Variable Valve Timing - Sample

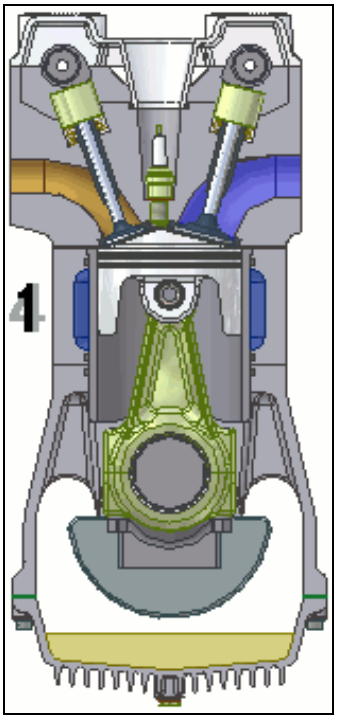
Contents

Objective

Prepare a landscape report on camless variable valve timing in diesel engines [Ford Motor Co.]

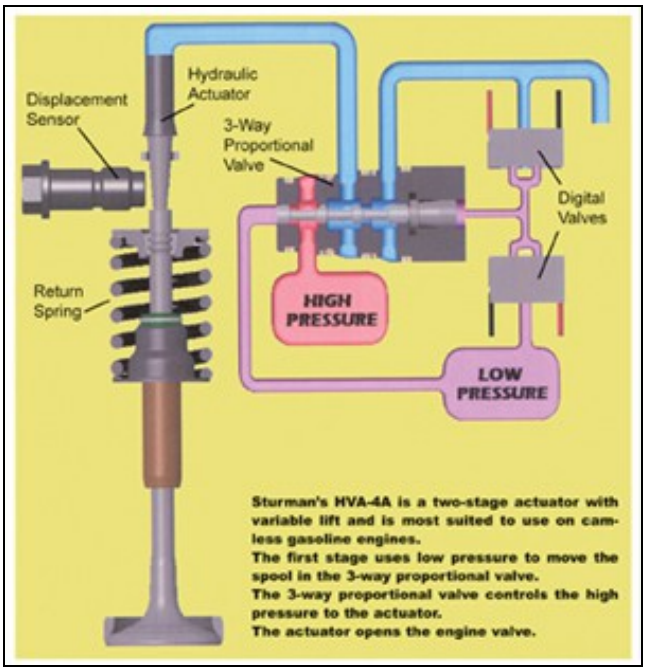
Background

4 Stroke Diesel Engine Operation

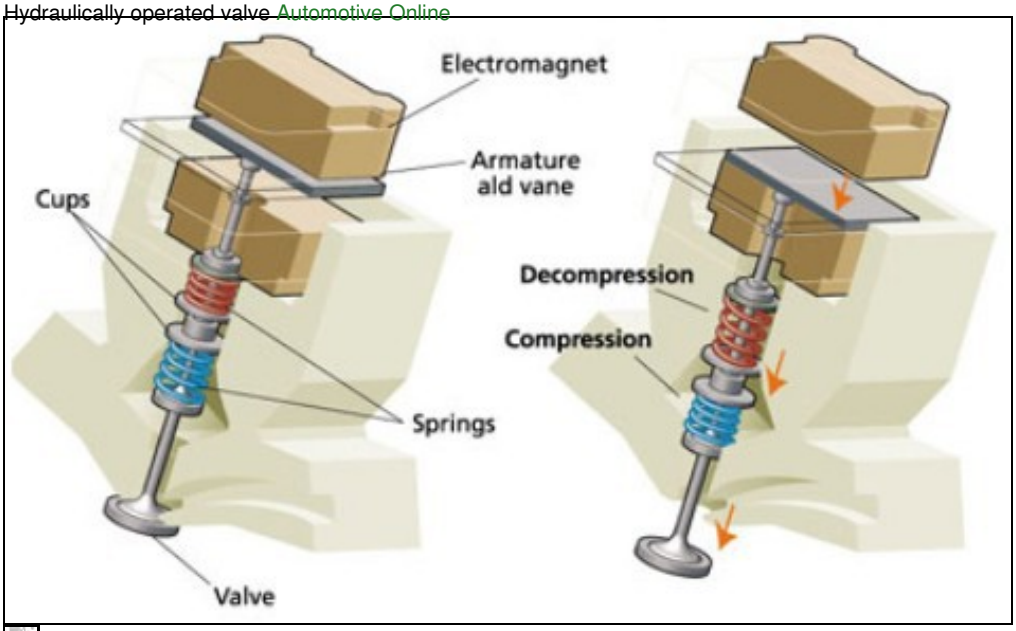


DIESEL ENGINE CYCLE
Diesel Cycle

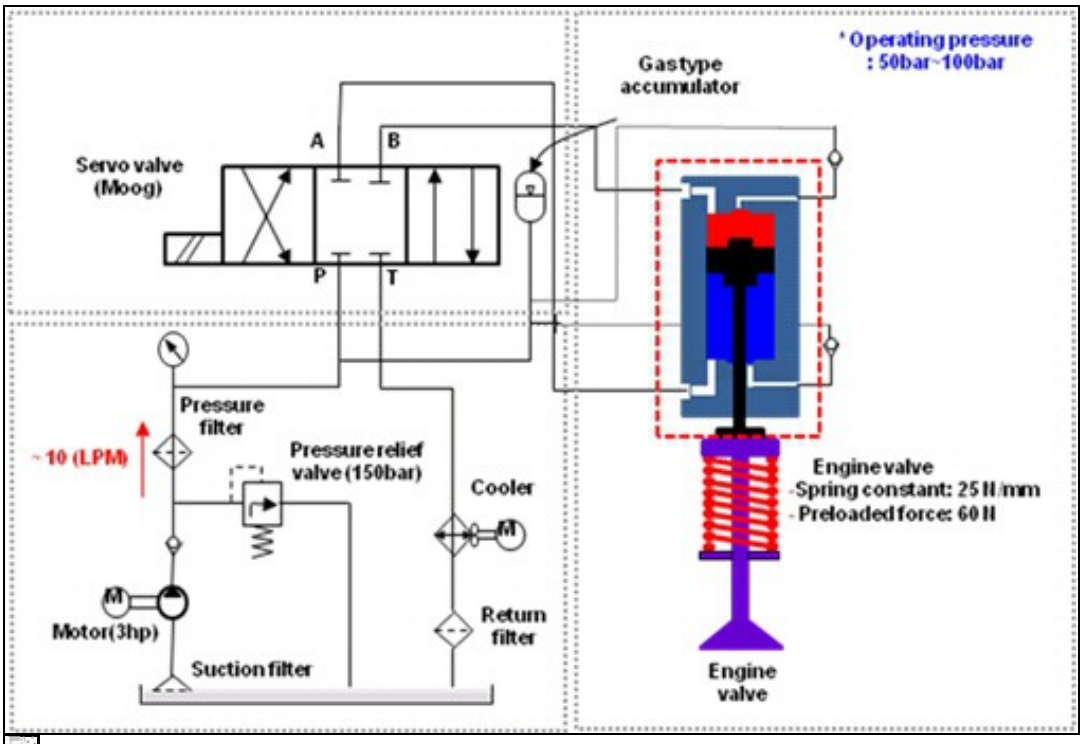
1. Air is drawn in the intake stroke of diesel engine
2. Followed by compression to raise temperature and pressure.
3. At this high T-P fuel is injected into the combustion chamber which self ignites due to high T. During the first phase of combustion pressure is relatively constant (2-3) followed by isentropic expansion in which the energy is transferred to the piston.
4. Next is the exhaust stroke when gases start escaping. Next the momentum of the piston compresses the next lot of air



Hydraulically operated valve Automotive Online



Electromagnetically operated valve Jalopnik.com



Camless Servo operated valve Kaist Research

Valve Timing

Camshaft engine: Timing is decided by the cams on the camshaft. The phase difference between the inlet and exhaust cam profiles will decide the opening and closing times of both the valves.

Through, mechanical, hydraulic, pneumatic, electronic, electromagnetic, piezoelectric or electrical means the phase between inlet and exhaust vales can be varied.

Parameters on which variable valve timing can be adjusted

- Load on engine : Torque requirements
  - Depending on gear- heavy traffic (lower gear), weather (snow, rain, storm, sunny day etc)
  - Topography,
  - Toad gradient
  - Compensate for lack of driver skill in negotiating different driving conditions.
- Compression ratio : For efficient combustion, measured through temperature, pressure in exhaust or combustion chamber itself.
- Residual gas traces in exhaust : (Reduce NOx emissions, un-burnt gases etc)

Prominent variations in relative valve timing

1. Early closing of Intake Valve
2. Early opening of Intake Valve
3. Late intake valve closing
4. Early/Late exhaust valve closing

Proprietary Terms for VVT Manufacturers use proprietary technology and therefore affix a proprietary term to distinguish their engines from the competition.

1. Alfa Romeo - Twinspark technology
2. Audi - VVT
3. BMW - Valvetronic, VANOS and Double VANOS
4. Ford - Variable Cam Timing
5. GM - Double Continuous Variable Cam Phasing (DCVCP), Alloytec and Variable Valve Timing (VVT)
6. Honda - VTEC, iVTEC and VTEC-E
7. Hyundai - MPI CVVT
8. Lexus - VVT-iE
9. Mazda - S-VT
10. Mitsubishi - MIVEC
11. Nissan - N-VCT, VVL , CVTC and VVEL
12. Porsche - VarioCam and VarioCam Plus
13. Subaru - AVCS and AVLS
14. Toyota - VVT, VVT-i and VVTL-i
15. Volkswagen - VVT
16. Volvo - CVVT

To understand which part of the above mentioned ways are these companies referring to through these names the following link is useful: Abbreviations for VVT

Patent Search

Concept Table

VALVE	TIMING	VARIABLE	DIESEL	ENGINE	Cam Operated	Camless
valve*	lift	vary	diesel	engine	cams	electronic*
actuat*	tim*	variable	compression ignition	internal combustion	cam shaft	electromagnetic*
activat*	duration	varying	self ignition	power source	cam phase	magnetic*
port	interval	var*	compression - ignition	2-stroke	cam drive	electric*
		control*	self - ignition	2 stroke		piezo*
		manipulat*		two stroke		electrohydraulic*
		set				electropneumatic*
		change*		4 stroke		electro*
		adjust		4-stroke		cam-less
				Four Stroke		

IPC Definitions

Useful Classes	Description
F01	CYCLICALLY OPERATING VALVES FOR MACHINES OR ENGINES
F01L 1/00 - 13/00	only valve-gear or valve arrangements without provision for variable fluid distribution
F01L 15/00 - 35/00	Valve-gear or valve arrangements specially adapted for machines or engines with variable working-fluid distribution are covered by groups
F01L 1/34	characterised by the provision of means for changing the timing of the valves without changing the duration of opening

F01L 9/00	Valve-gear or valve arrangements actuated non-mechanically
F01L 13/00	Modifications of valve-gear to facilitate reversing, braking, starting, changing compression ratio, or other specific operations
F01L 25/00	Drive, or adjustment during operation, of distribution or expansion valves by non-mechanical means
F01L 31/00	Valve drive, valve adjustment during operation, or other valve control, not provided for in groups
F01L 33/00	Rotary or oscillatory slide-valve gear or valve arrangements, specially adapted for machines or engines with variable fluid distribution
F01L 35/00	Lift-valve gear or valve arrangements specially adapted for machines or engines with variable fluid distribution

Search String

#	Concept	Search Query	Hits
1	Keywords for VVT (Claim, Title, Abstract)	(vary* or chang* or control* or variable or *adjust* or set or *manipulat*) near2 ((valve* or port or actuat*) near2 (time or timing or interval or duration or lift or system))	**6165**
2	Keywords for D.Engine (Claims Title Abstract)	(diesel or ((compression or self) adj ignition) or (internal or combustion)) near2 (engine or (power near2 source)) not ((spark adj ignit*) or (spark adj plug) or (external adj combustion))	**81239**
3	Combined Query	1 AND 2	**2587**
4	Keywords for Cam (Full Spec)	(cam or camshaft or cams or (cam near2 drive) or (cam near2 phase)) not (camless or (cam near2 less) or electronic* or electromagnetic* or magnetic* or electric* or piezoelectric* or electro*)	**64464**
5	Combined Query	3 NOT 4	**2090**
6	Keywords and IPC search	(diesel or ((compression or self) adj ignition) or (internal or combustion)) near2 (engine or (power near2 source)) not ((spark adj ignit*) or (spark adj plug) or (external adj combustion))	**3426**
		F01L0009 or F01L0013 or F01L0025 or F01L0031 orF01L0033 or F01L0035	
7	Keywords and IPC search	(vary* or chang* or control* or variable or *adjust* or set or *manipulat*) near2 ((valve* or port or actuat*) near2 (time or timing or interval or duration or lift or system))	**517**
		F02B	
8	Combined Query	6 OR 7	**3868**
9	Combined Query	8 NOT 4	**2792**

10	Combined Query	9 OR 5	**4054**
11	Ford Patents (Assignee/Applicant)	Ford* or Volvo* or (premier adj automotive) or (fmc adj automobil*) or (manhattan adj automobil*) or (american adj road adj services) or (apco adj automobile) or (detroit adj downtown) or fairlane or greenleaf or (granite adj management) or (pacific adj bay adj homes) or carey or (egyptian adj trading) or (FCE adj bank)	**8546**
12	Ford Patents (Assignee/Applicant .. Non standard)	Ford* or Volvo* or (premier adj automotive) or (fmc adj automobil*) or (manhattan adj automobil*) or (american adj road adj services) or (apco adj automobile) or (detroit adj downtown) or fairlane or greenleaf or (granite adj management) or (pacific adj bay adj homes) or carey or (egyptian adj trading) or (FCE adj bank)	**8290**
13	Combined Query	11 OR 12	**8546**
14	Combined Query	13 AND 10	**131(81 unique families)**

Assignee Subsidiaries

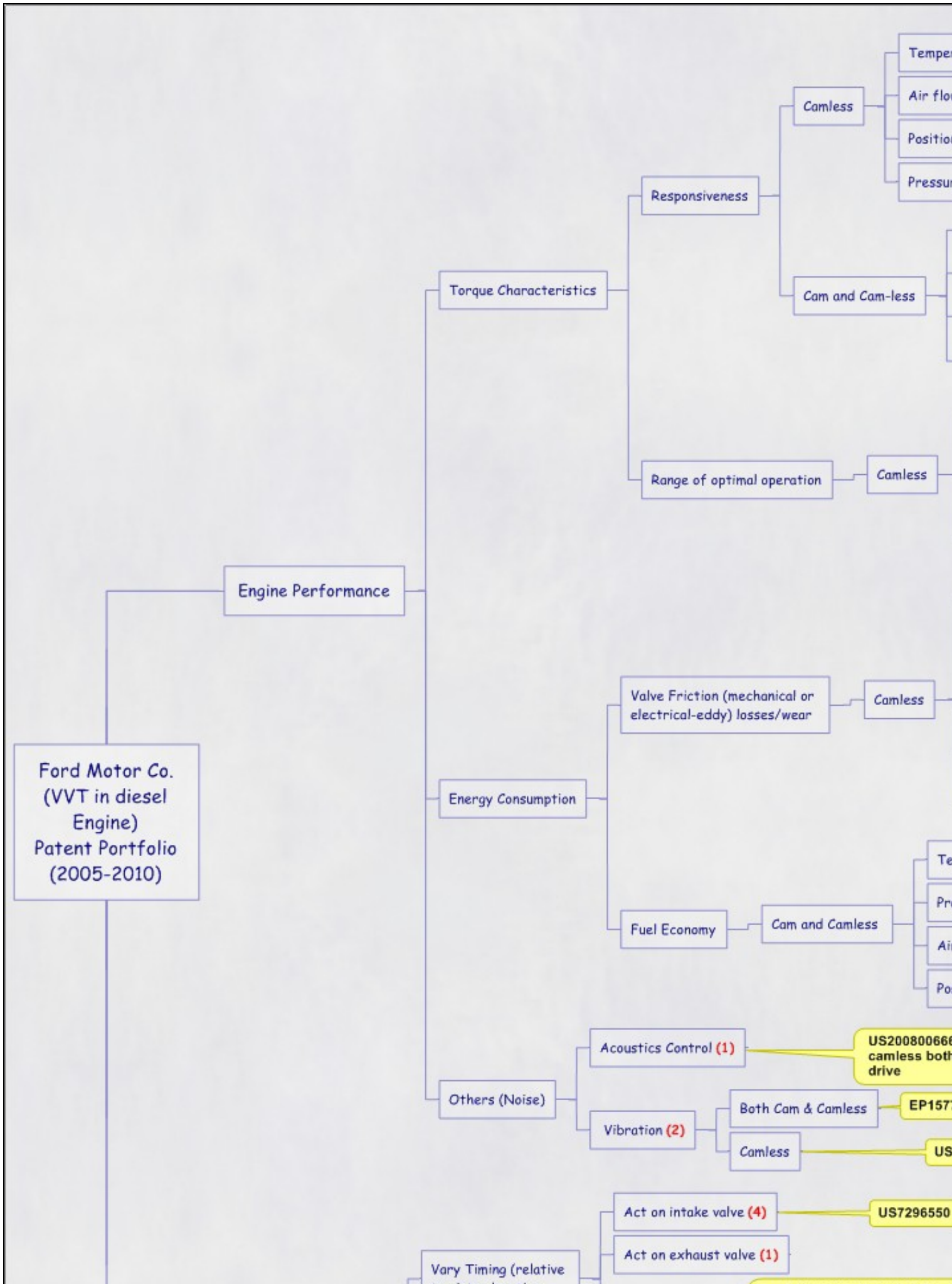
Serial No.	Ford Motor Company - Subsidiaries
1	AMERICAN ROAD SERVICES COMPANY
2	A P C O AUTOMOBILE PROTECTION CORPORATION
3	DETROIT DOWNTOWN DEVELOPMENT CORP
4	FAIRLANE GOLF, INC
5	GRANITE MANAGEMENT CORP
6	GREENLEAF LLC
7	MANHATTAN AUTOMOBILE COMPANY
8	PACIFIC BAY HOMES, LLC
9	CAREY INTERNATIONAL INC
10	THE EGYPTIAN TRADING & INDUSTRIAL CO.
11	FCE BANK PLC - Salzburg, Austria
12	FMC AUTOMOBILES SAS
13	PREMIER AUTOMOTIVE GROUP
14	VOLVO CAR CORP

(Source : LexisNexis.com)

Sample Analysis of Control Patents

S.No	Reference Patents	Assignee/Applicant	Dolcera Summary	US class	Intl Classification
1	US7235034 B2	Volvo Lastvagnar AB, Dec 2005 (Dec 2005 filed)	This invention uses electronic controlling devices to detect a future change in resistance to forward motion (road gradient, shift of gears etc) using GPS technology and electronic maps and use it as input to prechange the valve timing and prechange the mode of operation of engine to have better engine performance	477/107	F01L 1/34 (20060101)
2	EP1460253 A1	FORD GLOBAL TECH INC	In camless VVT mechanism, controlling the inlet valve closing timing is done by determining the value of lambda (air -fuel ratio) for the next combustion cycle(of same cylinder). An ECU controls the fuel injection quantity in each cycle and also consists of a lambda controller which calculates the difference between actual lambda and theoretical lambda and decide whether early or late closing time for inlet valve is required in the next cycle. Actual lambda is sensed through a sensor which can be either a pressure sensor, or intake air temperature, or intake air mass flow		F02D001302 20060101
3	US6994061 B2	FORD GLOBAL TECH LLC(Feb 2006)	Detect interference between valve and piston (mechanical wear) through sensor and adjust Valve timing, lift or compression ratio to reduce interference. This is done by an electronic controller connected to pressure sensor and temperature sensors	123/09015	F01L0001344E F01L000902 F01L000904
4					

	WO2010036094 A1	PETROLIAM NASIONAL BERHAD (Feb 2010)	Relates to exhaust valve opening timing, compression ratio and lift strategy for 2-stroke internal combustion engine. It involves a fuel injector to selectivelyinject fuel into the combustion chamber; inlet valve to selectively deliver pressurised oxidising agent into the combustion chamber and an exhaust valve to selectively open and allow exhaust gases. The cylinder temperature near top dead center (just before combustion) can be accurately controlled		F01L000100, F02D001302, F01L001300
5	US7383820 B2	FORD GLOBAL TECH LLC (June 2008)	Adjusts intake valve timing electromechanically to have a target intake amount of air in a given cylinder which is calculated by a the temperature in that cylinder. Advantage is of controlling emissions during the start of the engine	123/491	F01L001300, F01L000904, F01L000100
6	JP2006077680 A	TOYOTA MOTOR CORP	Improves the follow up ability of valve charateristic to target charateristic. Oil from an engine driven oil pump and from another electric motor are used as input for valve timing. As engine speed goes up oil temperature rises , viscosity decreases, pressure falls and thus follow up ability of valve falls. The oil from motor is set to compensate for this fall by increasing the flow of oil as temperature rises		F01L000134, F01L000118, F02D001302


Ford Motor Co. (VVT in diesel Engine) Patent Portfolio (2005-2010)
Engine Performance
Torque Characteristics
Responsiveness
Camless
Tempe
Air flo
Positio
Pressu
Cam and Cam-less
Range of optimal operation
Camless
Energy Consumption
Valve Friction (mechanical or electrical-eddy) losses/wear
Camless
Fuel Economy
Cam and Camless
Te
Pr
Ai
Po
Others (Noise)
Acoustics Control (1)
US20080066
camless both
drive
Vibration (2)
Both Cam & Camless
EP157
Camless
US
Vary Timing (relative
Act on intake valve (4)
US7296550
Act on exhaust valve (1)

Ford Patent Portfolio

Analysis Sheet

Analysis Sheet

Sources

1. Control Patents
2. Wikipedia.org