Camshaft modification on gasoline single cylinder engine to increase engine performance

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Abstract. Motorcycle is the main transportation in urban and rural areas nowadays. Many users have not satisfied with performance of standard manufactured. The objective of this research is to improve motorcycle performance by modifying the camshaft duration. The research was conducted at Combustion Laboratory of Department of Mechanical Engineering Faculty of Engineering. The standard of camshaft duration is intake valve 221° LSA, 96.75° and exhaust valve 202° LSA 84°. The first modification camshaft is intake valve 235° LSA 100.5° and exhaust valve 235° LSA 102.5°. Second modification camshaft is intake valve 260° LSA 104° and exhaust valve 260° LSA 107°. The results of experiment show the good engine performance was in the second modification. Increased of torque are 19.182% and 22.902% for the first and second modification respectively. Moreover, increased of power are 7.378% and 13.45% for the first and second modification respectively.

1. Introduction
Motorcycle as transportation is very important for people. Recently, the statistic data of sales of motorcycle show increased significantly [1]. According to technological developments, motor vehicle companies apply high technological standards for their products. Some motorcycle users consider that the standard engine performance is still not suitable, that makes motorcycle users decide to make engine modifications to improve performance. One of the ways to improve motorcycle engine performance is to maximize camshaft performance. Camshaft modification can increase engine torque and power. According to [3], by changing the duration of the camshaft and increasing the size of the valve opening, the performance of the engine will increase. Changing the duration of the camshaft aims to change the opening and closing times of the valve. Improve volumetric efficiency, while the change in Lobe Separation Angle (LSA) will increase power in the upper rotation [4].

Generally, modification of camshaft is changing the duration and LSA to improve engine performance. However, according to [6] the change in duration and LSA on each camshaft is not as long as it is directly proportional between torque and speed of engine. Recently, the duration and LSA modifications are carried out using Computer Numerical Control (CNC) software and machines. The objective of this study is to improve the performance of a single cylinder engine capacity of 155 cc by modifying the duration and LSA camshaft.

2. Methodology
The modification of camshaft was conducted by changing the camshaft duration and Lobe Separation Angle (LSA). The standard of camshaft duration is intake valve 221° LSA, 96.75° and exhaust valve 202° LSA 84°. The first modification camshaft is intake valve 235° LSA 100.5° and exhaust valve 235° LSA 102.5°. Second modification camshaft is intake valve 260° LSA 104° and exhaust valve 260° LSA 107°. The study was conducted at the Motor Fuel Laboratory, Department of Mechanical Engineering, Faculty of Engineering.

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of Engineering, University of Sultan Ageng Tirtayasa. The comparison of the performance of a standard camshaft with a modify camshaft 1 and a modify camshaft 2 was examined. The performance to be known are power, torque and fuel consumption. Variable engine speed at 2000, 4000, 6000 and 8000 with a maximum load were setup. The loading test was carried out by brake mechanism. The engine specification is shown in table below:

| Table 1. Specification of Engine Test |
|---------------------------------------|
| Engine Specification                  |
| Engine type                           | 4 stroke, SOHC 2 Van Cooler          |
| Bore / Stroke                         | 50.0 x 57.9 mm                       |
| Volume Cylinder                       | 115 cc                               |
| Compression Ratio                     | 9.3 : 1                              |
| Engine Lubrication                    | 0.9 Liter                            |
| Fuel                                  | RONn 92                              |

| Table 2. Mathematical Formula for Calculation |
|-----------------------------------------------|
| Formula                                      |
| Force moment at handle                       | $F_1 = m \times g = N$               |
| Force at piston brake                        | $F_2 = \frac{T_1}{X_2}$               |
| Force at piston Kaliver                      | $F_3 = \frac{F_2 \times A_2}{A_1}$   |
| Constanta of Spring                         | $k = \frac{6 \times d^3}{8 \times N \times D^2}$ |
| Center of Friction                          | $r_m = \frac{(r_b + r_k)}{2}$        |
| Force friction at disk brake                | $F_{gesek} = F_3 \times \mu$          |
| Torque                                      | $T = F_3 \times \mu \times k_t \times r_m$ |
| Power                                       | $P = 2\pi \times T \times r_m \times 10^{-3}$ |
| Fuel Consumption                            | $S_{fc} = \frac{F_c}{P}$              |

- $n$ = Engine speed (rpm)  
- $X_1$ = Distance of brake handle (m)  
- $P$ = Engine Power (hp)  
- $X_2$ = Distance to the piston (m)  
- $T$ = Torque (Nm)  
- $m$ = load (kg)  
- $S_{fc}$ = Specific Fuel  
- $g$ = gravitation (9.8 m/s²)  
- $p$ = Hydraulic Pressure  
- $G$ = Modulus (Gpa)  
- $F_1$ = Brake Force in Handle  
- $K$ = Constanta  
- $F_2$ = Piston trust (N)  
- $d$ = thin of braking (m)  
- $F_3$ = Breaking Force at Piston  
- $D$ = diameter of braking (m)  
- $N$ = Number of coil spring  
- $F_{pegas}$ = Spring Force (N)  
- $A_1$ = Area of Piston Brake (m²)  
- $F_1'$ = Force at Brake (N)
3. Results and Discussions

The test conducted with variable of engine speed on the modification of camshaft. Figure 1 shows the force of brake by variable of engine speed at 2000, 4000, 6000 and 8000 rpm.

![Figure 1. Force Brake by variable of engine speed](image1)

The experimental result shows the force of brake on second modification of camshaft higher than standard and modification 1. The peak of data is on the 6000 rpm, its shown that the best performance of engine is on the 6000-rpm engine speed with second modification of camshaft. Increased of force brake is shown the increased of engine performance. Increased of force brake comparing between first modification and standard camshaft are 50%, 22%, 22.6% and 3.5% at 2000, 4000, 6000 and 8000, respectively. Meanwhile, comparing standard and second modification are 65%, 25.4%, 23.8% and 8.6% at 2000, 4000, 6000 and 8000 rpm, respectively. The increase of brake force on the second modified camshaft is caused by the high angle of the camshaft duration. Its result in a longer valve opening time and causes a greater amount of fuel and air carburized in the combustion chamber.

![Figure 2. Power by variable of engine speed](image2)

![Figure 3. Torque by variable of engine speed](image3)
Figure 2 and 3 shows the power and torque comparison between standard, first modification and second modification of camshaft by variable of engine speed. The complete results of comparison between standard, first and second modification is shown in table 3 and 4.

### Table 3. Results of Power Comparison

| RPM  | Power (Horse Power) | Percentage of Power Increased (%) | Cam std vs Cam 1 | Cam std vs Cam 2 |
|------|---------------------|----------------------------------|------------------|------------------|
|      | Camshaft Standard   | Camshaft 1                       | Camshaft 2       | Cam std vs Cam 1 | Cam std vs Cam 2 |
| 2000 | 2.63                | 3.76                             | 4.27             | 30.1             | 38.4             |
| 4000 | 7.49                | 9.4                              | 9.66             | 20.3             | 22.5             |
| 6000 | 11.86               | 14.69                            | 15.15            | 19.3             | 21.7             |
| 8000 | 14.62               | 15.53                            | 16.41            | 5.9              | 10.9             |

### Table 4. Results of Torque Comparison

| RPM  | Torque (Nm) | Percentage of Torque increased (%) | Cam std vs Cam 1 | Cam std vs Cam 2 |
|------|-------------|-----------------------------------|------------------|------------------|
|      | Camshaft Standard | Camshaft 1 | Camshaft 2       | Cam std vs Cam 1 | Cam std vs Cam 2 |
| 2000 | 8.8         | 12.58                             | 14.28            | 30.0             | 38.4             |
| 4000 | 12.53       | 15.72                             | 16.14            | 20.3             | 22.4             |
| 6000 | 13.68       | 16.3                              | 16.81            | 16.1             | 18.6             |
| 8000 | 12.2        | 12.97                             | 13.7             | 5.9              | 10.9             |

Based on the experimental results on table 3 and 4, we can conclude that the optimum performance is in second modification of camshaft. Percentage of increased in power and torque is greater than first modification.

**Figure 4. Fuel Consumption by variable of engine speed**

Figure 4 shows the results of consumption of fuel by engine speed variable and modification of camshaft. Based on the calculation of fuel air ratio, the second camshaft modification is slightly efficient compare to the others. the optimum ratio of air and fuel will produce good fuel consumption.

### 4. Conclusions

In this study, the engine performance output of a single cylinder gasoline engine running with two different camshaft is analysed. The samples include three kinds of camshaft, standard, first modification and second modification. The engine is running at four different engine speeds which are 2000 rpm, 4000 rpm, 6000
rpm, and 8000 rpm with the constant load. In the paper, brake force, the engine power and torque, fuel consumption was taken and analysed. From the results obtained, several conclusions are made:

1. Second camshaft modification, intake valve 260° LSA 104° and exhaust valve 260° LSA 107°, gives highest performance output compare to other camshaft
2. The percentage of torque and power decrease when the engine speed is increases

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