

Handmade Series Direct Current Motor

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Abstract. *It is possible to build a variety of very simple – and yet functioning – electric devices using common materials. These devices can be used to verify Electromagnetism fundamentals. Electric currents within magnetic fields originate forces and that is the basic principle of operation of electric motors. This paper describes a universal series motor made with iron bars, insulated copper wire, two small brass plates, insulating tape, six screws and a couple of hoops. The motor is fed with a personal computer 12V DC switched power supply. Rotor speed can achieve several rotations per second.*

Keywords. Electric Motors, Universal Series Motor.

1. Introduction

The device described in this paper (Fig.1) is a handmade *universal series motor* [1]. It is called *universal* because it works both with direct current (DC) or alternating current (AC) and *series* because the windings of the stator are in series with those of the rotor [2]. Both windings must have the same polarity.

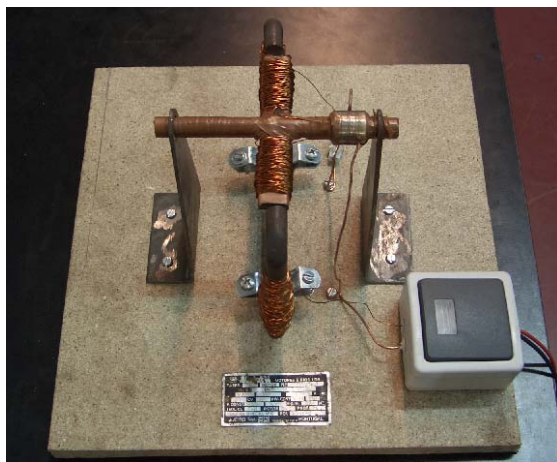


Figure 1. Handmade universal series motor.

An electric current flowing in a solenoid originates a magnetic field in the surrounding

space and two magnetic fields interact with each other originating forces [3,4]. These are the Electromagnetism fundamentals that explain the principle of operation of the constructed motor. Direct current was used to feed it.

Materials used to build the motor are listed in Section 2. Construction details are given in Section 3. The principle of operation of the motor is explained in Section 4.

Conclusions are presented in Section 5, followed by the due acknowledgements (Section 6) and the list of references cited (Section 7).

2. Materials used to make the motor

The following materials were used to build the motor:

- 20cm x 20cm wood board;
- 68cm x 10mm iron rod;
- 18cm x 15cm x 3mm iron sheet;
- 25cm x 10mm x 3mm iron bar;
- copper wire 10cm of length;
- 25m of varnished copper wire;
- copper tube with 14mm inner diameter and 2cm of length;
- two handles, each with a 13mm hole;
- roll of insulating tape;
- six medium screws.

3. Motor construction

To build the core of the stator, a 53cm *per* 10mm iron rod is bent as shown in Fig. 2 and the 140mm sides of the resulting piece are covered with insulating tape.

Then, the stator windings are coiled over the insulated portions of the core as shown in Fig. 3. Each winding is made of 200 turns of varnished copper wire. Special care has to be taken in order to coil the windings in opposite directions, as Fig. 3 suggests. After this, the finished stator should look like the one depicted in Fig. 4.

The traverse bar of the rotor core is made of two equal 12,5cm x 10mm x 3mm iron bars. An

arch is made at the middle of each bar (the side view of the bars is shown on Fig. 5). The bars are then fastened on a 15cm x 10mm iron rod using insulating tape, as shown in Fig. 6. The rod is previously insulated with tape (only its extremities are left without insulation).

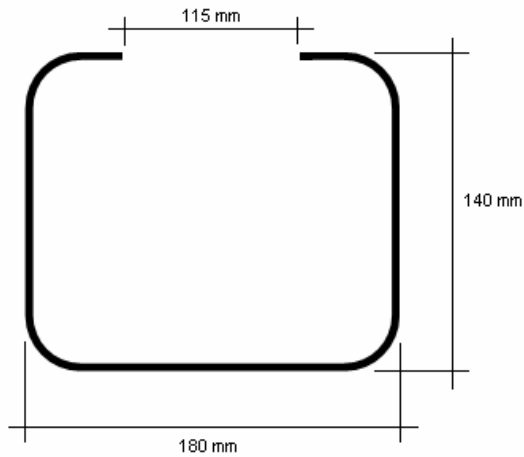


Figure 2. Core of the stator.

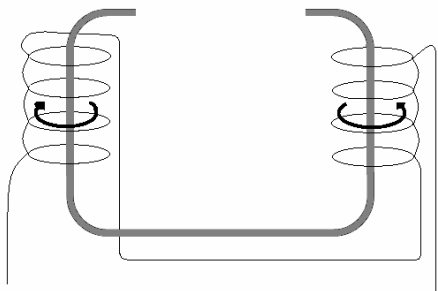


Figure 3. Making the windings of the stator.

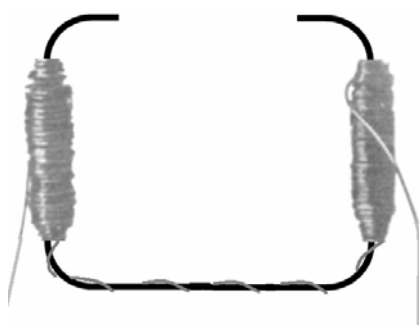


Figure 4. Final aspect of the stator.

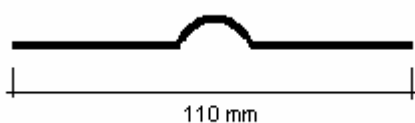


Figure 5. Side view of the iron bars used to make the traverse bar of the rotor core.

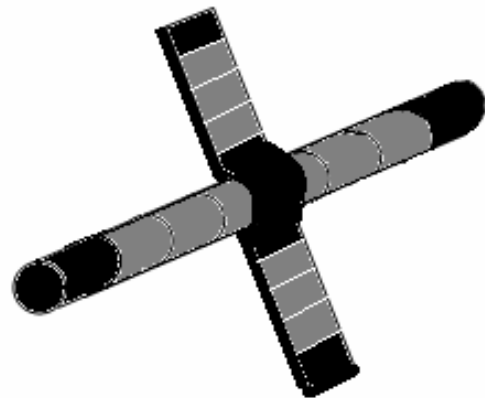


Figure 6. Core of the rotor.

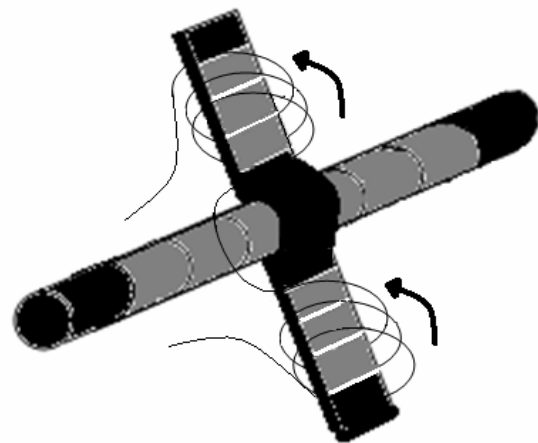


Figure 7. Making the windings of the rotor.

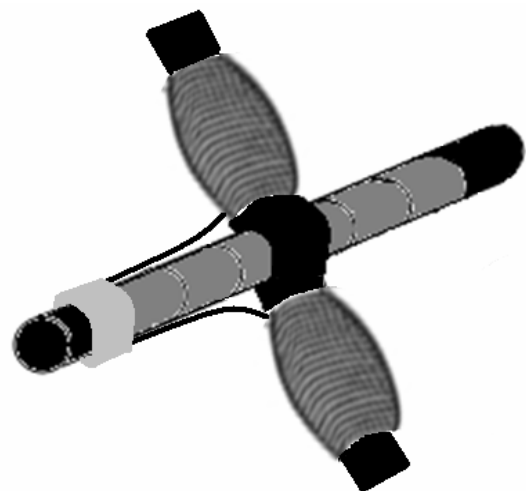


Figure 8. Final aspect of the rotor.

The rotor windings are coiled over the insulated portions of the traverse bar of the rotor core (Fig. 7). Each winding is made of 200 turns of varnished copper wire. Special care has to be

taken in order to coil the windings in the same direction, as Fig. 7 suggests.

A copper tube is cut to half. Each of the resulting halves is connected to one of the terminals of the rotor windings. The two halves are then fastened on the rotor, forming the collector. The finished rotor looks like the one depicted in Fig. 8.

To hold the rotor, two identical pieces of 3mm iron sheet were made according to the blueprint depicted on Fig. 9.

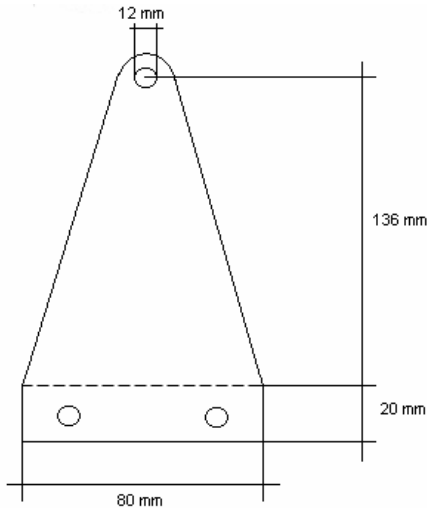


Figure 9. Support of the rotor.

Two terminals of the stator windings are connected to a personal computer 12V DC switched power supply. The other two are leaned on the collector. Connections must be made according Fig. 10.

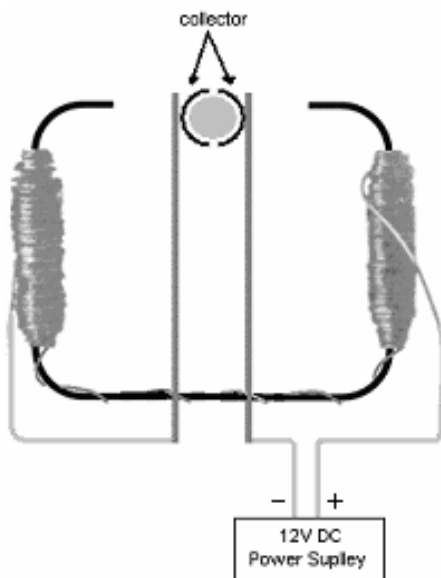


Figure 10. Connections of the stator windings terminals.

4. Motor operation

Feeding the windings of the stator with a constant current originates a constant and uniform magnetic field in the space between the two magnetic poles shown in Fig. 11.

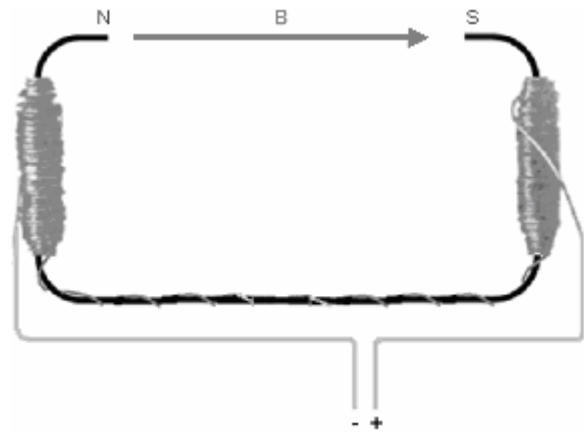


Figure 11. Magnetic field of the stator.

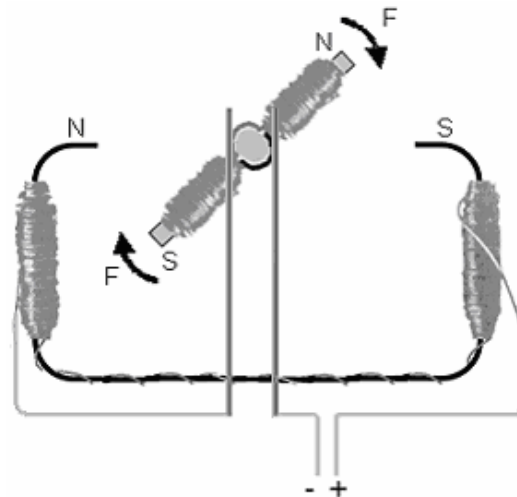


Figure 12. Forces actuating on the rotor.

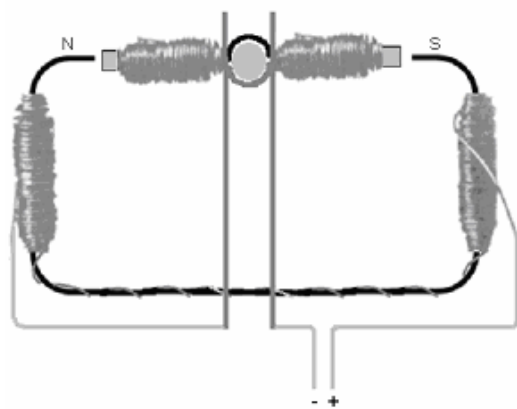


Figure 13. There are no forces acting on the rotor.

When the rotor is connected in series with the stator, the current passing in the stator windings flows through the rotor windings, too, creating a second magnetic field around it. Since the rotor is within the magnetic field of the stator, the two fields interact with each other, originating forces that move the rotor. These forces, which determine the sense of rotation of the rotor, are such that opposite poles attract each other and similar poles repel each other (Fig. 12).

When the rotor reaches the position depicted in Fig. 13, the current flowing in its windings falls to zero due to the connections between collector and brushes. There are no forces in this situation. However, the rotor keeps turning due to inertia. Immediately after, its current is re-established but with the opposite direction, which changes the polarity of the magnetic field of the rotor. Forces appear again, keeping the rotor turning in the same direction (Fig. 14). Without the polarity change of the magnetic field of the rotor – which occurs every half turn – the rotor would stop in the position shown in Fig. 13. Rotor speed can achieve several rotations per second.

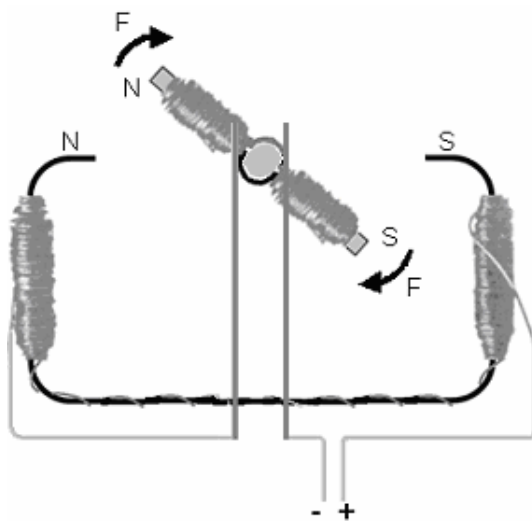


Figure 14. Forces actuating on the rotor after a polarity change of its magnetic field.

5. Conclusions

A handmade universal series motor has been presented. The device, very suitable for science fair events, was built with common materials and can be used to verify Electromagnetism fundamentals that explain the operation of all electric motors. Feeding the motor with 12V DC makes the rotor turn at a speed of several rotations per second.

6. Acknowledgements

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7. References

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