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ST RIVER DRIVING CYCLE CHARACTERIZATION

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ABSTRACT

This paper indicates the results of the Seberang Takir (ST) river driving cycle characterization for plug-in hybrid electric recreational boat (PHERB) powertrain. The real world data are obtained using on-board measurement techniques, which is global positioning system, in order to collect boat speed-time data along the selected route. The designated route based on the previous daily average traffic of the ST passenger boat record. Multiple variables are implemented in the characterization of ST river driving cycle for PHERB powertrain. The constructed driving cycle consists of 466 s speed time series, with a distance of 939.42 m, come along with an average and maximum speed of 7.26 km/h and 14.18 km/h, respectively. The results obtained from the analysis are within adequate range and satisfactory.

Keywords: PHERB, riving cycle, powertrain, emissions, fuel consumption.

INTRODUCTION

Boat is the third important transportation after car and motorcycle in Seberang Takir (ST). Instead of using high distance route, the locals intend to use water transportation since it save more time rather ordinary route. The driving cycle in ST river is untraceable or nearly unfound, so the purpose of this study is to obtain a better understanding of driving characteristics for ST river such as average speed, running speed, acceleration, deceleration, mean length, time proportion of idling, cruise, acceleration and deceleration, root mean square of acceleration and deceleration, and acceleration energy per kilometer. This paper explains a step and methodology to construct ST river driving cycle for plug-in hybrid electric recreational boat (PHERB). Driving cycle is an important core for inventive vehicle emission models and powertrain input (Amirjamshidi, *et al*., 2013). Figure-1 presents a schematic diagram of the PHERB powertrain. It consists of one electric machine, which generate as either a motor or generator at the time and energize by batteries and ultracapacitors packs.The purpose of a driving cycle is to simulate an actual river driving characteristics, in order to measure the boat exhaust emission and fuel consumption (Tong *et al*., 1999). This method of driving cycle had been developed, or already implemented around the world including America, Europe, Australia and Asia (Hung *et al*., 2007).

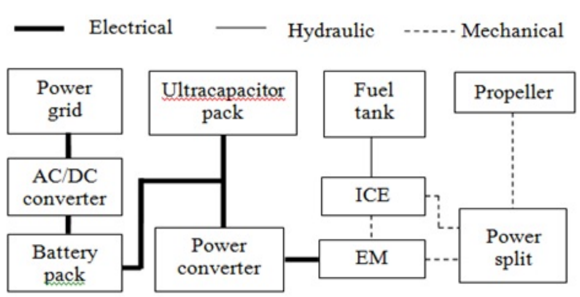

Figure-1. Schematic illustration of series-parallel PHERB power train.

DRIVING CYCLE DEVELOPMENT

In Commonly, on top of developing driving cycle, it's include of recording the driving condition using one or multiple instrumented vehicles, which are usually driven for general purpose. Data will be taken as the image of the river traffic situation. Next the data will be analyzed, in order to subsequently explained or characterized this condition. Cycle construction, route selection and data collection are the three major task to produce a driving cycle. In this study, on-board measurement techniques will be implemented to obtain vehicle speed data. The data are produced using previous techniques, together along ,with global positioning system (GPS) to collect boat speed-time data along designated interested route as in Figure-2. This technique involves recording a set or real world speed-time data. This process will be repeated to obtain large amount of data. During the test run, the boat speed with respect to time will be recorded then the route is determined throughout the interested area. For ST river driving cycle, the data will be collected based on regularly route used by locals. Once the data are obtained, it will be analyzed and characterized, then the situation can be described. The flowchart indicate the step by step method to collect the data at Seberang Takir, for PHERB powertrain to obtain ST river driving cycle and it shown in Figure-3.

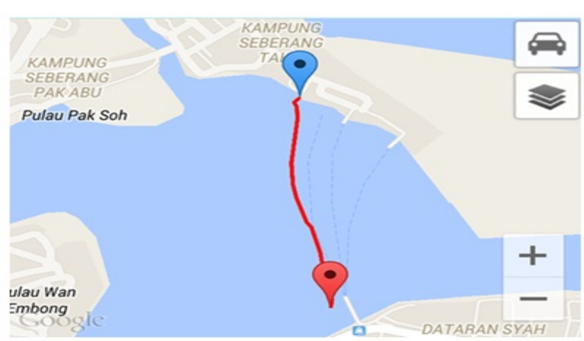

Figure-2. Selected route at ST river.

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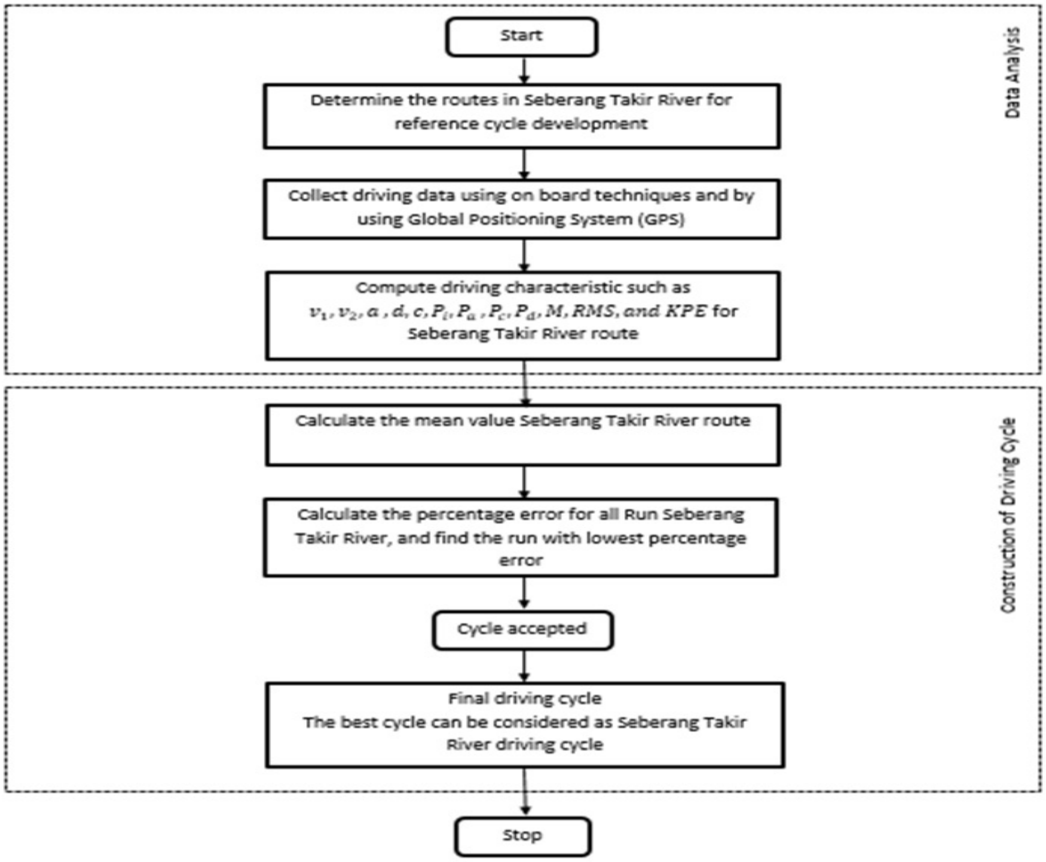

Figure-3. Flowchart for ST river driving cycle.

Table-1. Variables used in ST river driving cycle construction (Barlow *et al.* 2009).

No	Variable	Unit	Formula
1	Average speed ,	km/h	$v\_avg = 3.6\dfrac{dist}{T_{total}}$
2	Average running speed, v_2	km/h	$v\_run = 3.6\dfrac{dist}{T_{drive}}$
3	Average acceleration of all acceleration phases, 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 of all deceleration phases, 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	-
6	Time proportion of idling, P_i	%	$\%drive = \dfrac{T_{drive}}{T_{total}}$
7	Time proportion of acceleration, P_a	%	$\%acc = \dfrac{T_{acc}}{T_{total}}$
8	Time proportion of cruise, P_c	%	$\%cruise = \dfrac{T_{cruise}}{T_{total}}$
9	Time proportion of deceleration, P_d	%	$\%dec = \dfrac{T_{dec}}{T_{total}}$
10	Average number of acceleration-deceleration changes within one driving period, M		-
11	Root mean square of acceleration, RMS	m/s²	$RMS = \sqrt{\dfrac{1}{T_{total}}\sum_{i=1}^{n}a_i^2}$
12	Acceleration energy per kilometer, PKE	m/s²	$PKE = \dfrac{1}{dist}\sum_{i=2}^{n}\begin{cases}{v_i}^2 - v_{i-1}^2 & (v_i > v_{i-1})\\ & (else)\end{cases}$

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RESULTS AND DISCUSSIONS

The Speed-time data is collected using GPS along the selected route around ST river. During 20 days of collecting data, as many as 20 runs are recorded for 1 run per day. The data is obtained during the period of 5:30 - 6:00 pm for 20 days on March 2015. In Table-1 its indicate the variables and formulas that been use through out the research. The formulas consist of the average speed,running speed,acceleration and etc. The value of 12 data variables are shown in Table-2.The mean values in Table-3 are obtained from Table-2. After the mean value is gained, the percentage error for all run is calculated and it shown in Table-4. In the Table-5 it shown the most minimum percentage error is from Run 17 that has been calculated in the Table 4. Run 17 is the most significant choice to represent ST river driving cycle because it has the lowest percentage error. From the data collected at ST river, the average speed for ST river is 8.87 km/h and the average running speed is 8.81 km/h. Based on the results, it can be concluded that the speed is very slow. During the test run, the four vehicle operating modes is calculated. The time spent by boat in different operating mode, it was observed that 3.22 % for the time proportion of idling that counts 12.56 s , 19.96 % for time proportion of cruising that counts 77.84 s ,38.06 % time proportion of acceleration that counts 148.43 s and 38.92 % time proportion of deceleration that counts 151.79 s respectively. The rate for acceleration and deceleration is 0.25 and 0.24. The value of mean length of driving period is 2058 s. The mean length of driving period is high, it indicates that the path is good and clear without any obstacles. The root mean square for this run is 0.31 and the acceleration energy per kilometer is 0.20. The best ST river driving cycle is constructed as presented in Figure-4.

Table-2. ST 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	7.62	7.85	0.17	0.17	411	2.92	17.27	40.24	39.76	0.80	0.21	0.15
Run 2	7.70	7.98	0.18	0.17	401	3.49	14.46	40.00	42.25	0.82	0.24	0.15
Run 3	6.08	6.30	0.22	0.25	396	3.54	13.13	44.05	39.49	0.83	0.30	0.20
Run 4	8.21	8.47	0.35	0.32	390	3.08	56.67	19.28	21.08	0.40	0.42	0.13
Run 5	8.28	8.59	0.26	0.24	385	3.64	16.36	39.06	41.15	0.80	0.33	0.21
Run	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Run	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Run 16	7.54	7.77	0.24	0.24	465	3.01	20.00	38.36	38.79	0.77	0.31	0.20
Run 17	7.26	7.50	0.25	0.24	466	3.22	19.96	38.06	38.92	0.77	0.31	0.20
Run 18	5.64	5.86	0.21	0.25	408	3.68	12.75	44.72	39.07	0.84	0.29	0.20
Run 19	5.17	5.37	0.22	0.25	408	3.68	12.99	44.96	38.57	0.83	0.30	0.20
Run 20	5.42	5.63	0.22	0.26	408	3.68	13.24	44.96	38.33	0.83	0.29	0.20

Table-3. Mean values of the assessment parameters of 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 (run 1 – run 20)	7.29	7.53	0.22	0.23	405.80	3.19	17.59	40.73	38.68	0.79	0.29	0.18

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Table-4. Percentage difference relative to target summary statistics.

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s²)	d (m/s²)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s²)	KPE (m/s²)
j	1	2	3	4	5	6	7	8	9	10	11	12
Mean Value	7.29	7.53	0.22	0.23	405.80	3.19	17.59	40.73	38.68	0.79	0.29	0.18
Run 1	4.53	4.25	22.73	26.09	1.28	8.46	1.82	1.20	2.79	1.27	27.59	16.67
Run 2	5.62	5.98	18.18	26.09	1.18	9.40	17.79	1.79	9.23	3.80	17.24	16.67
Run 3	16.60	16.33	0	8.70	2.41	10.97	25.36	8.15	2.09	5.06	3.45	11.11
Run 4	12.62	12.48	59.09	39.13	3.89	3.45	222.17	52.66	45.50	49.37	44.83	27.78
Run 5	13.58	14.08	18.18	4.35	5.13	14.11	6.99	4.10	6.39	1.27	13.79	16.67
Run	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Run	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Run 16	3.43	3.19	9.09	4.35	14.59	5.64	13.70	1.20	0.28	2.53	6.90	11.11
Run 17	0.41	0.40	13.64	4.35	14.83	0.94	13.47	1.79	0.62	2.53	6.90	11.11
Run 18	22.63	22.18	4.55	8.70	0.54	15.36	27.52	8.15	2.79	6.33	0	11.11
Run 19	29.08	28.69	0	8.70	0.54	15.36	26.15	52.66	9.23	5.06	3.45	11.11
Run 20	25.65	25.23	0	13.04	0.54	15.36	24.73	4.10	2.09	5.06	0	16.67

Table-5. Minimum percentage error of the assessment parameters of grouped runs.

Criterion	v_1 (km/h)	v_2 (km/h)	a (m/s²)	d (m/s²)	c (s)	P_i (%)	P_c (%)	p_a (%)	P_d (%)	M	RMS (m/s²)	KPE (m/s²)
j	1	2	3	4	5	6	7	8	9	10	11	12
Run 17	0.41	0.40	13.64	4.35	14.83	0.94	13.47	1.79	0.62	2.53	6.90	11.11

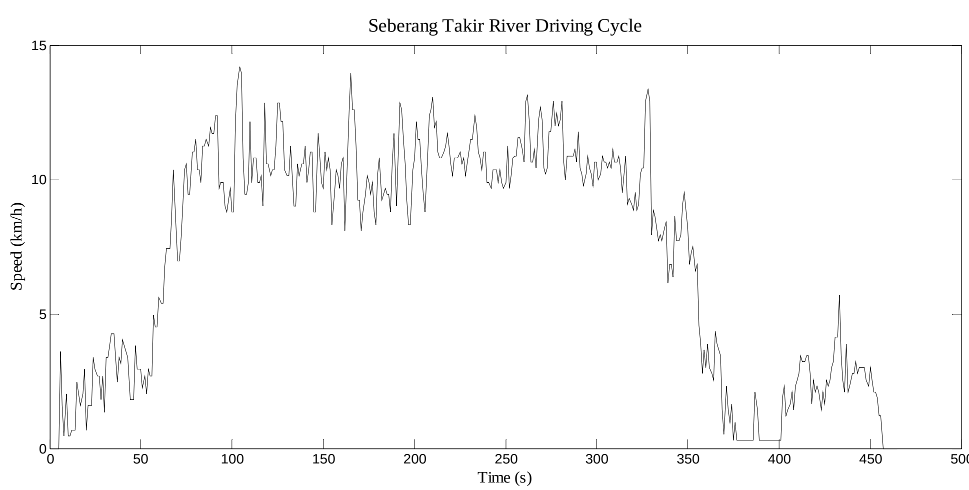

Figure-4. The recommended ST river driving cycle.

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CONCLUSIONS

Based on the results of this study, it can be concluded that the proposed method is possible to generate a recommended ST river driving cycle that can be used for PHERB powertrain, in order to measure fuel consumption and emissions. This paper also proved that from executed research above that there is potential ability to use this data on PHERB powertrain.

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