Intake and Exhaust Tuning

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BASED UPON S.C. SORENSEN
CHAPTER 7 SECTIONS 6 AND 7

Effect of Air Charge

- The single most factor effecting engine power is air charge. The effect of air charge on engine torque and power can be seen through a variety of casual-effects.

- Intake and exhaust tuning can have a significant effect on engine power. The application of intake and exhaust tuning are inevitably determined with both computational and experimental techniques. However it is important to understand the fundamental principles behind these iterative solutions to a relatively complex problem.

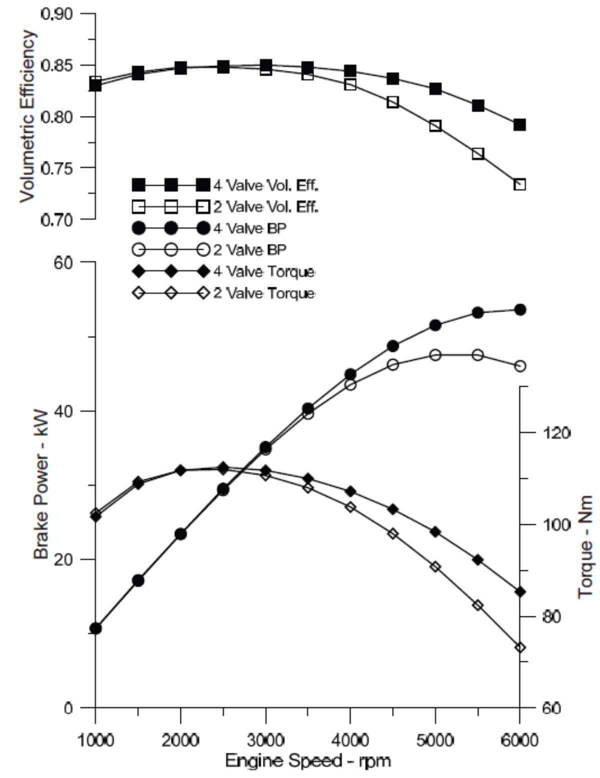


Figure 7.19: Simulated effect of increasing from 2 valves to 4 valves on the performance of the engine in 7.1.

Basic Concepts

- a sound wave is a pressure wave
- speed of sound – a pressure wave caused by a disturbance in the flow field travels at the speed of sound
- pressure waves are superimposed on the flow

pulsating flow

Timing the rarefaction portion of the pressure wave to meet the timing of the source of pulsations (the engine) can have a beneficial or detrimental effect.

pressure wave caused by the end of the tube (a disturbance)

$$a = \sqrt{\frac{\gamma R_o T}{M}}$$

$$u = \pm \frac{2a_o}{\gamma - 1} \left[\left(\frac{\rho}{\rho_o} \right)^{\frac{\gamma-1}{2}} - 1 \right] = \pm \frac{2a_o}{\gamma - 1} \left[\left(\frac{p}{p_o} \right)^{\frac{\gamma-1}{2\gamma}} - 1 \right] = \pm \frac{2}{\gamma - 1} (a - a_o)$$

$$u_p = a \pm u = a_o \pm \frac{\gamma + 1}{2} u = a_o \left(1 \pm \frac{\gamma + 1}{\gamma - 1} \left[\left(\frac{\rho}{\rho_o} \right)^{\frac{\gamma-1}{2}} - 1 \right] \right) \tag{7.50}$$

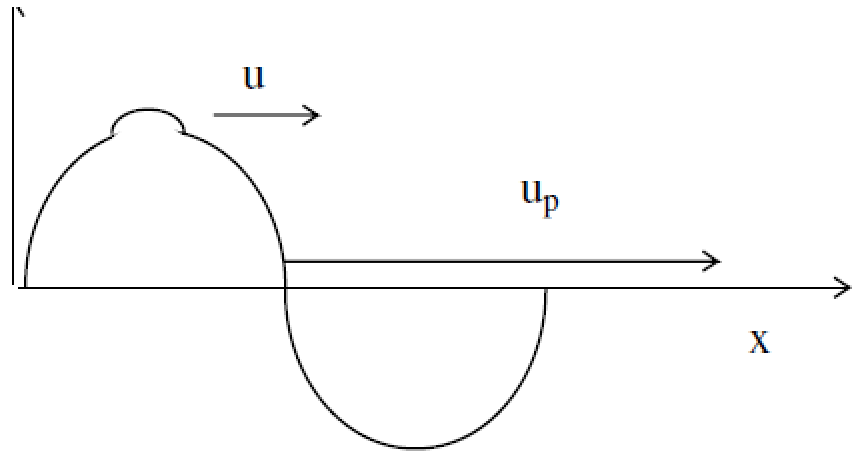
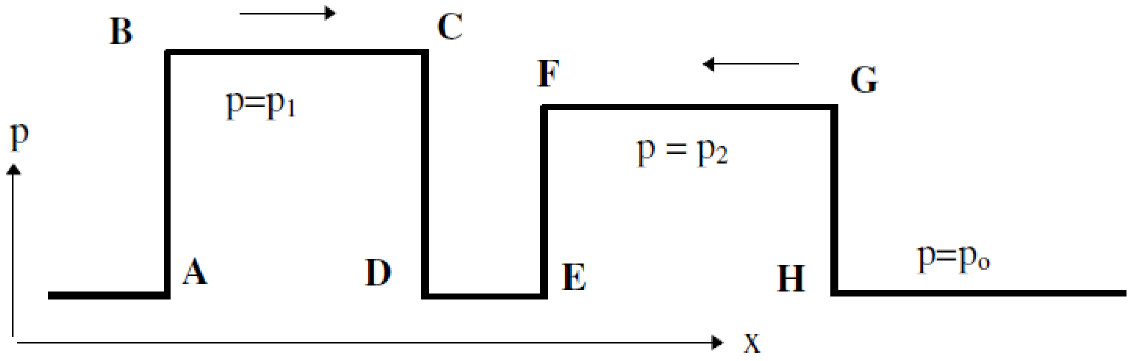
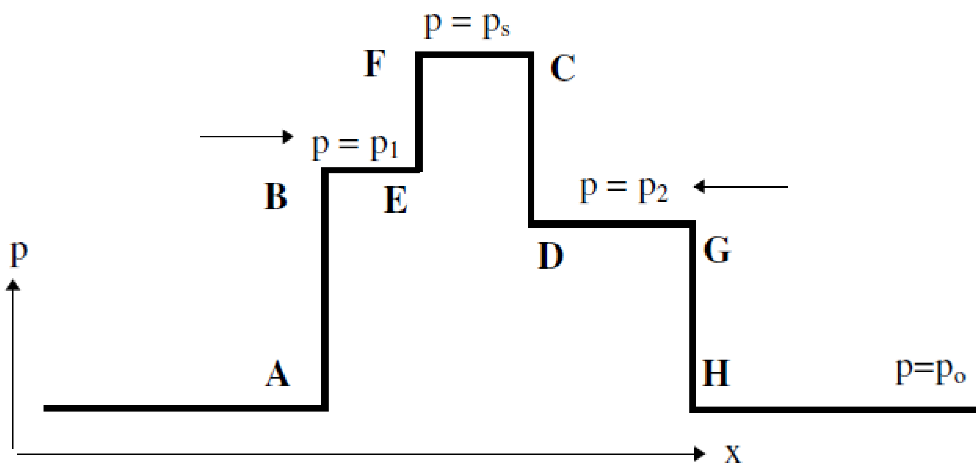


Figure 7.21: Simple representation of a disturbance superimposed on a propagating wave.



A. Two compression wave moving in opposite directions, about to meet.



B. The compression waves passing each other.

Figure 7.24: The intersection (superposition) of two compression waves. A. Before intersection. B. During the superposition.

Wave Reflections

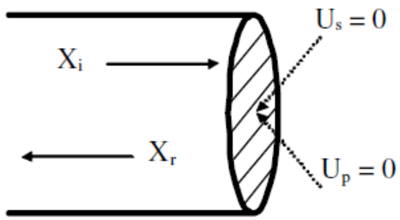


Figure 7.25: A pressure wave approaching a closed end of a pipe.

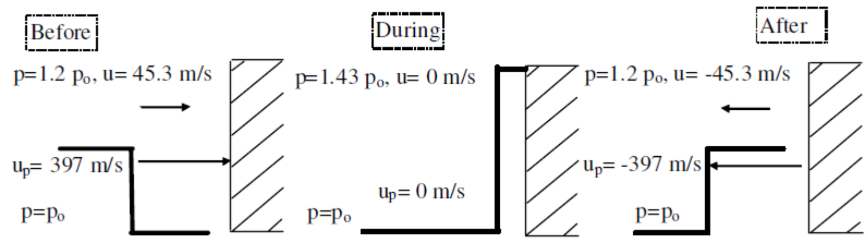


Figure 7.26: Reflection of a compression wave at a closed end of a pipe.

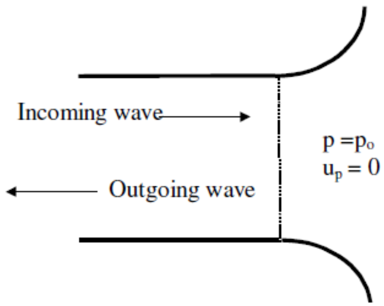


Figure 7.27: Incident and reflected waves at the open end of a pipe.

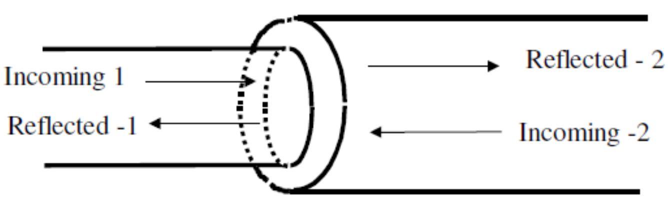


Figure 7.28: Sudden change in the cross section area of the pipe.

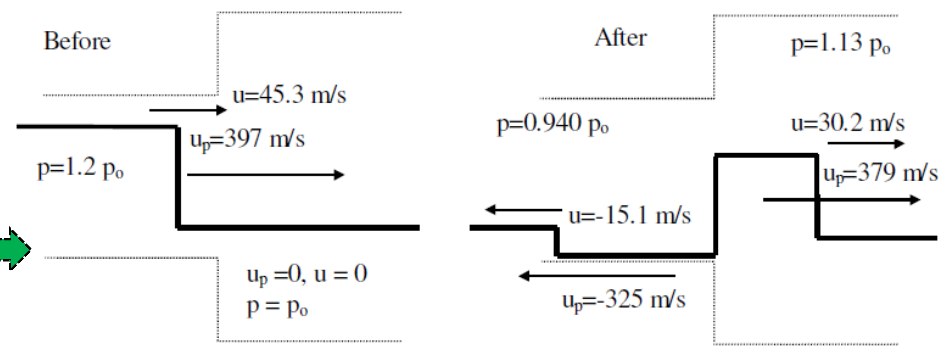


Figure 7.29: Compression wave encountering a sudden expansion.

Pulse Timing

$$2L = \Delta t \cdot u_g \tag{7.55}$$

$$L = \frac{\Delta t \cdot u_g}{2} = \frac{\Delta\theta \cdot u_g}{2 \cdot 6 \cdot N} \tag{7.56}$$

$$\approx \frac{180 \cdot 340}{2 \cdot 6 \cdot 6000} = 850mm \tag{7.57}$$

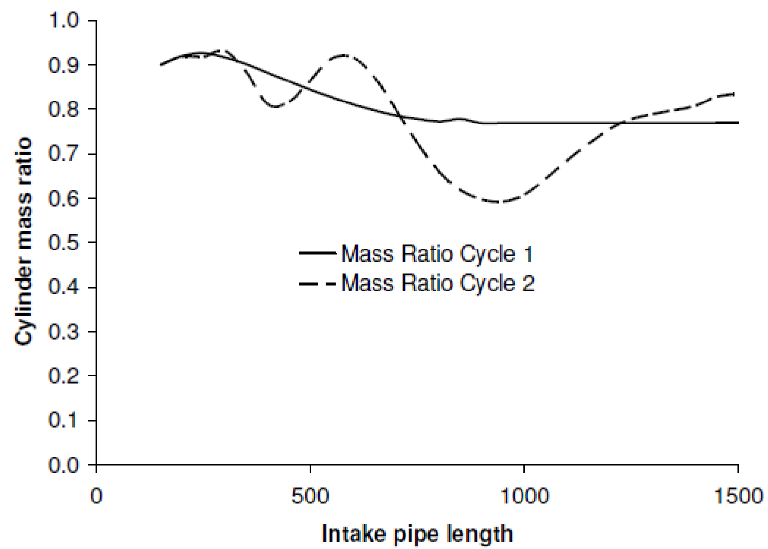


Figure 7.33: The effect of intake pipe length on the simulated example for an equivalent two stroke engine speed of 6000 rpm.

Intake Manifold: Predictions and Experiment

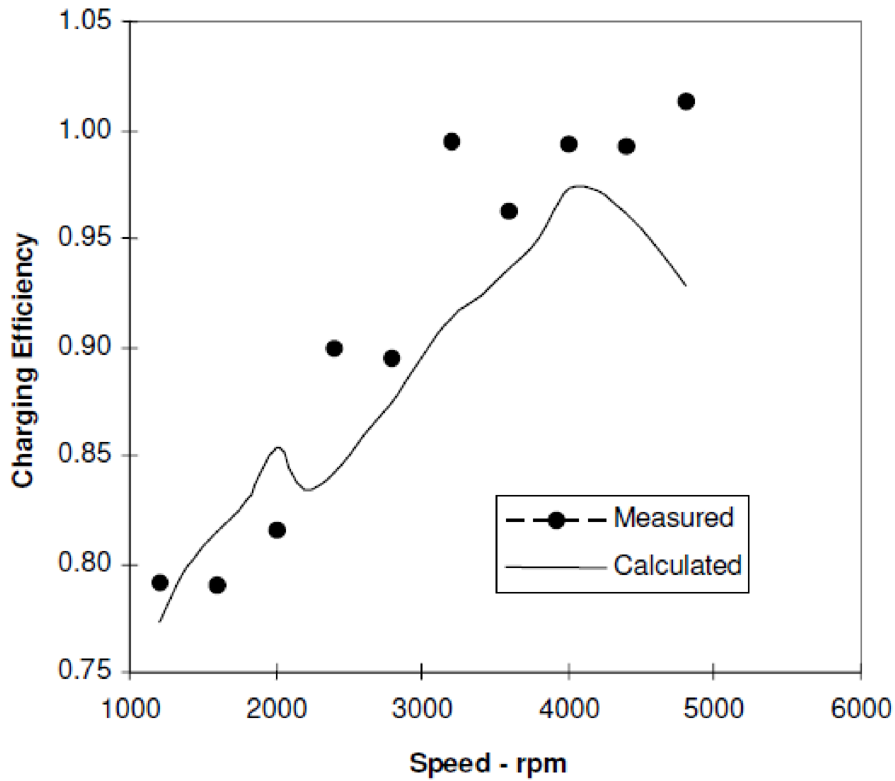


Figure 7.34: A comparison between experimental filling efficiencies and those calculated by an intake manifold simulation program for the GM Quad 4 engine.

Intake Manifold Length

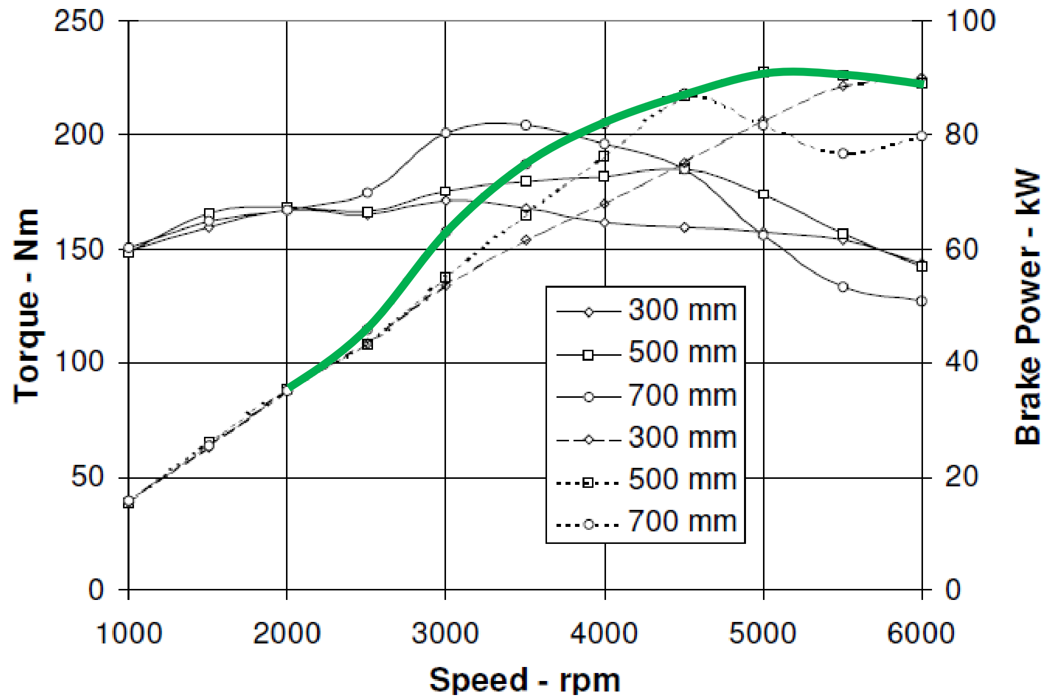


Figure 7.35: The effect of intake manifold length on engine torque and power at WOT. (Torque - solid lines, Power - dotted).

Effect of Engine Speed

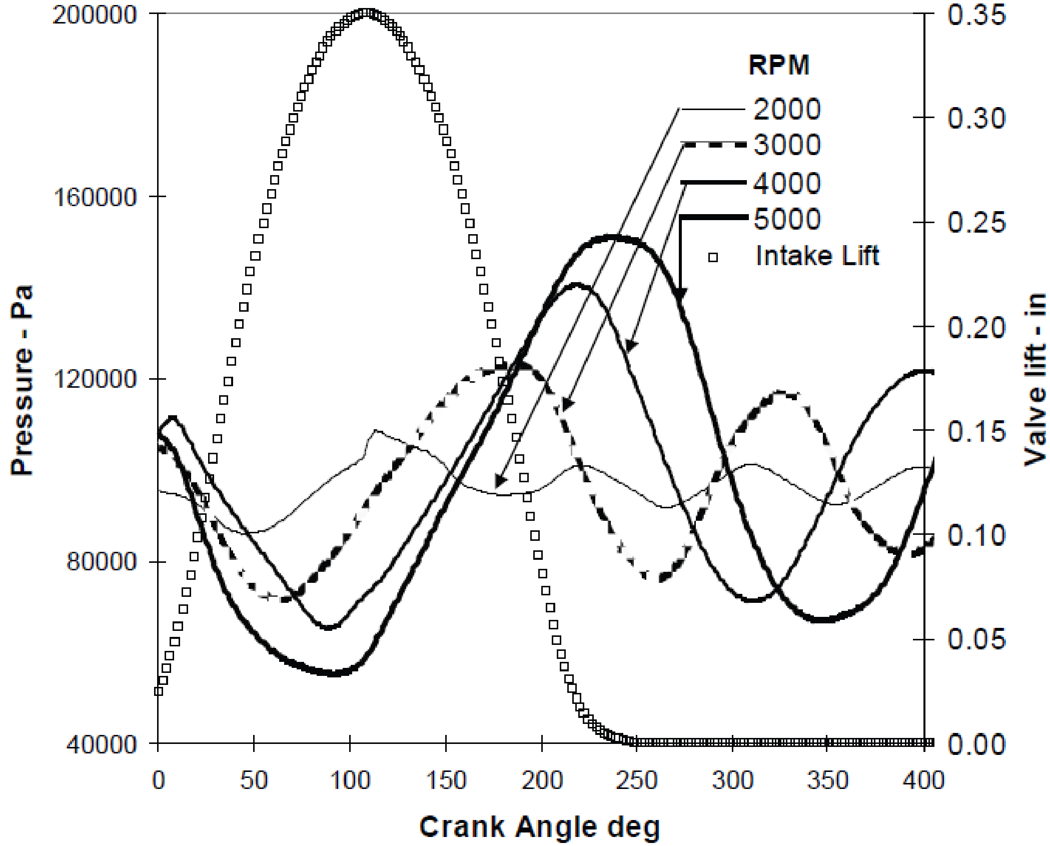


Figure 7.36: Pressure time histories as a function of engine speed near the intake valve for the 700 mm intake runner.

Practical Systems: Opel

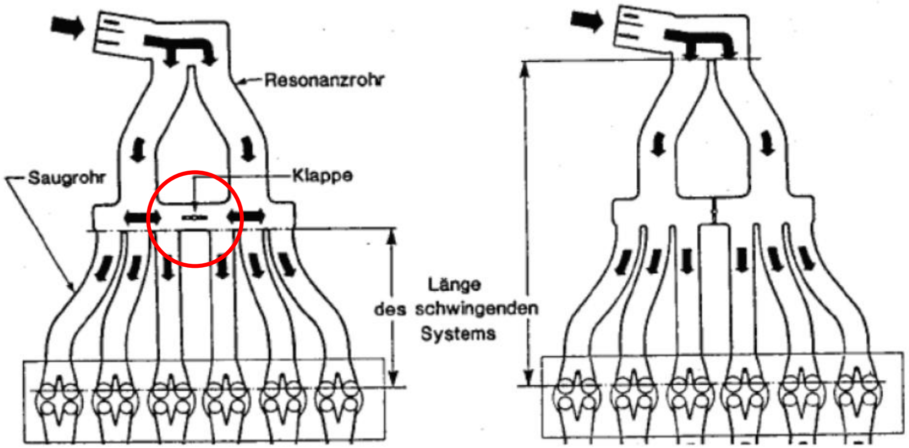


Figure 7.42: Principle of the dual length system on a 6-cylinder inline Opel engine. Figure from MTZ.

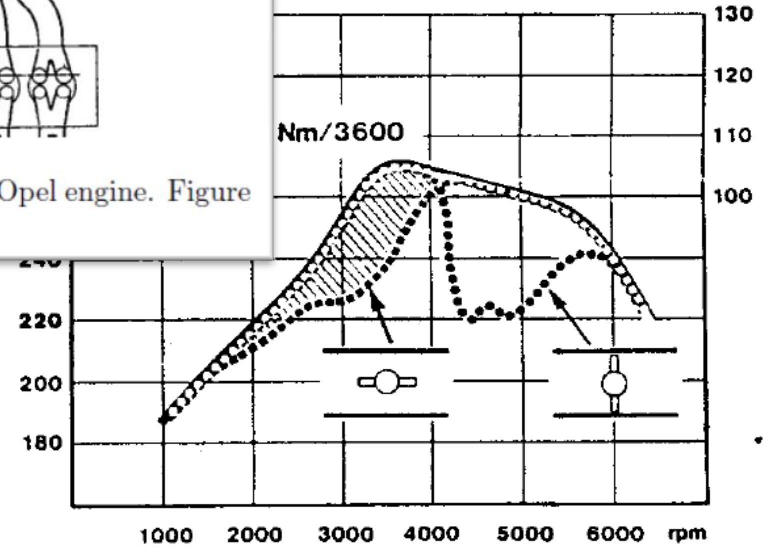


Figure 7.43: Torque curve for the Opel 6 cylinder inline engine with the chamber valve in the open and closed position.

Practical Systems: Audi V6

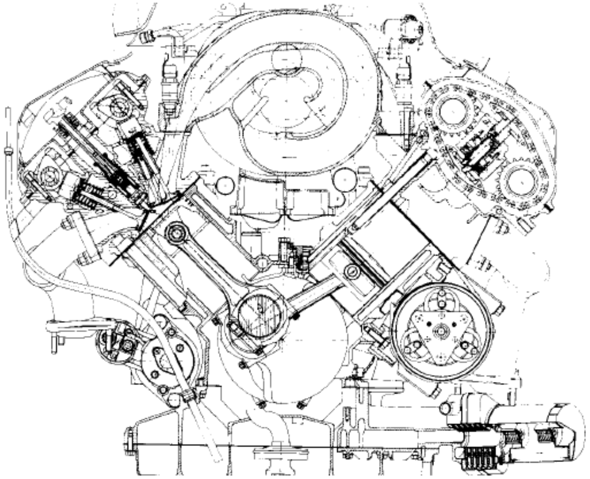


Figure 7.44: Cross section of the engine and intake manifold system used on the Audi V6 engine (from MTZ).

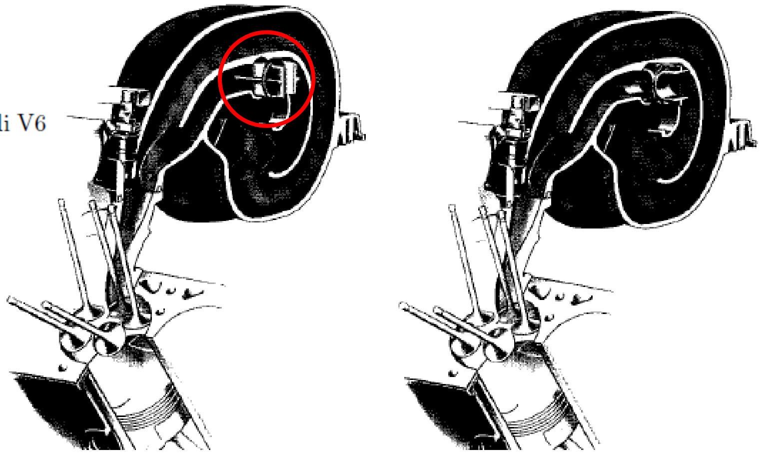


Figure 7.45: Operational view of the Audi V6 intake manifold (From MTZ).

Monday's Quiz Chapter 5

Monday's Quiz Chapter 6

Monday's Quiz Chapter 7