.11	0.11	2066	0.53	39.16	29.78	30.56	0.60	0.17	0.07
Run …..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
Run …..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
Run 17	14.89	15.01	0.14	0.14	2041	0.78	26.85	36.13	36.27	0.72	0.19	0.10
Run 18	14.94	15.06	0.29	0.30	2054	0.78	62.95	18.27	18.02	0.36	0.36	0.11
Run 19	15.14	15.22	0.27	0.26	2048	0.49	58.11	20.42	21.01	0.41	0.31	0.11
Run 20	15.04	15.16	0.27	0.26	2053	0.78	57.35	20.65	21.24	0.42	0.31	0.11

TABLE III. MEAN VALUES OF THE ASSESSMENT PARAMETERS OF GROUPED RUNS

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s^2)	d (m/s^2)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s^2)	KPE (m/s^2)
j	1	2	3	4	5	6	7	8	9	10	11	12
Mean Value Route 1 (run 1 – run 20)	14.87	14.98	0.18	0.18	2051.05	0.78	41.90	28.49	28.87	0.57	0.22	0.09

TABLE IV. PERCENTAGE DIFFERENCE RELATIVE TO TARGET SUMMARY STATISTICS

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s^2)	d (m/s^2)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s^2)	KPE (m/s^2)	Total Error (%)
j	1	2	3	4	5	6	7	8	9	10	11	12	
Mean Value	14.87	14.98	0.18	0.18	2051.05	0.78	41.90	28.49	28.87	0.57	0.22	0.09	
Run 1	2.42	2.54	38.89	38.89	0.19	19.23	4.30	3.23	3.53	3.51	40.91	22.22	179.86
Run 2	2.22	1.94	22.22	22.22	0.25	32.05	33.99	25.62	23.14	24.56	18.18	11.11	217.15
Run 3	1.55	1.07	50.00	44.44	0.44	55.13	38.21	29.24	28.16	28.07	40.91	22.22	339.44
Run 4	0.07	0.07	22.22	22.22	0.34	0	18.93	13.65	13.99	14.04	0	11.11	116.64
Run 5	0.87	1.07	38.89	38.89	0.73	32.05	6.54	4.53	5.85	5.26	22.73	22.22	179.63
Run …..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
Run …..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
Run 17	0.13	0.20	22.22	22.22	0.49	0	35.92	26.82	25.63	26.32	13.64	11.11	184.7
Run 18	0.47	0.53	61.11	66.67	0.14	0	50.24	35.87	37.58	36.84	63.64	22.22	375.31
Run 19	1.82	1.60	50.00	44.44	0.15	37.18	38.69	28.33	27.23	28.07	40.91	22.22	320.64
Run 20	1.14	1.20	50.00	44.44	0.10	0	36.87	27.52	26.43	26.32	40.91	22.22	277.15

TABLE V. MINIMUM PERCENTAGE ERROR OF THE ASSESSMENT PARAMETERS OF GROUPED RUNS

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s^2)	d (m/s^2)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s^2)	KPE (m/s^2)	Total Error (%)
j	1	2	3	4	5	6	7	8	9	10	11	12	
Run 4	0.07	0.07	22.22	22.22	0.34	0	18.93	13.65	13.99	14.04	0	11.11	116.64

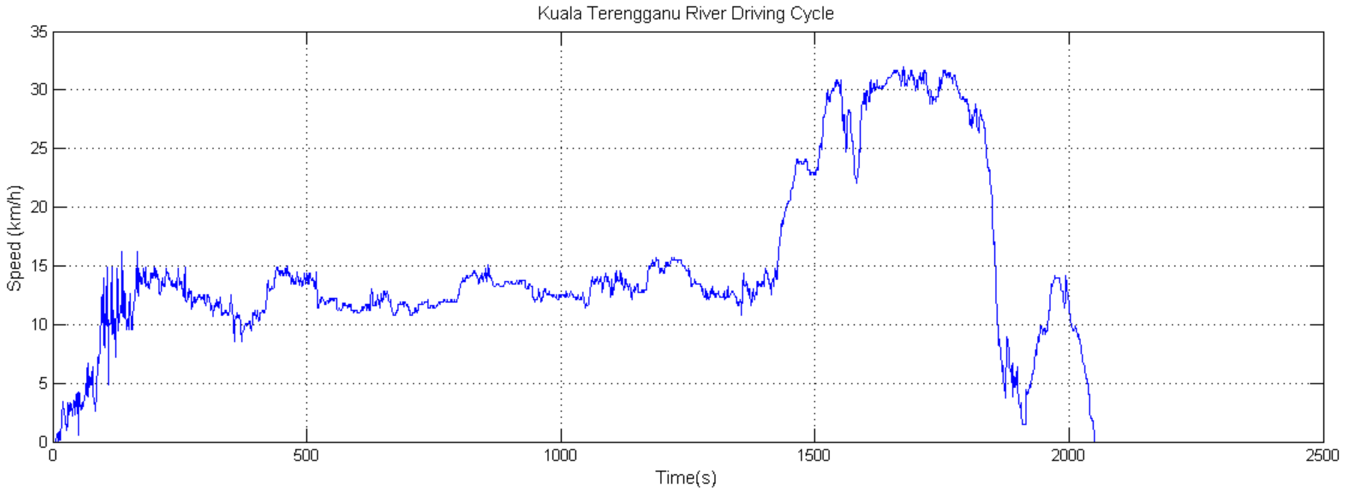

Fig 3. The KT river driving cycle

IV. CONCLUSIONS

The results of the KT river driving cycle, in terms of average speed, running speed, acceleration and deceleration, mean length, time proportion of idling, cruise, acceleration and deceleration, root mean square of acceleration and acceleration energy per kilometer are within reasonable and expected range. Based on the results, it can be concluded that the KT river driving cycle can be used to measure fuel consumption and emissions of the PHERB powertrain.

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REFERENCES

[1] T. J. Barlow, S. Latham, I. S. McCrae and P. G. Boulter, "A Reference Book of Driving Cycles for Use in the Measurement of Road Vehicle Emissions", published project report PPR354 for the Department for Transport, version 3, June 2009.

[2] K. Wipke, T. Markel and D. Nelson, "Optimizing Energy Management Strategy and Degree of Hybridization for a Hydrogen Fuel Cell SUV", EVS 18, Berlin, 2001.

[3] M. A. Mallouh, B. Denman, B. Surgenor and B. Peppley, "A study of Fuel Cell Hybrid Auto Rickshaws Using Realistic Urban Drive Cycles", Jordan Journal of Mechanical and Industrial Engineering, vol. 4, no. 1, pp. 225 – 229, Jan. 2010.

[4] J. D. Wishart, Y. Zhou and Z. Dong, "Review, Modelling and Simulation of Two-Mode Hybrid Vehicle Architecture", Proceedings of IDETC/CIE, Las Vegas, Nevada, USA, Sept. 2007.

[5] Hung, W.T., Tong, H.Y., Lee, C.P., Ha, K., & Pao, L.Y. (2007).Development of a practical driving cycle construction methodology: A case study in Hong Kong. *Transportation Research Part D*, 132-140.

[6] Kamble, S.H., Mathew, T.V., & Sharma, G. (2009).Development of real world driving cycle: Case study of Pune, India. *Transportation Research Part D*, 132-140.