

## A Review on Remote Control Muffler for Two Wheeler

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**Abstract** – An exhaust system is used to evacuate all the gases from an IC engine, but when an exhaust system is evacuating exhaust gases from IC engine it also carrying exhaust gas noise. so for minimizing exhaust gas noise muffler is used. In this paper there is study about operating an exhaust system with remote switch by which we can control noise of the, whether we want loud noise for race track and highway or low noise in crowded area. This paper review components of exhaust system, types of muffler, design of muffler. As we are working on a two wheeler, we are using YAMAHA R15 bike. Main component in our system is butterfly valve which is controlled by remote switch. When butterfly open all exhaust gas passes through it which will create loud noise and when it is closed it will go through muffler which create low noise. An automobile exhaust system has primary function which is evacuate exhaust gas as quick as possible so that performance of engine should increase. So in this system that function can be achieved.

**Key Words:** YAMAHA R15, Butterfly valve, Muffler, Exhaust system

### 1. INTRODUCTION

The purpose of an automobile muffler is to reduce engine noise. If a vehicle did not have muffler then it will direct all the engine noise to surrounding. This is stressful for surrounding people and driver itself. The Automobile muffler has to pass the exhaust gas to outside while restricting sound. As restricting sound muffler also restrict some amount of gas which create some backpressure. As there is high backpressure it decreases engine performance at higher RPM.

So our motive is for sport bike when it is on highway or race track there should be high engine performance and loud noise. And when it is in crowded area there should be low engine noise as it will follow noise regulation.

For such functionality we are making some arrangement or modification in an exhaust system. As exhaust gases passes firstly through exhaust manifold after that there is catalytic convertor which convert harmful gases like carbon monoxide and hydrocarbon to carbon dioxide and water, after that we are creating two opening one goes to normal muffler and one goes

to butterfly valve. When exhaust gas goes to muffler it will reduce noise and when exhaust gas goes to butterfly valve it will create loud noise. As butterfly valve is operated by remote switch there are two condition, first is when butterfly valve is open at 90 degree exhaust gas goes through it which create loud noise, and second when butterfly valve is closed exhaust gases will directed towards muffler which create low noise. By this rider can choose whenever he wants loud noise or low noise with option of button switch. As reviewing multiple research paper papers and online videos on muffler and exhaust we come to a conclusion that system like this is only implemented on four wheeler, and now we are implementing this system on two wheeler.

### 2. MAIN COMPONENTS OF EXHAUST SYSTEM

An exhaust system is usually piping used to guide exhaust gases coming from combustion chamber and supplied it to atmosphere. Exhaust gases while passing from system goes through various components such as manifold, catalytic converter, muffler and primary pipes. It is very most important part of vehicle which may affects factors like noise, pollutants gases etc. Figure shows the exhaust system and components of exhaust system.

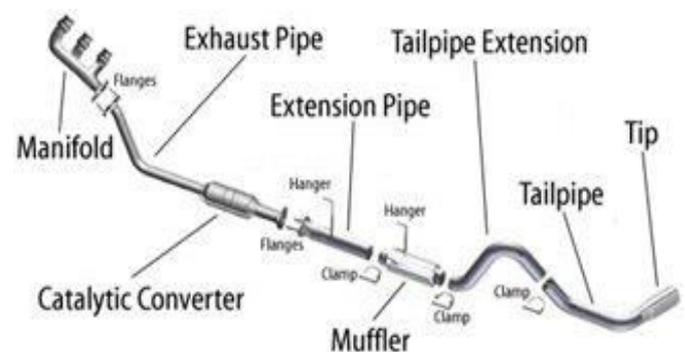


Fig 1:- Exhaust system

**2.1 Manifold:**

The function of an exhaust system manifold is to collect the exhaust gases from multiple cylinders and supply it to catalytic converter through pipe. Exhaust manifolds are generally simple cast iron or stainless steel units which collect engine exhaust gas from multiple cylinders and deliver it to the exhaust pipe.

Mostly stainless steel is used for manifold as it may not affect with temperature and should not easily worn out.



**Fig 2:-** Exhaust manifold

**2.2 Primary Pipes:**

Pipes used for passing the exhaust gases. It collects the gases from manifold and forwards it to catalytic converter and other components like muffler and then to atmosphere.

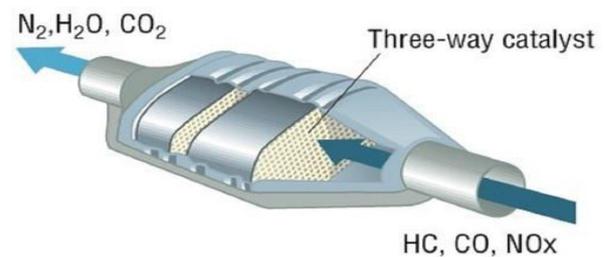


**Fig 3:-** Primary piping

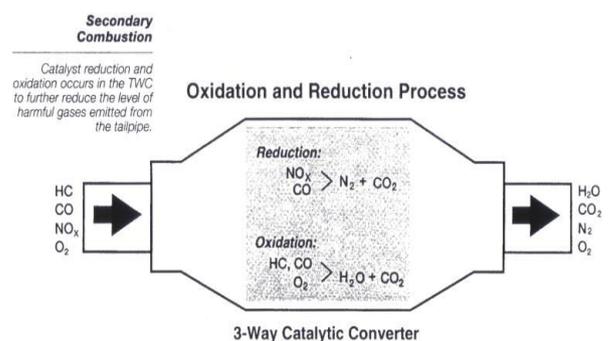
Pipes are used of stainless steel because it will not affect the increasing temperature of exhaust gases and will give long life service.

**2.3 Catalytic Converter:**

A catalytic converter is an exhaust emission control device that converts toxic harmful gases formed due to combustion and pollutants in exhaust gas from combustion engine into less-toxic and harmless pollutants by chemical reaction performed by catalyst usually like platinum, palladium and rhodium. Harmful gases coming from combustion chamber are- Hydrocarbon- It forms due to unburnt gasoline. Carbon Monoxide- Forms due to Combustion of gasoline. Nitrogen oxide- Form when nitrogen in air mix with oxygen.



**Fig 4:-** Catalytic converter



**Fig 5:-** Catalytic converter

**2.4 Muffler:**

The last and one of the most important function of vehicle is of muffler. It is necessary because the gas coming from the combustion in the pistons of the engine would generate an extremely loud noise which affects the environment and rider also. Inside

a muffler are a set of tubes. These tubes are perforated [ small holes are provided on it] and are designed to reflect sound waves produced by the engine to minimize the noise of engine and also work to remove exhaust gases from the engine to atmosphere.

The muffler helps reduce the amount of noise produced by your engine as well as also controlling the backpressure of the engine, which improves the endurance and performance of your vehicle engine. There are two types of muffler they are absorptive and reactive muffler.

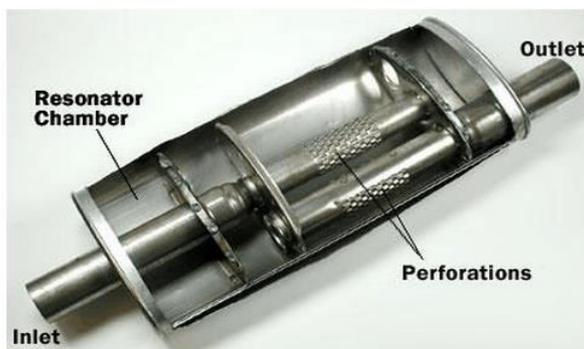


Fig 6:- Muffler

### 3. TYPES OF MUFFLER

When designing a muffler for making it silent its length should be as maximum as possible.

There are two basically two types of muffler

- A. Reactive type muffler
- B. Absorptive type muffler

#### 3.1 Reactive or Reflective muffler

Reactive type muffler works on the concept of reflective, as the waves passing through the perforated tubes of muffler they reflects.

When multiple sound wave stream flows through muffler with multiple chambers and small pipes they collide with each other in perforated tubes and as they collides there frequencies starts to decrease and sound level minimized.

Due to more reflection and collision of sound waves problem of backpressure arises in muffler. Below figure shows the reactive muffler having perforated tubes inside it. There are two chambers one having one

perforated tube and other one having two perforated tubes, which decreases the sound level partially.

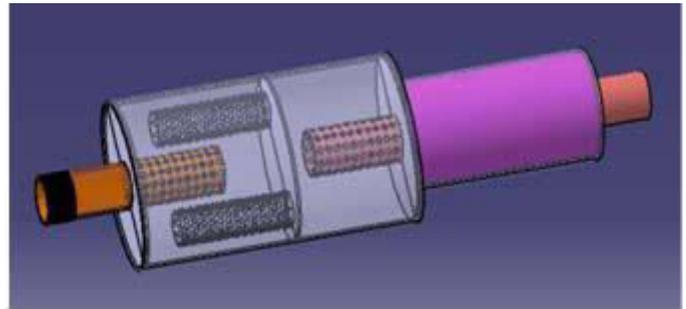


Fig 7:- Reactive muffler

#### 3.2 An Absorptive or Dissipative Muffler

Absorptive type muffler works on the concept of absorbing sound energy with use of glass wool like material around muffler pipe. As this muffler not eliminating more sound energy, noise reduction is less when using absorptive type muffler, but performance of the vehicle is more as exhaust gas are goes straight outside.

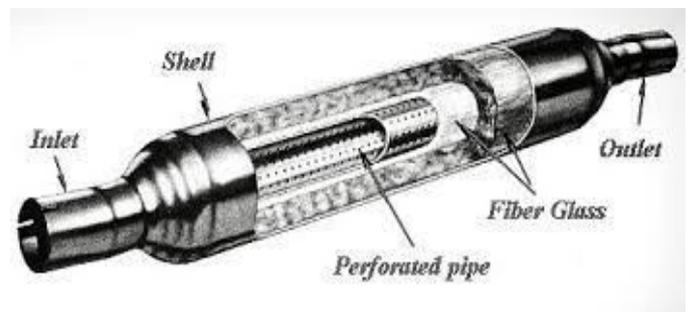


Fig 8:- Absorptive muffler

Figure 8 shows the abs

#### 3.3 Modified muffler

As making muffler for a sport bike it should give best performance for engine. For this we designed muffler which is combination of both reactive type muffler and absorptive type muffler. In modified muffler the disadvantages of both muffler are overcomes and gives the better working performance. In this muffler we are designing three chambers with different size and where there are three baffle pipes in which one pipe with enclosed in glass wool is placed. While running on low RPM we will get adequate backpressure resulting increase in velocity and therefore gases will quickly exhausted hence performance of muffler and engine increases.

## 4. FACTOR AFFECTING EXHAUST SYSTEM

### 4.1 Transmission loss

Transmission loss is defined as difference between power incident on duct acoustic devices (muffler) and transmitted downstream into an anechoic termination. Transmission loss is independent of the source and presumes an anechoic termination at downstream end. Transmission loss does not involve the source impedance and the radiation impedance inasmuch as it represents the difference between incident acoustic energy and that transmitted into an anechoic environment. Being made independent of the terminations, TL finds favor with researchers who are sometimes interested in finding the acoustic transmission behavior of an element or a set of elements in isolation of the terminations. But measurement of the incident wave in a standing wave acoustic field requires uses of impedance tube technology, may be quite laborious, unless one makes use of the two-microphone method with modern instrumentation. Transmission loss is a characteristic parameter which shows the performance of muffler. Selection of suitable muffler is based on transmission loss because transmission loss does not depend on the source of noise. Graph is plotted for frequency verses transmission loss. Transmission loss is vary w.r.t. change in geometry parameters such as number of holes, diameter of pipe, number of pipes.

### 4.2 Backpressure

Backpressure of an automotive four stroke engine has negative effect on engine efficiency resulting increased in power output. Backpressure is nonstandard term used to describe resistance or opposing flow of fluid. Back pressure is a nonstandard term used to describe resistance or force opposing the desired flow of fluid through pipes.

In a two-stroke engine however, the situation is more complicated due to the need to prevent unburned fuel/air mixture from passing right through the cylinders into the exhaust. During the exhaust phase of the cycle. Backpressure is even more undesirable than in a four-stroke engine due to the shorter time available for exhaust and the lack of pumping action from the piston to force the exhaust out of the cylinder.

However, since the exhaust port necessarily remains open for a time after scavenging is completed, unburned mixture can follow the exhaust out of the cylinder, wasting fuel and increasing pollution, and this can only be prevented if the pressure at the exhaust port is greater than that in the cylinder.

Considering how widely it is established among engine designers, we will use the term *back pressure* as defined above, to denote the exhaust pressure at the turbo (or exhaust manifold) outlet, which is numerically equal to the exhaust gas pressure drop over the entire exhaust system. However, we feel that the usage of this term should not be extended to denote the exhaust gas *pressure drop* over particular exhaust system components, as occasionally used by some authors. For instance, we avoid using the term “muffler back pressure” in favor of “muffler pressure drop” (or “pressure loss”), in accordance with the terminology used in fluid dynamics.

Backpressure represents the extra static pressure exerted by the muffler on the engine through the restriction in flow of exhaust gasses. Generally the better a muffler is at attenuating sound the more backpressure is generated. In a reactive muffler where good attenuation is achieved the exhaust gasses are forced to pass through numerous geometry changes and a fair amount of backpressure may be generated, which reduces the power output of the engine. Backpressure should be kept to a minimum to avoid power losses especially for performance vehicles where performance is paramount. Every time the exhaust gasses are forced to change direction additional backpressure is created. Therefore to limit backpressure geometric changes are to be kept to a minimum, a typical example of this is a “straight through” absorption silencer. Exhaust gasses are allowed to pass virtually unimpeded through the straight perforated pipe.

### 4.3 Effect of Increased Back Pressure

As backpressure increases velocity of flow of gas also increase to a certain limit. When backpressure will increased at higher rate it will start to block flow of exhaust gas which also reduce engine performance as exhaust gas cannot flow. So we have to create adequate backpressure at our muffler so that exhaust gas velocity will increase and performance of vehicle at low rpm will be good.

#### IV. Engine Noise

Pulses which are generated from the exhaust gases leads to cause of engine noise. When the expansion stroke of the engine comes near the end, the outlet valve tends to open and the remaining pressure from the cylinder discharges exhaust gases. These pulses of range between 0.1 and 0.4 atmospheres in amplitude as well as having pulse duration between 2 and 5 milliseconds. The frequency spectrum is related directly with the pulse duration. The cut-off frequency having range between 200 and 500 Hz. In general, engines make noise of 100 to 130 dB depending on the size as well as the type of the engine.

#### 5. MUFFLER DESIGN

An exhaust muffler should satisfy some basic requirements like adequate insertion loss, low backpressure. As we know muffler sizing could affect the cost of overall exhaust system. Muffler should have high durability to withstand with rough use and extremely high temperature. For requirement like this some design consideration should be taken.

1. Muffler which have extended tubes with perforated holes are better than simple chambers.
2. The greater the number of chambers greater will be insertion loss.
3. If area of chamber is large insertion loss will increase.

##### 5.1 Design calculation of muffler

A muffler have been designed, which is of supercritical grade type of making the muffler calculations have to use the exhaust muffler grades shown in the Table 1.

Table 1:Exhaust muffler grades[2]

Muffler grades	Insertion loss	Body/Pi pe	Length/Pi pe
Industrial/commercial	15 to 25 dB	2 to 2.5	5 to 6.5
Residential grades	20 to 30 dB	2 to 2.5	6 to 10
Critical grades	25 to 35 dB	3	8 to 10
Supercritical grade	35 to 45 dB	3	10 to 16

#### 5.2 Input parameters

- Max. Engine speed (N) = 8500 RPM
- No. of cylinders (n) = 1
- Inlet pipe diameter (d) = 26 mm
- Maximum temperature at inlet of muffler = 350°C

#### 5.3 Chamber design

Chamber length and diameter: according to ASHRAE Technical committee 2.6, design muffler grades and their dimensions, the requirement matches with the super critical grade.

Length of muffler chamber is  $L = 10 \cdot 0.026 \text{ m}$  to  $16 \cdot 0.026 \text{ m}$ ,  $L = 0.26 \text{ m}$  to  $0.416 \text{ m}$

Chamber diameter is  $D1 = 3 \cdot d = 3 \cdot 0.026 \text{ m} = 0.078 \text{ m}$

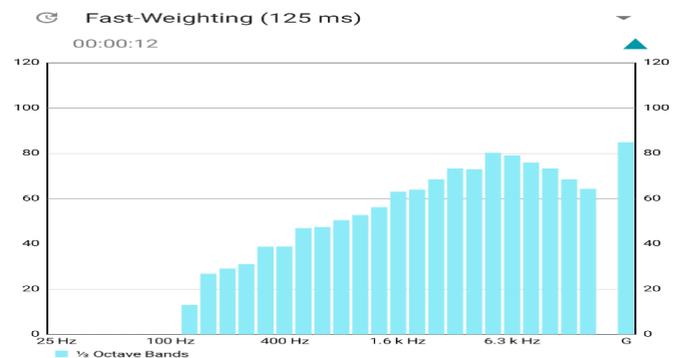


Fig 9:- Sound VS frequency

Experimental peak low level frequencies are found from the above Figure are 125 Hz, 200 Hz, 250 Hz, 300 Hz, 370 Hz, 470 Hz , 590 Hz, 730Hz and 850 Hz.

#### 5.4 Resonance method

Where  $\lambda$  is the wavelength of sound (m). And  $n = 1, 3, 5, \dots$  (Odd integers). But for economical consideration we take  $n = 1$ . And the reference value of speed of sound Vs is taken as 330 m/s. The length miscalculated for frequencies 590 Hz, 730 Hz and 850 Hz (other frequencies are either very short or very long chamber length) so that the length of the chamber method is satisfied. The wavelength  $\lambda$  is calculated for different frequencies.

Maximum attenuation occurs when  $L = n\lambda/4 \dots (1)$

Table 2: Wavelength  $\lambda$  is calculated

Wavelength	Sound velocity(vs)	Frequency (Hz)	Vs/f
$\lambda_1$	330	590	0.560m
$\lambda_2$	330	730	0.452m
$\lambda_3$	330	850	0.388m

Table 3: Calculated length of chambers

Chamber wave length	$\lambda/4, \lambda/4, 3\lambda/4$	Length of chamber
$\lambda_a$	0.560/4	0.140
$\lambda_b$	0.452/4	0.113
$\lambda_c$	0.388/4	0.097

We choose the length of chambers are 0.140 m for I chamber and II & III Chamber are 0.113 & 0.097 m Total length of chambers is taken as  $\lambda_a + \lambda_b + \lambda_c = 0.140 + 0.113 + 0.097 = 0.350$  m

**5.5 Dimensions of chamber**

Diameter of chamber D1 = 78 mm Total  
 Length of chamber Lc = 350 mm  
 Length of I chamber = 140 mm  
 Length of II chamber = 113 mm  
 Length of III chamber = 97 mm  
 Diameter of perforated holes:  
 $d = 1.29 \sqrt{N} = 3$  mm

**5.6 Baffle pipes design**

Diameter of pipes inside the baffles are so that the cross section area doesn't reduce. So the Area of inlet pipe = Total area of baffle pipe, 2 pipes for the baffle are considered. So the diameter d2 is calculated as:  
 $d_2 = [\pi/4 * d_2^2 = 2 * (\pi/4 * d_1^2)] \dots (3)$  Design

**5.7 Dimensions of muffler**

Reactive muffler has been designed in SOLID WORKS using the above data in Table 4.

Table 4: Dimensional data

Sr.no	Description	Dimension(mm)
1	Shell length and diameter	350 and 78
2	Inlet pipe length and	100 and 26

	diameter	
3	Outlet pipe length and diameter	100 and 26
4	Perforated pipe diameter	26
5	Perforated hole diameter	3
6	Shell thickness	1

**6. MODIFIED SYSTEM**

**6.1 Butterfly Valve-**

It is also known as bypass valve which are used to control the flow. It is quarter turn rotary motion valve which open and closed in certain angle. It works between 0 to 90 degree. It consist of circular disc pivoted at axis at right angle in close element. Mostly it is made of stainless steel, aluminum or cast iron. When it opens it allow full passage of flow and when it starts closing it offers restriction to flow. Combined with velocity that tend to produce this scavenging effect.

You may have noticed that turbo charged engines tend to have larger exhaust pipes. Because the turbo is in the exhaust stream, the gas flow spinning the impeller tends to come out of the turbo with pulses greatly diminished, which tend to negate the scavenging effect. So turbo charged cars typically have larger pipes to accommodate gas volume — leaving the turbo to perform the task of scavenging the spent exhaust gases.



Fig 10:- Butterfly valve

## 6.2 Exhaust Bypass

In modified cars mostly exhaust bypass cutout valve is used. it is used for increasing performance as exhaust gas will pass quickly without muffler and sometimes used to increase noise of the vehicle for sporty experience. exhaust bypass is made by creating a hole in exhaust pipe In between muffler and catalytic convertor. When hole is created extending that hole with a pipe and attaching butterfly valve exhaust bypass is created.

## 6.3 How do Automobile Manufacturers Control the Bypass Valves

Exhaust bypass valves can be manually actuated, electrically actuated or vacuum actuated. It has been more common in high end cars to utilize vacuum actuation, although many are moving to electrically actuated valves.

When controlling it by electrically there is use of electrically operated butterfly valve which is connected to port in the car. And It is operated by remote switch.

## 7. EXHAUST BYPASS CONTROLLER DESIGN CONSIDERATION.

The Controller Kit consists of two key components:

1. Control unit and remote transmitter
2. Connector cables

### 7.1 Key considerations went into the design:

- The kit must be plug-and-play. Design requires no wiring modifications, no splicing of wires and no drilling of holes.
- Everything has to resist high temperatures. Nothing is going withstand direct contact with the hot exhaust pipes or catalytic converters, but temperatures may easily exceed 100° C in the engine bay. The control box is aluminum and exposed wiring is manufactured using with heat tolerant wiring that is both oil and water resistant.

- The electrical circuits must minimize any risk of causing electrical failures. By performing any switching on the ground side of the vehicle's electrical connections, this satisfies that requirement. All relays on the PCB use diode protection which reduces risks of reverse EMF back through the vehicle wiring.

- Most exhaust bypass valves default to open when vehicle ignition is off and no vacuum is available. Some exhaust bypass valves are the opposite. The controller module can be configured for either situation.

- The electrical cables use weatherproof connectors.

## 8. EXPECTED RESULTS:-

As our systems main focus is on noise of exhaust gases, when this exhaust system will made it will satisfy following conditions

1. As sport bikes customer demand loud noise for sport bike that can be achieved.
2. As our system can reduce noise by remote control rider can go silently in crowded area.

## ACKNOWLEDGMENT

Every orientation work has imprint of many people and this work is no different. This work gives me an opportunity to express deep gratitude for the same. While preparing project we received endless help from number of people. This report would be incomplete if we dont convey our sincere thanks to all those who were involved. Finally, we wish to thank my friends and my family for being supportive, without whom this project would not have seen the light of day. Every work is an outcome of full-proof planning, continuous hard work and Organized effort. This work is a combination of all the three put together sincerely.

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