**Career Orientation Through Interdisciplinary Interactive Teaching of the Topic “Self-Induction and Inductance” in the School Physics Course**

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**Abstract.** This article explores how the phenomenon of self-induction in managing industrial technologies—specifically, the exponential behavior of connection and disconnection currents that do not follow Ohm's law—can be accurately calculated using theoretical and electronic software tools. The aim is to develop students’ innovative thinking and guide them toward the profession of automotive engineering by teaching the application of these concepts in ignition systems of internal combustion engines.

**Keywords:** self-induction, connection current, disconnection current, inductance, exponential, internal resistance, automotive engineer, induced electromotive force

**INTRODUCTION**

The physics course is one of the fundamental disciplines that form the theoretical foundation for engineering education. It provides a solid basis, without the understanding of which an engineer cannot successfully engage in professional activities aimed at developing competitive production technologies. Over the past fifty years, technological progress has significantly accelerated due to the application of scientific advances in physics. Research conducted by physicists has predicted and scientifically substantiated fundamentally new directions in engineering.

In the 21st century, this interconnection has taken on an organic character. The rapid advancement of the scientific and technological revolution has necessitated a fundamental revision of the physics curriculum in higher technical education institutions. The current stage of technological development requires engineers to master not only classical physics but also modern theories such as relativity, quantum mechanics, and solid-state physics.

The global automotive industry, textile industry, medical equipment manufacturing, pharmaceutical sector, aviation industry, water infrastructure and transport, railway transport, mining and metallurgical industry, as well as the food production sector, are all experiencing rapid development. The advancement of industrial production is the result of applying scientific research in physics to practical contexts, which contributes to its continuous improvement. “At present, particular attention is being paid to improving the quality of physics education in academic institutions, integrating modern teaching methods into the educational process, identifying and supporting talented students, training competitive specialists for the labor market, promoting scientific research and innovation, and focusing on practical effectiveness” [1]. Thus, in order to train competitive production engineers, it is important to integrate scientific advancements into the school physics curriculum using an interdisciplinary approach — by incorporating new knowledge into textbooks and teaching materials, as well as by creating invention models. This contributes to the formation and development of innovative ideas among students. However, advanced technological solutions in the field of production are still being imported into developing countries by such states as China, South Korea, Germany, and Japan.

**LITERATURE ANALYSIS AND EXPERIMENTAL METHOD**

The moral obsolescence of production technologies introduced and currently operating in our country necessitates their improvement by the engineers managing these systems. This requirement places a responsibility on educators to incorporate the results of scientific research in physics into the school curriculum and to provide students with interdisciplinary instruction that reflects the achievements of modern production technologies and related technical disciplines. Furthermore, the methodology of teaching the laws of electric current in the school physics course in connection with subjects related to automotive transport is a relevant topic for career guidance toward engineering specializations in the field of automotive engineering.

The proper management of technologies in developed countries, the production of high-quality goods, and the enhancement of efficiency depend on the switching time of current in an electromagnetic relay. Therefore, accurate calculation of these physical quantities is required. Since the phenomenon of self-induction occurs during the switching on and off of the relay by means of an electromagnet, the switching-on and switching-off currents are calculated using the appropriate formulas.

I (1)

(2)

The magnitude of the induced electromotive force (EMF) generated in a closed circuit is equal to the rate of change of the magnetic flux passing through the circuit, and its direction is opposite to that change [2, 3].

(3)

The electromotive force of the power source is denoted by , Ris the resistance of the external circuit, **r** is the internal resistance of the source, L is the inductance of the coil, and **t** represents the time of switching on and off. By substituting these values into formulas (1) and (2), the connection and disconnection currents can be calculated [4, 5].

**RESULTS**

The values of the connection and disconnection currents depend solely on the switching time t, provided that the resistance of the circuit (R), the electromotive force of the power source (𝓔), and the inductance of the coil (L) remain constant.

(4)

Given the initial current value in the electric circuit when the power source is connected. [6, 7, 8].

(5)

we obtain the following expression:

(6)

By transforming equation (3), we derive:

(7)

Using equation (4), we calculate the time required for the connection current.

To determine the disconnection current due to self-induction, we use the formula:

(8)

After several transformations, we obtain the formula to calculate the disconnection time:

(9)

**DISCUSSION**

Based on the following formula, it can be concluded that when I = 0, the connection time t₁ = 0 also follows**.**

 (10)

This means, firstly, when the value of the connection current is zero, the connection time is likewise zero. Secondly, the relationship between the connection current and time does not increase linearly but rather grows exponentially. Using the device created by the students (Figure 1), we demonstrate how the light bulb turns on with a delay when the current is connected, and similarly, how it remains lit for a short time after the current is disconnected.



**FIGURE 1.** Demonstration of connection and disconnection currents during the phenomenon of self-induction

At the Fergana Regional Specialized Boarding School for Physics and Mathematics, we created this device together with the students. It consists of a transistor-based alternating current generator and a lamp connected to it through a receiving inductive coil. The students reproduced the phenomenon of self-induction themselves and witnessed it in action.

While building this model, we discussed the experiments of the Serbian scientist Nikola Tesla on wireless transmission of electric current. We also introduced the research of American scientist Royal Raymond Rife, who used electromagnetic oscillations to affect and destroy cancer cells. Students were encouraged to design models based on this topic.

Thus, mastering the course of physics plays a vital role in preparing future specialists in fields such as medicine and engineering.

In the ignition system of an internal combustion engine, it is essential to accurately select the inductance of the “Rumford coil” when determining the timing of current connection and disconnection. If the ignition system is properly adjusted, ensuring precise timing for switching the current on and off, the fuel-air mixture combusts completely. Premature ignition produces a metallic knocking sound from the engine, while delayed ignition causes the mixture to continue burning as it exits the cylinder, resulting in a reddish tint of the muffler and unstable vehicle performance. In both scenarios, fuel consumption exceeds the standard rate [9, 10]. As the above results indicate, accurately calculating the timing of current connection and disconnection serves as a foundation for increasing the efficiency coefficient of an internal combustion engine.

By integrating this knowledge into the study of internal combustion engines and applying the "FSMU" method in teaching, students' interest in the field of automotive engineering can be significantly enhanced, while also fostering their creative thinking.

Moreover, engaging students in the construction of the models illustrated in Figure 1 not only deepens their interest but also cultivates their capacity for innovation and the development of forward-looking ideas.

**CONCLUSION**

Modern requirements include maintaining environmental cleanliness, saving fuel, increasing the power and efficiency of the internal combustion engine. In order to reduce the emission of exhaust gases into the atmosphere, it is necessary to ensure complete combustion of the fuel in the cylinder and piston of the engine. To meet this condition, it is important to accurately calculate the time required for complete combustion.

This is achieved using electronic programs that apply the exponential time-dependent characteristics of current during connection and disconnection [4, 5, 6, 7, 8, 9, 10].

During the ignition stroke in the cylinder of an internal combustion engine, it is necessary to explain the flow of current through the working mixture using the analogy of a lightning phenomenon. Due to the high potential difference between a charged cloud and the Earth, and the extremely short duration of current flow, the resulting current is very large. According to Joule–Lenz’s law, the amount of heat released is proportional to the square of the current. However, the total amount of heat released during combustion in the cylinder of an internal combustion engine is determined by taking into account the specific heat of combustion of the working substance and is summed with the amount of heat released during the passage of electric current.

This is expressed by the formula: , where *qm* is the heat of combustion of the working substance, *U* is the voltage, *R* is the resistance, and *t* is the time. Therefore, a Rumford coil (ignition coil) is used to supply high voltage.

To sum up, conveying these ideas to students contributes to increasing their interest in the profession of automotive transport engineering. However, the amount of heat released during the combustion of the working mixture directly depends on the duration of the connection current. In summary, when explaining the topic of "Self-induction and Inductance," it is advisable to relate it to the operation of an internal combustion engine and base the explanation on the knowledge mentioned above. This approach fosters the development of innovative thinking and creativity in students as they explore the field of automotive engineering.

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