ISSN Print : 2621-3745
ISSN Online : 2621-3753
(Page.89-96)

Journal of Science and Applied Engineering (JSAE)
Vol. 5, No. 2, October 2022
DOI : 10.31328/jsae.v5i2.4038

ANALYSIS OF THE EFFECT OF INTAKE MANIFOLD SHAPE ON MOTORCYCLE ENGINE PERFORMANCE

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Submitted : 27 July 2022; *Revision :* 14 September 2022; *Accepted :* 30 September 2022

ABSTRACT

The intake manifold is a vehicle component where air and fuel flow from the carburetor to the combustion chamber through the intake valve. In order to get turbulent flow, it is necessary to modify the intake manifold. This research method uses data collection techniques using observation. Torque, power, fuel consumption, and exhaust emissions for each use of the intake manifold modification were tested three times at engine cycles of 2500-9000 rpm. In this study, the data were obtained from independent variables affecting dependent variation. The independent variable in this study was the shape of the intake manifold with a distance of 1 cm, 2 cm, and 3 cm. The dependent variable results from the independent variables are torque, power, fuel consumption, and exhaust emissions. It is necessary to control variables, including motorcycles according to the manufacturer specifications, testing engine performance using a 4-stroke transmission gear, engine working temperature (80-90 ^{o}C), and 92 octane fuel. 2 cm has the most significant impact on power, which is 5.47 HP. In testing the shape of the intake manifold, the threaded distance of 3 cm has the most significant impact on Torque, which is 7.15 Nm. In testing the shape of the intake manifold, which has an efficient impact on fuel consumption on a thread distance of 2 cm at 3000 rpm engine cycle with a time duration of 155.33 seconds. The peak engine cycle at 8000 rpm is the most economical on a 3 cm wine thread, with 71.67 seconds. The results of exhaust gas emissions for Hydrocarbon (*HC*) that are not burned out in the combustion process of the motor are the lowest, namely at a thread distance of 1 cm with an engine cycle of 2000 rpm with a result of 263.33 ppm, for engine cycle 9000 rpm with a yield of 246 ppm. For levels of Carbon Monoxide (*CO*), which is incomplete combustion in the process of engine performance, the lowest is at a 2 cm threaded distance at a 2000 rpm engine cycle with a result of 2.22%, and for an engine cycle of 9000 rpm with a result of 0.23%.

Keywords *Intake Manifold; Motorcycle*; *Exhaust; Emissions*
Paper type Research paper

INTRODUCTION

The development of automotive technology is increasingly rapid, followed by the development of various components used in every motorcycle. One of the essential components of a motorcycle is the intake manifold. The intake manifold is a vehicle component where air and fuel flow from the carburator to the combustion chamber through the intake valve. The manufacturer standard makes the intake manifold construction according to the calculations, and they form the intake manifold construction to ensure the airflow into the combustion chamber is turbulent. If the airflow becomes turbulent, the incoming fuel mixture is more homogeneous, making the resulting combustion more perfect than the airflow that does not occur in turbulence. In order to obtain turbulent flow, modifications to the engine are needed, namely modifications to the intake manifold. The modification of the intake manifold affects the homogeneity and velocity of the air and fuel mixture flow from the carburator to the combustion chamber. The results to be achieved by changing the shape of the intake manifold, an increase in the flow pressure of the air and fuel mixture entering the combustion chamber is higher, which affects the performance of the engine produced on a motorcycle. To produce great power requires a perfect mixture of air and fuel [1]–[6].

Changes that can be made to the intake manifold are threading the surface of the intake manifold in the form of threads with a specific thread wavelength. The surface of the intake manifold is expected to produce a complete combustion process in the combustion chamber on a motorcycle. It

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can be seen from the effect of threading on the intake manifold inside the surface, which causes the airflow into the cylinder to be turbulent (swirl flow) [7], [8].

Research by Daniel Fr Sinaga, Semin Sanuri, and Aguk Zuhdi with the title "The Effect of Changes in the Shape of the Intake Manifold on the Performance of Diesel Motors with the Simulation Method" [9], [10]. The tighter the distance between the threaded waves, the more turbulent airflow enters the combustion chamber. The test results show that installing each intake manifold design on a diesel engine can operate up to the maximum loading for the same engine cycle.

Based on the various studies above, it can be concluded that modifying the shape of the intake manifold in the form of a screw on the intake manifold significantly affects engine performance in a motor vehicle. So the researchers conclude research that has been done previously. The researcher took the title Analysis of the Effect of Intake Manifold Shapes on Engine Performance on Motorcycles.

METHOD

The research method uses data collection techniques using observation. The engine performance test for each modified intake manifold was tested thrice at every 2500-9000 rpm engine cycle. Furthermore, testing was carried out on Torque, power, fuel consumption, and exhaust emissions Hydrocarbon (*HC*) and Carbon Monoxide (*CO*). This study uses the Dyno test, Gas Analyzer, and fuel consumption tools for real-time data retrieval. The data based on the Dyno test Monitor, Gas Analyzer, and fuel consumption tool are processed and analyzed graphical and statistically using the Annova Two-Way analysis technique to prove whether there is an effect on torque, power, fuel consumption and emissions. Exhaust gas (*HC*) (*CO*) on engine performance on motorcycles. In this study, the independent variable was also used: the intake manifold screw spacing of 1 cm, 2 cm, and 3 cm. At the same time, the dependent variables are torque, power, fuel consumption, and exhaust emissions (*HC*) (*CO*). Figure 1 shows the screw position installed in the intake manifold.

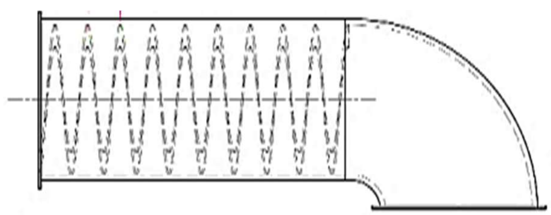

Figure 1. The modification intake manifold of the engine

Figure 2 prepares a motorcycle vehicle to be tested on a dyno test. After that, check all the equipment on sample testing, monitoring, blower, chassis dynamometer, rpm counter, fuel meter, stopwatch, and gas analyzer.

Figure 2. Setting motorcycle research equipment on the dyno test

Then test the motorcycle vehicle on the chassis dynamometer with an engine cycle of 2000-9000 rpm and after testing, see the data on the Monitor and Rpm counter. If the graph results and test

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numbers are out, continue with the following data. Fuel consumption is measured using a burret size containing Pertamax fuel 10 ml, and the motor cycle's engine cycle is 2000-9000 rpm. They are testing exhaust emissions *HC* and *CO* by inserting the gas analyzer into the vehicle exhaust of the motorcycle.

The research was conducted in December-June at the Vehicle Maintenance Workshop- the study program Automotive Engineering at the Malang State Polytechnic to analyze data on torque, power, fuel consumption, and exhaust emissions.

DISCUSSION

The testing results from the performance of the Honda Supra X 125 cc motorcycle using three intake manifolds with threaded distances of 1 cm, 2 cm, and 3 cm, as shown in the table below.

Power

TABLE I. TESTING POWER WITH THREE TYPES OF THE INTAKE MANIFOLD

Engine Cycle (rpm)	Thread Testing 1 cm	Thread Testing 2 cm	Thread Testing 3 cm
2500	2,27	2,63	2,67
3000	2,63	3,03	3,13
3500	3,13	3,33	3,47
4000	3,60	4,00	3,93
4500	4,20	4,50	4,50
5000	4,73	5,00	5,03
5500	5,07	5,23	5,20
6000	5,27	5,47	5,17
6500	5,37	5,40	5,03
7000	5,30	5,23	4,80
7500	5,07	4,87	4,33
8000	4,53	4,50	3,97
8500	4,10	4,00	3,33
9000	3,60	3,33	2,83

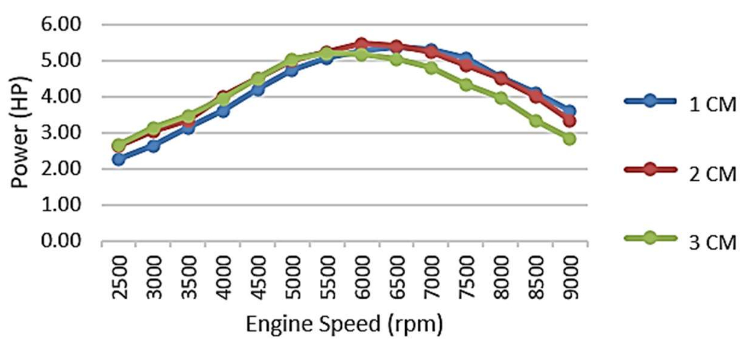

Figure 3. Comparison of power data for three types of the intake manifold

Power calculation:

$$P = \frac{2.\pi.n.T}{60} \quad (1)$$

where,

P = Power (HP)
T = Torque (N.m)
n = Engine cycle (rpm)

Calculating Average Data on Power:
(1 cm distance thread + 2 cm distance thread + 3 cm distance thread)/3 = (58,867+60,533+57,400) / 3 = 58.9333 HP.

From the table above, it can be seen the effect of intake manifold variations on the power generated on a motorcycle. The intake manifold variation data produces the most significant power with a threaded distance of 2 cm and a power of 5.47 HP. In comparison, a threaded distance of 1 cm produces a power of 5.37 HP, and a threaded distance of 3 cm produces 520 HP. The highest power is obtained on a manifold with a threaded distance of 2 cm, which is 5.47 HP.

Data analysis using Annova Two-way produces data for engine cycle P-value <0.05, which is 0.003. The data rpm influences the power of the motorcycle, and testing the screw variable produces a P-value <0.05, which is 0.03; then, for the screw variable, there is an effect on the engine power of the motorcycle.

Torque

Torque Calculation:

$$T = (716,2 \times Ne)/n \quad (2)$$

where,

T = torque (Nm)
Ne = effective power (Hp)
N = engine cycle (rpm)

TABLE II. TESTING TORQUE WITH THREE TYPES OF THE INTAKE MANIFOLD

Engine Cycle (rpm)	Thread Testing 1 cm	Thread Testing 2 cm	Thread Testing 3 cm
2500	5,91	5,73	6,54
3000	6,04	6,38	7,00
3500	6,39	6,71	7,14
4000	6,49	6,97	7,15
4500	6,60	6,99	7,10
5000	6,69	6,89	6,83
5500	6,53	6,88	6,56
6000	6,18	6,44	6,18
6500	5,87	5,89	5,72
7000	5,34	5,20	5,36
7500	4,76	4,56	5,01
8000	4,02	3,96	4,69
8500	3,41	3,36	4,39
9000	3,02	2,56	4,05

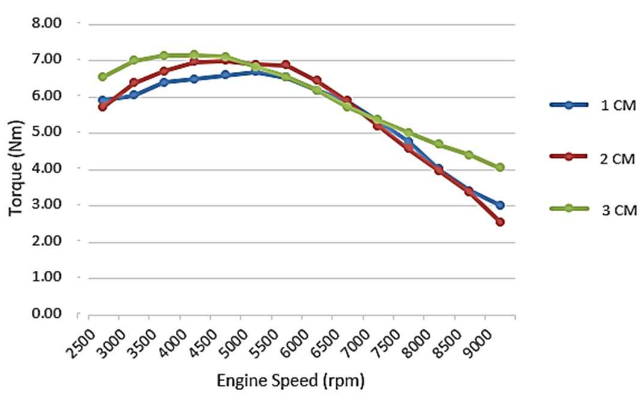

Figure 4. Comparison of torque data for three types of the intake manifold

From the table above, it can be seen the effect of intake manifold variations on the torque produced on a motorcycle. This data shows that the intake manifold variation is the largest, with a threaded distance of 3 cm and a torque of 7.15 Nm. In comparison, a thread with a distance of 1 cm produces the highest Torque of 6.69 Nm, and a threaded distance of 2 cm produces the highest Torque of 6.99 Nm. For the graph above, the highest torque for the 3CM thread is 7.15 Nm.

In data analysis, using Annova Two way produces data for the engine cycle with a P-value <0.05, i.e., 0.000. The data on the engine cycle influences engine torque on a motorcycle, and testing the

Journal of Science and Applied Engineering (JSAE)
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screw variable produces a P-value < 0.05, which is 0.00073. Then for the screw variable, there is an effect on engine torque on a motorcycle.

Fuel Consumption (SFC)

Based on the data and graphs of the fuel consumption test, it can be seen that for a variable threaded distance of 1 cm starting at 3000-8000 rpm engine cycle, and the result is 141.7-49.3 seconds. For the variable threaded distance of 2 cm starting with 3000-8000 rpm, the engine cycle produces a time of 155.33-68.33 seconds. The variable threaded distance of 3 cm with an engine cycle of 3000-8000 rpm produces a time of 127.00-71.7 seconds. It can be concluded that the initial engine cycle at 3000 rpm is the most fuel-efficient on the variable threaded distance of 2 cm with a time of 155.33 seconds. For the peak engine cycle at 8000 rpm, the most fuel-efficient on the variable screw distance is 3 cm with 71,7 seconds.

TABLE II. TESTING FUEL CONSUMPTION WITH THREE TYPES OF THE INTAKE MANIFOLD

Variable 1	Variable 2	Engine Cycle (rpm)					
		3000	4000	5000	6000	7000	8000
Thread Distance 1 cm	Q (average)	141,7	113,3	89,3	71,3	59,7	49,3
	Power (HP)	2,70	3,70	5,10	5,60	5,70	5,00
	Debit (cc/s)	0,07	0,09	0,11	0,14	0,17	0,20
	cc/hp.s	0,03	0,02	0,02	0,03	0,03	0,04
	gr/hp.s	0,02	0,02	0,02	0,02	0,02	0,03
	SFC : gr/watt.s	**14,43**	**13,16**	**12,11**	**13,81**	**16,23**	**22,37**
Thread Distance 2 cm	Q (average)	155,33	134,33	112,33	95,33	80,00	68,33
	Power (HP)	3,10	4,00	5,10	5,60	5,70	4,90
	Debit (cc/s)	0,06	0,07	0,09	0,10	0,13	0,15
	cc/hp.s	0,02	0,02	0,02	0,02	0,02	0,03
	gr/hp.s	0,02	0,01	0,01	0,01	0,02	0,02
	SFC : gr/watt.s	**11,46**	**10,27**	**9,63**	**10,34**	**12,10**	**16,48**
Thread Distance 3 cm	Q (average)	127,00	114,00	102,67	89,00	80,33	71,67
	Power (HP)	3,30	3,90	5,30	5,90	6,10	5,40
	Debit (cc/s)	0,08	0,09	0,10	0,11	0,12	0,14
	cc/hp.s	0,02	0,02	0,02	0,02	0,02	0,03
	gr/hp.s	0,02	0,02	0,01	0,01	0,02	0,02
	SFC : gr/watt.s	**13,17**	**12,41**	**10,14**	**10,51**	**11,26**	**14,26**

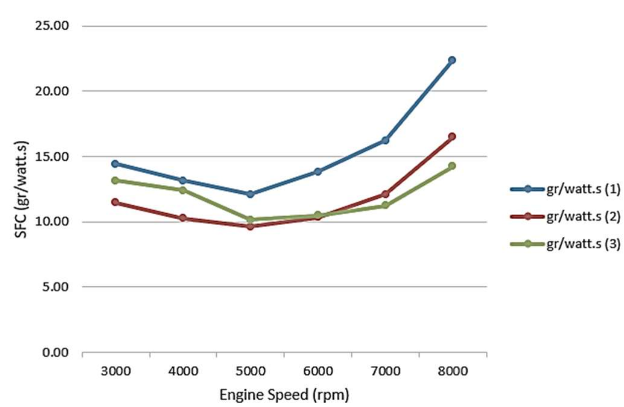

Figure 5. Comparison of fuel consumption data for three types of the intake manifold

In data analysis using Annova Two way, it produces data for engine cycle P-value < 0.05, which is 0.000. Data on engine cycle influences fuel consumption on motorcycles, and for testing, the screw variable on the intake manifold produces a p-value of <0.05, which is 0.00418. Then for the screw variable, there is an effect on fuel consumption on a motorcycle.

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Exhaust Emissions HC and CO

CO is a toxic gas compound formed due to incomplete combustion in the motor work process, and *CO* is measured in units of % volume. When the vehicle is operating, it will experience a combustion process. Combustion often occurs imperfectly so that it will produce pollutants.

Based on the 2006 Minister of Environment Regulation, it is explained that the 2006 Supra X motor has a threshold value of *HC* levels of 7000 ppm and *CO* of 3%. So from the table and graph above, it can be concluded that for the smallest 2000-9000 rpm engine cycle at 2cm threaded distance with 2.22% results for the 2000 rpm engine cycle and 0.23% results for the 9000 rpm engine cycle.

TABLE III. TESTING AVERAGE EXHAUST EMISSIONS (*CO*) WITH THREE TYPES OF THE INTAKE MANIFOLD

No	Engine Cycle (rpm)	1 cm CO 1	1 cm CO 2	1 cm CO 3	Average	2 cm CO 1	2 cm CO 2	2 cm CO 3	Average	3 cm CO 1	3 cm CO 2	3 cm CO 3	Average
1	2000	2,75%	2,31%	2,00%	2,35%	2,38%	2,20%	2,09%	2,22%	2,43%	2,32%	2,10%	2,28%
2	3000	2,57%	2,11%	1,73%	2,14%	1,96%	1,49%	1,21%	1,55%	1,76%	1,41%	1,96%	1,71%
3	4000	2,43%	2,03%	1,34%	1,93%	1,44%	1,25%	1,09%	1,26%	1,12%	1,87%	1,24%	1,41%
4	5000	2,21%	1,83%	1,13%	1,72%	1,12%	1,03%	0,92%	1,02%	1,34%	1,02%	1,47%	1,28%
5	6000	1,98%	1,31%	1,07%	1,45%	0,93%	0,72%	0,54%	0,73%	1,18%	0,89%	0,78%	0,95%
6	7000	1,47%	1,05%	0,96%	1,16%	0,72%	0,47%	0,27%	0,49%	0,69%	0,65%	0,87%	0,74%
7	8000	1,03%	0,87%	0,90%	0,93%	0,65%	0,23%	0,13%	0,34%	0,45%	0,34%	0,63%	0,47%
8	9000	0,29%	0,36%	0,27%	0,31%	0,43%	0,17%	0,10%	0,23%	0,20%	0,16%	0,48%	0,28%

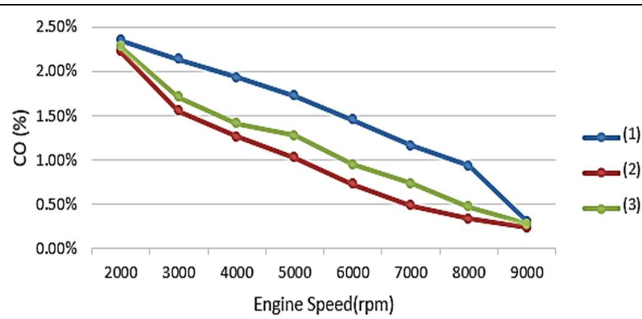

Figure 6. Comparison of exhaust emissions (*CO*) data for three types of the intake manifold

TABLE IV. TESTING AVERAGE EXHAUST EMISSIONS (*HC*) WITH THREE TYPES OF THE INTAKE MANIFOLD

No	Engine Cycle (rpm)	1 cm HC (ppm) 1	1 cm HC (ppm) 2	1 cm HC (ppm) 3	average	2 cm HC (ppm) 1	2 cm HC (ppm) 2	2 cm HC (ppm) 3	average	3 cm HC (ppm) 1	3 cm HC (ppm) 2	3 cm HC (ppm) 3	average
1	2000	300	285	205	263,33	432	489	521	480,67	350	328	386	354,67
2	3000	472	324	387	394,33	357	441	490	429,33	445	358	399	400,67
3	4000	289	346	437	357,33	324	422	451	399,00	383	428	438	416,33
4	5000	263	457	345	355,00	297	403	425	375,00	358	390	411	386,33
5	6000	314	336	312	320,67	263	388	400	350,33	326	373	395	364,67
6	7000	295	275	294	288,00	231	367	376	324,67	302	345	374	340,33
7	8000	274	234	276	261,33	204	341	358	301,00	276	298	338	304,00
8	9000	258	226	254	246,00	197	323	331	283,67	254	279	303	278,67

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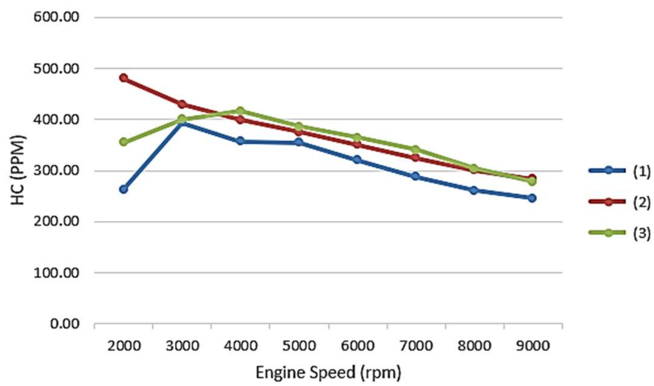

Figure 7. Comparison of exhaust emissions (*HC*) data for three types of the intake manifold

Data analysis using Annova Two way shows that the engine cycle P-value < 0.05, which is 0.000 then, for data at engine cycle, it influences *CO* exhaust emissions on motorcycles. Furthermore, testing the screw variable on the intake manifold produces P- the value is < 0.05, which is 0.0000, so for the screw variable there is an effect on *CO* exhaust emissions on motorcycles.

HC is an element of gasoline fuel compounds. The *HC* in the exhaust gas is from fuel compounds that are not burned out in the combustion process of the motor. The table and graph of the data above show a low *HC* level at a threaded distance of 1 cm with a 2000 rpm engine cycle of 263.33 ppm and an engine cycle of 9000 rpm with a result of 246 ppm. Data analysis using Annova Two way, the P-value is < 0.05, which is 0.000; the data at engine cycle influences *HC* exhaust emissions on motorcycles. The screw variable on the intake manifold produces P-value is < 0.05, which is 0.0000, such that the screw variable affects *HC* exhaust emissions on motorcycles.

CONCLUSION

Based on the results of testing and data analysis that has been carried out, the following conclusions are in testing the shape of the intake manifold, which has the most significant impact on power, the shape of the intake manifold is screwed at a distance of 2 cm, which is 5.47 HP. In testing the shape of the intake manifold, which has the most significant impact on torque, the shape of the intake manifold is screwed with a distance of 3 cm, which is 7.15 Nm. In testing the shape of the intake manifold, which impacts fuel consumption efficiency at a thread distance of 1cm with a duration of 174.9 seconds. The results of exhaust gas emissions for *HC* and *CO* have data results for the level of exhaust gases from fuel compounds that are not burned out in the motor combustion process is the smallest, namely at a thread distance of 1cm with 310.748 PPM. The results of *CO* for the 2000-9000 rpm engine cycle are the smallest at a 2 cm distance thread, with 2.22% results for the 2000 rpm engine cycle and 0.23% results for the 9000 rpm engine cycle.

ACKNOWLEDGMENT

The researcher would like to thank the Head of the Study Program Electronic Automotive Engineering at the State Polytechnic of Malang for providing the opportunity to conduct this research.

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Journal of Science and Applied Engineering (JSAE)
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