

# SMALL ENGINES

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## 2 STROKE VS 4 STROKE

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### Objective

The purpose for this review is to look at the small motor alternatives currently available in the marketplace and if possible to see if there is a specification that could be used by Government in future procurement processes.

### 2 Stroke

- A two-stroke engine is an internal combustion engine that completes the thermodynamic cycle in two movements of the piston compared to twice that number for a four-stroke engine. This increased efficiency is accomplished by using the beginning of the compression stroke and the end of the combustion stroke to perform simultaneously the intake and exhaust (or scavenging) functions. In this way two-stroke engines often provide strikingly high specific power. Gasoline (spark ignition) versions are particularly useful in lightweight (portable) applications such as chainsaws and the concept is also used in diesel compression ignition engines in large and non-weight sensitive applications such as ships and locomotives
- A four-stroke engine uses valves that open and close. By contrast, a two-stroke engine does not have valves. Instead, the air/fuel mixture is drawn into and the exhaust gasses are expelled out of the cylinder via ports that sit opposite each other in the cylinder wall. Both the intake and exhaust ports in a two-stroke engine are open at the same time as the piston moves past them. The intake of the air/fuel mixture and the removal of exhaust gases occur simultaneously. This results in a significant portion of the air/fuel mixture being expelled directly into the environment unburned as it mixes with the exhaust gases as they are expelled before combustion takes place.
- Additionally, in order to provide lubrication to the piston as it moves against the cylinder wall in a two-stroke, oil is added directly to the fuel. A two-stroke's dependence on this oil/gasoline combination, called "fuel mix," is another reason why two-strokes release a high level of emissions. The release of this combination of unburned and partially burned fuel and oil is the cause of the two-stroke's classic blue smoke characteristics.

- The two-stroke engine was popular throughout most of the 20th century in motorcycles, small engine devices such as chainsaws and outboard motors and some cars. This was due to their simple design (and resulting low cost) and higher power-to-weight ratios. Most designs used total-loss lubrication, with the oil being burnt in the combustion chamber, causing visible and other pollution. This is the major reason for two-stroke engines being replaced with four-stroke engines in most applications. Two-stroke engines are commonly used in high-power, handheld applications such as string trimmers and chainsaws. The light overall weight, and light-weight spinning parts give important operational and even safety advantages. Only a two-stroke running on a gasoline-oil mixture can power a chainsaw running in any position
- To a lesser extent, these engines may still be used for small, portable, or specialized machine applications such as outboard motors, high-performance, small-capacity motorcycles, scooters, tuk-tuks, snowmobiles, karts, ultralights, model airplanes (and other model vehicles) and lawnmowers. The two-stroke cycle is used in many diesel engines, most notably large industrial and marine engines, as well as some trucks and heavy machinery.

## 4 Stroke

- Four-stroke engines offer significant environmental benefits over two-stroke designs. These benefits include reduced emissions, improved fuel economy and less noise output.
- In a four-stroke motor, four separate and essential steps must take place at the correct time and in the correct sequence in every cylinder of the engine. This process is known as the four-stroke process. The name "four-stroke" is derived from the number of piston strokes required to complete the engine's combustion cycle.
- Four-strokes are inherently much cleaner than two-strokes for three reasons.
  - First, they burn clean gasoline, not gas mixed with oil.
  - Second, the fuel is burned much more completely and therefore with much greater efficiency than in a two-stroke.
  - Lastly, four-stroke motors draw in the air/fuel mixture and expel exhaust gases on separate strokes of the piston, which means that large amounts of unburned fuel are not released from a four-stroke as in a two-stroke (a fact that also contributes substantially to a four-stroke's much greater inherent fuel efficiency).
- A four-stroke engine requires much less fuel to achieve an equivalent amount of output. In fact, the four-stroke outboard motors now in use burn forty percent less fuel and release ninety percent fewer hydrocarbon emissions into the environment than the two-stroke motors they replaced.
- Old-fashioned 2-stroke machines generate an annoying racket and spew out blue clouds of unburned hydrocarbons. But the same Environmental Protection Agency (EPA) rules that are forcing outboard motors, dirt bikes and ATVs to clean up their act by 2006 are forcing snowmobile manufacturers to switch to quieter, more economical, clean-burning 4-stroke engines. This revolution is revitalizing the whole snowmobile industry.

- **Yamaha RX-1**  
The industry's argument against 4-strokes has always been that the equivalent 2-stroke engine weighs less and produces more power. Yamaha engineers neatly torpedoed that theory. The new RX-1 snowmobile is powered by the same 4-stroke, 998cc, 4-cylinder, DOHC, 5-valves-per-cylinder, liquid-cooled Genesis Extreme engine that powers the Yamaha YZF-R1 sport bike. The proven 4-stroke not only makes incredible torque, it should be at least as reliable and long-lasting as any 2-stroke and is competitively priced.
- The 2008 Polaris 4-stroke FS IQ Touring snowmobile has been certified by the U.S. Department of the Interior as having BAT (Best Available Technology), which means, it is approved for use in Yellowstone and Grand Teton National Parks. The Polaris 4-stroke engine used in the 2008 FS IQ Touring is clean and quiet with an efficient liquid-cooled twin with displacement of 750cc and 80 hp. With the recent changes in snowmobile usage in these parks, Polaris says that it is proud to have this model and it is striving to continually develop environmentally friendly engines.

## What's happening in the market today?

If we just look at the above bullet points it would be easy to say that due to the 4 strokes cleaner emissions and better reliability that this is the way we should proceed, but the 2 stroke will always be a requirement in applications where a 4 stroke engine is too large or too heavy for the application. Also manufacturers are working hard to improve 2 stroke engines and are making headway in reducing emissions. There are definitely two sides to this argument and the decisions on which way to go will continue to be in debate as the market makes better, faster and lighter 4 stroke engines as well as better cleaner 2 stroke engines. Here is what is happening in the marketplace.

- Recently, the great 2-stroke vs. 4-stroke debate changed. Conventional wisdom sounded the death knell of 2-strokes since perception was that only 4-stroke engines could deliver the cleaner, quieter, more fuel-efficient technology demanded by regulators. Some folks even thought that the 2-stroke was being outlawed by the Environmental Protection Agency (EPA). This is a misconception: the EPA regulates emissions, not technologies. So an engine can be 2-stroke or 4-stroke as long as it meets their emission compliance levels. The preponderance of 4-stroke ATVs and the recent emergence of new 4-stroke snowmobiles further skewed the debate. 4-stroke also seemed to be the way for boats.
- **2-stroke resurrection**  
But anyone who thinks the 2-stroke engine is dead should be prepared for a resurrection. Ski-Doo's existing 2-stroke Semi Direct Injection (SDI) Engine is just the first wave of a new generation of 2-strokes that will compete head-on-head with any 4-stroke. Fuel efficiency is already equal to or better than that of a comparable 4-stroke. The SDI is

considerably cleaner than a conventionally carbureted motor, although not yet up to 4-stroke levels for that or sound.

- One need only to look at other power sports to detect other evidence of a 2-stroke comeback. In Sea-Doo watercraft, Direct Injection (DI) delivers 4-stroke gas mileage in a clean, 2-stroke engine. Sea-Doo's DI followed on the heels of its own SDI technology.
- Another BRP subsidiary, the venerable Evinrude marine brand, upped the 2-stroke ante last year with its advanced E-TEC outboard engine technology. Essentially a next generation DI, Evinrude E-TEC engines are lighter, cleaner, more fuel efficient, and as quiet as any marine 4-stroke, while retaining the performance and handling characteristics loved by 2-stroke aficionados. Best of all, the E-TEC engines promise to be as or more reliable than 4-strokes, without the usual maintenance costs. Consider that E-TEC engines require no break-in period, no winterization, no spring service, no oil or filter changes and no regularly scheduled maintenance for three years or 300 hours. E-TEC brings another new development to recreational engines. At idle speeds, an E-TEC outboard produces 80 percent less carbon monoxide (CO) than comparable 4-strokes. An odourless, colourless, and as yet unregulated gas, carbon monoxide can be lethal at levels exceeding 1,200 parts per million. E-TEC CO emissions measure less than 600 parts per million, while available marine 4-strokes and even new cars with catalytic converters measure well over the lethal limit. And E-TEC is smokeless, with no smelly fumes.

- **Ski Doo 2009- 2 Stroke Technology**

Ski-Doo pioneered E-TEC direct injection 2-stroke technology in its Evinrude outboard engines, where it won the Clean Air Technology Excellence Award from the US Environmental Protection Agency. This E-TEC system, developed specifically for snowmobiles, delivers several benefits

Ski-Doo makes that claim as it announces an early limited release 2009 MX Z TNT with an all-new Rotax 600 HO E-TEC engine. What does this new E-Technology mean to consumers? Check out these points enumerated by Ski-Doo to its dealers:

- **Fuel Economy:** Ski-Doo claims up to 21-mpg US/25 mpg CDN with the 600 HO E-TEC.
- The claim based on Ski-Doo tests is that the new E-TEC version uses:
  - 15% less fuel than its current Rotax 600 HO semi-direct injection (SDI) engine;
  - 78% less fuel than a Polaris 600 CFI;
  - And 92% less than an Arctic Cat's 600 EFI.
- **Oil Economy:** Ski-Doo claims that based on its tests, some owners will have to add oil just once per season. This is due to the extremely precise nature of the system's electronic oil pump and sophisticated computer mapping. Based on its own testing of competitive products, Ski-Doo claims that its 600 HO E-TEC uses

half the oil of the SDI and Polaris 600 CFI, and just a third the oil (66% less) of the Arctic Cat 600 EFI.

- **Emissions/smoke and smell:** Just as the Evinrude E-TEC outboards have seen reduced emissions, the 600 HO E-TEC is expected to be the cleanest two-stroke snowmobile engine by a wide margin—meaning there's virtually no smoke or smell.
- **Lightweight:** In the 2stroke versus 4stroke battle, weight has been a focus. Ski-Doo expects its new high-efficiency E-TEC 2stroke to retain its advantage over 4stroke competitors such as Yamaha. Because of its two-stroke configuration, the new E-TEC-equipped MXZ TNT the 600 HO E-TEC should retain a weight advantage for better handling and reducing rider fatigue.
  - Points to be made by Ski-Doo E-Tec versus its competition:
    - Best fuel economy of any 2-stroke;
    - The lowest oil consumption of any 2-stroke;
    - Cleanest 2-stroke in the snowmobile industry;
    - Virtually no smoke and smell.
    - E-TEC is a simple system;
    - There's minimal weight increase over SDI

## In Conclusion:

When we look at specifications for Snowmobiles, ATV's and Outboard motors we always take into consideration where the unit will be going. For instance if a snowmobile is required in Prince George we need to look at the models available in that area so that warranty and service work can be accommodated. This may mean that certain models will not be available. Taking ministry requirements into account and availability we should always look at the engine options available. With the recent innovations, 2 stroke motors can compete with 4 stroke motors as they now run much cleaner and are more fuel efficient than in previous years Certainly when we are looking at Snowmobiles and Outboard marine motors we should consider the Ski Doo and the Evinrude 2 stroke E-Tec models. We should not discount a 2 stroke motor without first looking at the technology behind it. Not all manufacturers are as far along in 2 stroke technologies as the above two companies but things are continuing to change and we should always look at the options in the 2 and 4 stroke engine design when an opportunity arises.

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