4.0 The valve and valve seat

Functions

Valves control the gas flowing into and out of the engine cylinder. The camshaft and valve spring make up the mechanism that lifts and closes the valves. The valve train determines the performance characteristics of four stroke- cycle engines.

There are two types of valve, inlet and exhaust. Figure 4.1 shows an exhaust valve. An inlet valve has a similar form. The commonly used **poppet valve** is mushroom-shaped. Figure 4.2 illustrates the parts of the valve.

Figure 4.1: Exhaust valve. The inlet valve has a similar shape, but the crown size is normally larger than that of the exhaust valve.

A **cotter** which fixes the **valve spring retainer** to the **valve**, is inserted into the **cotter groove**.

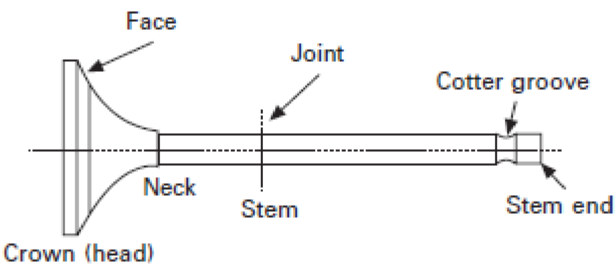

Figure 4.2: Nomenclatures of the valve. The shape from the crown to the neck is designed to give a smooth gas flow.

Figure 4.3 shows the position and relative motion of each part of the valve mechanism. The motion of the cam lobe drives the valve through the valve lifter. The valve spring pulls the valve back to its original position. During the compression stroke, the valve spring and combustion pressure help to ensure an air-tight seal between the valve and the valve seat.

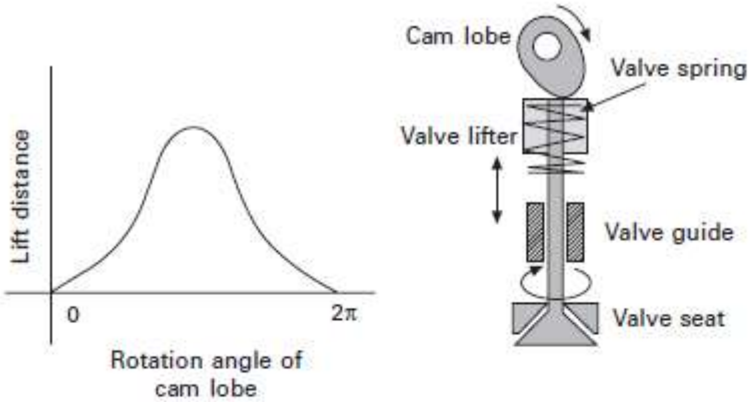

Figure 4.3: Rough sketch of a valve train showing valve lift distance in the valve timing diagram. The lift distance (vertical arrow) given by the cam lobe is the displacement along the axial direction of the valve.

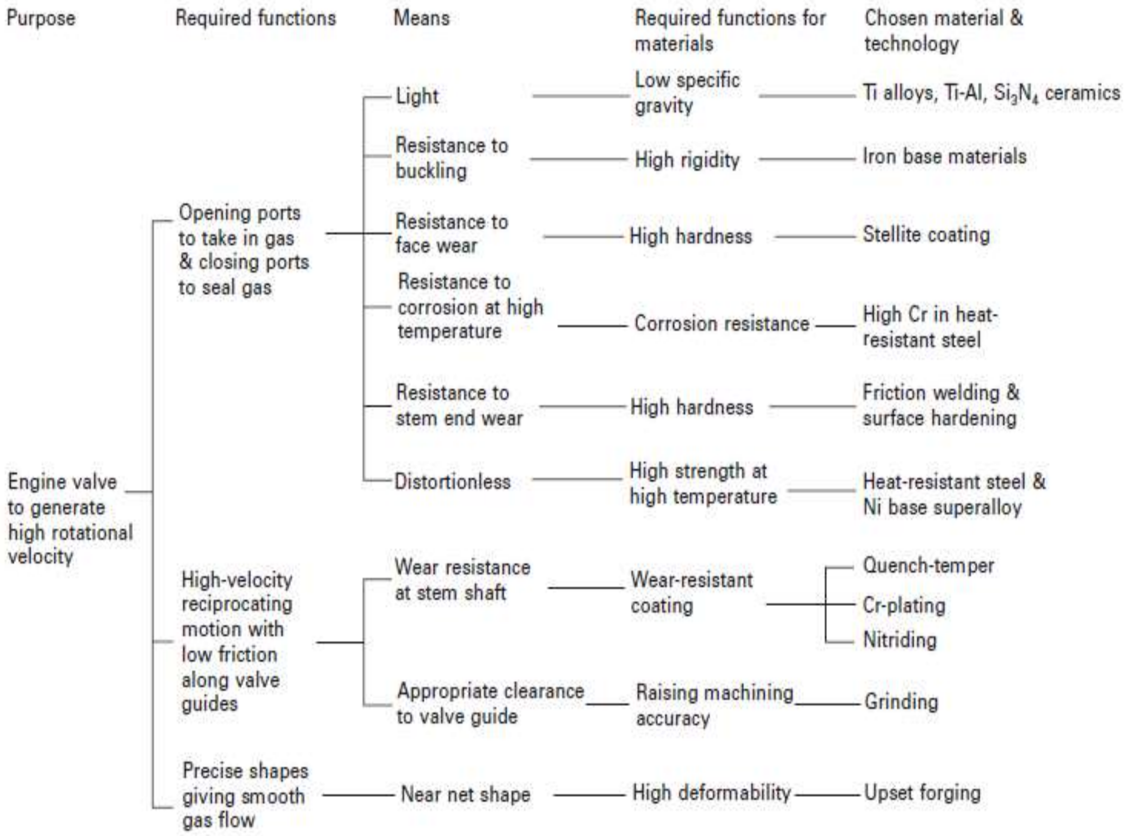

Figure 4.4: Functions of valves

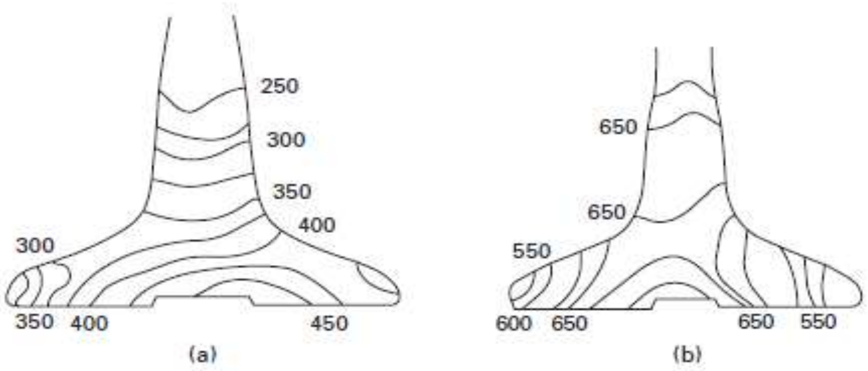

Figure 4.5: Temperature distribution (°C) of valves during operation. An air-cooled 200 cm^3 engine. (a) Inlet valve (30 ϕmm). (b) Exhaust valve (26 ϕmm).

One revolution of the camshaft gives the amount of valve lift shown in Figure 4.3. The valve stem moves in the valve guide and also revolves slowly around the stem. The revolving torque is generated by the expansion and contraction of the valve spring.

An engine basically needs one inlet valve and one exhaust valve per cylinder but most modern engines use four valves per cylinder. This multivalve configuration raises power output, because the increased inlet area gives a higher volume of gas flow. Contemporary five-valve engines use three inlet valves and two exhaust valves to increase trapping efficiency at medium revolutions. Figure 4.4 summarizes the functions of the valve. The shape of the neck, from the crown to the valve stem, ensures that the gas runs smoothly. The valve typically receives an acceleration of 2000 m/s^2 under high temperatures. Valves must be of light weight to allow the rapid reciprocating motion.

In modern vehicles, various valve crown shapes are used. High-performance engines generally use recessed (vertical section is shown in Figure 4.5) or tulip crown shapes. The shape of the valve crown controls the flexibility of the valve face. Some high-speed engines need a flexible valve so that the valve does not bounce off its seat when closing. The recessed or tulip valve is elastically flexible as well as light. Figure 4.5 illustrates typical temperature distributions of an exhaust valve and an inlet valve. The combustion gas heats the inlet valve to around 400 °C, while the exhaust valve is heated to between 650 °C and 850 °C. The temperatures depend on engine types, with high-performance engines generating a great deal of heat. The exhaust valve always gets hotter than the inlet valve, because the cold inlet gas cools the inlet valve.

Summary

The exhaust valve, exhaust pipe, exhaust gas turbine in a turbo-charger, honeycomb catalyst holder and brake disks are exposed to high operating temperatures of around 900 °C. The exhaust valve, exhaust gas turbine and honeycomb always operate under red-hot conditions. For these parts, iron based heat-resistant alloys, nickel-based super-alloys and ceramics are functionally competitive.

The exhaust valve seat, brake pad and friction plate (for a dry clutch), do not receive lubricating oil during operation, so these operate in the tribology area, where composite materials are most suitable.