Aim of this document

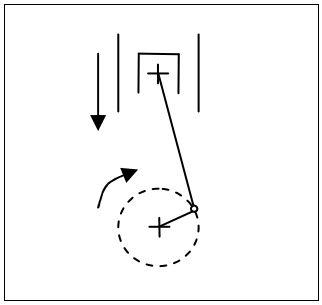
This exercise is designed to show you how a simple four-stroke engine is constructed and how it operates. You will also have to answer questions about the engine. These questions relate to topics which you will encounter in the core courses, such as measurement, thermodynamics, and materials. Please carefully take notes, as you have to submit a report answering the questions in October 2010 (this will count towards 10% of the PSSD2 module)

Disassembly

Take your engine to pieces (do not take the carburettor to pieces!).
You need to remove the cylinder head to answer questions 1 and 2, and the piston/connecting rod to answer questions 4.
Keep all your engine parts together and return the tools to the correct places as soon as you have finished using them (some tools need to be shared).

1 Mechanical cycle

Draw four or five simple sketches of the engine, covering the entire cycle (see figure on the right for an example).
If drawing the piston part through a stroke, indicate the direction of travel. Make sure that the position of the connecting rod on the shaft is consistent with the position of piston. For each sketch, explain what has happened, what will happen, how it is occurring. Pay attention to the timing of the opening and closing of valves (you could sketch a valve-timing diagram).



2 Compression ratio and nominal size

Measure the cylinder bore and the piston stroke. Calculate the swept and unswept volume (V_S and V_U respectively), and derive the compression ratio (R_C), which is given by

$$R_C = \frac{V_S + V_U}{V_U}.$$

What is the engine nominal size? What type of lawnmower did the engine comes from? Is the compression ratio what you would expect? Justify.
The bore is the cylinder diameter. The stroke is the distance travelled by the piston in one stroke. The swept volume is the volume swept out by the top of the piston head in one stroke (also nominal size of the engine). The unswept volume is the volume above the piston head when it is at its highest point (Top Dead Centre, TDC). Quote bore and stroke in mm, and both volumes in cm^3 (also cc, equivalent to ml). You can use water to measure the unswept volume (do not forget the gasket thickness and valve head volume)

3 Thermodynamical cycle (Not during tutorial, but answer in report)

Draw an indicator diagram (thermodynamical cycle, pV diagram). Show how the "net work per cycle" can be derived from this diagram (volume in cc, pressure in bar, work in J -careful with conversions-)
What effect would increase the compression ratio have on the net work per cycle ?
What effect would opening the throttle have on the pV diagram and on the net work per cycle.

The pV diagram should be drawn for an ideal cycle (known as an Otto cycle in the case of an internal combustion engine), using the dimensions of the engine you are working on. The points should be labelled as following:

1. Start of induction (intake) stroke
2. End of induction (intake) stroke/start of compression stroke
3. End of compression stroke
4. Start of working stroke
5. End of working stroke
6. Start of exhaust stroke
7. End of exhaust stroke

Make the following assumptions for the ideal cycle:

1. The valve open and close at TDC and BDC, as appropriate
2. The intake and exhaust strokes each last for 180 of crank rotation. The pressure in the cylinder is 1 atm during these strokes
3. The compression and working stokes are adiabatic and reversible. The gases in the cylinder obey the following equation of state, $P.V^{\gamma}$ =constant , where the value of γ is 1.4.
4. Combustion takes place quasi instantaneously at TDC, leading to a pressure increase by a 1.5 factor
5. At the end of the working stroke (at BDC), the pressure in the cylinder falls very fast to atmospheric value as the exhaust valve open.

4 Stress analysis

Calculate the maximum expected stress in the connecting rod. What mechanical property of the materials would you compare this to? What are typical values of this property?

Use the maximum pressure as found in the previous section. The actual stress will be different; we do not take into account the kinetic forces in this exercise.

Assembly

Reassemble the engine. Demonstrate that the valve timing is correct before putting the cylinder head back on.

Make sure the engine rotates after reassembly. There are timing marks on the gear wheels to help you.

Additional information

Lawn mower	Push along	Self propelled	Sit upon
Engine size	75 cc	100-150 cc	200 cc

Vehicle	Small motorbike	Small car	Diesel/HP car
Compression ratio	7:1	10-12.1:1	>15:1