Chapter 4
Design Fabrication and Testing of a Single Actuator DCALS (Part 1)

ABSTRACT

Suspension of a sphere is mostly reported in literature. Only single-axis levitation makes complete suspension of any spherical mass due to its structural symmetry. It is convenient to levitate a ferromagnetic sphere under the force of any electromagnet. The complete levitation of a cylindrical rod needs control of at least three degrees of freedom movement (roll, pitch, and yaw). So, the suspension of a long cylindrical rod without tilting is an interesting and challenging task. In this book two different kinds of experimental levitation systems have been reported. In this chapter, design and development of a DC attraction type levitation system where a cylindrical rod is made to remain suspended under an E-core electromagnet with a single degree of freedom in movement is explored. Here the E-core electromagnet is fixed, and the levitating cylindrical rod is attracted towards the magnet, and the resulting air-gap is controlled.

INTRODUCTION

Suspension of a sphere is mostly reported in literature. Only single-axis levitation makes complete suspension of any spherical mass due to its structural symmetry. It is convenient to levitate a ferromagnetic sphere under the force

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of any electromagnet. For the complete levitation of a cylindrical rod needs control of at least three degree of freedom movement (roll, pitch and yaw). So the suspension of a long cylindrical rod without tilting is an interesting and challenging task. The concept for the suspension of a cylindrical rod may be utilized in different industrial applications such as induction heating, manufacturing industry, active magnetic bearing, precision instrumentation, mechatronics etc.

In this book two different kinds of experimental levitation systems have been reported. In this part of work design and development of a DC attraction type levitation system where a cylindrical rod is made to remain suspended under an E-core electromagnet with a single degree of freedom in movement. Here the E-core electromagnet is fixed and the levitating cylindrical rod is attracted towards the magnet and the resulting air-gap is controlled. Detailed description of the experimental setup, modeling, design of controller, hardware circuits and analysis of results are presented in different sections of this chapter.

DESCRIPTION OF THE EXPERIMENTAL SETUP

Electromagnetic levitation requires essentially two necessary subsystems. A primary system used for generating the magnetic field is called actuator and another system is required for shaping or trapping the magnetic flux and is generally termed as guide-way (Moon, 1994). In this prototype an E-core electromagnet is used as an actuator and a ferromagnetic cylindrical rod is used as object. The mechanical structure is such that E-core magnet is fixed with wooden frame and the cylindrical rod is placed below it on a wooden platform (Figure 1). The magnet core is made of laminated sheets of silicon steel and enamelled copper wire is used for winding the coil. The detailed specifications of the electromagnet are given in Table 1. Since the single axis movement of the electromagnet has to be controlled, other degrees of movement have been restricted by providing two tiny rods, fitted vertically between the wooden base and two sides of the rod. The photograph of the complete experimental setup during stable levitation of object is shown in Figure 20 in Chapter 5. When the electromagnet is excited there will be a force of attraction between the magnet pole-face and the ferromagnetic rod. When coil current exceeds the pick-up value, the rod will lift and hit the guide-way. The main aim here is the stable suspension of this rod at some desired operating gap position. To fulfil this objective it is essential to regulate the current of the electromagnet accurately and quickly with the