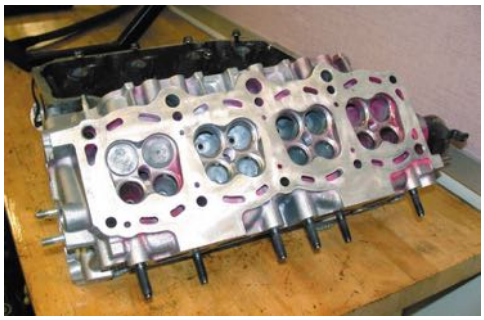
18

GASOLINE ENGINE OPERATION, PARTS, AND SPECIFICATIONS

Figure 18-1 The rotating assembly for a V-8 engine that has eight pistons and connecting rods and one crankshaft.

Figure 18-2 A cylinder head with four valves per cylinder, two intake valves (larger) and two exhaust valves (smaller).



FREQUENTLY ASKED QUESTION

What Is a Flat-Head Engine?

A flat-head engine is an older type engine design that has the valves in the block. The valves are located next to the cylinders and the air-fuel mixture, and exhaust flows through the block to the intake and exhaust manifolds. Because the valves are in the block, the heads are flat and, therefore, are called flat-head engines. The most commonly known was the Ford flat-head V-8 produced from 1932 until 1953. Typical flat-head engines included:

- Inline 4-cylinder engines (many manufacturers)
- Inline 6-cylinder engines (many manufacturers)
- Inline 8-cylinder engines (many manufacturers)
- V-8s (Cadillac and Ford)
- V-12s (Cadillac and Lincoln)

Figure 18-3 The coolant temperature is controlled by the thermostat, which opens and allows coolant to flow to the radiator when the temperature reaches the rating temperature of the thermostat.

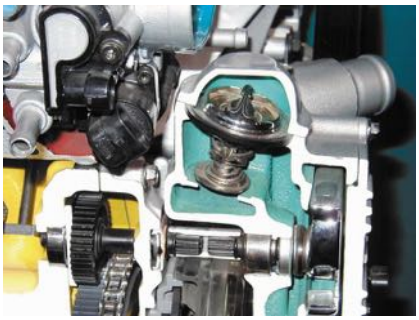


Figure 18-4 A typical lubrication system, showing the oil pan, oil pump, oil filter, and oil passages.

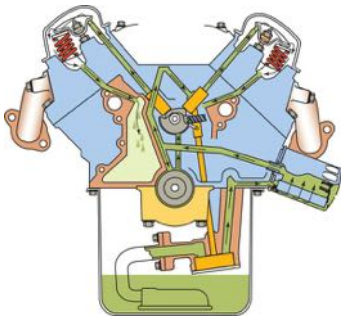


Figure 18-5 The downward movement of the piston draws the air-fuel mixture into the cylinder through the intake valve on the intake stroke. On the compression stroke, the mixture is compressed by the upward movement of the piston with both valves closed. Ignition occurs at the beginning of the power stroke, and combustion drives the piston downward to produce power. On the exhaust stroke, the upward-moving piston forces the burned gases out the open exhaust valve.

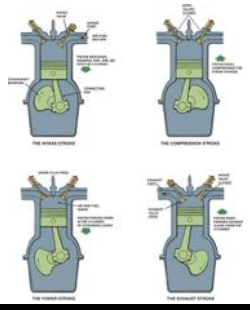


Figure 18-6 Cutaway of an engine showing the cylinder, piston, connecting rod, and crankshaft.

Figure 18-7 Automotive engine cylinder arrangements.

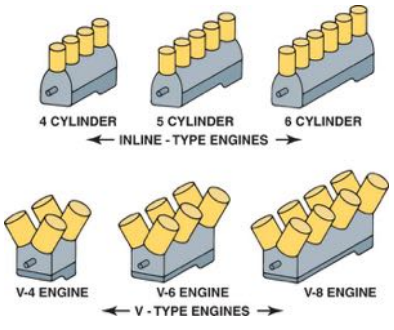


Figure 18-9 A horizontally opposed engine design helps to lower the vehicle's center of gravity.

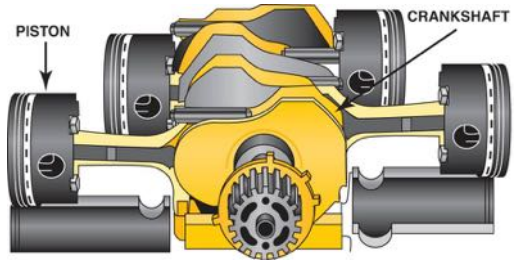


Figure 18-9 A longitudinally mounted engine drives the rear wheels through a transmission, driveshaft, and differential assembly.

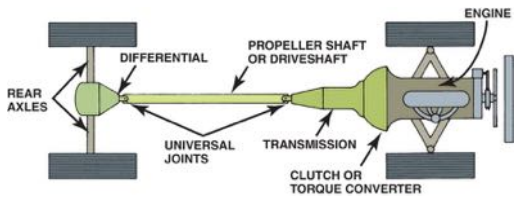


Figure 18-10 Two types of front-engine, front-wheel drive mountings.

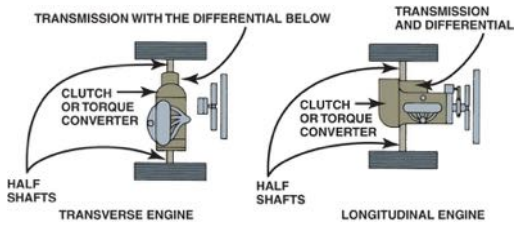


Figure 18-11 Cutaway of an overhead valve (OHV) V-8 engine showing the lifters, pushrods, roller rocker arms, and valves.

Figure 18-12 SOHC engines usually require additional components, such as a rocker arm, to operate all of the valves. DOHC engines often operate the valves directly.

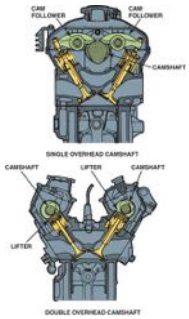


Figure 18-13 A DOHC engine uses a camshaft for the intake valves and a separate camshaft for the exhaust valves in each cylinder head.

FREQUENTLY ASKED QUESTION

What Is a Rotary Engine?

A successful alternative engine design is the **rotary engine**, also called the **Wankel engine** after its inventor, Felix Heinrich Wankel (1902–1988), a German inventor. The Mazda RX-7 and RX-8 represent the only long-term use of the rotary engine. The rotating combustion chamber engine runs very smoothly, and it produces high power for its size and weight.

The basic rotating combustion chamber engine has a triangular-shaped rotor turning in a housing. The housing is in the shape of a geometric figure called a two-lobed epitrochoid. A seal on each corner, or apex, of the rotor is in constant contact with the housing, so the rotor must turn with an eccentric motion. This means that the center of the rotor moves around the center of the engine. The eccentric motion can be seen in ● **FIGURE 18–14**.

FREQUENTLY ASKED QUESTION

Where Does an Engine Stop?

When the ignition system is turned off, the firing of the spark plugs stops and the engine will rotate until it stops due to the inertia of the rotating parts. The greatest resistance that occurs in the engine happens during the compression stroke. It has been determined that an engine usually stops when one of the cylinders is about 70 degrees before top dead center (BTDC) on the compression stroke with a variation of plus or minus 10 degrees.

This explains why technicians discover that the starter ring gear is worn at two locations on a 4-cylinder engine. The engine stops at one of the two possible places depending on which cylinder is on the compression stroke.

Figure 18-14 A rotary engine operates on the four-stroke cycle but uses a rotor instead of a piston and crankshaft to achieve intake, compression, power, and exhaust stroke.

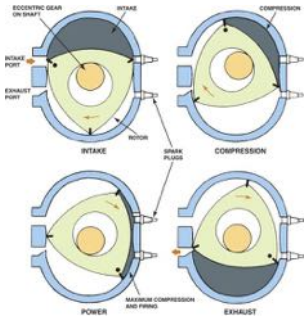


Figure 18-15 Inline 4-cylinder engine showing principal and nonprincipal ends. Normal direction of rotation is clockwise (CW) as viewed from the front or accessory belt (nonprincipal) end.

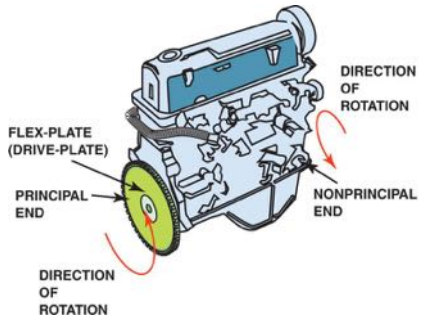


Figure 18-16 The bore and stroke of pistons are used to calculate an engine's displacement.

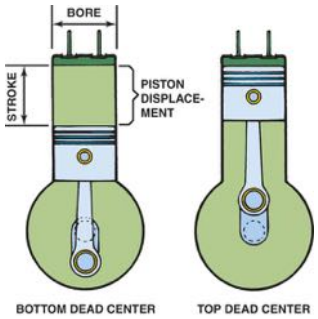


Figure 18-17 The distance between the centerline of the main bearing journal and the centerline of the connecting rod journal determines the stroke of the engine. This photo is a little unusual because it shows a V-6 with a splayed crankshaft used to even out the impulses on a 90-degree, V-6 engine design.

TECH TIP

How Fast Can an Engine Rotate?

Most passenger vehicle engines are designed to rotate at low speed for the following reasons.

- Maximum efficiency is achieved at low engine speed. A diesel engine used in a large ship, for example, will rotate at about 100 RPM for maximum efficiency.
- Piston ring friction is the highest point of friction in the engine. The slower the engine speed, the less loss to friction from the piston rings.

However, horsepower is what is needed to get a vehicle down the road quickly. Horsepower is torque times engine speed divided by 5,252. Therefore, a high engine speed usually indicates a high horsepower. For example, a Formula 1 race car is limited to 2.4 liter V-8 but uses a 1.6 in. (40 mm) stroke. This extremely short stroke means that the engine can easily achieve the upper limit allowed by the rules of 18,000 RPM while producing over 780 horsepower.

The larger the engine, the more power the engine is capable of producing. Several sayings are often quoted about engine size:

"There is no substitute for cubic inches."
"There is no replacement for displacement."

Although a large engine generally uses more fuel, making an engine larger is often the easiest way to increase power.

Chart 18-1 To find the cubic inch displacement, find the bore that is closest to the actual value, then go across to the closest stroke value.

V-8 ENGINE					
STROKE	3.50	3.75	3.875	4.00	4.125
BORE	Cu. In.	Cu. In.	Cu. In.	Cu. In.	Cu. In.
3.00	199	212	219	226	233
3.125	214	229	237	244	252
3.250	232	249	257	265	274
3.375	251	269	277	286	295
3.500	269	288	298	308	317
3.625	288	309	319	330	339
3.750	309	332	343	354	365
3.875	331	354	366	378	390
4.00	352	377	389	402	414
4.125	373	399	413	426	439

Chart 18-1 (continued) To find the cubic inch displacement, find the bore that is closest to the actual value, then go across to the closest stroke value.

6-CYLINDER ENGINE					
STROKE	3.50	3.75	3.875	4.00	4.125
BORE	Cu. In.	Cu. In.	Cu. In.	Cu. In.	Cu. In.
3.00	148	159	164	169	175
3.125	161	172	178	184	190
3.250	174	186	193	199	205
3.375	188	201	208	215	222
3.500	202	216	223	228	238
3.625	216	232	239	247	255
3.750	232	249	257	265	273
3.875	248	266	275	283	292
4.00	264	283	292	301	311
4.125	280	299	309	319	329

Chart 18-1 (continued) To find the cubic inch displacement, find the bore that is closest to the actual value, then go across to the closest stroke value.

4-CYLINDER ENGINE					
STROKE	3.50	3.75	3.875	4.00	4.125
BORE	Cu. In.	Cu. In.	Cu. In.	Cu. In.	Cu. In.
3.00	99	106	110	113	117
3.125	107	115	119	123	126
3.250	116	124	129	133	137
3.375	125	134	139	143	148
3.500	135	144	149	152	159
3.625	144	158	160	165	170
3.750	155	166	171	177	182
3.875	165	177	183	189	195
4.00	176	188	195	201	207
4.125	186	200	206	213	220

CHART 18-1

Chart 18-2 Liters to cubic inches is often not exact and can result in representing several different engine sizes based on their advertised size in liters.

LITERS TO CUBIC INCHES					
LITERS	CUBIC INCHES	LITERS	CUBIC INCHES	LITERS	CUBIC INCHES
1.0	61	3.2	196	5.4	330
1.3	79	3.3	200 / 201	5.7	350
1.4	85	3.4	204	5.8	351
1.5	91	3.5	215	6.0	366 / 368
1.6	97 / 98	3.7	225	6.1	370
1.7	105	3.8	229 / 231 / 232	6.2	381
1.8	107 / 110 / 112	3.9	239 / 240	6.4	389 / 390 / 391
1.9	116	4.0	241 / 244	6.5	396
2.0	121 / 122	4.1	250 / 252	6.6	400
2.1	128	4.2	255 / 258	6.9	420
2.2	132 / 133 / 134 / 135	4.3	260 / 262 / 265	7.0	425 / 427 / 428 / 429
2.3	138 / 140	4.4	267	7.2	440
2.4	149	4.5	273	7.3	445
2.5	150 / 153	4.6	280 / 281	7.4	454
2.6	156 / 159	4.8	292	7.5	460
2.8	171 / 173	4.9	300 / 301	7.8	475 / 477
2.9	177	5.0	302 / 304 / 305 / 307	8.0	488
3.0	181 / 182 / 183	5.2	318	8.8	534
3.1	191	5.3	327		

CHART 18-2

Figure 18-18 Compression ratio is the ratio of the total cylinder volume (when the piston is at the bottom of its stroke) to the clearance volume (when the piston is at the top of its stroke).

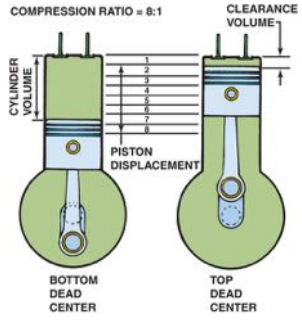


Figure 18-19 Combustion chamber volume is the volume above the piston when the piston is at top dead center.

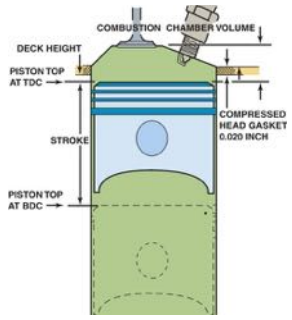
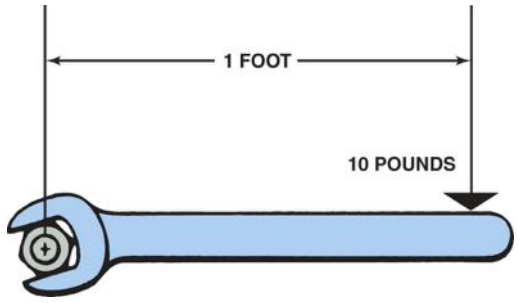


Figure 18-20 Torque is a twisting force equal to the distance from the pivot point times the force applied expressed in units called pound-feet (lb-ft) or newton-meters (N-m).



FREQUENTLY ASKED QUESTION

Is Torque ft-lb or lb-ft?

The definition of torque is a force (lb) applied to an object times the distance from that object (ft). Therefore, based on the definition of the term, torque should be:

lb-ft (a force times a distance)

Newton-meter (N-m) (a force times a distance)

However, torque is commonly labeled, even on some torque wrenches as ft-lb.

TECH TIP

Quick-and-Easy Engine Efficiency Check

A good, efficient engine is able to produce a lot of power from little displacement. A common rule of thumb is that an engine is efficient if it can produce 1 horsepower per cubic inch of displacement. Many engines today are capable of this feat, such as the following:

Ford: 4.6 liter V-8 (281 cu. in.): 305 hp
Chevrolet: 3.0 liter V-6 (207 cu. in.): 210 hp
Chrysler: 3.5 liter V-6 (214 cu. in.): 214 hp
Acura: 3.2 liter V-6 (195 cu. in.): 260 hp

An engine is very powerful for its size if it can produce 100 hp per liter. This efficiency goal is harder to accomplish. Most factory stock engines that can achieve this feat are supercharged or turbocharged.