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Novita ducati 2025

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necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Ducati, il celebre marchio motociclistico di Borgo Panigale, continua a sorprendere gli appassionati con una serie di novità entusiasmanti per il 2025. Nonostante le numerose presentazioni già avvenute durante le
precedenti Ducati World Première e all'EICMA, l'azienda ha deciso di non fermarsi qui. Oggi pomeriggio, infatti, si svolgerà un nuovo episodio della World Première, intitolato "Next Level Formula", che promette di svelare ulteriori dettagli sui modelli futuri. Le attese novità: Multistrada V2 e oltre Tra le novità più attese c'è sicuramente la nuova
Ducati Multistrada V2, un modello che ha suscitato grande interesse tra gli appassionati. La domanda che molti si pongono è: sarà finalmente presentata oggi? La Multistrada V2 rappresenta un'evoluzione significativa nel segmento delle crossover, e i fan sono ansiosi di scoprire le sue caratteristiche innovative. Tuttavia, non è solo questo il motivo
per cui i fan di Ducati dovrebbero rimanere sintonizzati. Infatti, l'azienda ha in programma ulteriori episodi della World Première, incluso un evento dal Salone di Colonia a dicembre, dove verranno svelate altre sorprese. Un futuro luminoso per Ducati dovrebbero rimanere sintonizzati. Infatti, l'azienda ha in programma ulteriori episodi della World Première, incluso un evento dal Salone di Colonia a dicembre, dove verranno svelate altre sorprese. Un futuro luminoso per Ducati dovrebbero rimanere sintonizzati.
settore motociclistico. L'azienda non solo si concentra sull'innovazione tecnologica, ma anche sull'aspetto estetico e sulla performance delle sue moto. Ogni nuovo modello è il risultato di un'attenta ricerca e sviluppo, mirata a soddisfare le esigenze di un pubblico sempre più esigente. Gli appassionati possono aspettarsi un mix di tradizione e
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vedere, ma anche incredibilmente performanti. Type of car engine A cylinder has more than two valves (an intake, and an exhaust). A multi-valve engine has better breathing, and with more smaller valves (having less mass in motion) may be
able to operate at higher revolutions per minute (RPM) than a two-valve engine design has three, four, or five valves per cylinder to achieve improved performance. In automotive engine design has three, four, or five valves per cylinder to achieve improved performance. In automotive engine design has three, four, or five valves per cylinder to achieve improved performance.
often fuel[3]), and another for exhaust of combustion gases. Adding more valves increases valve area and improves the flow of intake and exhaust gases, thereby enhancing combustion, volumetric efficiency, and power output. Multi-valve geometry allows the spark plug to be ideally located within the combustion chamber for optimal flame
propagation. Multi-valve engines tend to have smaller valves that have lower reciprocating mass, which can reduce wear on each cam lobe, and allow more power from higher RPM without the danger of valve float. Some engines are designed to open each intake valve at a slightly different time, which increases turbulence, improving the mixing of air
and fuel at low engine speeds. More valves also provide additional cooling to the cylinder head. The disadvantages of multi-valve engines are an increase in oil consumption due to the greater number of valve stem seals. Some single overhead camshaft (SOHC) multi-valve engines (such as the Mazda B8-
ME) use a single fork-shaped rocker arm to drive two valves (generally the exhaust valves) so that fewer cam lobes will be needed in order to reduce manufacturing costs. [citation needed] Three-valve cylinder head This has a single large exhaust valve and two smaller intake valves. A three-valve layout allows better breathing than a two-valve head,
but the large exhaust valve results in an RPM limit no higher than a two-valve design can be lower than for a four-valve design was common in the late 1980s and early 1990s; and from 2004 the main valve arrangement used in Ford F-Series trucks, and Ford SUVs. The Ducati ST3 V-twin
had 3-valve heads. Four-valve cylinder head This is the most common type of multi-valve head, with two exhaust valves and two similar breathing as compared to a three-valve head, and as the small exhaust valves allow high RPM, this design is very suitable for high power outputs. Five-valve
cylinder head Less common is the five-valve head, with two exhaust valves and three inlet valves are similar in size. This design allows excellent breathing, and, as every valve is small, high RPM and very high power outputs are theoretically available. Although, compared to a four-valve engine, a five-valve design should have a higher
maximum RPM, and the three inlet ports should give efficient cylinder-filling and high gas turbulence (both desirable traits), it has been guestioned whether a five-valve heads more difficult to engineer, as the injector must take up
some space on the head. After making five-valve Genesis engines for several years, Yamaha has since reverted to the cheaper four-valve design. Examples of the Ferrari Dino V8, and the 1.6 L 20-valve 4A-GE engine made by Toyota in
collaboration with Yamaha. Beyond five valves For a cylindrical bore and equal-area sized valves, increasing the number of valves beyond five decreases the total valve area. The following table shows the effective areas of differing valve area.
account orifices for spark plugs or injectors, but these voids will usually be sited in the "dead space" unavailable for valves. Also, in practice, intake valves are often larger than exhaust valves in heads with an even number of valves. Also, in practice, intake valves are often larger than exhaust valves.
valve timing system on SOHC 4-valve-per-cylinder EJ25 boxer engine at Tokyo Motor Show 2007. Turbocharging are technologies that also improve engines to variable valve timing and variable length intake manifolds. Rotary valves
also offer improved engine breathing and high rev performance but these were never very successful. Cylinder head porting, as part of engine tuning, is also used to improve engine performance. The 1908 Ariès VT race cars had 1.4 litre supercharged single cylinder engines with four valve per cylinder desmodromic systems. (Source: [1]) The 1910
Isotta-Fraschini Tipo KM had a 10.6 litre inline 4 with single overhead camshaft and four valves per cylinder and it had one of the first motorcar in the world to have an engine with two overhead camshafts and four valves per cylinder was the 1912 and [2].
Peugeot L76 Grand Prix race car designed by Ernest Henry. Its 7.6-litre monobloc straight-4 with modern hemispherical combustion chambers produced 148 bhp (110 kW) (19.5 HP/Liter(0.32 bhp per cubic inch)). In April 1913, on the Brooklands racetrack in England, a specially built L76 called "la Torpille" (torpedo) beat the world speed record of
170 km/h.[1] Robert Peugeot also commissioned the young Ettore Bugatti to develop a GP racing car for the 1912 Grand Prix. This chain-driven Bugatti Type 18 had a 5-litre straight-4 with SOHC and three valves per cylinder (two inlet, one exhaust). It produced appr. 100 bhp (75 kW; 101 PS) at 2800 rpm (0.30 bhp per cubic inch) and could reach
99 mph (159 km/h). The three-valve head would later be used for some of Bugatti's most famous cars, including the 1922 Type 29 Grand Prix racer and the legendary Type 35 of 1924. Both Type 35 had a 100 bhp (75 kW) 2-liter SOHC 24-valve NA straight-8 that produced 0.82 bhp (0.61 kW) per cubic inch. A.L.F.A. 40/60 GP was a fully
working early racing car prototype made by the company now called Alfa Romeo. Only one example was built in 1914, which was later modified in 1921. This design of Giuseppe Merosi was the first Alfa Romeo DOHC engine. It had four valves per cylinder, 90-degree valve angle and twin-spark ignition.[4] The GP engine had a displacement of 4.5-liter
(4490 cc) and produced 88 bhp (66 kW) at 2950 rpm (14.7 kW/liter), and after modifications in 1921 102 bhp (76 kW) at 3000 rpm. The top speed of this car was 88-93 mph (140-149 km/h). It wasn't until the 1920s when these DOHC engines came to Alfa road cars like the Alfa Romeo 6C. In 1916 US automotive magazine Automobile Topics described
a four-cylinder, four-valve-per-cylinder car engine made by Linthwaite-Hussey Motor Co. of Los Angeles, CA, USA: "Firm offers two models of high-speed motor with twin intakes and exhausts.".[5] Early multi-valve engines in T-head configuration were the 1917 Stutz straight-4, White Motor Car Model GL 327 CID Dual Valve Mononblock four, and
1919 Pierce-Arrow straight-6 engines. The standard flathead engines of that day were not very efficient and designers tried to improve engine performance by using multiple valves, twin-spark ignition and aluminium pistons to produce 80 bhp (59 kW) at 2400 rpm from a 360.8 cid (5.8-
liter) straight-4 (0.22 bhp per cubic inch). Over 2300 of these powerful early multi-valve engines were built. Stutz not only used them in their famous Bearcat sportscar but in their standard touring cars as well.[6][7][8] The mono block White Motor Car engine developed 72 horsepower and less than 150 were built, only three are known to exist today.
In 1919 Pierce-Arrow introduced its 524.8 cid (8.6-liter) straight-6 with 24 valves. The engine produced 48.6 bhp (0.09 bhp per cubic inch) and ran very quietly, which was an asset to the bootleggers of that era.[9][10][11] Multi-valve engines continued to be popular in racing and sports engines. Robert M. Roof, the chief engineer for Laurel Motors,
designed his multi-valve Roof Racing Overheads early in the 20th century. Type A 16-valve heads were successful in the teens, Type B was offered in 1918 and Type C 16-valve in 1923. Frank Lockhart drove a Type C overhead cam car to victory in Indiana in 1926.[12][13] Bugatti also had developed a 1.5-liter OHV straight-4 with four valves per
cylinder as far back as 1914 but did not use this engine until after World War I. It produced appr. 30 bhp (22.4 kW) at 2700 rpm (15.4 kW/liter or 0.34 bhp/cid). In the 1920 Voiturettes Grand Prix at Le Mans driver Ernest Friderich finished first in a Bugattis Type 13 with the 16-valve engine, averaging 91.96 km/h. Even more successful was Bugattis
clean sweep of the first four places at Brescia in 1921. In honour of this memorable victory all 16-valve-engined Bugattis were dubbed Brescia. From 1920 through 1926 about 2000 were built. Peugeot had a triple overhead cam 5-valve Grand Prix car in 1921.[14] Bentley used multi-valve engines from the beginning. The Bentley 3 Litre, introduced in
1921, used a monobloc straight-4 with aluminium pistons, pent-roof combustion chambers, twin spark ignition, SOHC, and four valves per cylinder. It produced appr. 70 bhp (0.38 bhp per cubic inch) and the 1929 supercharged
4½ Litre (Blower Bentley) reached 240 bhp (0.89 bhp per cubic inch). The 1926 Bentley 6½ Litre added two cylinders to the monobloc straight-6 produced appr. 220 bhp (0.45 bhp per cubic inch). In 1931 the Stutz Motor
Company introduced a 322 cid (5.3-liter) dual camshaft 32-valve straight-8 with 156 bhp (116 kW) at 3900 rpm, called DV-32. The engine offered 0.48 bhp per cubic inch. About 100 of these multi-valve engines were built. Stutz also used them in their top-of-the-line sportscar, the DV-32 Super Bearcat that could reach 100 mph (160 km/h).[15][16] The
1935 Duesenberg SJ Mormon Meteor's engine was a 419.6 cid (6.9-liter) straight-8 with DOHC, 4 valves per cylinder and a supercharged 5.7-liter straight-8 with DOHC and four valves per cylinder. The
engine produced 592-646 bhp (441.5-475 kW) at 5800 rpm and achieved 1.71-1.87 bhp per cubic inch (77.8-85.1 kW/liter). The W125 top speed was appr. 200 mph (322 km/h). Combustion chamber of a 2009 Ford Ecoboost 3.5-liter turbocharged V6 petrol engine (77.8 kW/liter) showing two intake valves (right), two exhaust valves (left), centrally
placed spark plug, and direct fuel injector (right). The 1967 Cosworth DFV F1 engine, a NA 3.0-liter V8 producing appr. 400 bhp (298 kW; 406 PS) at 9,000 rpm (101.9 kW/liter), featured four valves per cylinder. For many years it was the dominant engine in Formula One, and it was also used in other categories, including CART, Formula 3000 and
Sportscar racing. Debuting at the 1968 Japanese Grand Prix in the original 300 PS (221 kW; 296 hp) 3.0-liter version the Toyota 7 engine participated in endurance races as a 5.0-liter (4,968 cc) non-turbo V8 with DOHC and 32-valves. It produced 600 PS (441 kW; 592 hp) at 8,000 rpm (88.8 kW/liter) and 55.0 kg·m (539 N·m; 398 lb·ft) at 6,400 rpm.
There is much discussion about which was the first 'mass-produced' car to use an engine with four valves per cylinder engines, and considering special versions of mass-produced cars, the first appears to have been the 1969 Nissan Skyline, using the Nissan S20 six cylinder DOHC four-valve engine. This engine was also fitted to
Nissan Fairlady Z432 racing edition. For a four-cylinder engine, the first mass-produced car using a four valves per cylinder engine which was a Ford 'Kent' block with a Cosworth 16 valve twin cam cylinder head. The car went on to become a rallying legend in the 1970s
winning many domestic and World Championship events. Other cars claiming to be first are the Jensen Healey, launched in 1972 which used a Lotus 907 belt-driven DOHC 16-valve 2-liter straight-4 producing 140 bhp (54.6 kW/liter, 1.20 bhp/cid). All of these, although mass-produced, are also of relatively limited production, so it is argued that the
first widely available and popularly priced mass-production car with a four valve per cylinder engine was the 1973 Triumph Dolomite Sprint. This Triumph used an in-house developed SOHC 16-valve 1,998 cc (122 ci) straight-4 engine that produced 127 bhp (47.6 kW/liter, 1.10 bhp/cid) at introduction. The 1975 Chevrolet Cosworth Vega featured a
DOHC multi-valve head designed by Cosworth Engineering in the UK. This 122-cubic-inch straight-4 produced 110 bhp (82 kW; 112 PS) at 5600 rpm (0.90 bhp/cid; 41.0 kW/liter), 1976 Lotus Esprit with Lotus 907 engine (54.6 kW/liter, 1.20 bhp/cid), and 1978 BMW M1
with BMW M88 engine (58.7 kW/liter, 1.29 bhp/cid) all used four valves per cylinder. The BMW M8/3 engine was used in the 1983 BMW M635CSi and in the 1985 BMW M5. The 1978 Porsche 935/78 racer used a twin turbo 3.2-liter flat-6 (845 bhp/630 kW@8,200 rpm; 784 Nm/578 ft.lbs@6,600 rpm). The water-cooled engine featured four valves per
cylinder and output a massive 196.2 kW/liter. Porsche had to abandon its traditional aircooling because the multi-valve DOHC hampered aircooling of the spark plugs. Only two cars were built. Ferrari developed their Quattrovalvole, bringing
power back up to the pre-FI high of 245 hp (183 kW). A very unusual Dino Quattrovalvole was used in the 1986 Lancia Thema 8.32. It was based on the 308 QV's engine, but used a split-plane crankshaft rather than the Ferrari-type flat-plane. The engine was constructed by Ducati rather than Ferrari, and was produced from 1986 through 1991. The
Quattrovalvole was also used by Lancia for their attempt at the World Sportscar Championship with the LC2. The engine was twin-turbocharged and destroked to 2.65 litres, but produced 720 hp (537 kW) in qualifying trim. The engine was later increased to 3.0 litres and increased power output to 828 hp (617 kW). The 1984 Ferrari Testarossa had a
 4.9-liter flat-12 with four valves per cylinder, Almost 7,200 Testarossa were produced between 1984 and 1991. In 1985 Lamborghini V12 engine (64.8 kW/liter). The Mercedes-Benz 190E 2.3-16 with 16-valve engine debuted at the Frankfurt
Auto Show in September 1983 after it set a world record at Nardo, Italy, recording a combined average speed of 154.06 mph (247.94 km/h) over the 50,000 km (31,000 mi) endurance test. The engine was based on the 2.3-liter 8-valve 136 hp (101 kW) unit already fitted to the 190- and E-Class series. Cosworth developed the DOHC light alloy cast
cylinder head with four large valves per cylinder. In roadgoing trim, the 190 E 2.3-16 produced 49 hp (36 kW) and 41 ft lbft (236 N·m) at 4,500 rpm. In 1988 an enlarged 2.5-liter
engine replaced the 2.3-liter. It offered double valve timing chains to fix the easily snapping single chains on early 2.3 engines, and increased peak output by 17 bhp (12.5 kW) with a slight increased peak output by 17 bhp (12.5 kW) with a slight increased peak output by 17 bhp (12.5 kW) and Evolution II (1990) models were produced that had a redesigned engine to allow for a higher rev limit
and improved top-end power capabilities. The Evo II engine offered 235 PS (173 kW; 232 hp) from 2463 cc (70.2 kW/liter). Saab introduced a 16-valve head to their 2.0-liter (1985 cc) straight-4 in 1984 and offered the engine with and without turbocharger (65.5 kW/liter and 47.9 kW/liter respectively) in the Saab 900 and Saab 9000. The 2.0-liter
Nissan FJ20 was one of the earliest straight-4 mass-produced Japanese engines to have both a DOHC 16-valve configuration (EFI) when released in October 1981 in the sixth generation Nissan Skyline. Peak output was 148 hp (110 kW) at 6,000 rpm and 133 lb ft (180 N·m) and electronic fuel injection (EFI) when released in October 1981 in the sixth generation Nissan Skyline.
at 4,800 rpm. The FJ20 was also offered with a turbocharger, producing 188 hp (140 kW) at 6,400 rpm and 166 lb ft (225 N·m) at 4,800 rpm. Following Nissan's lead, Toyota released the 1.6-liter (1,587 cc) 4A-GE engine in 1983. The cylinder head was developed by Yamaha Motor Corporation and was built at Toyota's Shimayama plant. While
originally conceived of as a two-valve design, Toyota and Yamaha changed the 4A-GE to a four-valve after a year of evaluation. It produced 115-140 bhp (86-104 kW) at 5,800 rpm. To compensate for the reduced air speed of a multi-valve engine at low rpms, the first-to-second generation
engines included the T-VIS intake system. In 1986 Volkswagen introduced a multi-valved Golf GTI 16V. The 16-valve Golf GTI engine. The GM Quad 4 multi-valve engine family debuted early 1987. The Quad 4 was the
first mainstream multi-valve engine to be produced by GM after the Chevrolet Cosworth Vega. The NA Quad 4 achieved 1.08 bhp (1 kW; 1 PS) per cubic inch (49.1 kW/liter).[2][20] Such engines soon became common as Japanese manufacturers adopted the multi-valve concept. A cylinder head from a 1987 Honda CRX Si showing SOHC, rocker arms,
valve springs, and other components. This is a multi-valve configuration with two intakes, one exhaust valves and one exhaust valve for each cylinder. The 1975 Honda Civic introduced Honda's 1.5-liter SOHC 12-valve straight-4 engines. Nissan's 1988-1992 SOHC KA24E engine had three valves per cylinder (two intakes, one exhaust) as well. Nissan upgraded to
DOHC after 1992 for some of their sports cars, including the 240SX. In 1988, Renault released a 12 valve version of its Douvrin 4 cylinder 2.0l SOHC. Mercedes and Ford produced three-valve V6 and V8 engines, Ford claiming an 80% improvement in high RPM breathing without the added cost of a DOHC valve train. The Ford design uses one spark
plug per cylinder located in the centre, but the Mercedes design uses two spark plugs per cylinder fuel injector at a later date. The 1989 Citroën XM was the first 3-valve diesel-engined car. Nissan SR20VE 2.0-liter straight-4-cylinder head with DOHC, Nissan's Neo VVL
variable valve timing with lift control and four valves per cylinder. Multi-valve train of Volvo's 2005 truck diesel engine D13A, a 12.8-liter turbocharged straight-6 (21.1-28.1 kW/liter) with SOHC and four valves per cylinder located around a central injector, and VEB engine brake that operates both exhaust valves. Examples of SOHC four-valve
engines include the Honda F-series engines, D-series engines, the R-series engines, the R-series engines, the R-series engines, the R-series engines, the Mazda B8-ME, and the Chrysler 3.5 L V6 engine. The V12 engines of many World War II fighter aircraft also used a SOHC configuration with four valves for each cylinder. The V12 engines of many World War II fighter aircraft also used a SOHC configuration with four valves for each cylinder. The V12 engines of many World War II fighter aircraft also used a SOHC configuration with four valves for each cylinder.
diesel-engined car. Peugeot had a triple overhead cam five-valve Grand Prix car in 1921.[14] In April 1988 an Audi 200 Turbo Quattro powered by an experimental 2.2-liter turbocharged 25-valve straight-5 rated at 478 kW/650 PS@6,200 rpm (217.3 kW/liter) set two world speed records at Nardo, Italy: 326.403 km/h (202.8 mph) for 1,000 km (625 mph
miles) and 324.509 km/h (201.6 mph) for 500 miles.[21][22] Mitsubishi were the first to market a car engine with five valves per cylinder, with the 548 cc 3G81 engine in their Minica Dangan ZZ kei car in 1989.[23][24] Yamaha designed the five-valve cylinder head for the 20-valve 4A-GE engines made by Toyota for use in some Toyota Corolla models
in Japan and South Africa, in 1991. Yamaha also developed five-valve Formula One engines, the 1989 OX88 V8, 1991 OX99 V12, 1993 OX10 V10 and 1996 OX11 V10, but none of these were very successful. For their YZ250F and YZ450F motocross bikes, Yamaha developed five-valve engines. Bugatti (EB 110), Ferrari (F355, 360 and F50), Volkswagen
- Audi (Audi Quattro) - Skoda (Octavia vRS) and Toyota (4A-GE 20V) have all produced five-valve-engined vehicles. In 1985, Maserati made an experimental 2.0-liter turbo V6 engine with six valves per cylinder (three intakes, three exhaust). It achieved 261 bhp (195 kW; 265 PS) at 7,200 rpm (97.5 kW/liter).[25] Although most multi-valve engines have
overhead camshafts, either SOHC or DOHC, a multivalve engine may be a pushrod overhead valve engine (OHV) design. GM has revealed a three-valve version of its Generation IV V8 which uses pushrods. Moreover, Cummins makes a four-valve OHV
straight six diesel, the Cummins B Series (now known as ISB). Ford also uses pushrods in its 6.7L Power Stroke engine built by Navistar also used pushrods with four-valve heads. Pushrod multi-valve systems are common on diesels because they need
to be able to meet emissions standards, but also produce more low-end torque. The Harley-Davidson Milwaukee Eight engine, introduced in 2016, uses four-valves per cylinder driven by pushrods and a single in-block camshaft. [26][27] The 1980 Lotus Essex Turbo Esprit (with type 910 2.2-liter inline four engine) was the first production car to use a
multi-valve turbocharged engine. Rare 8-valve-per-cylinder arrangement of 1979 Honda NR500 V4 GP motorcycle engine delivered over 115 PS@19,000 rpm (170 kW/liter). Examples of motorcycles with multivalve-engines include: 1914 Peugeot Grand Prix racer, 500 cc DOHC 8-valve
parallel twin (top speed over 122 km/h).[28] 1915 Indian board track racer, 61-cid (1.0-liter) OHV 8-valve single-cylinder machine, copied by Rudge-Whitworth with their 1924 Rudge Four 350 cc OHV 4-valve single-cylinder machine, and 1929 Rudge Ulster 500 cc OHV 4-valve single-cylinder
machine. 1923 British Anzani 1098cc OHV 8-Valve V-twin, used in Morgan three-wheelers and McEvoy motorcycle). 1973 Yamaha TX500 "pent-roof" 500cc DOHC 8-valve parallel-twin (the first mass-produced DOHC 4-valve per cylinder
motorcycle)[30] 1977 Honda CB400 SOHC 6-valve parallel-twin. 1978 Honda CX500, a 498 cc SOHC, pushrod actuated OHV, 4-valve per cylinder V-twin; 1982 CX500 Turbo was the first factory multi-valve turbocharged motorcycle. 1978 Honda CBX1000, a 1,047 cc DOHC 24-valve straight-6 (105 bhp (78 kW; 106 PS)). 1979 -1992: Honda NR series,
racing & production motorcycles with 8-valve-per-cylinder "oval-piston" V4 engines (actually 32-valve V8s with adjoining cylinders merged). 1985 Yamaha TDM and TRX parallel twin motorcycles with 5 valves per cylinder 1998-2006 Yamaha YZF-R1
superbike with redesigned (more compact) "Genesis" engine. 2006 model delivered 180 bhp (134 kW; 182 PS) at 12,500 rpm (130.3 kW/liter). The Yamaha XT660 single once had five valves per cylinder, but a subsequent redesign reduced the valve-count to four. The Aprilia Pegaso 650 single also started out with five valves, but current models only
have four. The jointly developed BMW F650 single always had four valves. Sectioned Junkers Jumo 213, showing three-valve design 1916 Benz Bz.IV 19-liter water-cooled straight-6 aircraft engine with aluminium pistons, dual camshaft and four valves per cylinder achieved 230 bhp/170 kW@1,400 rpm (9.0 kW/liter). Appr. 6,400 engines were
produced. Cutaway view of 1941 Packard Merlin 28 V12 aircraft engine showing SOHC and four valves per cylinder. This widely used supercharged WWII engine produced 1,390 bhp (1,037 kW; 1,409 PS) from 1,649 cid (38.5 kW/liter). Ettore Bugatti designed several multi-valve aircraft engines. The 1916 Bugatti U-16 1484.3 cid (24.32 L) SOHC 16-
cylinder, consisting of two parallel 8-cylinder banks, offered 410 bhp (305 kW) at 2,000 rpm (12.5 kW/liter or 0.28 bhp/cid). Each cylinder had two vertical inlet valves and a single vertical exhaust valve, all driven by rocking levers from the camshaft. Other advanced World War I aircraft engines, such as the 1916 Maybach Mb.IVa that produced
300 bhp (224 kW; 304 PS) at altitude and the 1916 Benz Bz.IV with aluminium pistons and the 1918 Napier Lion (a 450 bhp 24-liter DOHC 12-cylinder), used two intake valves and two exhaust valves. Long after the King-Bugatti "U-16" aviation engine used them, shortly before World War II, the Junkers aviation firm began production of the Third
Reich's most-produced military aviation engine (68,000+ produced), the 1936-designed, 35-litre displacement, inverted V12 design, the 1932-origin Junkers Jumo 210[32] — this was carried through into the later, more
powerful 1940-origin Junkers Jumo 213, produced through 1945, the production versions of which (the Jumo 211's three-valve cylinder head design.[33] The V12 engines of many World War II fighter aircraft used a SOHC configuration with four valves for each cylinder. An example of a modern multi-valve
piston-engine for small aircraft is the Austro Engine AE300. This liquid-cooled turbocharged 2.0-liter (1,991 cc) DOHC 16-valve straight-4 diesel engine uses common rail direct fuel injection and delivers 168 bhp (125 kW; 170 PS) at 3,880 rpm (62.0 kW/liter). The propeller is driven by an integrated gearbox (ratio 1.69:1) with torsional vibration
damper. Total power unit weight is 185 kg (408 lb). In 1905 car builder Delahaye had experimented with a DOHC marine racing engine with 6 valves per cylinder that produced 300 bhp (0.07 bhp/cid). It allowed the motor boat Le Dubonnet piloted by Emile Dubonnet to
set a new world's speed record on water, reaching 33.80 mph (54.40 km/h) on the lake at Juvisy, near Paris, France.[35] An example of modern multi-valve engines use combined charging (turbo and supercharger, except IPS450) with
aftercooler, common rail fuel injection and DOHCs with hydraulic 4-valve technology. Propshaft power ranges from 248 to 850 bhp (185 to 634 kW; 251 to 862 PS) (highest efficiency 59.7 kW/liter for IPS400 3.7-liter straight-4 diesel). Multiple units can be combined. [3] a b Clemens, Kevin. "An Echo of the Past: The history and evolution of twin-
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Design Digital Library (KMODDL) - Movies and photos of hundreds of working mechanical-systems models at Cornell University. Also includes an e-book library of classic texts on mechanical design and engineering. Retrieved from " 2Family of internal combustion engineer For the A25 engines produced since 2017, see Toyota Dynamic Force
engine. For the Austin A-series engine, see BMC A-series engine Toyota A engine4A-C engineOverviewManufacturerToyotaProduction1978-2006LayoutConfigurationInline 4Cylinder block materialCast ironCylinder head materialAluminumValvetrainSOHC, DOHCCombustionFuel systemCarbureted, Fuel to the Austin A-series engine and the A-series engine an
injectedFuel typeGasoline The Toyota A Series engines are a family of inline-four internal combustion engines with displacement from 1.3 L to 1.8 L produced by Toyota Motor Corporation. The series has cast iron engine blocks and aluminum cylinder heads. To make the engine as short as possible, the cylinders are siamesed.[1] The development of
the series began in the late 1970s, when Toyota wanted to develop a completely new engine for the Toyota as well as low emissions with a modern design.[3][4] The A-series includes one of the first Japanese mass-production DOHC, four-valve-
per-cylinder engines, the 4A-GE, and a later version of the same engine was one of the first production five-valve-per-cylinder engines. [5] Toyota joint venture partner Tianjin FAW Xiali produces the 1.3 L 8A and resumed production 1978-
1980LayoutConfigurationInline-four engineDisplacement1.5 L (1,452 cc)Cylinder bore77.5 mm (3.05 in)Piston stroke77 mm (3.03 in)Cylinder block materialAluminumValvetrainSOHC 2 valves x cyl.Compression ratio9.0:1CombustionFuel systemSingle 2-barrel downdraft carburetorFuel typeGasolineCooling
systemWater cooledOutputPower output80 PS (59 kW; 79 hp)Torque output11.5 kg·m (113 N·m; 83 lbf·ft)ChronologyPredecessorTSuccessor3A The 1.5 L 1A was produced between 1978 and 1980.[6] All variants were belt-driven 8-valve counter-flow SOHC engines with a single, twin-barrel downdraft carburetor. It used Toyota's Turbulence
Generating Pot (TGP) lean combustion system to meet Japanese emissions standards at the time with only an oxidation (2-way) catalyst. Output: 80 PS (59 kW; 79 hp) at 5,600 rpm and 11.5 kg·m (113 N·m) at 3,600 rpm (compression at
9.0:1)[9] Applications: AL10 Tercel/Corsa (Japan only) Reciprocating internal combustion engine 2AOverviewManufacturerToyotaProduction1979–1989LayoutConfigurationInline 4Displacement1.3 L; 79.0 cu in (1,295 cc)Cylinder bore76 mm (2.99 in)Piston stroke71.4 mm (2.81 in)Cylinder block materialcast-ironCylinder head
materialaluminumValvetrainSOHC 2 valves x cyl.Compression ratio9.3:1CombustionFuel systemSingle downdraft carburetorFuel typeGasolineCooling systemWater cooledOutputPower output65 PS (48 kW; 74 hp)Torque output98 N·m (72 lb·ft)106 N·m (78 lb·ft)ChronologyPredecessor4KSuccessor2E The 1.3 L 2A was produced
from 1979 through 1989. 2A engines in 1982 onwards AL20 Tercels have a slightly different valve cover and timing belt cover than early AL11 Tercels, as well as an automatic choke, and automatic choke, and automatic choke, and timing belt cover than early AL10 Tercels have a slightly different valve cover and timing belt cover than early AL11 Tercels, as well as an automatic choke, and automatic choke, and automatic choke, and timing belt cover than early AL10 Tercels have a slightly different valve cover and timing belt cover than early AL11 Tercels, as well as an automatic choke, and autom
emissions. All variants used belt-driven SOHC eight-valve counter-flow cylinder heads with a single downdraft carburetor. Output: 65 PS (48 kW; 64 hp) at 6,000 rpm and 98 N·m (72 lb·ft) at 3,800 rpm (compression at 9.3:1) Applications: AE80 Corolla 1983–1985 (excluding Japan, 2A-LC in Australia) AL11 Tercel 1979–1982 (excluding Japan and
North America) AL20 Tercel 1982-1984 (excluding Japan and North America) Using Toyota TTC-C catalytic converter. Output: 75 PS (55 kW; 74 hp) at 6,000 rpm and 106 N·m (78 lb·ft) at 3,600 rpm (compression at 9.3:1)[10] Applications: AE80 Corolla 1983-1985 (Japan only) AL20 Corolla II 1982-1986 (Japan only) AL11 Corsa (Japan only) AL20
Corsa 1982-1989 (Japan only) AE80 Sprinter 1983-1985 (Japan only) AE11 Tercel AL20 Tercel 1982-1989 (Japan only) Reciprocating internal combustion engine 3A1979 Toyota 3A-U engineOverviewManufacturerToyotaProduction1979-1989LayoutConfigurationInline 4Displacement1,452 cc (1.5 L)Cylinder bore77.5 mm (3.05 in)Piston stroke77 mm
(3.03 in)Cylinder block materialCast ironCylinder block materialAluminumValvetrainSOHC 2 valves x cyl.Compression ratio 9.0:1, 9.3:1CombustionFuel systemSingle carburetorFuel typeGasolineCooling systemWater cooledOutputPower output 71 PS (52 kW; 70 hp)83.5 PS (61 kW; 85 hp)90 PS (66 kW; 89 hp)Torque output 108 N·m
(80 lb·ft)118 N·m (87 lb·ft)121 N·m (89 lb·ft)121 N·m (89 lb·ft)ChronologyPredecessor1ASuccessor5A, 3E The 1.5 L 3A was produced from 1979 through 1989. The 3A engine is the successor of Toyota's "Turbulence Generating Pot" pre-combustion
system from the 1A. Output: 71 PS (52 kW; 70 hp) at 5,600 rpm (N. America, AL-21 3 door liftback)[citation needed] 62 hp (46 kW; 61 PS) at 4,800 rpm (N. America, AL-25 5-door wagon)[citation needed] Applications: AL12 Tercel 1979-
1982 (excluding Japan) AL21/25 Tercel 1982-1988 (excluding Japan) Using Toyota TTC-C catalytic converter. On some models marked as 3A-II. Output: 83.5 PS (61 kW; 82 hp) at 5,600 rpm and 118 N·m (87 lb·ft) at 3,600 rpm (compression at 9.0:1)[6][10] Applications: AA60 Carina 1981-1987 (Japan only) AT150 Carina 1984-1988 (Japan only) AE70
Corolla 1979-1983 (Japan only) AE81/85 Corolla 1983-1987 (Japan only) AL21 Corona 1982-1986 (Japan only) AL21 Corona 1982-1987 (Japan only) AL21/25 Corsa (Japan only) AE10 Corona 1982-1987 (Japan only) AE10 Corona 1982-1987 (Japan only) AE10 Corona 1983-1987 (Japan only) AE10 Corona 1983-1987 (Japan only) AE10 Corona 1983-1987 (Japan only) AE110 Corona 1983-1987 (Japan only) AE10 Corona 1983-1987 (Japan only) AE110 Corona 
1983-1987 (Japan only) AL25 Sprinter Carib 1982-1988 (Japan only) AL21/25 Tercel 1982-1989 (Japan only) High compression with Toyota TTC-C catalytic converter. Output: 86 PS (63 kW; 85 hp) at 6,000 rpm and 121 N·m (89 lb·ft) at 4,000 rpm (compression at 9.3:1)[10][12] Applications: AL21 Corolla II 1982-1984 (Japan only) AL21 Corsa
1982-1984 (Japan only) AL21 Tercel 1982-1984 (Japan only) Twin carburetted swirl-intake version with Toyota Wanted to test in Japan before launching them in export
 along E series engine, albeit in single carburetted version. Because of the swirl-intake, the sealing surface between cylinder head and valve cover is different from other SOHC A-engines, featuring vertical curves on the manifold side of the head. Thus, those parts are not interchangeable between each other.[citation needed] The swirl was supposed to
improve burning of the air-fuel mixture, thus enabling cleaner emissions, improving fuel economy, and increasing power. Output: 90 PS (66 kW; 89 hp) at 6,000 rpm (compression at 9.3:1) Applications: AL21 Corolla II 1984-1986 (Japan only) AL21/25 Tercel 1984-
1989 (Japan only) Reciprocating internal combustion engine 4A4A-C Engine in a 1987 AE86 SR5 CorollaOverviewManufacturerToyotaProduction1982-2002LayoutConfigurationInline-4Displacement1,587 cc (1.6 L)Cylinder bore81 mm (3.19 in)Piston stroke77 mm (3.03 in)Cylinder block materialCast ironCylinder head
materialAluminumValvetrainSOHC 2 valves x cyl.DOHC 4 & 5 valves x cyl.DOHC 4 & 5 valves x cyl.DOHC 4 & 5 valves x cyl.Valvetrain drive systemVater-liming beltCompression ratio8.0:1, 8.9:1, 9.0:1, 9.3:1, 9.5:1, 10.3:1, 10.5:1, 11.0:1CombustionSuperchargerToyota SC12 (4A-GZE)TurbochargerNoFuel systemCarburetorEFIFuel typeGasolineOil systemWet sumpCooling systemWater-liming beltCompression ratio8.0:1, 8.9:1, 9.0:1, 9.3:1, 9.4:1, 9.5:1, 10.3:1, 10.5:1, 10.3:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 10.5:1, 1
cooledChronologyPredecessor2TSuccessor3ZZ The 4A was produced from 1980 through 2002. All 4A engines at 81 mm (3.19 in), but the stroke remained the same as the 3A at 77 mm (3.03 in), giving it an over-square bore/stroke ratio which favours
high engine speeds. Numerous variations of the 4A design were produced, from basic SOHC 8-valve all the way to DOHC 20-valve versions. The power output also varied greatly between versions, from 52 kW (71 PS; 70 hp) at 4,800 rpm in the basic California-spec 4A-C to 125 kW (170 PS; 168 hp) at 6,400 rpm in the supercharged 4A-GZE. The basic
4A is a SOHC 8 valve carburated engine which produces 78-90 PS (57-66 kW; 77-89 hp) at 4800 rpm and 115 N·m (85 lb·ft) of torque at 2800 rpm, though the power and torque output figures vary between different regions of the world. in European versions, the combustion chambers were reformulated in early 1986, resulting in an increase of 2 hp
up to 63 kW (86 PS; 85 hp) at 5600 rpm, along with improvements in fuel economy and emissions.[13] North American market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 4800 rpm 4A-C 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 4800 rpm 4A-C 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market engines: 4A-LC 1.6 L I4, 8-valve SOHC, 55 kW (70 hp; 71 PS) at 5200 rpm European (and other) market e
L, I4, 8-valve SOHC, 58 kW (79 PS; 78 hp) at 5600 rpm, and torque 12.5 kg·m (123 N·m; 90 lbf·ft) at 4000 rpm (compression at 9.0:1) (Europe)[15] Australian/Swiss/Swedish market engines:
Australia, Sweden, and Switzerland shared emissions rules for a period in the 1970s and eighties. 4A-LC 1.6 L, I4, 8-valve SOHC, 57 kW (78 PS; 77 hp) at 5600 rpm Applications AT151 Carina II 1983-1987 (Europe only) AE82/86
Corolla 1983-1987 (excluding Japan) AT151 Corona 1983-1987 (excluding Japan) A60 Daihatsu Charmant 1984-1987 (excluding Japan) Elfin Type 3 Clubman Chevrolet Nova (USA NUMMI rebadged Sprinter) 1985-1988 Fuel injection was added. This increased output to 74 kW (100 PS; 99 hp) at 5600 rpm and 13 kg·m (127 N·m; 94 lbf·ft) at
4000 rpm. This version is also equipped with Toyota TTC-C catalytic converter. Applications: AT151 Carina 1984-1988 (Japan only) AE82 Sprinter 1983-1987 (Japan
version, the 4A-F, was produced from 1987 through 1990. Output was 70 kW (95 PS; 94 hp) at 6,000 rpm and 13.8 kg·m (135 N·m; 100 lbf·ft) at 3,600 rpm (compression at 9.5:1, EU spec).[16][17] This engine featured an aluminum-alloy cylinder head with scissor-gear driven twin overhead camshafts, centered spark plugs, and employed pent-roof
combustion chambers which were designed to improve thermal efficiency. It also featured a fully counterweighted crankshaft with five journals and eight balance weights. The 4A-F was designed to provide more powerful torque in the low-to-mid RPM range as well improving top-end power output.[17] This engine was the first in the series to use
Toyota's dual camshaft system known as High-Mecha Twin Cam, where the timing belt drives the exhaust camshaft to the exhaust camshaft and the exhaust camshaft to the exhaust 
being unofficially known as the "slave-cam system". In contrast, on the 4A-GE engines, both camshafts are driven directly by the timing belts rather than being geared together. Applications: AT171 Carina II 1987-1992 (Europe only) AE92/95 Corolla 1987-1992 (Europe only) AE92/95 Corolla 1988-1989 (Japan only) AE101 Corolla 1992-1998 (Asia,
Africa & Latin-America) AE111 Corolla 1997-2001 (Asia, Africa & Latin-America) AT171/177 Corona 1987-1992 (excluding Japan) AE95 Sprinter 1988-1989 (Japan only) 1st generation 4A-FE engine. 2nd generation 4A-FE engine sticker. The fuel injected 4A-FE is the successor of the carbureted 4A-F, manufactured from 1987-2001.
Toyota designed this engine with fuel economy in mind. The 4A-FE is basically the same as the 4A-FE is basically the 4A-FE is basically the same as the 4A-FE is basically the 4A-FE is ba
of this engine, which can be identified by the external shape of the engine. The first generation (1987-1996) featured a plate on the head which read "16 valve EFI" and fuel injectors in the head. [21] The second generation had a higher profile cam design in the head which read "16 valve EFI" and fuel injectors in the head which read "17 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read "18 valve EFI" and fuel injectors in the head which read 
runners. Mechanically, the late-model engines received MAP load sensing and redesigned pistons, intake manifold. The second generation (1996-2001) was released exclusively for the Asian market (Japan, Philippines, Pakistan, Thailand,
Indonesia, and Malaysia) only. Although it is very similar to the second generation externally, it only has a slight difference in the top section of the intake manifold and throttle body. This last generation externally, it only has a slight difference in the top section of the intake manifold and throttle body. This last generation externally, it only has a slight difference in the top section of the intake manifold and throttle body. This last generation externally, it only has a slight difference in the top section of the intake manifold and throttle body. This last generation externally, it only has a slight difference in the top section of the intake manifold and throttle body.
Layout: DOHC Inline-4 Valves: 16, 4 for each cylinder Redline: 6300 rpm Compression ratio: 9.5:1 Fuel Delivery System: TCCS or MPFI North American market engines: 76 kW (102 hp; 103 PS) at 5,800 rpm, and torque 145 N·m (107 lb·ft; 14.8 kg·m) at 4,800 rpm[citation needed] European market engines: 105 PS (77 kW; 104 hp) at 6,000 rpm, and
torque 142 N·m (105 lb·ft: 14.5 kg·m) at 3.200 rpm[22] Asian market engines: 115 PS (85 kW: 113 hp) at 6.000 rpm[citation needed] Note: power and torque specs for North America and Europe are from the 4A-GE in terms of performance and power. Although both have the same displacement and
are DOHC, they were optimized for different uses. The first obvious difference are the valves, the engine's intake and exhaust valves were placed 22.3° apart (compared to 50° in the G-Engines). The second is that it employed Toyota's High-Mecha Twin Cam system,[18] where both camshafts are geared together with a singular timing belt driving the
exhaust camshaft and the exhaust camshaft drives the inlet camshaft via scissor gears (both camshafts on the G-Engine are driven by the timing belts instead).[20] Some of the less aggressive camshaft profiles, a cast crankshaft (rather than a
forged crankshaft in the 4A-GE), ports of a small cross sectional area, a very restrictive intake manifold with long runners joined to a small displacement plenum and other changes. Even though the valve angle is closer to what is considered in some racing circles who? I to be ideal for power (approximately 25 degrees), its other design differences and considered in some racing circles who? I to be ideal for power (approximately 25 degrees).
the intake which is tuned for a primary harmonic resonance at low RPM means that it has about 10% less power compared to the 4A-GE engine. This engine design improves fuel efficiency and torque, but compromises power. Power ratings varied from 75–78 kW (100–105 hp) in the US market. Applications AT220 Avensis 1997–2000 (excluding
Japan) AT171/175 Carina 1988-1992 (Japan only) AT190 Carina 1984-1996 (Japan only) AT190 Carina E 1992-1997 (Europe only) AT190 Carina E 1992-1998 (Japan only) AT190 Carina E 1992-1998 (Japan only) AT190 Carina E 1992-1998 (Japan only) AT190 Carina E 1992-1997 (Europe only) AT190 Carina E 1992-1998 (Japan only) AT190 Carina E 1992-
only) AE111 Corolla Spacio 1997-2001 (Japan only) AT175 Corona 1988-1992 (Japan only) AE101/104/109 Sprinter 1992-2002 (Japan only) AE111/114 Sprinter 1995-1998 (Japan only) AE101/104/109 (Japan only) AE101/104/109 (Japan only) AE101/104/109 (Japan only) AE101/104/109 (Japan only) AE101/104/104/10
1996-2001 (Japan only) AE101 Sprinter Marino 1992-1998 (Japan only) AE92/AE111 Corolla/Conquest 1993-2002 (South Africa) Geo Prizm base model (based on Toyota AE92/AE111 Corolla/Conquest 1993-2002 (South Africa) Geo Prizm base model (based on Toyota AE92/AE101 chassis) 1989-1997 Same as the first generation 4A-FE, only more aggressive tune for more output. Called an EFI-S engine. Output: 110 PS (81 kW; 108 hp) at
6,000 rpm and 14.5 kg·m (142 N·m; 105 lbf·ft) at 4,800 rpm (compression at 9.5:1) Applications: AT171 Carina 1990-1992 (Japan only) AE95 Sprinter Carib 1990-1995 (Japan only) AE95 Sprinter Carib 19
plenum. 4A-GE with T-VIS The most powerful of the 16-valve 4A-GE engines, commonly known as the "red top" (due to the red writing), which produces 130 PS (96 kW) at 6,600 rpm. The 4A-GE was a series of high-performance four-cylinder twincam engines made by Toyota in collaboration with Yamaha Motor Corporation. The cylinder head was
developed by Yamaha and was built at Toyota's Shimoyama plant alongside the 4A and 2A engines last and a fan base as they are a popular choice for an engine swap into other Toyota cars such as the KE70 and KP61. New performance parts are still
available for sale even today because of its strong fan base. Production of the various models of this versions and up to 2000 for the 20-valve 4A-GE versions. The first-generation 4A-GE which was introduced in May 1983 replaced the 2T-G as Toyota's most popular
twincam engine, [24] This engine was identifiable via silver cam covers with the lettering on the block, weighing in at only 123 kg (271 lb) - over fifteen percent
reduction compared to 2T-GEU. It was also 4 dB quieter. [24] While originally conceived of as a two-valve design, Toyota and Yamaha changed the 4A-GE produced 84 kW (112 hp) at 6,600 rpm and 131 N·m (97 lb·ft) of torque at 4,800 rpm in the American market. The use of a vane-type air flow
meter (AFM), which restricted air flow slightly but produced cleaner emissions that conformed to the U.S. regulations, limited the power considerably - the Japanese model, which uses a manifold absolute pressure (MAP) sensor, was originally rated at 130 PS (96 kW; 128 hp). However, this was a gross power rating and the engine was later re-rated
at 120 PS (88 kW; 118 hp) in net output. Nonetheless, Japanese cars tested no faster than their American counterparts despite their higher power rating and a lower curb weight. [26] Yamaha designed the engine for performance; the valve angle was a relatively wide 50 degrees, which at the time was believed to be ideal for high power production.
[25] Today, many modern high-revving engines have decreased the valve angle to 20 to 25 degrees, allowing for a more smaller and compact cylinder head and is now believed to be ideal for high-revving engines which allow for
straighter ports and more efficient air flow. The first-generation 4A-GE is nicknamed the "bigport" engine because it had intake ports of a very highly modified engine at very highly mod
speeds at those rpm. To compensate for the reduced air speed, the first-generation engines included the T-VIS feature, in which dual intake runners are fitted with butterfly valves that opened at approximately 4,200 rpm. The effect is that at lower rpm (when the airspeed would normally be slow) four of the eight runners are closed, which forces the
engine to draw in all its air through half the runners in the manifold. This not only raises the airspeed which causes better cylinder filling, but due to the asymmetrical airflow a swirl is created in the combustion chamber, meaning better fuel atomization. This enabled the torque curve to still be intact at lower engine speeds, allowing for better
performance across the entire speed band and a broad, flat torque curve around the crossover point. [27] During rising engine speed, a slight lurch can occur at the crossover point and an experienced driver will be able to detect the shift in performance. Production of the first-generation engine model lasted until May 1987. The second-generation 4A
GE produced from June 1987 to May 1989 featured larger diameter bearings for the connecting-rod big ends 42 mm (1.65 in) and added four additional reinforcement ribs on the back of the engine block, for a total of seven. The T-VIS feature is retained, as well as the MAP sensor in the US-market). It is visually similar to the first-
generation engine (only the upper cam cover now featured red and black lettering) and the US-market power output was only increased to 115 hp (86 kW). The first- and second-generation engines are very popular with racers and tuners because of their availability, ease of modification, simple design, and lightness. The third-generation appeared in
June 1989 and was in production until June 1991. This engine has the silver cam covers with the words only written in red, hence the nickname "red top". Toyota increased the compression ratio from 9.4:1 to 10.3:1. To correct the air-speed problems of the earlier generations, the intake ports in this cylinder head were re-designed to have a smaller
cross-section, and hence it has been nicknamed the "smallport" head. This change in the intake manifold and it was replaced with a single-runner manifold. Additional engine modifications to extend life and reliability included under-piston cooling oil squirters, thicker connecting rods and other
components. Also of note, the pistons were changed to utilize a 20 mm (0.79 in) fully floating gudgeon pin unlike the 18 mm (0.71 in) pressed-in pins of the earlier versions. Other internal revisions were made to the pistons. They were slightly modified to make space for the under-piston cooling oil squirters found in this engine version. In addition to
this, the piston ring size were changed to 1.2 mm (0.047 in) (top ring), 1.5 mm (0.047 in) (second ring), and 2.8 mm (0.11 in) (oil ring), [citation needed] All non-US market
4A-GEs continued to use a MAP sensor, while all of the US-market 4A-GE engines came with a MAF sensor. For US-market cars, this revision increased the power to 92 kW (123 hp; 125 PS) at 7200 rpm with a torque of 15.2 kg·m (149 N·m; 110 lbf·ft) at 4800 rpm. In non-US market cars, this revision produced 100 kW (140 hp; 140 PS) at 7200 rpm
and torque at 15 kg·m (147 N·m; 108 lbf·ft) at 4800 rpm. The 4A-GE as a rear wheel drive (RWD or FR) mounted engine. Alongside the RWD AE86/AE85 coupes, a front wheel drive (FWD or FF) Corolla was produced and
all future Corollas/Sprinters were based around the FF layout. The AW11 MR2 continued use of the engine as a rear mid-engine, rear-wheel-drive layout, transversely-mounted midship. The engine was retired from North American Corollas in 1991, although it continued to be available in the Geo Prizm GSi (sold through Chevrolet dealerships) from
1990 to 1992. All 4A-GE engines (including the 20-valve versions below) feature a forged crankshaft rather than a cheaper and more commonly used cast version. Clarification: In the U.S. market, the 4A-GE engine was first used in the 1985 model year Corolla GT-S only, which is identified as an "AE88" in the VIN but uses the AE86 chassis code on
the firewall as the AE88 is a "sub" version of the AE86. The 4A-GE engines for the 1985 model year are referred to as "blue top" as opposed to the later "red top" engines, because the paint color on the valve covers is different engine revision, using different engine revision, using different airflow metering, and other minor differences on
the engine. The American Spec AE86 (VIN AE88, or GT-S) carried the 4A-GE engine. In other markets, other designations were used. Much confusion exists, even among dealers, as to which models contained what equipment, especially since Toyota split the Corolla line into both RWD and FWD versions, and the GT-S designation was only well known
as a Celica version at that time. Applications AA63 Carina 1983.06-1985 (Japan only) AT160 Carina 1985-1989 (Japan only) AT171 Carina 1985-1989 AE82 Corolla saloon, FX 1984.10-1987 AE86 Corolla Levin 1983.05-1987 AE92 Corolla 1987-1993 AT141 Corona 1983.10-1985 (Japan only) AT171 Carina 1985-1989 AE82 Corolla saloon, FX 1984.10-1987 AE86 Corolla saloon, FX 1984.10-1987 AE96 Corolla Saloon, FX 1984.10-1987 AE92 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina 1985-1989 AE82 Corolla Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina Saloon, FX 1984.10-1987 AE98 (Japan only) AT171 Carina Saloon, FX 1984.10-1987 AE98 (Japan only) AT181 Carina Saloon, FX 1984.10-1987 AE98 (Japan only) AT181 Carina Saloon, FX 1984.10-1987 AE98 (Japan only) AT181 Carina Saloon, FX 1984.10-1987 AE98
only) AT160 Corona 1985-1988 (Japan only) AW11 MR2 1984.06-1989 AE82 Sprinter 1984.10-1987 (Japan only) AE86 Sprinter Trueno 1983.05-1987 (Japan only) AE92 Sprinter T
(based on Corolla AE92 chassis) 1990-1992 4A-GE (16-valve) specifications Gen 1 "Blue Top" (Early Bigport) Gen 2 "Red & Black Top" (Early Bigport) Gen 2 "Red & Black Top" (Smallport) Production May 1983-May 1987 June 1987-May 1989 June 1989-June 
× 77.0 mm (3.19 in × 3.03 in) Valves 16 valves, 4 per each cylinder Ignition Distributor Fuel Delivery System MPFI Fuel Metering Manifold Absolute Pressure (MAP) (Japan-spec) Fuel Requirements Regular / Premium Switch Selectable (US: 87-91 AKI; Japan: 90-100 RON) Maximum Redline 7,600 rpm Dry Weight
154 kg (340 lb) (with T50 gearbox) Horsepower 130 PS (96 kW; 118 hp) at 6,600 rpm (Japan-spec; net output)112 hp (84 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,600 rpm (Japan-spec) 120 PS (88 kW; 118 hp) at 6,6
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7,200 rpm (Japan-spec)125 PS (92 kW; 123 hp) at 7,200 rpm (US-spec) Torque 15.1 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec; net output)13.4 kg·m (131 N·m; 97 lbf·ft) at 5,800 rpm (US-spec) 14.5 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 97 lbf·ft) at 5,800 rpm (US-spec) 14.5 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (142 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (131 N·m; 105 lbf·ft) at 5,800 rpm (Japan-spec)13.4 kg·m (Japan-spe
97 lbf·ft) at 5,800 rpm (US-spec) 15.1 kg·m (148 N·m; 109 lbf·ft) at 4,800 rpm (Japan-spec)15.2 kg·m (149 N·m; 110 lbf·ft) at 4,800 rpm (US-spec) Compression Ratio 9.0:1 9.4:1 10.3:1 Variable Intake Valve Diameter 29.5 mm (1.00 in) Intake Valve Lift 7.1 mm (0.28 in) Exhaust
Valve Lift 7.1 mm (0.28 in) Injector Size Top-Feed 365 cc Piston Cooling No Silver Top 20-Valve 4A-GE engine was produced from 1991. It has silver cam covers with chrome lettering, hence the nickname "silver top". This engine yet again features a completely new cylinder head which uses five valves per
cylinder instead of four. It uses Toyota's Variable Valve Timing (VVT) system on the intake cam, an increased compression ratio (10.5:1), and the intake system was replaced with a short manifold with individual throttles and velocity stacks, however the vane-type airflow meter was retained, requiring the use of a plenum. The previous 16-valve head
used a sharply curved intake port, while the 20-valve engine used a very upright straight port. This engine produces 160 PS (118 kW; 158 hp) at 7,400 rpm with 16.5 kg·m (162 N·m; 119 lbf·ft) of torque at 5,200 rpm. In South Africa, the 7A-FE engine was used in place of the 20-valve 4A-GE engine in 1993 despite other countries (except North
America) moving towards the new engine, as South African fuel was not suitable at the time for the 20-valve 4A-GE engine would eventually arrive in the Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXi and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSi in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSI in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSI in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSI in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSI in the "black top" revision in 1997.[citation needed] Applications: AE101 Corolla RXI and RSI in the "black top" revision in 1997.[citation needed] AP10 Corolla RXI and RSI in the "b
 1991-1995 (Japan only) AE101 Corolla Ceres hardtop 1992-1995 (Japan only) AE101 Sprinter Marino hardtop 1992-1995 (Japan only) AE101 Sprinter 1991-2000 (Japan only) AE101 Sprinter 1991-2000 (Japan only) AE101 Sprinter Marino hardtop 1992-1995 (Japan only) AE101 Sprinter 1991-2000 (Japan only) AE101 Sprinter Marino hardtop 1992-1995 (Japan only) AE101 Sprinter 1991-2000 (Japan only) AE101 Sprinter Marino hardtop 1992-1995 (Japan only) AE101 Sprinter Mar
 final version of the 4A-GE engine and has black cam covers. It uses Toyota Variable Valve Timing (VVT) system on the intake cam. This engine is commonly known as the "black top" due to the color of the valve cover, and yet again features an even higher compression ratio (11:1). The air flow sensor was replaced by a MAP sensor, the diameter of the
four individual throttle bodies was increased from 43 to 45 mm (1.69 to 1.77 in), the exhaust ports diameter were increased from 7.9 to 8.2 mm (0.31 to 0.32 in), and the intake ports were significantly improved in shape and contour, with the width of the opening at the head increased as well. Additionally,
the black top had a lighter flywheel, a larger plenum, lighter connecting rods and revised rubber velocity stacks, and was also offered in 1997 with a six-speed C160 transaxle. This revision increased the power to 165 PS (121 kW; 163 hp) at 7,800 rpm with 16.5 kg·m (162 N·m; 119 lbf·ft) of torque at 5,600 rpm. The 'Blacktop' has become a favorite
among enthusiasts and is used as an easy power upgrade for the early Toyota Corolla models, especially for use in the drift scene. Due to the relatively high state of tuning of the stock engine, most power/torque gains come from higher lift cams and engine management. It has been believed that Toyota's power figures for the 20-valve engines are
inflated; this statement was more than likely caused by people using less than 100 RON fuel (Japanese premium fuel standard; roughly equivalent to 94 AKI or (R+M)/2 fuel) that both 20-valve engines require.[citation needed] Applications AE111 Corolla Levin coupe 1995–2000 (Japan only) AE111 Sprinter Trueno coupe 1995–2000 (Japan only) AE101
Corolla Ceres hardtop 1995-1998 (Japan only) AE101 Sprinter Marino hardtop 1995-1998 (Japan only) AE111 Corolla BZ touring wagon 1995-1999 (Japan only) AE111 Sprinter Carib 1997-2000 (Japan only) AE111 Sprinter Marino hardtop 1995-1999 (Japan only) AE111 Sprinter Marino hardtop 1995-1999 (Japan only) AE101 Sprinter Marino hardtop 1995-1999 (Japan only) AE111 Sprinter Marino hardtop 1995-1999 (Japan o
1996-2001 (Japan only) 4A-GE (20-valve) specifications Gen 4 "Silver Top" Gen 5 "Black Top" Production June 1991-May 1995 August 2000 Layout DOHC Straight-4 (Inline-4) Capacity 1,587 cc (1.6 L; 96.8 cu in) Bore × Stroke 81.0 mm × 77.0 mm (3.19 in × 3.03 in) Valves, 5 per each cylinder Ignition Distributor Fuel Delivery
 System MPFI Fuel Metering Air Flow Meter (AFM) Manifold Absolute Pressure (MAP) Fuel Requirements 100 RON Premium (94 AKI or (R+M)/2) Maximum Redline 8,000 rpm Torque 16.5 kg·m (162 N·m; 119 lbf·ft) at 5,200 rpm 16.5 kg·m (162 N·m; 119 lbf·ft)
 at 5,600 rpm Compression Ratio 10.5:1 11.0:1 Variable Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.28 in) 7.4 mm (0.29 in) Intake Valve Diameter 7.1 mm (0.29 in) Intake Valve Dia
Cooling No The 1st generation 4A-GZE used in the Toyota MR2 Supercharged engines manufactured by Toyota. The 4A-GZE and 2TZ-FZE are the only factory supercharged engines manufactured by Toyota. The 4A-GZE used in the first image. The 4A-GZE and 2TZ-FZE are the only factory supercharged engines manufactured by Toyota.
1986 through 1995. All three generations shared forged and ceramic coated pistons, a SC12 Roots type supercharger, and a stronger 7-rib block and crankshaft, similar to the 1987-1989 "Late Bigport" second-generation 4A-GZE engines.[clarification needed] The 4A-GZE engines.[clarific
GZE is popular for turbo conversions, as many parts do not need to be modified to support the extra boost. [29] The first-generation 4A-GZE produced 8 psi (0.55 bar) peak manifold pressure. It used dished, forged and coated pistons with an 8.0:1 compression ratio. Compared to the 4A-GE, the main differences for the long block were casting holes for
a knock sensor and coolant bypass pipes, lower duration cam timing (232°), the upgraded pistons, different valve covers, and the omission of T-VIS. The first-generation 4A-GZE was first used in the 1986 supercharged Toyota MR2 AW11
until May 1989. It was also used in the 1987-1989 Toyota Corolla AE92 and Sprinter AE92 (Japan-only). Despite having the same specifications, the MR2 was equipped with a distributor and a single ignition coil while the Corolla and Sprinter was equipped with a distributor and a single ignition soll while the Corolla AE92 and Sprinter AE92 (Japan-only).
 1988-1989 North America) AE92 Corolla 1987-1989 (Japan only) AE92 Sprinter 1987-1989 (Japan only) In late 1989, the 4A-GZE was updated with an 8.9:1 compression, and MAP D-Jetronic load sensing and a smaller supercharger pulley producing 10 psi (0.69 bar). These updated 4A-GZE engines were rated at 165 PS (121 kW; 163 hp) and
21.2 kg·m (208 N·m; 153 lbf·ft).[30] Fuel requirements were increased from this generation onwards, requiring at least 100 RON fuel. It can be denoted by a gray cover on the top-mounted intercooler with an emblem reading "Twin Cam 16 Supercharger". While this cover was also used on early AE92s with the first-generation 4A-GZE, the lack of
AFM and its subsequent replacement with MAP in the later AE92s makes this generation easily recognizable. Applications: AE92 Corolla 1989-1991 (Japan only) In mid 1991, the 4A-GZE was further upgraded with the "smallport" cylinder head and the block was equipped with piston skirt oil jets for cooling.
These minimal updates further increased output to 170 PS (125 kW; 168 hp) and 21.2 kg·m (208 N·m; 153 lbf·ft).[30] It can be denoted by a black cover on the top-mounted intercooler with an emblem featuring Toyota's then-new logo followed by the word "Supercharger". While its naturally aspirated counterpart (4A-GE) used five valves per cylinder
for a total of 20 valves in its redesigned cylinder head during this timeframe, the 4A-GZE's cylinder head remained unchanged and continued to use four valves per cylinder for a total of 16 valves. Applications: AE101 Corolla 1991-1995 (Japan only) 4A-GZE Specifications[28] Gen 1 Gen 2 Gen 3 Production June
 1985-May 1989 May 1989-June 1991 June 1991 June 1991-May 1995 Layout DOHC Straight-4 (Inline-4) Capacity 1,587 cc (1.6 L; 96.8 cu in) Bore × Stroke 81.0 mm × 77.0 mm (3.19 in × 3.03 in) Valves 16 valves, 4 per each cylinder Ignition Distributor (AW11), DLI (AE92) DLI Fuel Delivery System MPFI Fuel Metering Air Flow Meter (AFM) Manifold Absolute
 Pressure (MAP) Fuel Requirements Regular / Premium Switch Selectable (US: 87-91 AKI; Japan: 90-100 RON) 100 RON Premium (94 AKI or (R+M)/2) Maximum Redline 7,600 rpm Horsepower 145 PS (107 kW; 143 hp) at 6400rpm 170 PS (125 kW; 168 hp) at 6400rpm Torque 19.4 kg·m (190 N·m; 140 lbf·ft) at
4400rpm 21.2 kg·m (208 N·m; 153 lbf·ft) at 4400rpm Compression Ratio 8.0:1 8.9:1 Variable Intake Valve Diameter 29.5 mm (1.00 in) Intake Valve Diameter 29.5 mm (1.16 in) Exhaust Valve Diameter 29.5 mm (1.28 in) Exhaust Valve Diameter 29.5 mm 
(0.48-0.55 bar) 9-10 psi (0.62-0.69 bar) Piston Cooling No Oil Jets Due to its durability, performance and their derivatives have been popular for both professional and amateur racing since their introduction. The most notable application of the 4A-GE in racing was as in the Formula Atlantic series.
 where in full race trim the engine will produce 250 PS (184 kW; 247 hp) at 10,000 rpm. Reciprocating internal combustion engine 5A5A-FE engineOverviewManufacturerToyotaProduction1987-2006LayoutConfigurationInline 4Displacement1,498 cc (1.5 L)Cylinder bore 78.7 mm (3.10 in)Piston stroke 77 mm (3.03 in)Cylinder block materialCast
ironCylinder head materialAluminumValvetrainDOHC 4 valves x cyl.CombustionFuel typeGasolineCooling systemWater cooledOutputPower output85 PS (63 kW; 84 hp)100 PS (74 kW; 99 hp)105 PS (77 kW; 104 hp)120 PS (88 kW; 118 hp)Torque output12.4 kg·m (122 N·m; 90 lbf·ft)13.3 kg·m (130 N·m;
96 lbf·ft)13.4 kg·m (131 N·m; 97 lbf·ft)14.1 kg·m (138 N·m; 102 lbf·ft)14.1 kg·m (138 N·m; 10
78.7 mm × 77 mm (3.10 in × 3.03 in) and had 4 valves per cylinder with DOHC heads using the narrow-valve (22.3°) angle. It uses the same High-Mecha Twin Cam system from the 4A-F. Output for the carb version was 85 PS (63 kW; 84 hp) at 6000 rpm and 12.4 kg·m (122 N·m; 90 lbf·ft) at 3600 rpm. Applications: AT170 Carina 1988-
 1990 (Japan only) AE91 Corolla 1987-1989 (Japan only) AT170 Corona 1987-1989 (Japan only) AT170 Corona 1987-1989 (Japan only) AE91 Sprinter 1987-1989 (Japan only) Output for the 1987 FI version was 105 PS (74 kW; 99 hp) at 5600 rpm and 14.1 kg·m (138 N·m; 102 lbf·ft) at 4800 rpm. A later one produced 100 PS (74 kW; 99 hp) at 5600 rpm and 14.1 kg·m (138 N·m; 102 lbf·ft) at 4800 rpm.
 4400 rpm. Toyota joint venture partner Tianjin FAW Xiali produces the 5A-FE (dubbed 5A+) for its Vela and Weizhi (C1) subcompact sedans.[citation needed] This version produces 100 PS (74 kW; 99 hp) at 6000 rpm and 13.3 kg·m (130 N·m; 96 lbf·ft) at 4400 rpm. Applications Yema SQJ6451 Xiali Vela (China) Xiali Weizhi (China) Geely CK (China)
Geely MK (China) AT170 Carina 1990-1992 (Japan only) AT192 Carina 1995-2001 (Japan only) AT192 Carina 1995-2001 (Japan only) AT170 Corolla 1995-2001 (Japan onl
1996-2003 (Asia) AE91 Sprinter 1989-1992 (Japan only) AE100 Sprinter 1995-2006 (China only) AE100 Sprinter 1
to 120 PS (88 kW; 118 hp) due to slightly larger throttle than the standard 5A-FE and different cam profiles. Applications: AE91 Corolla 1989-1992 (Japan only) AE91 Sprinter 1989-1992 (Japan only) Reciprocating internal combustion engine
6AOverviewManufacturerToyotaProduction1988-1992LayoutConfigurationInline 4Displacement1.4 L (1,397 cc)Cylinder block materialAluminumValvetrainDOHC 4 valves x cyl.CombustionFuel typeGasolineCooling systemWater cooledOutputPower output60 kW
(80 hp; 82 PS)Specific power42.9 kW (57.5 hp; 58.3 PS)Torque output11.9 kg·m (117 N·m; 86 lbf·ft). It is a 4-valve, narrow-valve angle DOHC engine using Toyota's
 High-Mecha Twin Cam system, mainly installed in Australia only) Reciprocating internal combustion engine 7A7A-FE EngineOverviewManufacturerToyotaProduction1990-2002LayoutConfigurationInline 4Displacement1,762 cc (1.8 L)Cylinder
bore81 mm (3.2 in)Piston stroke85.5 mm (3.37 in)Cylinder block materialCast ironCylinder block materialAluminumValvetrainDOHC 4 valves x cyl. Compression ratio9.5:1CombustionFuel typeGasolineCooling systemWater cooledOutputPower output78 kW (110 hp; 112 PS)86 kW (115 hp; 117 PS)88 kW (
(118 \text{ hp}; 120 \text{ PS})Torque output 15.2 kg·m (149 \text{ N·m}; 110 \text{ lbf·ft})15.9 kg·m (156 \text{ N·m}; 115 \text{ lbf·ft})16.2 kg·m (156 \text{ N·m}; 115 \text{ lbf·ft})16.3 kg·m (156 \text{ N·m}; 115 \text{ lbf·f
× 3.37 in). The largest production A-series engine was the 7A-FE, produced from 1993 through 2002. It is a 4-valve DOHC narrow-valve angle economy engine stroked out from the 4A, also reusing the 4A-FE's High-Mecha Twin Cam concept. It is a non-interference type engine. An early Canadian version produced 86 kW (115 hp; 117 PS) at 5600 rpm
and 15.2 kg·m (149 N·m; 110 lbf·ft) at 2800 rpm. The common (1993 to 1995 North American) version is rated at 82 kW (110 hp; 112 PS) at 5600 rpm and 15.9 kg·m (156 N·m; 115 lbf·ft) at 2800 rpm. The engine output was changed for the 1996 to 1997 (North American) version mainly due to a different antipollution system and different intake
which made it rate at 78 kW (105 hp; 106 PS) at 5200 rpm and 16.2 kg·m (159 N·m; 117 lbf·ft) of torque at 2800 rpm. In the United States, the 7A-FE's most common application was in the 1993-1997 Corolla (7th generation). The engine was also used in some 1994-1999 Celicas (6th generation) at the base ST trim level, as well as the Toyota
Corolla's clone, the Geo Prizm. The Indonesian and Russian version of the 7A-FE has the strongest naturally aspirated output, with 9.5 compression ratio. It appears in the eighth generation Corolla (AE112). In the Australian market, the AE112 Corolla Sportivo
had a turbocharged and intercooled 7A-FE, sometimes unofficially referred to as the 7A-FTE. Output was 115 kW (154 hp; 156 PS) at 5,600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lbf·ft) at 3600 rpm, torque 24.2 kg·m (237 N·m; 175 lb
compression ratio as the naturally aspirated 7A-FE.[31] Only 110 Corolla Sportivos were built. Toyota never made a wide-valve angle high-performance engine based on the 7A called the "7A-GE", however many enthusiasts have created one using a combination of 7A-FE parts (block and crank), 4A-GE parts (head, pistons) and custom connecting rods
The 7A-FE has a smaller crank journal and smaller wrist pins (press fit), and so a few companies have made special rods. Applications: AT221 Avensis 1997-2000
(Europe only) AT191 Caldina 1996-1997 (Japan only) AT211 Carina 1994-1996 (Japan only) AT211 Carina 1994-1996 (Japan only) AT211 Carina 1994-1997 (Europe only) AT211 Carina 1996-2001 (Japan only) AT211 (Japan 
(Australia only) AE102/103 Corolla 1997-2001 (Japan only) AE112 Corolla 1997-2002 (excluding Japan) AE111 Corolla 1997-2002 (excluding Japan) AE115 Corolla 1997-2002 (Europe only) AE115 Corolla 1997-2002 (Europe only) AE115 Corolla 1997-2002 (Europe only) AE111 Corolla 1997-2002 (Europe only) AE1111 Corolla 1997-2002 (Europe only) AE1
Corona 1994-1997 (excluding Japan) AT211 Corona 1996-2001 (Japan only) AE115 Sprinter Carib 1995-2001 (Japan only) AE115 Sprinter Carib 1995-2001 (Japan only) AE115 Sprinter Carib 1996-2001 (Japan o
(3.10 in)Piston stroke69 mm (2.72 in)Cylinder block materialCast ironCylinder head materialAluminumValvetrainDOHC 4 valves x cyl.Compression ratio 9.3:1CombustionFuel systemFuel injectionFuel systemFuel systemFue
output11.2 kg·m (110 N·m; 81 lbf·ft)ChronologyPredecessor3TSuccessor4ZZ The 1.3 L (1,342 cc) 8A was produced from 1990 through 2006 by Tianjin FAW Xiali for its Daihatsu and Toyota-based subcompacts. It uses the same cylinder
DOHC head with narrow-valve angles. The High-Mecha Twin Cam system from the 4A-FE and 5A-FE was retained. Compression ratio is 9.3:1. Output is 64 kW (86 hp; 87 PS) at 6,000 rpm and 11.2 kg·m (110 N·m; 81 lbf·ft) at 5200 rpm. Applications: AXP41 Toyota Vios 2002–2006 (China only) AXP41 Xiali Vizi 2002–2006 (China only) Haima CA7130
(China) Xiali 2000/Vela 2000-2012 Xiali A+ 2005-2011 Xiali Weizhi (China) Etsong Lubao QE6400/QE6440/FAW Lubao CA6410/Jiefang CA6440UA The 1.3 L and 1.5 L A engines are built in Tianjin FAW Toyota Engine Co., Ltd. Plant No. 1.[32] List of Toyota engines ^ Hogg, Tony (ed.). "A better car than its styling would indicate". Road & Track's
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 '80s, p. 10 ^ "Tekniikan Maailma Magazine" (in Finnish) (10). 1986. {{cite journal}}: Cite journal}}: Cite journal|}: Cite journal|}: Cite journal|}: Cite journal|}: Cite journal|}: Cite journal|}: Cite journal|
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All About the Toyota Twin Cam, 2nd ed., Tokyo, Japan: Toyota Motor Company, 1984, p. 14 ^ a b Toyota Twin Cam, p. 15 ^ Road & Track Magazine, November 1984 ^ Toyota Twin Cam, p. 15 ^ Road & Track Magazine, November 1984 ^ Toyota Twin Cam, p. 11 ^ a b "4AGZE Specs". Club4ag. ^ 4AG Tech Notes Archived 2005-02-06 at the Wayback Machine. ^ a b "Tech: 4A-GZE". Club4ag. ^ Lithgow, Ian. "7A-FE
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 vehicles "4AGE to 7AGE conversion"—A good how-to "4A-GE engine rebuild by RSChita" 4A-GE tech notes The Stock 4AGE Description Page "S-86.com"—SQ Engineering - has many 4age related articles Phil Bradshaw's 4A-GE info page Archived 2018-11-29 at the Wayback Machine Retrieved from "Internal combustion engine type Four-stroke cycle
used in gasoline/petrol engines: intake (1), compression (2), power (3), and exhaust (4). The right blue side is the exhaust port and the left brown side is the exhaust port. The cylinder wall is a thin sleeve surrounding the piston head which creates a space for the combustion of fuel and the genesis of mechanical energy. A four-stroke (also four-cycle)
engine is an internal combustion (IC) engine in which the piston completes four separate strokes while turning the crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction. This stroke of the piston begins at top dead center (T.D.C.)
and ends at bottom dead center (B.D.C.). In this stroke the intake valve must be in the open position while the piston pulls an air-fuel mixture into the cylinder by producing a partial vacuum (negative pressure) in the cylinder through its downward motion. Compression: This stroke begins at B.D.C., or just at the end of the suction stroke, and ends at
T.D.C. In this stroke the piston compresses the air-fuel mixture in preparation for ignition during this stage. Combustion: Also known as power or ignition during the power stroke (below). Both the intake and exhaust valves are closed during this stage. Combustion: Also known as power or ignition during the power stroke (below). Both the intake and exhaust valves are closed during this stage.
degree revolution. While the piston is at T.D.C. (the end of the compression stroke) the compression stroke produces mechanical work from the engine to turn the crankshaft. Exhaust:
 Also known as outlet. During the exhaust stroke, the piston, once again, returns from B.D.C. to T.D.C. while the exhaust valve is open. This action expels the spent air-fuel mixture through the exhaust valve is open. This action expels the spent air-fuel mixture through the exhaust valve is open.
diesel trains, light aircraft and motorcycles. The major alternative design is the two-stroke cycle (1] Main article: Otto engine from 1880s US Manufacture Nikolaus August Otto engine from 1880s US Manufacture 
expatriate Jean Joseph Etienne Lenoir. In 1860, Lenoir successfully created a double-acting engine that ran on illuminating gas at 4% efficiency. The 18 litre Lenoir Engine produced only 2 horsepower. The Lenoir engine ran on illuminating gas at 4% efficiency.
engine in 1861, Otto became aware of the effects of compression on the fuel charge. In 1862, Otto attempted to produce an engine that would compress the fuel mixture prior to ignition, but failed as that engine would run no more than a few minutes
prior to its destruction. Many other engineers were trying to solve the problem, with no success.[2] In 1864, Otto and Cie (NA Otto and Cie succeeded in creating a successful atmospheric engine that same year.[2] The factory ran out office with a successful atmospheric engineers were trying to solve the problem, with no success.[2] In 1864, Otto and Cie (NA Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[2] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[2] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[3] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[4] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[5] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no success.[6] In 1864, Otto and Cie succeeded in creating a successful atmospheric engineers were trying to solve the problem, with no successful atmospheric engineers.
 space and was moved to the town of Deutz, Germany in 1869, where the company was renamed to Deutz Gasmotorenfabrik AG (The Deutz Gasmotorenfabrik AG (The Deutz Gasmotorenfabrik AG). [2] In 1872, Gottlieb Daimler was technical director and Wilhelm Maybach was the head of engine design. Daimler was a quinsmith who had worked on the Lenoir engine. By
1876, Otto and Langen succeeded in creating the first internal combustion engine that compressed the fuel mixture prior to combustion for far higher efficiency than any engine created to this time. Daimler and Maybach left their employ at Otto and Cie and developed the first high-speed Otto engine in 1883. In 1885, they produced the first
automobile to be equipped with an Otto engine. The Daimler Reitwagen used a hot-tube ignition system and the fuel known as Ligroin to become the world's first vehicle powered by an internal combustion engine. It used a four-stroke engine based on Otto's design. The following year, Karl Benz produced a four-stroke engine automobile that is
regarded as the first car.[3] In 1884, Otto's company, then known as Gasmotorenfabrik Deutz (GFD), developed electric ignition and the carburetor. In 1890, Daimler and Maybach formed a company known as Daimler Motoren Gesellschaft. Today, that company is Daimler and Maybach formed a company known as Daimler Motoren Gesellschaft.
 petrol-electric hybrid engine The Atkinson Gas Cycle Main article: Atkinson cycle is designed to provide efficiency at the expense of power density, and is used in some modern hybrid electric applications. The
original Atkinson-cycle piston engine allowed the intake, compression, power, and exhaust strokes of the four-stroke cycle engines.[4] Due to the unique crankshaft design of the Atkinson, its expansion ratio can differ from its
compression ratio and, with a power stroke longer than its compression stroke, the engine can achieve greater thermal efficiency than a traditional piston engine. While Atkinson's original design is no more than a historical curiosity, many modern engine can achieve greater thermal efficiency than a traditional piston engine.
power stroke, thus realizing the fuel economy improvements the Atkinson cycle can provide.[5] Main article: Diesel cycle Audi Diesel R15 at Le Mans The diesel engine is a technical refinement of the engine could be increased by first compressing the fuel mixture prior
to its ignition, Rudolf Diesel wanted to develop a more efficient type of engine that could run on much heavier fuel. The Lenoir, Otto Atmospheric, and Otto Compression engines (both 1861 and 1876) were designed to run on Illuminating Gas (coal gas). With the same motivation as Otto, Diesel wanted to create an engine that would give small
industrial companies their own power source to enable them to compete against larger companies, and like Otto, to get away from the requirement to be tied to a municipal fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply.[citation needed] Like Otto, it took more than a decade to produce the high-compression engine that could self-ignite fuel supply the high-compression engine that could self-ignite fuel supply the high-compression engine that could self-ignite fuel supply the high-compression engine that could self-igni
spray combined with fuel in his first engine. During initial development, one of the engines burst, nearly killing Diesel. He persisted, and finally created a successful engine in 1893. The high-compression engine, which ignites its fuel by the heat of compression, is now called the diesel engine, whether a four-stroke or two-stroke design. The four-
stroke diesel engine has been used in the majority of heavy-duty applications for many decades. It uses a heavy fuel containing more energy and requiring less refinement to produce. The most efficient Otto-cycle engines run near 30% thermal efficiency. [clarification needed] The idealized four-stroke Otto cycle p-V diagram: the intake (A) stroke is
performed by an isobaric expansion, followed by the compression (B) stroke, performed as an adiabatic expansion, characterizing the power (C) stroke. The cycle is closed by an isochoric process and an isobaric compression, characterizing the
 exhaust (D) stroke. The thermodynamic analysis of the actual four-stroke and two-stroke cycles is not a simple task. However, the analysis can be simplified significantly if air standard assumptions of the engine, as
the air/fuel mixture is being compressed, an electric spark is created to ignite the mixture. At low rpm this occurs close to TDC (Top Dead Centre). As engine rpm rises, the speed of the flame front does not change so the spark point is advanced earlier in the cycle to allow a greater proportion of the cycle for the charge to combust before the power
stroke commences. This advantage is reflected in the various Otto engine designs; the atmospheric (non-compressed charge engine has an operating efficiency whereas the compressed charge engine has an operating efficiency around 30%. A problem with compressed charge engine has an operating efficiency around 30%.
ignition. If this occurs at the wrong time and is too energetic, it can damage the engine. Different fractions of petroleum have widely varying flash points (the temperatures at which the fuel may self-ignite). This must be taken into account in engine and fuel design. The tendency for the compressed fuel mixture to ignite early is limited by the chemical
composition of the fuel. There are several grades of fuel to accommodate differing performance levels of engines are designed with higher compression ratios the result is that pre-ignition is much more likely to occur since the fuel mixture is
compressed to a higher temperature prior to deliberate ignition. The higher temperature more effectively evaporates fuels such as gasoline, which increases the efficiency of the compression ratio also mean that the distance that the piston can push to produce power is greater (which is called the expansion ratio). The
octane rating of a given fuel is a measure of the fuel's resistance to self-ignition. A fuel with a higher compression ratio, which extracts more energy from the fuel and more effectively converts that energy into useful work while at the same time preventing engine damage from pre-ignition. High Octane fuel
is also more expensive. Many modern four-stroke engines employ gasoline direct injection or GDI. In a gasoline direct injector injects gasoline under a very high pressure into the cylinder during the compression stroke, when the piston is closer to the top.[7]
Diesel engines by their nature do not have concerns with pre-ignition. They have a concern with whether or not combustion can be started. The description of how likely Diesel fuel is to ignite is called the Cetane rating. Because Diesel fuels are of low volatility, they can be very hard to start when cold. Various techniques are used to start a cold Diesel fuels are of low volatility, they can be very hard to start when cold. Various techniques are used to start a cold Diesel fuels are of low volatility, they can be very hard to start when cold.
engine, the most common being the use of a glow plug. The four-stroke cycle 1=TDC 2=BDC A: Intake B: Compression C: Power D: Exhaust The maximum amount of power generated by an engine is determined by the maximum amount of power generated by an engine is related to its size (cylinder volume).
whether it is a two-stroke engine or four-stroke design, volumetric efficiency, losses, air-to-fuel ratio, the calorific value of the fuel, oxygen content of the air and speed (RPM). The speed is ultimately limited by material strength and lubrication. Valves, pistons and connecting rods suffer severe acceleration forces. At high engine speed, physical
breakage and piston ring flutter can occur, resulting in power loss or even engine destruction. Piston grooves the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in. Ring flutter compromises the seal between the rings oscillate vertically within the piston grooves they reside in the rings oscillate vertically within the piston grooves they reside in the rings oscillate vertically within the piston grooves they reside in the rings oscillate vertically within the piston grooves they reside in the rings oscillate vertically within the piston grooves they reside in the rings of the
valve springs cannot act quickly enough to close the valves. This is commonly referred to as 'valve float', and it can result in piston to valve contact, severely damaging the engine. At high speeds the lubrication of piston cylinder wall interface tends to break down. This limits the piston speed for industrial engines to about 10 m/s. The output power of
an engine is dependent on the ability of intake (air-fuel mixture) and exhaust matter to move quickly through valve ports, typically located in the cylinder head. To increase an engine's output power, irregularities in the intake and exhaust paths, such as casting flaws, can be removed, and, with the aid of an air flow bench, the radii of valve port turns
and valve seat configuration can be modified to reduce resistance. This process is called porting, and it can be done by hand or with a CNC machine. An internal combustion engine is on average capable of converting only 40-45% of supplied energy into mechanical work. A large part of the waste energy is in the form of heat that is released to the
environment through coolant, fins etc. If somehow waste heat could be improved by improving the engine's performance and/or fuel efficiency greatly.[8]
Many methods have been devised in order to extract some useful work, decreasing the exhaust and use it further to extract some useful work, decreasing the exhaust pollutants at the same time. Use of the Rankine Cycle, turbocharging and thermoelectric generation can be very useful as a waste heat out of an engine exhaust pollutants at the same time. Use of the Rankine Cycle, turbocharging and thermoelectric generation can be very useful as a waste heat out of an engine exhaust pollutants at the same time.
to force more air into the cylinder so that more power can be produced from each power stroke. This can be done using some type of air compression device known as a supercharger, which can be powered by the engine crankshaft. Supercharging increases the power output limits of an internal combustion engine relative to its displacement. Most
commonly, the supercharger is always running, but there have been designs that allow it to be cut out or run at varying speeds (relative to engine speed). Mechanically driven supercharger, while power is wasted in the high pressure exhaust, as the air has been
compressed twice and then gains more potential volume in the combustion but it is only expanded in one stage. A turbocharger is a supercharger that is driven by the engine's exhaust gases, by means of a turbine. A turbocharger is a supercharger that is driven by the engine's exhaust. It consists of a two piece, high-
speed turbine assembly with one side that compresses the intake air, and the other side that is powered by the exhaust gas outflow. When idling, and at low-to-moderate speeds, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume, the turbine produces little power from the small exhaust volume from t
much more power output is required, the engine speed and throttle opening are increased until the exhaust gases are sufficient to 'spool up' the turbocharger's turbine to start compressing much more air than normal into the intake manifold. Thus, additional power (and speed) is expelled through the function of this turbine. Turbocharging allows for
more efficient engine operation because it is driven by exhaust pressure that would otherwise be (mostly) wasted, but there is a design limitation known as turbo lag. The increased engine power is not immediately available due to the need to sharply increase engine RPM, to build up pressure and to spin up the turbo, before the turbo starts to do any
useful air compression. The increased intake volume causes increased exhaust and spins the turbo faster, and so forth until steady high power operation is reached. Another difficulty is that the higher exhaust pressure causes the exhaust pressure causes 
length of the connecting rod to the length of the piston stroke. A longer rod reduces sidewise pressure of the piston on the cylinder wall and the stress forces, increasing engine life. It also increases the cost and engine where the bore diameter
is larger than its stroke length is an oversquare engine, conversely, an engine with a bore diameter that is smaller than its stroke length is an undersquare engine. The valves are typically operated by a camshaft rotating at half the speed of the crankshaft. It has a series of cams along its length, each designed to open a valve during the appropriate
part of an intake or exhaust stroke. A tappet between valve and cam is a contact surface on which the cam slides to open the valve. Many engines use one or more camshaft is in the
crankcase, in which case each cam usually contacts a push rod, which contacts a rocker arm that opens a valve, or in case of a flathead engine apush rod is not necessary. The overhead cam design typically allows higher engine apush rod is not necessary.
valve lifter and a valve stem that ensures that the valve completely closes. On engines with mechanical valves not closing properly. This results in a loss of performance and possibly overheating of exhaust valves. Typically, the
clearance must be readjusted each 20,000 miles (32,000 km) with a feeler gauge. Most modern production engines use hydraulic lifters to automatically compensate for valve train component wear. Dirty engine oil may cause lifter failure. Otto engines are about 30% efficient; in other words, 30% of the energy generated by combustion is converted
into useful rotational energy at the output shaft of the engine, while the remainder being lost due to waste heat, friction and engine accessories.[9] There are a number of ways to recover some of the energy lost to waste heat. The use of a turbocharger in diesel engine is very effective by boosting incoming air pressure and in effect, provides the
same increase in performance as having more displacement. The Mack Truck company, decades ago, developed a turbine system that converted waste heat into kinetic energy that it fed back into the engine's transmission. In 2005, BMW announced the development of the turbosteamer, a two-stage heat-recovery system similar to the Mack system
that recovers 80% of the energy in the exhaust gas and raises the efficiency of an Otto engine by 15%.[10] By contrast, a six-stroke engine may reduce fuel consumption by as much as 40%. Modern engines are often intentionally built to be slightly less efficient than they could otherwise be. This is necessary for emission controls such as exhaust gas
recirculation and catalytic converters that reduce smog and other atmospheric pollutants. Reductions in efficiency may be counteracted with an engine control unit using lean burn techniques.[11] In the United States, the Corporate Average Fuel Economy mandates that vehicles must achieve an average of 34.9 mpg-US (6.7 L/100 km; 41.9 mpg-imp)
compared to the current standard of 25 mpg-US (9.4 L/100 km; 30.0 mpg-imp).[12] As automakers look to meet these standards by 2016, new ways of engineering the traditional internal combustion engine (ICE) have to be considered. Some potential solutions to increase fuel efficiency to meet new mandates include firing after the piston is farthest
from the crankshaft, known as top dead centre, and applying the Miller cycle. Together, this redesign could significantly reduce fuel consumption and NOx emissions. Starting position, intake stroke, and exhaust stroke, and exhaust stroke, and exhaust stroke, and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke, and exhaust stroke, and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke, and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke and exhaust stroke and exhaust stroke. Ignition of fuel, power stroke, and exhaust stroke and exhau
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