8.0 AUTOMOBILE EMISSIONS

Automobile emissions include carbon monoxide (CO), oxides of nitrogen (NOx), unburnt hydrocarbons (HC), soot etc which contribute to air pollution and carbon dioxide responsible for global warming. About 60% of the air pollution is attributed to automobile emissions and the remaining 40% is generated from refineries, factories, etc. Human exposure to CO concentration above 100 ppm can lead to death. Reducing emissions into the air is technically difficult and expensive. However, good air quality depends on pollution control through proper maintenance of automobile vehicles.

8.1 Effects of automobile pollutant on human health

1. It causes eyes irritation, objectionable odour, etc.
2. It causes reduction in visibility and increase traffic hazards.
3. High concentration of carbon monoxide can lead to death.
4. It aggravates health conditions such as asthma, allergy, cancer, etc.
5. It destroys vital organs in human body.

8.2 Effects of automobile pollutant on environment

1. Formation of smog and acid rain
2. It brings about changes in ecosystem.
3. Soot particles in the exhaust gases can change the colour of buildings and trees
4. It causes colouring patches on plant leaves.

8.3 Types of Automobile emissions

Carbon monoxide

Unburnt hydrocarbons

Oxides of nitrogen

Lead oxides

Sulphur dioxide

Smoke

8.4 Exhaust gases treatment

A catalytic converter is a cylindrical unit installed between the exhaust manifold and silencer in the exhaust system. The converter contains honeycomb structure of a ceramic or metal coated with aluminum base material and precious metals such as platinum, palladium or rhodium or combination of them. As the exhaust gases pass over the converter substance, toxic gases such as CO and NOx are converted into harmless CO_2, H_2 and N_2.

Types of catalytic converters:

1. A two way converter which is used to control only CO and HC commissions by oxidation.

2. A three way converter which is used almost in all petrol cars to controls CO and HC by oxidation as well as NOx by reduction.

8.5 Emission Control system

Emission control system	**Function**
1. Positive crankcase ventilation	Reduces HC
2. Evaporative emission control	Reduces evaporative HC
3. Exhaust Gas Recirculation	Reduces NOx
4. Three Way Catalytic Converter	Reduces HC, CO and NOx
5. Sequential Multiport fuel injection	Injects precisely at a time optimum amount of fuel for reduced exhaust gas emissions

9.0 AUTOMOTIVE ENGINE PARTS

A simple automotive engine consists of cylinder, piston, connecting rod, crankshaft, etc. Figure 9.1 shows a sectional profile of a typical four-stroke engine.

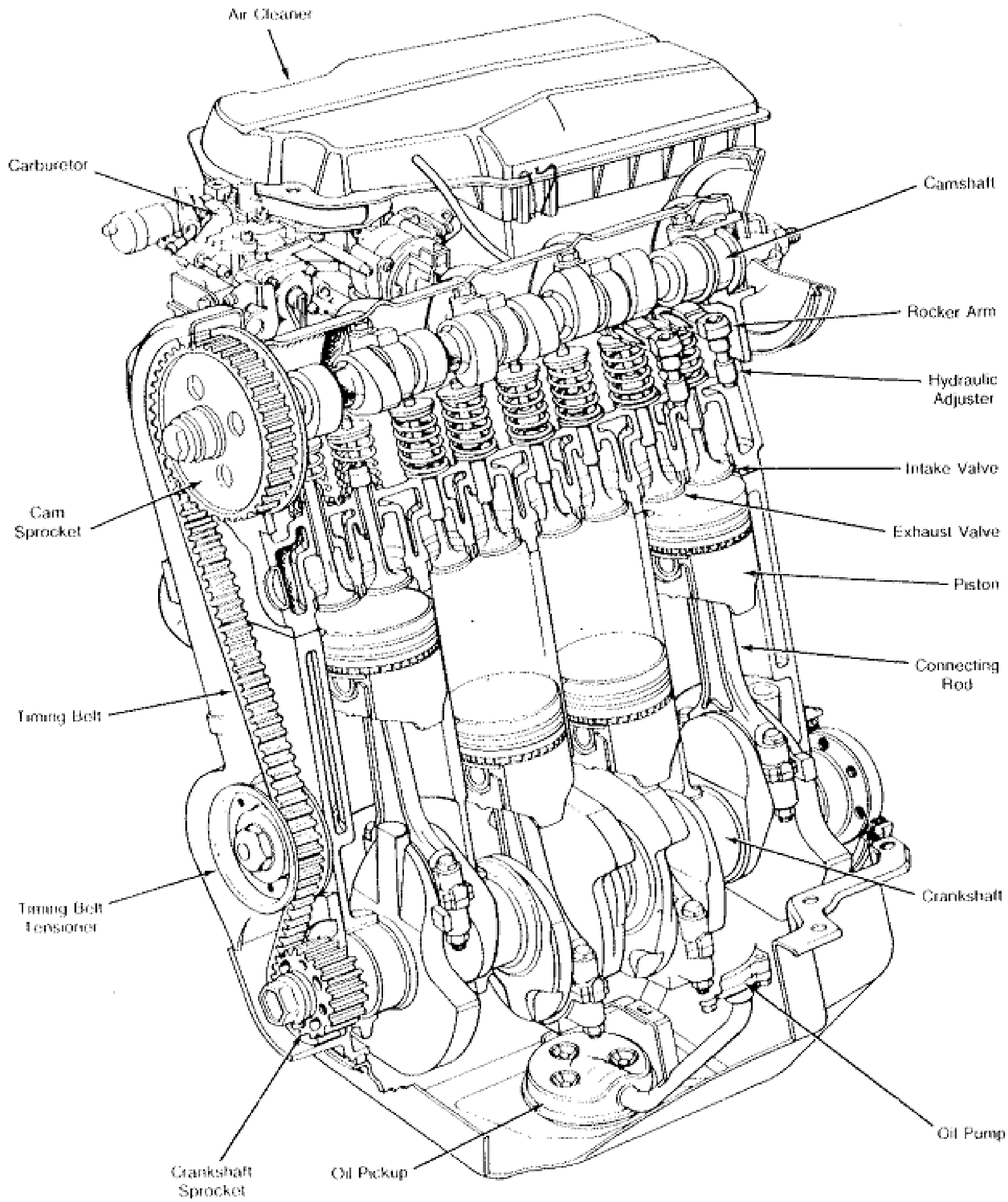

Figure 9.1: Sectional profile of four-stroke engine

The engine crankshaft is supported by five bearings on the inside of the crankcase. These bearings are made of aluminum. The crankshaft is integrated with eight weights which are cast along with it for balancing. Oil holes are built into the center of the crankshaft for supplying oil to the connecting rod.

The engine's firing order (Figure 7.1) is 1 – 3 – 4 – 2. The cylinder head is made of cast iron with intake and exhaust layout. The cylinder head contains the spark plug in the case of SI engine or fuel injector and glow plugs in the case of CI engine, and overhead valve and parts of the valve mechanism.

The camshaft is driven by timing belt or chain. The camshaft journal is supported at five places between the valve lifters of each cylinder and on the cylinder head of front end. Lubrication of the camshaft journal and cam is accomplished by oil supplied through the port in the camshaft journal.

Adjustment of valve clearance is done by means of an outer shim type system, in which valve adjusting shims are located above the valve lifters. This allows replacement of the shim without removal of the camshafts.

Pistons are made of highly temperature-resistance aluminum alloy. Piston pins are full-floating type, with the pins fastened to neither the piston boss nor the connecting rods. Instead, snap rings are fitted on both ends of the pins, thus preventing the pin from falling out.

The compression and oil rings are made of steel. The outer diameter of each piston ring is slightly larger than the piston diameter and the flexibility of the rings allows them to hug the cylinder walls when they are mounted on the piston. The compression rings help to prevent gas leakage from the cylinder and the oil ring help to scrape oil off the cylinder walls to prevent it from entering the combustion chamber.

The cylinder block is made of cast iron because of its good wear resistance and cost. It contains the cylinders which are approximately two times the length of piston stroke. Heavy-duty and truck engines often use removable cylinder sleeves pressed into the block that can be replaced when worn. These are called wet liners or dry liners depending on whether the sleeve is in direct contact with the cooling water. Aluminum is being used increasingly in smaller S1 engine blocks to reduce engine weight.

The top of each cylinder is closed off by the cylinder head and the lower end of the cylinder becomes the crankcase, in which the crankshaft is installed. In addition, the cylinder block contains water jacket, through which coolant is pumped to cool the cylinders.

The oil pan is bolted onto the bottom of the cylinder block. The oil pan or sump is an oil reservoir made of pressed steel sheet. A divided plate is included inside the oil pan to keep sufficient oil in the bottom of the pan even when the vehicle is tilted. The divided plate also prevent the oil from making waves when the vehicle is stopped suddenly, thus shifting the oil away from the oil pump suction pipe.

9.1 ENGINE PROBLEMS

The problems of engines range from engine not crank (start) to complete damage. Engine problems can lead to poor performance in terms of the low shaft power, pollutant emissions, etc.

Some of the causes of engine problems are:

1. Wear and tear of engine parts
2. Poor or lack of maintenance
3. Engine problems resulting from previous work on the engine
4. Problem of automotive parts such as transmission or emission control
5. Owner’s driving habits or maintenance culture

The following indicates engine problems, causes and possible solutions.

1. Engine does not crank

(Possible Cause)	(Check Procedure and Correction Method)
1. LOOSE OR CORRODED BATTERY CABLES	Check cables from battery to starter and make necessary repairs.
2. DISCHARGED BATTERY	Check alternator output and drive belt. If necessary, repair. (See page CH-3)
3. INOPERATIVE STARTER	Check for battery voltage at starter terminals 30 and 50. If okay, see STARTING SYSTEM for repair procedure.

2. Engine cranks slowly but does not start

(Possible Cause)	(Check Procedure and Correction Method)
1. LOOSE OR CORRODED BATTERY CABLES	Check cables from battery to starter and make necessary repairs.
2. DISCHARGED BATTERY	Check alternator output and drive belt. If necessary, repair. (See page CH-3)
3. IMPROPER ENGINE OIL	Check engine oil. If improper viscosity, drain and refill with oil of viscosity recommended by manufacturer. (See page LU-4)

3. Engine crank normally but does not start

(Possible Cause)	(Check Procedure and Correction Method)
1. NO FUEL TO NOZZLE	Loosen any one injection pipe union nut from its nozzle holder. Crank engine for about 5 seconds while confirming that fuel is being discharged from pipe. If fuel is coming out, begin diagnosis from item 4. If not, begin from item 2.
2. NO FUEL CUT SOLENOID OPERATION	With starter switch turned ON, check for fuel cut solenoid operation noise (clicking sound) while repeatedly connecting and disconnecting fuel cut solenoid. If no noise, check if there is battery voltage to solenoid when starter switch is ON. If battery voltage is confirmed, fuel cut solenoid is faulty and should be replaced. If no voltage, refer to ELECTRICAL DIAGNOSIS and make necessary repairs.
3. NO FUEL INTO INJECTION PUMP	Disconnect inlet hoses from fuel filter, and feed clean fuel from separate container directly into fuel pump. HINT: When feeding fuel tank directly into pump, keep container at same level as vehicle fuel tank. If engine starts, either fuel filter or line between fuel tank and filter is clogged and should be repaired accordingly. If engine still does not start (no fuel intake), check fuel line between filter and pump. If normal, pump is faulty and should be replaced.
4. FUEL LEAKAGE FROM INJECTION PIPES	Check for loose unions or cracks. If leaking, tighten to standard torque or, if necessary, replace pipe(s).
5. INOPERATIVE PRE-HEATING OPERATION	With starter switch turned ON and glow plug indicator light illuminated, check that there is voltage applied to glow plug. If not, refer to ELECTRICAL DIAGNOSIS and repair as necessary.

Cause	Check
6. FAULTY GLOW PLUG OPERATION	Check glow plug for continuity. If no continuity, a broken wire is indicated and glow plug should be replaced.
7. IMPROPER INJECTION TIMING	Check injection timing. (See page EM-24 or 25) **Plunger stroke:** **2L-T (Austria)** **Within the marks of belt case and pump flange. (See page EM-24)** **2L-T (Others)** **0.54 – 0.66 mm (0.0213 – 0.0260 in.)** **3L** **0.84 – 0.96 mm (0.0331 – 0.0378 in.)** If not as above, injection pump is improperly adjusted.
8. (2L-T) IMPROPER COLD START ADVANCE AND FAST IDLE	Check timer piston stroke and fast idle lever opening angle with an injection pump tester when cold start advance is operated.
9. FAULTY INJECTION NOZZLES	Check injection pressure with a nozzle tester. **Opening pressure:** **145 – 155 kg/cm² (2,062 – 2,205 psi) (14,220 – 15,200 kPa)** If not as above, nozzle adjustment is improper and pressure should be readjusted. If pressure cannot be adjusted to specification, replace injection nozzle.

4. Rough idle with worm engine

(Possible Cause)	(Check Procedure and Correction Method)
1. IMPROPER ADJUSTMENT OF ACCELERATOR CABLE	With accelerator pedal released, check that adjusting lever is in contact with idle speed adjusting screw. Also check if accelerator cable or linkage is catching on something. If necessary, adjust so that lever is in contact with screw, or make other required repairs.
2. IDLE SPEED TOO LOW	Check idle speed. (See page EM-27) **Idle speed: 2L-T 700 – 800 rpm** **3L 650 – 750 rpm** HINT: If less than standard, idling would normally be rough. If not as above, adjust with idle speed adjusting screw.
3. FUEL LEAKAGE	Check for leaks at injection pump connections, pump distributive head bolt, injection nozzles and delivery valve holders. Tighten any loose connections to specified torque or replace parts as necessary.
4. IMPROPER INJECTION TIMING	Refer to step 7 of ENGINE CRANKS NORMALLY BUT WILL NOT START, above.
5. IMPROPER OPERATION OF INJECTION NOZZLES OR DELIVERY VALVES	With engine idling, loosen injection pipe to each cylinder in order, and check if idle speed changes. If no change, a faulty cylinder is indicated. Check according to following procedure. • Faulty injection nozzle Check injection nozzle with a nozzle tester. **Opening pressure: 145 – 155 kg/cm² (2,062 – 2,205 psi) (14,220 – 15,200 kPa)** If not as above, nozzle adjustment is improper and pressure should be readjusted. If pressure cannot be adjusted to specification, replace injection nozzle. • Faulty delivery valve If injection pressure is as specified, delivery valve is defective and should be replaced.

5. Engine suddenly stops

(Possible Cause)	(Check Procedure and Correction Method)
1. ENGINE WILL NOT RE-START	Check to see if engine re-starts according to prescribed procedure. If not, refer to ENGINE CRANKS NORMALLY BUT WILL NOT START, above, and repair as necessary.
2. ROUGH IDLE	Refer to ROUGH IDLE WITH WARM ENGINE and repair accordingly.
3. MALFUNCTION OF FUEL CUT SOLENOID	Refer to ENGINE CRANKS NORMALLY BUT WILL NOT START, above, and check accordingly. HINT: No operation noise from fuel cut solenoid may be due to loose electrical connections, so check connectors before proceeding with further repairs.
4. NO FUEL INTO INJECTION PUMP	Refer to step 3 of ENGINE CRANKS NORMALLY BUT WILL NOT START, above.

6. Lack of power

(Possible Cause)	(Check Procedure and Correction Method)
1. IMPROPER ADJUSTMENT OF ACCELERATOR CABLE	With accelerator fully depressed, check that adjusting lever is in contact with maximum speed adjusting screw. Also check if accelerator cable or linkage is catching on something. If necessary, adjust so that lever is in contact with screw, or make other required repairs.
2. INSUFFICIENT MAXIMUM SPEED	Check maximum speed. (See page EM-27) **Maximum speed:** **2L-T 4,700 – 4,900 rpm** **3L (Hong Kong, Singapore and Malaysia) 4,300 – 4,500 rpm** **3L (Others) 4,500 – 4,700 rpm** If not as above, adjust with maximum speed adjusting screw.

Possible Cause	Check Procedure and Correction Method
3. INTERCHANGED OVERFLOW SCREW (OUT) AND INLET (NO MARK) FITTING	HINT: Overflow screw is marked "OUT" and has an inner jet. Although both fittings are same size, they must not be interchanged.
4. FUEL LEAKAGE	Refer to step 3 of ROUGH IDLE WITH WARM ENGINE.
5. CLOGGED FUEL FILTER	Disconnect inlet hose to fuel filter, and feed clean fuel directly into pump. HINT: When feeding fuel directly into pump, keep container at same level as vehicle fuel tank. If engine condition improves, fuel filter is clogged and should be replaced. If no increase in engine condition after replacing fuel filter, check priming pump (hand pump) or perform other necessary repairs.
6. IMPROPER INJECTION TIMING	Refer to step 7 of ENGINE CRANKS NORMALLY BUT WILL NOT START.
7. FAULTY INJECTION NOZZLES	Refer to step 9 of ENGINE CRANKS NORMALLY BUT WILL NOT START.

7. Excessive exhaust smoke

(Possible Cause)	(Check Procedure and Correction Method)
1. IMPROPER INJECTION TIMING	Refer to step 7 of ENGINE CRANKS NORMALLY BUT WILL NOT START. HINT: Black smoke indicates advanced timing while white smoke indicates retarded timing. Adjustments should be made accordingly.
2. CLOGGED FUEL FILTER	Refer to step 5 of LACK OF POWER. HINT: At high speed (2,000 – 3,000 rpm), a clogged filter tends to make exhaust smoke white.
3. FAULTY INJECTION NOZZLES	Refer to step 9 of ENGINE CRANKS NORMALLY BUT WILL NOT START. HINT: Excessive exhaust smoke is often caused by nozzle pressure being too low.

8. Excessive fuel consumption

(Possible Cause)	(Check Procedure and Correction Method)
1. FUEL LEAKAGE	Refer to step 3 of ROUGH IDLE WITH WARM ENGINE.
2. IDLE SPEED TOO HIGH	After sufficiently warming up engine, check idle speed. (See page EM-27) **Idle speed: 2L-T 700 – 800 rpm** **3L 650 – 750 rpm** If not as above, adjust with idle speed adjusting screw.
3. MAXIMUM SPEED TOO HIGH	Check maximum speed. (See page EM-27) **Maximum speed:** **2L-T 4,700 – 4,900 rpm** **3L (Hong Kong, Singapore and Malaysia) 4,300 – 4,500 rpm** **3L (Others) 4,500 – 4,700 rpm** If not as above, adjust with maximum speed adjusting screw.
4. IMPROPER INJECTION TIMING	Refer to step 7 of ENGINE CRANKS NORMALLY BUT WILL NOT START.
5. FAULTY INJECTION NOZZLES	Refer to step 9 of ENGINE CRANKS NORMALLY BUT WILL NOT START.

9. Engine noise when warm (cranking noise with excessive vibration)

(Possible Cause)	(Check Procedure and Correction Method)
1. ENGINE COOLANT TEMPERATURE TOO LOW	Check coolant temperature with water temperature gauge. If not sufficiently warm, thermostat is faulty and should be replaced.
2. IMPROPER INJECTION TIMING	Refer to step 7 of ENGINE CRANKS NORMALLY BUT WILL NOT START.
3. FAULTY INJECTION NOZZLES	Refer to step 9 of ENGINE CRANKS NORMALLY BUT WILL NOT START.

10. Engine does not return to idle

(Possible Cause)	(Check Procedure and Correction Method)
BINDING ACCELERATOR CABLE	Operate adjusting lever on top of injection pump. and check if engine returns to idle. (See page EM-27) If so, accelerator cable is binding or improperly adjusted and should be repaired accordingly. If engine does not return to idle, injection pump is faulty and should be replaced.

11. Engine does not shut off with key

(Possible Cause)	(Check Procedure and Correction Method)
IMPROPER FUEL CUT SOLENOID OPERATION	Disconnect connector of fuel cut solenoid, and check if engine stops. If so, starter switch is faulty and should be repaired as necessary or replaced. If engine does not stop, either fuel cut solenoid is faulty or there is interference by foreign particles. Repair as necessary.

10.0 ENGINE DIAGNOSIS

Although service and maintenance requirements for modern vehicles are declining steadily due the use electronic systems which are essentially maintenance-free, yet malfunctions can still occur as a result of so many factors. For example, factors such as wear, contamination and corrosion can impair the operation of engine and electronic systems, and settings can drift over time. Therefore, rapid and reliable diagnosis of engine problem symptoms is the most important function of automotive service vehicle before disassembly to be sure whether overhauling is necessary and to determine the exact location of a problem.

Engine diagnosis is one of the maintenance practices carried out to correlate deviations from specified values with system functions and behaviour patterns so that the failure mode or defective components can be determined. This is usually achieved with the use of on-board monitoring or on-board diagnostic (OBD) system.

10.1 DIAGNOSIS SYSTEM

The diagnosis system comprises all the sensors for recording the current engine operating data and all the actuators for the adjustments to be carried out on the engine. It also comprises of the electrical control unit (ECU) which employs sensors to monitor the relevant status of engine at extremely short intervals (milliseconds).

In the ECU, the input circuits suppress sensor-signal interference and convert the signals to a single unified voltage scale. An analog-digital converter then transforms the conditioned signals into digital values. Further signals are received by way of a digital interface.

Using this information, the microprocessor identifies the operating state desired by the driver.

A semiconductor memory chip stores all programs and performance maps, ensuring system consistency which remains completely impervious to fluctuations resulting from signal-level and component tolerances.

10.2 PROCEDURE TO CARRYING OUT ENGINE DIAGNOSIS

The OBD tool complying with SAE regulation is connected to the vehicle and the various output data are read from the vehicle ECU memory. OBD regulations require that the vehicle’s on-board computer lights up the malfunction indicator light (MIL) on the instrument panel when malfunction is detected. In addition, the applicable diagnostic trouble code (DTC) prescribed by SAE J2012 are recorded in the ECU memory.

To check the DTC, connect the OBD scan tool to data linked connector on the vehicle. The OBD scan tool also enables one to erase the DTC and checked freezed frame data and various forms of engine data.

10.3 FAIL-SAFE CHART

If any of the following codes is recorded, the ECU memory enter fail-safe mode.

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0105	Ignition timing fixed at 5° BTDC	Returned to normal condition
P0110	Intake air temp. is fixed at 20°C (68°F)	Returned to normal condition
P0115	Engine coolant temp. is fixed at 80°C (176°F)	Returned to normal condition
P0120	VTA is fixed at 0°	The following condition must be repeated at least 2 times consecutively When closed throttle position switch is ON: 0.1 V · VTA · 0.95 V
P0141	The heater circuit in which an abnormality is detected is turned off	Ignition switch OFF
P0325	Max. timing retardation	Ignition switch OFF
P1300	Fuel cut	IGF signal is detected for 4 consecutive ignitions