



**SET A**

**UNIVERSITI KUALA LUMPUR**  
**Malaysia France Institute**

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# **ANSWER SCHEME**

## **JANUARY 2014 SESSION**

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|----------------------|-----------------------------------------|
| <b>SUBJECT CODE</b>  | <b>: FVB40403</b>                       |
| <b>SUBJECT TITLE</b> | <b>: ENGINE PERFORMANCE ENHANCEMENT</b> |
| <b>LEVEL</b>         | <b>: BACHELOR</b>                       |
| <b>DURATION</b>      | <b>: 2.5 Hours</b>                      |
| <b>EXAMINER</b>      | <b>: JUFRIADI</b>                       |

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**Answer 1. (25 marks)****(a) (8 marks)**

There are many air enhancement devices available, which are intended to increase the volumetric efficiency of the engine. One of the devices is reported to use crossed pin at a location before the throttle body of the engine to produce a swirl effect inside the manifold and consequently induce more air-fuel mixture in the cylinders.

Another device, which uses a conical-shaped element, alters the pressure and velocity of the gas flow in order to improve fuel efficiency.

There is also a device that employs an air induction element with a honeycomb treatment structure to provide a uniform directional air flow pattern for reduction of turbulence and improvement of air velocity delivery to the carburetor.

Another device system, which is integrated with the engine air management system, consists of an electronically controlled inlet air compressor.

**(b) (9 MARKS)**

This illustration shows the difference between a poor performing port and an excellent design after porting modification. The difference between the two shows the general idea of improving port flow. Higher and straighter is better for peak power. The modification shown is commonly referred to "increasing the downdraft angle".

Larger ports flow will supply more fuel/air at higher RPM's but sacrifice torque at lower RPM's due to lower fuel/air velocity.

**(c) (8 marks)**

The requirement for the selection of a good induction manifold.

- To provide as direct a flow as possible to each cylinder
- To provide equal quantities of charge to each cylinder
- To provide a uniformly distributed charge of equal mixture strength to each cylinder
- To provide equal aspiration intervals between branch pipes
- To provide the smallest possible induction tract diameter that will maintain adequate air velocity at low speed without impeding volumetric efficiency in the upper speed range
- To create as little internal surface frictional resistance in each branch pipe as possible
- To provide sufficient pre heating to the induction manifold for cold starting and warm up periods

- To provide a means for drainage of the heavier liquid fraction of fuel
- To provide a means to prevent charge flow interference between cylinders as far as possible
- To provide a measure of ram pressure charging

**Answer 2. (25 marks)**

**(a) (10 marks)**

Tumble flaps are individual plates located within the intake manifold runners that can either stay in a flat position to allow maximum airflow or move up to redirect the airflow into the combustion chamber. At different engine rpm, the tumble flaps are activated to enhance the air/fuel mixture.

The tumble flaps are actuated:

- To improve cold engine idling
- To improve charge efficiency at start-up
- In overrun mode

At other engine speeds, the tumble flaps are open to eliminate flow resistance and reduction in engine performance.

**(b) (15 MARKS)**

**(i) (7 marks)**

$$\begin{aligned} \text{since } V &= \frac{nQN\eta_v}{2 \times 60A} \text{ then } N = \frac{180AV}{nQ\eta_v} \\ \text{hence } N &= \frac{180\pi/4(0.03)^2 \times 10}{4 \times \pi/4(0.08)^2 \times 0.082 \times 0.85} \\ &= \frac{180 \times 0.03 \times 0.03 \times 10}{4 \times 0.08 \times 0.08 \times 0.082 \times 0.85} \\ &= 907.9 \text{ rev/min.} \end{aligned}$$

**(ii) (8 marks)**

$$\begin{aligned}
 N &= \frac{180AV}{nQ\eta_v} \\
 &= \frac{180 \times \pi/4(0.03)^2 \times 75}{4 \times \pi/4(0.08)^2 \times 0.082 \times 0.85} \\
 &= \frac{180 \times 0.03 \times 0.03 \times 75}{4 \times 0.08 \times 0.08 \times 0.082 \times 0.85} \\
 &= 6809 \text{ rev/min.}
 \end{aligned}$$

**Answer 3. (25 marks)****(a) (10 marks)**

The size of the exhaust valve is smaller when compared to the size of inlet valve. It is done so because the region closer to the exhaust valve is at a higher temperature compared to that of the temperature surrounding the inlet valve. Now if the exhaust valve size is increased there will be higher possibility of knocking because the charge coming inside the combustion chamber has a higher probability of combusting at exhaust valve's surface (due to large surface area). On the other hand if the size is too small then, there will be greater possibility of dilution in the intake charge because there is no enough space for the burnt gas to leave the chamber.

**(b) (15 MARKS)****(i) (7 marks)**

$$V_p = \frac{SN}{30000} = \frac{85 \times 6000}{30000} = 17 \text{ (m/s)}$$

**(ii) (8 marks)**

$$\begin{aligned}
 V_g &= \frac{SN}{30000} \left( \frac{D}{d} \right)^2 = 17 \left( \frac{80}{25} \right)^2 \\
 &= 17 \times 10.24 = 174 \text{ (m/s)}
 \end{aligned}$$

**Answer 4. (25 marks)**

**(a) (8 marks)**

The development of fuel injection resulted in a change in manifold design. Engineers discovered that pulsating flow can be used to force additional air into the engine making it more efficient. The level of influence is mainly determined by pipe diameter and length.

Long pipes with small diameters were used to optimize efficiency at lower engine speeds while bigger diameter manifolds with shorter pipes were used for higher engine speeds.

**(b) (8 marks)**

On many of the older cars a single pipe was used to supply more than one cylinder with air. Later, engineers developed manifolds with a common plenum and equal pipe lengths to utilize pulsating flow to improve volumetric efficiency. Variable intake manifolds were developed to improve engine efficiency over a wider rpm range. This is done by changing the length of the pipe via a butterfly in the manifold. At low engine speeds the air had to travel through an elongated pipe to improve low end torque. At higher engine speeds the butterfly in the manifold opened to shorten the intake path which increased volumetric efficiency at high engine speeds.

**(c) (9 marks)**

The intercooler effectiveness:

$$\varepsilon = \frac{T_2 - T_3}{T_2 - T_1} = \frac{120 - 90}{120 - 80} = \frac{30}{40} = 0.75$$

**Answer 5.****(a) (15 marks)****Figure 3 (a)****Operation of Single Turbocharging**

Since the actuators for the intake air control valve and exhaust gas control valve are inactive during low engine rpm operation, these valves remain closed.

The waste gate valve is also closed, and only the No. 1 turbocharger will provide the boost pressure. When the intake air turbocharging pressure downstream from the No. 1 turbocharger reaches a predetermined level, the exhaust bypass valve executes a boost pressure control. At the same time, the exhaust bypass valve opens to supply the exhaust gas to the turbine side of the No. 2 turbocharger, causing the No. 2 turbocharger turbine wheel to start rotating.

Accordingly, when the No. 2 turbocharger starts boosting, this process can smooth out the

joining of the boost pressures.

**Figure 3 (b)****Single Turbocharging and Twin Turbocharging Operations**

When the engine operation passes from the low-rpm to the high-rpm region, at first the exhaust gas control valve opens, and this is followed by the opening of the intake air control valve. When the exhaust gas control valve opens, it causes the No. 2 turbocharger turbine wheel, which had already begun its rotation, to quickly raise its rpm. Thus, the pressure of the intake air flowing through the No. 2 turbocharger becomes higher than that of the intake air of the No. 1 turbocharger.

Since this high pressure intake air pushes open the reed valve described below, and flows to the No. 1 turbocharger side, further rise in pressure is averted.

Then, when the intake air control valve opens, the highly pressurized intake air smoothly joins the intake air coming from the No. 1 turbocharger (see illustration below).

Conversely, when the engine operation passes from the high-rpm to low-rpm region, in order to stop the No. 2 turbocharger, the valves close in an order opposite to the one described above. The intake air control valve closes first, followed by the closing of the exhaust gas control valve.

**(b) (5 marks)**

The exhaust manifold is split. A divider in the manifold ensures a steady flow of exhaust gases to the turbine. The ports of cylinders 1 and 4 and cylinders 2 and 3 are separated based on the firing order. The divider also prevents the exhaust gas pressure from expanding into the other cylinders.

**(c) (5 marks)****Boost Pressure Overrun**

If the throttle valve closes when the engine is in overrun, back pressure develops in the turbo housing. Back pressure reduces the speed of the turbine, which reduces boost pressure and increases turbo lag when the engine accelerates again.

At other engine speeds, the tumble flaps are open to eliminate flow resistance and reduction in engine performance.

To avoid this, the Turbocharger Recirculating Valve is opened by an electrical actuator. This allows the compressed air to flow back to the intake side of the circuit through the turbine. This maintains turbine speed. The Turbocharger Recirculating Valve closes when the throttle valve opens again and boost pressure is immediately available.

**Answer 6. (25 marks)****(a) (20 marks)**

| Problem                                         | Possible causes                                                                                                                                                                                                                                               | Solutions                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (a) <b>Leaking or burning oil</b>               | <ul style="list-style-type: none"> <li>- Plugged oil drain line</li> <li>- Worn bearings or bushings</li> <li>- Bad seals</li> <li>- Oil feed line or drain line (external leaks)</li> </ul>                                                                  | <ul style="list-style-type: none"> <li>- Clear oil drain line</li> <li>- Replace worn parts</li> <li>- Replace seals</li> <li>- Replace gaskets or lines as necessary</li> </ul>                                                                                                                     |
| (b) <b>No or low boost pressure</b>             | <ul style="list-style-type: none"> <li>- Waste gate stuck</li> <li>- Unit damaged</li> <li>- Intake system not sealed</li> </ul>                                                                                                                              | <ul style="list-style-type: none"> <li>- Check for free operation of waste gate - replace bad parts</li> <li>- Replace damaged parts or replace unit</li> <li>- Check all clamps and ducting from the turbo to the engine</li> </ul>                                                                 |
| (c) <b>Too much boost pressure (over boost)</b> | <ul style="list-style-type: none"> <li>- Waste gate not opening</li> <li>- Waste gate control valve damaged</li> <li>- Waste gate control diaphragm damaged</li> <li>- Waste gate too small for application (boost creeping higher as rpm goes up)</li> </ul> | <ul style="list-style-type: none"> <li>- Check for free operation of waste gate - replace bad parts</li> <li>- Make sure control valve is operational</li> <li>- Replace diaphragm unit</li> <li>- Replace the waste gate assembly, or the whole unit with one more suited for the engine</li> </ul> |
| (d) <b>Excessive noise under boost</b>          | <ul style="list-style-type: none"> <li>- Worn bearings or bushings</li> <li>- Damaged unit</li> <li>- Intake system not sealed (air noise)</li> </ul>                                                                                                         | <ul style="list-style-type: none"> <li>- Replace worn parts</li> <li>- Replace damaged parts or replace unit</li> <li>- Check all clamps and ducting from the turbo to the engine</li> </ul>                                                                                                         |
| (e) <b>Excessive turbo lag</b>                  | <ul style="list-style-type: none"> <li>- Worn bearing or bushings</li> <li>- Damaged unit</li> <li>- Unit too large for application</li> <li>- Exhaust restriction</li> <li>- Intake system not sealed</li> </ul>                                             | <ul style="list-style-type: none"> <li>- Replace worn parts</li> <li>- Replace damaged parts or replace unit</li> <li>- Replace unit with one more suited for the application</li> <li>- Replace bad exhaust parts</li> <li>- Check all clamps and ducting from the turbo to the engine</li> </ul>   |

**(b) (5 marks)****(i) (2 marks)**

The graph does not start at zero because the engine needs to run at a minimum idle speed in order to keep running.

**(ii) (3 marks)**

The main reason why the power does not increase in direct proportion to the engine speed is because the amount of air that can be drawn into the cylinder is limited by factors such as valve lift and port design. The amount of air actually drawn into the cylinders compared with the amount that could theoretically be drawn into them is known as the volumetric efficiency. Above a certain speed, volumetric efficiency drops and this, coupled with frictional and pumping losses, affects the amount of power produced.

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**END OF ANSWER SCHEME**

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