Induction voltages square and triangle solenoid as alternatives electrical energy resources

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Abstract. Solenoids have been made with square and triangular cross-sections. Both kinds of solenoids are made with an iron core and without an iron core. The solenoids specification were 12 cm long and 3.5 cm wide with 220 windings and 900 windings. The iron core specification was 12.5 cm long and 8 mm diameter. The induction voltages both of solenoids have calculated with experiments method in the laboratory. Calculation of induction voltages with the experiment method used the motor as the magnetic drive, full-wave rectifier circuit, neodym magnet, and led lamp. Induction voltage and electric current obtained of each solenoid for range from two cm until ten cm. The closest distance between the solenoid with the motor as magnetic drive and the greater the number of solenoid windings produced the greater the induction voltages. Triangular-sided solenoids with 220 windings produced faster induction voltages than the square-sided solenoid for the same number of windings. While an iron core solenoids produced faster induction voltages than solenoid without an iron core.

1. Introduction

The scarcity of alternative energy in the 21st century was very worrying. The reserves of non-renewable energy sources such as oil and natural gas have been very depleted in the future. Recent studies in various fields of science on alternative energy sources must continue. Many of research had been done about alternative energy like science and engineering research.

The first research was about producing induction voltages using solenoid as alternative energy. Research has been made solenoid side circle. This study produces an induced voltage as an alternative source of electrical energy by varying the distance of the solenoid to the source of the magnetic field, the number winding, the addition of iron core to the solenoid, the cross-sectional area, and the different angular placement can produce different induction voltages as well [1]. The second research about utilization of magnetic flux as a source of the power plant by using the solenoid. This research made a circle solenoid too [2]. The third research about magnetic field produced by change core of the solenoid. The core of solenoid made from air and replaced it with ferromagnetic (Fe), paramagnetic (Cu) and diamagnetic (Al) materials. This research made a circle solenoid too [3].

Likewise, many researches have been done about characteristic and benefit of the solenoid in industry. In 2011, there was research about the experimental method of determining the inductance of non-ideal solenoid (restive inductor). It was a simple experiment [4]. In other research, solenoids have
been used as a measure of conductivity of electrical conductor metal using induction methods and magnetic discharges. At the time of the experiment, the measuring instrument consisted of a solenoid, a sample tube, an audio function generator (AFG), a capacitor C, a probe coil, a digital voltmeter (V), and a digital amperemeter (A). Solenoids produced the alternating current which low frequency less than 2.5 kHz. This experiment also produces a low-frequency ac magnetic induction field [5].

Also, Korea Electrotechnology Research Institute (KERI) had developed an inductor on SMES technology that is superconducting magnetic energy storage. This technology used 3-ply BSCCO-2223 wire as conductor, two coils (solenoid) and magnetic energy storage device [6].

In the other research, using the solenoid in an industry can influence the power factor for electric energy efficiency. The value of power factor 20%-50 % [7]. So, There were many benefits of the solenoid which certainly very useful in helping the welfare of human life. In this research, the author tried to design a study to compare the induced voltages between the square and triangular solenoid as the alternative energy. The goal of this research was the calculation of the induction voltages both of solenoids with experiments method in the laboratory.

2. Research Method
This research belongs to experiment research in the laboratory. It did in instrumentation and electronic laboratory engineering faculty Jambi university. For making a solenoid, it used a copper wire coated with an e-mail. This wire had a type resistance of 1.72x10^8 Ω m. Solenoid had been made with square and triangular cross-sections. Both kinds of solenoids were made with the iron core and without the iron core. The solenoids specification was 12 cm long and 3.5 cm wide with 220 windings and 900 windings. The iron core specification was 12.5 cm long and 8 mm diameter. Calculation of induction voltages with experiment method used the motor as a magnetic drive, full-wave rectifier circuit, neodym magnet, and led lamp. The design of the experiment done as shown in Figure 1.

![Figure 1. Block diagram produced an induction voltage of solenoid](image1)

The real experiment has been done as shown in Figure 2. From figure 2, we saw solenoid, full wave rectifier with the neodym magnet, and multimeter for measuring induction voltages producing.

![Figure 2. experiment in a laboratory](image2)

3. Results and Discussion
This research focused measuring induction voltages triangle and square solenoids as alternative energy. The resulted of the experiment shown in from figure 3, figure 4, and figure 5. Figure 3 graph
compare Induction Voltages with range square solenoid 220 winding and 900 winding without an iron core. Figure 4 graph compare Induction Voltages with range square solenoid 220 winding and 900 winding with an iron core. Figure 5 graph compare induction voltages with range triangle solenoid 220 winding without iron core and with an iron core.

![Figure 3. Graph between Induction voltages with range square solenoid 220 winding and 900 winding without an iron core](image1)

Figure 3. Graph between Induction voltages with range square solenoid 220 winding and 900 winding without an iron core

Figure 4 shown that induction voltages decreased in increasing range. Induction voltages with range square solenoid 220 winding in the range 0.08 m and 0.1 m were zero. When solenoid added the winding be 900 winding, it increased the induction voltages for all range using. So, the greater number of winding solenoid can increase the induction voltages for all range using. Copper wire was a good conductor. More copper wire on turns of the solenoid made increasing induction voltages based on faraday law [8].

![Figure 4. Graph between Induction voltages with range square solenoid 220 winding and 900 winding with an iron core](image2)

Figure 4. Graph between Induction voltages with range square solenoid 220 winding and 900 winding with an iron core

Figure 4 shown that no zero induction voltages for all range using. The square solenoid added iron core. When solenoid added the iron core, it increased the induction voltages for all range using. So, adding iron core can increase the induction voltages for all range using. Comparing figure 3 and figure 4, it is shown that induction voltages increased significantly for square solenoids 220 winding and 900 winding addition iron core.
Figure 5. Graph between Induction voltages with range triangle solenoid 220 winding without the iron core and with the iron core

Figure 5 shown that comparing induction voltages produced triangle solenoids between 220 winding without iron core and with an iron core. It is shown that induction voltages decreased or both of winding but it increased for triangle solenoids without iron core and with an iron core in all range using. The researcher did not continue looking induction voltages triangle solenoids 900 winding because researcher got the good data for triangle solenoids 220 winding.

From figure 3, figure 4, and figure 5, let's compare induction voltages between the triangle and square solenoids producing. It is shown that the closest distance between the solenoid with the motor as magnetic drive and the greater the number of solenoid windings produced the greater the induction voltages. Triangular-sided solenoids with 220 windings produced faster induction voltages than the square-sided solenoid for the same number of windings. So, producing induction voltages depended on the shape of solenoids.

While iron core triangle or square solenoids produced faster induction voltages than solenoid without an iron core. Solenoid with motor drive and neodym magnet as a magnetic field source will cause a great force of motion electric induction. Magnetic field value increased when the core is replaced from the air into an iron core. It caused by the nature of iron was a ferromagnetic material. It was inside small areas of magnetization called magnetic domain. When iron got the outer magnetic field from neodym magnet, the total magnetic field measured was the sum of the terrain magnetic solenoid and ferrous magnetic fields magnetic [9].

4. Conclusion
From theory references and the data analysis, there were some conclusion like greater the number winding of solenoid can increase the induction voltages for all range using. Induction voltages increased from 220 winding to 900 winding without an iron core. Addition iron core can increase the induction voltages for all range using. Induction voltages increased from solenoids without an iron core to the solenoid with the iron core for 220 winding and 900 winding. The closest distance between the solenoid with the motor as magnetic drive and the greater the number of solenoid windings produced the greater the induction voltages. Triangular-sided solenoids with 220 windings produced faster induction voltages than the square-sided solenoid for the same number of windings. Producing induction voltages depended on the shape of solenoids.
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