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The Effect of Changes in Squish Head Angle on Compression and Torque Ratio Pressure on a 160 cc Motorcycle

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ABSTRACT

This research is to direct the mixture of air and fuel exactly to the top of the midpoint of the dome in the cylinder head. In addition, Squish Head also determines the character of the motorcycle. Moreover, what is very prominent in the initial pull is that if the compression ratio is denser, the pull is lighter. This study aims to determine the effect of changes in the slope angle of the squish head of 15, 17 and 19 degrees on compression and torque. In this study, experimental research is used with a quantitative method, where information that can be calculated and measured is factual because it is in the form of numbers. Researchers to get the data will conduct tests using the dynotest tool. Changes in slope of the squish head have an effect on the torque. At an angle of 15 degrees, torque is produced at 9.91 N.m at 6000 RPM engine rotation. At an angle slope of 17 degrees, the torque increases by 0.14 N.m to 10.05 N.m at 6000 RPM engine rotation. At an angle of 19 degrees, the torque increases by 0.17 N.m to 10.22 N.m at 6000 rpm.

Keywords: comprettion, squish head, torque

1. INTRODUCTION

The automotive world, especially motorbikes, continues to innovate to achieve optimal and efficient performance. One crucial aspect in engine performance is the compression ratio, which has a direct impact on the power and torque produced. On the other hand, the design of the combustion chamber, including the squish head corner, plays an important role in the burning process. The problem that is often faced is how to find optimal configuration of these components in order to produce more perfect combustion, reduce emissions, and increase fuel efficiency without sacrificing performance. Research on the effect of changes in the slope of the squish head on the pressure of compression and torque ratios on 160cc motorbikes became very relevant in an effort to answer this challenge, considering that 160cc motorcycles are widely used and become large market segments.

Various studies have been conducted to understand and optimize engine performance with modifications to the combustion chamber component. For example, a study by H. Zhang et al. shows that changes in the geometry of the combustion chamber can significantly affect the combustion characteristics [1]. Other research by K. Liu et al. Analyze the impact of the design of the cylinder head on the thermal efficiency of the engine [2]. Aspects of compression ratio and their relationship with engine performance have been studied in depth by W. Chen et al. [3] and D. Lee et al. [4]. Then, the effect of modification of the squish area on emissions and fuel consumption has also been investigated by J. Kim et al. [5] and R. Prakash et al. [6]. Furthermore, the CFD simulation to predict the flow of fluid in the combustion chamber continues to be developed by S. Kumar et al. [7] and P. Wang et al. [8]. The use of alternative fuels and its impact on the compression ratio is also the focus of research by M. Al-Sharafi et al. [9]. Vibration and noise analysis due to engine modification is carried out by G. Li et al. [10]. Increased power and torque through the optimization of the Combustion Chamber has been studied by F. Wu et al. [11] and B. Singh et al. [12]. The development of material for engine components also affects the Squish Head design as studied by C. Zhao et al. [13]. Evaluation of engine performance with a variety of valve angles has also been carried out by Y. Tanaka et al. [14]. The impact of swirl and tumble on combustion efficiency in gasoline engines has been discussed by L. Wang et al. [15] and Q. Zhou et al. [16]. In addition, this cylinder pressure measurement technique also experienced progress as described by D. Xu et al. [17]. Optimizing the ignition system in relation to the geometry of the combustion chamber is also a concern in the latest research by E. S. Tan et al. [18]. The study of heat transfer in the combustion chamber is also relevant as done by A. K. Gupta et al. [19]. Finally, research on the impact of thermodynamics from changes in compression ratios on motorcycle engines has also been carried out by G. S. B. Subrahmanyam et al. [20].

Continuing from previous research, several studies have also examined specific effects from the squish angle on engine performance. Research by D. Chen et al. [21] In detail analyzing the effect of various squish head designs on turbulence characteristics in the cylinder. Aspects of detonation and knocking as a result of changes in compression ratios and squish design have also been investigated by M. A. Hasan et al. [22]. Furthermore, the impact of Squish angular optimization on decreased CO and NOx emissions on motor engines is also the focus of research by S. R. Ahmad et al. [23]. The validation of the numerical simulation model to predict the performance of the engine with a modification of squish head has also been developed as described by Z. Ali et al. [24]. Experimental studies on the effect of the form of combustion chamber on fuel consumption are also relevant, as did F. Li et al. [25]. In addition, research on the influence of squish angles on the speed of fire in the combustion chamber has also been published by P. K. Sharma et al. [26]. Finally, optimization of squish area to improve the volumetric efficiency of the engine has also become a research topic by R. S. Pathak et al. [27].

Although many studies have been carried out related to the optimization of the combustion chamber and compression ratio, there is still a significant research gap. Most research tends to focus on simulations or testing on machines with different capacities, or on car applications. Research that specifically tests the effect of squish head slope changes on 160cc motorcycles with a focus on pressure pressure compression and torque ratios empirically and comprehensively is still very limited. Emphasis on 160cc motorcycles, which is a large market segment in Indonesia, makes this research crucial. Therefore, the purpose of this study is to fill the emptiness by conducting in -depth investigations on the impact of the squish head angle variation on the compression ratio and torque on a 160cc motorcycle engine.

Based on the background and identification of the research gap, the main purpose of this study is to find out and analyze the effect of changes in the slope of the squish head angle on the compression ratio pressure and torque produced on the 160cc motorcycle engine. This study aims to provide accurate empirical data regarding the correlation between the Squish Head angle modification with an increase in engine performance, especially in terms of power and efficiency. The results of this study are expected to be the basis for the development of more optimal combustion chamber design, relevant to the current 160cc motorcycle market needs, as well as contributing to increasing fuel efficiency and emission reduction which is the main focus of the modern automotive industry.

2. RESEARCH SIGNIFICANCE

This study has a large significance both theoretically and practically, especially in the context of the 160cc motorcycle market which is very dynamic in Indonesia. Theoretically, this research will enrich the treasures of science in the field of mechanical engineering, especially regarding the dynamics of combustion and optimization of combustion chamber in internal combustion engines. The results of this study will provide a deeper understanding of how the slope of the squish head angle precisely affects the pressure of the compression and torque ratio, which is a crucial parameter in engine performance. The empirical data produced can be used as a basis for validation for more accurate computational simulation models in the future.

Practically, the findings of this study will provide concrete guidelines for engineers and motorcycle manufacturers in designing and developing a more efficient and powerful 160cc engine. By knowing the optimal squish head angle configuration, producers can produce motorbikes with more efficient fuel consumption without sacrificing performance, as well as the potential to reduce exhaust emissions that are in line with increasingly stringent environmental regulations. For consumers, this means the availability of 160cc motorcycles that are not only reliable and responsive, but also more economical in daily operations. In addition, this research also opens opportunities for the modification and engine tuning industry to apply these findings to improve the performance of motor racing or daily motorbikes optimally and measurantly.

3. RESEARCH METHODS

This study adopted an experimental method to investigate the effect of the slope of the squish head angle on the compression and torque ratio on the 160cc motorcycle engine. Squish head modification is carried out in three variations of the slope angle, namely 15 °, 17 °, and 19 °, which will then be compared with standard squish head performance characteristics. This approach allows observations and direct measurements to changes in engine performance in response to the geometric modification of the combustion chamber. The research hypothesis is submitted in the form of alternative hypotheses (H1), stating that there is a significant effect on the compression and torque ratio after the slope of the squish head angle with a variation of 15 °, 17 °, and 19 ° compared to standard conditions.

The variables in this study are divided into two categories. The independent variable is the slope of the squish head angle, which is tested at three levels (15 °, 17 °, and 19 °) with each measurement is made three times to ensure data reliability. Meanwhile, the dependent variable includes compression and torque ratios. The compression ratio is measured by determining the volume of the upper dead point (TMA) using a burette/injection, where TMA volume, spark plug thread volume, and cylinder volume are used in the calculation of static compression ratios. Torque, as an indicator of rotational force and engine acceleration, is measured using a dynotest device and expressed in the Newton meter (NM) unit.

The main data collection method is carried out through direct observation via a series of tests on a modified 160cc motorcycle. The modification procedure involves changes in the slope of the squish head angle from standard conditions (15 °) to 17 °, and then 19 °, with detailed illustrations attached in Figure 3.1. Data processing is carried out through comparative analysis, where the test results from tester compression and dynotest are analyzed. Dynotest testing produces data in the form of a power run.

The data collection method in this study is observation. The observational steps in this study start from the beginning are as follows:

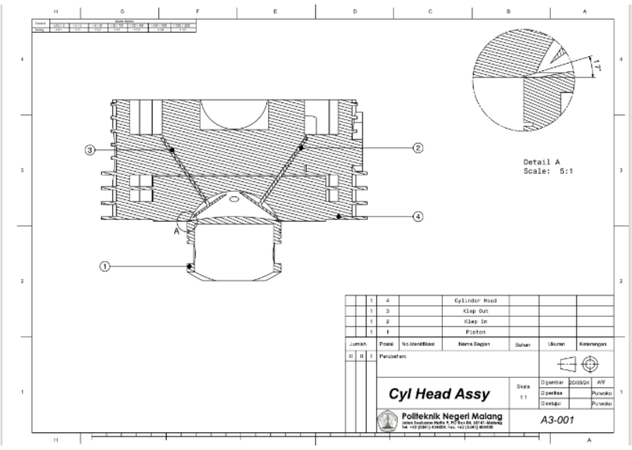

Figure 1 Squish Head Front View

In the picture above is the compression space which will later be modified by changing the slope of the squish head angle like an arrow above with a standard angle of 15 °, then proceed with an angular slope of 17 °, and finally at an angle of 19 °.

In this study data was analyzed using comparison analysis with data analysis done after motor testing that uses tester and dynotest compression tools so that data and tables / graphs / graphs of static and torque are accurate and automatic.

Dynotest testing functions to measure the maximum torque produced by the engine after modifying the slope of the squish head, the dynotest results in the form of graphics and several power runs are taken on average.

4. RESULTS AND DISCUSSION

The results of the study conducted using a dynotest test tool on a 160 cc motorcycle. This test was carried out to determine the amount of compression and torque produced with a variety of slope changes in Squish Head 15, 17 and 19 degrees.

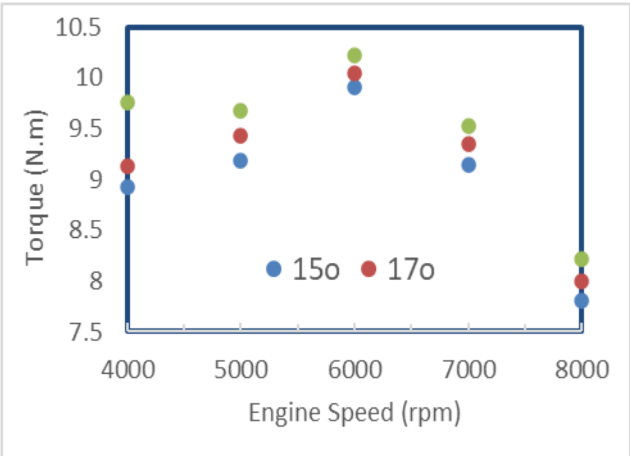

Figure 2 Relationship of torque with angle slope

Figure 2 presents the results of the average torque test on a 160cc motorcycle engine with three variations of squish head angles (15 °, 17 °, and 19 °) in the engine speed range of 4000 rpm to 8000 rpm. From this visualization, it can be seen an interesting pattern regarding the effect of squish head angle modification on torque performance. In general, the graph shows that the slope of the squish head angle 19 ° (green point) tends to produce a higher torque value compared to an angle of 15 ° and 17 ° at most of the engine speed range tested. At 4000 rpm, angle of 19 ° reaches around 9.75 N.m, higher than 15 ° (around 8.9 N.m) and 17 ° (around 9.2 N.m). The most significant increase in torque for an angle of 19 ° occurs at 6000 rpm, reaching its peak above 10.0 N.M (around 10.2 N.m), while the angles of 15 ° and 17 ° are below it, each of to around 9.9 N.M and 10.0 N.M. This phenomenon can be explained by several related factors related to the dynamics of combustion in the cylinder chamber.

Increased torque at a larger squish head angle (for example 19 °) can be connected with a more optimal squish effect. Squish angles that are more gentle or larger squish areas tend to create more intensive turbulence (squish and tumble movements) in the combustion chamber when the piston moves near the upper dead point (TMA). This increased turbulence accelerates the process of mixing between fuel and air (mixture homogenization), and increases the speed of vines after spark plugs spark. Faster and more efficient combustion results in an increase in peak pressure in the cylinder at a more optimal time after TMA. Higher pressure and longer duration of the piston's head as long as the power step will produce a larger force to rotate the crankshaft, which ultimately manifests itself as an increase in torque. In addition, an increase in turbulence can also help minimize the "dead" area or stagnant in the combustion chamber, ensure a more comprehensive combustion and reduce the remaining fuel fuel, thereby increasing the thermal efficiency of the engine.

a. Although the angle of 19 ° shows superior torque performance at low to medium RPM, it should be noted that at higher engine speed (7000 rpm and 8000 rpm), the difference in torque between the three angles tends to narrow and even show an absolute decrease in all variations. At 7000 rpm, torque at an angle of 19 ° slightly decreased compared to its peak at 6000 rpm, and at 8000 rpm, all angle variations showed a significant decrease in torque, with a return value to the range of 7.5-8.2 N.M. Decreased torque performance in this high RPM can be caused by several factors. At high rpm, the time available for the combustion process is very short. Although a larger squish angle increases turbulence, at a very high engine speed, the effect of gas inertia and flow resistance (pumping losses) can be more dominant. Cylinder filling (volumetric efficiency) also tends to decrease at high rpm due to limited air flow through valves and ported, which in turn reduces the amount of fuel-air mixture available to be burned, thereby limiting power production and torque. In addition, at very high RPMs, phenomena such as valve float or the inability of the ignition system to provide strong and timely sparks can also contribute to the decrease in torque.

5. CONCLUSIONS

Based on the results of research that has been carried out and explained in the previous chapter, the following conclusions can be drawn:

a. There is a maximum change in torque after passing the slope of the squish head angle on a 160 cc motorcycle. Where the maximum torque produced at an angular slope is 19 degrees with a value of 10.22 N.m at the engine speed of 6000 rpm.
b. There is a difference in the highest compression ratio of the slope modification of the squish head angle on a 160 cc motorcycle. In Squish Head Standard with a slope of 15 degrees, 17 degrees, and 19 degrees increase compression from the first 9: 1 to 9.5: 1.

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7. AUTHOR CONTRIBUTIONS

Conception and design: Aviv Rahmadillah,
Methodology: Aviv Rahmadillah
Data acquisition**:** Aviv Rahmadillah
Analysis and interpretation of data Aviv Rahmadillah
Writing publication: Aviv Rahmadillah
Approval of final publication: Aviv Rahmadillah, Purwoko
Resources, technical and material supports: Aviv Rahmadillah, Sugeng Hadi Susilo
Supervision: Purwoko, Sugeng Hadi Susilo

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