FORD’S SMALL CARS GAIN A BIG NEW HEART

- New 90PS Duratorq 1.6L TDCi 16V diesel engine significantly extends Fiesta and Fusion model ranges
- Takes Ford’s small cars into the large and growing premium diesel market
- High standards of driveability and fuel economy
- Flexibility and lively performance showcased in sporty new Fiesta Zetec S 1.6 TDCi

A new 16-valve intercooled and turbocharged diesel engine makes its debut in **Fiesta** and **Fusion**.

The new 90PS Duratorq 1.6L TDCi engine joins the existing 68PS 1.4 litre eight valve Duratorq turbo-diesel, and drives **Fiesta** and **Fusion** into an important and fast growing area of the small diesel market. The ‘premium diesel’ sub-segment accounts for nearly a quarter of B-Class diesel sales in the UK, Germany, France and Spain, and is growing fast as customers recognise the benefits of performance, flexibility and economy that these larger engines can offer.

The new power unit is the latest engine to come from the cooperative agreement in diesel engine development between Ford Motor Company and PSA Peugeot Citroën. The first Ford product of this agreement was the existing 1.4L Duratorq TDCi fitted to the **Fiesta** and **Fusion** model ranges.

The 1.6 TDCi engine features lightweight, all aluminium alloy construction, third-generation ultra high pressure common rail diesel injection, twin overhead camshafts and electronic ‘drive-by-wire’ throttle control.

The 1.6L TDCi offers more power and, importantly, more torque than its smaller brother. It develops 90PS at 4,000 rpm and its outstanding 204 Nm pulling power is delivered from only 1,750 rpm. The result is an exceptionally flexible engine. It also already passes the tough new Euro IV emissions regulations. Official CO2 rating is 119g/km.

It achieves high standards of fuel economy under all operating conditions with a combined economy figure of 62.8 mpg in **Fiesta**. The engine will be available in three-door and five-door Ford **Fiesta** models as well as in the Ford **Fusion**. In addition, it is available in the new **Fiesta** Zetec Sport where its flexibility and lively performance help create a fun-to-drive and economical ‘warm hatch’.

The 1.6L TDCi engine has already been seen in the Focus C-MAX and the new Focus. This new 90PS version has been specially developed for the smaller **Fiesta** and **Fusion** models. Its key feature is a very flat and wide torque curve that provides good performance and emissions, but not at the expense of fuel economy or noise.

“This is a terrific engine,” says Mark Stanton, Chief Engineer for **Fiesta** and **Fusion**. “It has the perfect blend of performance and economy and will make **Fiesta** and **Fusion** very strong contenders in the premium diesel category.”

THE ENGINE IN DETAIL

**Tough targets more than met**

Ford’s engineers set out tough standards of power, performance, economy, emissions and refinement for the new 1.6L TDCi power unit. It has not just met these targets but exceeded many of them.

A very important target was to achieve the best possible standards of low end and drive-away pulling power by providing high levels of torque from very low engine revs.
The 1.6L TDCi engine develops its peak 204Nm of torque from just 1,750 rpm through to nearly 3,000 rpm and 90 per cent of peak torque is available from 1400 rpm to 3200 rpm. Nearly 170 Nm of torque is available from as low as 1,250 rpm.

The result is strong acceleration from standstill together with the sort of flexibility that can reduce the need for gearshifts. Its superb flexibility is particularly of benefit in the Fusion with its greater load carrying capabilities.

Driveability is further aided by careful calibration of Fiesta’s drive-by-wire throttle system. Its Powertrain Control Module (PCM) has been tuned to give sporty response to throttle inputs, as well as smoothness during pull away and gear shifting. Retaining this fun-to-drive, Ford feel – the ‘Ford DNA’ as it is called by insiders – has been a very important part of the engine’s development process. Ford engineers have optimised the calibration to achieve a unique ‘feel’ in the Fiesta.

The lightweight construction of the all-aluminium engine has enabled impressive performance standards to be achieved, as well as handling equivalent to petrol derivatives. The 16-valve power unit is only some 15 kg heavier than the eight-valve 1.4TDCi and its overall weight of under 120 kg compares favourably with petrol Fiesta engines. The 1.6L TDCi Fiesta is capable of 112mph and reaches 60 mph from a standstill in 11.2 seconds.

One of the biggest challenges in the engine’s development was achieving the high standards of fuel economy expected of a diesel as well as meeting the rigorous new Euro IV emissions standards that will be mandatory from the start of 2006. In fact, the engine will be available in both Euro III and Euro IV forms, depending on market needs.

The new Euro IV standards effectively demand a 50 per cent reduction in emissions and at the same time require the engines to achieve these levels after 100,000 km. Effectively, this raises the bar higher still for new engines to allow for natural wear and deterioration with age. CO2 emission levels for the new engine are 119g/km.

The 90PS TDCi uses a wide variety of state-of-the-art measures to achieve its high standards of fuel economy, emissions, performance and refinement. Most notably it uses the latest Bosch ultra-high pressure fuel injection system, a digital mass air-fuel sensor, electric exhaust gas recirculation valve, electronic turbocharger wastegate control and a revised exhaust catalyst.

"Developing a small diesel engine today is a great challenge", explains Rashed Khan, Programme Manager for the TDCi engine. "It is a critical balance of emissions, noise reduction, fuel economy and performance. I’m very pleased with what we have achieved in this engine."

Light yet strong construction

The Duratorq 1.6L TDCi engine is constructed in the form of a multi-layer, cast aluminium alloy sandwich with each element having its own highly optimised reinforcing webs. The result, when assembled, is an extremely stiff structure which generates low levels of NVH (noise, vibration and harshness).

At the heart of the Duratorq 1.6L TDCi engine is an aluminium alloy cylinder block. This is a high-pressure die-casting with cast-iron cylinder liners that are assembled into the block to provide rigidity against the combustion firing forces.

The bottom-end of the cylinder block is bolted to a separate cast aluminium bedplate which has the cast-iron bearing housings inserted into it. As a result of the bearings being constrained from excessive movement, engine NVH is significantly improved.
At its top end, is the die-cast aluminium cylinder head which is sealed to the block by a multi-layer steel gasket optimised to head geometry for robust sealing over a long service life. Its four valves per cylinder are operated by two overhead camshafts. These are carried in two separate die-cast aluminium alloy castings, split on the camshaft centre lines, and bolted down onto the cylinder head.

The forged steel crankshaft is carried in five main bearings and has eight counterweights optimised to reduce vibration. Front and rear ends of the crankshaft are sealed with long-life PTFE seals. Connecting rods are a one piece forged steel design with fracture split big ends.

Lightweight alloy pistons are mounted on fully floating piston pins and fitted with three low friction rings. Tightly controlled bore tolerances ensure low blow-by hydrocarbon emissions and negligible oil consumption, so there should be no need to add oil between services.

The twin overhead camshafts are fabricated in a lightweight, tubular design with the individual lobes pressed on to the hollow shafts. This construction method achieves a camshaft that is 30 per cent lighter than a solid, cast-iron type, and the lower mass reduces inertia forces which helps to assure a long life of the drive belt system.

The camshafts each run in five bearings that are machined directly into the carrier castings. The inlet camshaft is driven by a long-life glass-fibre reinforced belt and the exhaust camshaft driven from the first by a short chain with hydraulic tensioner.

The cam lobes operate the 16 valves via low friction rollers mounted in finger followers that pivot on maintenance-free hydraulic lash adjusters. A special valve prevents oil draining from the adjusters to reduce cold start noise and wear, thus increasing service life.

Also driven from the primary drive belt are the high pressure fuel injection pump and the water pump. The oil pump is driven directly from the crankshaft.

A clever, weight-saving plastic air module assembly covers the top of the engine and mates to the engine’s inlet ports. This Integrated Air Module (IAM) brings together in one compact unit the engine air filter, intake manifold, air flow meter, oil separator, crankcase pressure regulator, disposable fuel filter, EGR controls, turbocharger output trunking and a sound-tuning resonator. It also acts as a cam cover with built-in noise damping and is easily removable in one piece for routine maintenance.

The 90PS Duratorq 1.6L TDCi engine features a compact fixed-geometry, low-inertia turbocharger and intercooler which have been developed to provide optimised performance, particularly at low speeds.

**Latest generation common-rail injection**

Common-rail diesel technology is becoming universally accepted by car manufacturers as the route to developing diesel engines that achieve ever higher standards of emissions together with improved fuel economy, greater torque output and high standards of NVH refinement.

The technology takes its name from the design of the engine’s fuel injection system. Common-rail systems employ a high-pressure reservoir – the 'rail' – that delivers fuel to the cylinders.

A high-output fuel pump maintains fuel pressure in the rail largely independently of engine speed, which allows control of the fuel injection process with a high degree of accuracy.

First and second generation common rail systems used mechanical methods to open and close the injectors but now new finer control methods have been devised to achieve even closer regulation of
The rapid speed at which the injectors can operate makes it possible to reduce the intervals between injections and split the quantity of fuel delivered into a large number of separate injections for each combustion stroke. The results are more precise metering of the amount of fuel injected and very fine control over the combustion process.

A technique called pilot injection tailors each cylinder’s combustion characteristics. This involves the injection of a small pulse of fuel prior to the main injection of fuel. Timed carefully by the engine’s electronic management system, pilot injections help to initiate a more controlled combustion event. This allows for more smooth and efficient burning of the main fuel dose.

The injectors deliver their spray into the cylinder by six spray holes, each with a diameter of 120 micrometres – about one-fifth the diameter of a human hair. The six-hole spray pattern results in fuel spray clouds arranged to avoid cylinder wall impingement that could increase the amount of particulate emissions.

The Duratorq TDCi has a full engine management system, taking data from sensors that measure camshaft position, crankshaft speed, mass air flow, coolant temperature, fuel pressure and temperature, and ambient temperature and pressure. This information is then compared by the management computer against a calibration map determined by extensive development to optimise fuelling.

**Installation in Fiesta and Fusion**

High levels of NVH suppression and first class driveability were key targets for the 1.6L TDCi Ford Fiesta and Ford Fusion. In addition, the TDCi versions of the Fiesta and Fusion have their own unique front-end ‘module’ housing a different radiator and fan, different air conditioning condenser and the intercooler.

The gear spacing and overall ratios of the Durashift five-speed manual transmission have been matched to the different performance characteristics of the engine and the gears themselves have been uprated in strength to cope with the engine’s high torque output.

Electro-hydraulic power assisted steering (EHPAS) has been adopted for the 1.6L TDCi models for reasons of space efficiency and fuel economy. The system can provide a fuel economy benefit of up to three per cent, depending on customer usage.

EHPAS uses an electrically activated hydraulic power steering pump that is only called upon when needed (for example during manoeuvring) rather than being permanently driven from the engine, as in a conventional power steering system. This results in an overall reduction in engine loading and hence an improvement in fuel economy.

At the same time EHPAS retains all the advantages to the user of traditional hydraulic assistance but offers the additional potential to be vehicle speed sensitive and calibrated to be intuitive in its response.

Suspension has been re-tuned to maintain Fiesta’s fun to drive feel. Front springs are around ten per cent stiffer to accommodate the small increase in engine weight and the front dampers have been re-calibrated.

“The 1.6L TDCi is a really enjoyable and easy engine to use,” comments Fiesta Vehicle Engineering Manager, Andy Boyle. “Its flexibility adds an extra dimension to Fusion, and the Duratorq TDCi version of Fiesta Zetec S pulls like a train.”
FIESTA 1.6 DURATORQ TDCI

Engine data
1.6L Duratorq 16V – 90 PS 1560 cc

4 cylinders in line; DOHC; 16 valves; alloy cylinder head and block; direct injection with high-pressure, common-rail, multipoint fuel injection system; fixed geometry turbocharger with intercooler; electronic throttle

Engine Technical Features
Maximum power 66kW (90PS) at 4000 rpm
Maximum torque 204 Nm at 1750 rpm

Transmission data
Transmission ratios
1st 3.583
2nd 1.926
3rd 1.281
4th 0.951
5th 0.756
Reverse 3.615
Final drive 3.368

Weights (kg)
Basic kerb kg 3-door 1118-1157 (1128-1167)
(5-door) 1118-1242 (1128-1167)
Gross vehicle mass
(5-door) 1610 (1615)

Performance and Fuel Economy
Max speed (mph) 112
0-60mph (secs) 11.2

Fuel consumption
(miles per gallon)
Urban 52.3
Extra Urban 68.9
Combined 62.8
CO2 – combined mode 119
(g/km)

Dimensions
Length (mm) 3916
Width without mirrors (mm) 1683
Height (mm) 1468
Wheelbase (mm) 2486
Track front/rear (mm) 1464/1434
Tyres 175/65R14
Wheels 5.5Jx14 inches

5-door
3916
1683
1463
2486
1464/1434
175/65R14
5.5Jx14 inches
FUSION 1.6 DURATORQ TDCI

Engine Data

1.6L Duratorq 16V – 90 PS 1560 cc

- 4 cylinders in line; DOHC; 16 valves; alloy cylinder head and block; direct injection with high-pressure, common-rail, multipoint fuel injection system; fixed geometry turbocharger with intercooler; electronic throttle

Engine Technical Features

- Maximum power: 66kW (90PS) at 4000 rpm
- Maximum torque: 204 Nm at 1750 rpm

Transmission data

- Transmission ratios:
  1st: 3.583
  2nd: 1.926
  3rd: 1.281
  4th: 0.951
  5th: 0.756
  Reverse: 3.615
  Axle: 3.368

Weights

- Basic kerb (kg): 1162-1200
- Gross vehicle mass (kg): 1675

Performance and Fuel Economy

- Max speed (mph): 109
- 0-60mph (secs): 12.2

Fuel consumption (miles per gallon)

- Urban: 51.4
- Extra Urban: 70.6
- Combined: 61.4
- CO2 – combined mode (g/km): 122

Dimensions

- Length (mm): 4018
- Width without mirrors (mm): 1720
- Height (mm): 1529
- Wheelbase (mm): 2486
- Track front/rear (mm): 1474/1434
- Tyres: 195/60R15
- Wheels: 6Jx15 inches