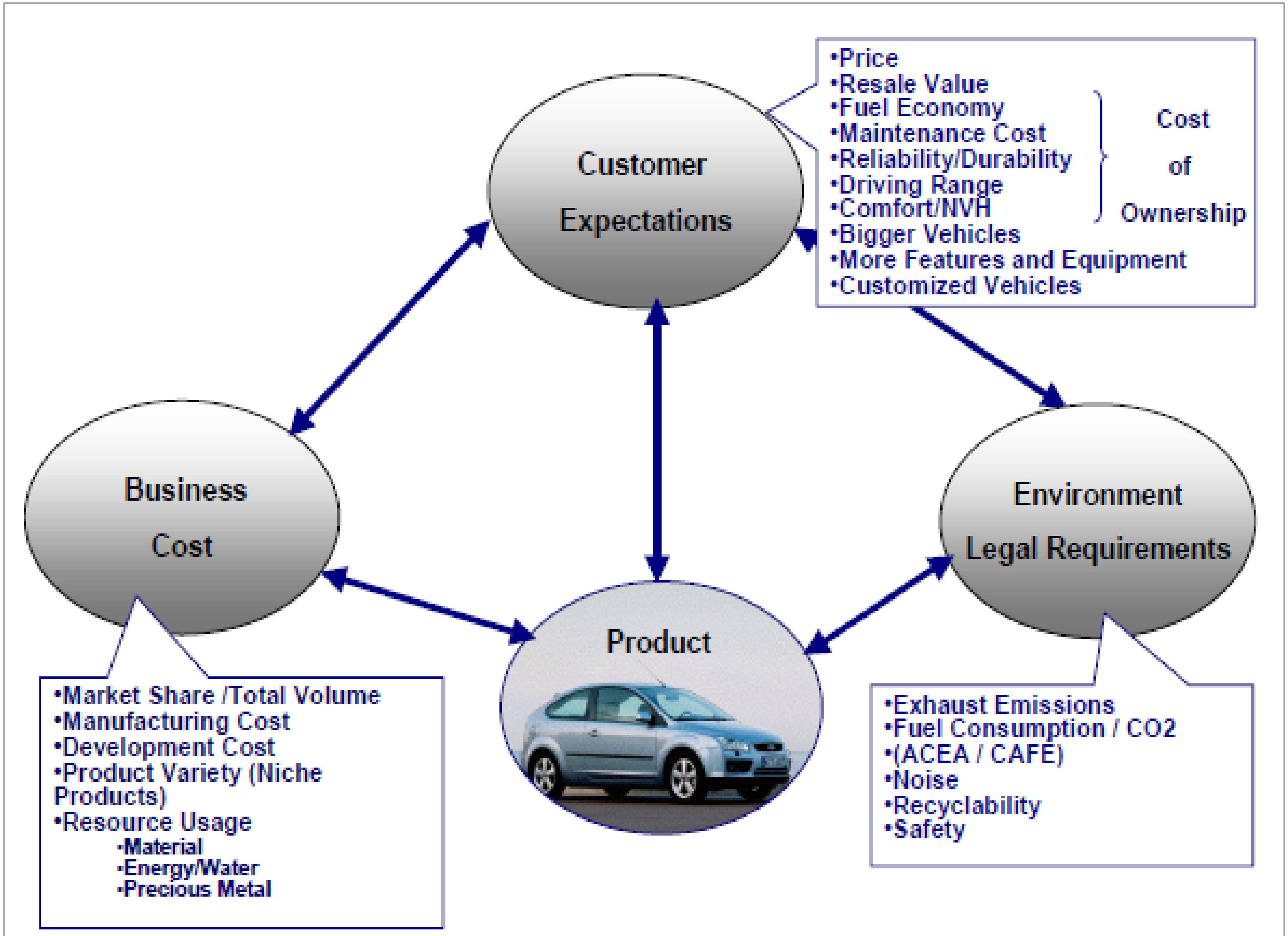
The Trend in Internal Combustion Engine

NAZARUDDIN SINAGA
Laboratorium Efisiensi dan Konservasi Energi
Universitas Diponegoro


Customer Expectations
•Price
•Resale Value
•Fuel Economy
•Maintenance Cost
•Reliability/Durability
•Driving Range
•Comfort/NVH
Cost of Ownership
•Bigger Vehicles
•More Features and Equipment
•Customized Vehicles
Business Cost
•Market Share /Total Volume
•Manufacturing Cost
•Development Cost
•Product Variety (Niche Products)
•Resource Usage
•Material
•Energy/Water
•Precious Metal
Product
Environment Legal Requirements
•Exhaust Emissions
•Fuel Consumption / CO2
•(ACEA / CAFE)
•Noise
•Recyclability
•Safety

Will the internal combustion engine be able to cope with these challenges also in the future?

- Exhaust emission
- Fuel Economy
- Safety
- Noise and vibration

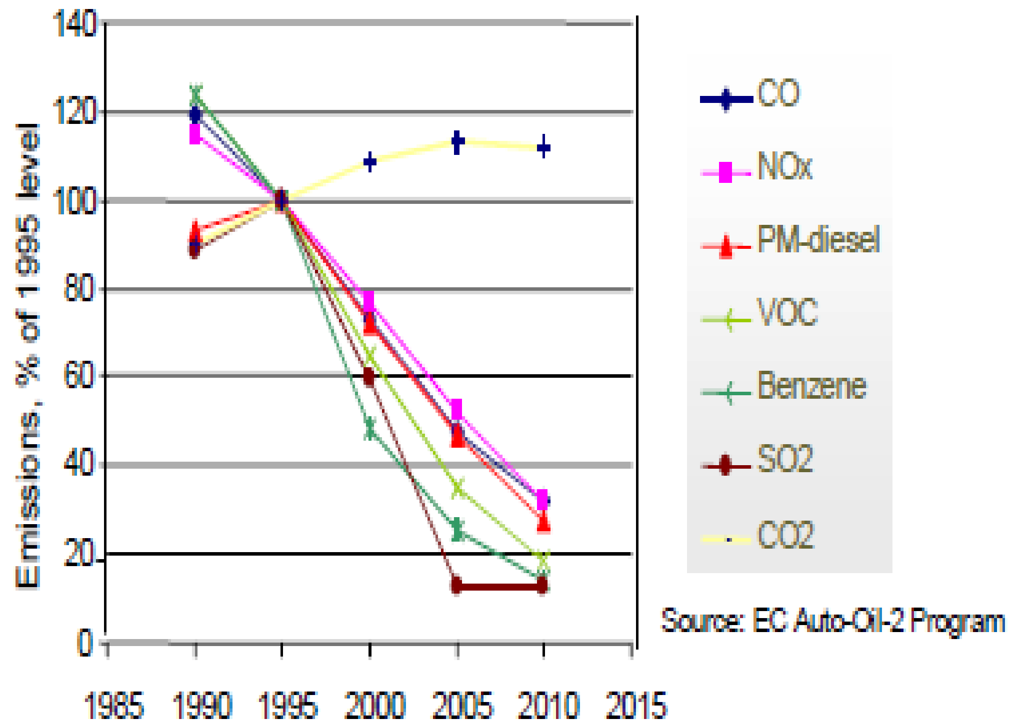
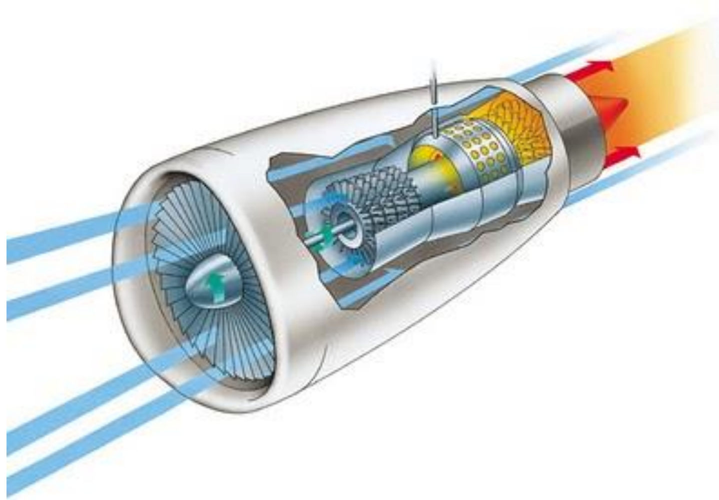


Figure 3: Road Transport Emission Trend

The Internal Combustion Engine

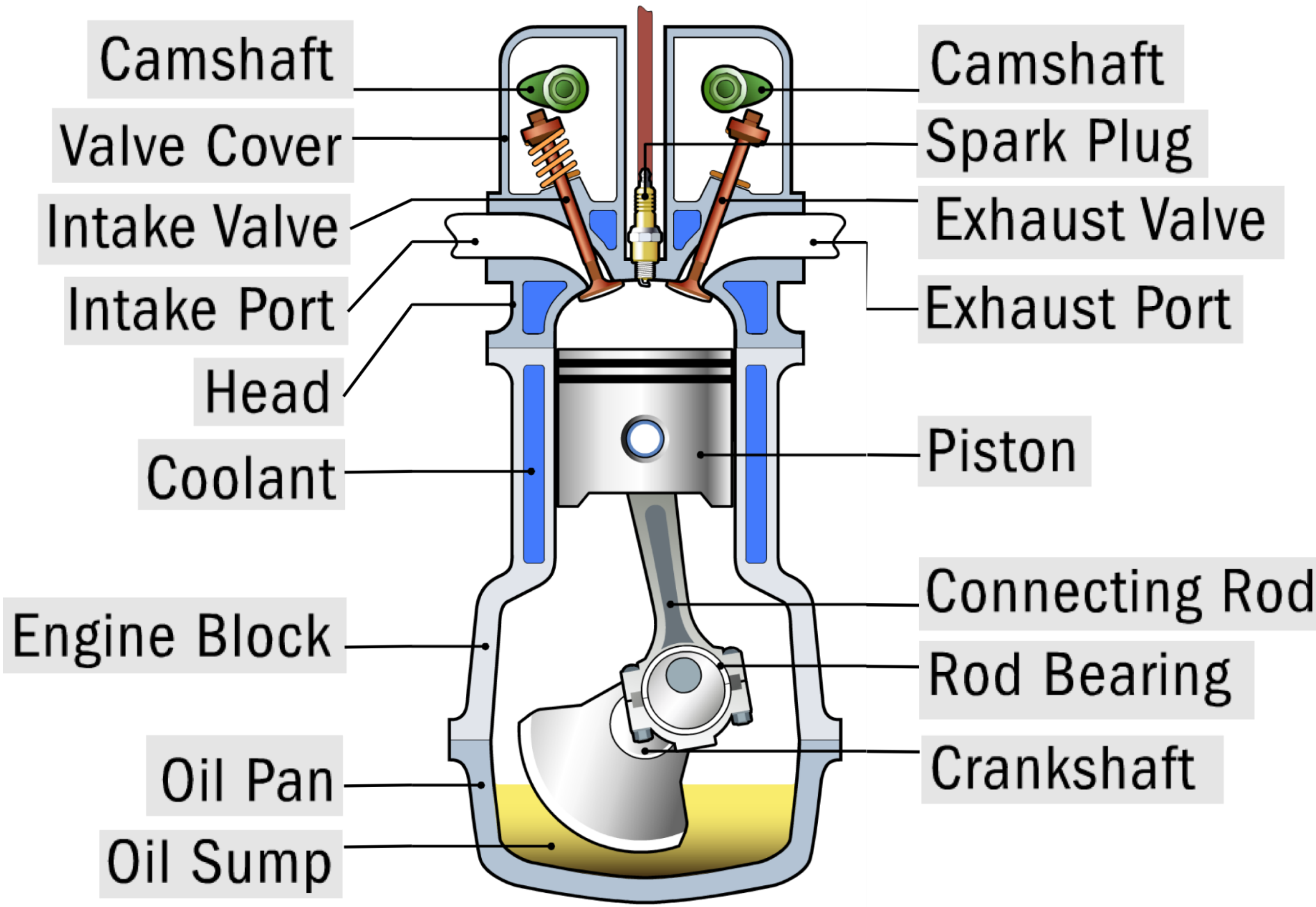


Piston engine

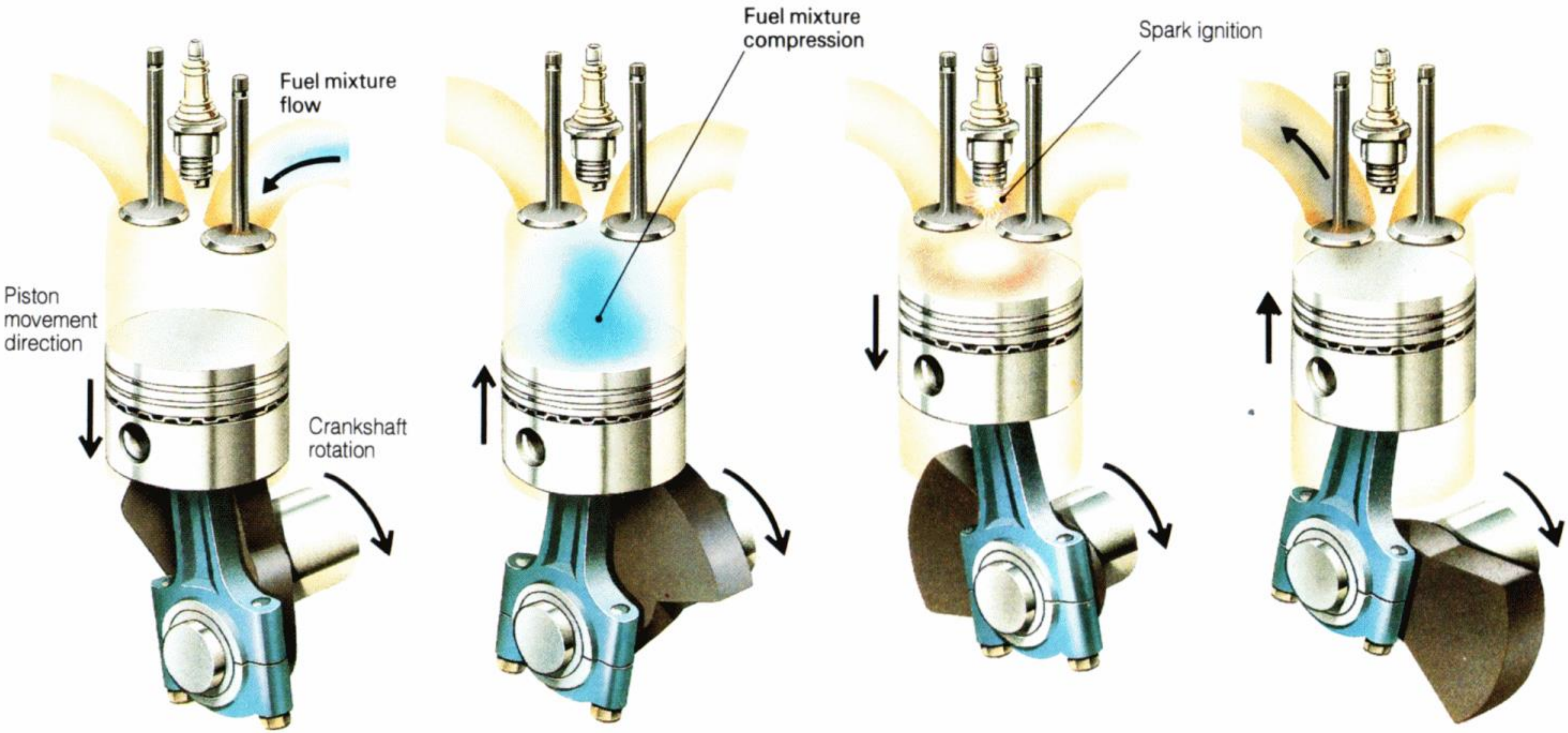
Jet engine

Rocket engine

Piston Engine- Basic Components



The 4-Stroke Cycle



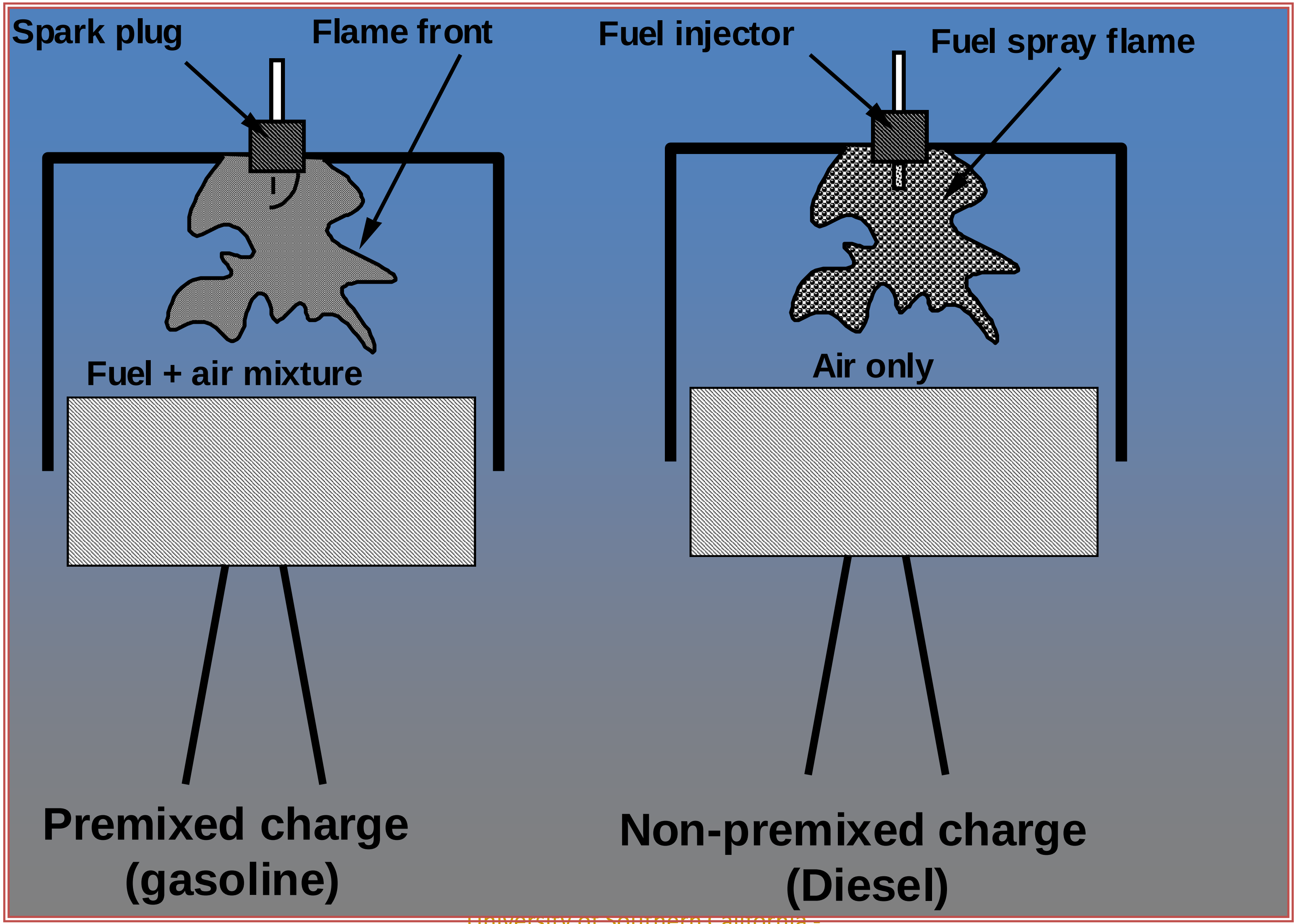
On the induction stroke the piston is descending, the inlet valve is fully open and the exhaust valve closed.

As the piston rises on its compression stroke the exhaust valve is still closed and the inlet valve is closing.

The power stroke drives the piston downwards as the ignited gases expand. Both the inlet and exhaust valves are closed.

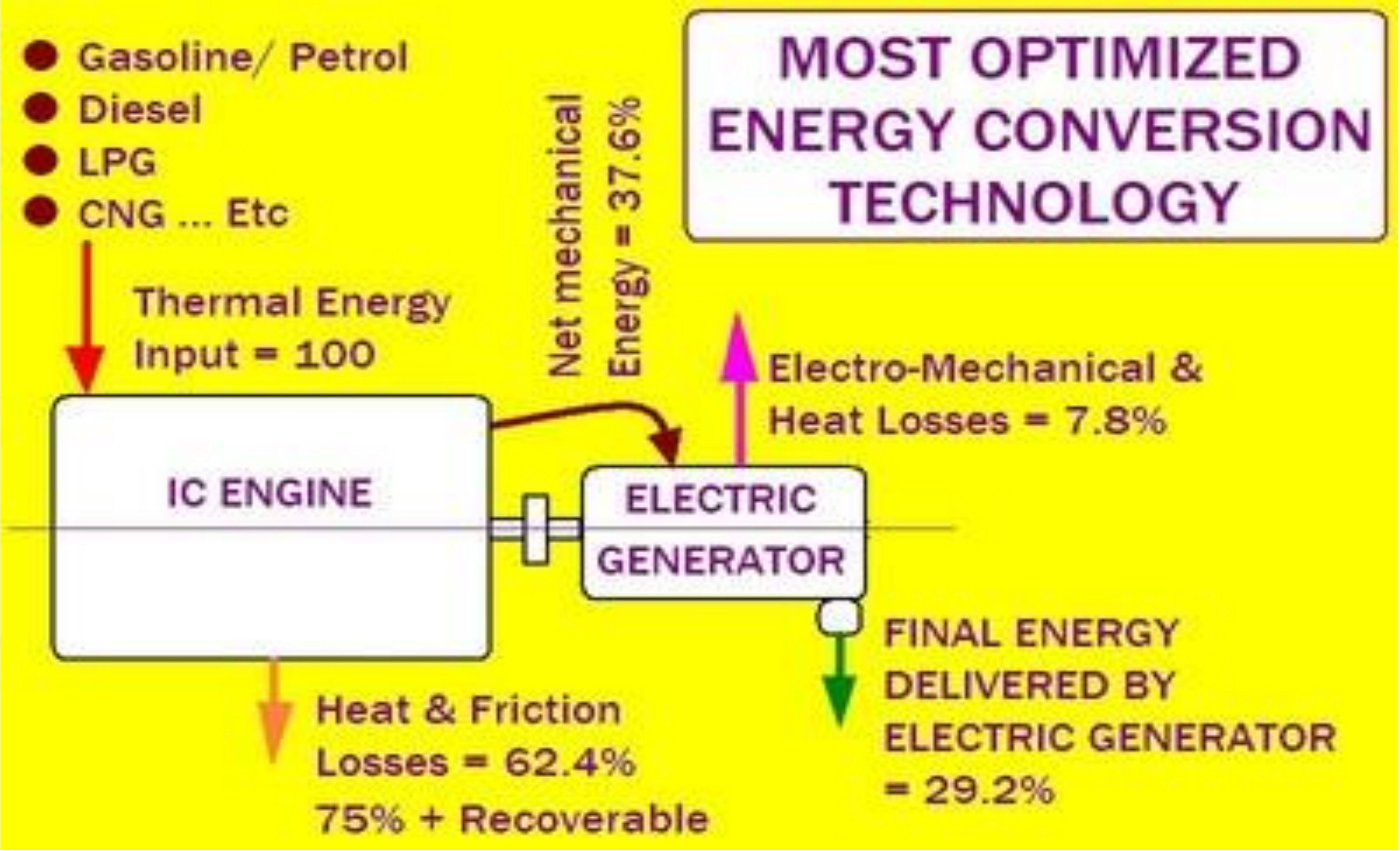
The hot gases in the cylinder escape through the open exhaust valve as the piston rises again for the exhaust stroke.

Premixed vs. non-premixed charge

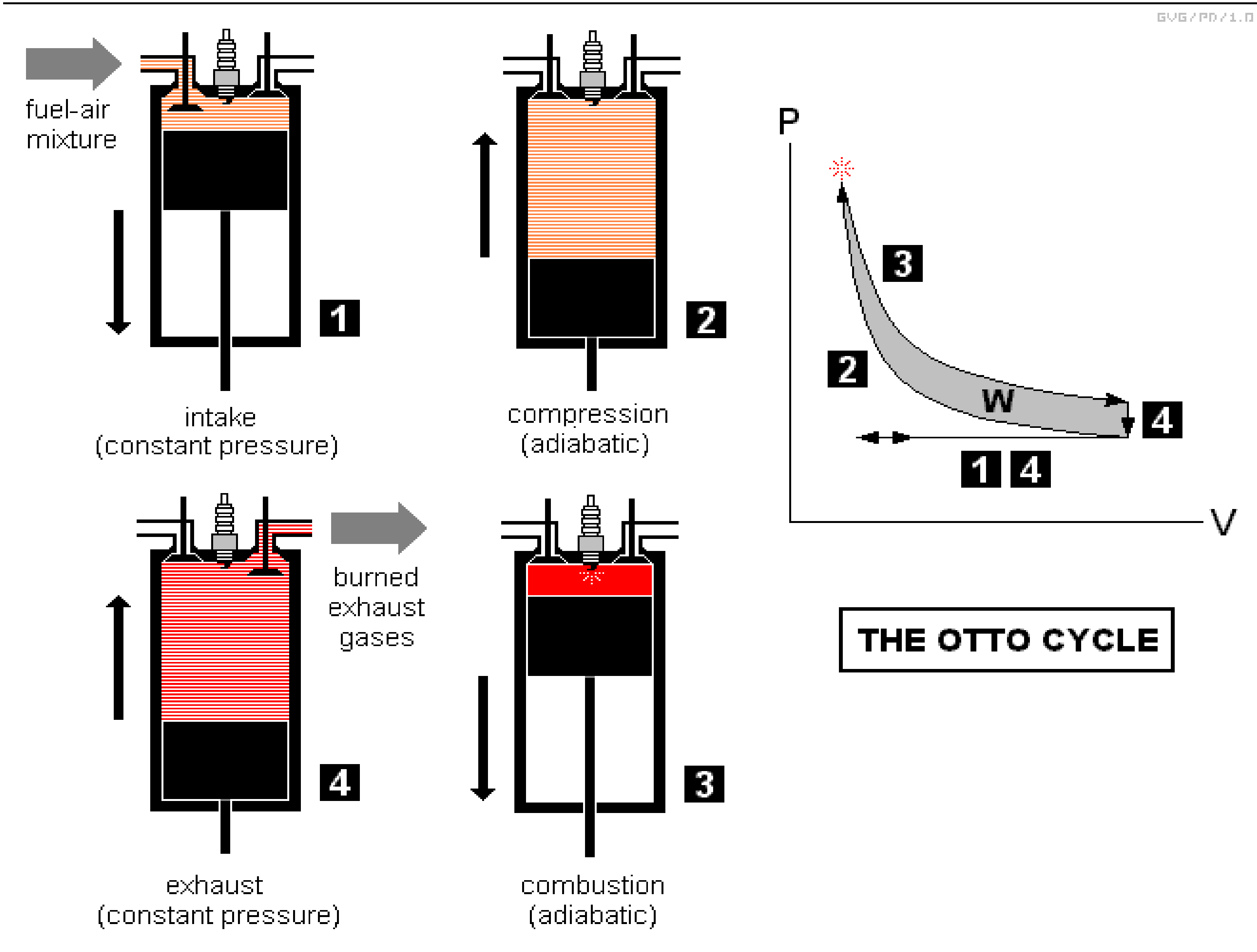


CONTINUE

I.C ENGINE



OTTO CYCLE



GVG/PD/1.0
fuel-air
mixture
1
intake
(constant pressure)
2
compression
(adiabatic)
P
3
2
W
4
1
4
V
THE OTTO CYCLE
burned
exhaust
gases
4
exhaust
(constant pressure)
3
combustion
(adiabatic)

CONTINUE

Engine Thermodynamic Analysis

Ideal Otto Cycle

Glenn Research Center

c_v = Specific Heat constant volume

γ = Specific Heat Ratio

p = pressure

T = Temperature

V = Volume

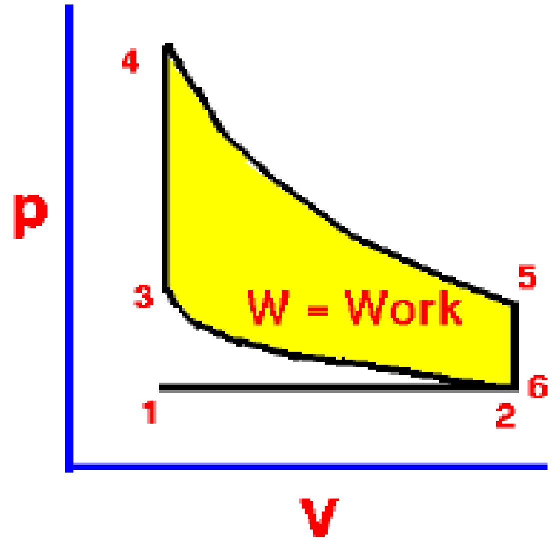
f = fuel / air ratio

Q = Fuel heating value

c p s = cycles per second

P = Power

$V_2 / V_3 = r$ = Compression Ratio



Compression Stroke:

$$p_3 / p_2 = r^{\gamma}$$
$$T_3 / T_2 = r^{\gamma - 1}$$

Combustion:

$$T_4 = T_3 + f\,Q / c_v$$
$$p_4 = p_3\,(T_4 / T_3)$$

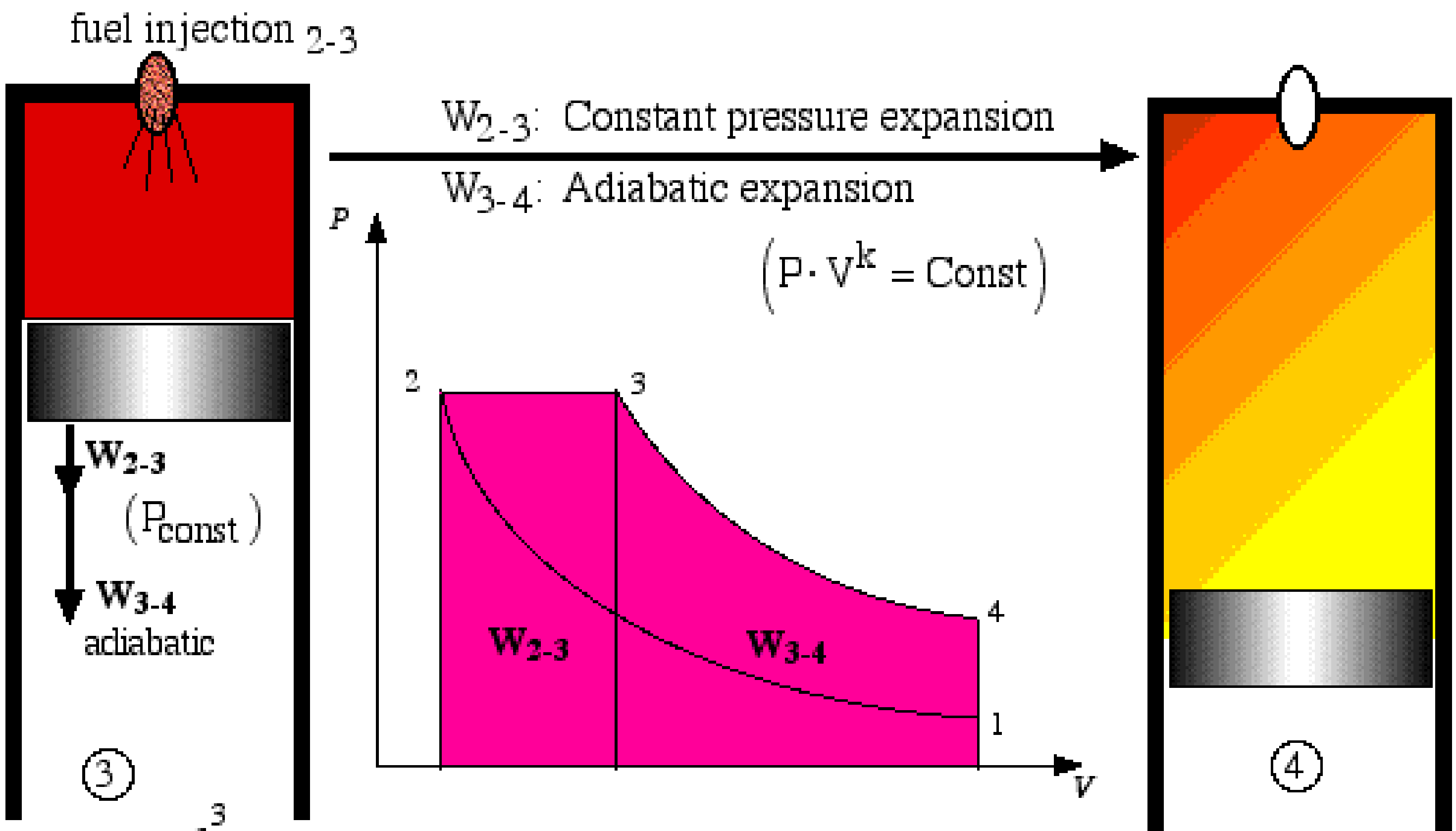
Power Stroke:

$$p_5 / p_4 = r^{-\gamma}$$
$$T_5 / T_4 = r^{1 - \gamma}$$

Work per cycle: $W = c_v[(T_4 - T_3) - (T_5 - T_2)]$

Engine Power: $P = W \text{ cps}$

DIESEL CYCLE



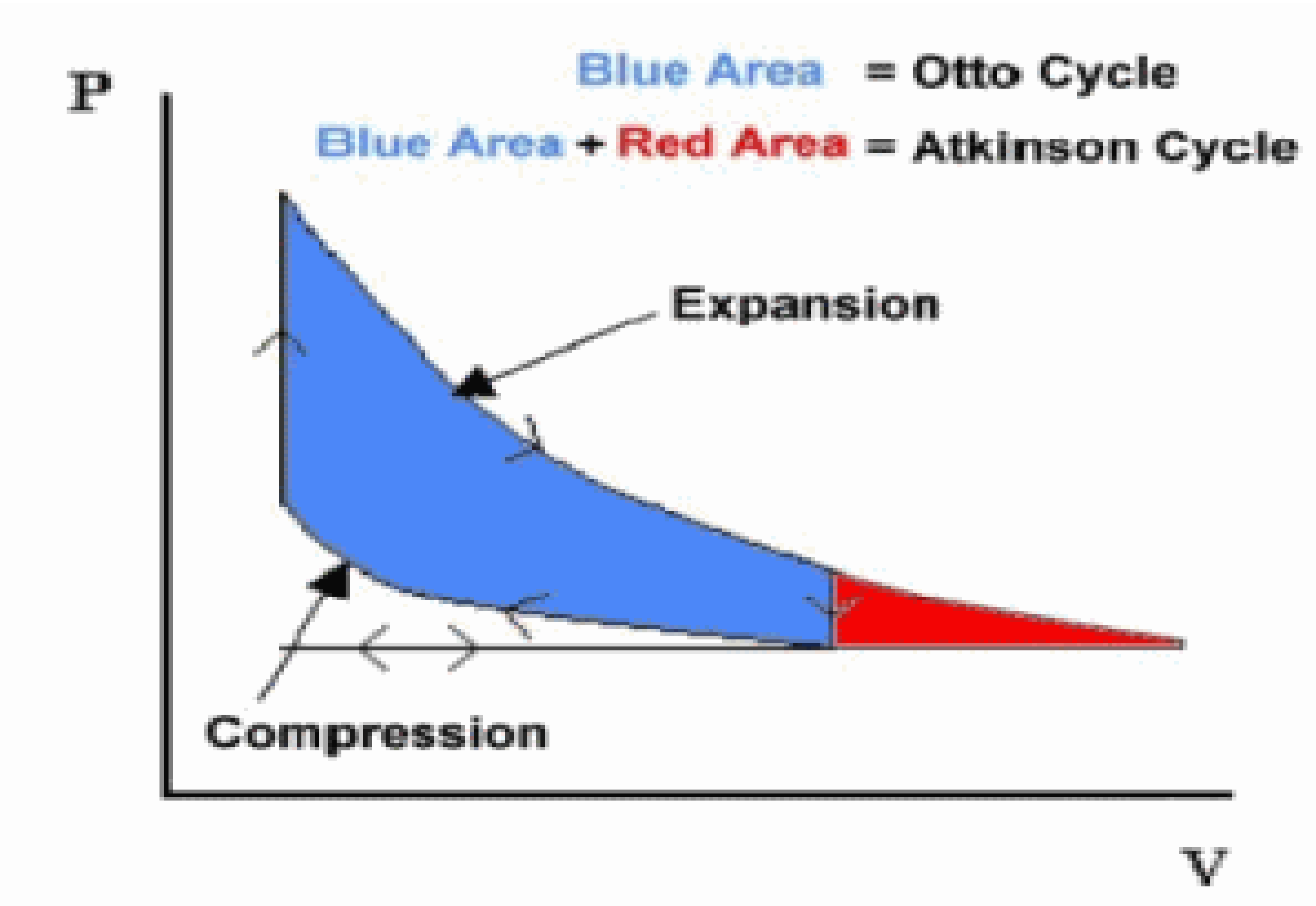
$$W_{2-3} = \int_2^3 P\,\mathbf{d}V = P_2 \cdot (V_3 - V_2)$$

$$Q_{3-4} - W_{3-4} = m \cdot \Delta u = m \cdot C_v \cdot \Delta T \;\Rightarrow\; W_{3-4} = m \cdot C_v \cdot (T_3 - T_4)$$

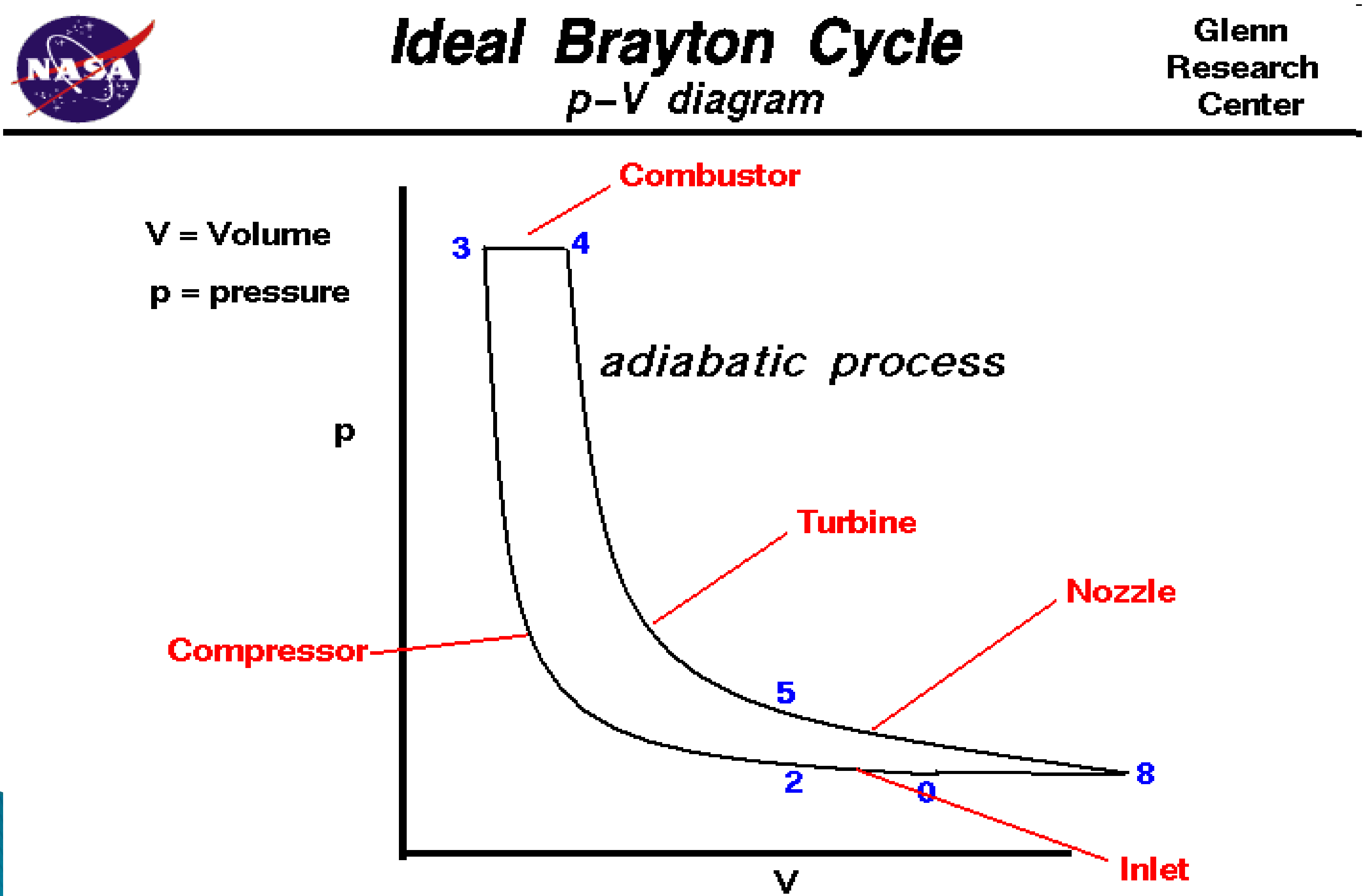
adiabatic

$$W_{exp} = W_{2-3} + W_{3-4}$$

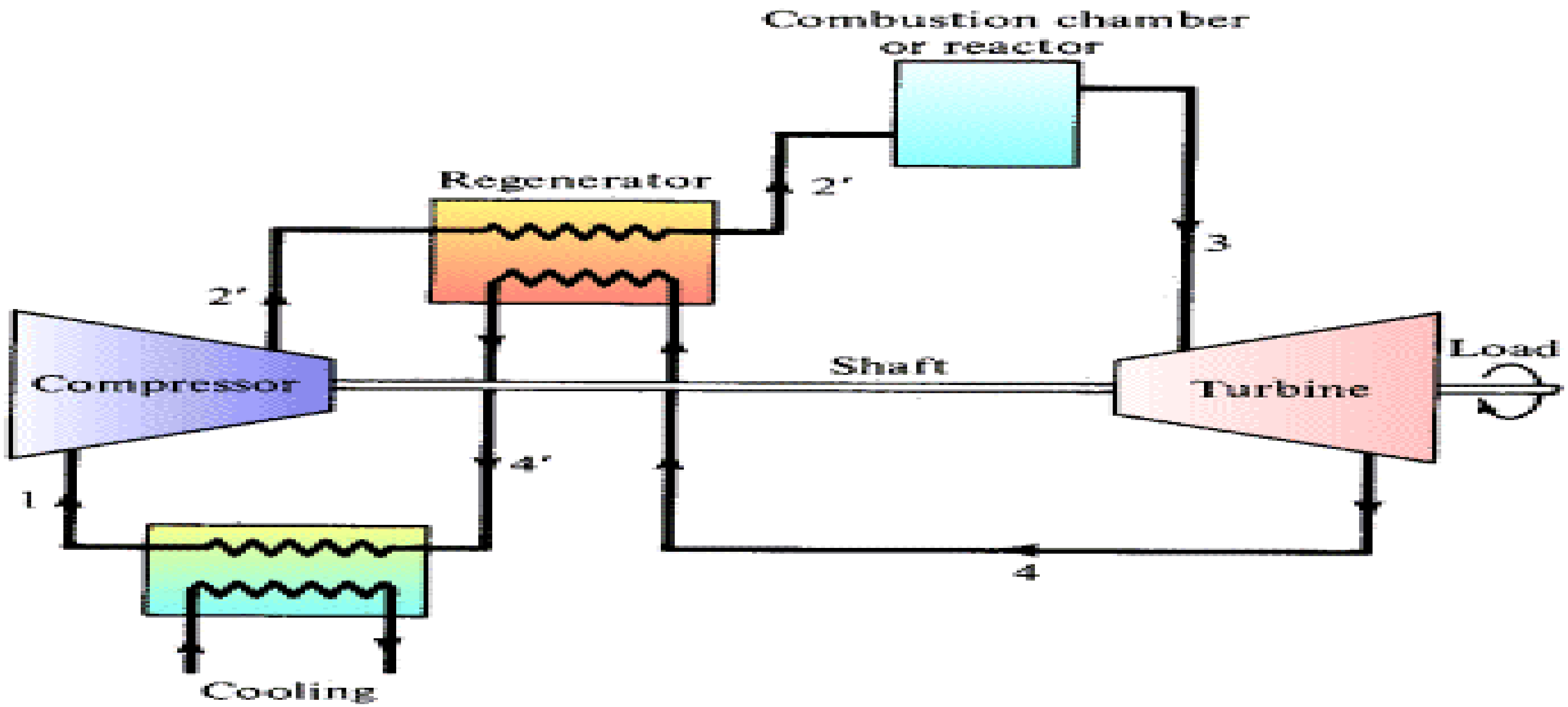
ATKINSON CYCLE

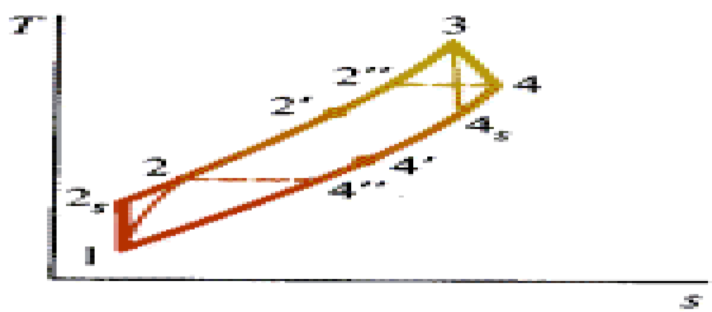


JOULE OR BRAYTON



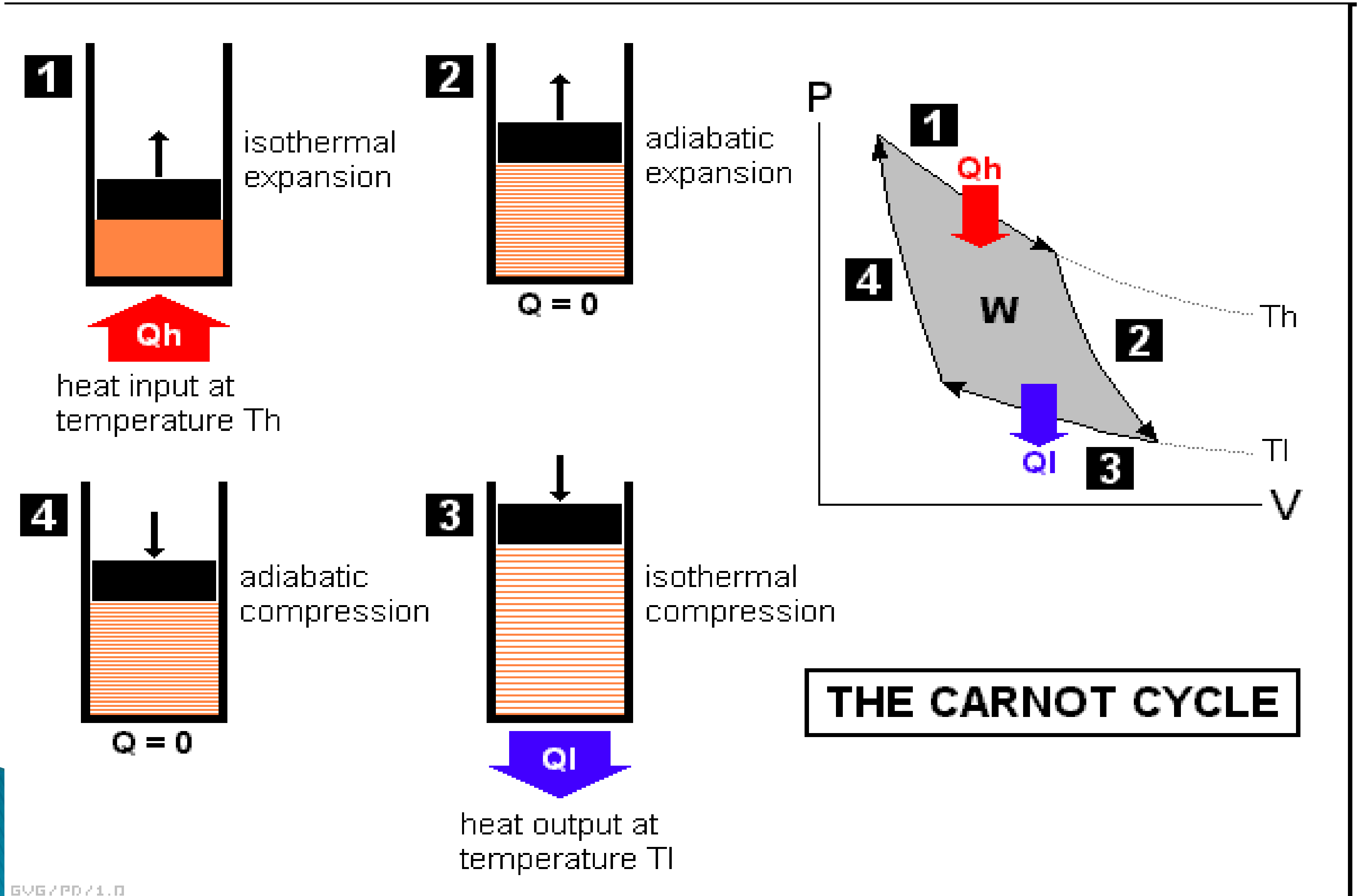
CONTINUE
BRAYTON CYCLE ENGINE



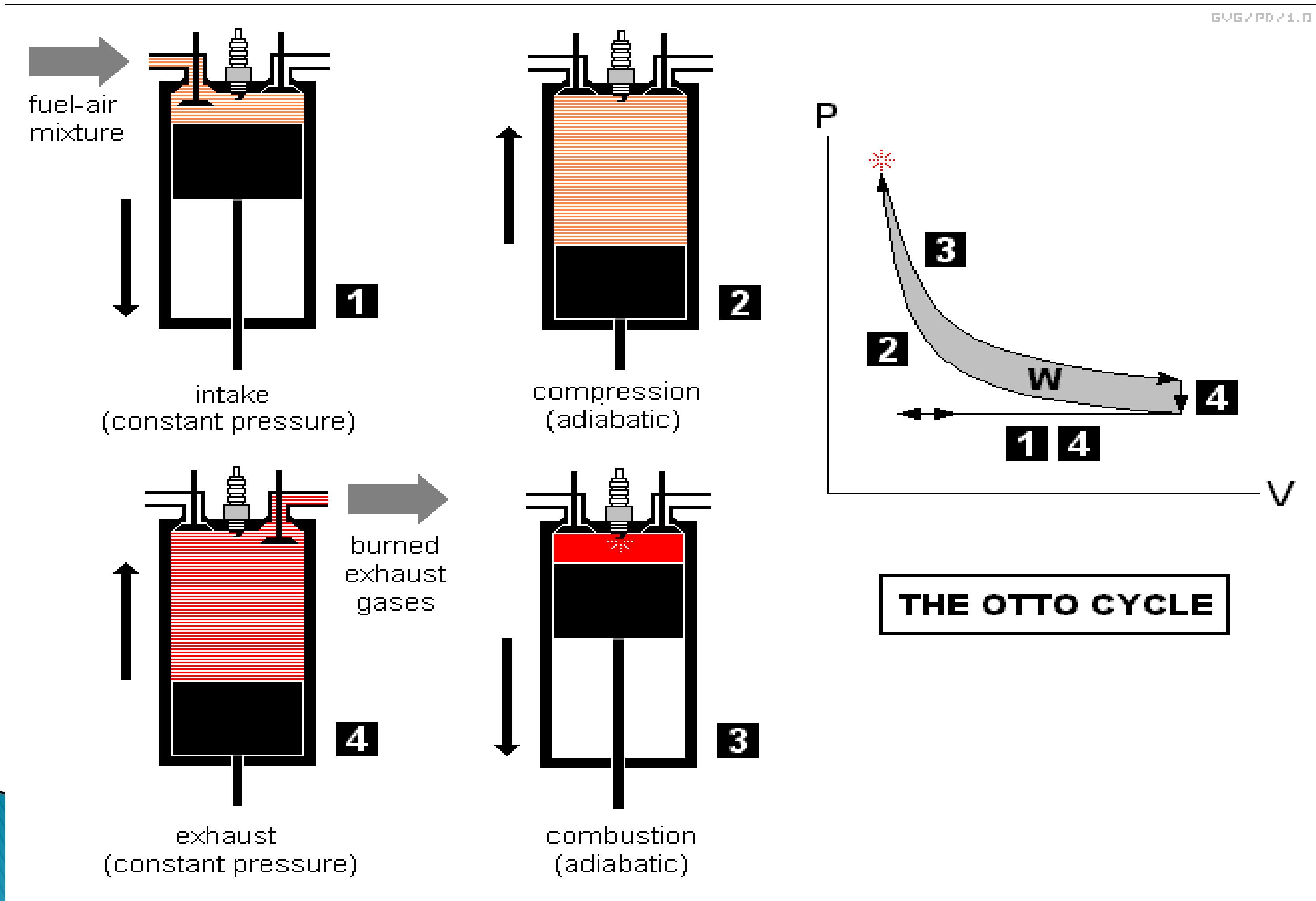


S.S.'2000

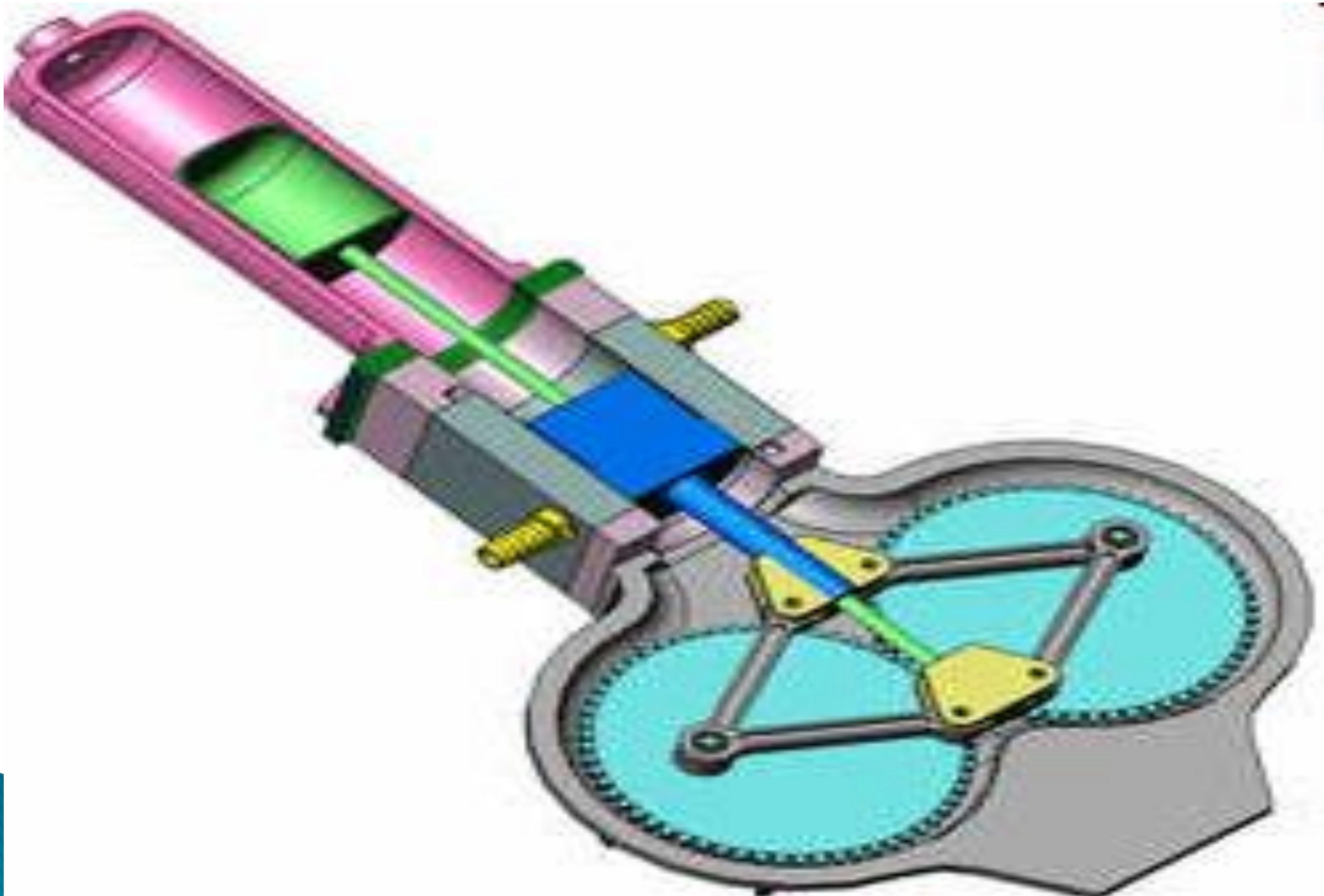
CARNOT CYCLE



OTTO CYCLE


GVG/PD/1.0
fuel-air
mixture
1
intake
(constant pressure)
2
compression
(adiabatic)
P
3
2
W
4
1 4
V
THE OTTO CYCLE
burned
exhaust
gases
4
exhaust
(constant pressure)
3
combustion
(adiabatic)

CONTINUE
SECTION VIEW OF
SRILING ENGINE



CLASSIFICATION OF FUEL INTAKE SYSTEMS

FUEL INTAKE SYSTEMS

- **CARBURATOR**
- **FUEL INJECTON SYSTEMS**
  - **THROTTLE BODY IGNITION (TBI)**
  - **MULTI-POINT INJECTION (MPFI)**

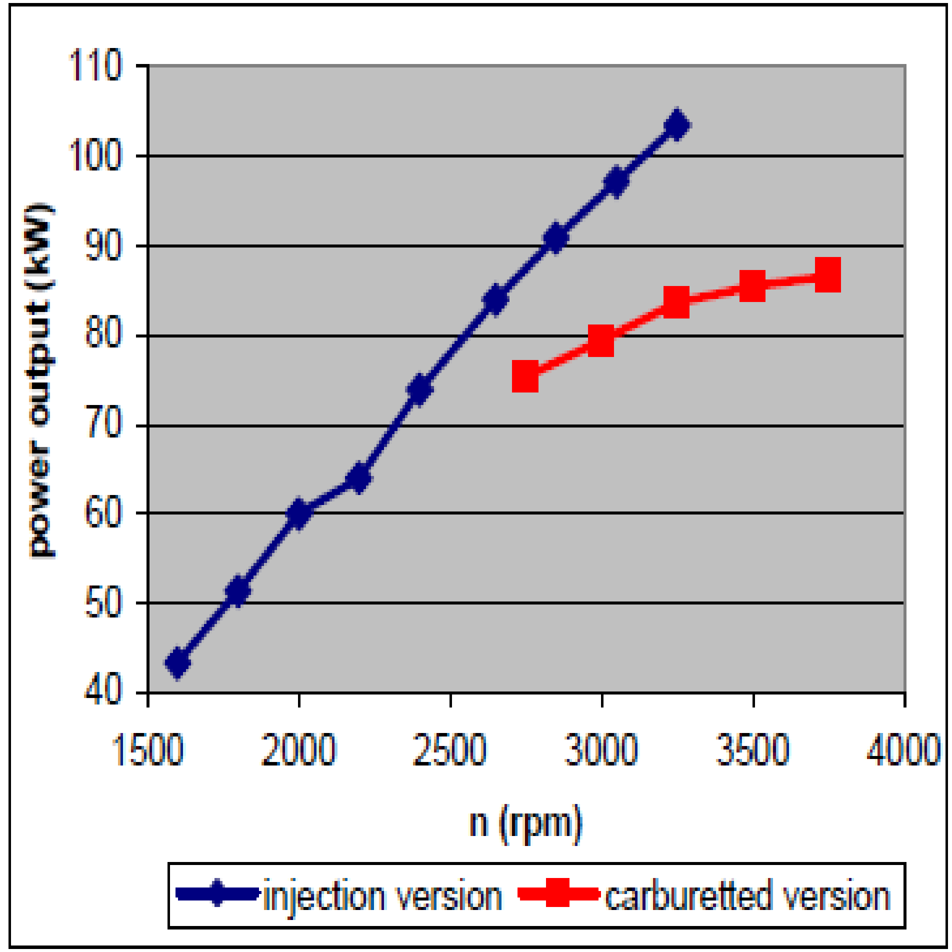
Current solutions

Direct fuel Injection

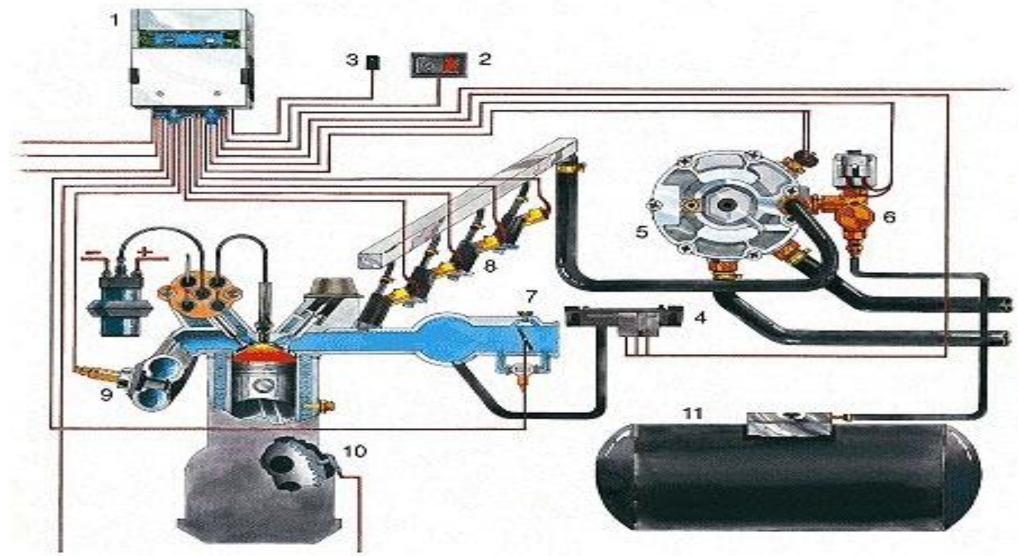
Direct injection is where fuel is injected (directly) into the cylinders, not mixed with air in the inlet manifold or inlet ports before being drawn into the cylinders.

Advantages of Direct fuel injection

- Due to multiple injections, uniform A/F mixture supplied to cylinder; thus difference in power developed in each cylinder is minimum. Noise and Vibration from the engine is less.
- Since the engine is controlled by ECU, accurate A/F mixture supplied resulting in complete combustion leading to effective utilization of fuel supplied and hence low emission level.



Some of the types of direct injection systems

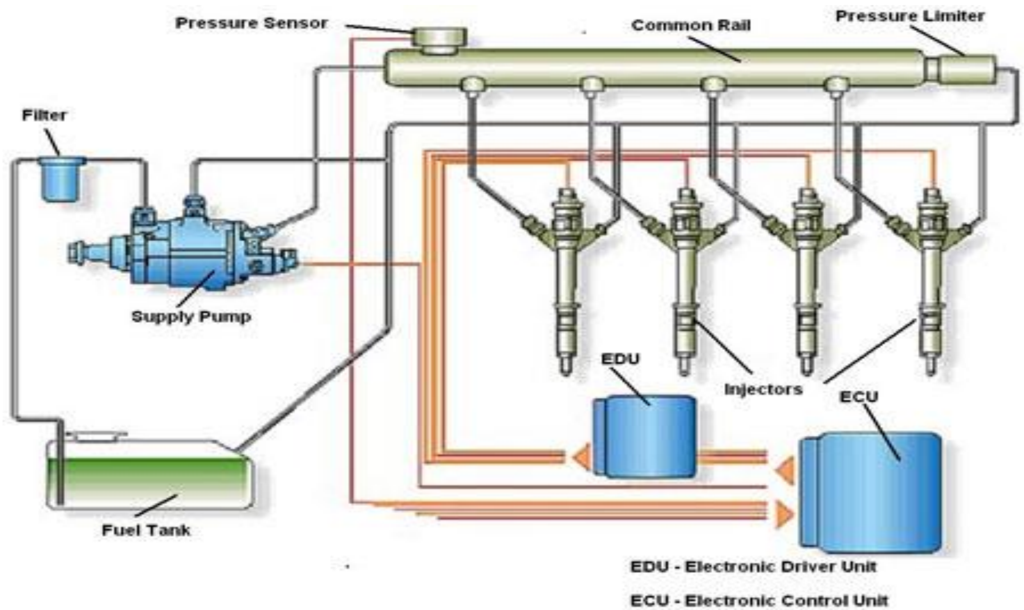


- **MPFi Engine**

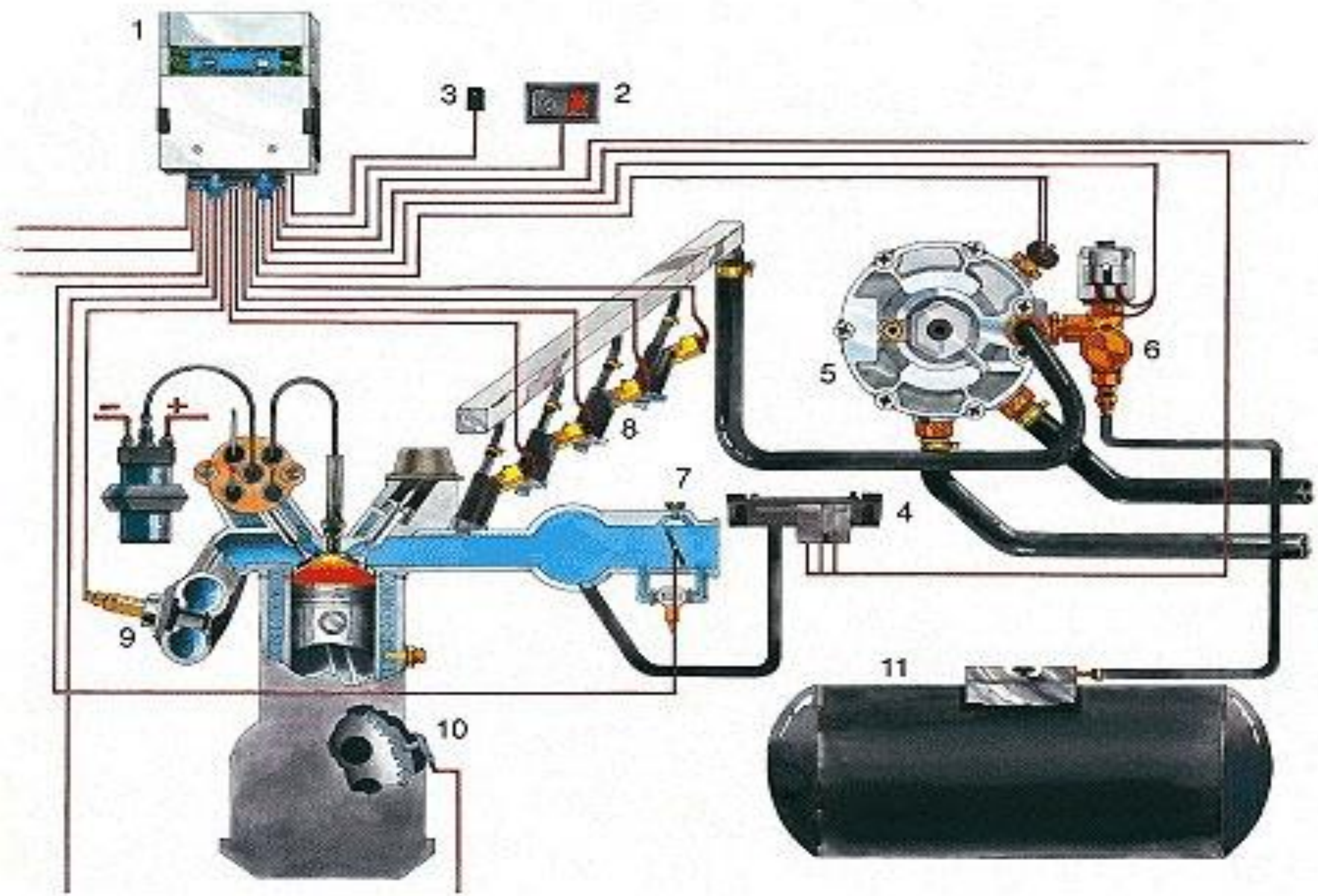
Multi Point Fuel Injection system. In this system each cylinder has number of injectors to supply/spray fuel into the cylinders .

- **CRDi Engine**

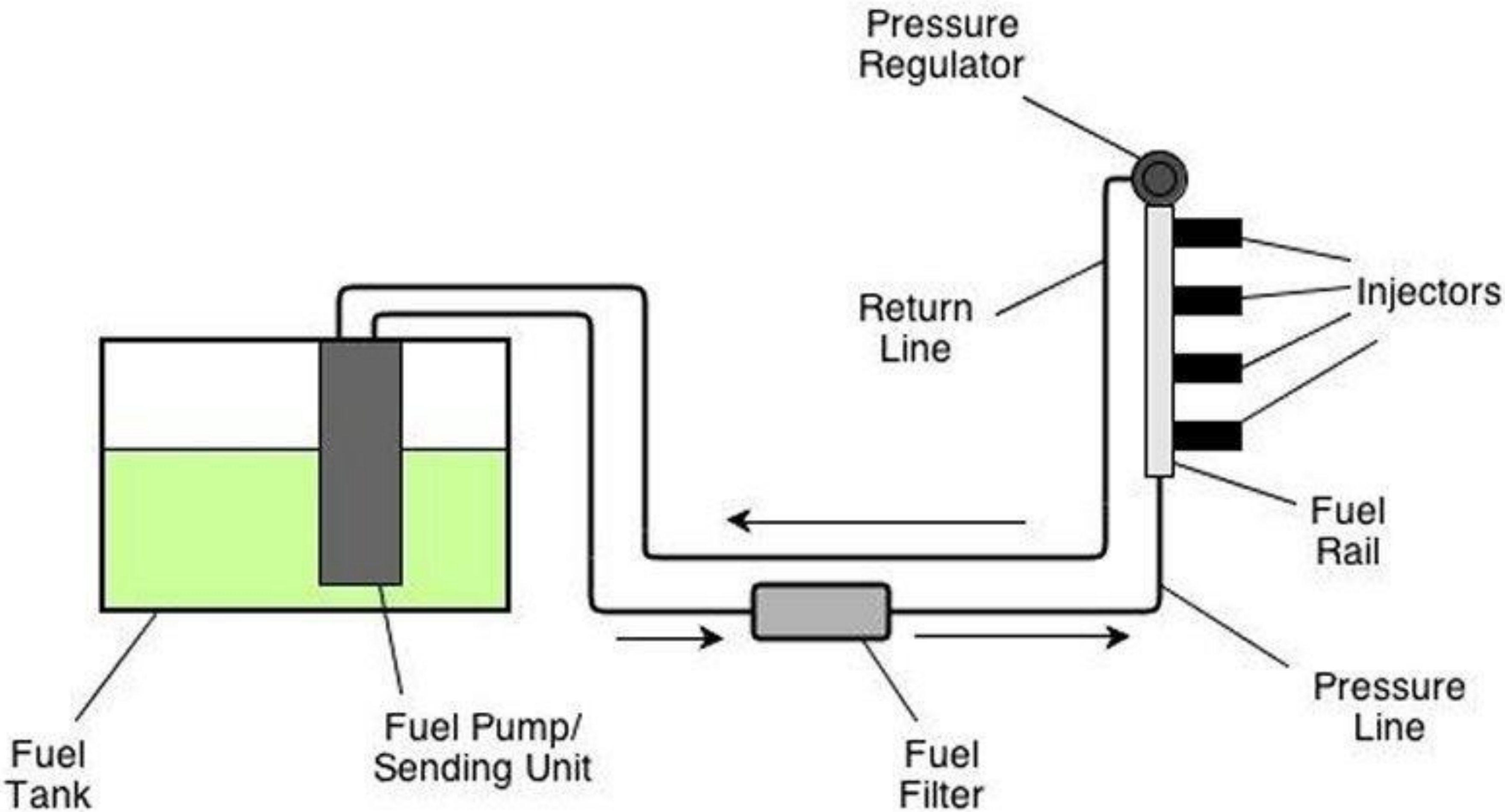
Common Rail Direct injection system. In this system, all the injectors are supplied by a common fuel supply line or a manifold called the common rail.



Bifuel System (Gasoline-Gas)



Multi-port Fuel Injection



DEFINTION AND COMPONENTS

- **DEFINITON:**
- M.P.F.I: stands of multi-point fuel injection system wherein fuel is injected into individual cylinders based on commands from the 'on board engine management system computer' – popularly known as the ***Engine Control Unit*** (ECU).
- **COMPONENTS:**
- FUEL TANK
- FUEL PUMP
- FUEL FILTER
- INJECTORS
- INTAKE MANIFOLD
- FUEL LINES
- ENGINE CONTROL UNIT (ECU)
- RELAY SYSTEMS

CLASSIFICATION OF MPFI SYTEM

M.P.F.I

SEQUENTIAL
(Direct injection into Individual cylinders Against their suction Strokes)

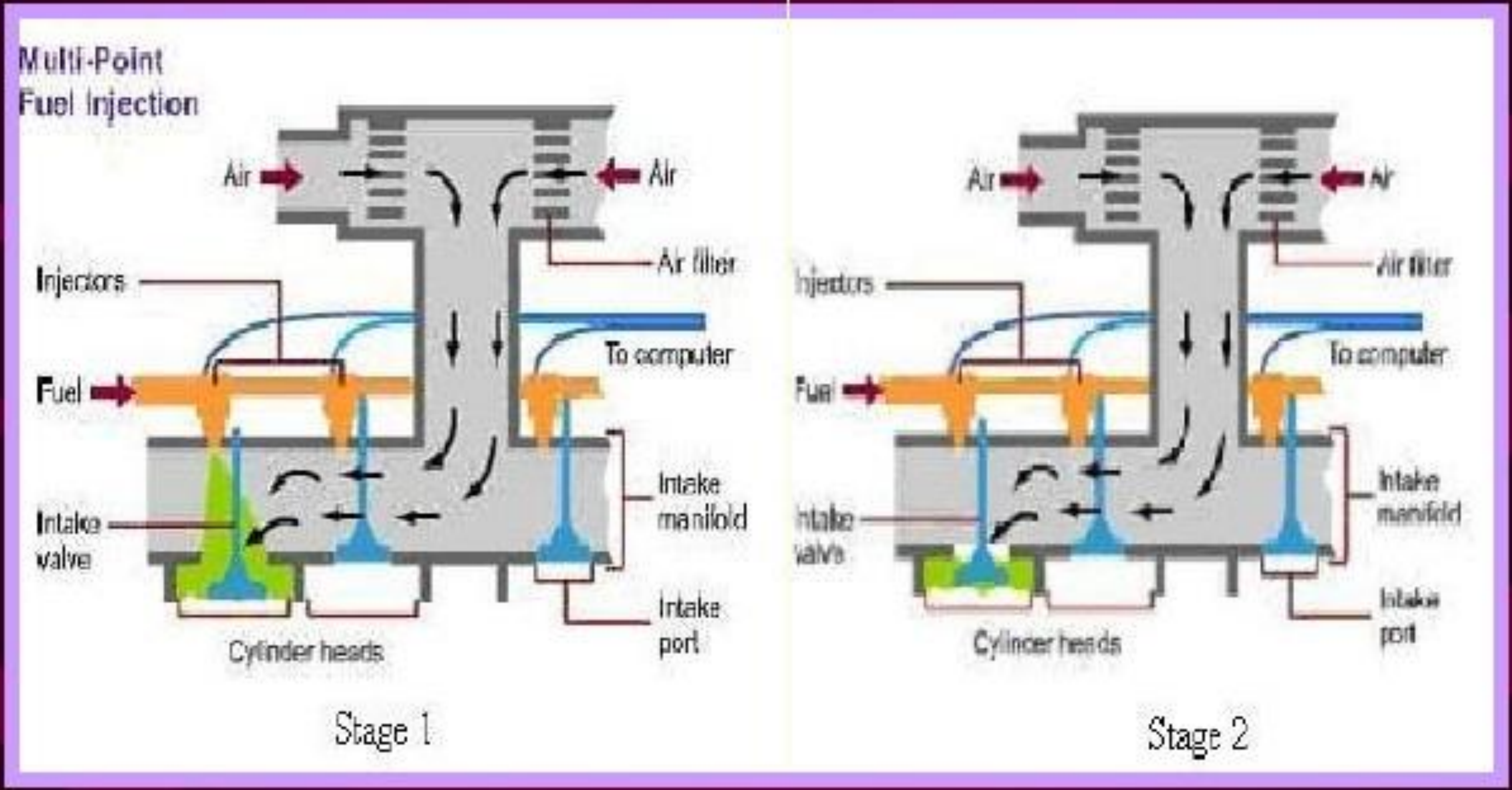
SIMULTANEOUS
(together for all the four or what ever the number of Cylinders)

GROUP
(into cylinder-pairs)

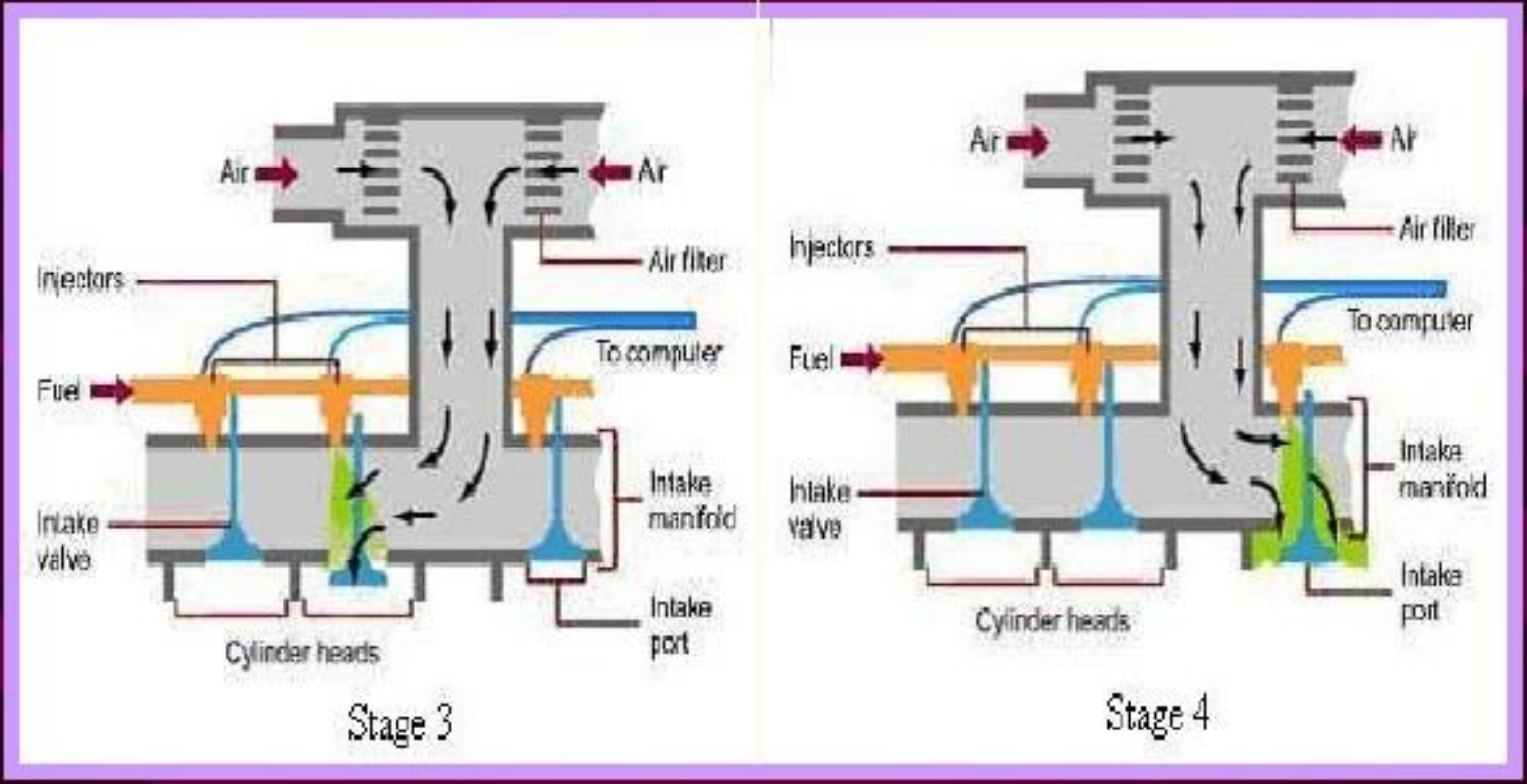
Examples:

SEQUENTIAL: ford icon, hundai, maruti,
SIMULTANEOUS\GORUP: cielo, matiz
SINGLE POINT INJECTION: older opel astra

STAGES (I & II)


Multi-Point
Fuel Injection
Air
Air
Air filter
Injectors
To computer
Fuel
Intake
manifold
Intake
valve
Intake
port
Cylinder heads
Stage 1
Air
Air
Air filter
Injectors
To computer
Fuel
Intake
manifold
Intake
valve
Intake
port
Cylinder heads
Stage 2

STAGE (III & IV)



Air
Air
Air filter
Injectors
To computer
Fuel
Intake manifold
Intake valve
Intake port
Cylinder heads
Stage 3
Air
Air
Air filter
Injectors
To computer
Fuel
Intake manifold
Intake valve
Intake port
Cylinder heads
Stage 4

COMPONENTS OF MPFI SYSTEM

- INJECTORS
- FUEL PUMP
- FUEL FILTER
- FUEL RAIL
- IDLE SPEED CONTROL ACTUATOR
- TRANSAXLE RANGE SWITCH
- DATA LINK CONNECTOR
- SOLENOID VALVE
- RELAY SYSTEM →
- SENSORS →

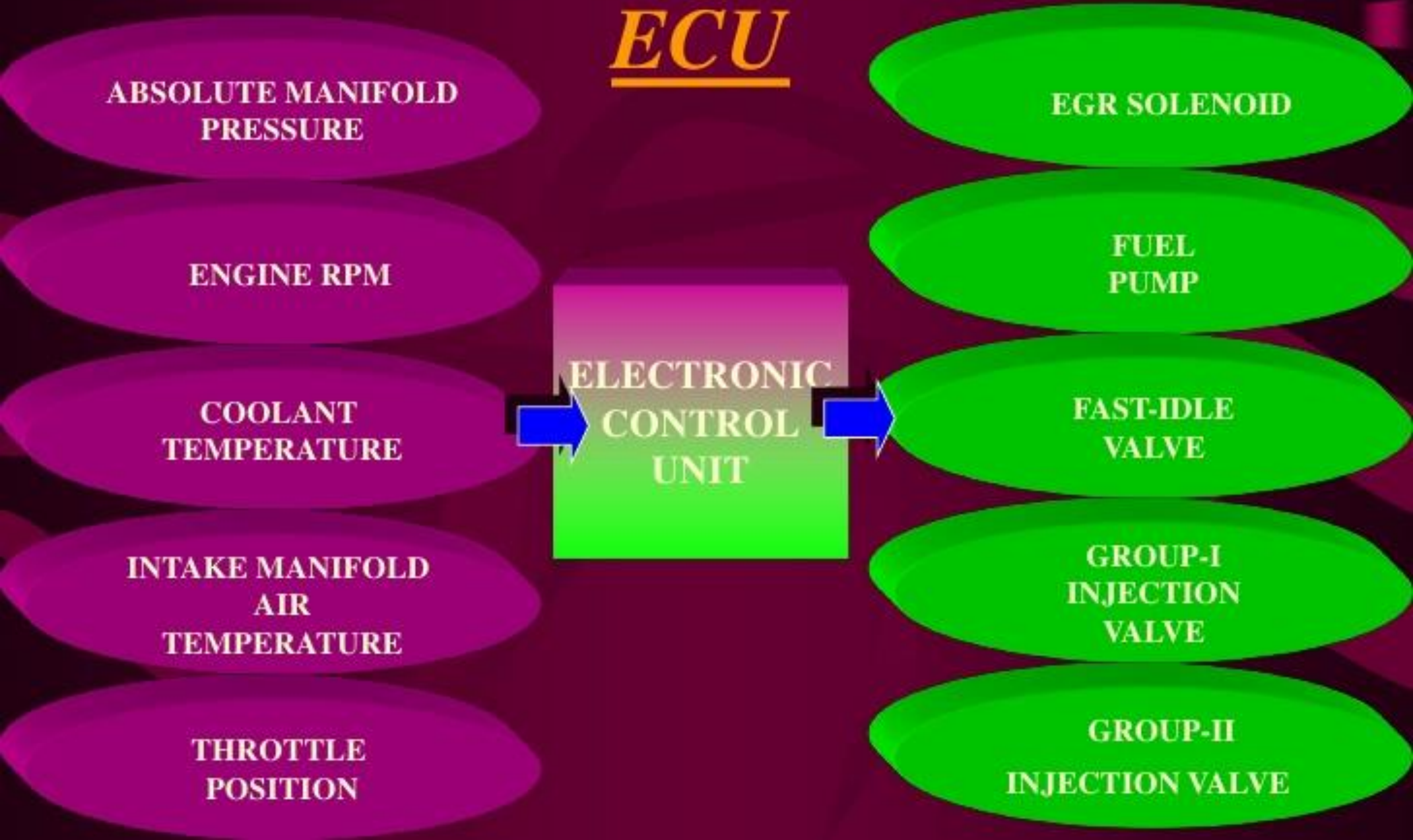
RELAY SYSTEM

- AIR CONDITIONING RELAY
- MFI RELAY

SENSOR SYSTEM

- MAP AND IAT SENSORS
- ECT SENSOR
- CKP AND CMP SENSOR
- OXYGEN SENSOR
- VEHICLE SPEED SENSOR

BLOCK DIAGRAM OF SENSORS PROVIDING INFORMATION TO ECU



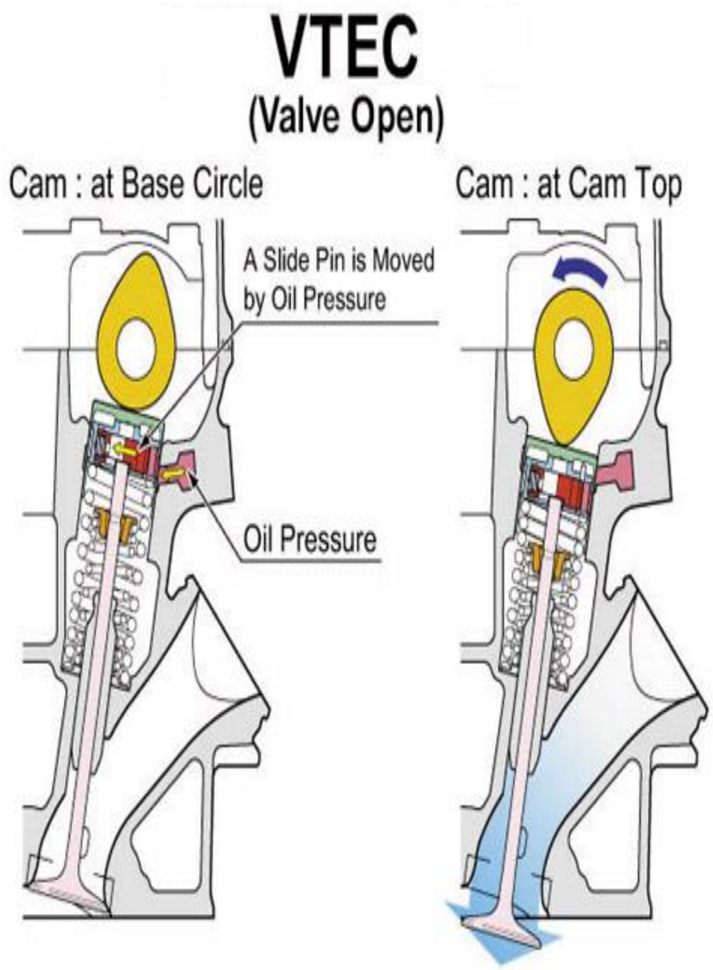
Variable valve timing and lift

Principle is to use a two-position advance or retard of either an engine's intake or exhaust camshaft to better match the engine's operating conditions.Two main factors that determine an I.C engine performance are

- The point at which valves open.
- The duration of the valves being open.

Some of the types of variable valve timing system

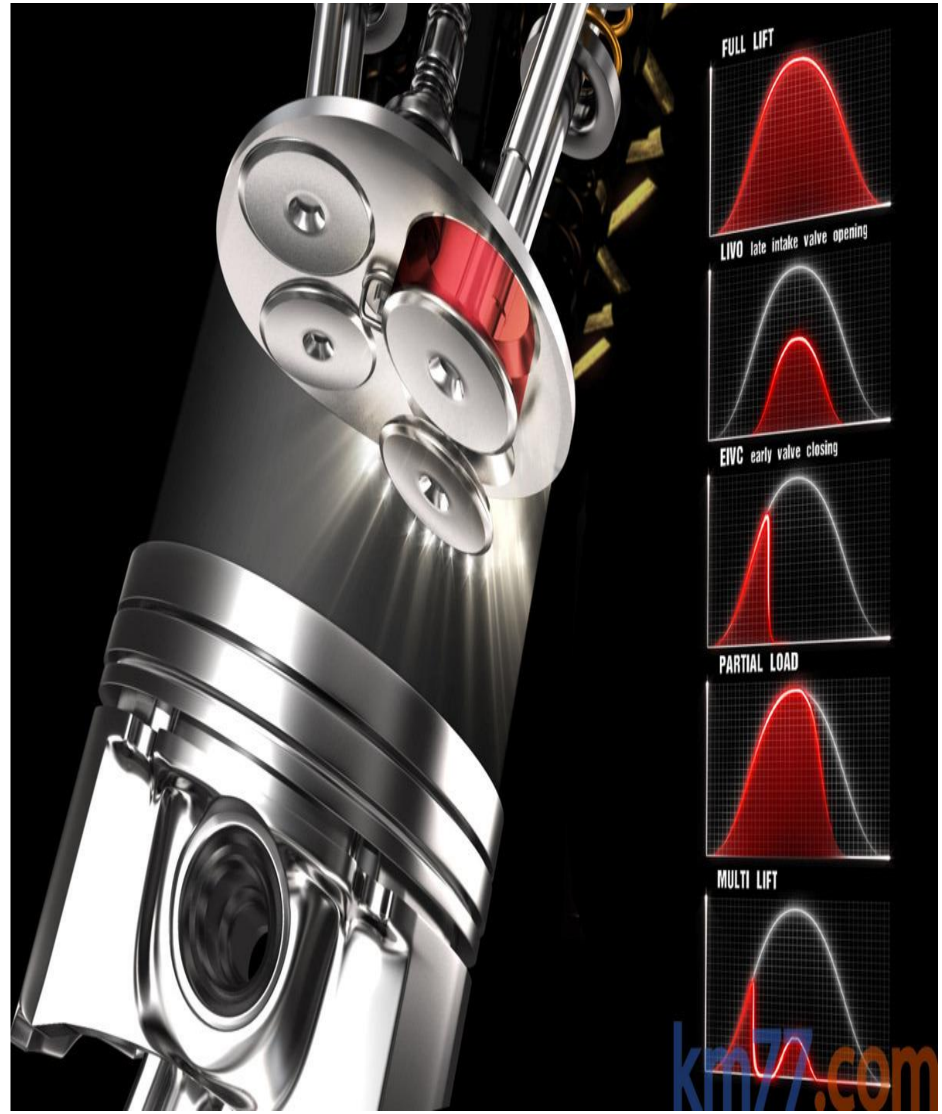
VTEC Engine (Variable Valve-Timing and Lift Electronic Control) VTEC works by varying valve timing and lift to compensate for the time delay and out-of-phase arrival of the air-fuel charge at the intake valve. Shifts valve between two separate sets of cam lobes—one for high-speed operation and one for low.



Advantages

- Low fuel consumption
- appreciable increase in power
- lower tail pipe emission.

- **Valvetronic System**, which can continuously vary the opening stroke of the intake valves to optimize engine power and efficiency.
- reduces pumping losses

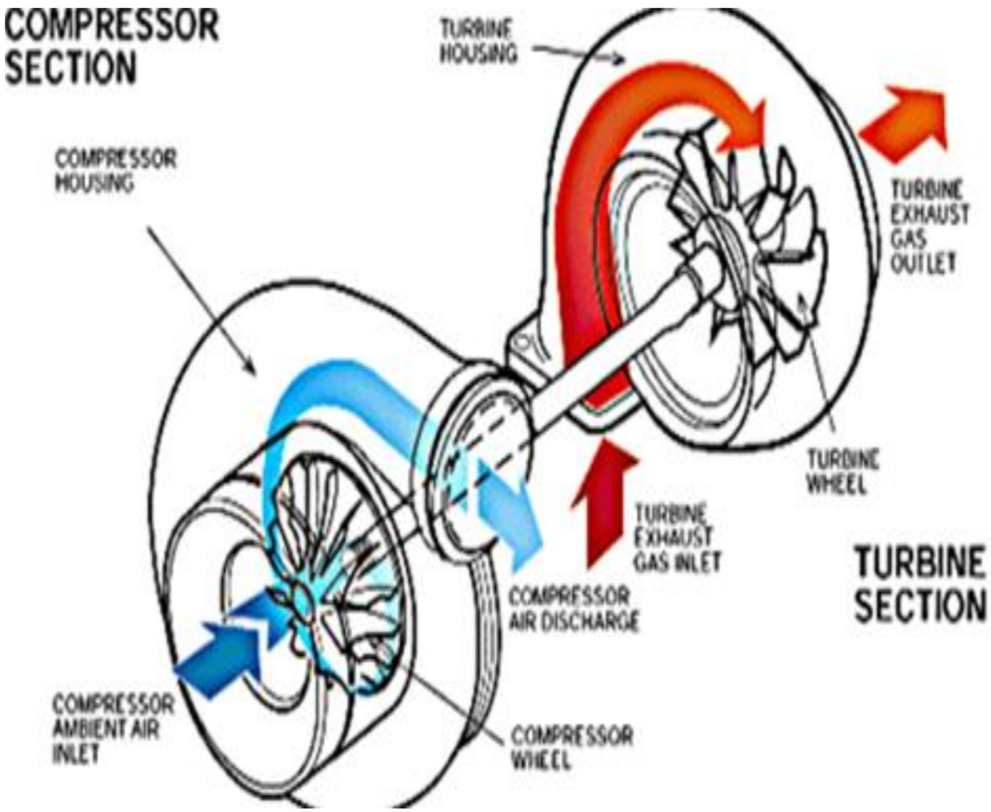


SUPER AND TURBO CHARGERS

Forcing more air into a cylinder allows more fuel to be burned, generating more power from an engine of a given weight and size; that's the basic idea behind super-charging and turbo-charging.

Turbocharger

After exhaust gases leave the cylinders, they pass into one of the chambers spinning turbine. As this turbine spins, it spins the turbine in the opposite chamber(compressor). As this compressor spins, it draws in outside air and forces it into the engine intake manifold and finally into the combustion chambers.

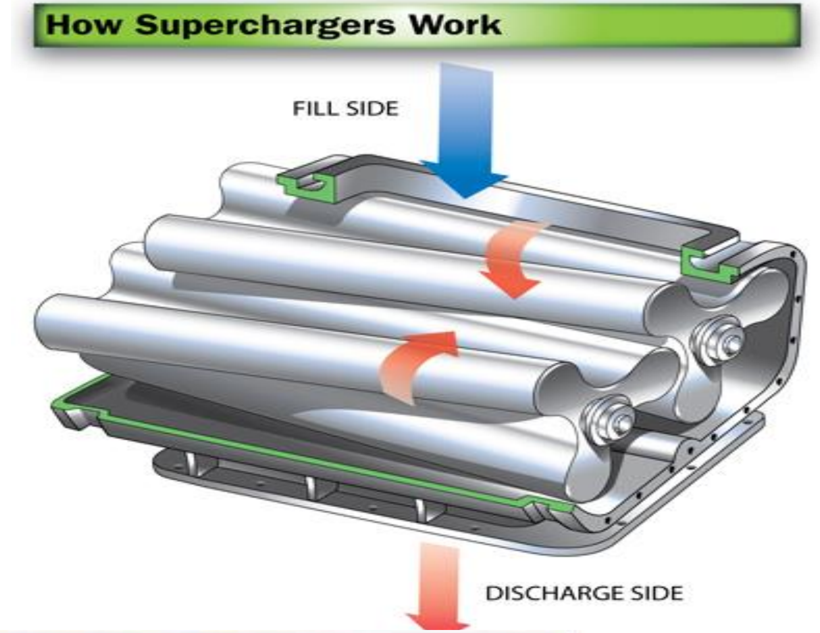


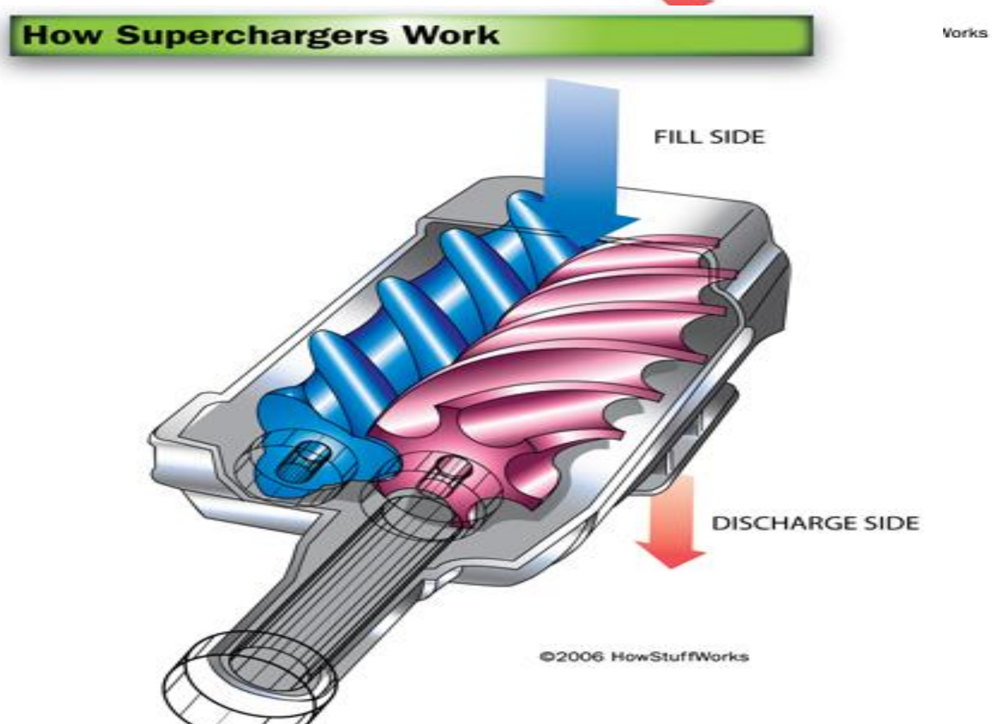
Supercharger

The key difference between a turbocharger and a supercharger is its power supply. Something has to supply the power to run the air compressor. In a supercharger, there is a belt that connects directly to the engine. It gets its power the same way that the water pump or alternator does.

Types of superchargers

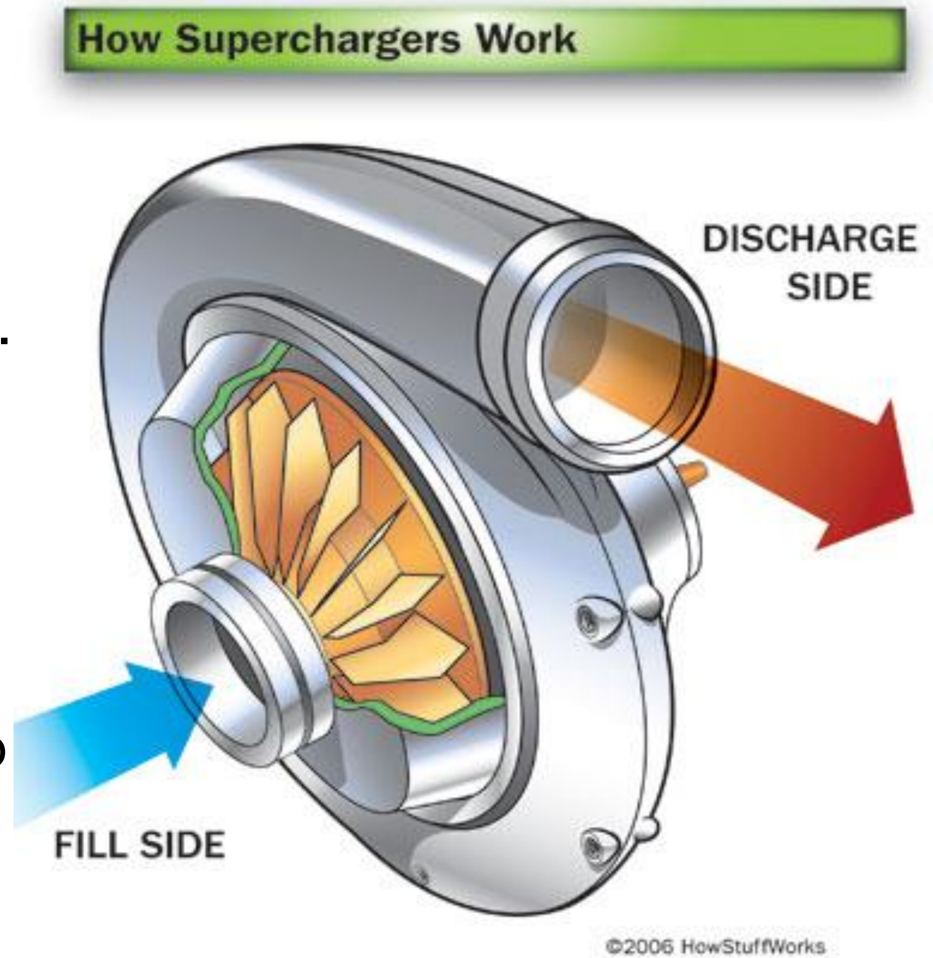
- Roots type
- Twin screw type
- Centrifugal type





Advantages of super and turbo chargers

- Turbochargers are light weight, mechanical simplicity and durability, uses engine exhaust, less fuel is consumed. Since the volume of exhaust gas is dependent upon engine load, The greater the load, the more the turbo boast.
- Superchargers are smaller and for lighter engine, easier to install
- Both help in control of detonation



Hybrid engines

A hybrid propulsion system uses a petrol or diesel engine with an electric motor in some combination.

One variation is to have the wheels driven only by the electric motor or motors, current coming from batteries. The petrol engine drives a generator to charge the batteries; it can be turned on and off as needed.

Other variation is to have a relatively small petrol engine drive the wheels through a mechanical transmission. An electric motor provides assistance when high power is needed - overtaking and climbing hills.

Types and advantages of hybrid engines

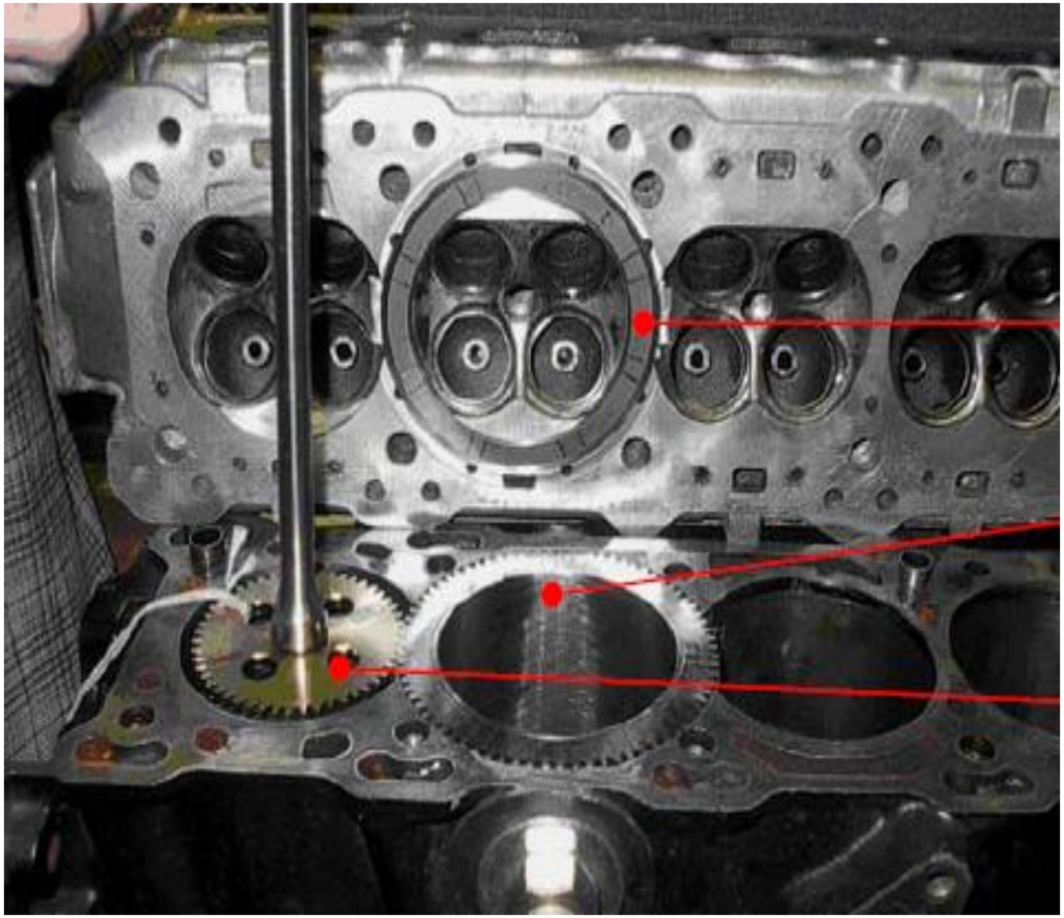
- Hybrid electric-petroleum vehicles
- Continuously outboard recharged electric vehicle (COREV)
- Hybrid fuel (dual mode)
- Fluid power hybrid

Advantages

- Lower emissions and better mileage.
- Braking are configured to capture kinetic energy thus batteries need not be charged by an external source.
- Reduce the dependency on fossil fuels which directly affects fuel prices.

Rotating Liner Engine

It is developed **to reduce engine friction** and increase fuel economy in Heavy Duty Engines. The cylinder liner rotates and a unique hydrodynamic face seal replaces the conventional head gasket. Thus over comings the piston ring-liner wear around TDC (due to low magnitude of sliding speed around)



Advantages

- Improve efficiency and reduce fuel consumption.
- Prolong engine life.

Conclusion

Despite the green hope, internal-combustion engines with its latest and advanced technology will keep powering vehicles for the foreseeable future.

THANK YOU

REFERENCES

1. **Heywood, J.** *Internal Combustion Engine Fundamentals*, McGraw-Hill, New York, 1988.
2. **Pulkrabek, W.C.** *Engineering Fundamentals of the Internal Combustion Engine*, Prentice Hall, Upper Saddle River, New Jersey, 2003.
3. **Colin R. Ferguson and Allan T. Kirkpatrick**. *Internal Combustion Engines: Applied Thermal Sciences*, 2nd Edition,, John Wiley and Sons, New York, 2000.
4. **Gupta, H.** N. *Fundamentals of Internal Combustion Engines*, PHI Learning Private Limited, New Delhi, 2009.
5. **Awaludin, W. Panuntun, W.S. Alam, N. Sinaga**. *Pemilihan Mesin Penggerak Generator Pada Sistem Pembangkit Listrik Tenaga Biogas (PLTBG)*, Seminar Nasional Teknik Kimia, Jurusan Teknik Kimia FT Undip, 2003.
6. **Sinaga, Nazaruddin, R. Ismail, R. Perangin-angin dan O. A. Wicaksono**. *Pembangkitan Listrik Menggunakan Bahan Bakar Biogas dari Hasil Fermentasi Kotoran Ternak*, Seminar Nasional Teknik Kimia, Jurusan Teknik Kimia FT Undip, 2003.
7. **Sinaga, Nazaruddin**. *Perancangan Mixer Biogas-Udara Untuk Mesin Diesel Dual Fuel Pembangkit Listrik Tenaga Biogas*, Majalah Teknik, Tahun ke XXV, Edisi I, 2005.
8. **Sinaga, Nazaruddin**. *Analisa dan Pemilihan Mesin Untuk Mesin Dual Fuel Campuran Biogas-Solar*, Majalah Rotasi, Jurusan Teknik Mesin FT Undip, Vol. 7 No. 2, April, 2005.
9. **Sinaga, Nazaruddin**. *Perancangan Conversion Kit Untuk Modifikasi Mesin Diesel Dual Fuel Pembangkit Listrik Tenaga Biogas*, Jurnal Ilmiah Nasional Efisiensi dan Konservasi Energi, Jurusan Teknik Mesin, FT Undip, Vol. 1 No. 1, September, 2005.
10. **Cahyono, Sukmaji Indro, Gwang-Hwan Choe, and Nazaruddin Sinaga**. *Numerical Analysis Dynamometer (Water Brake) Using Computational Fluid Dynamic Software*. Proceedings of the Korean Solar Energy Society Conference, 2009.
11. **Priangkoso, Tabah dan N. Sinaga**. *Tinjauan Beberapa Model Mekanistik Tingkat Konsumsi Bahan Bakar Untuk Diterapkan Pada Program Simulator Mengemudi Hemat Energi Smart Driving*,

Prosiding, Seminar Nasional Sains dan Teknologi ke-2, Fakultas Teknik Universitas Wahid Hasyim Semarang, Juni 2011.

12. **Mrihardjono, Juli dan N. Sinaga**. *Pengujian Model Driving Cycle Kendaraan Honda City Berbahan Bakar Premium*, Majalah Gema Teknologi, Volume 16, Nomor 3, April - Oktober 2011, ISSN : 0852 0232.
13. **Sinaga, Nazaruddin dan Tabah Priangkoso**. *Tinjauan/Review Model Empirik Konsumsi Bahan Bakar Kendaraan*, Journal Momentum, Vol. 7, No. 1, April 2011.
14. **Supriyo dan N. Sinaga**. *Perencanaan Daya Pendingin pada Dinamometer Arus Eddy,* Eksergi, Jurnal Teknik Eergi POLINES, Volume 7, Nomor 3, ISSN : 0216-8685, September 2011.
15. **Supriyo dan N. Sinaga**. *Perancangan Dinamometer Arus Eddy Kapasitas 250 KW*, Majalah Eksergi, Volume 7, Nomor 3, ISSN : 0216-8685, September 2011.
16. **Sinaga, Nazaruddin**. *Pengujian Teknik Mengemudi Hemat Energi pada Kendaraan Penumpang untuk Mendukung Program Smart Driving di Indonesia*, Prosiding, Seminar Nasional Teknik Mesin X (SNTTM X), Jurusan Teknik Mesin, Fakultas Teknik Universitas Brawijaya, Malang, November 2011.
17. **Sinaga, Nazaruddin, T. Priangkoso, D. Widayana dan K. Abdurrohman**. *Kaji Eksperimental Pengaruh Beberapa Parameter Berkendaraan Terhadap Tingkat Konsumsi Bahan Bakar Kendaraan Penumpang Kapasitas Silinder 1500-2000cc*, Prosiding, Seminar Nasional Teknik Mesin X (SNTTM X), Jurusan Teknik Mesin, Fakultas Teknik Universitas Brawijaya, Malang, November 2011.
18. **Sinaga, Nazaruddin dan B. Prasetiyo**. *Kaji Eksperimental Karakteristik Sebuah Dinamometer Sasis Arus Eddy*, Eksergi, Jurnal Teknik Energi POLINES, Volume 8, Nomor 2, Mei 2012, ISSN : 0216-8685.
19. **Sinaga, Nazaruddin dan A. Dewangga**. *Pengujian Dan Pembuatan Buku Petunjuk Operasi Chassis Dinamometer Tipe Water Brake*, Majalah Rotasi, Volume 14, Nomor 3, Juli 2012, ISSN:1411-027X.
20. **Sinaga, Nazaruddin**. *Smart Driving : Menghemat Bahan Bakar, Meningkatkan Kualitas Emisi Dan Menurunkan Resiko Kecelakaan,* Makalah, Seminar Astra – Jurusan Teknik Mesin Undip, Jurusan Teknik Mesin FT UNDIP, November 2012.
21. **Sinaga, Nazaruddin dan Mulyono**. *Kaji Eksperimental Dampak Pemakaian Pertamax Dan Pertamax-Plus Terhadap Emisi Gas Buang*

Pada Sepeda Motor, Prosiding, Seminar Nasional Unit Penelitian dan Pengabdian Kepada Masyarakat Politeknik Negeri Semarang 2013, ISBN : 978-979-3514-66-6, Halaman 168-172.

22. **Sinaga, Nazaruddin, dan M. H. Sonda**. *Pemilihan Kawat Enamel Untuk Pembuatan Selenoid Dinamometer Arus Eddy Dengan Torsi Maksimum 496 Nm*, Eksergi, Jurnal Teknik Energi Vol 9 No.1 Januari 2013.
23. **Sinaga, Nazaruddin dan S. J. Purnomo**. *Hubungan Antara Posisi Throttle, Putaran Mesin dan Posisi Gigi Terhadap Konsumsi Bahan Bakar pada Beberapa Kendaraan Penumpang*, Eksergi, Jurnal Teknik Energi, Vol.9 No. 1, Januari 2013.
24. **Sinaga, Nazaruddin**. Pelatihan Teknik Mengemudi Smart Driving Untuk Menurunkan Emisi Gas Rumah Kaca Dan Menekan Biaya Transportasi Angkutan Darat, Prosiding, Seminar Nasional Teknik Mesin XII (SNTTM XII), Fakultas Teknik Universitas Lampung, Oktober 2013.
25. **Sinaga, Nazaruddin, S. J. Purnomo dan A. Dewangga**. *Pengembangan Model Persamaan Konsumsi Bahan Bakar Efisien Untuk Mobil Penumpang Berbahan Bakar Bensin Sistem Injeksi Elektronik (EFI),* Prosiding, Seminar Nasional Teknik Mesin XII (SNTTM XII), Fakultas Teknik Universitas Lampung, Oktober 2013.
26. **Sinaga, Nazaruddin dan Y.N. Rohmat**. *Perbandingan Kinerja Sepeda Motor Berbahan Bakar Lpg Dan Bensin, Prosiding, Seminar Nasional Teknologi Industri Hijau*, Semarang 21 Mei 2014, Balai Besar Teknologi Pencegahan Pencemaran Industri (BBTPPI) Semarang, BPKIMI, Kementrian Perindustrian, Mei 2014.
27. **Syachrullah, L.I, dan N. Sinaga**. *Optimization and Prediction of Motorcycle Injection System Performance with Feed-Forward Back-Propagation Method Artificial Neural Network (ANN),* Prosiding, Seminar Nasional Perkembangan Riset dan Teknologi di Bidang Industri ke-2, Fakultas Teknik Universitas Gajah Mada Yogyakarta, Juni 2014.
28. **Paridawati dan N. Sinaga**. *Penurunan Konsumsi Bahan Bakar Sepeda Motor Sistem Injeksi Menggunakan Metode Optimasi Artificial Neural Network Dengan Algoritma Back-Propagation,* Prosiding, Seminar Nasional Perkembangan Riset dan Teknologi di Bidang Industri ke-2, Fakultas Teknik Universitas Gajah Mada Yogyakarta, Juni 2014.
29. **M. Rifal dan N. Sinaga**. *Impact of Methanol-Gasoline Fuel Blend on The Fuel Consumption and Exhaust Emission of an SI Engine*,

Proceeding, The 3rd International Conference on Advanced Materials Science and Technology (ICAMST 2015), Universitas Negeri Semarang, April 2015.

30. **Sinaga, Nazaruddin dan Mulyono**. *Studi Eksperimental Karateristik Kinerja Sepeda Motor Dengan Variasi Jenis Bahan Bakar Bensin*, Majalah Eksergi, Volume 11, Nomor 1, ISSN:0216-8685, Halaman 1-6 Januari 2015.
31. **Syahrullah, L. I. dan N. Sinaga**. *Optimization and Prediction of Motorcycle Injection System Performance with Feed-Forward Back-Propagation Method Artificial Neural Network (ANN),* American Journal of Engineering and Applied Sciences, Volume 9, Issue 2, ISSN: 1941-7039, Halaman 222-235, Februari 2016.
32. **Rojak, Amirur dan N. Sinaga**. *Pengaruh Penggunaan Bahan Bakar LGV Pada Mobil Penumpang 1200 CC Dan 1500 CC Terhadap Kebutuhan Udara Dan Bahan Bakar*, Politeknosains, Volume XV, Nomor 1, ISSN: 1829-6181, Maret 2016.
33. **Khudhoibi dan N. Sinaga**. *Pengaruh Engine Remap Terhadap Beberapa Parameter Operasi Mobil Berbahan Bakar LGV*, Jurnal Ilmiah Momentum, Volume 12, Nomor 1, ISSN : 0216-7395, April 2016.
34. **Rifal, Mohamad dan N. Sinaga**. *Impact of Methanol-Gasoline Fuel Blend on The Fuel Consumption and Exhaust Emission of an SI Engine*, AIP Conf. Proc. 1725, 020070-1–020070-6; Published by AIP Publishing, 978-0-7354-1372-6, Maret 2016.
35. **Sinaga, Nazaruddin dan D. Alcita**. *Perbandingan Beberapa Parameter Operasi Mesin Mobil Injeksi Terhadap Penggunaan Bahan Bakar Bensin dan Campuran Metanol-Bensin M15*, Eksergi, Jurnal Teknik Energi POLINES, Vol. 12 No. 3, September 2016.
36. **Nazaruddin Sinaga**. *Perancangan Awal Conventer Kit LPG Sederhana untuk Konversi Mesin Bensin Skala Kecil*, Eksergi, Jurnal Teknik Energi POLINES, Vol. 13, No. 1, Januari 2017.
37. **Nazaruddin Sinaga**. *Kaji Numerik Aliran Jet-Swirling Pada Saluran Annulus Menggunakan Metode Volume Hingga*, Jurnal Rotasi Vol. 19, No. 2, April 2017.
38. **Nazaruddin Sinaga dan M. Rifal**. *Pengaruh Komposisi Bahan Bakar Metanol-Bensin Terhadap Torsi Dan Daya Sebuah Mobil Penumpang Sistem Injeksi Elektronik 1200 CC*, Jurnal Rotasi Vol. 19, No. 3, Juli 2017.

39. **Nazaruddin Sinaga.** *Perancangan dan Pembuatan Data Logger Sederhana untuk Dinamometer Sasis Sepeda Motor*, Jurnal Rotasi, Vol. 20, No. 1, Januari 2018.

40. **Mohamad Rifal dan Nazarudin Sinaga**. *Kaji Eksperimental Rasio Metanol-Bensin Terhadap Konsumsi Bahan Bakar, Emisi Gas Buang, Torsi Dan Daya*, Gorontalo Journal of Infrastructure and Science Engineering, Vol 1 (1), April 2018, pp. 47-54.

41. **Nugroho, A., Sinaga, N., Haryanto, I**. *Performance of a Compression Ignition Engine Four Strokes Four Cylinders on Dual Fuel (Diesel-LPG)*, Proceeding, The 17th International Conference on Ion Sources, Vol. 2014, 2018, 21 September 2018, AIP Publishing.

42. **Nazaruddin Sinaga, B. Yunianto, Syaiful, W.H. Mitra Kusuma**. *Effect of Addition of 1,2 Propylene Glycol Composition on Power and Torque of an EFI Passenger Car Fueled with Methanol-Gasoline M15*, Proceeding of International Conference on Advance of Mechanical Engineering Research and Application (ICOMERA 2018), Malang, October 2018.

43. **Nazaruddin Sinaga, Syaiful, B. Yunianto, M. Rifal**. Experimental and Computational Study on Heat Transfer of a 150 KW Air *Cooled Eddy Current Dynamometer*, Proc. The 2019 Conference on Fundamental and Applied Science for Advanced Technology (Confast 2019), Yogyakarta, Januari 21, 2019.

44. **Nazaruddin Sinaga**. *CFD Simulation of the Width and Angle of the Rotor Blade on the Air Flow Rate of a 350 kW Air-Cooled Eddy Current Dynamometer*, Proc. The 2019 Conference on Fundamental and Applied Science for Advanced Technology (Confast 2019), Yogyakarta, Januari 21, 2019.

45. **Ahmad Faoji, Syaiful Laila, Nazaruddin Sinaga**. *Consumption and Smoke Emission of Direct Injection Diesel Engine Fueled by Diesel and Jatropha Oil Blends with Cold EGR System*, Proc. The 2019 Conference on Fundamental and Applied Science for Advanced Technology (Confast 2019), Yogyakarta, Januari 21, 2019.

46. **Johan Firmansyah, Syaiful Laila, Nazaruddin Sinaga**. *Effect of Water Content in Methanol on the Performance and Smoke Emissions of Direct Injection Diesel Engines Fueled by Diesel Fuel and Jatropha Oil Blends with EGR System*, Proc. The 2019 Conference on Fundamental and Applied Science for Advanced Technology (Confast 2019), Yogyakarta, Januari 21, 2019.

47. **Sinaga, Nazaruddin, M. Mel, D.A Purba, Syaiful, and Paridawati**. *Comparative Study of the Performance and Economic Value of a Small*

Engine Fueled with B20 and B20-LPG as an Effort to Reduce the Operating Cost of Diesel Engines in Remote Areas, Joint Conference of 6th Annual Conference on Industrial and System Engineering (6th International Conference of Risk Management as an Interdisciplinary Approach (1st ICRMIA) 2019 on April 23-24, 2019 in Semarang, Central Java, Indonesia.

48. **Sinaga, Nazaruddin, B. Yunianto, D.A Purba, Syaiful and A. Nugroho**. *Design and Manufacture of a Low-Cost Data Acquisition Based Measurement System for Dual Fuel Engine Researches*, Joint Conference of 6th Annual Conference on Industrial and System Engineering (6th International Conference of Risk Management as an Interdisciplinary Approach (1st ICRMIA) 2019 on April 23-24, 2019 in Semarang, Central Java, Indonesia.

49. **Y Prayogi, Syaiful**, **and N Sinaga**. *Performance and Exhaust Gas Emission of Gasoline Engine Fueled by Gasoline, Acetone and Wet Methanol Blends*, International Conference on Technology and Vocational Teacher (ICTVT-2018), IOP Conf. Series: Materials Science and Engineering 535 (2019) 012013 doi:10.1088/1757-899X/535/1/012013