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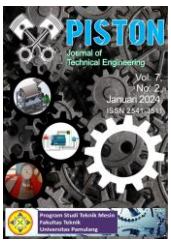

The Effect of Coil and Spark Plug Variation on Emission, Power, and Torque on Vixion 150

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Abstract: The development of technology in vehicles continues to be developed to meet human needs and be environmentally friendly. One technology that is still being developed is the use of spark plugs and coils. The function of spark plugs in motorized vehicles is to spark sparks caused by the electric voltage generated by the coil. Various kinds of coil produce different high voltage. This research uses a Yamaha Vixion 150 CC, 1 cylinder, four-stroke motorcycle. The research was conducted by providing spark plug and coil variations including standard U24ESR-N (Denso) spark plugs, 0.4mm Iridium spark plugs, and Brisk Silver spark plugs. Coil variations were also given including 3C1 H2310 spark plugs and Uma Racing spark plugs. The data taken includes a comparison of emissions produced, torque, and power. The highest power at RPM 8500 was generated by the U24ESR-N spark plug (Denso) with the use of the Uma Racing coil type of 8.69 kW. Spark plug and coil variations will also determine torque. The highest test on the use of Uma Racing coil and Brisk Silver spark plug at 6500 RPM engine speed produces a value of 9.35 Nm. The results also show changes in emissions produced such as CO2, CO, HC, and O2 emissions. The use of 0.4mm Iridium spark plugs with 3C1 H2310 coil and Brisk Silver spark plugs with 3C1 H2310 produces high voltage resulting in higher CO and HC gas production.

Keywords: Coil; Spark Plugs; Power; Torque; Emission.

Abstrak: *Perkembangan teknologi pada kendaraan terus dikembangkan agar dapat memenuhi kebutuhan manusia dan ramah lingkungan. Salah satu teknologi yang masih terus dikembangkan adalah penggunaan busi dan coil. Fungsi dari busi pada kendaraan bermotor adalah untuk memercikkan bunga api yang diakibatkan oleh tegangan listrik yang ditimbulkan oleh coil. Berbagai macam coil menghasilkan tegangan tinggi yang berbeda. Penelitian ini menggunakan motor jenis Yamaha Vixion 150 CC, 1 silinder dengan empat langkah. Penelitian dilakukan dengan memberikan variasi busi dan coil diantaranya busi standar motor jenis U24ESR-N (Denso), busi Iridium 0.4mm, dan busi Brisk Silver. Variasi coil juga diberikan diantaranya busi 3C1 H2310 dan busi Uma Racing. Data yang diambil diantaranya perbandingan emisi yang dihasilkan, torsi serta power. Power tertinggi pada RPM 8500 dihasilkan oleh busi jenis U24ESR-N (Denso) dengan penggunaan coil jenis Uma Racing sebesar 8.69 kW. Variasi busi dan coil juga akan menentukan torsi. Pengujian tertinggi pada penggunaan coil Uma Racing dan busi Brisk Silver pada putaran mesin 6500 RPM menghasilkan nilai sebesar 9.35 Nm. Hasil penelitian juga menunjukkan adanya perubahan emisi yang dihasilkan seperti emisi CO_2, CO, HC, O_2. Penggunaan busi Iridium 0,4mm dengan coil 3C1 H2310 dan busi Brisk Silver dengan 3C1 H2310 menghasilkan tegangan tinggi sehingga memproduksi gas CO dan HC lebih tinggi.*

Kata kunci: *Coil; Busi; Power; Torsi; Emisi.*

INTRODUCTION

Transportation technology is currently being developed because this field is very in demand in daily activities. One of the developments in transportation technology is motorcycles [1]. The purpose of developing this transportation tool is to assist humans in carrying out various activities, along with the increasing use of motorbikes, the production of air pollution also increases [2][3]. The ozone assessment research institute in Indonesia states that the emissions produced by transportation equipment are as much as 85% [4]. The remaining

exhaust gas in addition to air pollution can also endanger human health, which can cause death [5] [6]. This motor vehicle exhaust pollution will be inhaled by humans through the respiratory tract and will be bound to the blood so that it will limit the amount of oxygen needed by the body [7].

In the combustion process, air containing N_2, O_2 and other elements when reacted with gasoline fuels such as Heptane C_7H_{16} and Isoctane C_8H_{18} will form emissions [8]. Vehicle emissions can be in the form of Carbon Dioxide (CO_2), Nitrogenoxide (NO_x), Hydrocarbons (HC), Carbon Monoxide (CO) and other small particles. Controlling these emission gases can be in the form of improving the combustion process or from fuel selection [9][10]. The principle of combustion that occurs on a motorcycle is to spark a fire coming from the spark plug with fuel and oxygen in the engine cylinder [11].

PP No. 41 of 1999 which regulates air pollution control states that all forms of substances, energy or components that can affect or not the environment, resulting from an activity that affects the air environment are called emissions [12]. Exhaust emissions are the production of the remaining internal or external combustion process, then discharged through the exhaust [13]. Exhaust emissions are considered good for the environment if these emissions do not exceed predetermined limits.

Ideally, exhaust emissions can occur if the combustion process that occurs in the combustion chamber is perfect by maximizing the Air Fuel Ratio (AFR), valve opening and closing system and ignition system [14]. The spark generated from the spark plug determines the combustion process in the cylinder with the right time. There are two types of combustion in gasoline motor combustion, namely perfect combustion and imperfect combustion [15][16]. Perfect combustion that occurs in the engine makes the fuel in the combustion chamber burned out so as to produce exhaust emissions that tend to be below the predetermined limit value [17].

Incomplete combustion occurs because some of the fuel does not burn simultaneously when compressed [18]. Incomplete combustion can also be caused by the accumulation of dirt in the cylinder head so that it causes detonation and pre-ignition in the combustion chamber so that it will produce high enough gas emissions coming out of the exhaust [19][20]. In the ignition of fire in the combustion process is known as the fire triangle where there are three components namely oxygen, fuel and heat (heat source) [21][22]. From some of the above elements will produce a flame in the combustion chamber. A good chemical reaction chain also greatly affects the combustion and explosion of fire [23]. Improvement of the combustion system can be done by selecting the appropriate fuel with engine compression [24]. The heat source must also be considered in the combustion process, the intended thing is the ignition system. Replacing inadequate ignition components such as spark plugs, coils or by controlling AFR also affects combustion control [25].

Ignition coil technology continues to be developed so that the voltage produced can be maximized. There are 3 kinds of ignition coil, including ignition coil with single coil type. Parts in the ignition coil such as the primary coil and secondary coil have their respective uses, one of which is to produce electromagnets. The size of the electric voltage is influenced by the number of wire turns, wire diameter and the ability to deliver electricity [26].

A good electric voltage will spark maximum sparks and this process will occur continuously so that a magnetic field occurs in the ignition coil, this process continues as long as the engine is still running. The voltage generated from the ignition coil is determined by the condition of the spark plug. This will also affect engine performance and exhaust emissions. The type of spark plug used also determines the combustion process, the spark plugs used in this study include U24ESR-N standard spark plugs (Denso), 0.4mm Iridium spark plugs and Brisk Silver spark plugs. The difference from each spark plug used lies in the type of electrode used. The iridium spark plug diameter is small and pointed, the silver spark plug diameter is slightly larger and blunt, and the standard spark plug has a flat electrode.

In this research, experimental testing was carried out on the effect of spark plug and coil variations on emissions, power, and torque of the vixion 150 motorbike using dyno tests and emission tests, with spark plug variations in coil U24ESR-N (Denso) & 3C1 H2310, Iridium 0.4mm & 3C1 H2310, Brisk Silver & 3C1 H2310, Brisk Silver & Uma Racing, Iridium 0.4mm & Uma Racing, U24ESR-N (Denso) & Uma Racing. This study aims to determine the effect of spark plug and coil variations on emissions, power, and torque on the vixion 150 motorcycle.

METHODS

The method used is experimentation, which is research conducted to find the effect of certain variables on other variables under certain conditions and this research is carried out in the laboratory. The research was carried out with several tests, then the results of the study were taken on average. This research is a quantitative descriptive

type research that describes the results of experiments in the laboratory on the number of test objects, then analyzed using descriptive.

The independent variables carried out in this study include U24ESR-N (Denso) spark plugs with standard coil type 3C1 H2310; 0.4mm iridium spark plugs with standard coil type 3C1 H2310; Brisk Silver spark plugs with standard coil type 3C1 H2310; U24ESR-N (Denso) type spark plugs with Uma Racing type coil; 0.4mm Iridium spark plugs with Uma Racing coil; and Brisk Silver type spark plugs with Uma Racing coil. The control variable in this study is the new yamaha vixion lightning 150 engine RPM at 6000 RPM; 6500 RPM; 7000 RPM; 7500 RPM; 8000 RPM; 8500 RPM; 9000 RPM; and 9500 RPM. The dependent variables in this study are HC, CO, CO_2 and O_2 exhaust emissions and engine performance which includes power and torque.

RESULT AND DISCUSSION

CO_2 section results

The CO_2 exhaust emissions produced in this test can be seen in table 1. The study shows the ratio of coil and spark plug at a certain RPM.

Table 1. CO_2 content test (%vol)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	14.83	15.10	15.27	15.36	15.77	16.14	16.23	16.34
Iridium 0.4mm & 3C1 H2310	15.15	15.29	15.40	15.56	15.86	16.35	16.48	16.42
Brisk Silver & 3C1 H2310	15.23	15.34	15. 43	15.53	15.93	16.26	16.32	16.38
Brisk Silver & Uma Racing	15.16	15.25	15.51	15. 64	15.78	16.13	16.25	16.37
Iridium 0.4mm & Uma Racing	15.26	15.33	15.42	15. 53	15.75	16.23	16.57	16.53
U24ESR-N (Denso) (Nickel) & Uma Racing	14.98	15.19	15.24	15.41	15.67	16.12	16.19	16.22

The data obtained is then processed into a comparison diagram of the effect of using coil type variations and spark plug type variations on CO_2 exhaust emissions as follows:

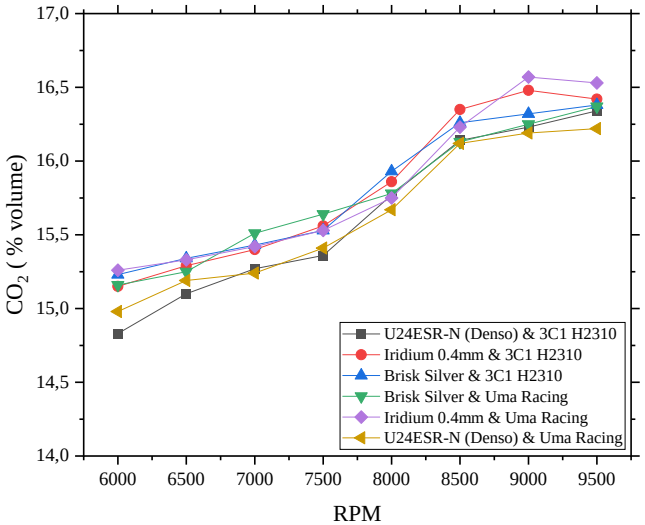

Figure 1. Comparison of CO_2 levels

The data above explains that the highest value occurs when using the Brisk Silver spark plug variation combined with the 3C1 H2310 coil at RPM 8000, which reaches a value of 15.93%, while the lowest value in CO_2 testing is produced by the U24ESR-N type spark plug (Denso) with the standard 3C1 H2310 coil setting built into the motor at RPM 6000, which is 14.83%. Fuel also affects the emissions produced, especially in CO_2 emissions.

The data displayed also shows the ups and downs of gas emissions produced, therefore the selection of spark plugs, coils and fuel needs to be considered in order to reduce CO_2 emissions. If you look closely, a good spark plug has good electrodes too, this is proportional to the CO_2 emissions produced. It can be concluded that the possibility of good combustion with maximum spark plugs will increase CO_2 gas emissions. The increase in CO_2 is due to better electrode material, because it produces the appropriate voltage so that the spark is better and then makes the combustion process better.

CO section results

Data on CO emission levels can be seen in table 2, with the provision of the use of spark plug variations, coil and certain RPM.

Table 2. CO content test (%vol)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	3.68	3.63	3.45	3.32	3.31	3.26	3.21	3.17
Iridium 0.4mm & 3C1 H2310	3.63	3.58	3.42	3.28	3.27	3.24	3.22	3.19
Brisk Silver & 3C1 H2310	3.71	3.62	3.44	3.26	3.25	3.23	3.19	3.16
Brisk Silver & Uma Racing	3.87	3.54	3.41	3.25	3.23	3.22	3.21	3.18
Iridium 0.4mm & Uma Racing	3.77	3.52	3.40	3.26	3.22	3.21	3.18	3.14
U24ESR-N (Denso) (Nickel) & Uma Racing	3.86	3.63	3.43	3.29	3.26	3.24	3.22	3.20

The CO gas emission data that has been obtained is then analyzed. The data above is then processed into a graph for easy reading and analysis, which can be seen in Figure 2.

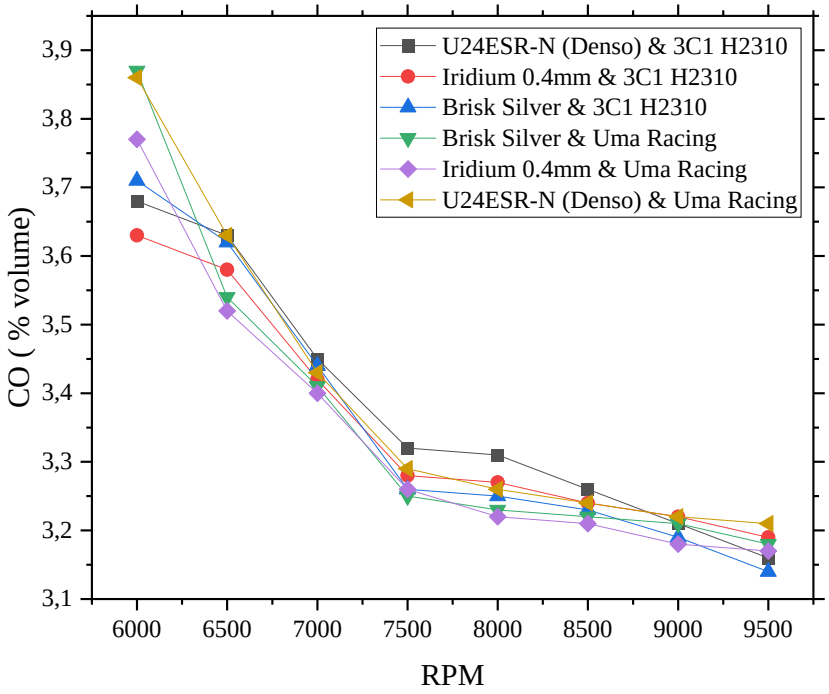

Figure 2. Comparison of CO levels

The variations used in this study gave results that at RPM 6000, the lowest value was produced by the 0.4mm Iridium spark plug combined with the standard 3C1 H2310 coil resulting in 3.63%, higher when compared to other variations at the same RPM. At RPM 8500, the highest CO emissions were produced by U24ESR-N (Denso) spark plugs with 3C1 H2310 coil. The highest CO emission at RPM 9000 resulted in a value of 3.87% with the Brisk Silver spark plug variation with the coil used by Uma Racing.

HC section results

The results of HC gas emission research by giving variations of spark plugs, coils in certain RPM can be seen in table 3.

Table 3. HC content test (ppm)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	327.83	296.33	267.41	159.41	144.67	142.33	137.41	136.33
Iridium 0.4mm & 3C1 H2310	317.67	278.41	266.65	147.65	145.41	143.41	139.63	139.65
Brisk Silver & 3C1 H2310	326.63	283.67	259.65	154.41	150.65	146.33	140.63	138.67
Brisk Silver & Uma Racing	393.41	315.63	297.65	169.33	162.65	148.41	147.33	143.65
Iridium 0.4mm & Uma Racing	389.63	306.67	278.33	163.65	158.41	152.41	143.41	142.67
U24ESR-N (Denso) (Nickel) & Uma Racing	353.41	276.33	267.41	156.63	151.63	145.41	138.67	138.41

The data that has been obtained is then processed into a comparison diagram to see how much difference the HC gas produced from each variation as shown below:

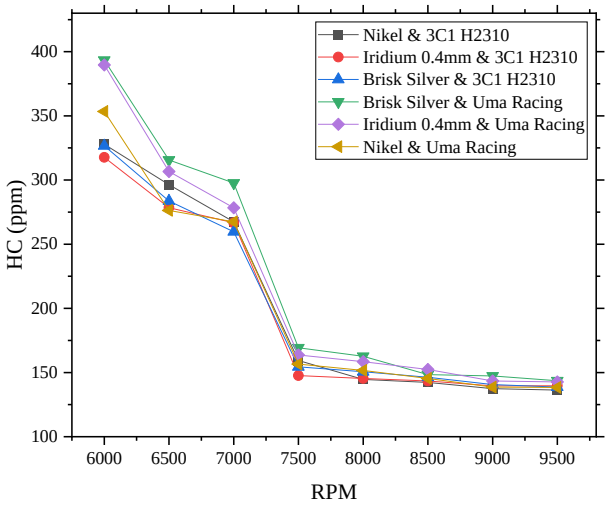

Figure 3. Comparison of HC levels

Conducting research on vixion motorcycles by providing spark plug and coil variations greatly affects HC exhaust emissions. The data above shows the 0.4mm iridium spark plug with 3C1 H2310 coil at RPM 6500 produces 317.67 ppm. The lowest HC emissions produced at RPM 7500 amounted to 154.41 ppm, this was produced from Brisk silver spark plugs with a standard coil 3C1 H2310. The effect of spark plug and coil variations produces the lowest HC emissions, namely U24ESR-N (Denso) spark plugs with 3C1 H2310 coil, this occurs due to the spark plug electrode being able to provide good conductivity and heat resistance so that it can transmit voltage by minimizing resistance losses to be small.

O_2 section results

The results of O_2 gas emission research by giving variations of spark plugs, coils in certain RPM can be seen in table 4.

Table 4. O_2 content test (ppm)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	2.35	1.95	1.72	1.64	1.58	1.57	1.46	1.37
Iridium 0.4mm & 3C1 H2310	2.19	1.95	1.92	1.86	1.74	1.71	1.68	1.55
Brisk Silver & 3C1 H2310	1.99	1.78	1.75	1.69	1.64	1.61	1.54	1.49
Brisk Silver & Uma Racing	2.48	1.93	1.87	1.85	1.82	1.79	1.68	1.56
Iridium 0.4mm & Uma Racing	2.37	1.92	1.78	1.69	1.65	1.59	1.44	1.38
U24ESR-N (Denso) (Nickel) & Uma Racing	2.09	1.94	1.86	1.78	1.72	1.68	1.58	1.46

The data that has been obtained is then processed into a comparison diagram to see how much difference the O_2 gas produced from each variation as shown below:

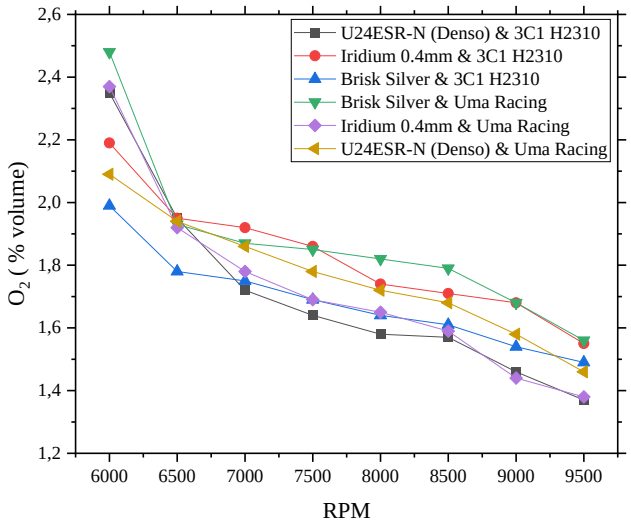

Figure 4. Comparison of O_2 levels

The effect of the type of coil and spark plug variation on the O_2 emissions produced shows a change in results. In the data above, the highest value of O_2 emission resulted from the use of spark plug type Brisk Silver with the use of coil type Uma Racing 2.48%, higher when compared to the use of other spark plug and coil types. At RPM 8500, the lowest O_2 emission resulted from the use of standard spark plug type U24ESR-N (Denso) and standard coil 3C1 H2310 with a value of 1.57%. As long as the O_2 emission does not exceed the specified limit, it will not be a problem in daily use.

Effect on Power

The comparison of standard spark plugs with spark plugs on the power produced by the New Vixion Lighning motorcycle varies greatly. The resulting data can be seen in table 5:

Table 5. Comparison of Power (kW)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	0	10.55	11.83	12.44	12.79	12.92	13.12	13.11
Iridium 0.4mm & 3C1 H2310	0	10.62	11.83	12.58	12.91	13.10	13.16	13.29
Brisk Silver & 3C1 H2310	0	11.40	12.44	13.06	13.49	13.79	13.76	13.48
Brisk Silver & Uma Racing	0	11.55	12.46	13.05	13.55	13.83	13.81	13.53
Iridium 0.4mm & Uma Racing	0	10.80	12.10	12.75	13.26	13.46	13.54	13.71
U24ESR-N (Denso) (Nickel) & Uma Racing	0	12.02	12.71	13.35	13.74	14.06	14.04	13.80

The data from table 5 is processed into a graph to make it easier to read the data, therefore a graphical form is obtained that matches the power comparison of standard spark plugs and coils with variants of racing spark plugs and coils.

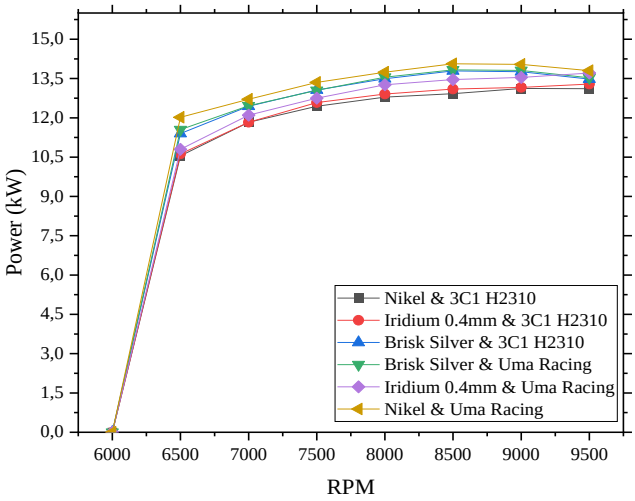

Figure 5. Comparison of Power

The spark plug and coil variations given to the Vixion motorcycle provide changes to power. The variation of U24ESR-N spark plugs (Denso) with Uma Racing type coil at 8000 RPM produces a power of 13.74 kW, higher when compared to Brisk spark plugs with Uma Racing coil and 0.4mm Iridium spark plugs with Uma Racing coil. The lowest power was generated at RPM 6500 resulting in 10.55 kW, higher when compared to the use of 04mm Iridium Spark Plugs with standard 3C1 H2310 coil. At RPM 6000, 0 was recorded for all spark plugs and coils due to the opening of the throttle and data collection starting from RPM 6000.

Comparison of Torque

The comparison of standard spark plugs and coils and variations of racing spark plugs and coils on the torque produced by Vixion motorbikes varies greatly. The data obtained can be seen in table 6, then processed into a graph.

Table 6. Comparison of Torque (Nm)

Spark Plug & Coil Types	6000 (RPM)	6500 (RPM)	7000 (RPM)	7500 (RPM)	8000 (RPM)	8500 (RPM)	9000 (RPM)	9500 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	0	8.53	8.88	8.71	8.40	7.98	7.66	7.25
Iridium 0.4mm & 3C1 H2310	0	8.59	8.88	8.82	8.48	8.09	7.68	7.35
Brisk Silver & 3C1 H2310	0	9.22	9.33	9.15	8.86	8.53	8.04	7.45
Brisk Silver & Uma Racing	0	9.35	9.36	9.14	8.89	8.55	8.06	7.48
Iridium 0.4mm & Uma Racing	0	8.73	9.08	8.93	8.71	8.32	7.90	7.58
U24ESR-N (Denso) (Nickel) & Uma Racing	0	9.72	9.53	9.35	9.02	8.69	8.20	7.62

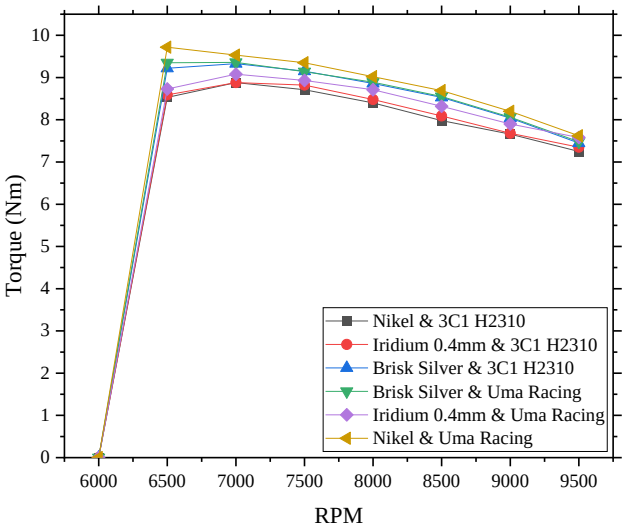

Figure 6. Comparison of Torque

The effect of spark plug and coil variations on the torque produced shows a change in results. In the data with the use of Uma Racing coil with U24ESR-N spark plug (Denso) at 6500 RPM engine speed produces a torque of 9.72 Nm, higher when compared to other spark plugs and coils. Torque data at RPM 6000 resulted in 0 Nm because when opening the throttle gas at RPM 6000, data was taken immediately. The smallest data from RPM 8500 was generated by the U24ESR-N spark plug (Denso) with the 3C1 H2310 coil at 7.98 Nm.

Comparison of Previous Research

There are differences between the results of the study and previous research in terms of power and torque test results. This study used a vixion 150 motorcycle in 2013 but in the previous study used a vixion 150 motorcycle in 2015. This research has also discussed several variables that are more than previous research regarding the variation of several spark plugs and coils and also testing at RPM 6000 to RPM 9500. Power comparison data can be seen in table 7 and table 8.

Table 7. Comparison of Power (kW) Spark Plug Iridium

Spark Plug & Coil Types	9000 (RPM)
Iridium 0.4mm & 3C1 H2310	13.16
Iridium 0.4mm & Uma Racing	13.54
Iridium CR8EIX [27]	13.3

Table 8. Comparison of Power (kW) Spark Plug Nickel

Spark Plug & Coil Types	9000 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	13.12
U24ESR-N (Denso) (Nickel) & Uma Racing	14.04
Nickel CPR6EA-9 [27]	12.7

The effect of variations in spark plug and coil types turns out to have little influence on vehicle engine power, due to differences in the voltage generated by the ignition coil which results in differences in sparks on the spark plug electrodes. The greater the voltage generated by the ignition coil, the greater the sparks on the spark plug electrodes, thereby increasing the power generated. From the test data of spark plug variations and coil Iridium 0.4mm & Uma Racing has a higher power of 13.54 kW. For testing spark plug variations Nickel and coil variation type U24ESR-N (Denso) (Nickel) & Uma Racing has a higher power of 14.04 kW.

Table 9. Comparison of Torque (Nm) Spark Plug Iridium

Spark Plug & Coil Types	7000 (RPM)
Iridium 0.4mm & 3C1 H2310	8.88
Iridium 0.4mm & Uma Racing	9.08
Iridium CR8EIX [27]	11.54

Table 10. Comparison of Torque (Nm) Spark Plug Nickel

Spark Plug & Coil Types	7000 (RPM)
U24ESR-N (Denso) (Nickel) & 3C1 H2310	7.66
U24ESR-N (Denso) (Nickel) & Uma Racing	8.2
Nickel CPR6EA-9 [27]	11.14

The effect of spark plug and coil variations on torque has a difference in this study with previous research. In the previous study, the type of Iridium CR8EIX spark plug and the type of Nickel CPR6EA-9 spark plug had a higher torque of 11.54 Nm and 11.14 Nm compared to the variation of spark plug and coil types in this study. This difference can be triggered due to differences in the year of manufacture of the vehicle used in the study. In this study using a vixion 150 vehicle in 2013 while the previous study used a vixion 150 vehicle in 2015. The 2015 Vixion 150 motorcycle has a newer Electronic Control Unit (ECU) system that affects the way the engine responds and produces higher torque.

CONCLUSIONS

Variations in spark plug and coil types greatly affect HC, CO, CO_2 and O_2 exhaust emissions on Vixion motorcycles. Spark plug type U24ESR-N (Denso) with standard coil 3C1 H2310 is able to suppress exhaust emissions well. HC and CO emissions are taken into consideration because they are very dangerous to the environment and health, so it is best to use U24ESR-N (Denso) spark plugs with 3C1 H2310 coils and Brisk Silver spark plugs with the use of 3C1 H2310 coils because they are able to reduce HC and CO emissions.

This study also looked at the comparison of power and torque by providing spark plug and coil variations, then the results obtained varied. The highest power at RPM 8500 is produced by spark plug type U24ESR-N (Denso) with the use of Uma Racing type coil of 8.69 kW. Spark plug and coil variations will also determine torque. The highest test on the use of Uma Racing coil and Brisk Silver spark plug at 6500 RPM produced a value of 9.35 Nm.

This study shows that with the variation of spark plugs and coils with higher specifications, the output voltage will make a bigger spark at the spark plug so that engine performance can increase and combustion becomes better and more stable. However, when the same vehicle is tested but the year of manufacture of the vehicle is different, it has a difference in torque because the new vehicle has a newer electronic control unit (ECU) system so that it can affect the engine response and produce higher torque.

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