DESIGN AND FABRICATION OF A MUFFLER FOR AUTOMOBILE EXHAUST SYSTEM

Jaya Prakash Swain and A K Raghav
Amity School of Engineering & Technology
Amity University Haryana, Gurgaon, India

Abstract : Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. The majority of the sound pressure produced by the engine is emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages. And chambers lined with roving fibre glass insulation and/or resonating chambers harmonically tuned to cause destructive interference where in opposite sound waves cancel each other out. An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. This is because the engine exhaust must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate.

Index Terms - Design, Auto CAD, CATIA, Engine, Exhaust Muffler etc.

I. INTRODUCTION

Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic sound proofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting.

For the majority of such systems, however, the general rule of "more power, more noise" applies. Several such exhaust systems that utilize various designs and construction methods:

Vector muffler - for larger diesel trucks, uses many concentric cones, or for performance automotive applications, using angled baffles to cause exhaust impulses to cancel each other out.

Spiral baffle muffler - for regular cars, uses a spiral-shaped baffle system.

Aero turbine muffler - creates partial vacuums at carefully spaced out time intervals to create negative back pressure, effectively 'sucking' the exhaust out of the combustion cylinder.

II. WORKING OF EXHAUST MUFFLER

Engine generates lots of pulsating noise as its exhaust valves open up to release highly pressurized gas. These thousands of little sound bursts per minute travel quickly down the exhaust pipe, and the noise bounces around to add up into a loud and potentially very annoying sound. The key, then, is to find a way to minimize this sound level before it exits the exhaust system.

[1] ENGINE NOISE

Mufflers are mounted in line with your exhaust pipes, typically towards the very end before the exhaust tips. They feature a series of perforated tubes or baffled chambers which are designed to tune and minimize your engine's sound output. As noise comes into the muffler, the sound waves bounce around against the baffles, creating opposing sound waves that cancel each other out. And much like an acoustical engineer designing an instrument or a concert hall, muffler manufacturers know how to "tune" the baffles and chambers to create a desired sonic effect. So whether you want to cut as much sound as possible or get a focused sound with an amplified growl range, there's a performance muffler out there for you.

[2] BACK PRESSURE

Engine exhaust *back pressure* is 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. For this discussion, the exhaust back pressure is the gage pressure in the exhaust system at the outlet of the exhaust turbine in turbocharged engines or the pressure at the outlet of the exhaust manifold in naturally aspirated engines.

[3] BACK PRESSURE LIMITS

All engines have a maximum allowable engine back pressure specified by the engine manufacturer. Operating the engine at excessive back pressure might invalidate the engine warranty. To facilitate retrofitting of existing engines with DPFs, especially using passive filter systems, emission control manufacturers and engine users have been requesting that engine manufacturers increase the maximum allowed back pressure limits on their engines.

Maximum Recommended Exhaust Back Pressure.

Engine Size	Back Pressure Limit
Less than 50 hp	40 kPa
50-500 hp	20 kPa
500 hp and above	10 kPa

Engine manufacturers are usually much more conservative on their back pressure limits. For example, diesel generator set engines from Caterpillar, Cummins, John Deere and DDC/MTU.

[4] EFFECT OF INCREASED BACK PRESSURE

At increased back pressure levels, the engine has to compress the exhaust gases to a higher pressure which involves additional mechanical work and/or less energy extracted by the exhaust turbine which can affect intake manifold boost pressure. This can lead to an increase in fuel consumption, PM and CO emissions and exhaust temperature. Increased backpressure may affect the performance of the turbocharger, causing changes in the air-to-fuel ratio-usually enrichment— which may be a source of emissions and engine performance problems. The magnitude of the effect depends on the type of the charge air systems. Increased exhaust pressure may also prevent some exhaust gases from leaving the cylinder (especially in naturally aspirated engines), creating an internal exhaust gas recirculation (EGR) responsible for some NOx reduction. Slight NOx reductions reported with some DPF system, usually limited to 2-3% percent, are possibly explained by this effect. Excessive exhaust pressures can increase the likelihood of failure of turbocharger seals, resulting in oil leak agent the exhaust system. In systems with catalytic DPFs or other catalysts, such oil leak can also result in the catalyst deactivation by phosphorus and/or other catalyst poisons present in the oil. All engines have a maximum allowable engine back pressure specified by the engine manufacturer. Operating the engine at excessive backpressure might invalidate the engine warranty. It is generally accepted by automotive engineers that for every inch of Hg of backpressure (that's Mercury – inches of Hg is a unit for measuring pressure) approximately 1-2 HP is lost depending on the displacement and efficiency of the engine, the combustion chamber design etc.

III. MUFFER SELECTION

In order to select a suitable muffler type, some basic information are necessary regarding how industrial mufflers work. Industrial mufflers, (and mufflers in general), attenuate noise by two fundamentally different methods. The first method, called reactive attenuation - reflects the sound energy back towards the noise source. The second method, absorptive attenuation - absorbs sound by converting sound energy into small amounts of heat. There are three basic industrial muffler types that use these methods to attenuate facility noise - reactive silencers, absorptive silencers and anyone or both of them combined with resonator.

The proper selection of a muffler is performed by matching the attenuation characteristics of the muffler to the noise characteristics of the source, while still achieving the allowable muffler power consumption caused by muffler pressure drop. Fortunately, industrial noise sources separate primarily into three different categories with specific characteristics.

The first category covers sources that produce mainly low-frequency noise, yet can typically tolerate relatively high-pressure drops. Engines, rotary positive blowers, reciprocating compressors, and rotary screw compressors are types of these sources. It is simply the nature of these machines to produce low-frequency noise and have pressure-volume relationships that are quite tolerant of system pressure drop. These machines are perfectly suited for reactive (chambered) silencers.

The second category of noise sources are those that produce mainly high-frequency noise and have performance that is very sensitive to system pressure losses. These sources are almost always moving or compressing a fluid with spinning blades. Examples include centrifugal fans, compressors, and turbines. By definition, this type of equipment is best treated with absorptive silencers for both low and higher temperature applications.

Resonators can be used to remove tones from the exhaust spectrum.

There are two major industrial facility applications that fall outside these categories, and are best silenced with specific combination reactive-absorptive mufflers. These sources are high-speed rotary positive blowers and high-pressure vents. Both sources have substantial high and low frequency noise content, and can tolerate moderate pressure drop. As a general rule, reciprocating or positive displacement machines should be attenuated with reactive silencers, and centrifugal equipment should use absorptive silencers. For all remaining major noise sources, combined reactive-absorptive silencers are appropriate with many designs available to choose from.

IV. DESIGN AND FABRICATION OF PARTS

A muffler have been designed which is of supercritical grade type and includes all the three attenuation principles i.e., reactive, followed by absorptive type muffler, and a side branch resonator. The interesting events of the design are continuous volume reduction of chambers in the reactive part, the flow pipe cross-sectional area is maintained constant throughout, a layer of insulation outside the reactive part, the placing of side branch resonator compactly, option for tuning the resonator using a screw and cylinder.

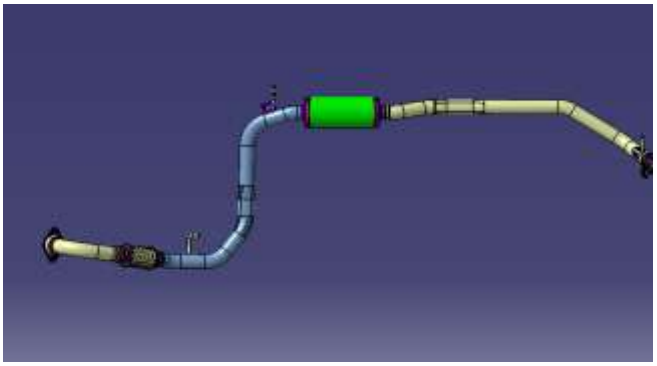

Figure 1 Pipe B Assembly

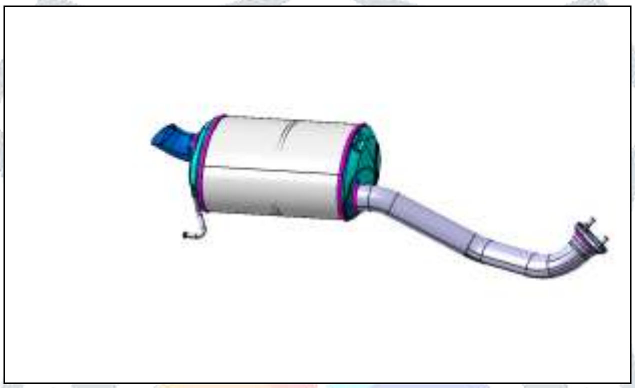

Figure 2 Muffler Assembly

Figure 3 Sub assy pipe B

Figure 4 Chamber EXH

Figure 5 Tail pipe

Figure 6 Shell

V. CONCLUSION

From the above discussions, the following conclusions can be drawn:

[5] The muffler is capable of attenuating noise by about25 to 35 dBA.
[6] The muffler is designed to attenuate both high and low frequency noises.
[7] There is a side branch resonator, which attenuates residual low frequency noise.
[8] There is an option of tuning the resonator, which makes the muffler flexible to use with different engines.
[9] The conventional design of side branch resonator construction involves the resonator connected perpendicularly to the tail pipe, but in the present design, the resonator is parallel to the main body of the muffler. This makes the muffler usable with engines having limited space

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