Sensors and Troubleshooting

Sensor

1. General

Fig. 1 is outline of engine control system. Engine's basic input is air and fuel, output is mechanical driving force and emission of exhaust gas.

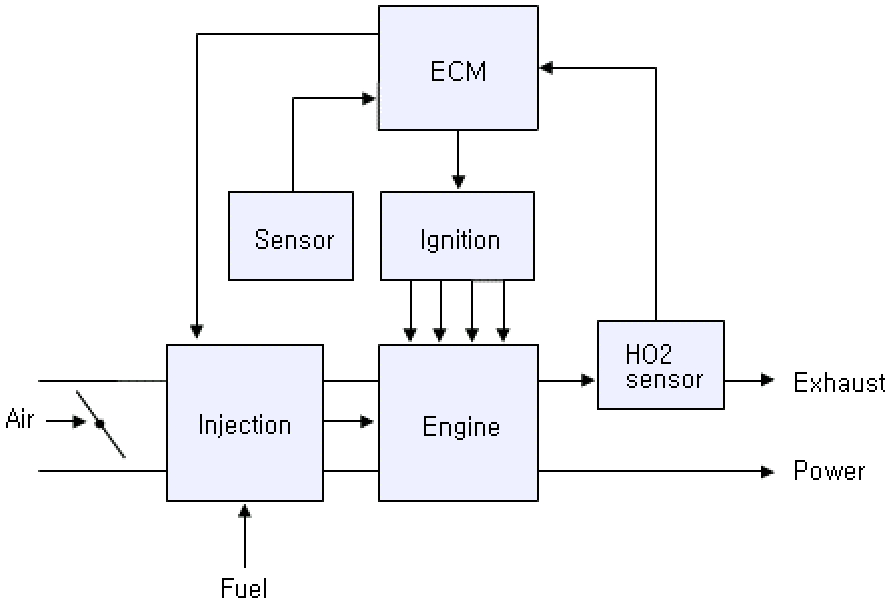

Fig. 1 Engine Control System Outline Diagram

Sensors measure physical variables generated by engine, and the measurements are sent to controllers, ECM as electric signals after processed by signal processors. Controllers decide various controlling variables and driving condition required for engine operation, and then generate electric output signal for operating actuators.

Typically engine control requires measuring variables, such as air flow rate, intake manifold and barometric pressure, coolant and intake air temperature, crank and cam angle, rotational speed, oxygen density in exhaust gas, throttle angle, presence of Knocking, etc. <Table 1> shows sensors typically used for engine control and their operating principle.

<Table 1> Sensors for Engine Control

Item	Sensor	Operation Principle	Operation Range	Temp Range	Use(System)
Temp	Therrmistor (general purpose) (MnCoNi type)	Resistance variation by temp.	-50~130°C	-40~120°C (coolant temp.)	Coolant temp., Air temp., Room temp.
	Thermistor (high temp.) (Al203, rO2 type)		600~1000°C	-40~900°C (catalyzer temp.)	Catalyzer temp.
	PTC	Resistance-temp.'s polar characteristic	ON, OFF at any temp. between 60~100°C	-40~900°C	Coolant temp., Coolant level, Chock burner
	Thermo-ferrite	Magnetic transformation			Coolant temp.
Pressure	LVDT	Bellows+Differential trans	100~780 Torr (intake air pressure) 500~780 Torr (atmospheric pressure)	-40~120°C	Intake air pressure, Atmospheric pressure (idle mileage control, ignition timing control, etc) engine oil pressure, brake oil pressure
	Semiconductor type	Piezo resistance effect			
	Static capacity type	Capacity variation by diaphragm position change			
Rotation	Electronic generation type	Magnet projection+Pick-up coil	0~360°C	-40~120°C	Crank angle, Throttle angle (ignition timing control, EGR control, etc), Engine rpm, Car speed
	Magnetic resistance type	Two way feature of magnetic resistance type effect			
	Hall element type	Semiconductor's Hall effect			
	Wiegand type	Wiegand effect			
	Optical type	Slit+Light emitint, receiving element			
Air flow rate	Vane Type	Fluid pressure and Vane rotation	0.1~10 m^3/min	-40~120°C	Intake air rate (idle mileage control, ignition timing control, etc)
	Karman Vortex	Karman Vortex's occurance frequency			
	Hot Wire Type	Quenching effect by fluid			
Gas	O2(zirconia)	Oxygen concentration battery	λ =1 detection 10-20<PO2<10-1	-40~900°C	Exhaust idle mileage (idle mileage control)
	O2(semiconductor type): TiO_2, $Nb2O_2$	Resistance variation by oxidation/ deoxidation			
	Wide band	Critical current feature, pump operation	1< λ <2		
	NOx (semiconductor type)	Resistance variation by absorption	10~1000 ppm	(-40~300°C)	NOx in emission (Emission control)
Torque	Magnetostriction type	Magnetic substance's Magnetostriction effect	$10 \sim 10_3$ N·m	-40~120°C	Engine Torque (drive line control)
	Optical type	Deformation detection by optical meter			
Knock	Piezo-electric type	Piezo-electric element's electronic distortion effect		-40~120°C	Knock detection (ignition timing control)
	Magnetostriction type	Magnetic substance's Magnetostriction effect			

2. Pressure Sensor

<Table 2> shows input variables used for engine control. Initially they were usually used for intake manifold pressure, engine oil pressure, etc.

<Table 2> Engine Controlling Input Variables

Variables	Pressure Measuring Range	Pressure Type
MAP	100 KPa	Absolute pressure
Turbo boost pressure	200 KPa	Absolute pressure
Atmospheric pressure(altitude)	100 KPa	Absolute pressure
EGR pressure	7.5 psi	Gauge pressure
Fuel pressure	2.5bar ~ 3.5bar	Gauge pressure
Fuel vapor pressure	15 inH_2O	Gauge pressure
Intake air rate		Pressure gap
Combustion pressure	100 Bar, 16.7 MPa	Pressure gap
Exhaust gas pressure	100 KPa	Gauge pressure
Second air pressure	100 KPa	Gauge pressure

That is, intake manifold pressure is used for indirectly calculating intake air rate for idle mileage control. Earlier ignition systems used vacuum pressure around throttle valve to measure ignition timing angle. However requirement for improved engine emission control, fuel mileage and output performance has measured various input variables used for engine control, and consequently various input sensors are developed and being used.

1) Intake Manifold Pressure Characteristic and MAP Sensor

Fig. 2 is outline of intake system simply. Intake manifold is the route through that air and air/fuel mixture are inhaled to cylinder. At that time engine works as a pump that draws air into intake manifold.

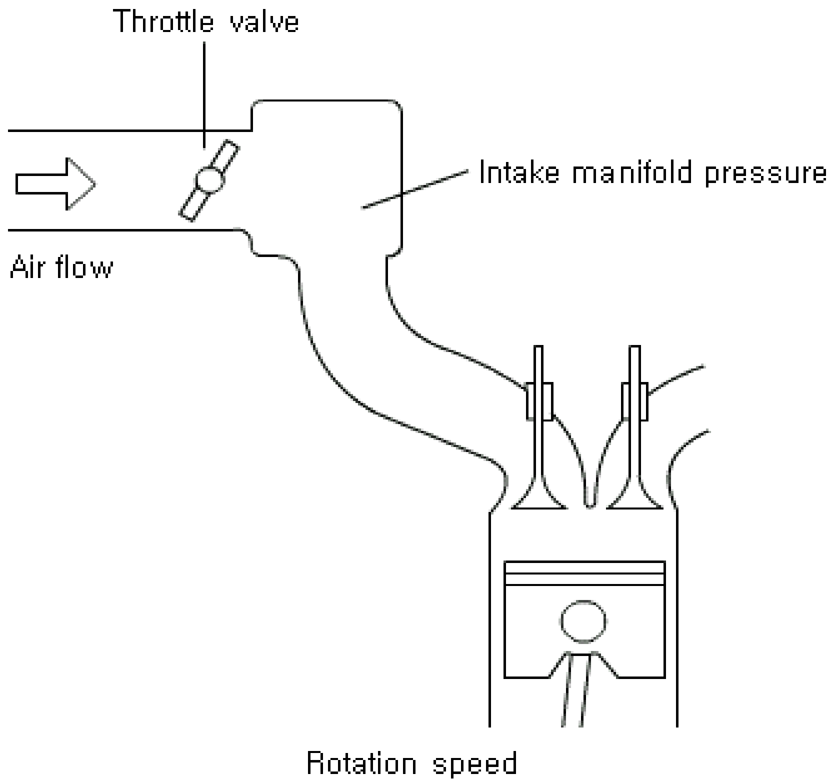

Fig. 2 Intake System Outline Diagram

When engine is not operating, air will not flow, and then intake manifold pressure will be same as atmospheric pressure. When engine operates, throttle valve located in intake manifold will partly interrupt air flow. Then pressure in intake manifold will decrease getting lower than atmospheric pressure to generate partly vacuum in intake manifold. If engine were a perfect air pump and throttle valve is close, then intake manifold pressure will be absolute zero pressure, say perfect vacuum. However an actual engine cannot be a perfect pump, and perfect vacuum is not available, intake manifold's absolute pressure is a little above zero. On the contrary when throttle valve is wide open, intake manifold pressure will be approx. atmospheric pressure. As described above, intake manifold's absolute pressure will vary from relatively low value to just a little lower value than atmospheric pressure during engine operation.

Let's observe pressure variation in intake manifold when throttle valve position is constant. Intake manifold pressure fluctuates rapidly by consecutive suction of air by cylinders. Each cylinder sucks air when intake valves open and piston drops from TDC, and the intake manifold pressure will decrease. Air intake of this cylinder will be ended upon closure of intake valve, and intake manifold pressure will continue to rise until next cylinder begins to take air in. This process will be repeated to fluctuate intake manifold pressure between each cylinder's cycle, and pumping will be done from one cylinder to another. Each cylinder's air intake action will occur once per two revolution of crank axis. When N cylinders rotate, intake manifold's pressure fluctuation frequency may be expressed in fig. 3:

$$f_p = \frac{N \times RPM}{120} ....(1)$$

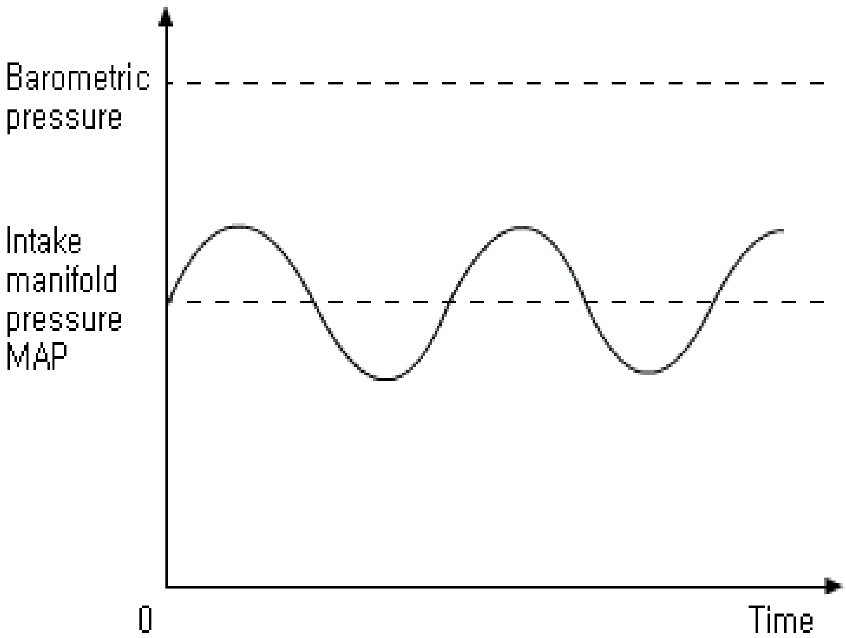

Fig. 3 Intake Manifold Pressure Variation(When throttle valve opening is constant)

Actual engine control system requires average pressure in intake manifold, and torque generated at constant engine rpm will be approximately proportional to average value of intake manifold pressure. To say instantly changing pressure in intake manifold is not used for engine control, and then average value after filtering fluctuation components will be used. Engine control system has MAP sensor that measures absolute pressure in intake manifold.