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Research article

# Induction Heating Based on Helical Coil Method by Using Arduino Mega 2560

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**A B S T R A C T**

*Galvanic corrosion is a type of corrosion that often occurs in aircraft structures. This type of corrosion occurs because of engagement of two different types of materials through an electrolyte media. As a result of this galvanic corrosion, several components in the aircraft structure can be damaged. One example of this damage is the corrosion of the bolts on the aircraft skin. So that it makes difficult to remove from the skin. One way to avoid the bolts due to galvanic corrosion is by heating. By using induction heat to the component, the rusty bolt can be loosened. The heat generated causes the bolt to stretch and break the corrosion and so that the bolt or nut can be opened easily. In this research, removing bolts and nuts was conducted by using an Arduino Mega 2560 model with an open loop and closed loop system. Arduino Model as a microcontroller which is needed to run a program. The specimens of the bolts are using steel bolts grade 8.8 with key sizes 13, 17, and 19. Induction heat temperature was set to 150 °C. The results show that different duration time is required to reach 150 °C for each of the key size. The smaller key size takes less times and power to gain temperature setting.*

## 1. INTRODUCTION

Aircraft structure are made by the philosophy that it should be in a minimum weight but having a high strength of structure. The minimum weight are can be obtained by using Aluminum Alloys in the primary structure of the aircraft, such as fuselage and wing structure. The other material that can be used are stainless steel as a fastener in the several location of the structure. This different type of material can be become a problem when it is in contact each other and there is an environment condition that can make corrosion occur.

Zhulkarnaen describes in his research that by changing the quantities frequency and input current would reach certain temperature at different time [1]. The energy efficiency decreases and makes the temperature reach longer when the working frequency approaches 40 KHz. Afterward, the process of reaching the temperature becomes faster.

Hakiki and Riandadari developed the tools to produce induction heat by using ATmega 328 or Arduino Uno, LCD, and thermocouple TO-800 temperature sensor [2]. It applies to heat up three different type of materials as such copper, steel and stainless steel. The result shows that copper undergoes the fastest time in reaching the temperature of 500°C which is 92 second and then following by steel and stainless steel.

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Adolf and Iryani [3] conducted the simulation of the induction heat by using Solid Works by investigating the effect of current value and frequencies. The result shows that the optimum current value and frequencies are 50 A and 500 kHz respectively to reach the temperature of 400 °C in 60 seconds.

The common method for overcoming stainless steel nut threads that are locked or cannot be opened is by heat it up by heat gun. A heat gun usually use with two temperature modes that have a maximum temperature of 400°C and 600°C. However, the hot air generated causes an negative effect to the surrounding components [4]. Therefore, the addition of a controlling system can be capable of that foreseen problem.

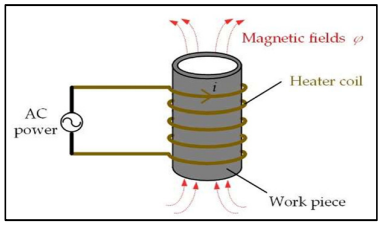


Figure 1. Induction heat principle (5)

Figure 1 shows the illustration of the induction heat principle (5). From the figure, it can be seen that Alternate current (AC) passing through to the heating coil would be initiated eddy which produces current magnetic flux as a consequence. An example of the helical coil system can be shown as in the Figure 2.

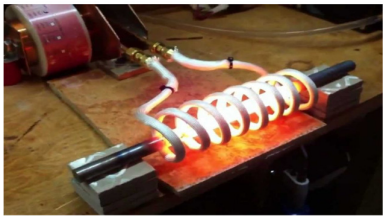

Figure 2. Helical Coil [6]

## 2. METHODOLOGY

The process to design tools that could help in loosen the corrosion nut/ bolt by using Arduino Model is shown in Figure 3.

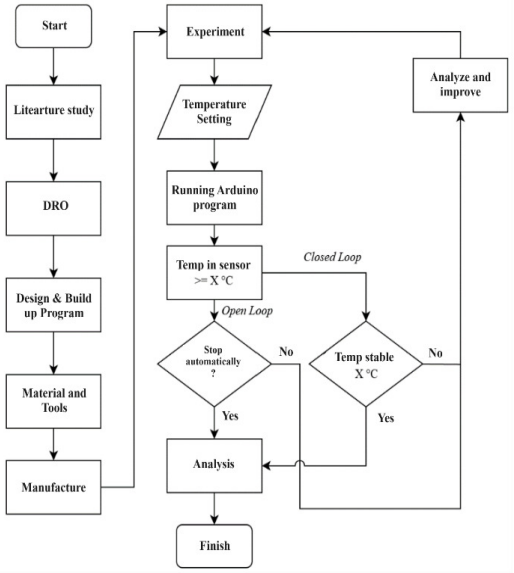


Figure 3. Research Methodology Stages.

As depicted in Figure 3, the methodology of the research begins with the literature study and follows with designing and manufacturing the tool to loosen the nut by using helical coil that were equipped with Arduino Mega 2560 using closed loop and open loop systems.

The designs of the system is given in Figure 4. The system was manufacture with the power supply locating on the bottom layer of the tool holder. Meanwhile several components such as induction heating modules, Arduino, and relays were positioned on the second layer using an acrylic sheet base and tightened using M3 spacers with a length of 5 mm. Additionally, LCD and keypad components were placed on the top layer using an acrylic base and secured by using using double-sided tape. The manufactured physical systems are revealed in Figure 5.

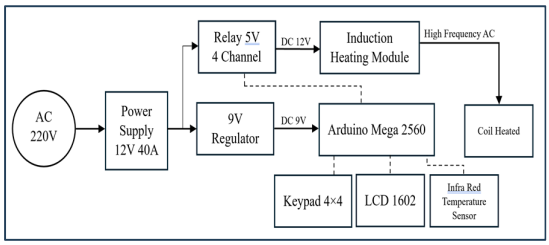


Figure 4. Scheme of Induction Hheating Coil Systems Using Arduino Mega 2560

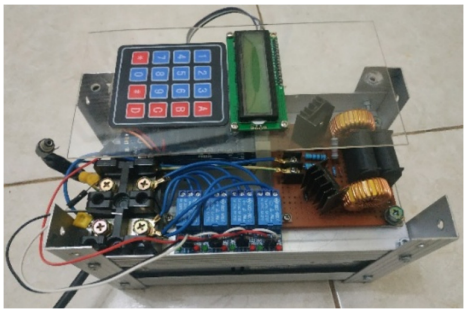

Figure 5. Physical Appearance of Induction Heating Systems Equipped with Arduino System.

Furthermore, the sample materials were prepared and the experiments were conducted by set up the temperature to 150ºC for three types of bolt, i.e. M8 key 13, M10 key 17, and M12 key 19 bolts of grade 8.8 (Figure 6). In addition, the time requires to reach its temperature for each of the bolts will be analyzed.

Figure 6. Types of Bolt.

## 3. RESULTS AND DISCUSSION

Initially, the manufactured testing devices was verified either in open loop and closed loop systems. To run in the open loop system, the metal cutters were heated until it reaches the temperature of 200 ºC. Whereas for a closed loop system, the temperature will be set to 100 °C by entering the temperature magnitude via equipped keypad and kept constant at at 100°C.

Table 1. Experimental Results for Temperature Controller

| Loop System | Temperature set in the program | Temp. when relay open | Temp. when relay closed |
|---|---|---|---|
| Open | 200ºC | 201.99 ºC | 202 ºC |
| Closed | 100ºC | 102.09 ºC | 96.45 ºC |

Table 1 shows the sensor reading of temperature in degree Celsius. Data in Table 1 signifies the capability of the controller to maintain temperature magnitude at setting value. There only has below 2% different between temperature setting and the legible temperature. Thus, it can be inferred its having a good accuracy.

Furthermore, the experiment was conducted by induction heating the sample bolts using Arduino system. The terminating temperature was set to be 150 ºC. After setting temperature is attained then time to get there was quantify from the Arduino's display. The result indicates that the heating time for all the sample bolt is size dependent as can be seen from Table 2 shows the result of the induction heating experiment.

Table 2. The Experimental Results of Induction Heating of Bolts

| Bolts grade 8.8 | Initial temp. | Final temp. | Time (s) |
|---|---|---|---|
| M8 Key 13 | 33.13 ºC | 154.59 ºC | 190 |
| M10 Key 17 | 32.53 ºC | 151.75 ºC | 279 |
| M12 Key 19 | 32.55 ºC | 151.41 ºC | 296 |

As size of bolt increases then the duration to obtain the final temperature would also take longer. As revealed in Table 2, the M12 key 19 bolt requires 296 second to reach the final temperature of approximately 150 ºC.

Further, the magnitude of voltage and electric current released from the power supply were also measure by means of a digital Avometer. This procedure was undertaken during the heating process on each bolt. The results are depicted in Table 3.

Table 3. Voltage and Current Released During Induction Heating Operations

| Bolts grade 8.8 | Voltage (V) | Ampere (A) |
|---|---|---|
| M8 Key 13 | 12.08 | 2.95 |
| M10 Key 17 | 12.08 | 3.06 |
| M12 Key 19 | 12.08 | 3.43 |

In line with the trend shown by effect of bolt size on induction heating duration, the measured current released also relies on the size of the bolts. The bigger the size of bolts the higher intensity of current released during induction heating. Whereas, the voltage is sort of non-size dependent as can be seen from data in Table 3.

Additionally, the relationship between Electrical Power and induction heating duration is established. The results figure out that the longer induction time the higher power demand. The bigger key size i.e. M12 Key 19 requires more power and longer induction time as indicated by data in Table 4.

Tabel 4. Electrical Power Demand for Each Induction Time

| Bolts grade 8.8 | Power (Watt) | Time (s) |
|---|---|---|
| M8 Key 13 | 35.64 | 190 |
| M10 Key 17 | 36.96 | 279 |
| M12 Key 19 | 41.43 | 296 |

Eventually, all the results shown an in-lined trend with theoretical concepts. Therefore, it declares that the built up systems supporting by Arduino Mega 2560 is capable of relieving the corrosion of the bolts. In other word, the performance is better indicating from its accuracy of the systems that is approximately only 2%.

## 4. CONCLUSION

The induction heat with Arduino and built up program of Arduino Mega 2560 had been developed and tested. The examined system shown a better performance due to having closely relationship with basic concept of induction heat. Therefore, it would have prospect to employ as corrosion depletion tools

In addition, from the three types of bolts had been tested indicates that electrical power as well as induction duration is bolt size dependent. Furthermore, the implemented systems have capability to get extend its capacity to setting temperature of 200 $^{o}$C.

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