Pearson BTEC Level 5 Higher Nationals in Engineering (RQF)

Unit 45: Industrial Systems

Unit Workbook 1

in a series of 4 for this unit

Learning Outcome 1

Fundamental Concepts of Industrial Systems

Contents

INTRODUCTION

Describe the main elements of an electronically controlled industrial system:

- Discrete control.
- Input and output devices; open and closed loop systems.
- Describe the system elements and the principles and applications of important and representative AC and DC motors.

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.

1.2 Open and Closed Loop Systems

Systems can operate under an open or closed loop system, the difference between the two is what is happens to the data after the transfer functions take place. We consider all actions and processes as a function of time.

1.2.1 Open Loop

An open loop system does not use the collected data to feed back into the system and will just display the current status for manual intervention to fix any problems. The control action is not performed automatically by a processing unit within the system. Let's say we are using a cheap fan to cool something down, we press a button which give a varying fan speed, the button completes the circuit and starts the motor. We model systems with a block diagram. When drawing the block diagram for an open loop system, we have a linear path between the input and the output, with transfer function blocks in between. A block diagram for a fan can be found in Fig.1.2 below. The main characteristics of an open loop system can be simplified to:

- desired and real values are not compared,
- no self-control or regulation,
- input is a fixed operating position for the controller,
- external disturbances do not result in a direct output change, unless manual alteration takes place.

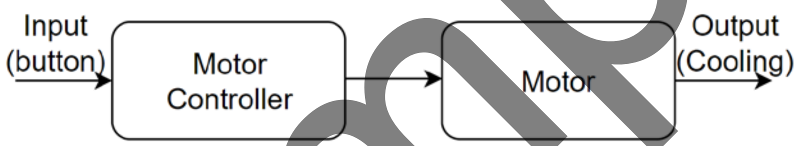

Fig.1.2: An open loop block diagram of a fan

1.2.2 Closed Loop

A closed loop system will collect data while it runs and will feedback into the system to correct to compensate for any disturbances without any external intervention. A closed loop system basically has its own element of control. Let's say our fan is now monitoring the temperature of the item we are cooling; the input is no longer the manual operator pressing the button, it is the desired temperature of the item. Fig.1.3 shows the block diagram for the closed loop fan.

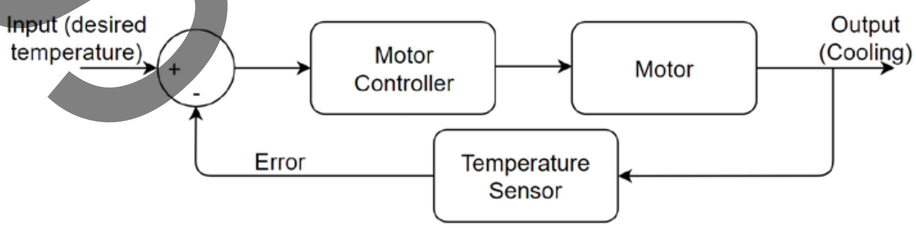

Fig.1.3: Closed loop diagram of a fan

Again, this is still a very basic system. Block diagrams can be huge pieces of work, with sensors analysing anything and everything. We can look at the block diagram for a car's power transmission in Fig.1.4, when the driver presses the pedal down to the floor as quickly as possible, the microprocessor that actually controls the throttle does not allow this, as it could damage the engine. Instead the throttle slowly opens for a more controlled and efficient acceleration. This is not all that is monitored on the engine, and a lot more is monitored to ensure the system is working at the optimal performance.

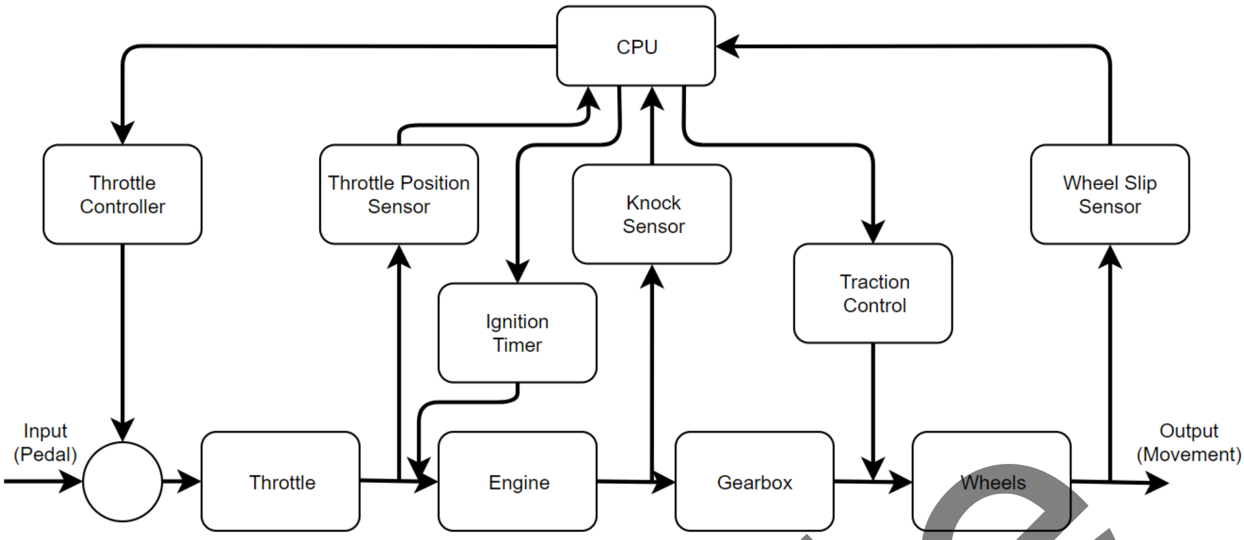

Fig.1.4: Power transmission block diagram

Of course, we can still go deeper, since there are about 60 different warning lights that a car could have, but the size of the block diagram for this would be difficult to read and doesn't really add to your knowledge. But some of the factors we could consider are:

- Environmental sensors such as:
  - Moisture for windscreen wipers
  - Light sensors for lights
- Brakes can incorporate different systems for feedback including:
  - Brake lights
  - Anti-lock brakes
  - The car could also use an air-brake
- We also haven't monitored the condition of the engine yet:
  - Oil Levels
  - Temperature
  - Fuel Levels
  - Fuel consumption
  - Remaining range of the car before it runs out of fuel
- Monitoring the condition of the catalytic converter
- There's also the passengers to consider:
  - Monitoring different aspects for cruise control
  - Climate control
  - Alerts for potential problems with the car
  - Airbags
  - Open Bonnet/Doors/Boot
  - A seatbelt is not fastened
- High performance road cars also have different performance settings that will adjust:
  - Suspension (ride height and firmness)
  - Aerodynamics

1.4 Motors

Motors are an electromechanical component that converts electrical energy into a rotational kinetic energy. Motors boast excellent efficiency (typically 80+%), they are also very reversible, and a generator is the same system, but instead kinetic energy is input to create electrical energy. Motors are designed to either run on an alternating current (AC) or direct current (DC), if you wish to power an AC motor with DC, then you must condition the current to match, and the same goes for powering DC with AC.

1.4.1 Motor Theory

It is well known that when electricity flows through a wire, it also generates a magnetic field, which is shown by the right-hand rule shown in Fig.1.7. Your thumb will follow the direction of the current in the wire, and you curled fingers will follow the direction of the magnetic field. The strength of the magnetic field is amplified by using a coil and increasing the number of turns.

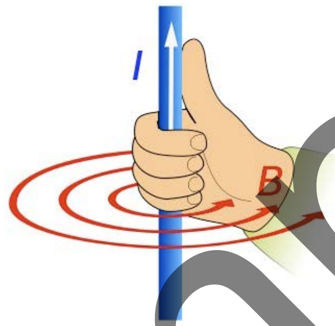

Fig.1.7: The right-hand rule.

So, what happens when a wire with a current is put into a magnetic field? Well, we know that magnetic fields interact with each other, and will create a force upon each other to either attract or repel, depending on the direction of the magnetic field. The maximum force generated by the conflicting magnetic fields occurs when the current of the wire is perpendicular to the magnetic field. The direction of the force is also determined by another right-hand rule shown in Fig.1.8.

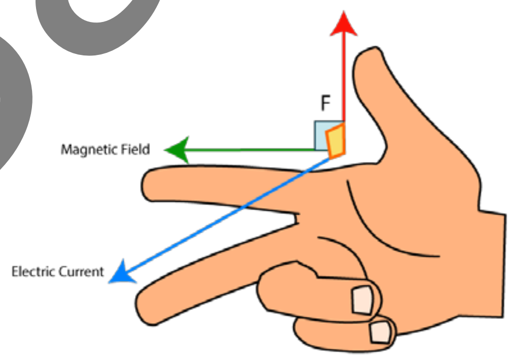

Fig.1.8: Right-hand rule for a wire in a magnetic field

The magnet is always trying to push the coil into the “zero torque position” and create an equilibrium in the system, where the wire is parallel to the magnetic flux. This means that, if current is flowing in one direction through the coil, then the system will stop. But if the current were to be reversed at zero torque position, then the system will carry on and rotate to the next zero torque position. This means that the force on the