A Study of Engine Exhaust Pressure as an Alternative Usage

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Abstract
This study investigated the ability of engine exhaust pressure on a gasoline engine as an alternative usage. The investigation is based on the similar idea in turbocharges system development which exhaust gas drive a turbine to spins an air compressor that push extra air and oxygen into the cylinders. Alternative usage in this study means the exhaust pressure produce by using simple tools act as an emergency pump for under inflation tyre. Implementation of this study is to ease the emergency situation that rarely occurred or may occur, especially for motorist in urgent situation. It will help many drivers either to repair or buy any special tools in market. This study focused on the experimental method by refill the air in the tyre with exhaust gas and discussion on the results. The pressure produces by the backpressure need to achieve required pressure (140kPa to 220kPa) to pump under inflation tyre. However, the major problem is this exhaust pressure will be decrease after the gas flow through the catalytic converter and muffler. The parameters were measured during the engine operation: one is revolution per minutes (rpm) produce by the exhaust stroke engine and the other is pressure increase in under inflation tyre. As a result, exhaust pressure can be used as emergency case but more prefer to refill motorcycle tyre pressure or unloaded tyre for a car. It also acts as an optional to conventional pump for pressurize the under inflation tyre. This study can be continuing by increasing the number of data includes any size of vehicle and redesign a special tool to increase the exhaust pressure after the exhaust manifold.
Keywords: Engine backpressure, exhaust pressure, alternative usage

1.0 Introduction

Exhaust gas was produced from combustion chamber in an engine. It will produce carbon dioxide (CO_2) and water (H_2O). The rest of the exhaust would be the nitrogen (N_2) that came in with the air. The fuels we burn are made up of hundreds of differently structured hydrocarbons that burn in different ways and at different rates. In practice this means that your exhaust contains some that were partially burned, some that reacted with others and some that reacted with the nitrogen. The amount of carbon dioxide (CO_2) produced is directly related to fuel consumption which is why car manufacturers have done a lot to improve new car fuel economy and why car tax rates have been based on official CO_2 emissions figures. (Katsuyuki, Hiroko & Hirofumi, 2009).

The average pressure in the exhaust pipe during the exhaust stroke is called the mean exhaust pressure and the atmospheric pressure is called the ambient pressure. The difference between the both pressures is defined as backpressure (Katsuyuki et al., 2009). Engine exhaust backpressure also 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. This exhaust gas will cause emissions in the environment where some of them are harmful for human being. Exhaust systems including catalytic converter and muffler in gasoline engine that use to reduce the engine emissions (Domkundwar, 2000). Excessive backpressure in the exhaust system create excessive heat, lower engine power and fuel penalty in the engine cylinder that may cause damage of the engine parts and poor performance (Mohiuddin, Rashidin & Shukri, 2005).

Meanwhile, in the servicing work there are many tools used to make sure the safety and ability of the work done by the individuals. In addition, time is also one of the important factors in vehicle maintenance work especially in a minor service. For an example, inflation tyre need a big scale of pump to pressurized the tyre to its normal level. Thus the study is to evaluate the pressure produce by engine in the exhaust stroke and ability to refill the pressure in the under inflation tyre. Under inflation tyre will increase the weight of the vehicle. So it is proportional to the usage of fuel consumption and also will increase wear of the tyre itself. If the pressure achieves the required volume of pressure, it will reduce time and reliability to be used in an emergency case. But it is used for a temporary because carbon contains in exhaust gas are not suitable to be used in tyre. The main objective for this study is to evaluate exhaust pressure produce on a gasoline engine. If the pressure achieves the requirement of the tyre pressure, so it can be proved as alternative source of air pump in case of emergency. But it is limited to the several factors and parameters to the study.

An automotive exhaust system is designed to evacuate gases from the combustion chamber quickly and efficiently. Within the exhaust system, there is an inherit resistance the flow of the exhaust gases which is called as backpressure. It is defined as the resistance to positive flow of the exhaust system. With any modern engine, the inherent backpressure within the exhaust system consists of the exhaust manifold, the catalytic converter, the system muffler (silencer) and the connecting pipes. Automotive exhaust designers produce systems that balance exhaust flow capacity with velocity. The objective is to evacuate the exhaust gases as fast as possible. At lower engine RPM and lower exhaust gas volume, the velocity of the exiting gases is lower. If one could artificially impose a restrictor in the exhaust system that would increase the back pressure, the velocity of the exiting gases will increase and this will improve the evacuation of the gases from the engine. (Mohammad, Shazib & Murari, 2010). Figure 1 demonstrates the conventional 4-stroke cycle of an internal combustion engine (Valve event, 2006).

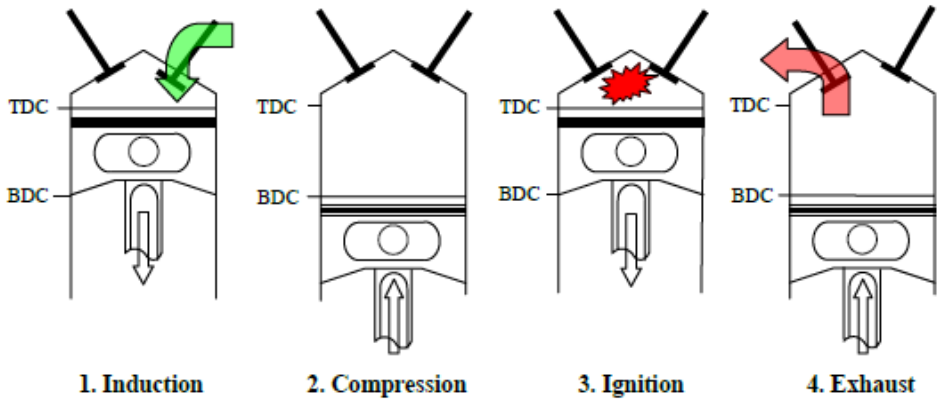

Figure 1: The illustration of the conventional 4-stroke cycle of an internal combustion engine

The diagrams above illustrate the conventional 4-stroke cycle of an internal combustion engine. Both the intake and exhaust valves remain closed during the compression and ignition phases of the cycle. The valve motion is controlled by a camshaft that rotates at half the speed of the crankshaft. During the four stroke cycle the crankshaft rotates twice, causing two piston cycles, whilst the camshaft rotates once, causing one cycle of each valve. The different speeds of the crankshaft and camshaft can be the cause of some confusion when describing the timing of valve opening and closing with angles, as 360° of crankshaft rotation is equivalent to 180° of camshaft rotation.

3.0 Experimental Setup and Measurement

This section will describe the experimental parameter that has been done to complete the study. There are three vehicles with four-stroke engine naturally aspirated gasoline engine was used in this experiment which are motorcycle, car with 850cc and car with 1500cc as described in Table 1, 2 and 3. There is multiset of variable used to find the result of experiment. The variable used to evaluate the effect of the exhaust pressure to the time and revolution per minute (rpm) of engine. The study will focus on the type of vehicle as input pressure or output pressure. The data shows the specification of engine by each type of vehicle used. The pressure of exhaust gas will be use as pneumatic pressure to refill under inflation tyre in an emergency case.

Table 1: Engine specifications for motorcycle 3. (Modenas GT128 Technical Specification, 2010)

Type	4-stroke, 1 cyl, SOHC
Bore X Stroke	53.0 x 59.1 mm
Displacement	130
Compression Ratio	10:1
Ignition System	DC-CDI
Fuel Tank Capacity	4.3 L

Table 2: Engine specification for car 850cc (Car A) (Specifications for Kancil 660 EX, 850 EX and 850 EZi, 2002)

Type	4-stroke, 3 cyl, SOHC
Bore X Stroke	66.6 x 81.0 mm
Displacement	847
Compression Ratio	9.5:1
Ignition System	Single carburettor
Fuel Tank Capacity	32 L

Table 3: Engine specification for a car 1500cc (Car B) (Toyota Vios 1.5G Specification, 2007)

Type	4-stroke, 4 cyl, SOHC
Bore X Stroke	75 x 84.7mm
Displacement	1497
Compression Ratio	10.5:1
Ignition System	Fuel injection
Fuel Tank Capacity	42 L

Figure 1 demonstrates the exhaust pressure is used to refill air pressure into inflate tyre.

Figure 1: Exhaust pressure is used to refill air pressure into inflation tyre

4.0 Experimental Results and Discussion

Evaluation of results produce after the engine reached the stabilized working condition for each test which are revolution per minute (rpm) engine, load and time taken to refill the pressure in the under inflation tyre. There are three major findings in this experiment. It is based on time comparison for pressure increase, output pressure on the different load and maximum pressure increase with different revolution per minutes (rpm) of engine. In this experiment Car B will be as source of the pressure to refill the under inflation tyre of motorcycle and Car A.

4.1 Time performance

This result is based on Car A, Car B and motorcycle. Exhaust pressure of Car B are used to pressurize the gas pressure to the motorcycle and Car A. The comparison has been made between times taken of conventional pump with air pressure pump from exhaust muffler. The result has shown that air pressure from exhaust muffler a bit lower than conventional pump. Maximum pressure produce is 160kPa in motorcycle and 110kPa in Car A compare to the conventional pump 200kPa after 30 seconds. There are a lot of time needs to refill the tyre pressure especially in Car A to achieve required normal tyre pressure as shown in Figure 2.

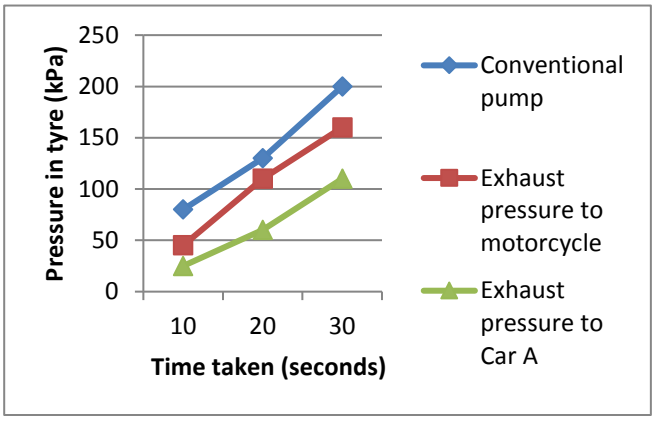

Figure 2: Graph pressure in tyre with time taken for both motorcycle and Car A

4.2 Maximum pressure

Maximum pressure needs to be measured to ensure either exhaust gas pressure can achieve requirement pressure as conventional pump. Although pressure of exhaust will be drop due to the unstable engine, throttle pedal will be used as constant input value to the pressure produced. The maximum pressure in tyre will measure by the constant value of revolution per minutes (rpm) engine. The graph has shown the effect to the maximum pressure in three constant input categories which is idle, normal and high revolution per minutes (rpm) engine. Maximum

pressure produce by the exhaust pressure is 200kPa for motorcycle and 140kPa for Car A at 6000 rpm. The required pressure in normal condition of tyre is 210kPa to 240 kPa due to the load of vehicle. In car A, maximum pressure cannot be achieved to the required pressure because the exhaust pressure will return back to the engine as the output pressure (pressure in tyre) increase. Meanwhile in motorcycle, the quantities of air (or gas in exhaust pressure) are low compared to the air in Car A tyre as shown in Figure 3.

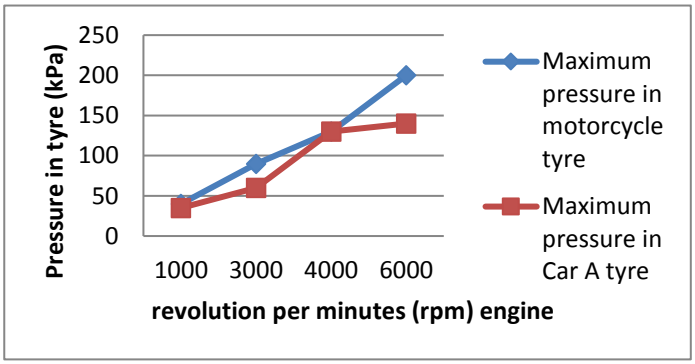

Figure 3: Graph pressure in tyre vs time taken for both motorcycle and Car A

4.3 Load effect to pressure

The other factors that will affect the pressure produced are load. This will affect the requirement of pressure to refill the air in tyre. In this experiment, load effect is based on weight of the vehicle itself. Maximum pressure to pressurize will be decrease as the load increase as shown in Figure 4. Different load will affect to each type of tyre either in motorcycle or Car A size.

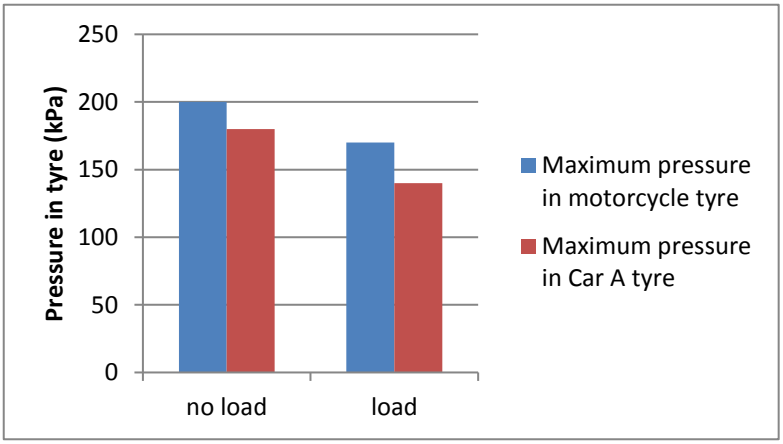

Figure 4: Graph pressure in tyre with load effect for both motorcycle and Car A

5.0 Conclusion

As a conclusion, the pressure from the exhaust can be used in the case of emergency. However, it is limited to be used in refilling the air pressure of motorcycle tyre or unloaded tyre for Car A. It can be used at least to increase ¾ of the required normal pressure. The limitation will be affected to be used for general condition. Thus, it is not the perfect replacement tools for pressurize the under inflation tyre like conventional pump because the exhaust pressure produced not fully achieved the requirement of the tyre pressure. The following conclusions can be drawn from the experimental investigation.

1. Exhaust pressure are not efficient as compared to conventional pressure pump in time taken to pressurize the air is nearly double lag especially if the pressure to be used as air pump for Car A. This is due to the time taken to refill the under inflation tyre.

2. However, the time taken can be considered to the ability of the exhaust pressure to refill the pressure in under inflation tyre. Maximum pressure produces are nearly to the required normal pressure in for motorcycle only. This will be considering as an option to be applying in emergency case. This exhaust pressure is not suitable to be used for car A.

3. The maximum exhaust pressure is affected with the load increase. In loaded case, the pressure produced in motorcycle tyre is maximum compare to pressure produced in Car A. For unloaded case, both maximum pressure produce can be considered as alternative used is for emergency case only.

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