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THE MILLER CYCLE

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Abstract: Engine cycles in which the actual compression ratio is smaller than the actual expansion ratio is called as the Miller Cycle . Miller cycle has been applied in mutually diesel and gasoline engines. In diesels, Miller cycle has been used largely to control NOx emissions at high engine load. In gasoline engines, the benefits of the Miller cycle include compact pumping losses at part load and improved efficiency, as well as knock mitigation. Over-expanded cycles are commonly referred to as Miller or Atkinson cycles. Miller challenged the thinking of the day by closing the inlet valve before the piston reached bottom dead centre.

Keywords: *compression , emissions , piston , bottom dead centre*

I INTRODUCTION

The Miller cycle was developed by Ralph Miller in the 1940s. The **Miller cycle** is a thermodynamic cycle used in a type of internal combustion engine**.** The engine may be two- or four-stroke and may be run on diesel fuel , gases, or dual fuel. An **internal combustion engine** (**ICE**) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit.

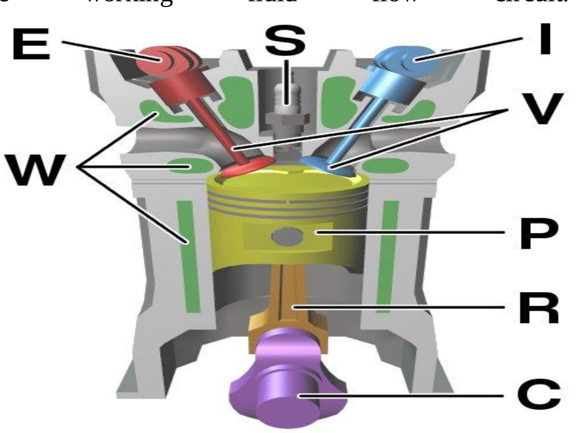

Figure No. 1 : 4-stroke gasoline engines

C – crankshaft.
E – exhaust camshaft.
I – inlet camshaft.
P – piston.
R – connecting rod.
S – spark plug.
V – valves. red: exhaust, blue: intake.
W – cooling water jacket.

In an internal combustion engine, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, rotor or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.

II STRUCTURE

Miller challenged the thinking of the day by closing the inlet valve before the piston reached bottom dead centre. This had the effect of lowering the cylinder pressure as the piston continued downwards, as well as dropping the temperature of the air (Boyles and Charles' Law). Although the engine is still doing work as the piston is descending on the inlet stroke, there is a saving in work during the compression stroke, and the maximum air temperature and pressure is reduced on compression. The timing of the inlet valve of Miller's engine was governed by a mechanical link arrangement, and varied automatically with engine load. Miller's engine doubled the MEP of the engine when compared with a naturally aspirated engine. Advances in design and materials led to more efficient turbochargers, higher compression ratios and more efficient cooling of marine diesel engines.

III 4 STROKE ENGINE

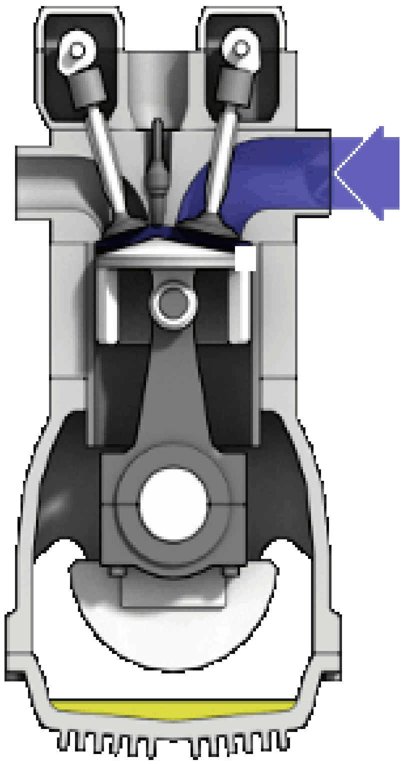

Figure No. 2 : 4-stroke SI engine

The 4 stroke in the SI engine are:

1 Induction
2 Compression
3 Power
4 Exhaust

The *top dead center* (TDC) of a piston is the position where it is nearest to the valves; *bottom dead center* (BDC) is the opposite position where it is furthest from them. A *stroke* is the movement of a piston from TDC to BDC or vice versa, together with the associated process. While an engine is in operation, the crankshaft rotates continuously at a nearly constant speed. In a 4-stroke ICE, each piston experiences 2 strokes per crankshaft revolution in the following order. Starting the description at TDC, these are

1. **INTAKE:**
   The intake valves are open as a result of the cam lobe pressing down on the valve stem. The piston moves downward increasing the volume of the combustion chamber and allowing air to enter in the case of a CI engine or an air fuel mix in the case of SI engines that do not use direct injection. The air or air-fuel mixture is called the *charge* in any case.

2. **COMPRESSION:**
   In this stroke, both valves are closed and the piston moves upward reducing the combustion chamber volume which reaches its minimum when the piston is at TDC. The piston performs work on the charge as it is being compressed; as a result its pressure, temperature and density increase; an approximation to this behavior is provided by the ideal gas law . Just before the piston reaches TDC, ignition begins. In the case of a SI engine, the spark plug receives a high voltage pulse that generates the spark which gives it its name and ignites the charge. In the case of a CI engine the fuel injector quickly injects fuel into the combustion chamber as a spray; the fuel ignites due to the high temperature.

3. **POWER:**
   The pressure of the combustion gases pushes the piston downward, generating more work than it required to compress the charge. Complementary to the compression stroke, the combustion gases expand and as a result their temperature, pressure and density decreases. When the piston is near to BDC the exhaust valve opens. The combustion gases expand irreversibly due to the leftover pressure—in excess of back pressure, the gauge pressure on the exhaust port—; this is called the *blowdown*.

4. **EXHAUST:**
   The exhaust valve remains open while the piston moves upward expelling the combustion gases. For naturally aspirated engines a small part of the combustion gases may remain in the cylinder during normal operation because the piston does not close the combustion chamber completely; these gases dissolve in the next charge. At the end of this stroke, the exhaust valve closes, the intake valve opens, and the sequence repeats in the next cycle. The intake valve may open before the exhaust valve closes to allow better scavenging.

IV OPERATION

There are two mode of the operation:

1. Low Load Operation
2. Full Load Operation

1. LOW LOAD OPERATION

The low load operation is also called as RETARDED. The throttle valve opens against a spring as the follower moves up the cam and oil is displaced under the push rod piston, opening the valve. When the follower comes off the cam, the throttle valve is closed and oil can only flow through the throttle orifice, delaying the closing of the inlet valves.

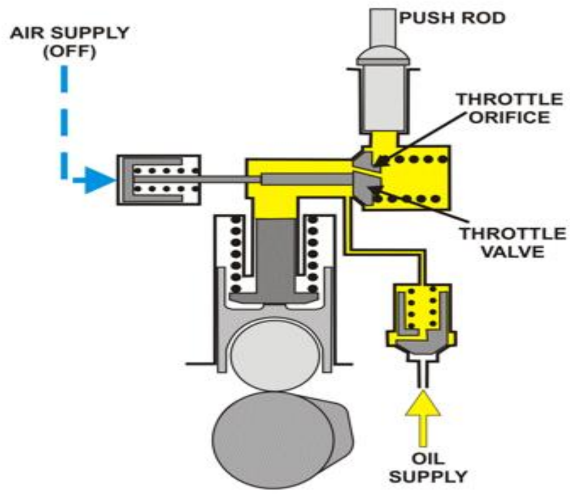

Figure No. 3 : Low Load Operation

2. FULL LOAD OPERATION

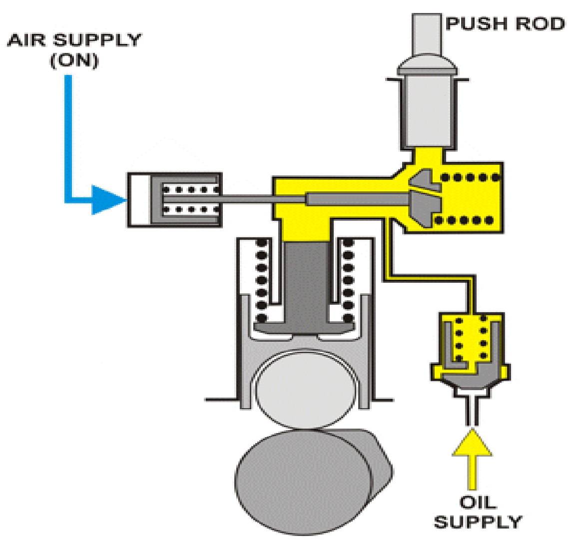

Figure No. 4 : Full Load Operation

The low load operation is also called as ADVANCE. At full load operation, an air signal opens the throttle valve. This means that as soon as the follower descends from the cam peak, the pushrod piston moves downwards, allowing the inlet valves to close.

V P-V Diagram of the Miller Cycle

When the exhaust valve of a conventional spark ignition engine opens at the end of the expansion stroke, a large quantity of high pressure exhaust gas is freed to the atmosphere, without using its availability. An engine that could use this lost energy should have a better efficiency. The equations for an over-expanded cycle (Miller cycle) are developed in this paper, together with equations for the Otto cycle, diesel cycle and dual cycle, all at part load, so they can be compared. Furthermore, indicated cycle thermodynamical comparisons of a S.I. engine at part load (Otto cycle at half load), a S.I. engine at WOT (with half displacement) and two over-expanded S.I. engines (with different compression strokes) are examined and compared, with the aim of extending the referred theoretical cycle comparisons.

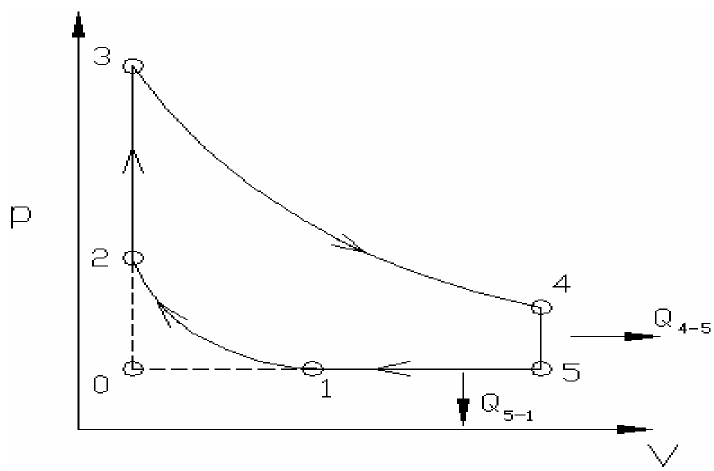

Figure No. 5 : P-V diagram of Miller cycle

VI ADVANTAGES OF MILLER CYCLE

The Engine cycles in which the *effective* compression ratio is smaller than the *effective* expansion ratio.

VII CONCLUSION

The conclusion from this review paper is that it cannot be use in the real practice. In the Miller Engine cycle the actual compression ratio is smaller than the actual expansion ratio.

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