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The Differences Overlap Camshaft Duration to Performance Motorcycle 4- Stroke 110cm3

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A R T I C L E I N F O

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A B S T R A C T

The loss of performance in a motorcycle that has been used for a long time makes it uncomfortable when used. The purpose of this research is to determine the results of the effect of camshaft overlap duration on the performance of a 110 cc petrol engine. To verify its performance, experimental research methods were used in this thesis research. The research results show that variations in camshaft overlap duration between 12^{o}, 15^{o}, 18^{o} (standard) 23^{o,} and 28^{o} have the effect of increasing vehicle performance. For example, using a variation of camshaft overlap duration of 28^{o} produces the highest torque of 7,82 (Nm) at an engine speed of 6500 rpm and the highest power of 7.45 (Hp) at an engine speed of 7000 rpm and produces maximum BMEP 909,96 (KPa) at engine speed 6500 rpm. This can happen because according to the theory the greater the camshaft overlap duration on a vehicle, the better the flushing of the combustion chamber at top speed.

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INTRODUCTION

Vehicles with a long service life will certainly experience a decrease in performance because the engine parts in the vehicle experience continuous friction, which will certainly cause rifts and wear, therefore the condition of the vehicle's performance will decrease. To keep the vehicle optimal when used, of course modifications are needed to improve performance. The vehicle remains optimal when used even though the vehicle is no longer new. There are several ways that can be done to improve vehicle performance with modifications such as porting polish.

Changing the overlap camshaft duration on a motorcycle camshaft will have an influence on the length of time the valve is open when the intake valve and exhaust valve open together so that air flushing in the combustion chamber is better at top speed of the vehicle.

One of the reference studies for improving vehicle performance is through modifying the camshaft overlap duration. From the results of research (Bhirowo, et al. 2016) entitled Experimental Study of the Effect of Changing the Camshaft Overlap Duration on the Performance of the DOHC Four-Stroke, One-Cylinder Otto Motor. It was concluded that the power increase was 11.94% greater than standard conditions when using a magnitude of 30o. Meanwhile, a magnitude of 17o produces lower power.

From the research that has been carried out previously, the difference in this research is using a 110 cm^3 single cylinder 4-stroke motorbike engine with variations in overlap camshaft duration 12^o, 15^o, 18^o (standard) 22^o, 28^o so researchers will conduct research in more detail entitled "THE DIFFERENCES OVERLAP CAMSHAFT DURATION TO PERFORMANCE MOTORCYCLE 4-STROKE 110cm^3".

THEORETICAL REVIEW

Internal Combustion Engine

An internal combustion engine in a petrol motorbike is a type of engine whose main power is produced from internal combustion in the combustion chamber, which uses a mixture of air and fuel (gasoline) and a fire starter (spark plug). The energy conversion process for a petrol motorbike starts from chemical energy (fuel) and is converted into heat (combustion) and then into mechanical energy (engine rotation). (Winoko Y.A., 2018)

Camshaft

In petrol engines, the camshaft is a component whose function is to regulate the duration of movement of the intake valves and exhaust valves. in order to regulate the incoming circulation of the air and fuel mixture into the combustion chamber and regulate the exit of exhaust gases resulting from the combustion process. This valve movement setting affects engine performance including power, torque, fuel consumption, average effective pressure and efficiency as well as exhaust gases resulting from combustion. According to (Ghali & Winoko, 2018). The camshaft overlap duration can be determined by calculating the intake Valve Open + Exhaust Valve Closed). (Wihardanto, 2016).

Table 1. Table of Camshaft Specification

No	Intake Valve			Exhaust Valve			*Overlap Camshaft Duration*
	Open	*Close*	Duration	*Open*	*Close*	Duration	*In Open + Ex Close*
1	5º	31º	216º	40º	7º	227º	12º
2	5º	31º	216º	37º	10º	227º	15º
3	6º	30º	216º	35º	12º	227º	(Standard) 18º
4	10º	26º	216º	34º	13º	227º	23º
5	11º	25º	216º	30º	17º	227º	28º

Torque

Torque is a measure of a machine's work in the engine, so torque is energy on the cylinder. The torque quantity is a derived quantity that is usually used to calculate the energy produced by an object rotating on its axis. (Fajari & Agong, 2019). The formulation of torque is as follows. If an object rotates and has a centrifugal force of GF, the object rotates on its axis G with a radius of b, with data H the torque is:

T = Fxd (N.m) …… (1)

H1: Different variations in overlap camshaft duration affect torque.

Power

Power is the number of amount work by internal combustion engine for each unit of time within a certain period of time. In motorized vehicles there are two types of power, namely indicator power (pure power produced by combustion in the cylinder) and effective power (power produced by the engine to move the shaft). (Winoko, Y.A., 2018)

The formula to determine BMEP is:

$$\mathbf{Ne}=\frac{2\,\pi\,x\,n\,x\,T}{60\,x\,746} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

With:
Ne = Power (Hp)
T = Torque (N.m)
n = Engine Rotation (rpm)

H2: Different variations in overlap camshaft duration affect on power.

BMEP (Brake Mean Effective Pressure)

Bmep (Break Mean Effective Pressure) or average effective pressure is the theoretical constant pressure that occurs on the piston during the working stroke which will produce net work per cycle that is the same as the actual conditions. The Following formula to determine BMEP is follow (Winoko & Wijaya), 2023:

$$\mathbf{Bhp}:\frac{2.\pi.n.T}{1000}\,\mathbf{kW} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

And

$$\mathbf{BMEP}:\frac{Bhp.\ z}{A.\ L.n.\ i}\,\mathbf{Kpa} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

With :

Bhp	:	kW	L	:	Stroke (m)
BMEP	:	KPa	n	:	Engine Rotation (rpm)
A	:	Piston diameter (m^2)	i	:	Number cylinder
z	:	Number of crankshafts revolutions, for 4 stroke: 2 and 2 stroke: 1			

H3: Different variations in overlap camshaft duration affect BMEP.

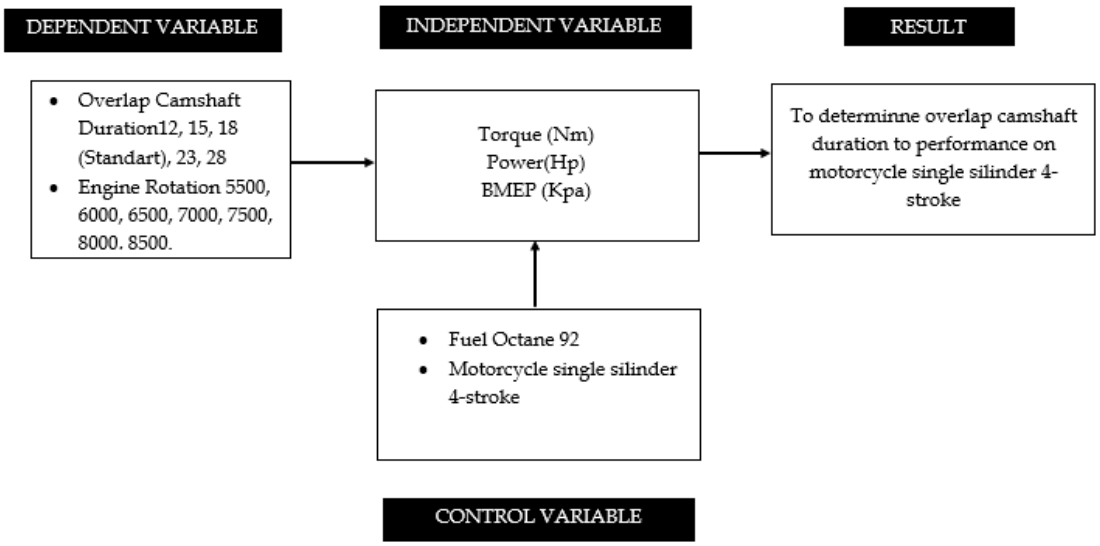

Figure 1. Conceptual Framework

METHODOLOGY

This research was conducted at Politeknik Negeri Malang, Malang, and at Berkah Motor Garum, Blitar. This research was conducted from March until May 2024.

The method used in this research is quantitative experimental methods. Experiment. The data collection method for overlap camshaft duration is carried out using a dyno test to determine the torque (Nm) power (Hp) and BMEP (Kpa) in the vehicle.

1. Starting is the beginning of the process of procuring tools and modifying them with various preparations.
2. The literature study required in preparing this thesis is the theoretical basis related to the effect of overlap camshaft duration on power.
3. Preparation for testing, namely before the vehicle is denoted, regular maintenance should be carried out to produce optimal performance.
4. Equipment settings, installation of modified camshaft into the vehicle cylinder head.

5. Testing was carried out using the dyno test method for standard camshafts and modified camshaft overlap durations of 12°, 15°, 23°, and 28°.
6. Start the vehicle engine and carry out the test using the full throttle method
7. Test 3 times on each variation.
8. After the data is obtained, the machine is turned off and the data is transferred to the computer.
9. Carry out data processing to analyze the data obtained with the Minitab application on the laptop
10. Then conclude the entire process that has been carried out.

RESULTS

In this research, In study, the number the independent variables namely the overlap camshaft duration variable is 5 the variations and variable number of engine rotation are 7 from 5500-8500 rpm. The results of the five variations are displayed in table form for each result of torque, power, and BMEP, then the table is converted into a graph of the relationship between the independent variable and the engine rotation. And After that the results of the table will be discussed for any changes.

Table 2. Table of Torque Results

Torque (Nm)					
Engine Rotation (RPM)	Overlap Camshaft Duration				
	12°	15°	18° (STD)	23°	28°
5500	6,89	6,30	5,93	6,27	5,90
6000	6,66	7,80	7,52	7,76	7,30
6500	6,12	6,38	7,15	7,74	7,82
7000	5,23	5,28	5,67	6,87	7,73
7500	4,45	4,70	4,99	6,16	6,12
8000	3,66	3,94	4,56	5,80	5,99
8500	2,47	2,90	4,04	5,22	5,74

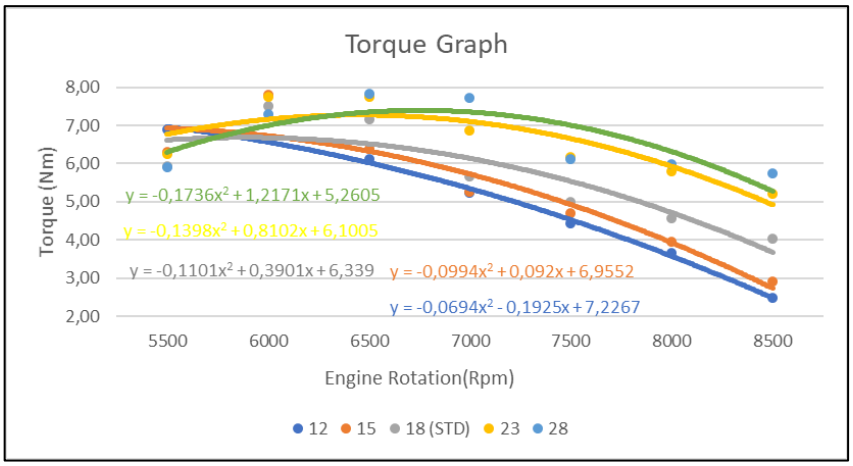

Figure 2. Graph of Torque

From the table 2, can be seen the dyno test results of the effect of overlap camshaft duration produced by a motorcycle single cylinder 4-stroke using 92 octane fuel. Obtained torque on the standard camshaft at 18^{o} overlap duration produced maximum torque 7,52 (Nm) at 6000 rpm engine speed. On the variations, camshaft overlap at 12^{o} produced a maximum torque of 6,89 (Nm) at 5500 rpm engine speed. On the variations, camshaft overlap at 15^{o} produced a maximum torque of 7,80 (Nm) at 6000 rpm engine speed. On the variations, camshaft overlap at 23^{o} produced a maximum torque of 7,76 (Nm) at 6000 rpm engine speed. On the variations, camshaft overlap at 12^{o} produced a maximum torque of 7,82 (Nm) at 6500 rpm engine speed.

From Figure 2, The best Torque value was obtained by varying the duration of the 28^{o} camshaft overlap, resulting in a torque of 7.82 Nm at an engine speed of 7000 rpm. As seen from the trend graph of the 18^{o} camshaft overlap duration variation, it shows the best trendline at middle to high rpm. This is based on the theory that because at high overlap duration, the valve opening is longer so more air and fuel mixture enters the combustion chamber. With a small overlap duration, it produces high torque in the start rotation. It is proven that the overlap duration of 12^{o} and 15^{o} in the initial rotation produces high torque. This is because the valve opens too quickly so that the torque produced in the initial rotation is high but in the middle and high engine rotation it decreases due to the engine speed high air supply and too little fuel.

Table 3. Table of Power Result

Power (Hp)					
Engine Rotation (RPM)	Overlap Camshaft Duration				
	12^{o}	15^{o}	18^{o} (STD)	23^{o}	28^{o}
5500	5,45	5,07	4,78	5,00	4,61
6000	5,71	6,85	6,58	6,66	6,21
6500	5,65	6,03	6,52	7,18	7,16
7000	5,16	5,35	5,75	6,81	7,45
7500	4,67	5,10	5,42	6,46	6,47
8000	3,86	4,55	5,27	6,42	6,34
8500	2,86	3,56	4,91	6,06	6,85

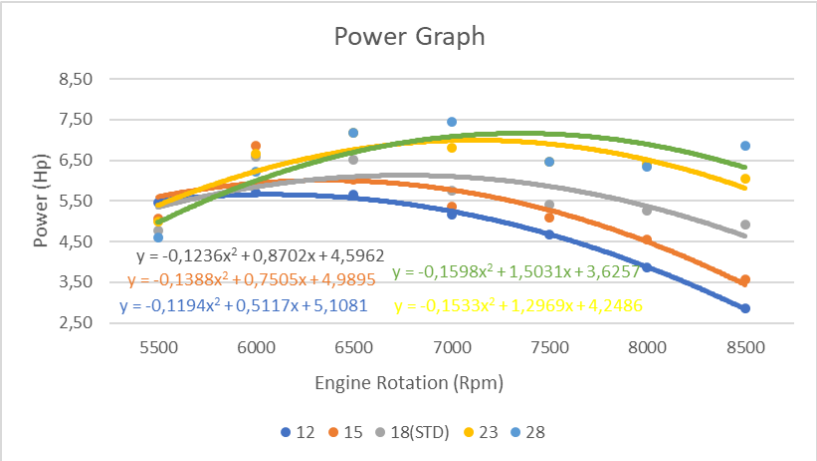

Figure 3. Graph of Power

From table 3, can be seen the dyno test results of the effect of overlap camshaft duration produced by a motorcycle single cylinder 4-stroke using 92 octane fuel. Obtained power on the standard camshaft at 18º overlap duration produced maximum power 6,58 (Hp) at 6000 rpm engine speed. On the variations, camshaft overlap at 12º produced a maximum power of 5,45 (Hp) at 5500 rpm engine speed. On the variations, camshaft overlap at 15º produced a maximum power of 6,85 (Hp) at 6000 rpm engine speed. On the variations, camshaft overlap at 23º produced maximum power 7,18 (Nm) at 6500 rpm engine speed. On the variations, camshaft overlap at 28º produced a maximum power of 7,45 (Hp) at 7000 rpm engine speed.

Figure 3 shows the best BMEP value obtained from the duration of the 28º camshaft overlap, resulting in a BMEP of 7.45 hp at 7000 rpm. and seen from the trend graph of the 28º camshaft overlap duration variation, it shows the best trendline at middle to high rpm. This is based on the theory that the higher the duration of the camshaft overlap, the higher the power at the top speed of the vehicle will be because flushing the combustion chamber at medium to high speed is better compared to the low duration of camshaft overlap. (Hammil, D. 1998)

Table 4. Table of BMEP Result

BMEP (kPa)					
Engine Rotation (RPM)	Overlap Camshaft Duration				
	12º	15º	18º (STD)	23º	28º
5500	801,75	733,48	690,42	729,21	686,16
6000	774,98	907,64	882,04	902,59	849,84
6500	712,53	742,79	840,92	901,04	909,96
7000	608,58	614,01	660,17	799,03	899,88
7500	517,43	547,30	581,04	716,80	712,53
8000	405,33	458,47	531,01	675,30	696,63
8500	287,42	337,45	470,50	607,42	668,32

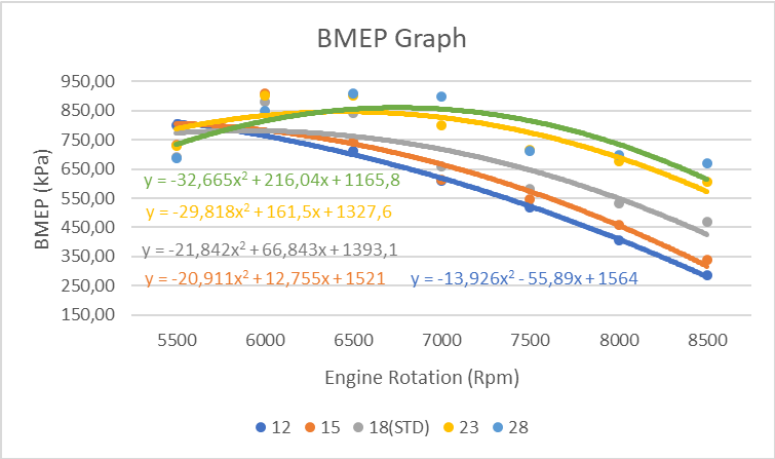

Figure 4. Graph of BMEP

From the table 4, can be seen the dyno test results of the effect of overlap camshaft duration produced by a motorcycle single cylinder 4-stroke using 92 octane fuel. Obtained BMEP on the standard camshaft at 18º overlap duration produced maximum BMEP 882,04 (Hp) at 6000 rpm engine speed. On the variations, camshaft overlap at 12º produced maximum BMEP 801,75 (Nm) at 5500 rpm engine speed. On the variations, camshaft overlap at 15º produced maximum BMEP 907,64 (Nm) at 6000 rpm engine speed. On the variations, camshaft overlap at 23º produced maximum BMEP 902,59 (KPa) at 6000 rpm engine speed. On the variations, camshaft overlap at 28º produced maximum BMEP 909,96 (KPa) at 6500 rpm engine speed.

Figure 4, The best BMEP value was obtained from varying the duration of the 38º camshaft overlap, resulting in a BMEP 909,96 (KPa) at 6500 rpm. seen from the trend graph of the 28º camshaft overlap duration variation, it shows the best trendline at middle to high rpm. This is based on the theory that the BMEP value is directly proportional to torque, meaning that if the torque value increases, the BMEP value will also increase (provided that the vehicle has the same engine speed)

DISCUSSION

Torque

Of all the variations in camshaft overlap duration, higher durations variations an increase in torque compared to standard, this is because the duration of turning on the valve becomes longer so that more air and fuel mixture enters the combustion chamber causing an increase in the piston's thrust force and can accelerate the rise and fall of the connected piston. . with the crankshaft connecting rod. In smaller duration variations, there is a decrease compared to the standard because the valve opening speed is only sufficient at lower engine speeds, so the air entering the combustion chamber at medium engine speeds and high engine speeds is not sufficient so the torque produced at high engine speeds is small.

Power

Of all the variations in camshaft overlap duration, higher durations variation an increase in power compared to standard, and at high engine speeds the difference is visible, this is because the valve opening time becomes longer so

that more air and fuel mixture enters the combustion chamber causing an increase in pressure resulting in an explosion. During the compression stroke, the thrust force of the piston increases and can speed up and down the piston which is connected to the crankshaft connecting rod so that the power on the motorbike at top speed remains better due to good air intake. In smaller duration variations, there is a decrease compared to the standard because the valve opening speed is only sufficient for the needs at lower engine speeds, so the air entering the combustion chamber at medium engine speeds and high engine speeds is not sufficient so that the air mixture required at high engine speeds is insufficient, causing the power produced by the engine is small.

BMEP (Brake Mean Effective Pressure)

Of all the variations in camshaft overlap duration, higher durations experience an increase in BMEP compared to standard, this is because the valve opening length becomes longer so that more air and fuel mixture enters the combustion chamber causing an increase in pressure so that an explosion during the compression stroke increases the piston thrust. and can speed up and down the piston which is connected to the crankshaft connecting rod. In smaller variations, the duration decreases compared to the standard because the valve opening speed is only sufficient at lower engine speeds, so the air entering the combustion chamber at medium engine speeds and high engine speeds is not sufficient so that the BMEP pressure produced by the engine is small. This is based on the theory that the BMEP value is directly proportional to torque, meaning that if the torque value increases, the BMEP value will also increase (provided that the vehicle has the same engine speed)

CONCLUSIONS

1. From the research that has been carried out there is an influence of changes in camshaft overlap duration on power and torque, in the highest variation with a camshaft overlap duration of 28^{o} producing torque of 7.82 N.m at 6500 rpm and power of 7.45 (Hp) at 7000 rpm engine speed.
2. After conducting test there is an influence of changes in camshaft overlap duration on the bmep value. The best value is found in the 28^{o} variation of BMEP 909,96 (KPa) at an engine speed of 6500 rpm.
3. After testing the dyno test and analyzing the results of overlap camshaft duration with 12^{o}, 15^{o}, 18^{o} (Standart) $23^{o,}$ and 28^{o} are most recommended to use according to power and torque test its variations 28^{o}.

RECOMMENDATIONS

Based on this study research, the following recommendation is:

1. Modification on overlap camshaft duration is recommended not to high if used on daily use motorcycles because high overlap duration will cause a rough sound in the engine and can cause the engine to be damaged because it works too hard

2. Camshaft overlap duration is recommended when you want to upgrade the engine accompanied by increasing the piston cross-sectional area and porting polish for extreme daily or racing needs

FURTHER STUDY

Further research related to development with overlap camshaft duration by adding porting polish and doing it on different motorbikes as a reference for modifying the camshaft overlap.

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