Pearson BTEC Level 4 Higher Nationals in Engineering (RQF)

Unit 21: Electrical Machines

Unit Workbook 2

in a series of 3 for this unit

Learning Outcomes 2 and 3

Electric Motors and Generators

Contents

INTRODUCTION

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.

Applications, construction, characteristics, and testing

Applications

The purpose of an electrical motor is to convert electrical energy into mechanical energy. Some common uses of electrical motors are;

- Electric car
- Washing machine
- Cooling fan
- Refrigerator or freezer
- Microwave oven
- Drive for a conveyor belt
- Robotics

The purpose of an electrical generator is the opposite to that of a motor i.e. to convert mechanical energy into electrical energy. Some common uses of generators are;

- Dynamo on a bicycle
- Power station turbines
- Fossil fuelled cars
- Diesel trains
- Vessels
- Roadworks tool power

An illustration of the motor and generator concepts is shown in figure 1.

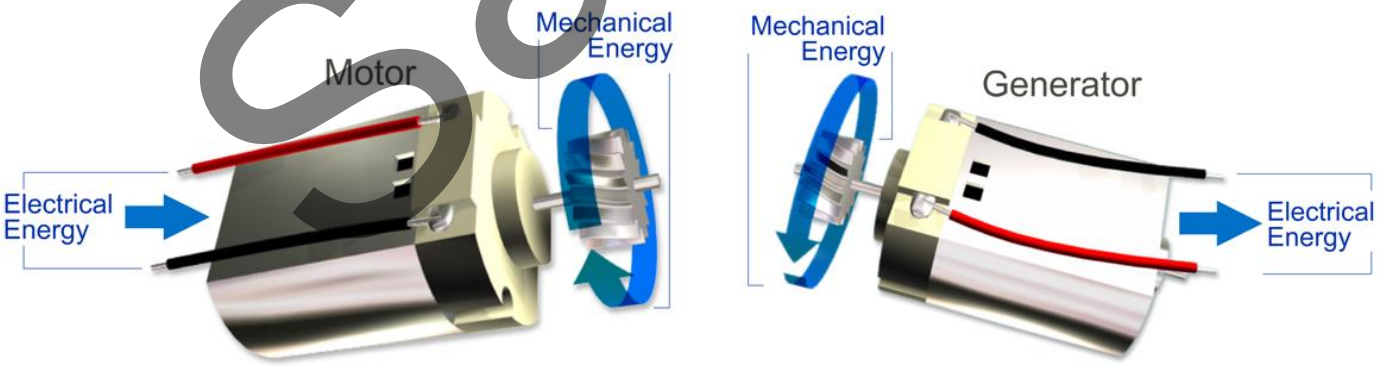

Figure 1 *The motor and generator concepts*

Construction

The two basic components common to both motors and generators are;

- Rotor – the spinning part at the centre
- Stator – fixed part which surrounds the rotor

Other components of motors and generators are;

- Bearings – these provide physical support for the rotor
- Air gap – the space between the rotor and stator
- Windings – usually copper coil placed around both the stator and rotor
- Magnets – these can be found in either or both the stator and rotor
- Slip rings and brushes – present on some types

The overall construction principle for a generator and motor is shown in figure 2.

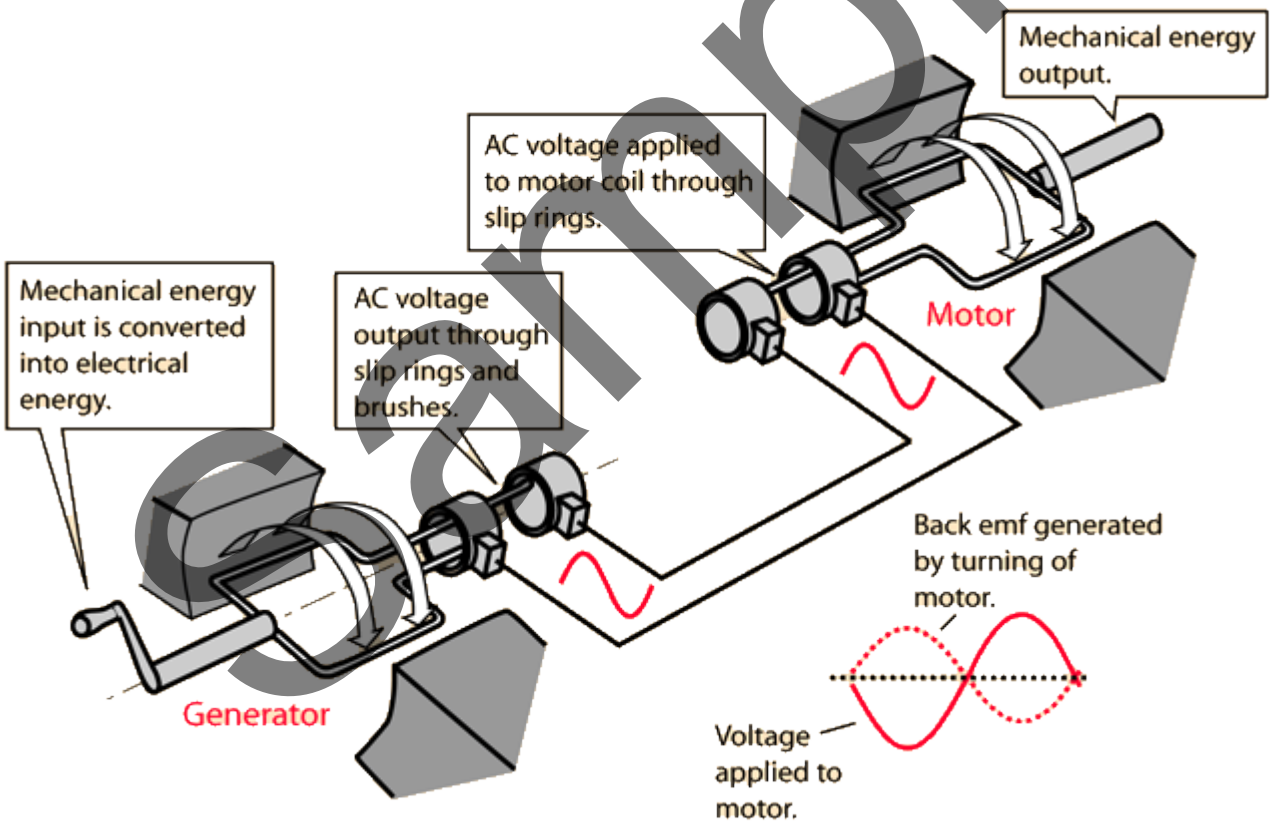

Figure 2 *An AC generator powering an AC motor*

Characteristics

Motors and generators can be made to operate on an AC or DC principle. The basic idea behind any motor or generator is that current-carrying coils which move within magnetic fields will experience a force, as shown in figure 3.

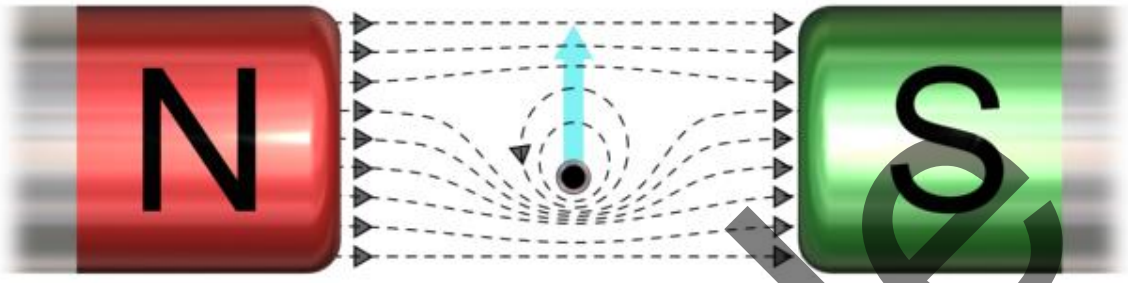

Figure 3 *Force on a current-carrying conductor within a magnetic field*

Any conductor which carries current will radiate a magnetic field. Placing such a conductor inside a larger magnetic field, perhaps constructed from permanent magnets, as shown in figure 3, will result in the conductor experiencing a force and thus movement.

Should we twist the conductor into the form of a loop then we have one turn of a coil, as shown in figure 4. Now the current will flow in opposite directions on either side of the coil. The magnetic forces then tend to work in opposite directions, producing a twisting force (torque) on the coil about its centre.

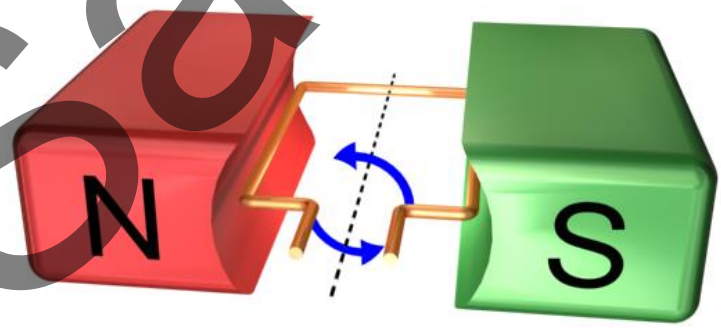

Figure 4 *Force on a current-carrying coil within a magnetic field*

Testing

Testing of motors and generators may be undertaken with a digital or analogue multimeter, clamp meter, temperature sensor, Megger or oscilloscope.

Electric motors can fail to start, run intermittently or become hot. A common cause is a faulty motor controller circuit. The actual load on the motor could be jammed, which may have damaged the motor. If the motor itself is faulty then the cause could be a burnt-out wire, loose or corroded connection, compromised insulation or a faulty bearing. Systematic tests, measurements and observations will usually quickly reveal the cause, as discussed in the previous workbook.

Similar testing will apply to portable generators, but, in either case, adequate personal protection measures should be employed.

Types of electric motors

The various categories and types of electric motor are presented in figure 5.

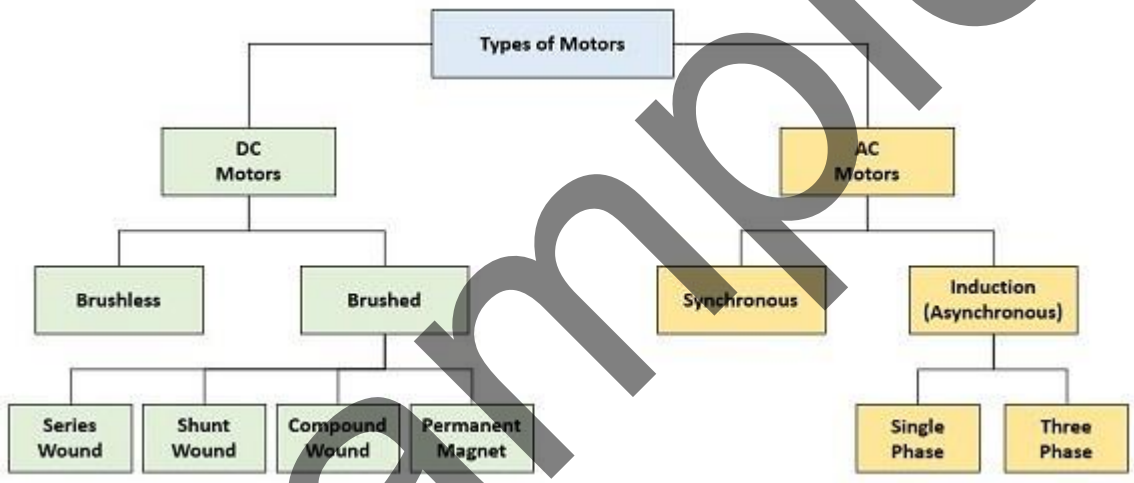

Figure 5 *Various types of electric motor*

DC Motors

Brushed

These are very commonly used and employed in consumer applications and light industry. Brushed motors can be sub-divided into four types, as explained below.

Series wound

The field winding (located in the stator) is connected in series with the rotor winding. Control of the motor speed is achieved by varying the supply voltage.