

Stixs here is some reading to go with the Back yard hacker babble gobble goo.

An **Expansion chamber** is an exhaust system **Exhaust system**  
used on a two-stroke cycle **Two-stroke cycle**  
engine to enhance its power **Power (physics)**  
output by improving its volumetric efficiency **Volumetric efficiency**

. It makes use of the energy left in the burnt exhaust exiting the cylinder to aid the filling of the cylinder for the next cycle. It is the two-stroke equivalent of the tuned pipes (or headers) used on four-stroke cycle engines.

## How it works

The high pressure **Pressure**  
gas exiting the cylinder initially flows in the form of a "wave" **Wave**  
front" as all disturbances in fluids do. The exhaust gas pushes its way into the pipe which is already occupied by gas from previous cycles, pushing that gas ahead and causing a wave front. Once the gas flow itself stops, the wave continues on by passing the energy to the next gas down stream and so on to the end of the pipe. If this wave encounters any change in cross section **Cross section (geometry)**

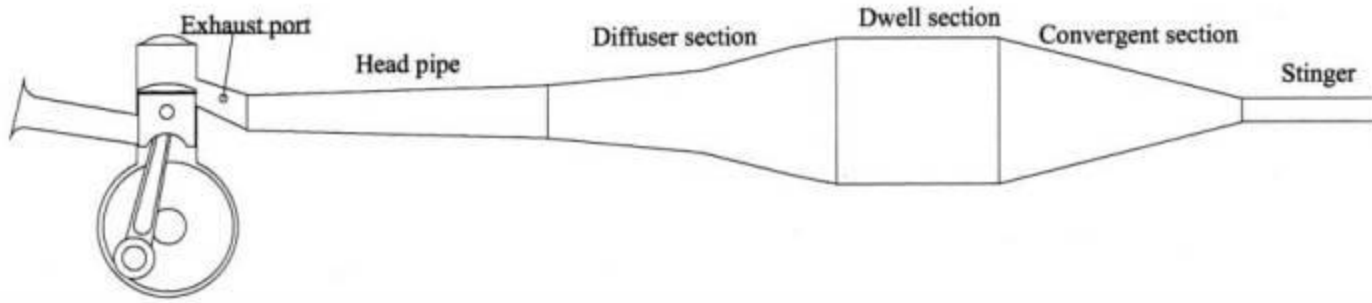
or temperature

**Temperature**

it will reflect a portion of its strength in the opposite direction to its travel. For example a high pressure wave encountering an increase in area will reflect back a low pressure wave in the opposite direction. A high pressure wave encountering a decrease in area will reflect back a high pressure wave in the opposite direction. The basic principle is described in wave dynamics **Cylinder**

**head porting**

. An expansion chamber makes use of this phenomenon by varying its diameter (cross section) and length to cause these reflections to arrive back at the cylinder at the desired times in the cycle.



There are three main parts to the expansion cycle.

## #1 Blowdown

When the descending piston Piston

first exposes the exhaust port on the cylinder wall, the exhaust flows out powerfully due to its own pressure without assistance from the expansion chamber and so the diameter/area over the length of the first portion of the pipe is constant or near constant with a divergence of 0 to 2 degrees which preserves wave energy. This section of the system is called the "head pipe" (the exhaust port length is considered part of the head pipe for measurement purposes). By keeping the head pipe diameter near constant, the energy in the wave is preserved because there is no expansion until needed later in the cycle. In any case the flow leaving the cylinder during most of the blowdown process is sonic or supersonic and therefore no wave could travel back into the cylinder against that flow.

## #2 Transfer

Once the exhaust pressure has fallen to near atmospheric level the **piston uncovers the transfer ports**. At this point **energy from the expansion chamber** can be used to aid the flow of fresh mixture into the cylinder. To do this the expansion chamber is increased in diameter so that the out going high pressure wave reflects a negative pressure wave back toward the cylinder. This negative pressure arrives in the cylinder during the transfer cycle and greatly increases the flow of fresh mixture into the cylinder and can even suck fresh mixture out into the headpipe. This part of the pipe is called the divergent (or diffuser) section and it diverges at 6 to 12 degrees. It may be made up of more than one diverging cone depending on requirements.

## #3 Port blocking

When the transfer is complete the **piston is on the way back up** on its compression stroke **but the exhaust port is still open**, an unavoidable problem with the two stroke design. To help prevent the piston pushing fresh mixture out the open exhaust port a strong high pressure wave from the expansion chamber is timed to arrive during the compression stroke. **The port blocking wave** is created by reducing the diameter of the chamber. This is called the convergent section (a.k.a baffle cone or section). The outgoing high pressure wave hits the narrowing convergent section and **reflects back a high pressure wave to the cylinder which arrives in time to block the port during the compression stroke and can push back into the cylinder any fresh mixture drawn out into the head pipe**. The convergent section is made to converge at 8 to 90 degrees depending on requirements.

**Combined with the high pressure wave there is a general rise in pressure in the chamber caused by deliberately restricting the outlet with a small tube called the stinger.** The stinger restricts flow out of the chamber to cause higher pressure during the compression cycle and empties the chamber during the compression/power stroke to ready it for the next cycle. The stingers length and inside diameter are selected to match the engines requirements. (The inside diameter has the greatest effect and so is the most sensitive of the two.)

## Complicating Factors

The detailed operation of expansion chambers in practice is not as straightforward as the fundamental process described above. Waves traveling back up the pipe encounter the divergent section in reverse and reflect a portion of their energy back out.

Temperature variations in different parts of the pipe cause reflections and changes in the local speed of sound **Speed of sound**

. Sometimes these secondary wave reflections can inhibit the desired goal of more power.

It is useful to keep in mind that although the waves traverse the entire expansion chamber over each cycle, the actual gases

leaving the cylinder during a particular cycle do not. **Note on EGT: The gas flows and stops intermittently and the wave continues on to the end of the pipe. The hot gases leaving the port form a "slug" which fills the header pipe and remains there for the duration of that cycle. This causes a high temperature zone in the head pipe which is always filled with the most recent and hottest gas.**

Because this area is hotter, the speed of sound and thus the speed of the waves that travel through it are increased. During the next cycle that slug of gas will be pushed down the pipe by the next slug to occupy the next zone and so on. The volume this "slug" occupies constantly varies according to throttle position and engine speed. It is only the wave energy itself that traverses the whole pipe during a single cycle. The actual gas leaving the pipe during a particular cycle was created two or three cycles earlier.

Expansion chambers almost always have turns and curves built into them to accommodate their fit within the engine bay. Gases and waves do not behave in the same way when encountering turns. Waves travel by reflecting and spherical radiation. Turns causes a loss in the sharpness of the wave forms and therefore must be kept to a minimum to avoid unpredictable losses.

Calculations used to design expansion chambers take into account only the primary wave actions. This is usually fairly close but errors can occur due to these complicating factors.

## Summary

**All these events need to be synchronized with the engine port timings and speed.** An expansion chamber "tuned" for 8,000 rpm will not deliver the proper wave timings at 4,000 or 11,000 rpm. In fact it is **likely to incur a power loss outside its "tuned" range.**

The length of the pipe determines at what time the waves arrive back at the cylinder. Longer pipes require more time for the waves to traverse and so will be tuned to a lower rpm than a shorter pipe. The shorter the pipe the higher the rpm it is tuned to.

The rate of convergence/divergence of the cones determines the duration of the wave returned. A gentle taper give a long duration but weaker return wave while a steeper taper gives a short but strong return wave. The longer the wave, the broader the

RPM range at which it is useful. This extra power band **Power band**

width is at the sacrifice of peak torque.

The diameter of the center or dwell section determines the ratio of scavenging suction to port blocking pressure as well as the over all energy recovery. The resulting volume determines the maximum pressure rise with large volumes giving less pressure rise. The fatter the pipe the harder it sucks but the weaker the blocking pressure. Thinner pipes will scavenge less but block the port very strongly. **The optimum diameter is related to compression ratio**, the quality of the transfer port layout and its scavenging efficiency.

A variety of devices are used to try to extend the tuned range of the expansion chamber. Pipes that slide like a

trombone **Trombone**

adjust the timing to match the rpm changes of the running engine. Devices that control the exhaust port timing to vary blowdown duration as well as extending the tuned range of the expansion chamber. Valves that open at certain speeds to absorb or dump waves arriving at undesirable times.

Another approach to altering the tuned RPM of an expansion chamber is to alter the speed of the pressure waves inside the exhaust pipe. The speed at which pressure waves travel is greatly affected by temperature: higher temperature means faster wave speed. As a result, expansion chambers can be retuned for higher-than-design RPM resonance, by increasing the average

temperature of the exhaust gases inside the pipe. Techniques to achieve this increase in gas temperature can include: insulating the pipe (thermal wrap), restricting flow from the pipe (smaller stinger diameter), or by retarding the ignition timing at the correct RPM (a later burn allows more heat to escape into the pipe).

Conversely, a pipe can be retuned to work at a lower-than-design RPM range by reducing the temperature of the exhaust gases. Injecting water or a water-alcohol mix into the headpipe of an expansion chamber can reduce temperatures significantly, enough to lower the tuned RPM of an exhaust system by as much as 1500- 2000 RPM. The heat absorbed as the liquid changes into a gas is responsible for the drop in temperature. As a result, the two stroke exhaust can be tuned to stay "on the pipe" over a remarkably wide RPM range, if the designer takes advantage of all the tools available.