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The Effect of Stroke Up with Ignition Timing Variations on The Programmable CDI on The Engine Performance of The Gl Pro Neotech Motorcycle in 1997

Iqbal Aditya Nugraha[1*], Dwi Widjanarko[2]
[1,2]Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Semarang
Building E5, Faculty of Engineering, UNNES Taman Siswa Street, Sekaran, Gunungpati, Semarang 50229, Indonesia
*Corresponding author. Email: adityabruno99@students.unnes.ac.id

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Abstract

Stroke-up modification and ignition timing adjustment are commonly used to improve motorcycle engine performance, yet their combined effect requires controlled empirical verification. This study examined the effect of a stroke-up crankshaft combined with programmable CDI ignition timing variations on compression pressure, torque, and power output of a GL Pro Neotech 160 cc motorcycle. Methods: A quantitative true-experimental method was applied through engine performance testing under controlled workshop conditions. The standard crankshaft was compared with a stroke-up crankshaft, while ignition timing was adjusted to 15°, 16°, and 17° before top dead center using a programmable CDI. Primary data were obtained from compression tests and chassis dynamometer measurements across 5000–10000 rpm, then analyzed descriptively using average values, tables, and performance graphs. Results: The stroke-up modification increased compression pressure from 12.43 bar to 15.67 bar, equivalent to a 26.1% increase. The 15° timing produced strong low-to-medium speed torque, while the 16° stroke-up configuration showed the most stable and superior performance at medium-to-high engine speeds, reaching 16.71 Nm at 6000 rpm and peak power around 7000 rpm. Conclusion: Stroke-up modification combined with 16° ignition timing is the most effective configuration for improving motorcycle engine performance under the tested operating conditions and rpm range.

1. INTRODUCTION

Technology has advanced rapidly in the automotive sector, including the development and modification of motorcycle engines. Motorcycles remain one of the most widely used modes of transportation in Indonesia because they are practical and economical (Iskandar et al., 2024). Data from Statistics Indonesia show that the number of registered motorcycles increased from 18,975,344 units in 2000 to 132,433,679 units in 2023, indicating the continuing dominance of motorcycles in national transportation (Badan Pusat Statistik, 2024). The large number of motorcycles also encourages maintenance and performance modification practices among users and automotive enthusiasts.

Engine modification is commonly performed when motorcycle performance decreases due to age, long-term use, or the need for higher output (Iskandar et al., 2024; Iskandar et al., 2020; Naryanto et al., 2026). One frequently used method is stroke-up modification. Stroke-up refers to increasing the piston stroke length by changing the crankshaft or shifting the crank pin position so that the piston travels farther between bottom dead center and top dead center (Ariyanto et al., 2018). A longer stroke increases the swept volume and can increase the pressure acting on the piston during combustion, which may improve torque and power.

Torque represents the rotational force generated by the crankshaft and is closely related to the ability of a vehicle to accelerate from low engine speed (Warhayadi, 2015). Increasing stroke length can improve torque because the crank mechanism produces greater leverage and the larger displacement can generate higher combustion pressure. Nevertheless, stroke-up modification changes combustion chamber conditions and may require proper ignition timing adjustment. If ignition occurs too early or too late, the combustion peak pressure may not occur at the most effective crank angle, which can reduce performance or increase the risk of knocking.

Programmable capacitor discharge ignition (CDI) allows more flexible ignition timing adjustment than a conventional CDI. Ignition timing determines the crank angle at which the spark is produced before top dead center. Earlier ignition timing may be needed at higher engine speeds because the air-fuel mixture requires finite time to burn; however, excessive ignition advance can cause combustion pressure to rise too early and reduce useful work (Goyi et al., 2021). Programmable CDI technology is therefore relevant for optimizing engine performance after stroke-up modification because it allows ignition timing to be adapted to modified engine characteristics (Aziz, 2022; Marlindo, 2012).

Previous studies have examined stroke-up modification, ignition timing variation, and CDI use separately. However, limited empirical evidence is available regarding the combined effect of stroke-up crankshaft modification and programmable CDI ignition timing on the GL Pro Neotech engine, especially through dynamometer-based comparison between standard and stroke-up configurations. This gap is important because the optimal ignition timing for a standard engine may not be identical to that for a stroke-up engine due to changes in compression pressure, combustion phasing, and rpm-dependent airflow characteristics.

This study aims to determine the effect of stroke-up crankshaft modification combined with programmable CDI ignition timing variations of 15°, 16°, and 17° BTDC on compression pressure, torque, and power output of a 1997 GL Pro Neotech motorcycle engine. The working assumption was that the stroke-up configuration would increase compression pressure and improve torque and power, but the highest performance would occur only when ignition timing was matched to the modified engine characteristics.

2. RESEARCH METHOD

This study used an experimental comparative design. The study compared engine performance under different crankshaft configurations and ignition timing settings. The design was selected because the treatments were applied directly to the test engine, but the study did not involve participant randomization or a control group in the sense of a true experimental design (Pratama et al., 2024). Therefore, the results are interpreted as a controlled laboratory comparison of engine configurations.

The object of the study was a 1997 GL Pro Neotech motorcycle engine with a nominal displacement of 160 cc. The tested configurations consisted of a standard crankshaft and a stroke-up crankshaft. Ignition timing was varied using a programmable CDI at 15°, 16°, and 17° before top dead center. The main dependent variables were compression pressure, torque, and power. Compression pressure was expressed in bar, torque in Newton meters (Nm), and power in kilowatts (kW). The study distinguished compression pressure from compression ratio because compression pressure is an empirical pressure reading, whereas compression ratio is a geometric ratio determined from cylinder volume and combustion chamber volume.

The research was conducted at MJM Garage, Purworejo, while chassis dynamometer testing was conducted at ANR Dyno Test, Kepek, Kabuaran, Prembun District, Kebumen Regency, Central Java. Before testing, the engine was tuned and prepared to reduce variation caused by maintenance condition. The same motorcycle was used for all configurations. Each dynamometer test was repeated three times for each ignition timing and crankshaft configuration, and the average value was used for analysis. Ignition timing adjustment was set through the programmable CDI map and verified according to the available CDI setting procedure before testing.

The available test documentation identified rpm points from 5000 to 10000 rpm. For each rpm point, torque and power were recorded for 15°, 16°, and 17° BTDC under both standard and stroke-up configurations. The reviewed manuscript did not provide complete numerical information on bore and stroke after modification, final compression ratio, spark plug specification, fuel octane, tire pressure, dynamometer brand/model, dynamometer calibration certificate, gear position, ambient temperature, or humidity. These missing details are therefore acknowledged as methodological limitations rather than being estimated.

The research procedure consisted of problem identification, literature review, preparation of tools and materials, engine tune-up, compression pressure testing, chassis dynamometer testing, data tabulation, descriptive analysis, and conclusion drawing. The research flow is presented in Figure 1.

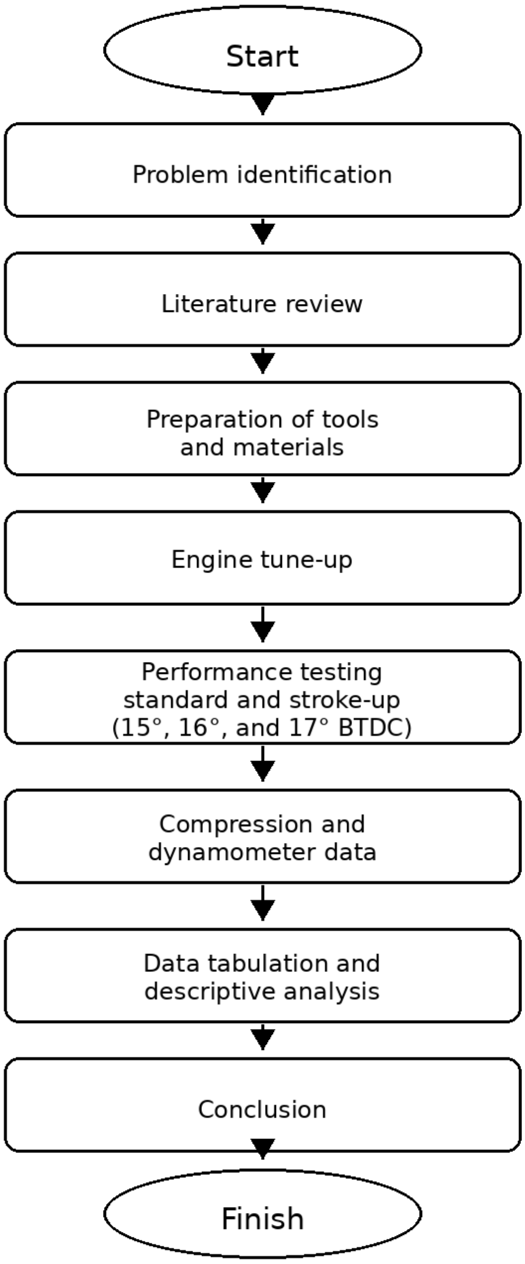

Figure 1. Research flowchart

Table 1. Tested variables and documented measurement conditions

Aspect	Description
Engine object	1997 GL Pro Neotech motorcycle engine, nominally 160 cc
Crankshaft configuration	Standard crankshaft and stroke-up crankshaft
Ignition timing	15°, 16°, and 17° BTDC using programmable CDI
Measured variables	Compression pressure, torque, and power
Engine speed range	5000, 6000, 7000, 8000, 9000, and 10000 rpm
Repetition	Three test repetitions for each configuration; mean values reported
Analysis	Descriptive comparison using tables, graphs, and percentage change

Data were analyzed descriptively by comparing the average values across crankshaft configurations and ignition timing settings. Because the study did not report inferential statistical testing, terms implying statistical significance were avoided. Percentage change was calculated using the standard configuration as the reference value.

3. RESULTS AND DISCUSSION

3.1 Compression pressure

The compression pressure test showed that the standard crankshaft configuration produced 12.43 bar, while the stroke-up crankshaft configuration produced 15.67 bar. The increase was 3.24 bar, equivalent to 26.1% relative to the standard configuration. This result indicates that the longer piston stroke increased the pressure measured at the end of the compression stroke.

Table 2. Compression pressure comparison

Configuration	Compression pressure (bar)	Change from standard
Standard crankshaft	12.43	Reference
Stroke-up crankshaft	15.67	+26.1%

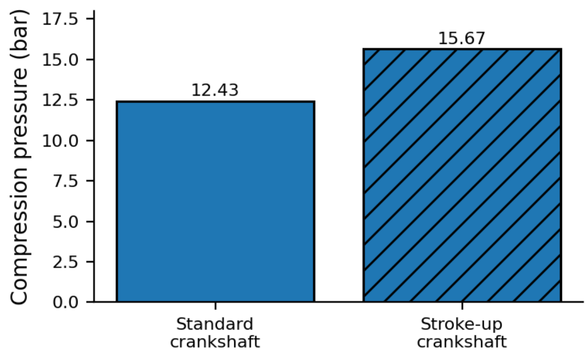

Figure 2. Comparison of compression pressure

The increase in compression pressure should not be interpreted directly as a compression-ratio increase because compression pressure and compression ratio are different concepts. Compression pressure is affected by stroke volume, valve condition, cranking speed, ring sealing, temperature, and throttle opening. By contrast, compression ratio requires geometric volume calculation. The reviewed data did not provide sufficient chamber-volume measurement to verify a numerical compression-ratio change; therefore, unsupported claims that the compression ratio increased from 9:1 to 15:1 were removed.

Mechanically, the stroke-up crankshaft increases piston travel and swept volume. A larger swept volume can increase the mass of mixture compressed and can raise cylinder pressure before ignition (Juwana, 2022). This condition can contribute to higher torque because combustion pressure acts on a longer crank mechanism. However, higher compression pressure may also increase thermal load and the risk of detonation if ignition timing, fuel octane, and cooling performance are not adjusted properly (Menacer et al., 2022; Utama et al., 2022).

3.2 Torque performance

Torque values under the standard crankshaft and stroke-up crankshaft configurations are presented in Tables 3 and 4. The complete numerical values are included to avoid overdependence on graphs and to clarify the effect of each ignition timing setting at every rpm point.

Table 3. Torque values of the standard crankshaft configuration

RPM	15° (Nm)	16° (Nm)	17° (Nm)
5000	10.69	10.84	10.65
6000	11.07	10.98	10.86
7000	11.18	11.17	11.04
8000	10.30	10.45	10.39
9000	8.56	9.00	8.96
10000	7.19	7.53	7.59

Table 4. Torque values of the stroke-up crankshaft configuration

RPM	15° (Nm)	16° (Nm)	17° (Nm)
5000	13.87	12.17	14.06
6000	16.19	16.71	16.17
7000	15.35	15.96	15.14
8000	13.10	13.90	12.93
9000	11.78	11.90	10.36
10000	9.58	10.15	9.53

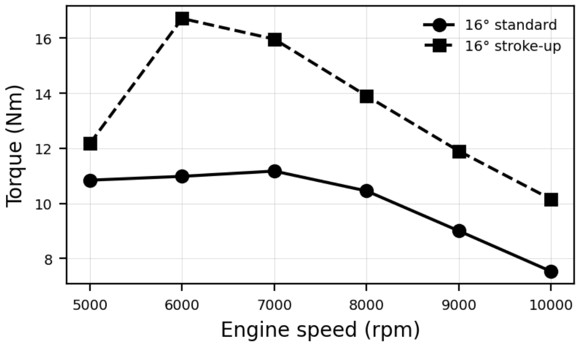

Figure 3. Torque comparison between standard and stroke-up configurations at 16° BTDC

The stroke-up configuration generated higher torque than the standard configuration at most rpm points. At 6000 rpm, the 16° stroke-up configuration produced the highest torque, 16.71 Nm, compared with 10.98 Nm in the 16° standard configuration. This represents an increase of approximately 52.2% at the same rpm and timing setting. The torque advantage remained visible at 7000 and 8000 rpm, where the 16° stroke-up configuration produced 15.96 Nm and 13.90 Nm, respectively.

The stronger torque after stroke-up can be explained by the increase in swept volume and the longer crank throw. A larger cylinder volume allows a greater mixture charge, while the longer crank mechanism improves the moment arm acting on the crankshaft. The 16° BTDC setting appears favorable in the medium-to-high rpm range because it gives the mixture sufficient time to burn so that peak pressure occurs closer to the effective crank angle after top dead center. The 15° setting still produced high torque at some low-to-medium rpm points, but its combustion phasing may be less suited to higher engine speeds. The 17° setting did not consistently improve torque, suggesting that excessive advance can shift pressure rise too early and reduce useful work.

These findings are consistent with studies showing that ignition timing and compression pressure affect combustion behavior and engine output (Arifiyanto et al., 2022; Dalimunthe et al., 2024; Yu et al., 2022). Nevertheless, the higher compression pressure caused by stroke-up modification requires careful tuning. If ignition advance is excessive or fuel octane is insufficient, detonation may occur, which can reduce durability and increase piston, bearing, and cylinder-head thermal stress.

3.3 Power performance

Power output was corrected to kilowatts (kW). The previous use of kWh was removed because kWh is a unit of energy, not power. Tables 5 and 6 present the complete power values for each ignition timing setting and rpm point.

Table 5. Power values of the standard crankshaft configuration

RPM	15° (kW)	16° (kW)	17° (kW)
5000	5.59	5.67	5.55
6000	6.96	6.96	6.82
7000	8.19	8.18	8.09
8000	8.58	8.69	8.70
9000	8.06	8.47	8.52
10000	7.48	7.85	7.94

Table 6. Power values of the stroke-up crankshaft configuration

RPM	15° (kW)	16° (kW)	17° (kW)
5000	7.26	6.37	7.36
6000	10.17	10.69	10.15
7000	11.23	11.69	11.10
8000	10.97	11.64	10.94
9000	11.04	11.21	9.71
10000	9.95	10.68	9.97

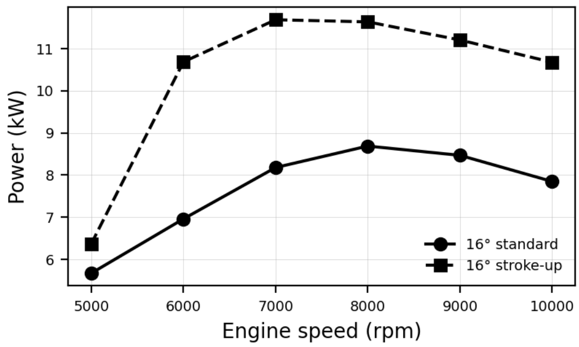

Figure 4. Power comparison between standard and stroke-up configurations at 16° BTDC

The 16° stroke-up configuration produced the highest power value in the tested data, reaching 11.69 kW at 7000 rpm. At the same rpm and timing setting, the 16° standard configuration produced 8.18 kW, so the stroke-up treatment increased power by approximately 42.9%. The 16° stroke-up configuration also maintained higher power than the standard configuration from 6000 to 10000 rpm. However, the statement that 16° was always the highest at every rpm was revised because the data show that 17° produced slightly higher power than 16° in the standard configuration at 8000, 9000, and 10000 rpm, and 15° or 17° was higher than 16° at 5000 rpm in the stroke-up configuration.

The power pattern indicates that stroke-up modification mainly improved medium-to-high rpm output. Power peaked around 7000-8000 rpm and declined afterward. The decline at high rpm may be caused by increased friction, reduced volumetric efficiency, valve-train limitations, intake and exhaust flow constraints, and greater mechanical load from the modified crank mechanism (Hermansyah et al., 2024). Thus, the stroke-up configuration provides a clear performance benefit in the tested range, but it does not remove the mechanical limitations that appear at very high rpm.

Ignition timing interacts with the stroke-up configuration. At low rpm, very advanced ignition may not be needed because the mixture has more time to burn. At medium-to-high rpm, moderate advance helps place peak combustion pressure at a useful crank angle Sun et al. (2024). The 16° BTDC setting therefore offered the most favorable balance in this study because it improved both torque and power at key rpm points without relying on the most advanced timing. This interpretation supports the view that programmable CDI tuning should be performed after mechanical modification rather than assuming that a standard ignition map remains optimal (Rachmanto et al., 2023).

3.4 Limitations and practical implications

This study has several limitations. First, the available test record did not provide complete engine geometry, fuel octane, spark plug type, gear position, tire pressure, dynamometer calibration status, ambient temperature, or humidity. Second, the analysis was descriptive, so the results should not be described as statistically significant. Third, the study used one motorcycle engine and one stroke-up configuration; therefore, the results may not be directly generalized to other engines, different stroke increases, or daily-use conditions. Fourth, durability, fuel consumption, exhaust emissions, and knock intensity were not measured.

For practical tuning, the 16° BTDC setting can be recommended as the most favorable option among the tested configurations for medium-to-high rpm performance. However, daily-use application requires additional attention to fuel octane, cooling, lubrication, piston clearance, bearing load, and knock prevention. The results are more appropriate as a performance-tuning reference than as a complete durability recommendation.

4. CONCLUSION

This study concludes that stroke-up crankshaft modification increased the compression pressure of the GL Pro Neotech engine from 12.43 bar to 15.67 bar, or 26.1%. The stroke-up configuration also improved torque and power across most tested rpm points compared with the standard crankshaft configuration. The most favorable result was obtained at 16° BTDC, which produced 16.71 Nm of torque at 6000 rpm and 11.69 kW of power at 7000 rpm. These results indicate that stroke-up modification should be accompanied by ignition timing adjustment because the modified engine requires combustion phasing that matches its increased compression pressure and changed mechanical characteristics. Further studies should include complete engine geometry, fuel and environmental data, calibrated dynamometer documentation, inferential analysis, knock measurement, emissions testing, fuel consumption analysis, and long-duration durability testing.

5. DECLARATION/STATMENT

5.1. Acknowlegment

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5.2. Author Contribution

Iqbal Aditya Nugraha contributed to conducting the research, collecting the data, analyzing the results, and drafting the manuscript. Dwi Widjanarko contributed to supervision, methodological direction, manuscript review, and final article revision.

5.3. Conflict of Interest

Authors declare that they have no conflicts of interest.

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