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Pearson BTEC Level 4 Higher Nationals in Engineering (RQF)

Unit 16: Instrumentation and Control Systems

Unit Workbook 2

in a series of 4 for this unit

Learning Outcome 2

Process Control Systems

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INTRODUCTION

Investigate process control systems and controllers

- The need for process control systems, including quality, safety, consistency, optimisation, efficiency, cost and environmental considerations.
- Defining deviation, range, set point, process variables, gain, on-off control, two step control and three term control PID (proportional, integral and derivative).

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose	Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.
Theory	Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.
Example	The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.
Question	Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.
Challenge	You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.
Video	Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

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Engineering would not be where it is today without the appropriate control systems, they are used to design and optimise systems, while also keeping a high quality and safety. Almost every discipline in engineering needs to consider how a design is to be monitored and controlled. We can take a car as an example, the modern car is much safer, comfier and more efficient than cars from even twenty or thirty years ago.

2.1 Control Systems in a Modern Car

The component in the modern car that is the least optimised is the human driving it, hence why the largest companies are researching and developing the driverless car. Humans are prone to mistakes or can sometimes just have the smallest lapse in concentration, they can be emotional and drive in a dangerous state of mind, or some just don't have any awareness whatsoever. Some drivers may never experience a car accident, but that doesn't mean some of the safety control systems shouldn't be built in. The control system will consider all aspects of the car, the condition of the engine, fuel tank, exhaust, safety, etc.

2.1.1 Airbags

The airbag of a car is one of the most important control systems in place, it takes the momentum out of the human body to limit injury as best as it can. But the timing and the control must be very carefully designed. The URLs below shows the effect of a delay in the airbag by seven hundredths of a second (0.07s) and its effect on a watermelon, as well as a crash test dummy.

https://www.youtube.com/watch?v=QS6ywFGcLSk (watermelon)

https://www.youtube.com/watch?v=YAwrq9-1oQQ (crash test dummy)

From the videos shown, the watermelon was completely destroyed in the small difference in time, and the crash test dummy, if it were human, would have had severe injuries. The airbag, in conjunction with a seatbelt, showed a drop in moderate and more extreme injuries based on the Maximum Abbreviated Injury Scale (MAIS) scale used in hospitals (MAIS ≥ 2) to describe the worst injury and the severity of the injury. Table.2.1 shows the MAIS scale in more detail.

Table.2.1: MAIS scores and an example of the injury

MAIS Score	Condition	Example
1	Minor	Sprained Ankle
2	Moderate	Closed Fracture
3	Serious	Open Fracture
4	Severe	Amputation
5	Critical	Ruptured Liver/Spleen
6	Untreatable	Heavy damage to brain or chest

So how does the airbag work? Well the cars are equipped with accelerometers that detect a change of speed (the same component used to detect if you're phone has changed from portrait to landscape), the conditions that the accelerometer must detect is the change in speed of the vehicle that clearly isn't caused by the typical acceleration or braking forces of the vehicle. Once the accelerometer has detected a significant

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change in speed, the airbag circuit is triggered, and a current is passed through a heating element (the same system in a toaster or a kettle). The heating element ignites a chemical explosive which will quickly produce a large amount of gas as it burns (this gas is harmless, usually Nitrogen or Argon). The gas floods into the airbag and the expanding bag blows the plastic cover off the steering wheel. To improve the unwrapping of the tightly packed bag, it is coated with a chalky substance (such as talcum powder). The driver will be moving forward from the impact and will push against the bag. As the driver moves forward into the bag, it will start to deflate from small holes in the edges, the deflation is how the momentum is slowly taken out of the driver.

2.1.2 Fuel Injection

The older generation of cars would mix the fuel and air in the intake manifold of the engine, by using a carburettor, the cross-section of which can be seen in Fig.2.1. The driver will press down on the accelerator and the throttle valve opens; as the valve opens, the suction from the intake stroke of the piston will force the fuel through the jet and mix with the air, before it is brought into the combustion chamber. This is a very simple method of control, and the most common problem is the poor mixing that this gives, which proceeds to give a poor burn and reduce the overall power produced by the engine. Incomplete combustion of the fuel also causes a variety of emission problems.

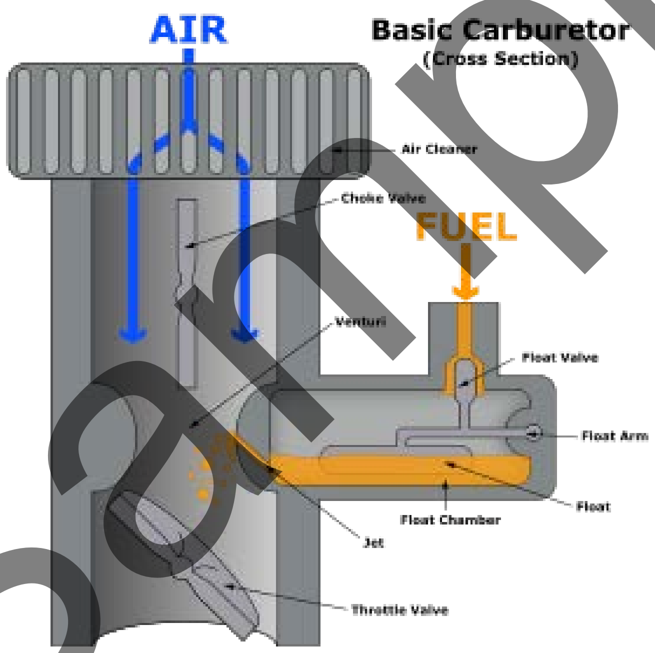

Fig.2.1: Carburettor cross section.

Fuel injection was originally designed for use in Diesel engines but has found its way into more and more petrol engines. Rather than mixing the fuel and air in the intake manifold, the fuel is squirted straight into the combustion chamber before ignition. The force from the injector provides a wider spread of fuel throughout the chamber, which allows a more complete burn of the fuel, which improves the power output, the efficiency, and the emissions of the engine. Fig.1.2 shows a diagram of the fuel injection system.

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