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Two-Stroke engines is it environmentally friendly?

Most South Asian cities do not have good public transport systems and the two wheelers offer an affordable means of personal transportation for a large section of the population. Similarly, the three wheelers are an economical means of public transport for the common masses. In the South Asian context, where a large proportion of two and three wheeler users belongs to the middle and lower middle classes, overall cost of ownership is an important consideration.

Two types of prime movers have been traditionally used to power small two and Three Wheelers-2-stroke petrol engines and 4-stroke petrol engines. World over, the 2-stroke engine is the preferred prime mover due to the many advantages it offered. In fact 2-stroke engines power 70% of the world population of two wheelers. 2-Stroke engines offer many advantages for small vehicles. The most important among these are; simplicity of construction and fewer moving parts and higher power per unit weight due to lightness.

4-Stroke engines require valves and valve train mechanisms, such as camshaft, timing chain, etc. to control intake, combustion and exhaust processes. In a 2-stroke engine, fixed ports in the engine which are covered and uncovered by the piston, control these processes. The 4-stroke engine thus has many moving parts that undergo wear and tear and need frequent adjustments. The adjustments required by 2-stroke engines are fewer and simpler.

The operating cycle in a 2-stroke engine is completed in one revolution (or two strokes) compared to two revolutions (or four strokes) in a 4-stroke engine. The 2-stroke engine thus develops twice the amount of power for the same size resulting in a much lower weight than the 4-stroke engine. The simplicity of construction and fewer moving parts also help to reduce the weight. Lower weight results in a reduction in the dead weight of the vehicle, leading to reduced fuel consumption for the same payload. Due to these advantages, advanced fuel injected 2-stroke engines are now being considered as potential alternatives to the 4-stroke engine used in passenger cars to reduce fuel consumption and CO^2 emissions.

The important feature of fuel efficiency of 4-stroke engine is strongly matched by modern 2-stroke engines. Notably from a regional perspective, strong demand of the Indian two wheeler user for better and better fuel efficiency has spurred rapid technological advances in 2-stroke technology in recent years in India, has become the most fuel-efficient in the world. Moreover, technologies employed to achieve better fuel efficiency have also led to a marked narrowing of the differences between the emission characteristics of these two types of engines.

Concerns regarding increasing urban air pollution have brought into focus the issues pertaining to air pollution caused by automotive vehicles. It is often believed that 2-stroke engines are more polluting than 4-stroke engines. This is a grossly erroneous premise as each type of engine has its own unique exhaust emission characteristics -in terms of types of pollutants and their quantities.

The Auto-Fuel Policy Committee appointed by the Government of India under the Chairmanship of Dr. Mashelkar, recommends that "The Government should decide only the vehicular emission standards and the corresponding fuel specifications without specifying vehicle technology and the type of fuel".

All petrol driven spark ignition engines emits relatively higher levels of CO compared to compression ignition engines. Conventional 4-stroke petrol engines generally emit higher levels of CO compared to their 2-stroke counterparts. CO emission can be brought down by design improvements that ensure more complete combustion.

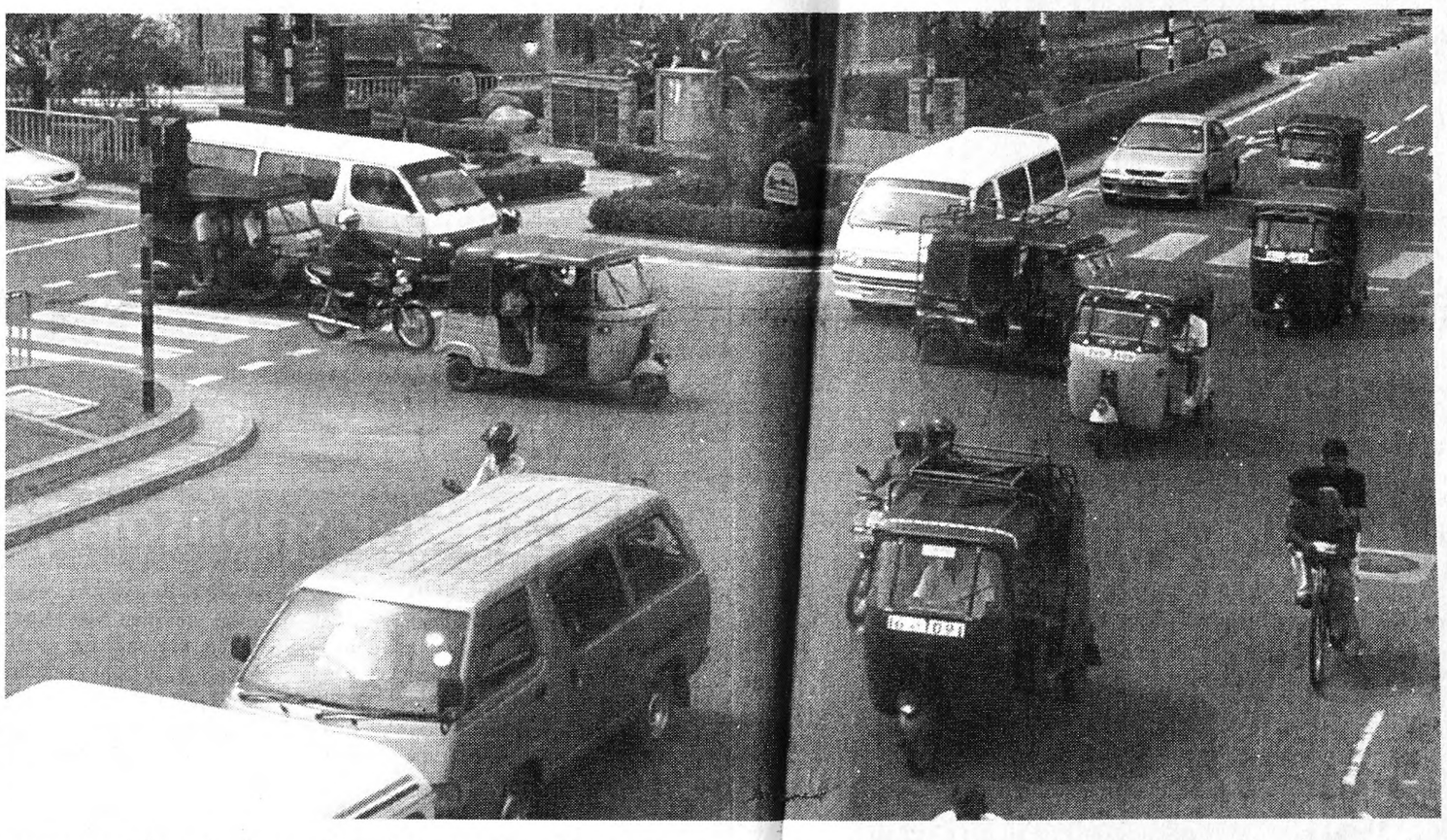
Compression ignition engines emit relatively high levels of NOx. 2-Stroke engines emit negligible quantities of NOx by virtue of lower availability of oxygen and nitrogen and lower flame temperatures compared to 4-stroke petrol engines. The system of port scavenging used in 2-stroke engines also helps to further reduce the emission of NOx. In fact NOx emission 4-stroke engine may be as much as 30 to 40 times higher than that of comparable 2-stroke engines.

Unburnt or partially burned fuel is emitted as HC from the exhaust of all internal combustion engines. The inability of the flames to reach all the parts of the combustion chamber of the engine is the primary source of HC emission. Though conventional 2-stroke engines tend to emit higher HC than corresponding 4-stroke engines due to the possibility of escape of some of the incoming fuel through the exhaust, this has been reduced substantially in modern 2-stroke engines through various design improvements. One of the functions of the catalytic converter used on petrol engines on passenger cars and two and three wheelers, is to reduce the HC emission.

In the environmental point of view it is customary to give a combined emission norm for HC and NOx since major environmental effects are caused by a combination of these two pollutants. Secondly, the technologies that reduce one pollutant tend to increase the other. In case of 2-stroke engines the HC emission may be high but the NOx is very low. In case of 4-stroke engines, the opposite is true, namely, the HC may be low but the NOx is high.

Among the vehicular engines, compression ignition engines are considered as the major source of fine particles. Petrol engines produce negligible quantities of PM. 2-stroke engines are sometimes considered as contributors of PM though the nature and extent of these particles are quite different from those contained in diesel engine exhaust. Studies show that the particles from diesel engines are derived from incomplete combustion of fuel whereas the 2-stroke particles may be due to unburnt lubricating oil. This shows itself up as visible smoke. An important finding is that the use of catalytic converters, which are required to reduce CO and HC emissions also reduce the emission of particles and visible smoke.

As pointed out earlier, conventional 2-stroke engines tend to emit higher levels of HC compared to the 4-stroke engines. The HC emission from the 4-stroke engine mainly comprises unburnt fuel that is trapped in the crevices in the combustion zone where the flame cannot reach. While this source of HC emission is also common to the 2-stroke engine, an additional contribution comes from the loss of fresh air-fuel mixture through the exhaust during the scavenging process. This happens on account of the fact that, in a 2-stroke engine, the transfer ports, which bring in the fresh fuel-air mixture and the exhaust ports, are open simultaneously for a short duration. This loss, also termed as 'mixture short-circuiting', can be minimised by improving the design of the ports, their sizes, locations, numbers, angular configurations etc.



HC reduction also results from the use of higher compression ratios, which help to improve the overall thermodynamic efficiency of the engine, thereby resulting in reduced fuel consumption. Similarly, improving the designs of the piston and piston rings to minimise the dead crevice volumes and friction losses also lead to reduction of HC emissions. An appropriate combination of all the above parameters, depending upon the engine, was employed to bring down the emissions of the conventional 2-stroke engines.

Among the 4-stroke engines, compression ignition (diesel) engines, are considered to be the main source of visible smoke emission. The exhaust gases in this case consist of fine particles of soot arising out of pyrolytic combustion of fuel. Some of the in-use 4-stroke engines, both petrol and diesel, with highly worn out piston rings or valve guides, also lead to the emission of visible smoke due to an increased consumption of lubricating oil that fails to burn properly in the engine.

With the achievement of extremely stringent emission standards in India, the differences between the emission levels of 2-stroke and 4-stroke engines have narrowed down substantially. With the adoption of advanced emission control technologies, it is now possible to say that these two types of engines are equally clean from the environmental point of view. Results of tests done on several 2-stroke and 4-stroke powered vehicles that meet the 2000 norms show that the values of both pollutants, namely HC + NOx and CO, fall within the same ranges, irrespective of technology.

Though, in its present form, the 4-stroke engine is a low emitter of HC, and a control is achievable on its CO emissions by using suitable after-treatment systems, the higher level of NOx emission may become a matter of greater concern to comply with the proposed 2005 and later emission regulations. With increasing use of lean air-fuel mixtures there is a tendency for higher emission of NOx from these engines. In such a situation, an advanced 2-stroke engine with inherently low NOx emissions could prove to be a better choice.

With regard to particulate matter emission from 2-stroke engines, the work recently carried out by the Japan Automobile Research Institute is extremely revealing. The authors of this paper conclude that the particulate matter (referred by them as O-PM) has different characteristics from diesel engine. The O-PM consists of about 98% of Soluble Organic Fraction, which mainly comes from unburnt engine oil. The paper further concludes that O-PM can be reduced by the reduction of oil supply rate to the engine and the use of low smoke type of engine oils. The investigations done by ASEC Manufacturing also concluded that the catalytic converters used on 2-stroke engines, to reduce CO and HC emissions, also help to reduce the PM by nearly 50 percent.

The Japanese researchers also carried out some tests to study the mutagenic responses of O-PM and found them to be different from those of diesel PM and found the responses to be decreasing with decreasing O-PM levels. While this is a preliminary result, it does point to the fact that the PM emissions from 2-stroke engines need to be looked at differently from the diesel PM and that there is a need for considerable more research in this area. Current trends in the development of 2-stroke engine technology are expected to reduce the PM emissions to negligible levels to be *of any major environmental concern.*

In the end no one will really care whether the engine operates on the 2-stroke cycle or the 4-stroke cycle. The solution for any application that is considered is a solution which, in addition to low cost, will also have to meet the emission and sound regulations promulgated, be user and environmentally friendly with respect to use, serviceability and recyclability, be easily manufactured and adapted to existing product.

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