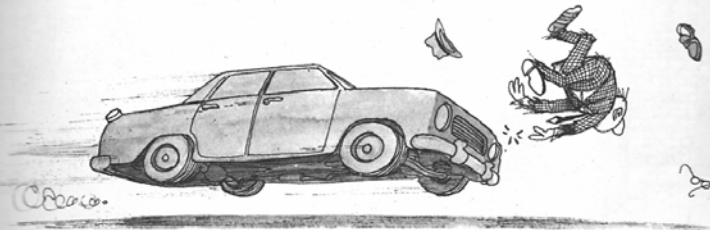


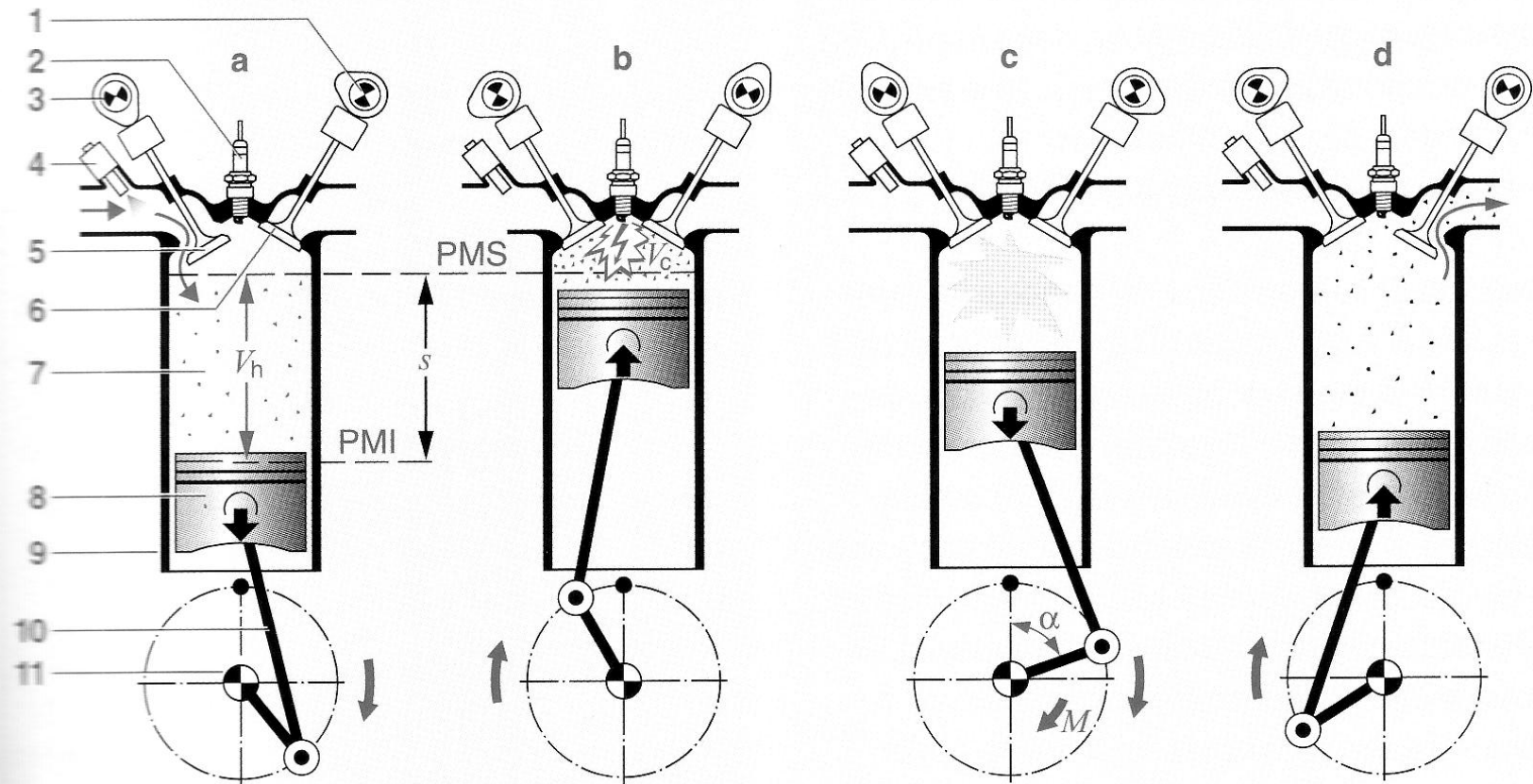
**ME742: Combustibles vehiculares convencionales  
y alternativos**

# Generalidades sobre motores de combustión interna gasolina y diesel

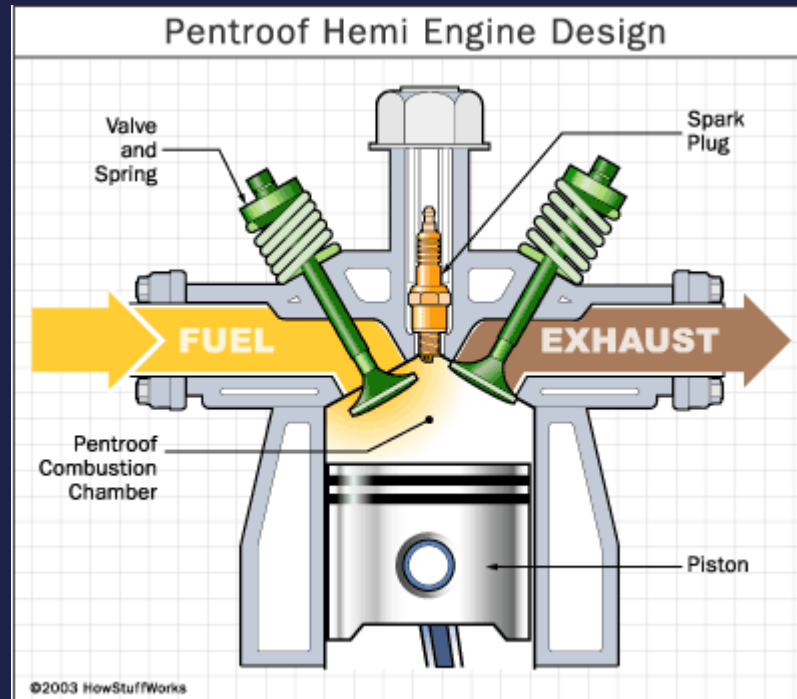
***Expositor: Dr. Mauricio Osses  
Departamento de Ingeniería Mecánica  
Universidad de Chile***



1 Ciclo de trabajo del motor de gasolina de 4 tiempos (tomando como ejemplo un motor de inyección en el tubo de admisión y árboles de levas separados para admisión y escape).

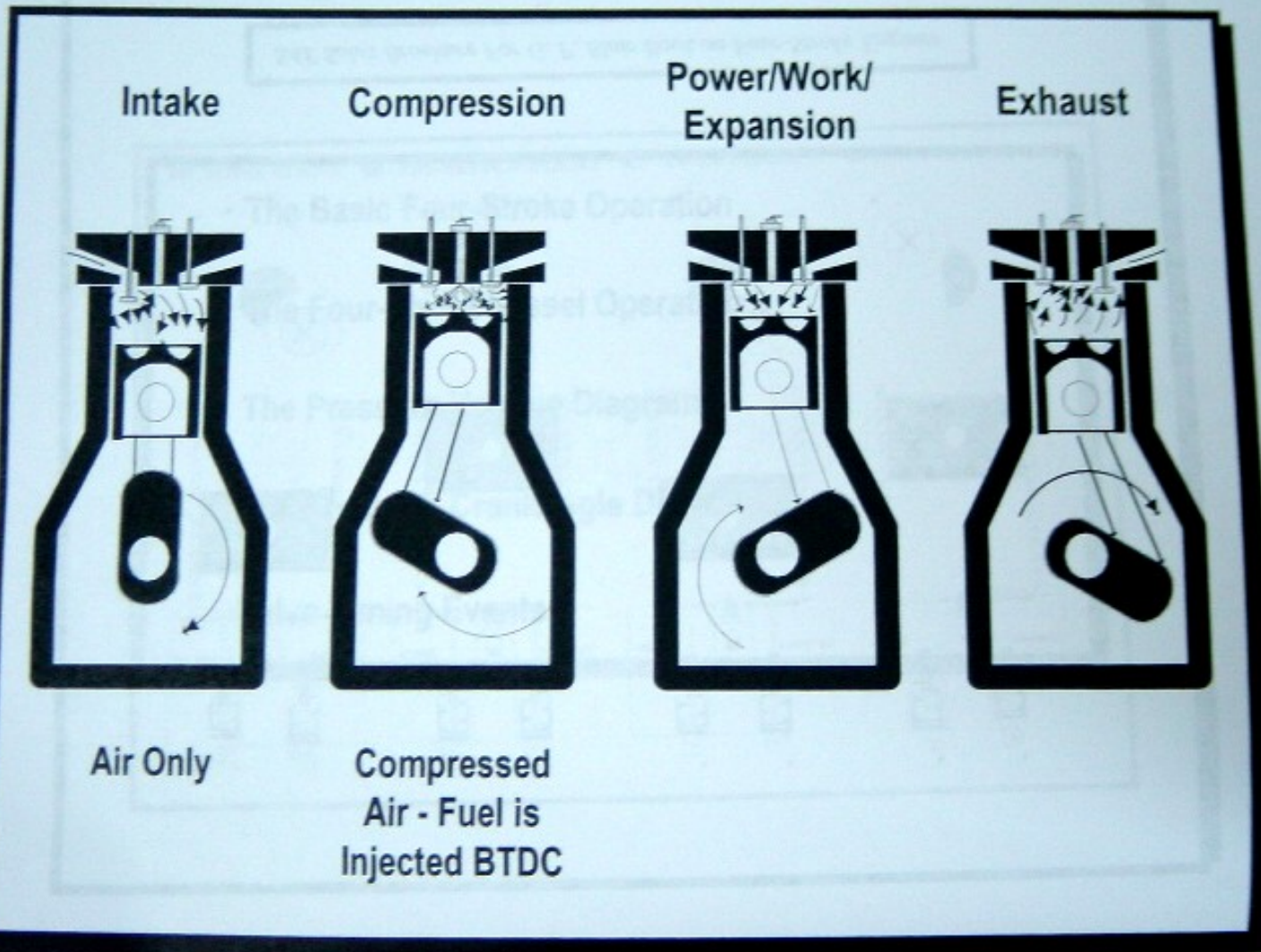


# Video SI

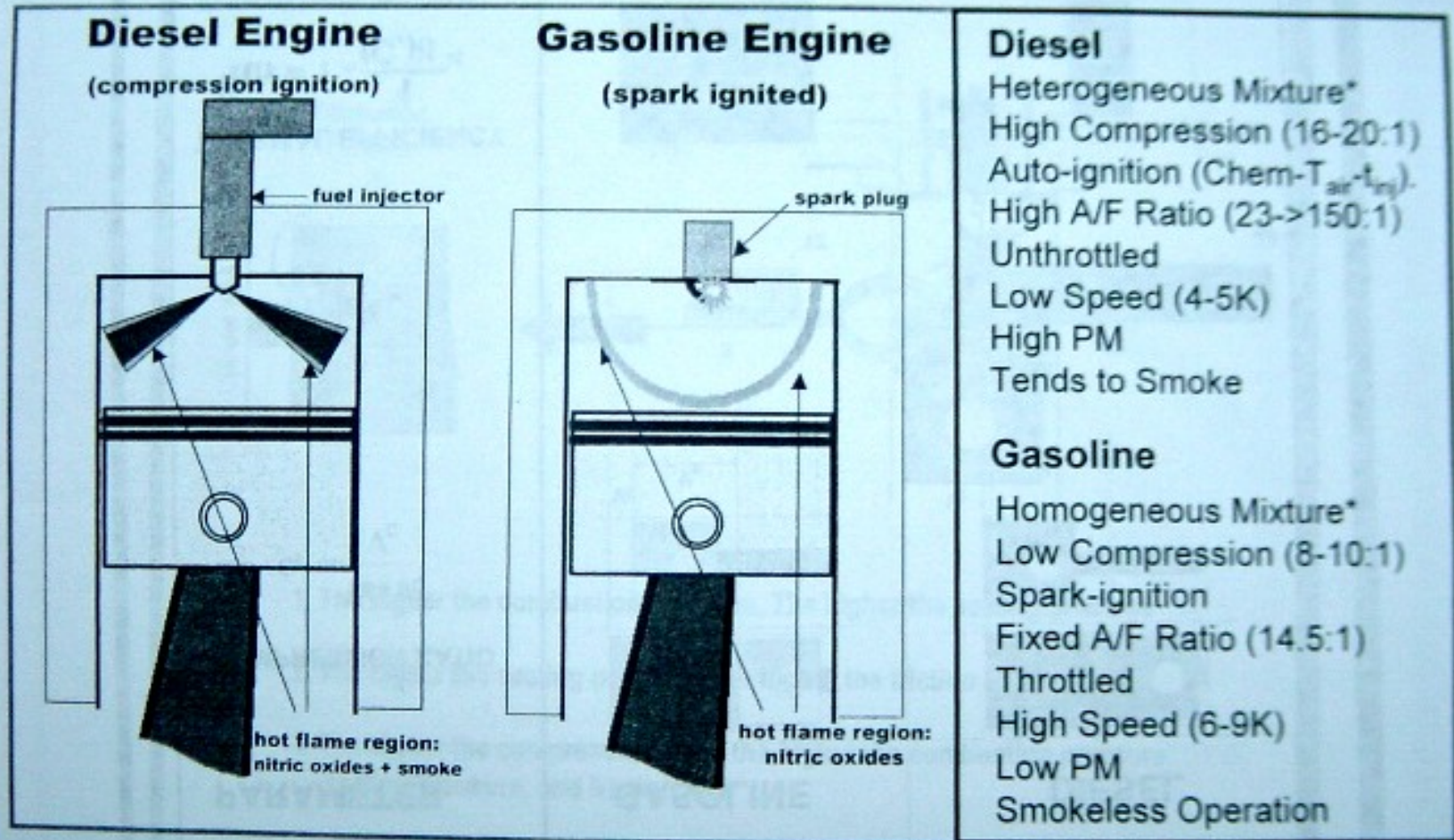




# The Four-Stroke Diesel Operation



# Brief Comparison Between Diesel and Gasoline



\*Heterogeneous: Fuel is injected into air

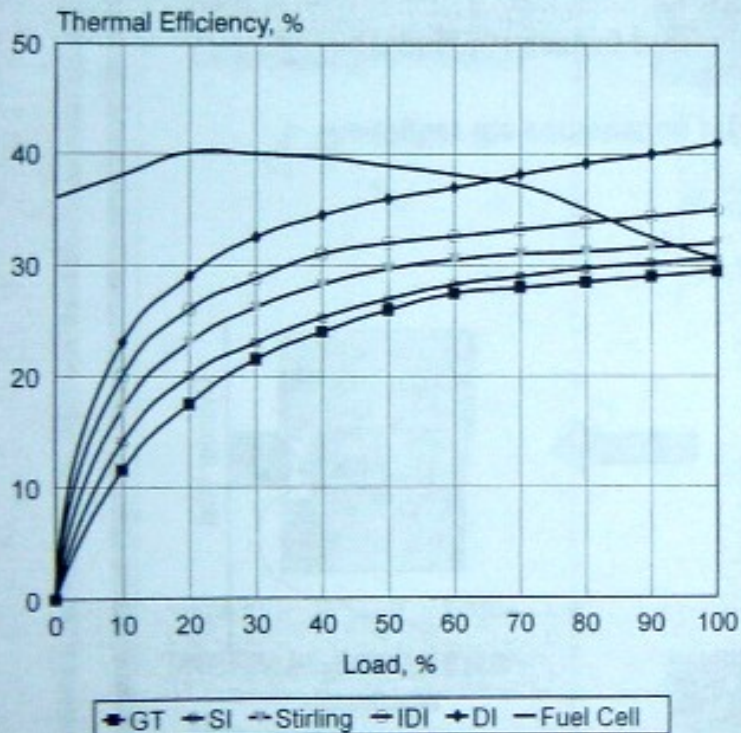
\*Homogeneous: Fuel is pre-mixed with air

Adapted From Caterpillar-K. Duffy-DEER 2002



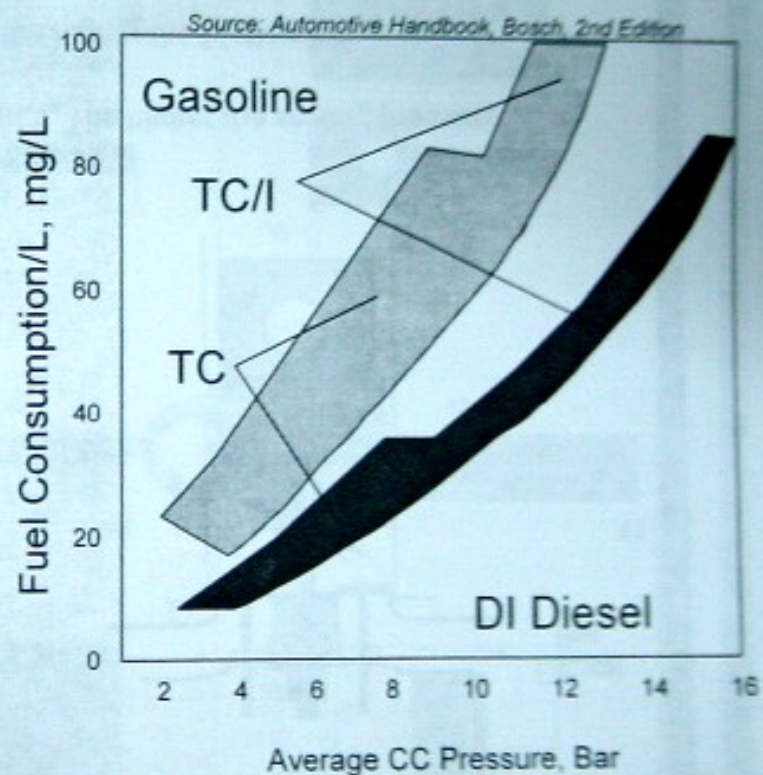
# Fuel Consumption

## Energy Conversion



Source: China Automotive Technology Conference/Workshop

## Gasoline Vs. Diesel

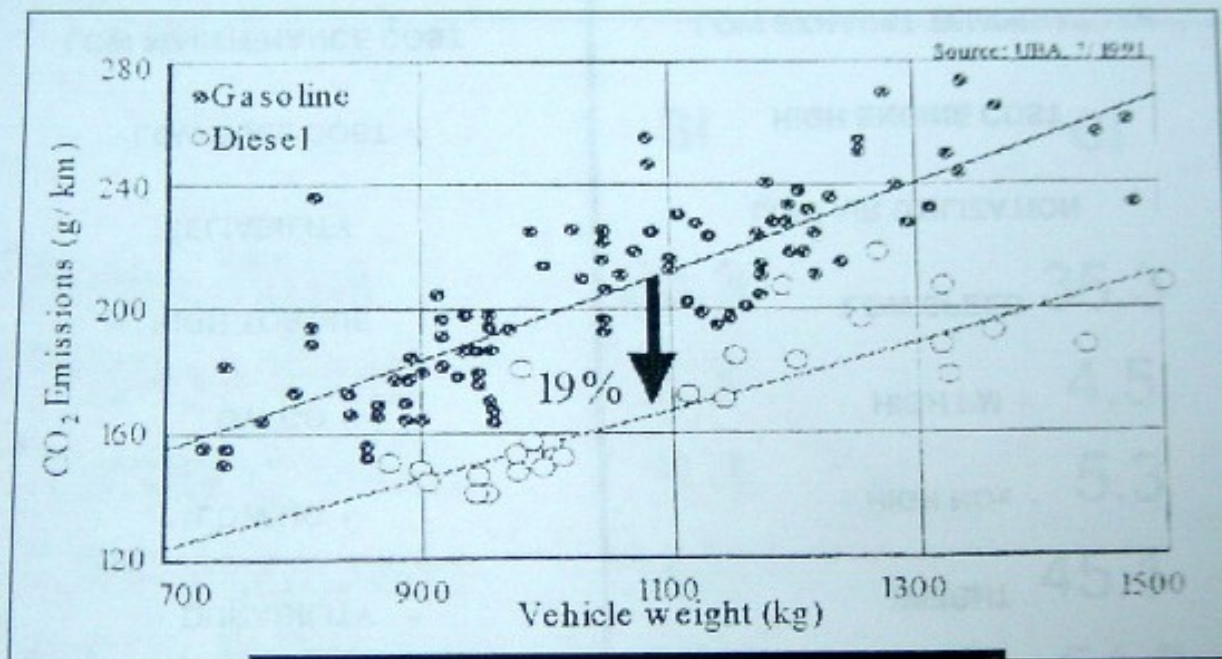


## SI/CI Cycle Comparison

	SI	CI
■ Brake Work	23.3	35.3
■ Friction Work	5.3	4.5
■ Pumping Work	6.4	5.3
■ Total Indicated	35.0	45.1
■ Other (losses)	65.0	54.9
■ Total Heat Added	100.0	100.0



## CO<sub>2</sub> Emission and The Future For Diesels

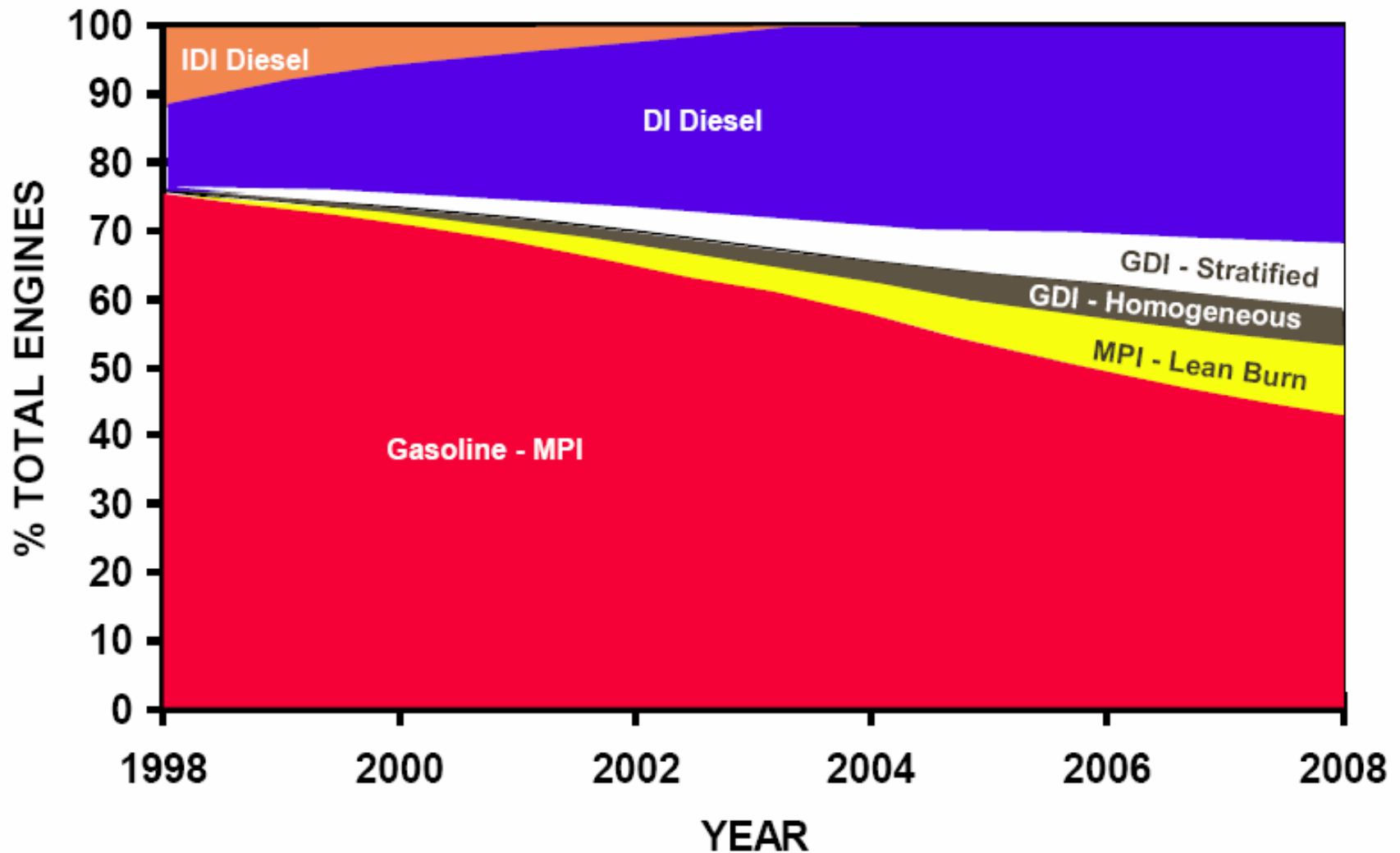


I'm Not a Hybrid

78 mpg



# Tendencias futuras G - D





# Seminario de Tecnología Diesel

Preparado por Mauricio Osses, DIMEC, Universidad de Chile  
Basado en el seminario “Diesel Engine Technology”

I.D.# 93014, 24-25 Noviembre 2003

SAE Automotive Headquarters

Troy, Michigan, USA

Instructor: Magdi Khair

# Sistema de Inyección

Main functions of the Diesel Fuel Injection System

Injection Timing  
Control

Injection Quantity  
Control

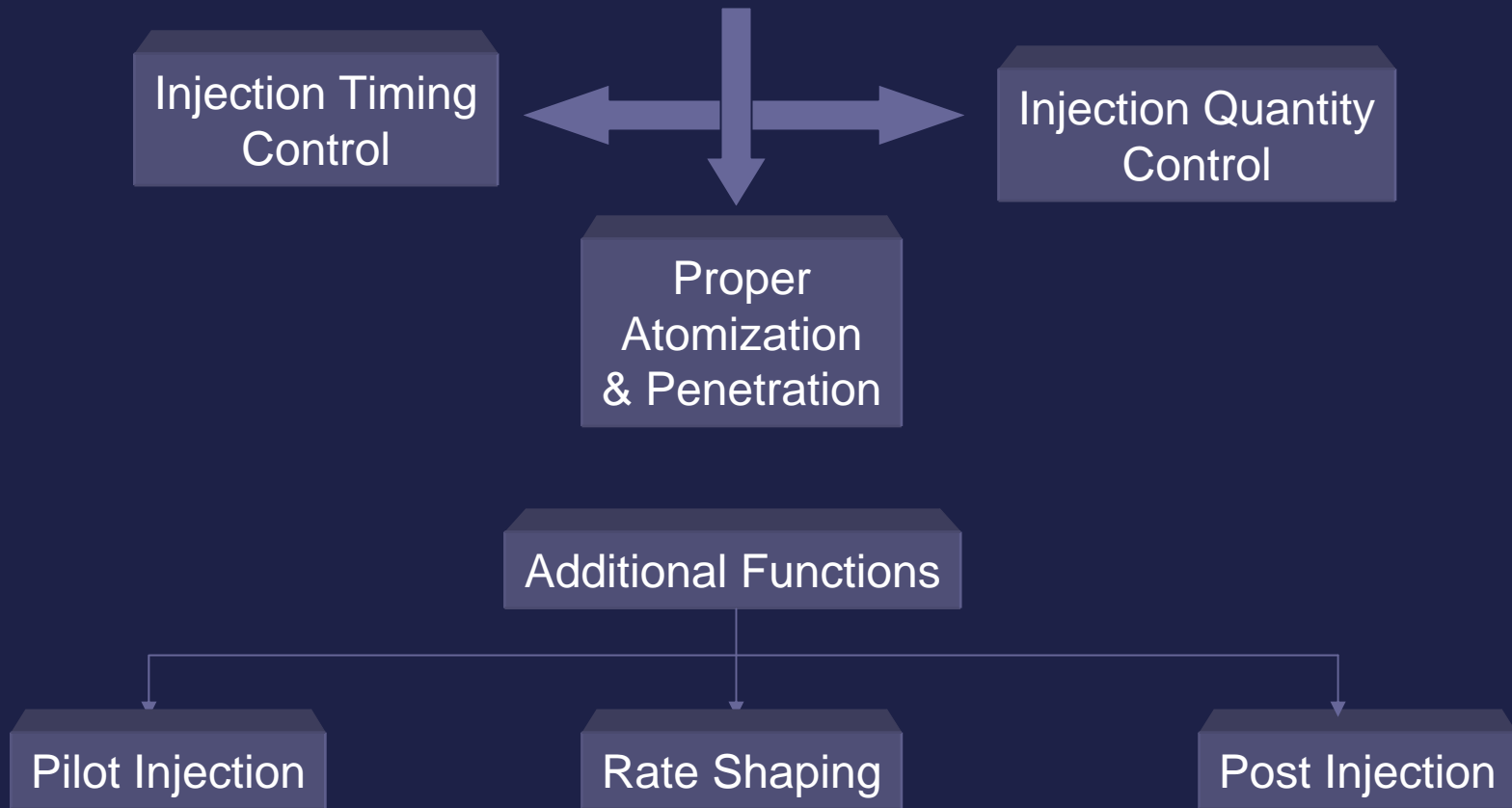
Proper  
Atomization  
& Penetration

Additional Functions

Pilot Injection

Rate Shaping

Post Injection



# Sistema de Inyección

## Types of Diesel Fuel Injection Systems

Pump-Line-Nozzle (P-L-N)  
Unit Pump (UP)



Unit Injector (UI)

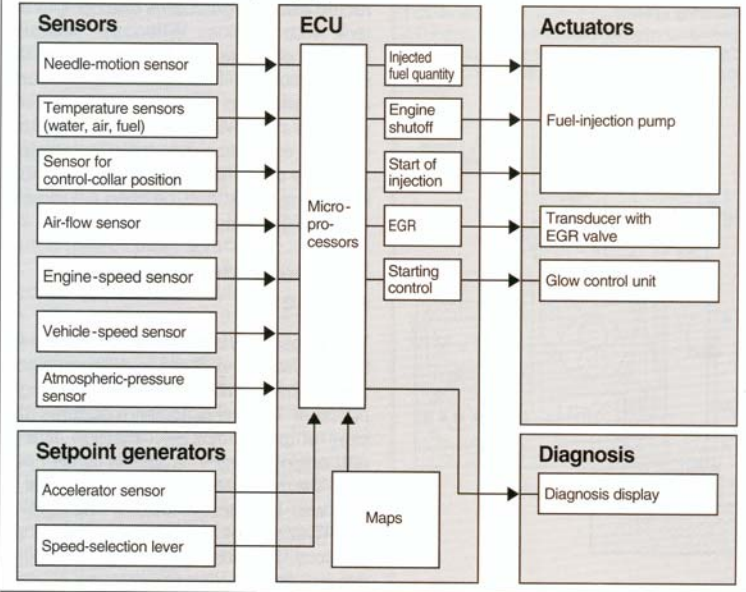
Common Rail System (CR)  
HDV & MDV: CR in the near future





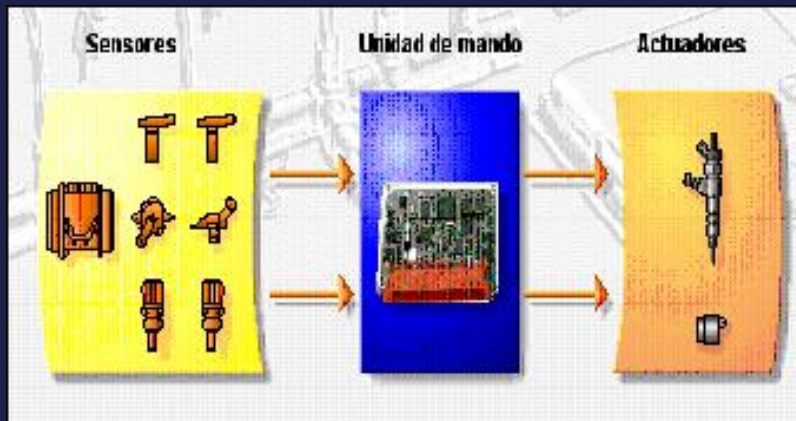
# Sistema de Inyección

Fig. 1: Electronic Diesel Control (EDC): System blocks

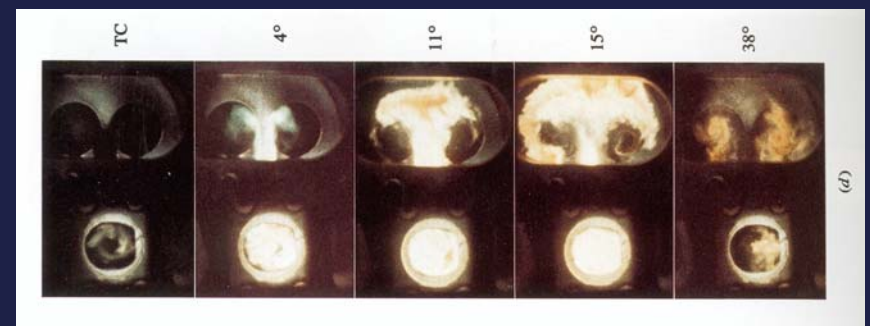
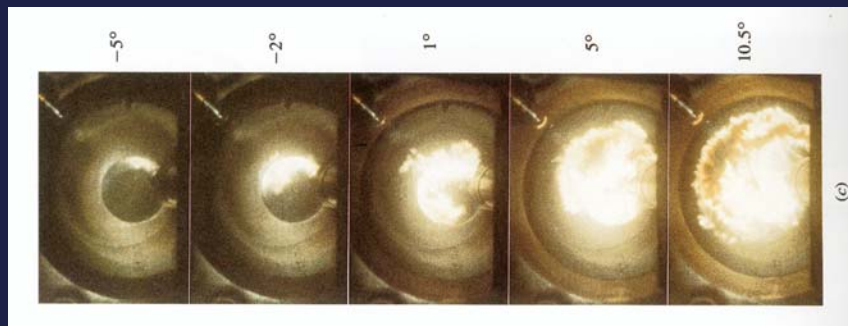
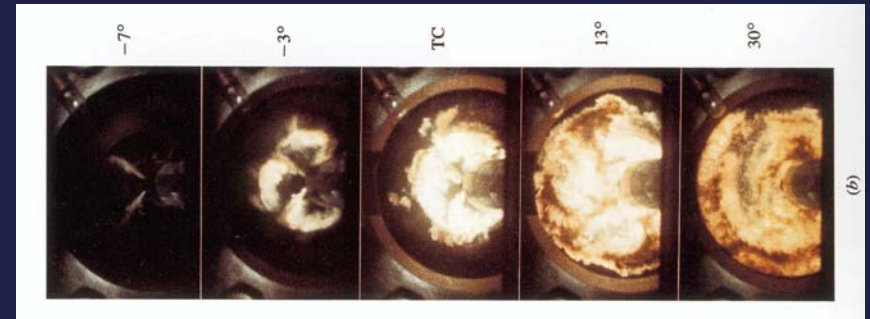
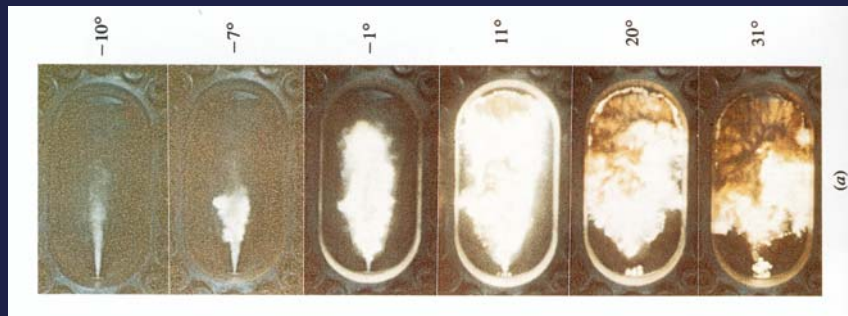


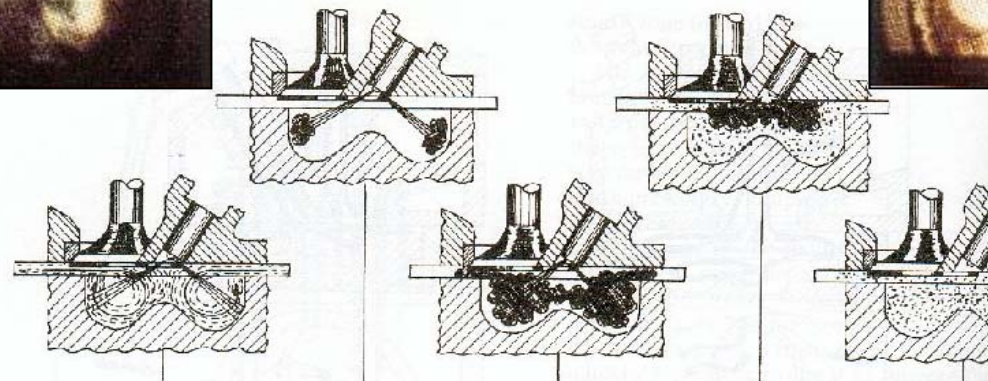
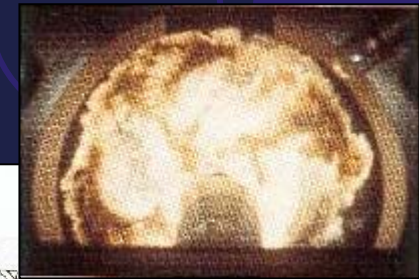
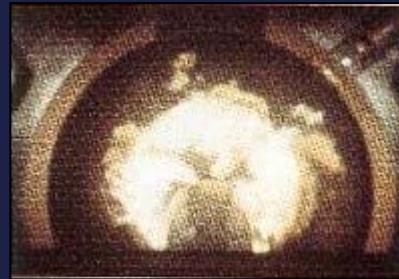
Motivation for using electronically-controlled Injection Systems in diesel engines

- ✓ Emissions regulations
- ✓ Improved engine response
- ✓ Improve fuel economy while complying with emission regulations
- ✓ Customized engines for various applications
- ✓ Value added features
- ✓ Lower cost to cumbersome mechanical add-ons
- ✓ Full-authority parameter control and flexible implementation of control strategies
  - ✓ Flexible injection timing
  - ✓ Flexible injected quantity metering
  - ✓ Reduced shot-to-shot variability
  - ✓ Reduced cylinder-to-cylinder variability
  - ✓ Smoke control strategies

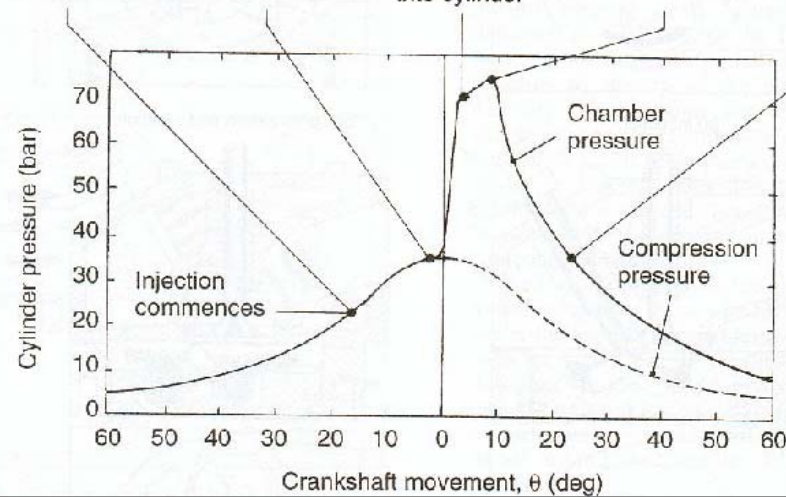


# Sistema de Inyección



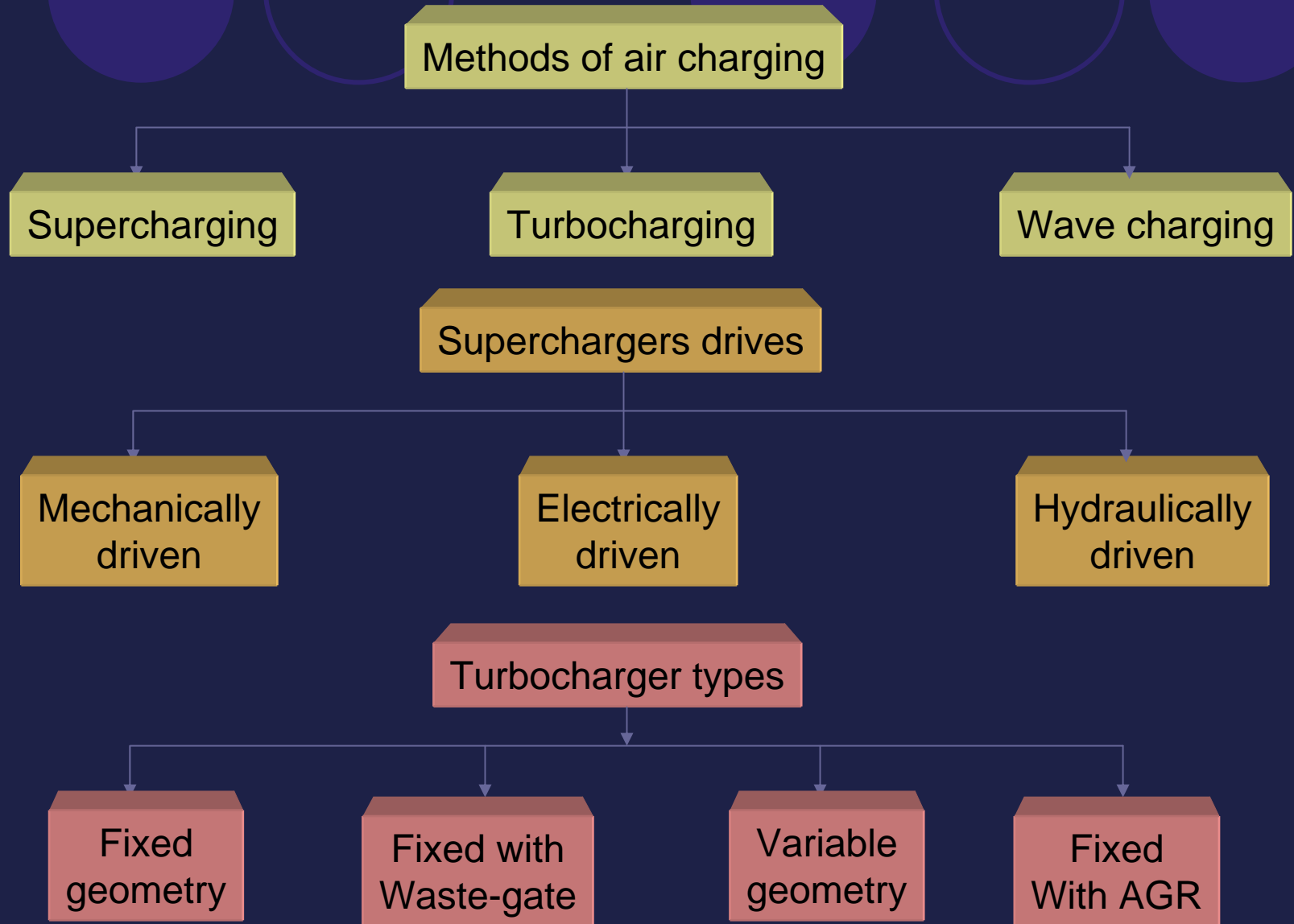


(a) Injection (b) Ignition (c) Combustion reverses flow into cylinder (d) End of injection (e) Products complete combustion





# Sistema de admisión de aire

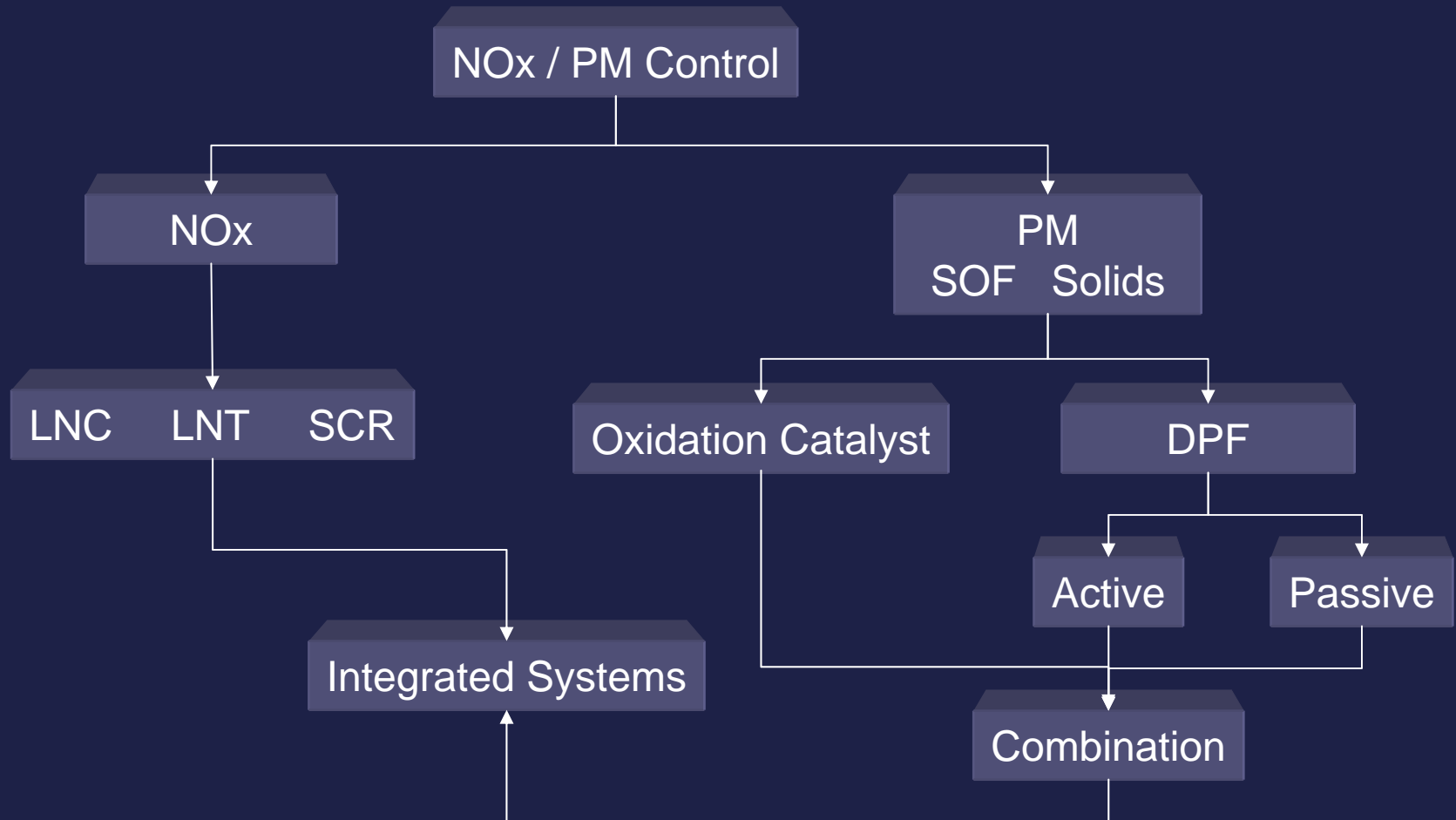


# Formación de emisiones (diesel)

## Advantages and Disadvantages of Diesel Engines

Advantages	Disadvantages
Fuel Economy	Noise
Durability	Weight
Low HC	High NOx
Low CO	High PM
High Torque	Low Speed
Reliability	Low Air Utilization
Low Fuel Cost	High Engine Cost
Low Maintenance Cost	Low Exhaust Temperature

# Tecnologías diesel actuales y futuras



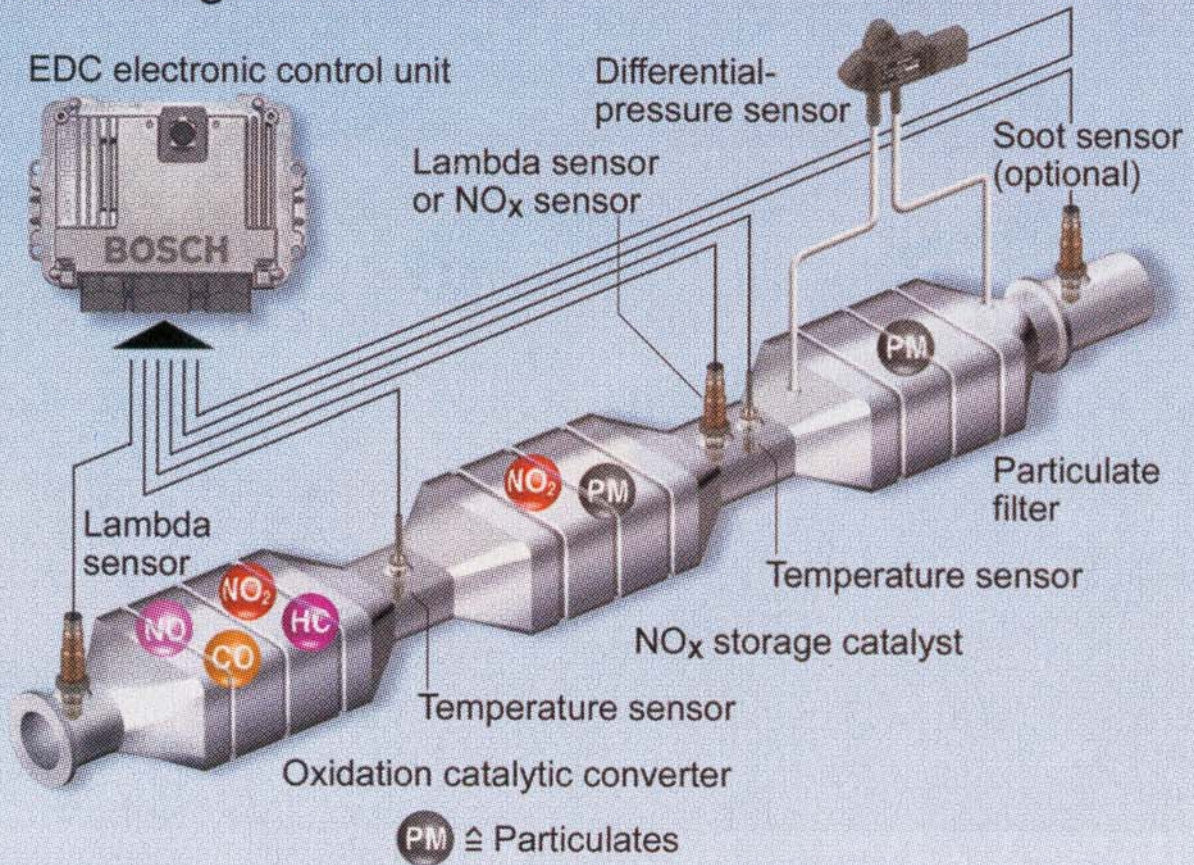
Auxiliary Emission Control Devices (AECD) – Formerly Aftertreatment Systems



# Tecnologías diesel actuales y futuras

*Apart from performing engine management functions, the Bosch Electronic Diesel Control (EDC) system controls particulate filters and NO<sub>x</sub> storage catalysts using information on exhaust gas temperature, back-pressure, and composition.*

## Exhaust-gas treatment



Auxiliary Emission Control Devices (AECD) – Formerly Aftertreatment Systems

# Tecnologías diesel actuales y futuras

Fuel injection	Combustion	Induction	Fuels	Auxiliary Emission Control Devices
<ul style="list-style-type: none"> <li>▪ High Injection Pressure</li> <li>▪ Small Hole Nozzle</li> <li>▪ Low Sac Volume</li> <li>▪ Injection Timing Retard</li> <li>▪ Injection Rate Shaping</li> <li>▪ Electronic Injection</li> <li>▪ Full Authority Injection Control</li> </ul>	<ul style="list-style-type: none"> <li>▪ Re-entrant Bowls</li> <li>▪ Higher Top Ring</li> <li>▪ Concentric Bowls</li> <li>▪ Better Air Utilization</li> <li>▪ Compliant Piston Rings</li> <li>▪ Variable Valve Actuation</li> <li>▪ Higher Compression Ratio</li> <li>▪ HCCI</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cold Charge Air</li> <li>▪ Better Turbo Match</li> <li>▪ New Intake Manifolds</li> <li>▪ Swirl Ratio</li> <li>▪ EGR</li> <li>▪ Cooled EGR</li> <li>▪ Cooled/Filtered EGR</li> <li>▪ Timed Port EGR</li> <li>▪ Fast Air Boost</li> </ul>	<ul style="list-style-type: none"> <li>▪ Low Sulfur</li> <li>▪ Sulfur-Free</li> <li>▪ Aromatic-Free</li> <li>▪ DME</li> <li>▪ CNG</li> <li>▪ LPG</li> <li>▪ Water Emulsion</li> <li>▪ Biodiesel</li> </ul>	<ul style="list-style-type: none"> <li>▪ Oxidation Catalysts (DOC)</li> <li>▪ Lean NOx Catalysts (passive)</li> <li>▪ Lean NOx Catalysts (active)</li> <li>▪ Lean NOx Adsorbers</li> <li>▪ Plasma-Assisted Lean NOx Catalysts</li> <li>▪ SCR (NH<sub>3</sub>, urea)</li> <li>▪ Traps (DPF)</li> </ul>

# LIGHT DUTY DIESEL ENGINE SYSTEM

SYSTEM	EURO III	EURO IV
4 Valve	Yes	Yes
Twin Port	Yes	Yes
Swirl Level [Rs]	1.8-2.2	1.5-2.0
Variable Swirl	Possible	Yes
Swirl range [Rs]	1.8-3.0	1.5-3.0
Port Deactivation	Possible	Yes
Compression Ratio	19	17-18
VVT	No	Possible
EGR	Yes	Yes
Electronically Controlled EGR	Yes	Yes
Cooled EGR	Possible	Yes
Variable Geometry Turbocharger	Possible	Yes



# DIESEL ENGINE FUEL INJECTION SYSTEM

SYSTEM	EURO III	EURO IV
Common Rail	Yes	Yes
● Max. Pressure	1400-1600	1600-1800
● Pilot Injection	Yes	Yes
● Post Injection	No	Possible
● Multiple Injection	No	Possible
EUI & EUP	Yes	Yes
● Max. Pressure	2000	2200
● Pilot Injection	Yes	Yes
Rotary Pump ( Light & Medium Duty Only)	Yes	Yes
● Max. Pressure LD / MD	1800-1600	2000-1800
● Pilot Injection	Possible	Yes



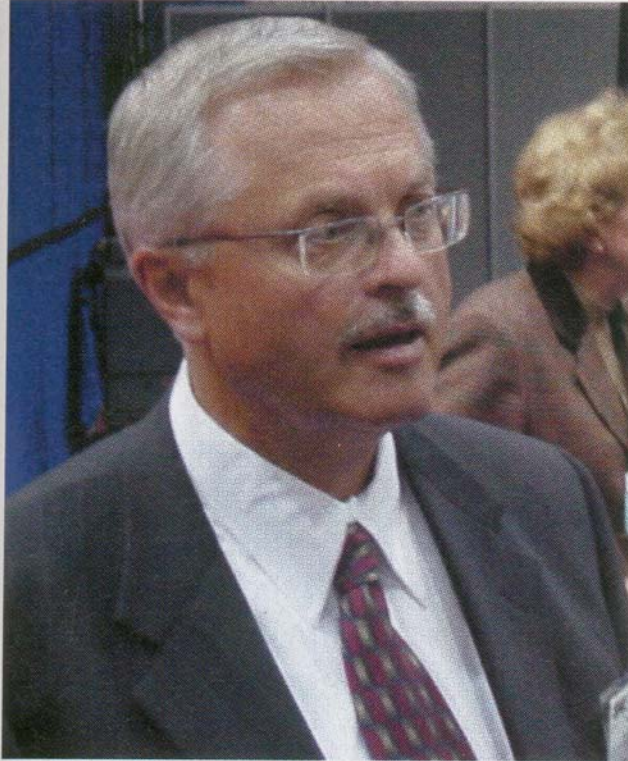
# DIESEL EXHAUST AFTERTREATMENT SYSTEM

ENGINE TYPE	EURO III	EURO IV
Light Duty		
● Oxidation	Yes	Yes
● DeNOx (passive)	Possible	Possible
● DeNOx (active)	No	Possible
● Selective Catalytic Reduction	No	Possible
● Particulate Traps	No	Possible
Heavy Duty		
● Oxidation (in combination with SCR?)	No	Possible
● DeNOx (passive)	No	Possible
● DNOx (active)	No	Possible
● Selective Catalytic Reduction	No	Possible
● Particulate Traps/Filters	No	Possible

# Tendencias Internacionales

Preparado por Mauricio Osses, DIMEC, Universidad de Chile  
Basado en los artículos 2003 “Global Viewpoints”  
Revista Automotive Engineering International  
Vol. 111, No. 5, Mayo 2003, pp. 44-70, Patrick Ponticel  
Vol. 111, No. 6, Junio 2003, pp. 48-66, Stuart Birch  
Vol. 111, No. 9, Sept. 2003, pp. 70-83, Jack Yamaguchi

# Tendencias internacionales (USA)



David Cole, President of the Center for Automotive Research at Altarum, is shown at the SAE 2003 World Congress. Overcapacity, he says, is one reason why the automotive industry's business model is broken. "There will be more consolidation, more bankruptcies, more assets taken out in certain areas."

Big 3 and foreign OEMs in USA Period February 2002-2003			
Group	Units	Market share	Sales increase
General Motors	622,000	27.0 %	11.8 %
Ford	509,000	22.1 %	1.8 %
Daimler Chrysler	300,000	13.0 %	7.8 %
Toyota	244,000	10.6 %	-3.4 %
Honda	189,000	8.2 %	9.9 %
BMW	39,000	1.7 %	8.2 %

- "Every segment with significant volume has brutal competition, which reinforces the idea that if you are not at or near low-cost in any segment, you've got a problem"
- Cole sees use of **flexible manufacturing** as an important key to success for all OEMs.
- "Among the Big3, GM is way out in front, Ford and Chrysler are really struggling with that issue ... and will be making a lot of investments in plant flexibility, whereas GM got on that track about 10 years ago. That's a key issue in manufacturing"

# Tendencias internacionales (Ford)

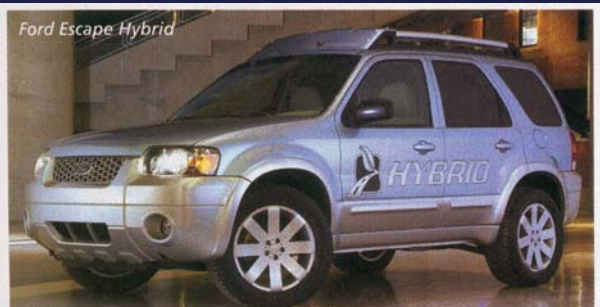


*Though the gasoline engine will remain the powerplant of choice in North America, "alternative approaches will continue to play an increasingly significant role," said Daniel Kapp, Chief Engineer of Ford's Powertrain Operations.*

- "We see the **gasoline engine** with continued evolution and improvements to its efficiency as being core **over the next 30-plus years**".
- Kapp said that "these improvements will come from **advanced valvetrain** systems such as fully variable intake valve lift and timing, **cylinder deactivation**, and **camless valvetrains**".
- Other areas for improvement, according to Kapp, are "**advanced combustion systems** that improve performance and fuel economy through maximization of thermal efficiency and reduction of pumping losses, **advanced emissions controls**, and the continued development of **diagnostic and prognostic controls**".

## Alternative power

- Though the gasoline engine will remain the powerplant of choice in North America, said Ford's Kapp, "alternative approaches will continue to play an increasingly significant role".
- According to Kapp, **hybrids** will be a "**supplementary**" technology, **hydrogen**-fueled ICEs a "**bridging action**" to a potential hydrogen economy, and **fuel cells** the potential "**end game**", with impact volume coming 20 years or so down the road.





# Tendencias internacionales (GM)

Perhaps the most widely debated issue relating to powertrain is whether or not diesel-powered vehicles will catch on in North America, particularly with tougher **Tier 2** emissions standards taking effect for **cars and light duty trucks in 2004**.

There have been several announcements in the past six months of new diesel offerings coming to the US, including the **Mercedes-Benz E320 CDI** sedan and **Jeep Liberty SUV** in 2004, and the **Volkswagen Passat** later this year. However, some question diesel's future in North America.



*"The potential for the gasoline engine is greater [than the diesel engine] currently because there are [so many] technologies ahead of us," said GM's Indra.*

- "Diesel engines are currently at a peak point of efficiency", said GM Powertrain's Indra. "But they have to fulfill more stringent exhaust emissions requirements and will have to use a **particle filter** or **one or two more catalytic converters**, which will **reduce their efficiency**. So you can estimate that the efficiency of diesel engines will go down...roughly 5%"
- Indra said, "there is no doubt that the diesel engine will become even more expensive, with the addition of aftertreatment systems".
- "The potential for the gasoline engine is greater currently because there are technologies ahead of us like **Displacement on Demand**, **two-step valvetrains**, and next-generation **gasoline direct injection**".
- "All of this technology...gives the gasoline engine a chance to close the fuel-economy gap with the diesel engine, which is currently about 25% more efficient".

# Tendencias internacionales (Chrysler)



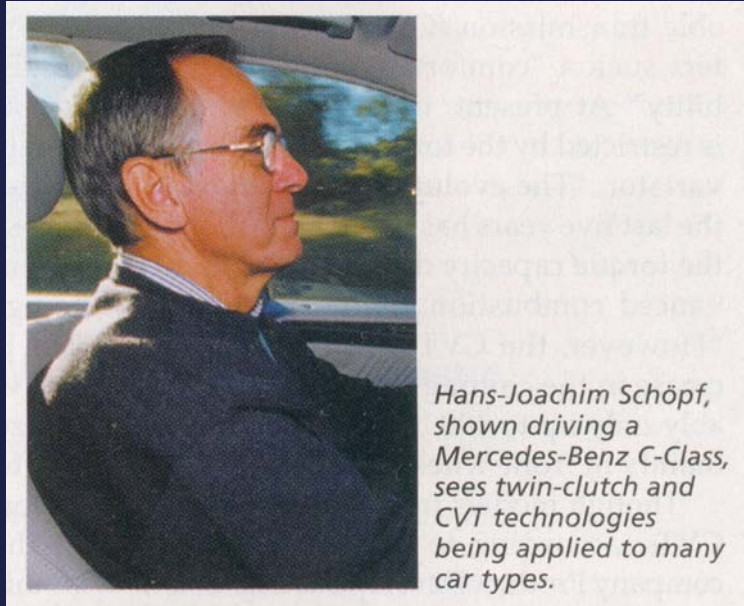
*"It's amazing to me how many degrees of freedom we now have in the powertrain area, particularly [with] the drivetrain and transmission," said Floyd Allen, Vice President of the Chrysler Group's Powertrain Product Team.*

- "Having been in the auto industry a number of years, it's amazing to me how many degrees of freedom we now have in the powertrain area, particularly with the drivetrain and transmission", said Floyd Allen.
- "There are probably half a dozen reasonable candidates for future transmissions", including **continuously variable transmissions (CVTs)**, **automated manual transmissions (AMTs)**, and DaimlerChrysler's patented **electromechanical automatic transmission (EMAT)**, which uses a dual-clutch arrangement.
- "Some of those technologies like the AMT, which is achieving some success in the European market, probably will never reach any large penetration in the US market because...the torque interruption that comes with automating the clutch and the shifter mechanism on a manual transmission just isn't pleasant enough to drive to satisfy most American consumers", said Allen.
- Chrysler's Allen said diesel "represent one of the better technologies from a fuel-economy-improvement standpoint" and that North America can expect to see an **increase in the diesel population over the 10 to 15 years** "if we are able to meet the very stringent emission standards".
- He added that diesel will probably **never achieve the levels of penetration seen in Europe**.

# Tendencias internacionales (Europa)

- The possibility of diesel and gasoline technology convergence and the emergence of synthetic fuels, the necessity for electronic chassis systems integration, the likely proliferation of dual-clutch transmissions, and the quest for improved driver ergonomics and more efficient interior design are just some of the key issues facing Europe's automotive industry.
- As always, the spectrum of opinion on these and other subjects central to the industry's future are many and varied. But there is almost total agreement on one of them: **chassis systems integration**.
- The **future of the diesel engine** is also very much brighter than once seemed probable or even possible. Within three years, **turbodiesel** engines may power half the cars sold in Europe.
- Another near-term issue concerns automatic transmissions. As European roads become even more crowded, the automatic transmission is becoming a more attractive proposition: **single-clutch AMT**, **dual clutch transmissions (DCT)**, and **continuously variable transmission (CVT)** may have a more positive future than was envisaged two or three years ago.

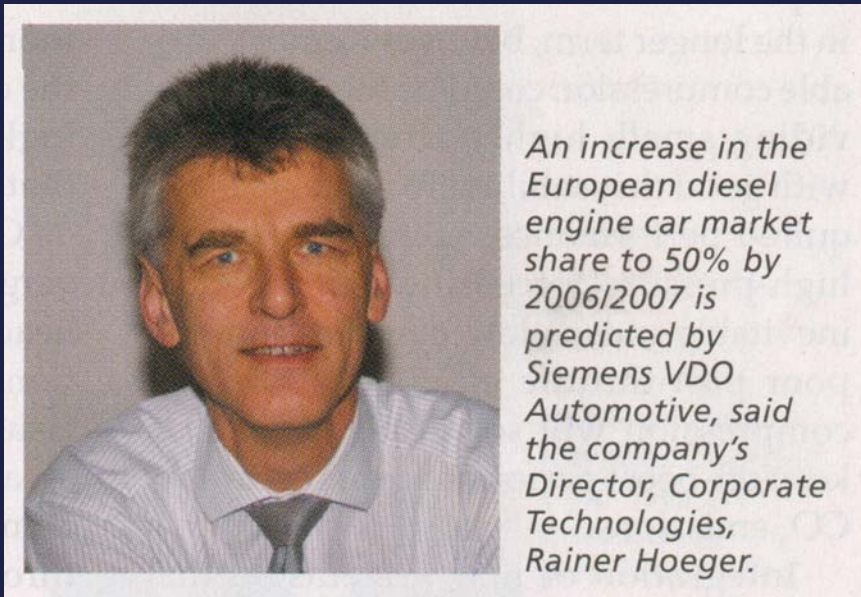
# Tendencias internacionales (Mercedes)



- “The need to fulfill **fuel-economy and emissions requirements** in worldwide markets without compromising customer expectations in other areas will be the driver for most of the powertrain innovations in coming years”, said Hans-Joachim Schöpf, Executive Vice President for Development, Mercedes Car Group, and one of Europe’s most senior automotive engineers. “The development of the gasoline engine will be mainly focused on fuel economy”.
- “There is a vision that the combustion systems of both engines may approach each other: the gasoline engine coming from port-injection and direct injection, the diesel engine moving from swirl chamber, direct injection, high pressure injection to partial homogeneous applied ignition. But from a present point of view, the gasoline engine will still need its spark plug, and the fuel needed for both combustion systems will remain different”.
- “As long as legislation does not advocate one technology or prohibit another, competition will lead to the best solution. Incentives are an effective way to contribute to the successful introduction of new technologies”. But in the long term, the automotive industry will have to compensate for the associated cost increase, he warned.
- One of the new technologies is the **hybrid-electric vehicle (HEV)**, the eventual success of which, Schöpf believes, depends on reducing costs and offering the technology in vehicles people are accustomed to driving.



# Tendencias internacionales (Siemens)



- Rainer Hoeger said the company (Siemens VDO Automotive) predicts an increase in the diesel market share in Europe to **50% in 2006/2007**.
- Commenting on emissions and fuel-consumption reductions, Hoeger said that since the early 1970s, NOx, CO, and HC emissions have been cut by more than 95%, and average fuel consumption reduced by some 20% over the past 12 years: "Because of these facts, improvements in environmental impacts by cars should now concentrate on **traffic management** and **telematics**".

- Hoeger feels the future of hybrid technology will depend on the market accepting the additional cost. "Siemens VDO expects to see the first large scale **42-V applications to hybrids by the beginning of the next decade**".
- Hoeger believes that a **mixture of both gasoline and diesel engine technology** is vital. Will the gasoline engine soon be eclipsed by the turbodiesel? "Definitely not", he said. "The challenge for the gasoline engine is **improvement in fuel economy and low-end torque**. Next generation high-pressure direct-injection engines with spray-guided combustion will boost fuel economy".

# Tendencias internacionales (Prodrive)



- Many European companies are aware of the promise that **hybrid systems** offer and of their main **drawback: cost**. At Prodrive, Engineering Director Hugh Kemp said, "Full hybrids will remain too costly unless operating conditions (such as congested city routes) specifically require an electric drive capability. Hybrids need too many parallel components and too much weight."
- **Engine downsizing** without any loss of performance is a likely development in the longer term, believes Kemp: "**Variable compression** could be the key to providing small, highly efficient engines with good driveability".
- Commenting on whether legislation and environmental requirements contribute to, or detract from, success in the race for greater powertrain efficiency, Kemp said, "Legislation is undoubtedly driving some major advances in powertrain efficiency, but whether these are in the best direction is debatable. For example, I'd like to see **more emphasis on clean combustion** rather than aftertreatment. The pace of improvement in **fuel quality** is also frustratingly slow, as is the significant difference in legislated **sulfur content** planned for Europe and the US. If legislators are no more aggressive with fuel quality, then the consumer will be paying for increasingly expensive aftertreatment systems that could have been avoided".
- "Gasoline and diesel technologies are heading towards universal **direct injection**".
- "Spark-less gasoline engines have tremendous potential, but there are so many unresolved issues that I cannot envisage production in my lifetime".

# Tendencias internacionales (Fiat - Bosch)



- Nevio di Giusto, Head of Product Development, Fiat/Lancia Business Unit, said that because of the “large difference” in the cycle of the two engines [gasoline and diesel], convergence is a medium-to-long-term prospect.
- Di Giusto believes that there will be increasing focus on **alternative fuels** including methane, LPG, and biodiesel.
- He foresees a “proliferation” of technology for treating exhaust gases, especially **particulate traps** and for the continual **control of the valves**.



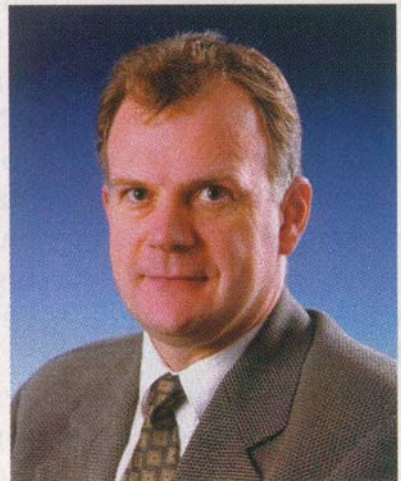
- For **gasoline direct injection**, Bosch will look at both wall-guided and spray-guided combustion methods, according to Siegfried Dais, Bosch Board Member.
- To increase available torque in the lower rpm range, he said, Bosch expects to see a combination of gasoline direct injection and an **exhaust gas turbocharger**.
- Dais expects new combustion methods for both diesel and gasoline engines in the longer term, leading towards **HCCI (homogeneous charge compression ignition)**.
- “Fuel is very important in this context, particularly **synthetic fuels**”.



# Tendencias internacionales (Ricardo - Jaguar)



*The main issue with hybrids is the cost/benefit ratio, said Neville Jackson, Technology Director, Ricardo Consulting Engineers.*



*Jaguar Programs Director Phil Hodgkinson sees an eventual trend to smaller, pressure-charged engines.*

- Neville Jackson, Technology Director of Ricardo Consulting Engineers, believes that, “in general”, there will be a significant move away from **manual to automatic transmissions** in Europe.
- In keeping with most senior auto technologists, Jackson said the main issue with **hybrids** is the **cost / benefit ratio**.
- As for diesel and gasoline technology, he believes that there will be **convergence in the longer term**.
- Despite the enormous strides made in diesel (notably turbodiesel) technology, Jackson believes it unlikely that the diesel will ever be able to compete on a **performance / cost basis** with the **gasoline engine** and that the gasoline will always have an edge in a number of key applications.
- Jaguar is unusual among major European companies in having no experience building diesel-powered cars, although this is expected to change within a few months with the introduction of a **diesel X-Type**.
- **Direct-injection gasoline** engines can present difficulties, said Hodgkinson, and may eventually require **NOx traps**.
- He believes **diesel engines** will always need **aftertreatments**, which are expensive.



# Tendencias internacionales (Peugeot Citroën – Renault)



*Robert Peugeot,  
Executive Vice  
President,  
Innovation and  
Quality, PSA  
Peugeot Citroën  
said, "There is  
always the risk of  
legislation going  
one step too far."*

- Robert Peugeot, Executive Vice President, Innovation and Quality, PSA Peugeot Citroën feels **diesel and gasoline** engines may become **closer in terms of unit cost**. "At present, sophisticated diesel engines are expensive", he said.
  - He does not see total convergence between the two technologies and also believes there will be **continuance of gasoline and diesel fuel production**.
- 
- The importance of particulate-filter technology was underlined by Philippe Gutierrez, who heads the management of Renault's Technical and Mechanical Department: "A number of technologies currently under development are likely to emerge as standard engine features, and **particulate filters** will become commonplace on **diesel engines**. And diesel engine NOx and particulate emissions will be brought down still further by new, **higher-pressure injection systems** supporting **multi-injection**".
  - "**Pollution control systems** capable of reducing NOx and particulates must consume energy and will therefore tend to **increase CO<sub>2</sub> emissions**".
  - Gutierrez sees **mild hybrids** becoming more prominent, but feels that **product costs** "**appear excessive**" considering likely fuel savings, particularly in the light of reduced gasoline and diesel engine fuel consumption.

# Tendencias internacionales (Volkswagen)

- Ulrich Eichhorn, until March this year Head of Research and Development for Volkswagen and now Member of the Board for Engineering, Bentley Motors, is very positive about **convergence between diesel and gasoline technology**. “Clearly it is happening and they will converge”, he said. “We call this **Combined Combustion Systems (CCS)**”.
- Eichhorn believes that when this happens, spark plugs will only be used for part of the operating range. The fuel used will be neither gasoline nor diesel, but a **zero-sulfur synthetic fuel**. When? “**Not less than five years**, certainly”, he said.
- And what of mild **hybrids** and fuel cells? The former Eichhorn sees as **potentially significant**, about the latter he is very cautious. “Fuel cells only make sense with hydrogen, but no one really knows how to produce it in large scale”, he said. “**I am in doubt about fuel cells**. I think they have potential but it is not a foregone conclusion that they will be the powertrain of the future”.
- Eichhorn believes serious **application of fuel-cell cars is at least 15 years off**, and then in small volumes.
- “So many people focus on the engine, but the **gearbox is also very important**”. Eichhorn is enthusiastic about the **DCT** and **CVT** (fitted to some Audi models).



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