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# Stop Making Sense: How Four Strokes Work

Article by: Don Redmon (Friday, March 1, 2002) (6653 reads)

Replika Maschinen inc.

We have received a number of requests to speak about the basics of how the Otto cycle internal combustion engine works. There are many books on this subject starting with the simplistic to the excruciatingly complex. We will try here to get some where in the middle information wise. There is of course more than one type of internal combustion engine. We have two strokes, Wankel rotaries, jet engines, diesel compression ignition engines and the topic of our current discussion 4 strokes Otto cycle engines. Each of these engines has its particular uses proponents and detractors. Each of these engines are both efficient and inefficient in different ways, this helps generally determines their usage. Jet engines for example are more efficient in their use of turning fuel to work and produce huge amounts of power. However there remains the problem of the exhaust. Car meltdowns might look cool at the monster truck races but they're more than a bit incontinent on the freeway. Two strokes and Wankel rotaries are lightweight, simple and powerful but suffer from some very bad environmental public relations at the moment. We can only hope that more intelligent minds will prevail and these wonderful engines will continue with us into the future. So in concluding this introduction I feel I can say without fear of contradiction that four-stroke gasoline and diesel engines are the most prolific forms of mobile power production on our planet. So how then do four stroke engines work? When I press the gas pedal down on my Hon-Yota-Ishi-San-Rolet I know I go faster but how does it happen?

The Otto cycle or four-stroke engine takes its name from the inventor and from the amount of times that the piston sweeps up and down the cylinder bore, two up and two down. Only one of these strokes produces power, the other three simply support it. The first or intake stroke starting at top dead center or TDC is a downward stroke whose object is to fill the cylinder with a suitable combustible charge. This charge is supplied to the cylinders via the induction system. The induction system currently consists of a computer controlled fuel injector system. This system controls the amount and timing of the fuel and ignition systems. Fuel is forced or injected into the air stream, mixed and sent through the intake port and into the cylinder. Returning back to the mechanical side of things, suffice to say that a closed cylinder needs some sort of path way and a door of some sort to allow the combustible charge to enter the cylinder. This door is currently the purview of the poppet valve in most cases but movable sleeves, roller/tubular valves, and even the piston itself has been used to accomplish this function. The valve is opened and closed by a mechanism in contact with or directly by the crankshaft. The valve opening mechanism is generally referred to as the camshaft. The camshaft has egg shaped lobes that contact the intake and exhaust valves and open and close them according to a predetermined sequence in accordance with the crankshaft and piston locations. The pistons location and the valve opening and ignition firing sequence must be coordinated or the engine will simply not function.

Returning to stroke number one, the piston sweeps downward, the intake valve is open and the combustible charge enters the cylinder. Myth number one, the piston while exerting influence over the mixture does not "pull" the mixture into the cylinder. Instead the piston sweeps down and crates a lower-pressure area inside the cylinder. The greater external pressure outside of the engine forces the charge towards the lower pressure area inside the cylinder. In short, "nature abhors a vacuum" and makes every effort to fill it. The piston continues down to the bottom of its stroke, bottom dead center or BDC.

The second or upward stroke is called the compression stroke. The camshaft rotates and closes the intake valve ending the intake charge-filling event of the cylinder. As its name implies, the compression stroke compresses the charge as it move upwards driving the charge towards the top of the cylinder. Air is a compressible fluid that contains some 25% oxygen by volume. This oxygen when mixed and compressed with an accelerant, gasoline, diesel, propane, LPG, methanol, ethanol, hydrazine, nitromethane, etc., and ignited will produce a very volatile but controllable combustion. Myth number two, the actual working fluid in an internal combustion engine is air, yes air is considered a fluid. The gasoline, etc. is simply an accelerant, a way of heating the air so that it will expand and exert force on the piston, rotor, etc.

The optimum mixture for general emission consideration and street automotive driving is called the "Stoichiometric Ratio". This mixture is approximately 14. 7 parts of air to one part of fuel. As I said earlier air is the working fluid and as can be seen here we need considerably more air than fuel to complete the job.

We now have a combustible air fuel mixture in our cylinder and the mixture has been compressed. So the next step is to ignite this mixture so that we can generate some work from all of our efforts. Igniting this compressed and flammable cylinder mixture is the job of the ignition/electrical system. Computers now control automotive ignition systems. The computer via sensors monitors the needs of the engine and adjusts the timing accordingly. Ignition systems are needed only in spark ignited type engines. Diesel engines or compression ignition type engines do not need a separate ignition system only a glow plug system to get them started when cold. This brings us to the third or power stroke, the actual working stroke of a four stroke or "Otto Cycle" engine. Just before the piston reaches top dead center or TDC, except in certain low emission low performance engines, which fire after TDC, the spark plug now ignites the compressed fuel mixture. The flame front sweeps out in all directions to ignite the mixture, superheating the air, which expands and presses against the entire cylinder assembly. As there is only one designed movable part of this system, the piston, it does so. Pressure exerted on the piston, which is attached to a connecting rod, exerts a pressure to the crankshaft, another lever, which converts reciprocating movement to a rotating or twisting movement commonly referred to as torque, this produces work or energy. This all works on pressure and leverage, as Archimedes said give me a long enough lever and I will move the world. He was obviously thinking of Top Fuel racing even way back then.

Power is the rate at which work is done.

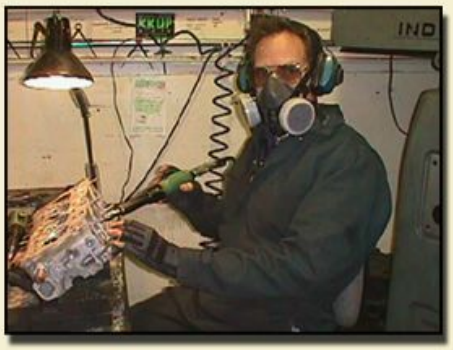
**HP = Torque x RPM / 5250**

**Torque = Force on Piston x Stroke / 2**

This brings us to the final stroke the evacuation or exhaust stroke. Somewhere around BDC the exhaust valve opens ending the pressure phase of the cycle. The end of the cycle also brings us back around to the beginning to start the process all over again. The piston starts on its way up the cylinder forcing the hopefully burned mixture out the exhaust system and into the atmosphere. As the intake stroke uses pressure differentials to help it function so to does the exhaust stroke benefit but in reverse. The cylinder pressures, now quite high force the burned mixture towards the lower outside pressure area. Changes in exhaust system dimensions cause wave reactions with in the system which when properly taken advantage of will aid greatly in both exhaust evacuation and intake filling. Do not underestimate the importance of the exhaust stroke or the entire exhaust system itself; it is an integral part of the overall whole. I hope that this will answer a few questions for those of you who are interested enough to want to learn more. This however is simply the beginning; there is an incredible library of books and texts on the internal combustion engine, I encourage you to seek them out and discover this world. Never blindly accept automotive mythology, go out and find out for your self, investigate and then cross-reference. When you move with the herd you get what the herd gets, fleas.

As always thanks to Dema Elgin of Elgin Camshafts 650-364-2187 for proofreading and continued encouragement.

Don Redmon is the owner of Replika Maschinen, Inc. an airflow and thermal Coating facility in Scotts Valley, California, 831-461-0806.



"Y'all be careful out there, yah hear."

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## Latest Comments

Posted by: **dagger187p** (6/30/02 10:49:43 AM)

cool good wrighting

Posted by: **somudo** (3/28/02 05:50:10 PM)

i have received my knowledge, i am ready for the world!!!

Posted by: **michaelbaker** (3/13/02 12:22:33 PM)

most ppl should know the basic principles behind this, good article to teach those who don't already. made me think a little bit too, with the details.

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Posted by: **lancerman** (3/10/02 06:56:28 AM)

u mean to tell me THAT MANY peeps on this website didnt know that.....thts just sad.

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Posted by: **aarowanaa** (3/7/02 05:52:33 PM)

do one on VVTL-i and i-VTEC

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Posted by: **holzer12** (3/5/02 07:16:39 PM)

very interesting and resourceful.....good diagrams.

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Posted by: **dogbite** (3/5/02 06:37:43 AM)

Motors are electric, you silly. But then again, we have motorcycles instead of enginecycles, and car manufacturers that have Motor Company in their names instead of Engine Co. so only the purists give a poop.

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Posted by: **LGND_sound** (3/5/02 02:02:04 AM)

Pretty good for those that want to know the basics of how a 4 stroke engine works. Quiz Time!!! Now, can anybody tell me what's the diffrence between a Engine and a Motor

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Posted by: **whiteRPS13** (3/3/02 09:34:49 PM)

im 14 and i knew most of that. but i guess for people who dont know about cars, whatever.

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Posted by: **96chevcav** (3/2/02 08:46:37 PM)

i knew most of that stuff but there was still stuff in there that was interesting

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Posted by: **300zfreak** (3/1/02 08:58:19 PM)

nice. i new the majority but i learned a couple new things

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Posted by: **weemanskater87** (3/1/02 07:34:31 PM)

who wouldnt kno that...im learning that in 9th grade science right now

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Posted by: **knuckles2000** (3/1/02 05:24:14 PM)

I didn't even read the whole article it's too long. I'm sure it was good info.

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Posted by: **mafa2004** (3/1/02 04:10:53 PM)

wowwwwwwwwwwwwwww

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Posted by: **tracebuzta** (3/1/02 02:14:01 PM)

cool beans

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Posted by: **mcheong** (3/1/02 12:08:31 PM)

hmm.. very interesting

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Posted by: **bzerkkiller** (3/1/02 09:07:24 AM)

I SEE

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Posted by: **dgm2** (3/1/02 08:40:29 AM)

great info for the begginers

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Posted by: **8seconds** (3/1/02 07:14:59 AM)

pretty insightful, i guess there are plenty of beginners on this site that could use this info. go SO!

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Posted by: **turbodirtdevil** (3/1/02 06:22:56 AM)

wow, I can't believe that many people wouldn't know this.

Posted by: **khme12** (3/1/02 12:44:17 AM)

koo koo

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