Nautilus Four Stroke, Six Cycle, Dynamic Multiphasic Combustion Engine

Nautilus Engineering, LLC

Document - 00005R01V00

Release 01

Date

Friday, March 16, 2018

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Table of Contents

Table of Contents i

Glossary ii

Abstract 1

Introduction 1

Concept of HCCI 1

History of HCCI 2

Current Challenges 3

Solution 3

Dynamic Multiphasic Combustion 3

Nautilus Design 5

Piston 5

Cylinder Head 5

Nautilus Four Stroke, Six Cycle Engine 7

Intake Stroke 7

Compression Stroke 8

Power Stroke 9

Fuels 11

Exhaust Gas Recirculation (EGR) 12

Benefits of Dynamic Multiphasic Combustion Engine Technology 13

Conclusion 13

The Nautilus Cycle Enables 15

Call-To-Action 15

About Nautilus Engineering 15

Bibliography 16

Appendix 1: Compression Ratios and Volumes 18

Appendix 2: Applicable Sensors/Hardware and Controllers 19

Glossary

AFR- Air Fuel Ratio. In the combustion process, the ratio of air to fuel in different stages.

BDC – Bottom Dead Center. The lowest point the piston can reach in a cylinder from the cylinder head.

Static Compression Ratio – CR Static. Ratio of the volume of the combustion chamber in its largest capacity to its smallest capacity.

°C. Degrees Celsius

CI. Compression Ignition

CO_2. Carbon Dioxide

CO. Carbon Monoxide

DMC. Dynamic Multiphasic Combustion

Dynamic CR - Compression Ratio. Represents the ratio of the cylinder volume at intake valve closing over the volume above the piston at TDC.

EGR. Exhaust Gas Recirculation

°F. Degrees Fahrenheit

FHCI. Forced Homogeneous Compression Ignition

FHCCI. Forced Homogenous Charged Compression Ignition

G2N. Nautilus Second Generation Engine

G3N. Nautilus Third Generation Engine

HC. Hydrocarbons

HCI. Homogeneous Compression Ignition

HCCI. Homogeneous Charged Compression Ignition

HEV. Hybrid and Electric Vehicles

IC. Internal Combustion

K. Kelvin (Temperature)

NOx. Nitrogen Oxides (NO, NO_2, NO_3)

MS. Milliseconds

NVH. Noise Vibration Harshness

ON. Octane Number, indicates the antiknock properties of a fuel.

PCV. Positive Crankcase Ventilation

PFI. Port Fuel Injection

PSI. Pound per Square Inch

RPM. Revolutions per Minute

SFI. Spark Forced Ignition

SI. Spark Ignition

SpCCI. Spark Controlled Compression Ignition

Static CR - Compression Ratio. Ratio of the volume of the combustion chamber for the engine's largest capacity to its smallest capacity.

TDC - Top Dead Center. The position of the piston in the cylinder closest to the cylinder head.

VCR. Variable Compression Ratio

VVT. Variable Valve Timing

Abstract

The Nautilus Multiphasic technology is applicable in a wide variety of industries, including automotive, agriculture, marine, recreational, aerospace, and power generation. The Nautilus DMC (Dynamic Multiphasic Combustion) engine has advanced current HCCI developments for all functions to occur in one place with a semi-isolated two stage chamber approach. Stage one is spark or compression ignition in the primary chamber, and stage two is forced compression ignition via pressure propagation into the secondary chamber. This achieves Forced Homogeneous Compression Ignition (FHCI) or Forced Homogeneous Charged Compression Ignition (FHCCI), which dramatically improves emissions, efficiency, and power to weight ratios.

Introduction

The transportation industry has continued its impressive growth for decades by focusing on drivability, comfort, convenience, and most recently, global demand for dramatic emissions reductions. Today, the modern internal combustion engine is the primary capitalized method of propulsion for original equipment OEMs (Original Equipment Manufacturers).

In the next decade, the global transportation industry must comply with significant emission reductions for propulsion that are extremely difficult to meet with current engine designs and technology. To meet these reductions, manufacturers have been forced to engineer solutions at a higher cost to consumers with a difficult cost of ownership benefit.

Concept of HCCI

HCCI (Homogenous Charged Compression Ignition) technology compresses the mixture of air and fuel to the point of auto-ignition. Currently, engineers are using this process to resolve the thermal efficiency shortcomings of IC engine designs.

The HCCI technology offers the advantage of harvesting the strengths of both CI and SI engine designs. Engines that operate unthrottled at light loads with a homogeneous charge are projected to deliver the key advantages of both SI and CI engines.

At partial loads, SI engines utilize air better than diesel engines. To deliver improved fuel economy and specific power outputs across the load range, it is essential to reap the benefits of gasoline engine performance with CI engine advantages. HCCI can allow light-load engine performance without throttling if it operates at very low air-fuel ratio (i.e. lean combustion). This makes HCCI as economical as CI engines. The mixture of fuel and air can be preheated by using the exhaust manifold, heat recovery, and EGR. In addition, HCCI engine can operate as an SI engine for specific output with gasoline fuel (Thring, Homogeneous-Charge Compression Ignition 2003).

HCCI engine design injects fuel during the intake stroke but compression raises fuel mixture density and temperature until this mixture combusts spontaneously (Zhao), rather than using electronic spark for ignition. The result of this compression combustion method is a flameless, low temperature auto-ignition that is inherently more efficient, thereby requiring less fuel than conventional SI engines as shown in Figure 1 (Thring). In addition, it also produces considerably lower overall emissions, specifically NO_x and carbon monoxides.

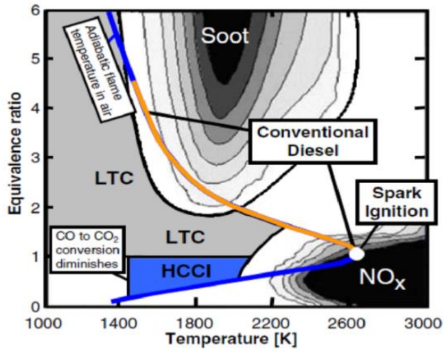


Figure 1: The relationship of temperature and air fuel ratio with soot and NO_x for SI, LTC and HCCI engines. (Dec, Advanced Compression-Ignition Engines - understanding the in-cylinder processes 2009)

History of HCCI

HCCI technology is not limited to certain fuel types, therefore, it can be commercially implemented (Angelos). The fuel's chemical composition, octane number, and volatility have effects on knock frequency (Wang Zhi). Engine knock is a result of hot pockets within the cylinder as combustion occurs.

HCCI engines have a long history, despite the lack of general implementation. The table below lists global automotive manufacturers that have attempted to put HCCI into production (Zhao).

Table 1: Attempted HCCI Prototypes

Company	Prototype
GM – General Motors *USA*	In 2007-2009, GM demonstrated HCCI with a **modified 2.2L Ecotec engine** installed in the Opel Vectra and the Saturn Aura. The engine operates in HCCI mode at speeds below 60 mph (97 km/h) or when cruising, switching to conventional SI when the throttle is opened.
Mercedes-Benz *Germany*	Mercedes had developed a prototype engine called **DiesOtto**, with controlled auto ignition.
VW - Volkswagen *Germany*	VW developed two types of engines for HCCI operation: • CCS (Combined Combustion System), is based on the following engine group: • VW Group 2.0L diesel engine GCI (Gasoline Compression Ignition uses HCCI during cruising and spark ignition during acceleration. Both engines have been demonstrated in Touran prototypes, and the company expected them to be ready for production in about 2015.
Hyundai *South Korea*	Hyundai introduced the GDCI (Gasoline Direct Injection Compression Ignition) engine, utilizing a supercharger and turbocharger to maintain cylinder pressure instead of relying on ignition plugs.

Honda *Japan*	Honda has been trying to develop an HCCI engine to produce the next generation of hybrid cars; however, no production of this concept is currently active.
Mazda Japan	**Skyactiv-X**– Consists of a compression ratio of 16:1 allowing the use of SpCCI combustion. A combination of Spark and HCCI engine (Adcock, Ice Breaker! 2017).

Current Challenges

Although HCCI engine prototypes have been designed and constructed, top engine researchers have been struggling to overcome the following challenges for over 30 years:

- Cold start capabilities (Angelos)
- Auto-ignition timing (Thring, Homogeneous-Charge Compression Ignition 2003)
- High heat release and the increase of pressures within the combustion chamber result in engine wear (Zhao)
- Intermittent transient auto-ignition events create engine knock and soot formation (Osborne)
- Lower power range due to lean flammability limits for lower loads and pressure restrictions for higher loads (Zhao)
- Maintaining the volumetric efficiency during higher RPMs (Morey)
- Unknown reliability and longevity periods due to lack of mass production

Operation at high loads in HCCI mode is not currently possible. However, an engine designed to operate with HCCI under part load conditions would be an engine like a conventional gasoline, rather than a diesel engine. Such an engine would not require a high-pressure fuel injection system, but possibly would require a spark ignition system for start-up and for high load operation. A low pressure electronic fuel injection system could also be used (Thring, Homogeneous-Charge Compression Ignition 2003).

Solution

The Nautilus Engineering design addresses the inherent challenges of HCCI and HCI. The Nautilus cycle utilizes various HCCI cycles through changes to the piston and cylinder head to achieve dynamic multiphasic combustion.

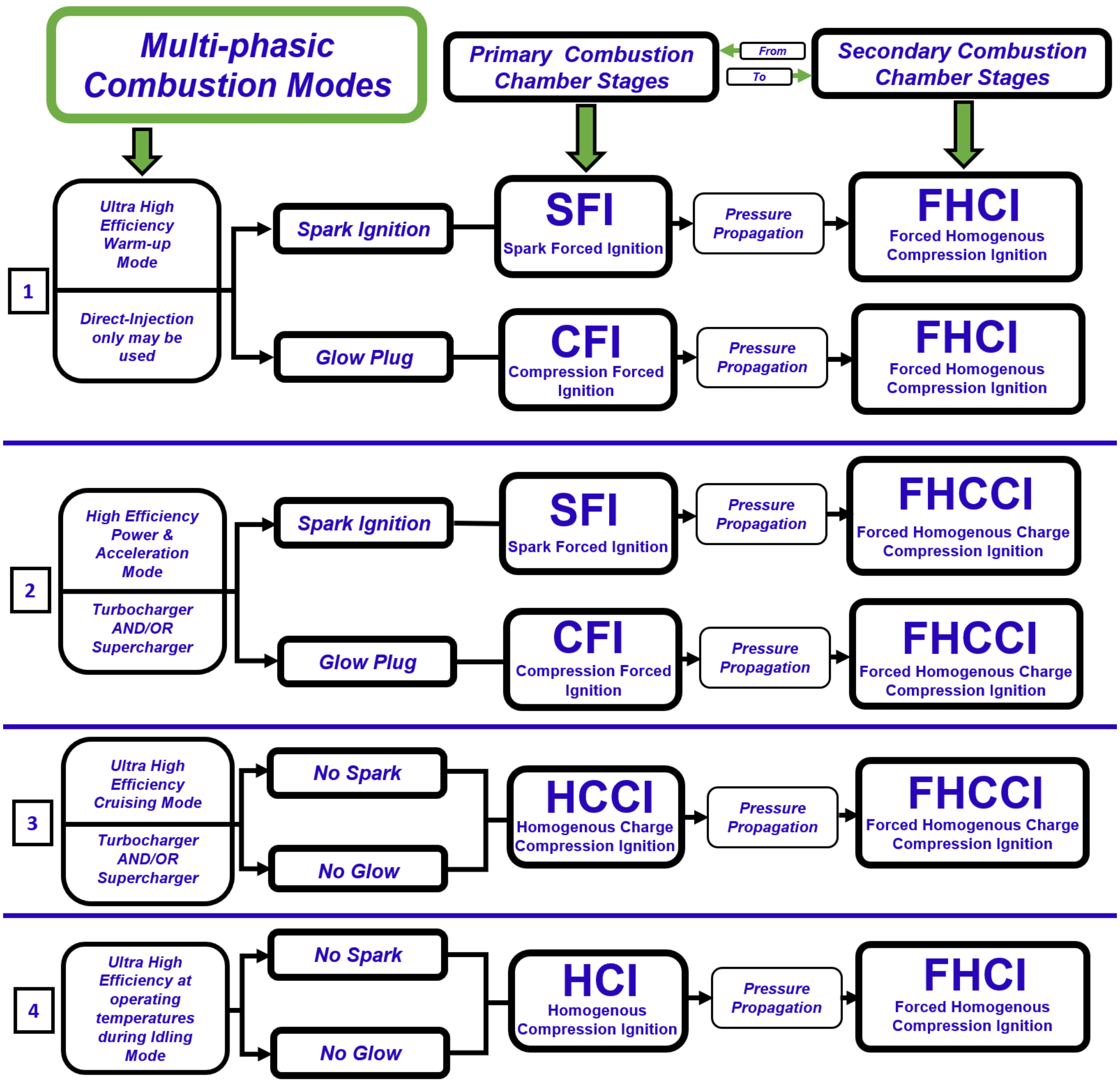
Dynamic Multiphasic Combustion

Nautilus DMC engine technology, as shown in Table 2, allows the addition of different fuel injection systems such as direct (enriched fuel mixture), port (lean fuel mixture), throttle body, and/or any combination thereof within the primary and secondary combustion chambers.

Incorporating spark and/or glow plugs, as well as fuel injection systems, enables primary and secondary combustion along with a multitude of combustion configurations through forced pressure propagation. This application enables the implementation of standard and/or blended fuels. Depending on the desired requirements, this engine can be operated in diverse operating modes.

Nautilus Engineering has designed, built, and achieved current goals. This concept went on to prove the enabling power of pressure propagation with HCI combustion ignition in the primary chamber as well as pressure propagation to secondary chamber of Nautilus G2N engine.

Table 2: Multiphasic Combustion Modes



Nautilus Design

Piston

Illustrated in Figure 2, the Nautilus cutting-edge technology redesigns the typical piston by placing a primary piston (small extrusion) on the top surface of the piston. The Nautilus Cycle is protected from a torching effect by employing a low-cost coating and oil cooling from underneath.

The redesigned piston plays a key role in dividing the combustion into a primary (Controlled Symmetrical Chamber) and secondary stages. An accurate primary piston was calibrated and designed through a twelve-month ANSYS CFD analysis. The multiphasic combustion consists of primary force-controlled complete combustion and secondary force-controlled complete combustion.

Note 1: Secondary chamber shape is not as relevant due to forced auto-ignition HCCI/HCI.

The top of the primary piston surface is concave when viewed from above. The convex surface enhances roll and tumble in a stoichiometric and/or HCCI/HCI controlled combustion event of secondary combustion, which is pressure propagation auto-ignition in the chamber.

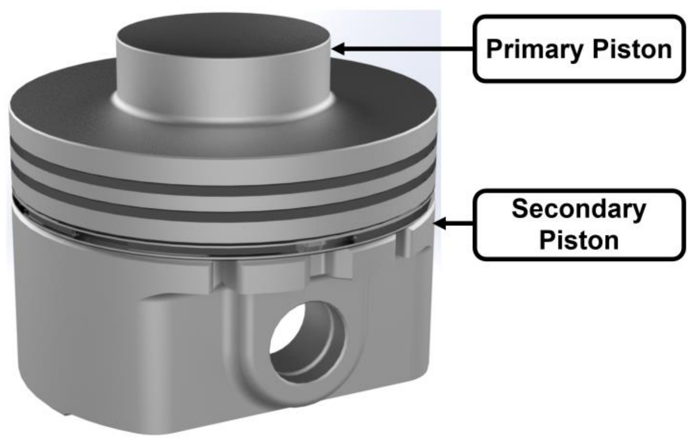


Figure 2: Piston

Cylinder Head

The matching cylinder head design contains a small cylinder. The top of the small cylinder is convex when viewed from profile view. This enables for proper roll and tumble in a stoichiometric and/or homogenous controlled combustion. The cylinder head also employs a low-cost coating to protect against torching effect, as well as liquid cooling in the cylinder head.

The primary chamber includes spark plug and/or glow ignitor, in addition to direct injection. All are available to assist in primary combustion using any combination as described in Table 2. The primary piston is projected into the reconfigured cylinder head without making physical contact to the cylinder head as the piston reaches TDC.

In-block Valve Configuration

Re-engineered valves enlarged by 20%, as shown in Figure 3, provide significantly improved breathing characteristics during the intake and exhaust strokes, which results in optimized efficiency. Intake and exhaust valve position plays a key-role to assist pre-heating the intake charge introduced to the combustion chamber through heat transfer from the exhaust valve. This results in the dramatic reduction of intermittent transient auto-ignition events caused by hot spots on the exhaust valve. This also results in an increased intake temperature to assist in combustion.

The optional Variable Compression Ratio (VCR) is accomplished by an adjustable displacement mechanism within the primary combustion chamber as shown in Figure 4.

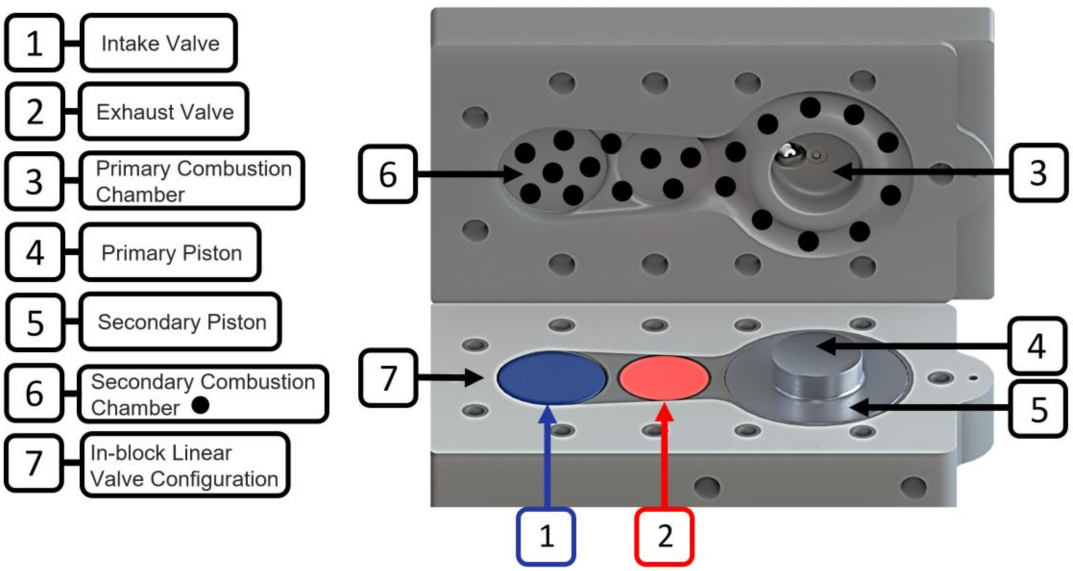


Figure 3: Engine Block and Cylinder Head

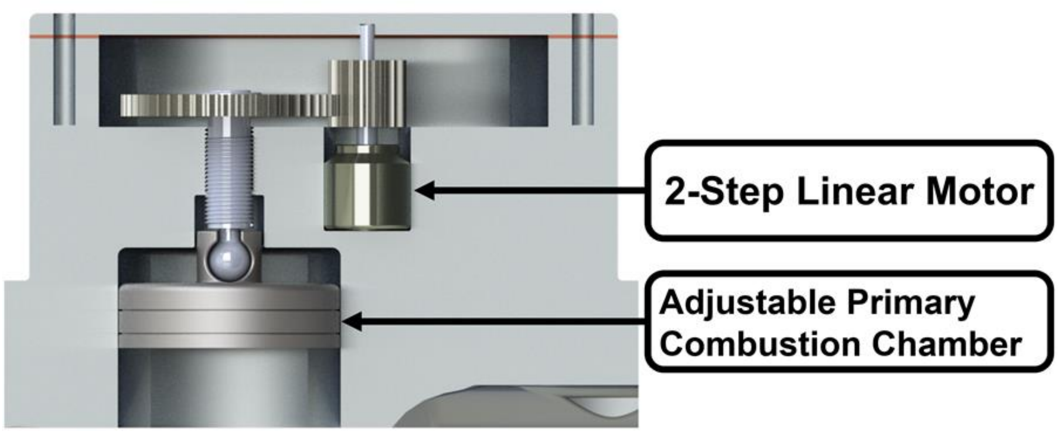


Figure 4: Adjustable Primary Combustion Chamber Displacement

Note 2: Bore Size

The engine bore size does not have the same emission limitations as a conventional flame propagation engine, where the cylinder bore size must be small enough to allow flame propagation to consume the air-fuel charge of the entire cylinder. This will prevent unburned fuel from entering the exhaust, i.e. poor emissions. The Nautilus engine's secondary auto-ignition event also assists in controlling emissions by spontaneously consuming the homogenous mixture at once. Therefore, the bore size can be enlarged while keeping the same stroke for a higher volume output in this design.

Nautilus Four Stroke, Six Cycle Engine

Intake Stroke

The fresh air inlet is heated to the required temperature by heat soaking from the exhaust manifold and/or by preheating electronically to over 100 ˚F as it passes through.

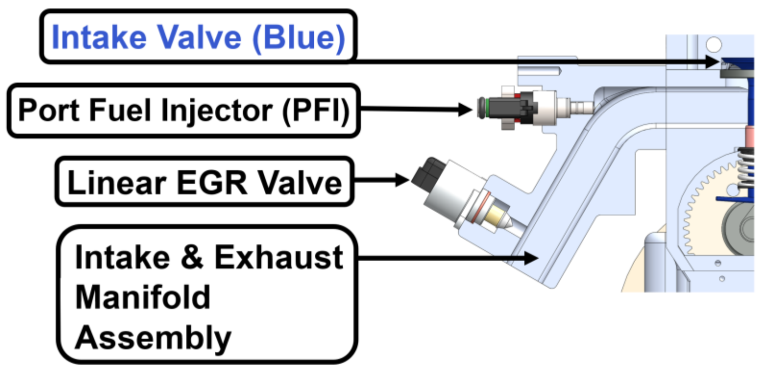


Figure 5: Intake Air-fuel mixture Through Manifold and PFI

Fuel injection and Exhaust Gas Recycling (EGR) are introduced to the intake. The engine's improved atomization and vaporization of fuel before it reaches the combustion chamber may be enriched or leaned per requirements.

The piston descends, and the intake stroke, which consists of stoichiometric or homogenous mixture, takes place. The valves are closed, and ambient pressure is established at bottom dead center (BDC) within the cylinder as shown in Figure 6.

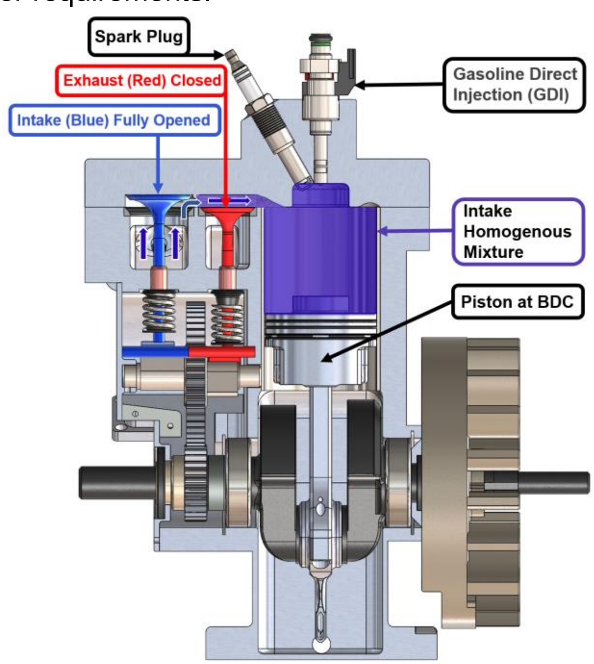


Figure 6: Intake Stroke

Compression Stroke

Pressure is established in the cylinder, and the piston is at BDC as shown in Figure 7. The piston ascends to TDC, while simultaneously, in-cylinder pressure increases exponentially.

The primary piston enters the primary chamber as shown in Figure 8 without making physical contact. The pressure rises to its optimal ignition pressure in the primary cylinder during the compression stroke. The volumes for each compression stroke are shown in Appendix 1.

For spark ignition, fuel may be injected to enrich the AFR in the primary chamber, and then spark or compression ignition will occur as pressure increases between 2:1-3:1 over the secondary combustion chamber, depending upon RPMs.

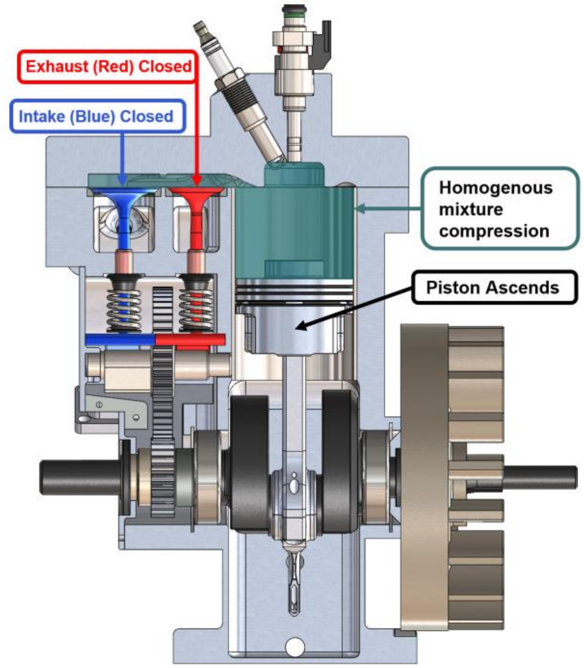


Figure 7: Main Compression Stroke

The fuel is ignited, and pressure propagation occurs from the primary to the secondary chamber, forcing critical stage pressure. This reduces the parasitic losses due to unrequired high compression ratio in the secondary chamber by utilizing primary pressure with a lower surface area of pressure on crankshaft during a compression stroke.

Note 3: Two compression cycles occur within one compression stroke.

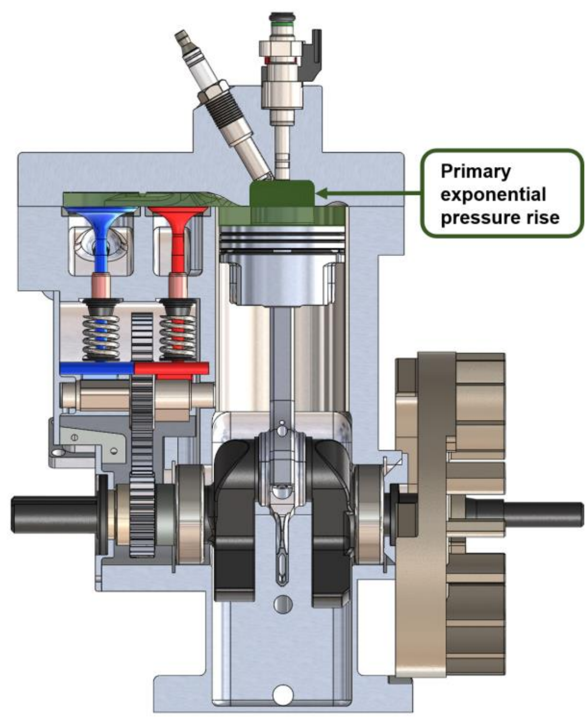


Figure 8: Primary Chamber Compression Stroke

Power Stroke

A conventional engine normally has minimal blow-by due to seated piston rings that separate oil from the crankcase in the combustion chamber.

In this technology, there are no piston rings on the primary piston, just a minimal gap between the cylinder wall and piston, which avoids physical contact.

Blow-by is utilized successfully in the primary power cycle, enabling gases to escape to the secondary chamber in a controlled manner, forcing primary hot EGR gases to mix rapidly in the secondary chamber, empowering the auto-ignition event.

The primary combustion chamber is forced to critical stage combustion before or at TDC as shown in Figure 9, while the secondary combustion chamber maintains a lower threshold, i.e. no critical stage ignition.

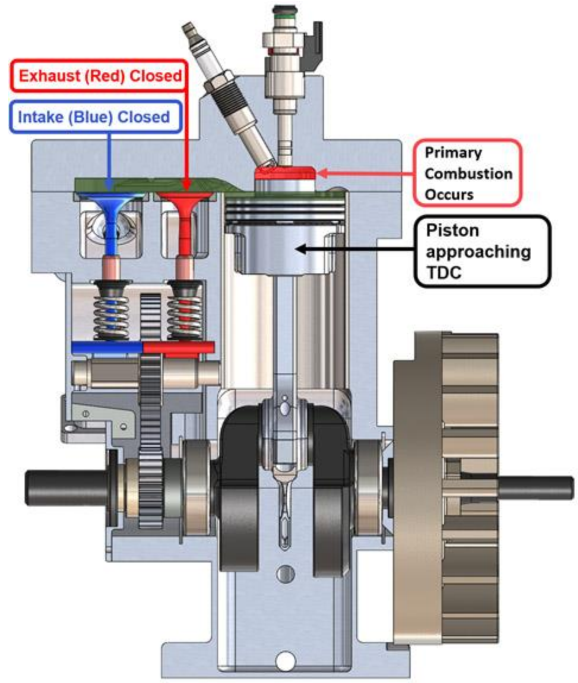


Figure 9: Primary Power Stroke

The crankshaft crests over TDC, and the piston descends within the cylinder as shown in Figure 10. The primary piston's combustion is exposed to the secondary combustion chamber, which forces pressure to accelerate to critical stage combustion (pressure propagation). After TDC, the secondary power stroke occurs.

This enables enriched HCCI/HCI combustion as flame front has been extinguished and has not been allowed to reach the secondary combustion chamber. Only pressure from the primary chamber propagates into the secondary chamber, which forces auto ignition.

During lower RPMs, pressure propagates from the primary combustion chamber to the secondary combustion chamber, allowing the auto-ignition to occur 5-10 degrees after TDC. During high RPMs, the smoother combustion occurs at 10-15 degrees past TDC. The auto-ignition event occurring after TDC creates lower Noise Vibration Harshness (NVH) unlike current ignition platforms.

Note 4: Two ignition cycles occur in one power stroke.

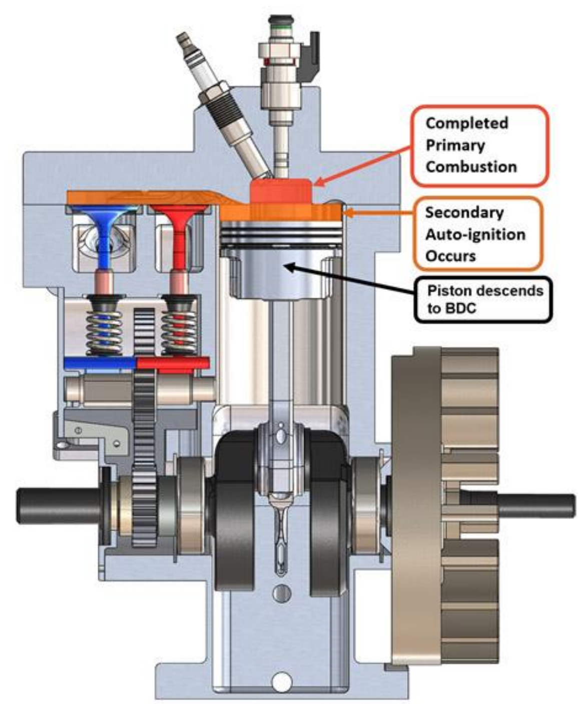
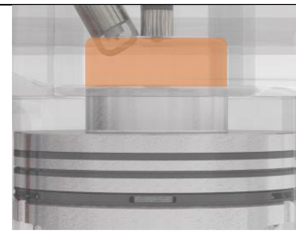
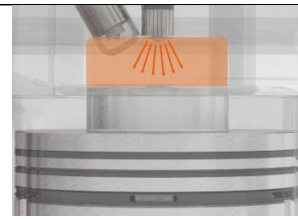
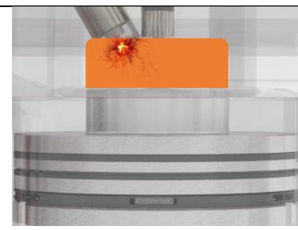
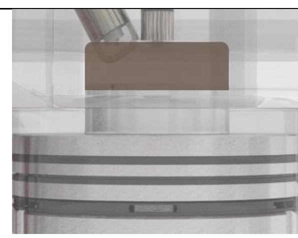


Figure 10: Secondary Power Stroke

Table 3: Power Stroke Process (Primary FHCCI & HCI)

Power Stroke Process **(Primary – FHCCI & FHCI)**	**Illustration**
• Piston enters the primary chamber at a crankshaft angle of 320º	
• The direct injection system introduces a calculated fuel amount at 100bar (1450 psi), to reach a stoichiometric AFR in the primary chamber	
• The spark plug ignites between 3º and 10º after the direct injection takes place. Ignition kernel propagation occurs in the primary chamber as shown at right • The flame front expires just after crankshaft crest over TDC	
• The resultant EGR from the primary combustion event past TDC is exposed to secondary chamber forcing the secondary auto-ignition event	

Note 5: Unlike SpCCI, Nautilus technology does not allow flame propagation to cross contaminate a lean combustion environment. i.e. by way of mechanical control separating the primary and secondary combustion events with the primary piston.

Fuels

The primary characteristics of fuels in an engine are dependent on the octane number, burning rate, and energy value. Octane number and burning rate play an important role in a DMC HCCI engine. Higher-octane fuels are resistant to pre-ignition and detonation, and they allow for the use of higher compression ratios. The burning rate is defined as the speed at which a fuel burns and its energy released.

In the Nautilus DMC technology, a faster fuel burning rate helps expire the flame front in the primary chamber before the piston descends just after TDC. The reduced flame front assists the flameless auto-ignition event in the secondary chamber. The table below shows different burning rates and energy released values for different fuels.

Table 4 highlights pump gasoline, E-30, and E-85. These fuels are preferred at this stage of development due to higher burning rate and higher energy value in combustion chambers.

Table 4: Fuels and its properties (iqlearningsystems.com n.d.)

Fuel	Octane Number	Burning Rate (ms @ stoichiometric)	Latent Heat (Btu/gal)	Energy Value (Btu/lb.)	Power Stoichiometric	Boiling Point (°F)
Pure Ethanol	113	0.39	396	12800	6.5/1	149
Pure Methanol	N/A	0.43	503	9750	5/1	172
Pump Gasoline	**86-93**	**0.34**	**150**	**18700-19100**	**12.5/1**	**130-430**
E-30	**91-94**	**0.36**	**337**	**17178**	**10.7/1**	**218**
E-85	**103-109**	**0.38**	**359**	**14021**	**7.4/1**	**164**

Exhaust Stroke

The piston ascends as the exhaust stroke begins, similar to a conventional engine. The exhaust valve opens near BDC, allowing exhaust gases to escape through the exhaust port. As the piston rises back to TDC of the combustion chamber, as shown in Figure 11, it allows the exhaust stroke to be completed. The intake valve opens as the exhaust valve is closed.

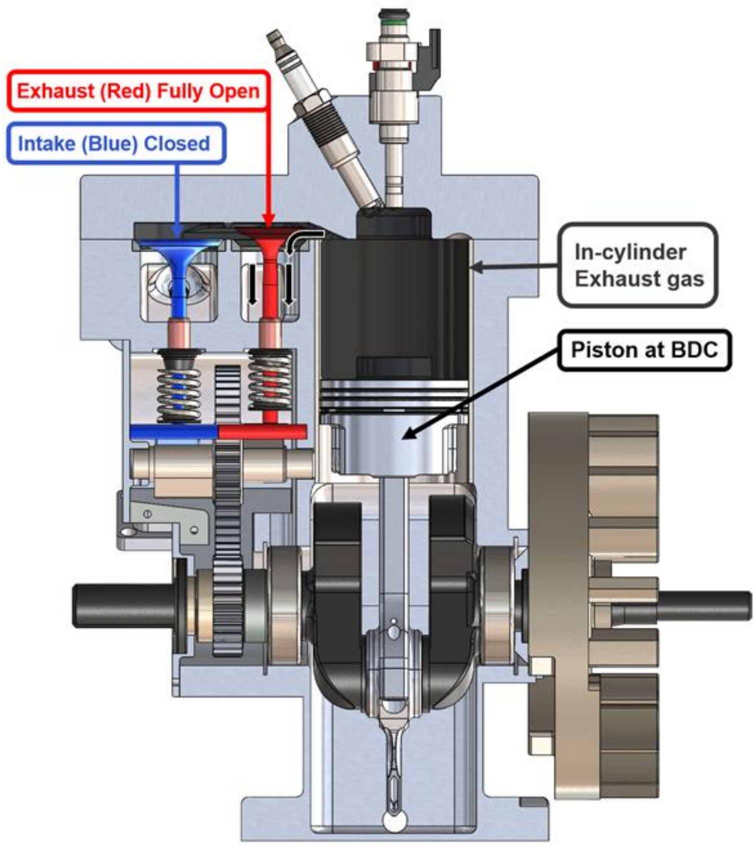


Figure 11: Exhaust Stroke

Exhaust Gas Recirculation (EGR)

The in-block in-inline valve arrangement shown in Figure 3 provides trap volume of hot EGR gases to influence the temperature and composition of the next cycle during the primary ignition event. EGR is created and transferred to the secondary chamber as illustrated in Figure 12. With this pressure and temperature increase, it forces secondary HCCI/HCI to critical ignition.

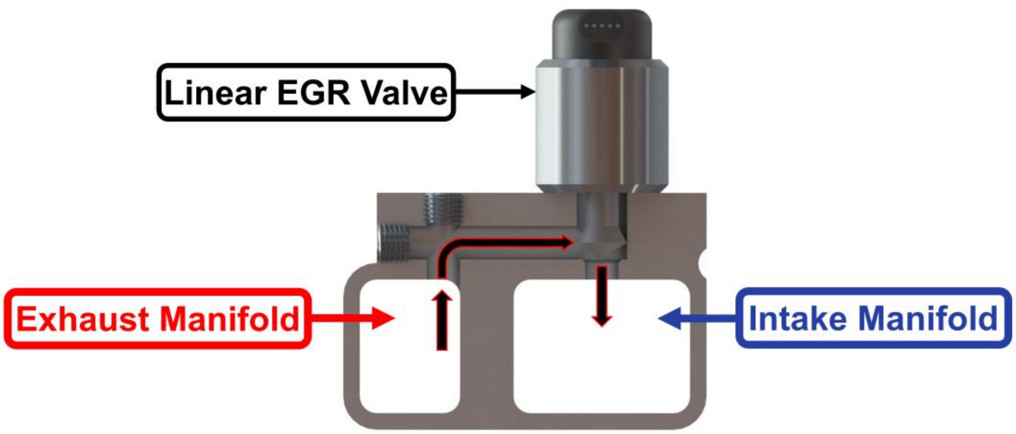


Figure 12: Exhaust Gas Recirculation

Benefits of Dynamic Multiphasic Combustion Engine Technology

- Depending on engine load requirements, the secondary compression ratio can be adjusted by the primary's VCR, (i.e. pressure propagation front).
- The primary combustion is capable of spark ignition or lean air-fuel compression ignition (HCCI/HCI) to accommodate forced ignition of secondary combustion.
- 30% more fuel efficiency due to fulltime FHCCI/FHCI in secondary chamber.
- Significantly lower CO, NOx, and HC emissions are produced than conventional SI and CI engines.
- The separation of spark ignition in the primary chamber and forced auto-ignition in secondary chamber as discussed in “Power Stroke” (pg. 9) guarantees forced pressure propagation instead of flame propagation to the secondary combustion chamber.
- Operating in different combustion cycles allows for adaptive, adjustable, and on-demand engine needs.
- Engine is capable of multiple ignition points at multiple crankshaft angles in primary chamber and/or secondary chamber.
- Engine is enabled to utilize multiple and/or blended fuels within primary and/or secondary injection.
- Complete atomization of air and fuel in combustion chamber due to additional fuel injectors as referred to in “Intake Stroke” (pg. 7).
- Improved controlled cold start.
- Improved volumetric efficiency.
- Reduce parasitic losses on crankshaft increases efficiency.
- Normal blow-by in a conventional engine is very minimal due to seated piston rings effectively separating oil from the crankcase in to the combustion chamber. In this technology, there are no piston rings on the primary piston, just a minimal gap between cylinder wall and piston to avoid physical contact. Blow-by is utilized successfully in the power cycle, enabling primary gases to escape to the secondary chamber in a controlled manner. This forces primary hot EGR gases to mix rapidly in the secondary chamber, which empowers the auto-ignition event.

Conclusion

The Nautilus DMC incorporates fuel injection and ignition systems in the primary chamber to achieve cleaner secondary chamber auto-ignition. A four stroke, six cycle combustion process achieves higher fuel efficiency, lower emissions, and improved power-to-weight ratio compared to conventional IC engines and current HCCI engines in research or on the market.

The Nautilus DMC technology consists of a redesigned piston, cylinder head, larger repositioned valves, and lifters that enable the engine to operate in multiple combustion cycles.

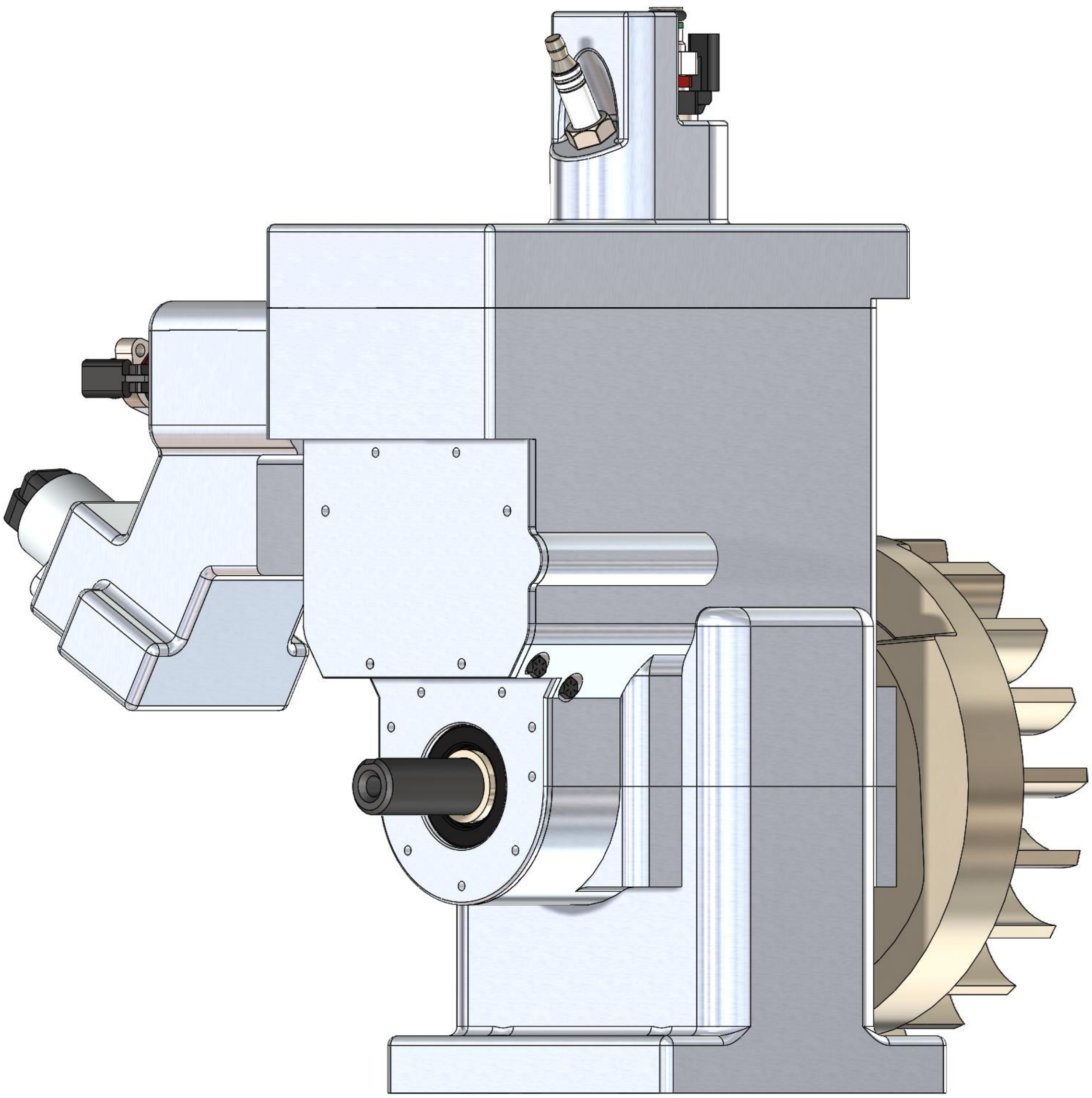
During the higher efficiency and warm mode, the primary combustion operates on either SFI or CFI, while the secondary combustion operates on FHCCI.

During the high efficiency power and acceleration mode, the primary combustion remains as SFI or CFI. Secondary ignition occurs through FHCCI at a lean air-fuel mixture condition.

During ultra-high efficiency cruising mode, the primary and secondary combustion both operate on HCCI mode.

When at operating temperature during idling mode, both primary and secondary combustion operate on HCI mode.

Lower emissions are generated due to HCCI and HCI operating modes. Using this technology, multiple engine performance loads can be achieved.



The Nautilus Cycle Enables

- Atomized mixture of fuel, air, EGR and/or water injection (homogenous mix)
- Improved emissions
- Fuel injection
- Eliminate throttle losses
- Lower HCCI compression ratios
- Reduced cost of manufacturing
- Multi load/RPM capabilities
- Increased fuel efficiency
- Achieved cold starting
- Enhanced durability
- Enriched multiphase combustion capabilities

Call-To-Action

Learn more about the Nautilus Cycle – All types of Homogenous Ignition technology at:

www.nautilusengineering.com

Matthew Riley – Chief Executive Officer / Chief Research Scientist

Email: mriley@nautilusengineering.com

About Nautilus Engineering

Nautilus Engineering is comprised of professionals, each with years of experience in technology validation, R&D, advertising, marketing, website development, mechanical and electrical engineering, patent and trademark counsel, CAD design, rapid prototyping, product testing, and manufacturing.

Matthew Riley, inventor of the Nautilus engine and/or his teams have been featured in the following:

- The Wall Street Journal
- The New York Times
- The Wichita Eagle
- The Business Journal
- Automotive Engineering Magazine (SAE)
- SAE.org
- Forbes Magazine
- Motor Trend Magazine
- Autoline.tv with John McElroy (PBS)
- Just Auto
- AutoHarvest.org

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Appendix 1: Compression Ratios and Volumes

Figure 5: Volume of combustion chamber when the piston at BDC

Primary Compression Ratio: 2.533:1, $CR = \frac{0.677 in^3}{0.267 in^3} = 2.533:1$

Table 5: Measured volume of combustion chamber while the piston is at BDC.

Total Surface Area	76.300 in^2
Center of Volume	(-2.154,5.658,10.445) in
Volume	14.455 in^3
Principal Moment and Axis	13.017 in^5 (0.00001, 0.90345, -0.4287)
Principal Moment and Axis	23.410 in^5 (-0.00011,0.4287,0.90345)
Principal Moment and Axis	25.256 in^5 (1,0.00004, 0.00011)
Known Relative Accuracy %	0.02

Figure 6: Volume of combustion chamber when piston at TDC

Secondary Compression Ratio: 8.852 to 1, $SCR = \frac{14.455 in^3}{1.633 in^3}$**=8.852: 1**

Table 6: Measured volume of combustion chamber while the piston is at TDC.

Total Surface Area	37.486 in^2
Center of Volume	(-2.154,3.692, 11.531) in
Volume	1.633 in^3
Principal Moment and Axis	0.423 in^5 (0, 0.9997, -0.02464)
Principal Moment and Axis	3.637 in^5 (1,0,0)
Principal Moment and Axis	4.037 in^5 (0,0.02464, 0.9997)
Known Relative Accuracy %	0.002

Appendix 2: Applicable Sensors/Hardware/Controllers

Sensor/ Controllers	Use
Air Temperature Sensor	Varies resistance based on temperature. As temperature increases, resistance decreases.
Cam Position Sensor	Used to monitor the cam position or rotational speed of the camshaft.
Crankshaft Position Sensor	Used to monitor the position or rotational speed of the crankshaft.
Engine Temperature Sensor	Used to measure the internal combustion chamber temperature.
Exhaust Gas Recirculation Valve	NOx emissions reduction technique used in gasoline and diesel engines.
Fuel Injectors	Used to control fuel delivery.
Idle Air Control Motor	Used to control the engine’s idling RPM.
MAP (Manifold Absolute Pressure) Sensor	Used to measure the amount of air density flowing through the intake manifold.
Mass Airflow Sensor	Used to calculate the mass flow rate of air entering the fuel injected internal combustion engine. Air mass data is required for the engine control unit (ECU) to balance and deliver the correct fuel mass to the engine during the intake stroke.
Oxygen Sensor (O2)	Used to measure the exhaust gas concentration.
Pressure Transducers	Used to measure in-cylinder and block pressures.
Pre-heater	Used to heat air before entering the combustion chamber. This is done to increase thermal efficiency of the process.
Throttle Position Sensor	Used to monitor the throttle position.
Temperature Sensor	Used to measure temperature outside of the block.
Throttle Actuation Motor	Used to actuate throttle control.
Spark plug/Ignition system	Used to control ignition timing.