Expanded Elbow Pipes and Mufflers: Its Effects on Fuel Consumption of Four Cycle Motorcycle Engine

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Abstract

In a pursuit towards determining the effect of Expanded Elbow Pipes and Mufflers in Fuel Consumption of Four-Cycle Motorcycle Engine, specifically this paper confined that there is no significant difference in the mean fuel consumption between stock elbow pipes and mufflers and expanded elbow pipes and mufflers. Engines' back pressure, defined as the exhaust gas pressure produced by the engine on its' exhaust system resulting to resistance of these gasses to be discharge into the atmosphere. Increased back pressure levels can cause increased emissions, fuel consumption, and negatively affect engine performance. Stock elbow pipe and mufflers installed in motorcycles does not possess the technology to limit the effect of back pressure that an Expanded elbow pipes and mufflers can provide, problems in back pressure can be address through the use of expanded elbow pipes and mufflers which can help the engine and better exhaust flow. This methodology shall give improved engine performance and afford lesser fuel consumption in a four-stroke motorcycle engine and the exhaust system setup reduced back pressure.

Key words: four cycle engine, motorcycle engine, fuel consumption, exhaust system

INTRODUCTION

Everyday innovation takes place as the search for improvement, efficiency and comfort becomes the necessity that every product should have, company's should be creative and produce outputs that have quality and efficiency as this is what customers are craving for. The transport industry and services should be on track with what the people demand and should deliver what they wanted for them to keep their edge in the market and enjoy the advantage through greater market share and profit. [1] Technology is always on the move, innovations, inventions, and creations continuously happen each day. The motorcycle industry has come up with various innovations to satisfy the demands and needs of motorcycle riders. Before, two-stroke engine was mostly used and manufactured. This engine although provides more input power it consumes more fuel and has more carbon emission which affects the environment. The challenge has made inventors and engineers create a motorcycle engine that is fuel-efficient and environment friendly, this is the birth of the four-stroke motorcycle engine. The four-stroke engine usually runs in gasoline without any oil being mixed and the piston goes up and down two times for every combustion cycle, hence it's called a "4-stroke." [1]

However, 4-stroke engines require valves for both the intake and exhaust that must operate with high precision, making this engine format more complex and heavier that made them disadvantage. But they provide stable power delivery, good fuel efficiency, cleaner emissions, and more. This is one the reason why almost all two-wheelers, from big motorcycles to small scooters, use 4-stroke engines. The invention of the four-stroke engine became the norm in most motorcycles as it is efficient in fuel consumption and exhausts less smoke. [1]

The four-stroke engines is the most common types of internal combustion engines and is used in various automobiles (that specifically use gasoline as fuel) like cars, trucks, and some motorbikes (many motorbikes use a two stroke engine). A four stroke engine delivers one power stroke for every two cycles of the piston (or four piston strokes).

Small engines stationary or in motorcycles, and even small cars have one, two, or three cylinders. If there is only one cylinder, the engine is called a single-cylinder engine, if there are two, two cylinders or twin-cylinder engines, and so on. Convenience in the operation of the vehicle is also dependent on the cylinder arrangements of the present-day automotive engines. [1]

Stock elbow pipe and muffler can be efficient in the first place as the owner does not require any more for additional cost in modifying by buying materials for modification of the motorcycle exhaust system. Stock exhaust system are factory made which has limitations in regards the motorcycle performance like distance mileage and fuel efficiency which is a common problem for motor vehicle owners nowadays.

With this reasons and findings, the researchers are ignited to conduct this study to find out the effects of stock and expanded elbow pipe and muffler to gasoline or fuel consumption of the motorcycle.

The research problem

This study determines the effect of Expanded Elbow Pipes and Mufflers on Fuel Consumption of Four Cycle Motorcycle Engine.

Specifically, this research sought to answer the following questions:

1. What is the effect of ordinary Elbow Pipe and Mufflers on Fuel consumption of four-stroke motorcycle engine?
2. What is the effect of Expanded Elbow Pipes and Mufflers on the fuel consumption of four-stroke motorcycle engines?
3. Is there a significant difference in the mean fuel consumption between Ordinary Elbow Pipe and mufflers and expanded elbow pipes mufflers?

Null Hypothesis

Based on the above question, the researcher advanced the null hypothesis which states that there is no significant difference in the mean fuel consumption between ordinary elbow pipes and mufflers and expanded elbow pipes and mufflers.

Conceptual Framework of the Study

Based on the book of Weather Jr. and Hunter, the four-stroke cycle engine, commonly called the four-cycle engine, derives its name from the action of a piston during one complete cycle of the engine. To complete one cycle of the four-stroke cycle engine, the piston travels the length of its stroke (up and down) four times as the crankshaft rotates two complete turns. The events took place in each engine cylinder are related to the four strokes of the piston. In this study, stroke is defined as either piston movement from the top dead center (TDC) to bottom dead center (BDC) or movement from bottom dead center to top dead center. Thus, each stroke represents one-half turn or 180-degree rotation of the crankshaft. A four-stroke-cycle engine, the four-piston strokes are called the intake stroke, compression stroke, power stroke, and exhaust stroke. [1]

First is the intake stroke, the intake valve opened as the piston moves down in the cylinder. The downward movement of the piston increases the volume of the cylinder causing atmospheric to push a mixture of air and fuel from the carburetor through an open intake valve. As the piston reaches the bottom of the intake stroke, the pressure reduction stops, and the intake of fuel and air nearly ceases. However, the weight and movement of the rushing air-fuel mixture cause some air-fuel mixture to continue flowing into the cylinder until the intake valve closes. The delayed closing of the intake valve increases the amount of combustible mixtures that enters the cylinder as possible during the intake stroke. [2]

The second is the compression stroke, as the piston starts to move upward, the compression stroke begins. The intake valve closes, trapping the air-fuel mixture in the cylinder. The upward movement of the piston compresses the air-fuel mixture to a fraction of its original volume. At the top of the compression stroke, the top of the piston and the cylinder walls form a combustion chamber in which the mixtures will be burned. The volume of the combustion chamber formed by the piston and cylinder walls with the piston at the top dead center compared to the volume of the cylinder as the piston reaches the bottom dead center determines the compression ratio of the engine. [2]

The third is the power stroke, this begins as the compressed air-fuel mixture is ignited within the combustion chamber. The spark produced across the electrodes of the spark plug does not explode the air-fuel mixture. Instead, the fuel burns rapidly during the power stroke. The heat of the burning mixture expands the gas within the cylinder and creates a very high pressure against the top of the piston and driving it down in the cylinder. This downward motion of the piston is transmitted through the connecting rod and converted to rotary motion by the crankshaft. [2]

And the fourth is the exhaust stroke. The exhaust valve opens just before the piston reaches the bottom of the power stroke. The pressure within the cylinder as the exhaust valve open causes the exhaust gas to rush through the open valve and into the exhaust manifold. The upward motion of the piston from the bottom of its stroke expels most of the remaining exhaust gas from the cylinder. As the piston reaches the top of each stroke and pauses momentarily before changing direction, the weight and motion of exhaust gas through the open exhaust valve causes the flow to continue. [3]

As the piston nears the top of the exhaust stroke, the intake valve begins to open while the exhaust valve starts to close so that both valves are open momentarily. This condition, with both valves partly open, is called valve overlap. During overlap, the incoming air-fuel mixture further purges the combustion chamber of the exhaust gas before the exhaust valve closes. [3]

The exhaust stroke completes the 4-cycle. The cycle then begins again with the intake stroke. This cycle is going on in each cylinder of a 4-cycle engine, and it is repeated over and over again as long as the engine is running.

Figure 1 on the succeeding page shows the operation of a 4-cycle engine. During the exhaust stroke, the cause of an engine to lose power is through backpressure. The exhaust valves open at the beginning of the exhaust stroke, and the piston pushes the exhaust gas out from the cylinder. If there is any amount of resistance that the piston has to push against the force the exhaust gasses out, power is wasted.

Engine back pressure, defined as the exhaust gas pressure that is produced by the engine to overcome the hydraulic resistance of the exhaust system in order to discharge the gases into the atmosphere. According to the study of Jaaskelainen, (2017), wherein his study resulted from coming out these findings about back pressure that Increased back pressure levels can cause increased emissions, increased fuel consumption, and can negatively affect engine performance. [4] Common stock mufflers installed in motorcycles does not possess the technology to limit the effect of back pressure that a modified muffler in the market can provide. [4]

Reducing back pressure can generate more speed, distance travel, and fuel consumption, as the restrictive exhaust flow that builds up back pressure is only hurting the power your vehicle can deliver because it's not working efficiently. Likewise, no back pressure can be bad for engines, there should be a little back pressure as it also helps your motor vehicle's performance. [5]

This common problem of back pressure can be address through the use of expanded or modified mufflers which can also help the engine and give the following advantages better exhaust flow, knowing the quality of materials attached, and better fuel economy. [5] [6]

This is the idea of how the expanded elbow pipe and muffler came into the mind of the researcher even if the engine is running at high speed, the exhaust gasses can flow out from the exhaust port freely eliminating back pressure, improved engine performance and afford lesser fuel consumption.

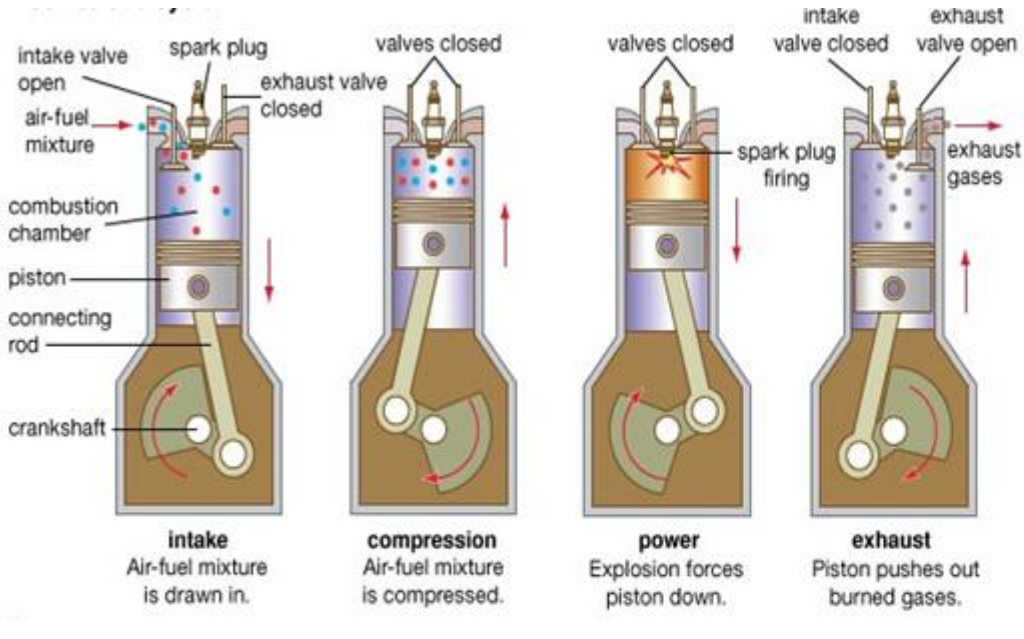

Figure 1 operation of a 4-cycle motorcycle engine.

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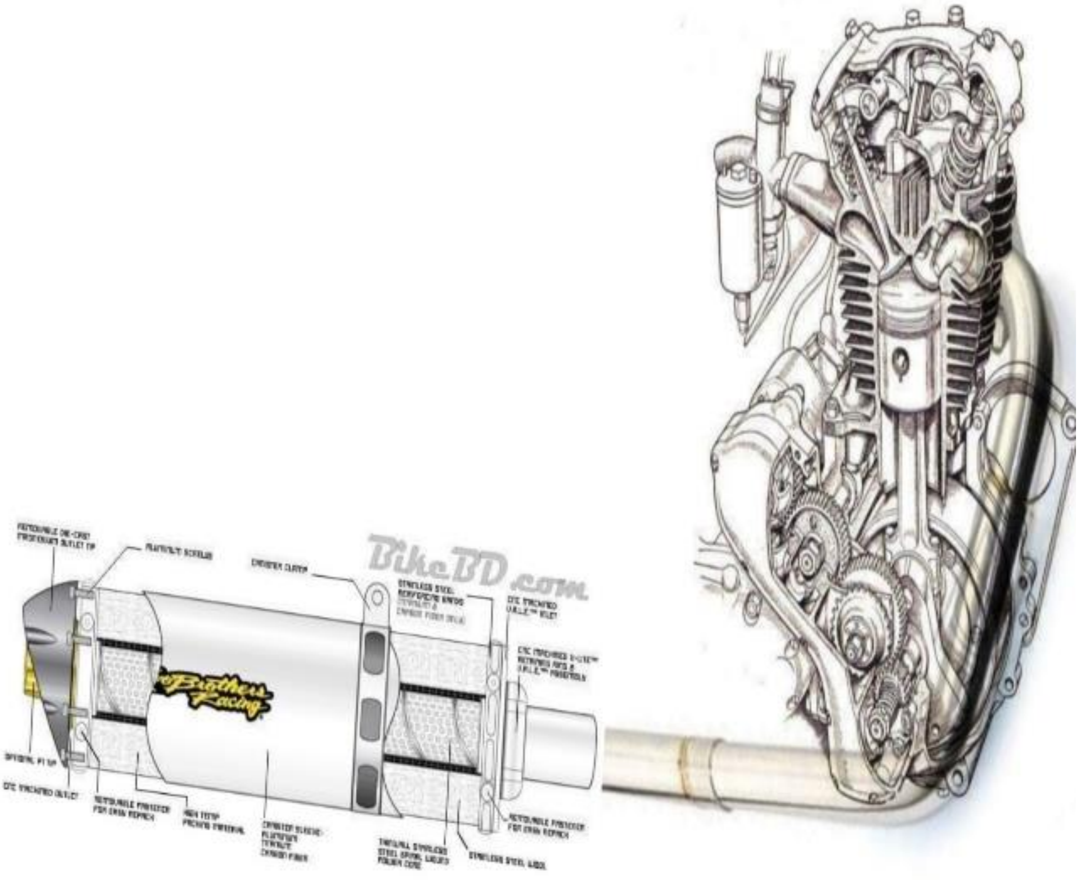

Figure 2. Piston on its exhaust stroke, with the attachment of expanded elbow pipe and muffler.

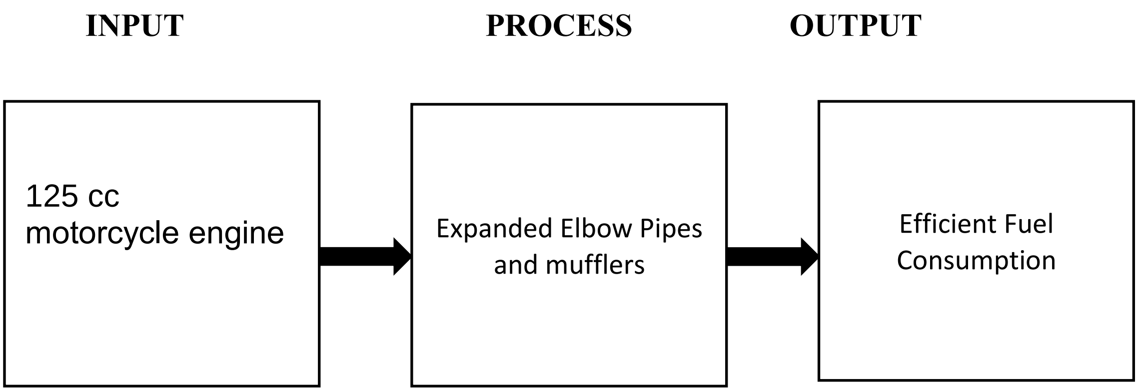

Figure 3. Schema showing the Concept of the Study

Figure 3, shows the research paradigm of this study, from which for the inputs the researchers generates first the different concepts of the two motorcycle exhaust system; the stock or the original elbow pipe and muffler, and the modified or expanded elbow pipe and muffler from the different kinds of literature and studies conducted. The gathered concepts were studied and analyzed to understand the principles that lie from these two kinds of an exhaust system which was the subject of the study.

After which, an experimental study or the research process was conducted testing the sub-variables of the study (speed, distance, and fuel consumption) from the two main variables (the expanded and the stock elbow pipe and muffler) on its effect to fuel consumption.

From this, the data gathered was tabulated and interpreted, wherein the result was the basis for recommendation and the product or the output of the study.

Scope of the Study

This was an experimental study on the expanded elbow pipe and mufflers it effects in fuel consumption of four-cycle motorcycle engine.

Before the experiment, the researcher ensures that the motorcycle engine is in a good condition. It was checked for any defects and materials that might disrupt its operation. Gasoline fuel was place in a transparent graduated cylinder for observation, motorcycle parts were checked in order to prevent any delays that might disrupt the research experiment.

This experiment was conducted on actual driving in a four-cycle motorcycle engine attached with stock elbow pipe and muffler and finally the expanded elbow pipe and mufflers. The experiment was conducted at the municipality of Basey, Samar, the place has a small volume of motor vehicles and the road is repaired making the experiment successful. Likewise, the area where the test runs were conducted was the place where most of the researcher reside.

The motorcycle of the same engine but a different exhaust system was tested. This experiment was undertaken upon the approval was granted to the researchers. This study focused on the effects on fuel consumption of expanded elbow pipe and mufflers of four-cycle motorcycle engines because the researcher wants to determine the fuel efficiency as a result of this kind of exhaust system. This study is limited to this investigation of four-cycle motorcycle engines particularly 125cc because of its design.

This experiment focused on the exhaust system of the engine because this is the system of the engine directly affected by the expanded elbow pipe and mufflers

Significance of the Study

The results of this study will be beneficial to motorcycle owners, the industry, school administrators, automotive students.

The motorcycle owner. The result of the study will help in minimizing the expenditure on fuel consumption of motorcycle owners. Thus, a longer and safe route of travel can be performed by motorcycle riders with fewer expenses

The industry. This will give new job opportunities for machinist and mechanical expert individuals as they will be needed in creating the new design or technology to be utilized in the motorcycle industry and help rule the economic enhancement in our country.

The school administrators. As a leading university that caters to technology and engineering courses the findings of the study can provide the university's school administrators to come up with a curriculum that will focus on research and development in regards to the motorcycle exhaust system which will become the solution to high fuel prices.

The Automotive Students. As the receiver of learning, the findings will give them new knowledge from the two different exhaust systems, the stock elbow pipe and muffler, and the expanded elbow pipe and muffler. Likewise, students who have their motorcycles will now have a solution on how to lower their expenses on fuel consumption of their motorcycles.

Definition of Terms

To facilitate a better understanding of the discussion, the following terms are defined technically and operationally.

Carburetor. This pertains to the part of the engines that prepares the air-fuel mixtures that enter the combustion chamber of the engine and converts that liquid gasoline into vaporized ready for combustion. [7]

Compression stroke. The piston movement from bottom dead center to top dead center immediately following the intake stroke. Include more terminologies used in your study to enhance more understanding of you research work. [7]

Elbow pipe - the pipe connecting the exhaust passage of the engine to the muffler of the motorcycle. [8]

Exhaust stroke: As the piston reaches the bottom, the exhaust valve opens. The remaining exhaust gas is pushed out by the piston as it moves back upwards. [8]

Expanded elbow pipe and muffler - modified elbow pipe and muffler attached to the motorcycle; change in the original factory-made exhaust system of the motorcycle. [9]

Intake stroke: The piston moves downward to the bottom; this increases the volume to allow a fuel-air mixture to enter the chamber. [9]

Muffler - also called a silencer**,** a device through which the exhaust gases from an internal- combustion engine are passed to attenuate (reduce) the airborne noise of the engine. [10]

Power Stroke: As the fuel reaches the end of its combustion, the heat released from combusting hydrocarbons increases the pressure which causes the gas to push down on the piston and create the power output. [10]

Stock elbow pipe and muffler – the original elbow pipe and muffler attached to the motorcycle; factory made, not modified and adjusted. [11]

REVIEW OF RELATED LITERATURES AND STUDIES

This part discusses related literature and the studies in the present investigation.

Related literature

The literature reviewed in this study includes a discussion of the different parts of the exhaust system of the engine.

By exhaust system in its most general sense, is meant any apparatus whereby flue gas (that is, a gas which emitted into the atmosphere via a pipe or flue) is channeled away from the controlled combustion of a given fuel. The smokestacks at a nuclear power plant, the chimney on one`s house, and, of course, and the tailpipes of automobiles are all components of exhaust systems. These three examples alone substantiate the claim that exhaust systems are ubiquitous and essential to our daily lives. [12] The focus of the present article is on exhaust systems in automobiles. As mentioned above, the point of contact for most of us with vehicle exhaust systems is the exhaust pipe. This is merely the terminal point, however, for a considerably more complex assembly that makes up the exhaust systems in total. As one might expect, there is considerable variation among exhaust systems depending on the nature of one`s automobile and his/her vehicle performance needs. [12]

This system serves as a passage of exhaust gasses out from the engine exhaust port. But before the exhaust gasses can flow out from the tailpipe, this will pass through the system called the engine exhaust system. In the operation of the four-cycle engine intake, compression, power, and exhaust strokes are repeated over and over. [13]

Related Studies

The study entitled "Real-world fuel efficiency and exhaust emissions of light-duty diesel vehicles and their correlation with road conditions" [13] shows that fuel efficiency has been achieved by modifying exhaust system of an ordinary motor vehicle. Likewise, the study also found out that carbon emission also lessened which decrease air pollution and sound vibration has been reduced as well.

Consequently, the study [14] wherein they use a magnetic device installed as a modifier suggests that a modified exhaust system reduces fuel consumption of up to eighteen percent (18%) also reducing air pollutants released to the environment 70% of carbon dioxide to the atmosphere and 68% reduction of nitrogen oxides. The said study likewise connects the relationship between the fuel efficiency and the engine performance of a motor vehicle as it enhances the combustion process which accounts for a more fuel efficiency and subtle sounds from a reduced vibration which limits noise pollution.

Another study [14] wherein they created a hybrid engine modifying the exhaust system of a Honda car resulted into an improvement in engine thermal efficiency which creates a more fuel efficiency of 35 km/l at 10-15 mode. The study also found out that carbon emission of the vehicle has drastically reduced thus making the new exhaust system design become more environmental friendly. The principles of hybrid engine is the combination of two different parts which somehow contemplates to a modified one. Which this study is sought to find out whether there is a difference in terms of engine performance of an ordinary and a modified exhaust system.

A team of engineers [15] conducted a study on how to improve fuel and car efficiency by enhancing an engine exhaust using electro-turbogenerators as a device added to the exhaust system. Their study wanted to reduce the 30% energy lost through the exhaust system of an ordinary exhaust system.

They formulated a plan in creating an "exhaust heat recovery" through a modified engine exhaust system. Their study has an aim in making the vehicle become a fuel efficient, reduced carbon emission, reduced harmful exhaust emission and improved engine power output. It can be inferred that these four factors they cited where not manifested in the ordinary engines as these engines causes these factors to manifests. The result of their experiment from which they came out to a new design of a modified exhaust system which has higher fuel efficiency, lesser carbon emission, and have a more mileage in terms of distance traveled compared to the ordinary exhaust system of a motor vehicle.

Their study has an aim in making the vehicle become a fuel efficient, reduced carbon emission, reduced harmful exhaust emission and improved engine power output. It can be inferred that these four factors they cited where not manifested in the ordinary engines as these engines causes these factors to manifests [15]. The result of their experiment from which they came out to a new design of a modified exhaust system which has higher fuel efficiency, lesser carbon emission, and have a more mileage in terms of distance traveled compared to the ordinary exhaust system of a motor vehicle [16].

“Most motorcycle owners prefer a customized muffler design than the ordinary mufflers installed in motorcycles” according to the study of Transparency Market Research [16]., as this boost torque in engine also its speed in horsepower. The study provided a clearer glimpse on the competitive edge of modified mufflers on its efficiency and effectiveness in regards with speed and engine performance. It also paves ways in the construction of a much more enhance motorcycle exhaust system that generates more fuel efficiency than the conventional motorcycle [17].

The study cited above showed that there is a difference in the performance of a motor vehicle between the stock exhaust system and the expanded exhaust system used in a vehicle. Although, these studies have been proven and tested the setting of these studies conducted is quite which still needs to be proven and conducted by the research proponents. The researchers wanted to prove the null hypothesis which states that there is no difference in terms of fuel consumption, distance traveled, and speed of a motor vehicle between the stock and expanded exhaust system.

METHODOLOGY

This part discusses the methodology involved in the conduct of the study, it includes procedures applied to the different variations of the operation and the materials used to conduct in the present study.

Research Design

An experimental research was used in the study. The expanded elbow pipe and muffler are expected to minimize fuel consumption by expanding the passage of the exhaust gasses that flow in a high amount from the exhaust port of the engine through the exhaust system. It is concern with two factors under study giving more emphasis to the factor over the other factor that was investigated. In this study, the factor that were investigated were the fuel consumption of same engine with different exhaust system one has a stock elbow pipe and muffler and one has an expanded elbow pipe and muffler. A correlational research from which it wanted to find out if there is a significant difference in terms of fuel consumptions between the two variables of study, using t – test to test the hypothesis of the study.

The researchers used 3000 level of rpm exclusively in same engine to obtain the uniformity of every test run with different types of exhaust system and run for twenty minutes from first gear, second gear, and third gear.

The whole activities and procedures were done on the next exhaust systems, the stock elbow pipe and mufflers and finally the expanded elbow pipe and Mufflers.

The researchers had two weeks duration of the study, which was divided into two stages; the initial stage was for first week and experimental stage lasted from the remaining second week.

During the initial stage, the engine was tested with all accessories attached. The ignition switch, temperature gauge, ammeter, speedometer, etc. and the experimental expanded was prepared by the researchers. The compression of cylinder was noted including the clearance of the valves; Capacitor Discharge Ignition (CDI's) as well as the spark plug and spark plug gap. These parts were seta to its specific clearance to determine the fuel consumption according to its varying gear speed for a period of twenty (20) minutes operation.

Each gear was tested during engine operation for the purpose of recording the fuel consumption, speed, revolutions per minute (rpm) and etc.

Variables of the study

The fuel consumption of the motorcycle engine with stock elbow pipes and Mufflers at different level gear number at 3000 rpm, represents independent variable of the study. The dependent variable is the fuel consumption of the same engine with expanded elbow pipe and Mufflers tested at different levels gear at 3000rpm. The researchers endeavored in observing carefully the effects of Expanded elbow pipes and Mufflers on fuel consumption of the engine.

Data Gathering Procedures

The data gathering was started by taking the compression of the cylinder and the corresponding clearance of its parts needed in the operation of the engine. The data gathered in this study were as follows:

Compression in the cylinder. This was done by measuring the compression of the cylinder, with the use of a compression tester.

Valve clearance. This was done with the use of a feeler gauge in order that air-fuel mixture was enough to power the engine

Sparkplug gap. It must have to be adjust the specific clearance to sufficient power to burn the fuel in the combustion chamber.

Experimental procedures

In this experiment, various procedures were taken this includes the preparation of expanded elbow pipe and muffler.

I. First phase test run (initial stage)

Preparation of the motorcycle engine with stock elbow pipe and muffler. The knowledge in fitting of the pipe and muffler, including the particular tools and equipment needed.

Assembling the expanded elbow pipe and muffler. All parts and components were secured and tested to eliminate possible irregularities of the elbow pipe and muffler.

II. Second phase of the test run (experimental stage)

Running with stock elbow pipe and muffler. The test run was made on the gasoline motorcycle engine with stock elbow pipe and muffler. The test runs in 20 minutes with the 3000 rpm with different gear level was recorded as the engine perform. The fuel was placed in a calibrated measuring container measured and recorded as the time consumed as stated. The same procedure was done on the next activity on the expanded elbow pipe and muffler. The fuel consumption of the motorcycle engine attached with different types of elbow pipes and mufflers where recorded.

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Materials

Expanded elbow pipe and muffler as modified exhaust systems are common in any type of motorcycle. The diameter fitted to the unit XRM HONDA 125 motorcycle was used in the study. The said exhaust system was used to expand and improve the passage of exhaust gasses at high amount from the exhaust port of the engine.

Figure 4 stock elbow pipes and mufflers

figure 5 Expanded Elbow Pipes and mufflers

Measuring instruments

The following measuring instruments were used by the researchers in order to achieved an accurate condition of the engine as the experiment conducted.

Tachometer. This was used to determine the engine revolution per minute (rpm).

Speedometer gauge. This was used to determine the speed of the vehicle in kilometer per hour (kph).

Graduated cylinder. This was used to measure the gasoline consumption at every level of speed and gear number during the operation.

Feeler gauge. This was used in measuring the sparkplug gap and valve tappet clearance.

OBSERVATION GUIDE SHHET

STOCK ELBOW PIPE AND MUFFLER						
No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (^{o}C)	**Fuel Consumption** (ml)

Mean Fuel Consumption =						

EXPANDED ELBOW PIPE AND MUFFLER						
No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (°C)	**Fuel Consumption** (ml)
Mean Fuel Consumption =						

Statistical Analysis of Data

The Percentage and the Weighted Mean formula was used in describing the Mean fuel consumption of the two exhaust system, the stock elbow pipe and muffler and the expanded elbow pipe and muffler

For the testing of the null hypothesis, Pearson - R statistical formula will be utilized.

1. **Mean. (X)** or arithmetic mean is the arithmetic average obtained by adding all the arithmetical values or data then divided by the number of observation. Such tool was used to determine the mean fuel consumption for the number of test run, the mean fuel consumption per type of gear used

2. ***t*-test: Two Sample of Unequal Variances**
   This statistical instrument was used as there were two means being compared from the two kinds of muffler. This formula is appropriate for the study to utilized in finding out the significant difference as it wanted to find out to prove the hypothesis that there is no significant difference between the stock elbow pipe and muffler and the expanded elbow pipe and muffler. [18]

To facilitate a correct and exact result SPSS and MS EXCEL data analysis was utilized to come up with a credible data interpretation as these applications are used by most researchers.

RESULTS AND DISCUSSIONS

This parts presents and discusses the analysis and interpretation of the data gathered in the study. This includes the table presentations that pertain to the variables being studied. The mean and the frequency count were the statistical tools used in interpreting the data gathered through the experimental procedure.

The study aimed to find out the effects of stock Elbow Pipe and Mufflers and the Expanded Elbow Pipes and Mufflers on the Fuel Consumption of Four Cycle Motorcycle Engine. The study wanted to determine the answers to the following.

- The effects of stock Elbow Pipe and Mufflers on Fuel consumption of four-stroke motorcycle engine.

- The effects of Expanded Elbow Pipes and Mufflers on the fuel consumption of four cycle motorcycle engines.
- The significant difference in the mean fuel consumption between Stock Elbow Pipe and mufflers and expanded elbow pipes mufflers, and
- The Null Hypothesis, which states that that there is no significant difference in the mean fuel consumption between stock elbow pipes and mufflers and expanded elbow pipes and mufflers.

The effects of stock Elbow Pipe and Mufflers on Fuel consumption of four cycle motorcycle engine.

The effects of Stock Elbow Pipes and Muffler on the fuel consumption of four-stroke motorcycle engines.

Table 1 shows the results of the study on the effect of stock Elbow Pipe and Mufflers on Fuel consumption of four cycle motorcycle engine. Utilizing the survey template to gather data on the variables of the study at gear number (1), with six test run to ensure the veracity and validity of the result, at twenty (20) kph and at the running time of twenty minutes (20 min.) all of the six test run the revolution rate per minute (rpm) is consistent three thousand (3000). It can be noted in the data gathered that as the engine temperature increases the fuel consumption increased as well.

Table 1
Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Stock Elbow Pipe and Muffler at Gear No. 1

No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (^oC)	**Fuel Consumption** (ml)
1	3000	1	20	20	50	110
2	3000	1	20	20	55	115
3	3000	1	20	20	60	120
4	3000	1	20	20	65	130
5	3000	1	20	20	70	150
6	3000	1	20	20	75	165
Mean Fuel Consumption = 131.67 ml.						

Starting at fifty degree (50^{o}C) the fuel consumption stands at one hundred-ten (110ml), 5ml) at fifty-five degree (55^{o}C) the fuel consumption rise up to one hundred-fifteen (115) on the sixth as the final run wherein the temperature reaches to seventy-five (75^{o}C) the fuel consumption reaches to one hundred-sixty-five (165ml). In total at gear number one (1) of all six test runs the average mean fuel consumption of the Honda XRM operating the ordinary or with stock elbow pipe and muffler got a mean fuel consumption of one hundred thirty-one point sixty-seven (131.67 ml).

Table 1.1

Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Stock Elbow Pipe and Muffler at Gear No. 2

No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (°C)	**Fuel Consumption** (ml)
1	3000	2	40	20	45	100
2	3000	2	40	20	50	105
3	3000	2	40	20	55	110
4	3000	2	40	20	60	120
5	3000	2	40	20	65	140
6	3000	2	40	20	70	155
Mean Fuel Consumption = 121.67 ml.						

Table 1.1 shows how the fuel consumption was affected by utilizing the stock elbow pipe and muffler. At gear number two (2) and at a consistent running time of twenty minutes (20 min), the revolution per minute (rpm) was still at three thousand (3000 rpm). At the speed of forty kilometers per hour (40kph) on all six test runs from which the temperature engine varies at forty-five degrees (45°C) the fuel consumption stood at one-hundred (100 ml) after an increase of five degrees (5°C) at fifty degrees (50°C) the fuel consumption recorded at one-hundred five (105ml). as the temperature increased by five degrees (5°C) the fuel consumption was increased as well by five (5ml.), it then doubled.

As the temperature reaches fifty-five degrees (55°C), at sixty degrees (60°C) the fuel consumption at one-hundred twenty (120ml). as the temperature reaches its peak at seventy degrees (70°C) the started to deviate by just five (5ml) which stood at one-hundred fifty-five (155ml). Overall the average mean fuel consumption of the motorcycle engine at gear number two (2) reached at one-hundred twenty- one point sixty-seven (121.67ml). this is much lower than the mean consumption at gear number one (1) by ten (10ml).

Table 1.2

Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Stock Elbow Pipe and Muffler at Gear No. 3

No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (°C)	**Fuel Consumption** (ml)
1	3000	3	60	20	40	85
2	3000	3	60	20	45	90
3	3000	3	60	20	50	95
4	3000	3	60	20	55	105
5	3000	3	60	20	60	125
6	3000	3	60	20	65	140
Mean Fuel Consumption = 106.67 ml.						

Gear number three (3) was used in Table 1.2 and at the speed of sixty kilometers per hour (60kph). All six text runs are consistent in the rpm at three thousand (3000) and the running time which stood at twenty minutes (20min). Similar results can be noted the same with the previous tables wherein as the temperature rises the fuel consumption increases as well. The fuel consumption rises by ten (10ml) on test run number four (4) when the engine temperature reaches fifty-five degrees (55°C) and were consistent adding twenty (20ml) and twenty-five (25ml) increased in fuel consumption at one-hundred twenty-five (125ml) and one hundred forty (140ml) when the temperature reaches sixty degrees (60°C) and sixty-five degrees (65°C) respectively. Further, the mean fuel consumption at gear number three (3) stood at one hundred sixty point sixty-seven (167ml) much lower than the previous two gears used, operating with the ordinary or stock elbow pipe and muffler.

Table 1.3

Summary of Mean Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Stock Elbow Pipe and Muffler at 3000 rpm

Kind of Exhaust System	Number of Gears	Mean Fuel Consumption (ml)
Stock Elbow Pipe and Muffler	1	131.67
	2	121.67
	3	106.67
	Standard Deviation	**12.58**
	Overall Mean Fuel Consumption = 120.03 ml	

The overall fuel consumption of the motorcycle engine operating with stock elbow pipe and muffler from the three gears as shown in the Table 1.3 were at gear number one (1) it utilized one hundred thirty-one point sixty-seven (131.67ml), at gear number two (2) it used up one hundred twenty-one point sixty-seven (121.67ml) of fuel while for the gear number three it consumed one hundred six point sixty-seven (106.67ml). the overall average mean fuel consumption stood at one hundred twenty point zero three (120.03ml). With a standard deviation of eight point thirty-three (8.33ml).

The effects of Expanded Elbow Pipes and Mufflers on the fuel consumption of four-stroke motorcycle engines.

Table 2 shows the result of the fuel consumption of the motorcycle engine using the expanded elbow pipe and muffler, operating at gear one (1) of the six (6) test runs and twenty kilometers per hour (20kph). The first three runs wherein the engine temperatures are at the forty-five (45°C) to fifty-five degrees (55°C) (the temperature just rises by five (5°C)) the fuel consumption increases by five (5ml). On the fourth run wherein the temperature stood at sixty degrees (60°C) fuel consumption is at one hundred twenty-five. A ten (10ml) increase was recorded, while at sixty-five degrees the increase was doubled to twenty (20ml) and decrease slightly when it reaches its peak temperature at seventy degrees (70°C) where it consumed one hundred sixty (160ml) of fuel or just add up fifteen (15ml). the total mean fuel consumption at gear one (1) and twenty (20kph) reached one hundred twenty-five (125ml).

Table 2

Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Expanded Elbow Pipe and Muffler at Gear No. 3

No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (°C)	**Fuel Consumption** (ml)
1	3000	1	20	20	45	105
2	3000	1	20	20	50	100
3	3000	1	20	20	55	115
4	3000	1	20	20	60	125
5	3000	1	20	20	65	145
6	3000	1	20	20	70	160
Mean Fuel Consumption = 125 ml.						

Table 2.1

Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Expanded Elbow Pipe and Muffler at Gear No. 2

No.of Test Run	**Revolution per minute** (RPM)	**Gear number**	**Speed** (kph)	**Running time** (minutes)	**Engine temperature** (°C)	**Fuel Consumption** (ml)
1	3000	2	40	20	40	95
2	3000	2	40	20	45	100
3	3000	2	40	20	50	105
4	3000	2	40	20	55	115
5	3000	2	40	20	60	135
6	3000	2	40	20	65	150
Mean Fuel Consumption = 116.67 ml.						

Table 2.2 tabulates the result of the experiment using the expanded elbow pipe and muffler at a speed of forty (40kph). Constant of the three test runs of the engine temperatures of forty (40°C) to fifty (50°C), the increase of fuel consumption stood at five (5ml). however, at the fourth test run when the engine heats up to fifty-five degrees (55°C) the fuel consumed was at one hundred fifteen (115 ml). it was doubled to one hundred thirty-five (135ml) when the temperature reached to sixty (60°) and slightly decrease to just fifteen (15ml) at its peak temperature in seventy degrees (70°C) where it consumed one hundred sixty (160ml) of fuel. With a total mean fuel consumed of one hundred twenty-five (125ml).

Table 2.2

Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Expanded Elbow Pipe and Muffler at Gear No. 3

No.of Test Run	Revolution per minute (RPM)	Gear number	Speed (kph)	Running time (minutes)	Engine temperature (°C)	Fuel Consumption (ml)
1	3000	3	60	20	35	80
2	3000	3	60	20	40	85
3	3000	3	60	20	45	90
4	3000	3	60	20	60	100
5	3000	3	60	20	60	120
6	3000	3	60	20	65	135
Mean Fuel Consumption = 101.67 ml.						

Operating at gear three (3) of the modified or expanded elbow pipes and muffler attached to the Honda XRM and was run at the clock speed of sixty (60kph). The result was similar to the first three runs with just five (5ml) increase of every five degrees (5°C) increase in the engine temperature. The fourth run at where the engine heats up to sixty degrees (60°C) and an increase of ten (10ml) was noted. It was again doubled to twenty (20ml) at one hundred twenty (120ml) at the same temperature of sixty (60°C) on the fifth run.

It slightly decreases to just fifteen (15ml) increase on the sixth run where the engine temperature stood at sixty-five (65°C) and consumed one hundred thirty-five (135ml) of fuel. The overall mean fuel consumption using gear three (3) of all six (6) test runs was at one hundred one point sixty-seven (101.67ml).

The fuel consumption of the expanded elbow pipe and muffler was computed with an overall mean at one hundred fourteen point forty-five (114.45 ml) on all three gears used. This is a much lower fuel consumption average compared to the ordinary or stock elbow pipe and muffler which fuel consumption recorded at one hundred twenty point zero three (120.03ml), lesser by five point fifty-eight (5.58ml). it can also be noted on the standard deviation (sd) that the modified or expanded elbow pipe and muffler got an sd of seven point seventy-eight (7.78ml) compared to eight point thirty-three (8.33ml) of the ordinary or stock elbow pipe and muffler

Table2.3

Summary of Mean Fuel Consumption of Four-Cycle Motorcycle Engine Operating with Expanded Elbow Pipe and Muffler at 3000 rpm

Kind of Exhaust System	Number of Gears	Mean Fuel Consumption (ml)
Expanded Elbow Pipe and Muffler	1	125
	2	116.67
	3	101.67
	Standard Deviation	**11.82**
	Overall Mean Fuel Consumption = 114.45 ml	

The significant difference in the mean fuel consumption between Stock Elbow Pipe and mufflers and the Modified or Expanded Elbow Pipes and Mufflers.

Table 3
Data Result Using Quantitative Analysis

Stock Elbow Pipe Mean Fuel Consumption (ml)			***Expanded Elbow Pipe Mean Fuel Consumption (ml)***	
Mean	120.00		Mean	114.45
Standard Error	7.26		Standard Error	6.83
Median	121.67		Median	116.67
Mode	#N/A		Mode	#N/A
Standard Deviation	12.58		Standard Deviation	11.82
Sample Variance	158.33		Sample Variance	139.78
Kurtosis	#DIV/0!		Kurtosis	#DIV/0!
Skewness	-0.59		Skewness	-0.82
Range	25.00		Range	23.33
Minimum	106.67		Minimum	101.67
Maximum	131.67		Maximum	125.00
Sum	360.01		Sum	343.34
Count	3.00		Count	3.00

Using descriptive analysis to find out the mean, variances, and the standard deviation difference. The result shows that the Stock Elbow Pipe fuel consumption with total weighted mean of one hundred twenty (120), standard deviation of twelve point fifty-eight (12.58) from the three (3) gears of observation. Likewise, for the Expanded Elbow Pipe and muffler, the weighted mean total is one hundred fourteen point forty-five (114.45), standard deviation of eleven point eighty-two (11.82).

Table 4, reveals the result of the T-test using Two-Sample Assuming Unequal Variances with the t (4) = 2.78, and p (0.30) which is above the minimum threshold of p = 0.05 suggests that there is no significant difference between the the mean fuel consumption between ordinary elbow pipes and mufflers and expanded elbow pipes and mufflers.

4. HO - Null Hypothesis

The researcher advanced the null hypothesis which states that there is no significant difference in the mean fuel consumption between ordinary elbow pipes and mufflers and expanded elbow pipes and mufflers.

Table 4

Data Result Using T-test: Two-Sample Assuming Unequal Variances

t-Test: Two-Sample Assuming Unequal Variances		
	Stock Elbow Pipe Mean Fuel Consumption (ml)	*Expanded Elbow Pipe Mean Fuel Consumption (ml)*
Mean	120.00	114.45
Variance	158.33	139.78
Observations	3.00	3.00
Hypothesized Mean Difference	0.00	
df	4.00	
t Stat	0.56	
P(T<=t) one-tail	**0.30**	
t Critical one-tail	2.13	
P(T<=t) two-tail	0.61	
t Critical two-tail	2.78	

*if $p < 0.05$ significant difference; $p > 0.05$ no significant difference.

Based on the result of the study from the t-test used in testing the hypothesis from which the *p* value is greater than 0.05 where $p = 0.30$ accept the Null Hypothesis that "there is no significant difference on the fuel consumption between the ordinary or the stock elbow pipe and muffler to the modified or expanded elbow pipe and muffler."

SUMMARY, COMCLUSIONS AND RECOMMENDATIONS

This part summarizes the findings, provides conclusions, and recommendations to the study based on the data interpretation. The conclusions and recommendations were based on the literature discussed and from the primary data that was gathered.

The study aimed to determine the effect of Stock Elbow Pipe and Mufflers and the Expanded Elbow Pipes and Mufflers in the Fuel Consumption of Four Cycle Motorcycle Engine. The study wanted to determine the answers to the following variables.

- The effect of stock Elbow Pipe and Mufflers on Fuel consumption of four cycle motorcycle engine.
- The effect of Expanded Elbow Pipes and Mufflers on the fuel consumption of four cycle motorcycle engines.
- The significant difference in the mean fuel consumption between stock Elbow Pipe and mufflers and Expanded Elbow Pipes Mufflers, and
- The Null Hypothesis, which states that that there is no significant difference in the mean fuel consumption between stock elbow pipes and mufflers and expanded elbow pipes and mufflers.

Summary of Findings

The study derives the following findings.

1. All test run conducted on the motorcycle engine using the stock elbow pipe and muffler at gear number one (1) it utilized one hundred thirty-one point sixty-seven (131.67ml), at gear number two (2) it used up one hundred twenty-one point sixty-seven (121.67ml) of fuel while for the gear number three (3) it consumed one hundred six point sixty-seven (106.67ml) of fuel. Likewise, the overall average mean fuel consumption stood at one hundred twenty point zero three (120.03ml). With a standard deviation of eight point thirty-three (8.33ml).
2. On the expanded elbow pipe and muffler used on motorcycle engine based on the data gathered, it has an overall mean at one hundred fourteen point forty-five (114.45 ml) on all three gears used. Which is a much lower in regards to fuel consumption average compared to the stock elbow pipe and muffler which fuel consumption recorded at one hundred twenty point zero three (120.03ml), lesser by five point fifty-eight (5.58ml). It can also be viewed that it has a standard deviation (sd) of the modified or expanded elbow pipe and muffler of seven point seventy-eight (7.78ml) compared to eight point thirty-three (8.33ml) of the stock elbow pipe and muffler.
3. There is no significant difference in terms of the fuel consumption between the stock elbow pipe and muffler and the expanded elbow pipe and muffler this is due to the t-test result of 0.30 which is above the normal threshold of $p = 0.05$.
4. HO - Null Hypothesis
   The researcher advanced the null hypothesis which states that there is no significant difference in the mean fuel consumption between stock elbow pipes and expanded elbow pipes and mufflers".

Based on the result of the study from the t-test used in testing the hypothesis from which the *p* value is greater than 0.05 where $p = 0.30$ accept the Null Hypothesis that "there is no significant difference on the fuel consumption between the stock elbow pipe and muffler to the expanded elbow pipe and muffler."

Conclusions

The analysis and interpretation of the gathered data led to the following conclusions:

1. The stock elbow pipe and muffler that are commonly used by motorcycles today consumes more fuel which will add up additional expenses to motorcycle owners. Expanding the said motorcycle exhaust system can be a good method to make it efficient in fuel consumption.
2. The expanded elbow pipe and muffler shows more efficiency in terms of fuel consumption based on the result of the study due to its lower fuel consumption.
3. There is a significant difference in regards to the fuel consumption ofthe two elbow pipe and mufflers used by motorcycle engine this is because the expanded elbow pipe and muffler is much more efficient in fuel consumption as it consumed less fuel compared to the stock elbow pipe and muffler.

4. the null hypothesis was accepted this is due to the result of the study from which the *p* value was 0.30 which is higher than 0.05, and therefore, the null hypothesis was accepted that "there is no significant difference in fuel consumption between the stock elbow pipe and muffler and the expanded elbow pipe and muffler."

Recommendations

1. Technical-Vocational Learning program in the field of mechanical technology should be enhance and supported by teaching and learning institutions to promote more research studies that can generate new ideas and inventions that can give relief and solutions to simple and complex problems.
2. A thorough study must be conducted on the modification of expanded elbow pipe and muffler on how its principles can be applied to stock elbow pipe and mufflers were it can become efficient in fuel consumption which will be beneficial to motorcycle owners.
3. Related studies must be push through by future researchers that deals on other variables where this study was not able to tackle due to time constraints and other factors that affects the research process.

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