5. EXPERIMENTAL FACILITIES

The research was undertaken on an existing portable engine-dynamometer facility, in the Thermodynamics section of the Mechanical Engineering Laboratory located in the NWE building. It should be noted that the equipment detailed below pertains to the final petrol and hydrogen tests. All previous equipment specifications may be found in the respective tests as discussed in the succeeding chapter.

The layout of the test equipment is indicated in Figure 5.1 below while Figure 5.2 illustrates the control circuitry used to drive the hydrogen generator.

Figure 5.1: Test Cell Layout indicating the portable test rig

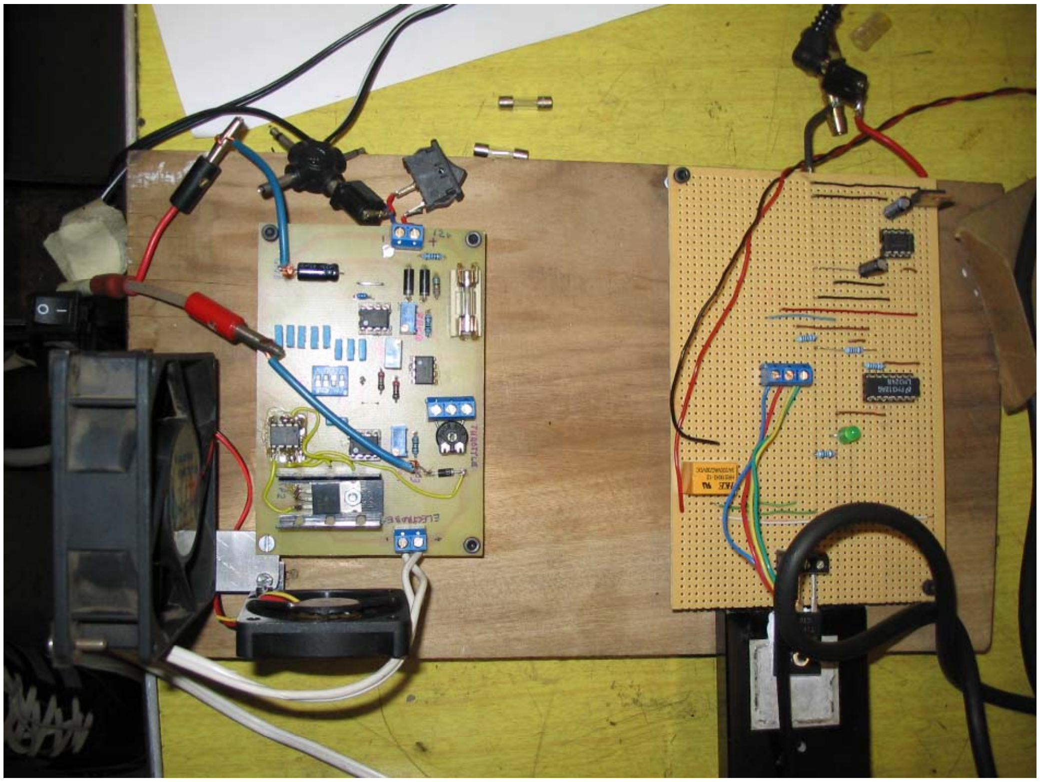

Figure 5.2: Hydrogen Generator Control Circuitry

5.1 Spark Ignition Engine

The engine used for the experiment was a four-stroke ACME Motori, carburetted, spark ignition engine. The specifications of the engine are summarized in Table 5.1 below.

Table 5.1: Engine Specifications

Description	
Manufacturer:	ACME Motori
Model:	ACT 340
Capacity:	338 cm^3
No. of cylinders:	1
Bore:	82 mm
Stroke:	64 mm
Max. Power:	8.1 kW @ 3600 rpm
Max. Torque:	23.7 Nm @ 2700 rpm
Max. Engine Speed:	4000 rpm
Auxiliary Systems	
Ignition System:	Electronic
Cooling System:	Forced Air
Fluid Capacity	
Fuel Tank	6.5 litres
Oil Sump	1.4 litres

5.2 Dynamometer

A water-cooled eddy current dynamometer was used for the duration of the testing. It comprised the dynamometer rotor attached to the engine shaft, a loadcell, complete with strain gauges and a cooling system.

The dynamometer served as a means of simulating and varying load conditions on the engine so as to keep either the torque constant while the speed was being varied or vice versa.

Once the dynamometer was loaded, the resulting electrical output signal from the loadcell was sent through a voltage amplifier and the voltage was displayed by means of a voltmeter. This voltage was then substituted into the calibration equation for the dynamometer and the corresponding torque values were determined.

5.3 Fuel System

5.3.1 Fuel Supply System

The fuel supply system for the engine comprised the hydrogen-generating unit and gas carburettor conversion kit, a glass pipette fuel flowmeter and the petrol tank.

Petrol fuel was supplied to the engine from the header tank, through the pipette and fuel filter respectively, all of which were situated above the engine test bed. Thereafter, the fuel passed through the fuel intake manifold under the influence of gravity and into the engine's butterfly carburettor from where it would be distributed to the combustion chamber.

Hydrogen fuel was supplied to the engine from the generator through a ball valve to the carburettor conversion kit. This allowed the hydrogen supply to the engine to be shut off without having to turn the entire generator off. The carburettor conversion kit was situated in the air intake manifold just prior to the original carburettor. The manifold also incorporated a fixture for the attachment of the air line from the air-damping unit as discussed below.

The original air filter as supplied by the engine manufacturer was removed so as to allow for the installation of the air inlet manifold and gas conversion kit. This entailed the removal of the throttle control which was remounted using a modified mounting bracket.

5.3.2 Air Supply System

The air supply system comprised a surge damper complete with an orifice plate so as to eliminate any pressure fluctuations in the air flow into the engine. This also allowed for the measurement of inlet air from Equation 5.1 below [30]:

$$\dot{m}_a = 1.29\left[C_d\left(\frac{\pi}{4}\right)d^2\sqrt{\left(\frac{2\Delta pRT_a}{p_a}\right)}\right] \tag{5.1}$$

Where:

C_d:	Coefficient of Discharge	0.596
d:	Orifice diameter	0.015 m
Δp:	Pressure difference	Pa
R:	Universal Gas Constant	287.1 $J.kg^{-1}.K^{-1}$
T_a:	Ambient Temperature	K
p_a:	Ambient Pressure	Pa

5.4 Cooling Fans

Engine cooling was facilitated by the use of a blower mounted on a portable stand, located on one side of the engine. A large extractor fan, which formed part of the room's ventilation system, was also utilized so as to induce a flow of cooler air through the test room.

5.5 Gas Analyser

A gas analyser was utilized so as to measure the exhaust emissions emitted by the engine. A small amount of exhaust gas was tapped off the engine exhaust and passed through the gas analyser. The gas analyser comprised four individual units, namely;

- Signal Series 200 Gas Cooler/Dryer
- Signal 4000 VM Heated Vacuum NO_x Analyser
- Signal 7000 GFIR CO_2 Analyser
- Signal 7000 GFIR CO Analyser

The accuracy of each of the analyser units was 0.1%.

The exhaust sample passed through a heated line to a filter and then to the oven, which heated the sample to the appropriate temperature required by the NO_x analyser. The remainder of the sample was passed through the gas cooler/dryer, which reduced the water content of the sample sufficiently for entry into the CO_2 and CO analysers.

5.6 Instrumentation

The instrumentation comprised a data acquisition system complete with interface cards and a variety of sensors that were used to measure the operating parameters of the engine. The data acquisition system consisted of a personal computer, which used a software package known as *"Signal"* in order to capture emissions readings and display running plots of these readings.

The relevant measured variables were as follows:

5.6.1 Ambient Pressure

Atmospheric pressure was measured with a pressure barometer situated in the North West Engineering Laboratories.

5.6.2 Air Flow rate

The flow rate of the air was measured by means of a pressure tap located directly behind an orifice plate. The tap was then connected to an electronic manometer, which indicated the difference in pressure between the reading and atmospheric pressure. This was inputted into equation 5.1 and the flowrate was determined using the equation for the orifice plate.

5.6.3 Fuel Flow rate

The flow rate of petrol fuel was determined with the aid of the calibrated pipette arrangement connected to the fuel supply line. Petrol from the tank was fed through a three-way valve at the base of the pipette to the engine. The valve then allowed for engine to be fuelled either, directly from the tank while the pipette was filled from the same supply, or solely from the pipette. The time taken for a set volume of fuel could then be measured once the engine was drawing fuel from the pipette, and the fuel flow rate could then be determined.

5.6.4 Engine Speed

Engine speed was measured by means of a stroboscope, which operated essentially as a timing light. A reflective sticker was fixed to the rotating output shaft of the engine and a light from the stroboscope was flashed at it. The frequency of the flashes was adjusted until it appeared as if the shaft was stationary. The corresponding rotational speed was then read off the frequency adjustment dial on the stroboscope.

5.6.5 Engine Torque

The applied load on the engine was determined from the dynamometer as discussed in Section 5.2. The amplified signal was interfaced to a voltmeter and the indicated voltage was inputted into the calibration equation to yield the corresponding torque reading.