Engine mechanical, lubrication and cooling systems are essential to the operation of every motorcycle. This chapter will help you develop an understanding of the construction and operation of these systems. It will also cover procedures you can use when removing, replacing and testing engine mechanical systems for correct function and operation. This chapter provides you with knowledge that will help you with both theory and practical assessments. It will help you plan a safe and systematic approach to engine mechanical, lubrication and cooling systems inspection and maintenance.

This chapter covers:

- Engine mechanical system operation
- Engine lubrication system operation
- Engine cooling systems operation
- How to check, replace and test motorcycle engine mechanical, lubrication and cooling system units and components
Replacing the engine oil and filter

A customer has left their motorcycle at your workshop for an intermediate service. You have been asked to change the engine oil and filter.

- Are there any health and safety risks involved with this activity?
- Make a list of personal protective equipment (PPE), vehicle protective equipment (VPE), tools and equipment that you might need.

Now turn to page 369–70 in this book and check your answers against the checklist and any safety information given for this task. Following the technical skills steps and observing all necessary health and safety precautions, practise changing the engine oil and filter on a motorcycle in your workshop.

Remember: as with any skill that you wish to develop, the more you practise, the better you will become.

Engine mechanical system operation

The engine is the motorcycle’s power plant. It provides energy for movement and to generate electricity.

A motorcycle engine uses petrol as a fuel, which it combines with air. This mixture is then burnt in a cylinder containing a piston. The heat energy given off by the burning mixture is used to drive pistons and operate the engine. As the combustion takes place directly in the cylinder containing the piston, it is known as an internal combustion engine.

Engines

Depending on the motorcycle type and how it will be used, manufacturers use different engine layouts and configurations within their bike design, as shown in Table 4.1.

Table 4.1 Engine types and configurations

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Configuration and features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline</td>
<td>The pistons are arranged in a line next to each other. This is the most common design. It takes up a great deal of space because of the length of the cylinder block needed to hold the pistons.</td>
</tr>
<tr>
<td>Flat</td>
<td>Sometimes known as a ‘boxer’ or ‘horizontally opposed’ engine. The pistons are laid out flat on each side of the crankshaft, so if you have a two-cylinder horizontally opposed engine, there will be one piston on each side of the crankshaft. Provides a low centre of gravity, and the crankshaft can be kept relatively short because there is only one piston each side, making the engine compact.</td>
</tr>
<tr>
<td>Vee</td>
<td>The cylinders are laid out in the shape of the letter V. In a similar way to the flat engine, the crankshaft can be made shorter and more compact. This design can allow for a long stroke, which is able to create a large amount of torque. It is a popular design for use in cruiser motorcycles.</td>
</tr>
</tbody>
</table>

In order to contribute to the productivity of your workshop, you need to develop practical skills that are beneficial to the company or organisation. With practice, you will become competent at these skills and increase your capabilities. The following exercise will help start your hands-on training and improve your abilities.

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Safe Working

- Always protect your skin from contact with waste engine oil. Waste engine oil can cause dermatitis or even cancer.
- Always clean up any oil spills immediately to reduce the possibility of accidents caused by slips, trips and falls.

Safe Environment

During the maintenance of motorcycles, you may be required to dispose of waste engine oil and filters. Under the Environmental Protection Act 1990 (EPA), you must dispose of all waste in the correct manner. You should store all waste safely in a clearly marked container until it is collected by a licensed recycling company. This company should give you a waste transfer note as the receipt of collection.
The advantages of liquid-cooled systems are:

✓ They provide more even cooling of engine components.
✓ They run much more quietly than air-cooled engines.

Some disadvantages of liquid-cooled systems are:

✗ Water boils at 100°C, and when it boils it changes to steam.
Once the water has changed to steam, it no longer acts as an efficient coolant.
✗ The cooling system will be complicated, with extra components such as radiators, water pumps and thermostats. Because of this, there is more to maintain and more to go wrong.

Radiator and radiator cap

The liquid coolant absorbs heat from the engine mechanical components. This heat energy is transferred into the surrounding air using a radiator.

A radiator is a series of metal tubes, surrounded by cooling fins (thin pieces of corrugated metal designed to increase the surface area). The radiator is mounted away from the engine, in a position that allows airflow to pass over it and dissipate heat to the surrounding air.

The pipework in the centre of the radiator zigzags backwards and forwards. This means that the coolant passing through it is in contact with the air for the longest time possible, which makes it efficient at getting rid of the heat.

- If the pipework is mounted top to bottom (up and down), the radiator core is known as upright.
- If the pipework is mounted side to side, the radiator core is known as crossflow.

Pressurising the cooling system

Antifreeze raises the boiling point of the water slightly, yet under normal circumstances, this would not be enough to stop the coolant boiling at some stage within the engine system. A method to raise the boiling point still further is to pressurise the cooling system.

Pressure has a direct effect on the boiling point of water:

- If the pressure is lowered, the boiling point is lowered.
- If the pressure is increased, the boiling point is raised.

To raise the boiling point of the cooling system, it can be pressurised by sealing it with a radiator cap, also called a pressure cap. As the coolant warms up, it tries to expand, but it has nowhere to go (because the radiator cap is sealing the system), so pressure increases. This pressure increase raises the boiling point of the liquid coolant in the system.

To make sure that the pressure does not continue increasing past safe limits, the radiator cap contains a spring-loaded valve. When a preset pressure is reached, the valve releases, allowing some coolant to escape into an overflow expansion tank.

As the system cools down, pressure falls. As some of the coolant has been allowed to escape past the radiator cap, this pressure fall would create a vacuum, making the cooling system hoses collapse. To overcome this, the radiator cap is fitted with another valve that works in the opposite direction. As cooling system pressure falls, this valve opens, allowing the expelled coolant to be drawn back into the system from the overflow expansion tank, keeping it topped up.

Thermostat

An engine runs most efficiently when its overall temperature is around 100°C (the boiling point of water). This means that when an engine starts from cold, it results in high levels of fuel consumption, emissions and wear.

To help with the rapid warm-up of the engine, a thermostat is fitted in the system (see Figure 4.34).

A thermostat is a temperature-sensitive valve. It is positioned in the system so that when it is closed, it will stop the flow of coolant into the radiator. This restricts the circulation of water until the engine has reached a certain temperature.
Testing the strength of coolant or antifreeze

To make sure that the system has the correct strength of coolant or antifreeze mixture, you can use a hydrometer to check the specific gravity.

Using a hydrometer to test the strength of coolant/antifreeze

**Checklist**

<table>
<thead>
<tr>
<th>PPE &amp; VPE</th>
<th>Tools and equipment</th>
<th>Source information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Steel toe-capped boots</td>
<td>• Cooling system hydrometer</td>
<td>• Cooling system technical data</td>
</tr>
<tr>
<td>• Overalls</td>
<td>• Latex or nitrile gloves</td>
<td>• Antifreeze mixture instructions</td>
</tr>
<tr>
<td>• Latex or nitrile gloves</td>
<td></td>
<td>• Job card</td>
</tr>
</tbody>
</table>

1. Allow the engine to cool.
2. Once the engine is cool, carefully remove the radiator pressure cap.
3. Select a hydrometer for the type of coolant in the system. Two main types of coolant are used: monoethylene glycol and polypropylene glycol. Each coolant type has a different hydrometer and will provide antifreeze protection.
4. Insert the hydrometer into the coolant and take a sample.
5. The indicator on the hydrometer will show the antifreeze strength.
6. While you are carrying out the hydrometer test, this is also a good time to assess the condition of the coolant. (Check it to see if it is dirty or contaminated.)
7. If the coolant is below the standard required, you should drain it, flush the system and refill it with the correct quantity and type.
8. If you are using an antifreeze and water mix, follow the manufacturer’s recommendations, including the ratio of water to antifreeze. Mix the antifreeze and water in a separate container and then fill the system.

Common faults in motorcycle engine mechanical, lubrication and cooling systems and their causes

**Worn piston rings**

Two problems can occur if piston rings wear. If the compression rings are worn, cylinder compression is reduced or lost, leading to poor performance on that particular cylinder. If the oil-control ring (the piston ring that keeps oil below the piston) becomes worn, the engine may start to burn its own lubrication oil. When this happens, the oil level will fall and excessive blue smoke in the exhaust may occur (see Figure 4.38).

- If piston rings are the cause of oil smoke, this will usually be most noticeable during acceleration.
- If lubrication oil is leaking past the valve stem seals, oil smoke will usually be most noticeable on start up, or after the engine has been left idling for a short time.

Remember that a two-stroke engine uses total loss lubrication, burning its own engine oil. This means that it is normal to see blue smoke coming from the exhaust of a two-stroke.

**Damage to the cylinder walls**

Overheating or lack of lubrication can lead to the cylinder walls being damaged. If this happens, you will often find scoring on the piston thrust side of the cylinder. The thrust side of the cylinder is the one that the piston presses against as it moves downwards on its power stroke. The throw of the crankshaft will force the piston to one side and this is where the greatest amount of wear and damage might occur.

**Incorrect valve clearance**

Because of expansion due to heat, inlet and exhaust valves require clearance between them and any operating mechanism. This is often known as tappet clearance.

If the clearance is too small, two problems can occur:

- When the valves expand due to heat, they might be held open when they come into contact with the valve-operating mechanism. This will lead to loss of compression and misfiring. Because the valves conduct their heat away through the cylinder head, if they are held open they may not cool and could burn out.
- If the valve clearance is too small, the operating mechanism will come into contact with the valves sooner, advancing the valve timing.

If the valve clearance is too large, you can often hear a rattling noise from the top end of the engine.

- The valves may not fully open. This reduces the amount of air/fuel mixture that can be drawn into the cylinder or reduces the amount of exhaust gas that can be expelled. This will affect the volumetric efficiency and therefore performance.
- The operating mechanism will come into contact later, delaying the valve timing.