

Application IOT (Internet of Things) Technology for Heat Input Variable in the FCAW (Flux Core Arc Welding) Welding Process: Studied at PT NOV Profab Batam

Diono¹, Sumantri Lukito², Adlian Jefiza³, Jhon Purba⁴, Illa Aryeni⁵, Fadli Firdaus⁶, Muhammad Jaka Wimbang⁷, Mohamad Alif Dzulfiqar⁸.

diono@polibatam.ac.id, sumantri.lukito@yahoo.com, adlianjefiza@polibatam.ac.id, jhonhericson@polibatam.ac.id, illaaryeni@polibatam.ac.id, fadlifirdaus@polibatam.ac.id, jakawimbang@polibatam.ac.id, mohamadalf@polibatam.ac.id.

^{1,2,3,4,5,6,7}Batam State Polytechnic
Electrical Engineering, Mechatronics Study Program
Jl. Ahmad Yani Batam Kota, Batam, Riau Islands, Indonesia.

Abstract

In the oil and gas sector, welding plays an important role in the construction, operation and maintenance phases. At this time, the construction industry has undergone many changes, especially changes in the technology sector. The construction industry, especially the metal fabrication industry related to welding, also experienced the impact of these changes. One of the changes is integrating welding machines with IOT (Internet of Things). This integration makes it easier for personnel including welders, supervisors, welding engineers and management to analyze data from the welding machine. The data from this welding machine can be used as a reference for the quality of welding results, production efficiency and the ability of the welder to produce a good welding result according to the expected standard.

In this final project prototype, the integration of FCAW (Flux Core Arc Welding) welding machine with IOT (Internet of Things) uses several components including ESP32-32S as a microcontroller, voltage sensor (voltage), HSTS023R current sensor (amperes), speed sensor Infrared Optocoupler LM393 (travel speed), MySQL database management system (database management system), ThingSpeak website application media and Blynk software application to monitor welding data variables via the internet in real time (real time).

The testing result of the 600 data shows that the tool can read and wirelessly transfer the welding parameter values (voltage, current, welding wire speed and heat input) properly through ThingSpeak, Blynk media and stored data via MySQL database storage media. These data can be evaluated by interested parties such as welding department, quality department and management representative and then they can assess and conclude the welding quality acceptance based on those data analysis. Based on the WPS (welding procedure specification) used, the Heat Input acceptance is 0.2 KJ/mm – 1.2 KJ/mm. It

was found that the 21 welding data were not acceptable and corrective action shall be made by interested parties.

Keywords: IOT (Internet of Things), Heat Input, FCAW (Flux Core Arc Welding).

1 Introduction

In the development of the world oil and gas industry in particular, there have been significant changes with the presence of IOT (Internet of Things) technology [1]. The metal fabrication industry is slowly entering the automation stage, and also no exception in the welding sector. Most of the welding machines that have been produced by welding machine manufacturers have implemented IOT (Internet of Things). In general, these welding machine manufacturers apply IOT (Internet of Things) to automatic welding so that these manufacturers can control the welding parameters as desired. However, it is very difficult to control the welding parameters in semi-automatic welding where the role of the welder has a huge contribution to the welding process.

The author on this occasion wants to display a very important welding parameter, namely the Heat Input parameter / variable [2]. By analyzing these parameters, the relevant departments in the welding process can evaluate the welding results produced are in accordance with the desired or not.

2 Review of Literature

2.1. Definition of welding (welding).

There are 4 techniques to unite / combine metal materials, namely by welding (welding), brazing, soldering techniques (soldering) and adhesive bonding [3]. In the discussion of this Final Project, it is specifically discussed only for the welding process.

Welding is a fabrication process to combine 2 materials, usually metal and thermoplastic (polymer material) using heat application so that they melt simultaneously and through a cooling process to create fusion between the 2 metals. Arc welding is a welding process that uses an electric arc as a heat source and uses filler metal [4].

Welding processes in general and those commonly used in metal fabrication can be grouped into several processes: [4].

- SMAW (Shielded Metal Arc Welding)
- GTAW (Gas Tungsten arc Welding)
- GMAW (Gas Metal Arc Welding)
- FCAW (Flux Core Arc Welding)
- SAW (Submerged Arc Welding)
- PAW (Plasma Arc Welding)
- Electro gas Welding
- Stud Welding
- ESW (Electroslag Welding)
- Oxyfuel Gas Welding

In the design of this prototype, the discussion will be more specific on the FCAW (Flux Core Arc Welding) welding process.

2.2. Effect of Heat Input in the welding process.

Heat input is the transfer of heat energy per unit length in the welding process. Thermal energy is caused by welding parameters, namely current, voltage, electrode contact with the parent metal and welding travel speed. Heat input is an important factor in welding because it can affect the cooling rate. The cooling rate will play a role in the formation of metallurgical structures in the HAZ (Heat Affected Zone) and weld metal as well as the mechanical properties of the joint. To calculate the heat input in the welding process, you can use the following equation:

$$HI = \frac{V \times I}{Travel\ speed} \quad (1)$$

Where:

HI = Heat Input (J/mm or J/in)
V = Welding arc voltage (Voltage)
I = Welding current (Ampere)
Travel speed = Welding speed (mm/min or inch/min)

Citing research from the journal entitled "Effect of welding Heat Input on a microstructure and mechanical properties at coarse grain heat affected zone of ABS" (Effect of welding Heat Input on a microstructure and mechanical properties at coarse grain heat affected zone of ABS grade A) [5]. From this journal, several points are explained about the effect of the influence of Heat Input on the welding, including the microstructure of the welded product and its mechanical properties.

In the figure below, the Heat Input is explained by using a welded specimen that has been cut and analyzed for its macro and micro structures. You can see the difference in Heat Input from low, medium and high Heat Input.

Heat Input analysis based on its macro structure.

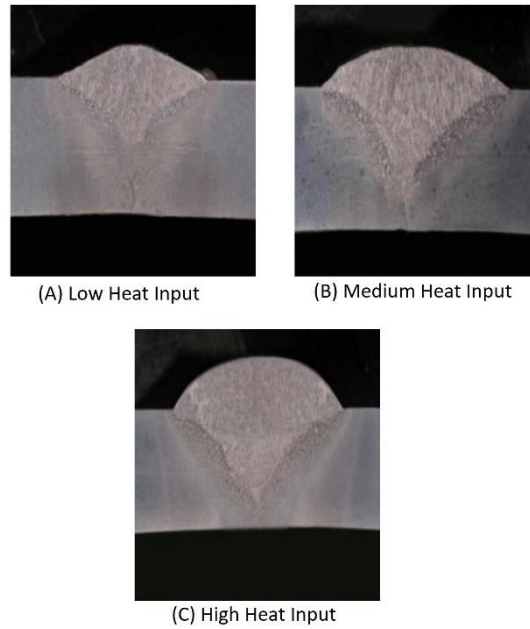


Figure 2.1 Comparison of Heat Input of welding results in macro structural analysis (Welding profile). In Figure 2.1, we can see the effect of Heat Input. At the crown of the weld (weld capping) and HAZ (Heat Affected Zone) will be wider along with the higher the Heat Input.

Heat input analysis based on its microstructure.

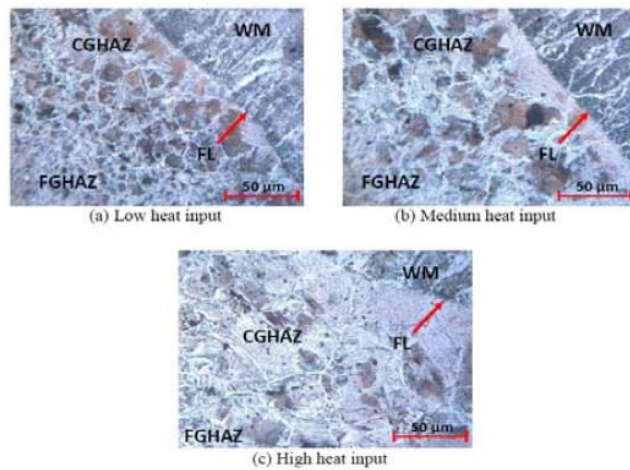


Figure 2.2 Comparison of the heat input of welding results in micro structure analysis. The microstructure analysis in Figure 2.2 above consists of an analysis of several zones, namely: the weld metal zone (WM-Weld Metal), the fusion line zone (FL-Fusion Line) and the Heat Affected Zone (HAZ). Where HAZ is divided into CG-HAZ (Coarse Grain HAZ) and FG-HAZ

(Fine Grain HAZ). When the Heat Input is up or high then the HAZ area will also increase proportionally. Heat Input will move the HAZ area away from the Fusion zone (FL-Fusion Line). And the size of the micro grain increases with the increase in the value of the Heat Input. Heat Input Analysis based on the strength of the hardness value (hardness).

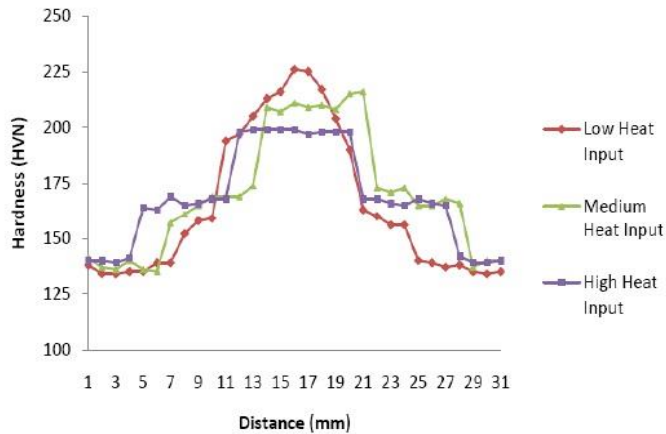


Figure 2.3 Comparison of the Heat Input of the welding results in the analysis of the hardness value (hardness).

From the data above, it shows that a low heat input produces a high hardness value, whereas a high heat input produces a low hardness value. Generally, in the world of metal fabrication, most fabricators want the end result of welding in a medium Heat Input area.

The conclusions of the Heat Input effect in welding are:

- The higher the Heat Input, the coarser the iron grains in terms of their microstructure. CG (Coarse Grain) occurs in thermal and diffusion cycle operations. Grain will approach the fusion line which is exposed to high temperatures so that grains are formed. On the other hand, at Low Heat Input, the roughness level of the iron grains is not very clear. This happens because of the recrystallization process in the HAZ (Heat Affected Zone).
- The higher the Heat Input, the hardness value will decrease at CGHAZ (Coarse Grain-HAZ). The high heat buildup that occurs in CGHAZ contributes to a decrease in the hardness value. While at Low Heat input, CGHAZ has not experienced heat buildup so that the Hardness value is relatively higher.
- The higher the Heat Input, the lower the Impact toughness. The higher the number of grains, the strength of the material will decrease and initiate cracks to appear. And on the other hand, at low heat input, the number of grains is less and it causes a high impact toughness value.
- The larger the grain size, the hardness and Impact toughness* value will decrease, and vice versa. The smaller the grain size, the higher the hardness and Impact toughness value.

2.3. Welding Procedure Specification – WPS.

The data needed to get a variable value from the Heat Input is data on welding current (amperes),

voltage and welding wire speed (travel speed). Parameter data for welding is made by a welding engineer referring to the welding standards to be used, for example, AWS (American Welding Society) standards, ASME (American Society of Mechanical Engineers), API (American Petroleum Institute) ISO (International Organization for Standardization) and so on. In the WPS there are various parameter values and the desired welding rules including the type of material to be welded.

In the Arduino IDE software, the value of the welding parameter / variable is set before the sensor is installed on the welding machine. Every change of WPS (Welding Procedure Specification) it must be reset on the Arduino IDE software.

2.4. IOT (Internet of Things) [1].

The basic concept of IoT is to connect electronic objects or devices together, making it possible to communicate with each other and enabling people to communicate with the equipment.

2.4.1 Microcontroller

The choice of microcontroller used in the prototype of this prototype is ESP32-32S.

2.4.2 Arduino IDE (Integrated Development Environment) software for programming languages.

Arduino IDE software is a special program that is open source for a computer whose role is to write programs, then compile it into binary code and upload it to the memory of the microcontroller [6].

2.4.3 Sensors used in data collection of welding parameter values.

- DC Voltage Sensor (Voltage)

Using analog pin ADC3 on the ESP32-32S microcontroller with 3.3V power. For that we need a voltage divider circuit using a resistor that matches the capacity of the microcontroller we are using.

- DC Current (Amperage) Strong Sensor

In the design of this prototype, using the welding current sensor HSTS023R. It is a hall effect based current sensor with $100\mu\Omega$ current conductor. The welding current sensor used is the Split core hall effect type (open loop circuit).

- Welding Speed Sensor

The welding speed sensor used is a sensor to measure the speed of the welding wire. In the FCAW welding process, the infrared sensor method is used to measure the speed of this welding wire using an LM393 optocoupler.

2.4.4 Blynk application for monitoring sensors on the smartphones.

Blynk is an application for iOS and Android operating systems to control Arduino, NodeMCU, Raspberry Pi and the like over the Internet. This application can be used to control hardware (hardware), display sensor data, store data, visualize and others.

2.4.5 ThingSpeak Website Application.

The ThingSpeak application is an open source "Internet of Things" application and API for storing and retrieving data from things using HTTP over the Internet or over a LAN (Local Area Network).

2.4.6 Database management system for data storage.

The database management used is MySQL which is supported by XAMPP and PHPMyAdmin applications.

2.4.6.1 MySQL

According to Sibero (2013: 97) "MySQL or read "My Sequel" is an RDBMS (Relational Database Management System) which is a system application that performs data processing functions "[7].

According to Hidayatullah and Jauhari (2015: 180) "MySQL is one of the DBMS applications that has been widely used by web application programmers. Examples of other DBMS are: PostgreSQL (freeware), SQL Server, MS Access from Microsoft, DB2 from IBM, Oracle and Oracle Corporation, Dbase, FoxPro, and so on.

Based on the two theories above, it can be concluded that MySQL is a SQL database management system software or DBMS that performs data processing functions to build web applications. Several MySQL support applications include PHPMyAdmin and XAMPP.

2.4.6.2 PHPMyadmin

According to Su Rahman (2013:21) "PhpMyAdmin is a PHP programming-based software that is used as a MySQL administrator through a (web) browser that is used for database management. PhpMyAdmin supports various MySQL activities such as managing data, tables, relations between tables, and so on" [9].

According to Agung Baitul Hikmah (2015:2) "PhpMyAdmin is an application that can be used to create databases, modify tables, and send databases quickly and easily without having to use SQL commands" [10].

Based on the two theories above, it can be concluded that PhpMyAdmin is a programming application that is used for database management via a browser (web) to control data and web content that will be displayed on a website without having to use SQL commands.

2.4.6.3 XAMPP

According to Purbadian (2016:1), argues that "XAMPP is an open-source software which is a development of LAMP (Linux, Apache, MySQL, PHP and Perl)" [11].

According to Kartini (2013: 27-26), "XAMPP is a tool that provides software packages into one package" [12].

Based on the two theories above, it can be concluded that XAMPP is an open-source software package development tool that combines Apache web server, MySQL, PHP and several other modules in one application package.

3 Methodology

3.1. Prototype Design

3.1.1 Block Diagram

The block diagram scheme below is a scheme for taking the value of the Heat Input parameter until that value can be accessed by all interested parties so that it can produce the desired weld quality and increase productivity and efficiency in the fabrication process.

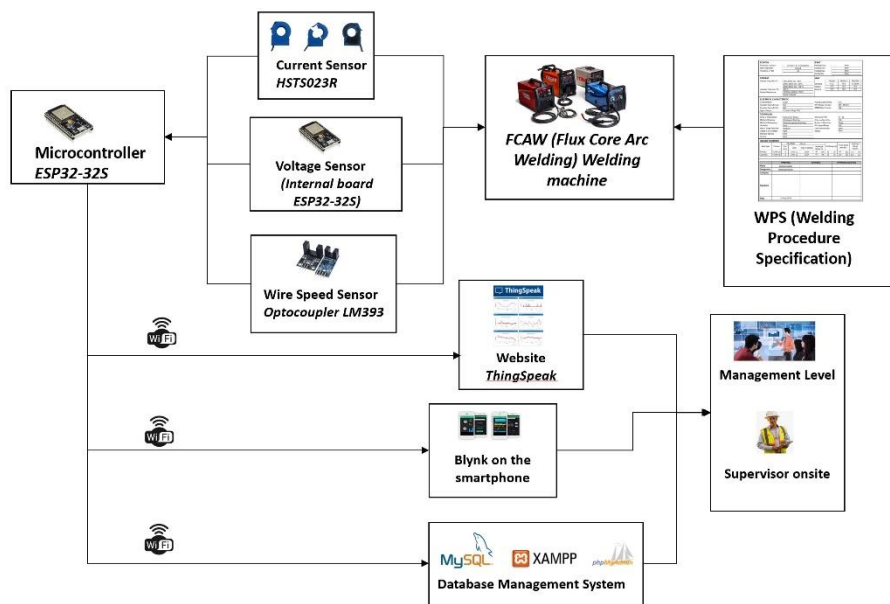


Figure 3.1 Block diagram

The above activities can be described with the following explanation:

1. The start of the activity is to set the welding parameter values as stated in the WPS on the FCAW welding machine both analogously and digitally depending on the type of welding machine.
2. The microcontroller is programmed so that its value limits correspond to the parameter values in the WPS.
3. All sensors are connected to the FCAW welding machine and the microcontroller.
4. The result of reading the value of each sensor is read by the microcontroller, namely the value of voltage (Voltage), current (Amperes) and welding wire speed (Travel Speed). And in the microcontroller also the Heat Input value is calculated by a mathematical function.
5. The values of those parameters are passed to multiple apps at the same time with WIFI connection. The applications are the ThingSpeak website application, the Blynk application and the MySQL database management application.
6. Relevant departments in this case the production and quality departments and management can access the application for monitoring / monitoring the Heat Input parameters where these

- parameters are the main parameters desired from a welding result. Monitoring the value of this Heat Input parameter can be accessed directly (online) or indirectly (offline).
- From the monitoring results, a decision can be made whether the parameter values are in accordance with the desired or not, so that the welding results can be accepted or not. If it is not accepted, then an evaluation is carried out both on the equipment / welding machine factor and the human error factor / welder. The sooner this data is analyzed, the faster the related parties will take action so that efficiency and productivity can be well maintained.

3.1.2 Prototype Electrical Design

This design tool uses EAGLE software to design Schematic diagrams and PCB's. The design of this tool also added an additional feature to measure AC welding current using the PZEM-004T sensor.

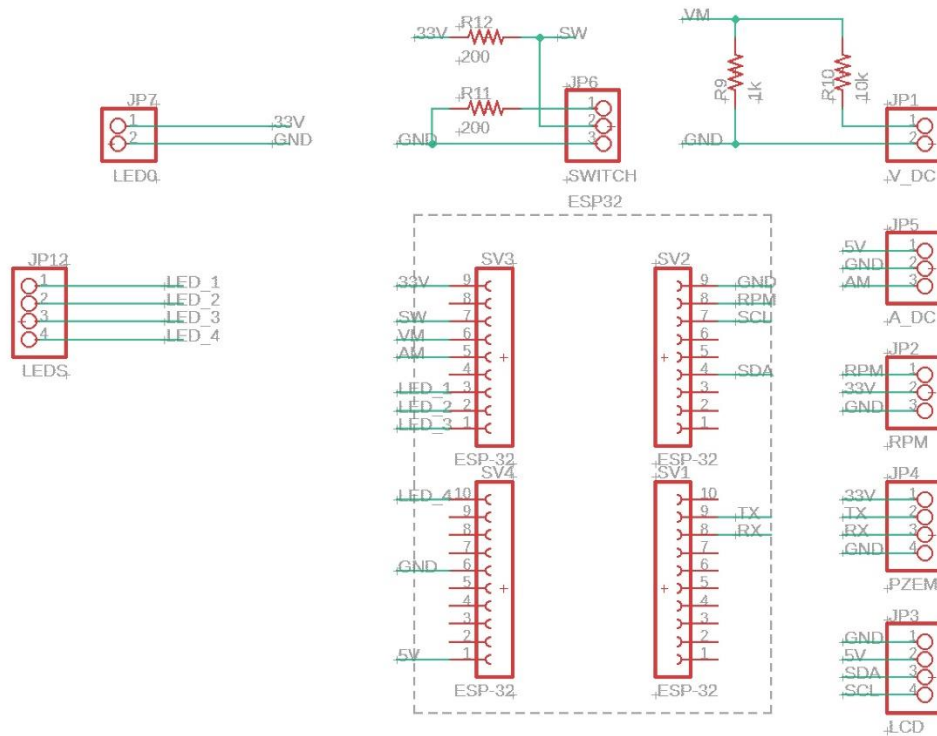


Figure 3.2 Schematic Diagram

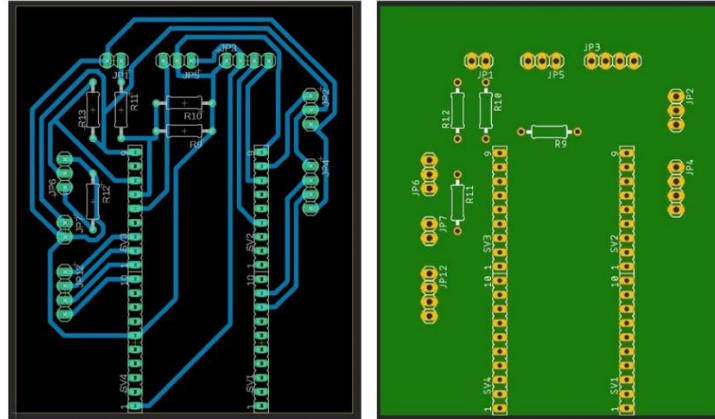


Figure 3.3 Printed Circuit Board (PCB).

3.1.3 Prototype Mechanical Design

The author designed the prototype using several components, such as 4 pcs red LED lights, 4 pcs blue LED lights, 1 pc 20x4 LCD, Toggle switch to change from AC, DC & AC/DC currents and a box with dimension 180mm x 110mm x 70mm from ABS plastic material.



Figure 3.4 Prototype of the mechanical design

Table 3.1 Description table of the mechanical design

No.	Description	Sensor type
1	Sensor for measuring DC welding current	HSTS023R
2	Sensor for measuring DC Voltage	ESP32-32S
3	Sensor for measuring welding wire speed (travel speed)	LM393
4	The toggle switch changes the display of the AC/DC, AC and DC system on the LCD.	-
5	LED indicator for welding wire speed (travel speed)	-
6	LED indicator for DC voltage	-
7	LED indicator for welding DC current	-
8	LED indicator for Heat Input	-

No.	Description	Sensor type
9	Socket for measuring AC current (ADD ON)	PZEM-004T
10	AC power input socket	-
11	LCD monitor to display data.	LCD 20x4
12	Power indicator (green LED)	-
13	USB connection (Power by power supply and to upload program from Arduino IDE)	-
14	Switch (Boot) button when uploading programs from Arduino IDE.	-

3.2. Testing the prototype

Testing the prototype is based on the test flow scheme below.

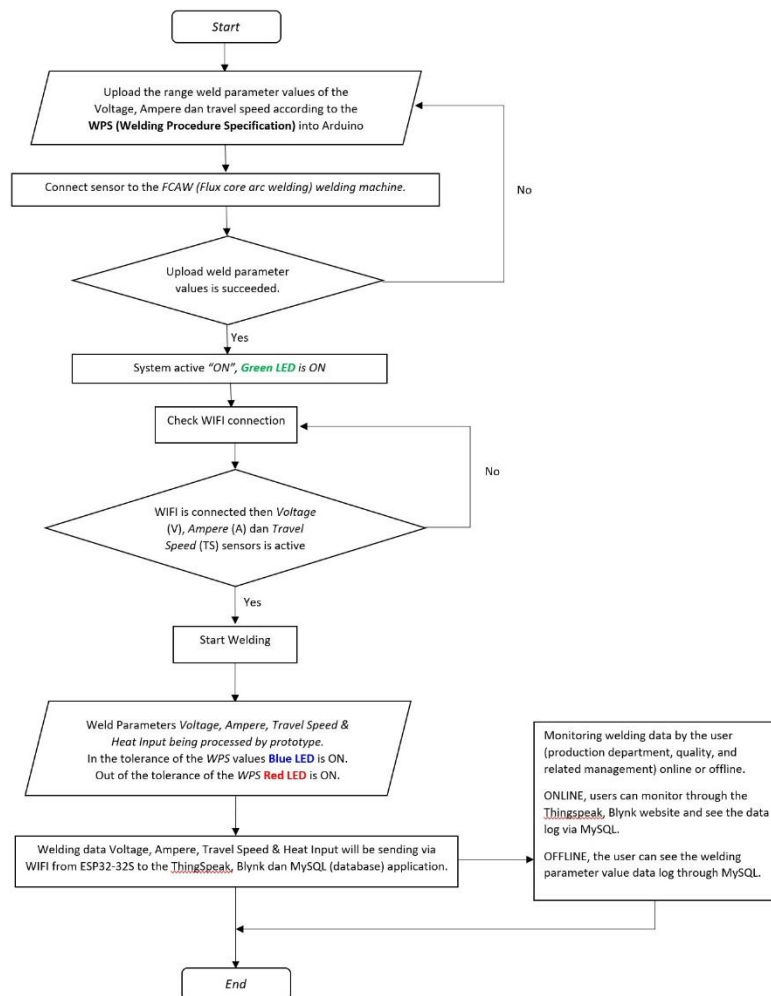


Figure 3.5 Flow scheme of the prototype testing.



1. Connect with a power supply (USB).



2. After connecting to WIFI, a detailed parameter display will appear.



3. Connect the speed sensor where the welding wire rotates.



4. Connecting the ESP-32S Voltage Sensor, the DC current positive and negative side.



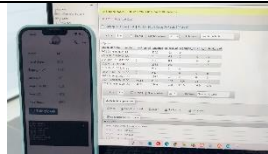
5. Positive current lies in the workpiece because the FCAW polarity is DCEN (Negative electrode).



6. Connect the HSTS023R 100A current sensor to the welding handlebars which are Negative current.



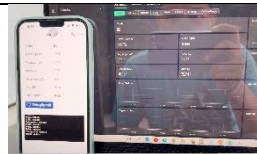
7. Comparing the measurement results between the Final Project prototype and the Blynk application and the results are the same.



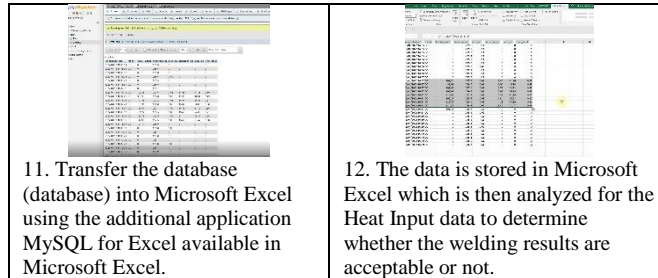
8. Checking the data in the MySQL database and confirmed that it is stored.



9. Monitoring from ThingSpeak app on online websites and stored data.



10. Compared the data on the Blynk smartphone app and the Blynk website and the results were the same.



11. Transfer the database (database) into Microsoft Excel using the additional application MySQL for Excel available in Microsoft Excel.

12. The data is stored in Microsoft Excel which is then analyzed for the Heat Input data to determine whether the welding results are acceptable or not.

Figure 3.6 Step by step of the prototype testing.

4 Data Analysis and Conclusion

4.1 Analysis of test data results based on the value of the Heat Input parameter that has been determined in the Welding Procedure Specification (WPS) by the Welding Engineer.

In testing of this prototype, the desired Heat Input Limit is 0.2 KJ/mm – 1.2 KJ/mm. The following is a graphic display of the welding that has been carried out during the test / data collection.

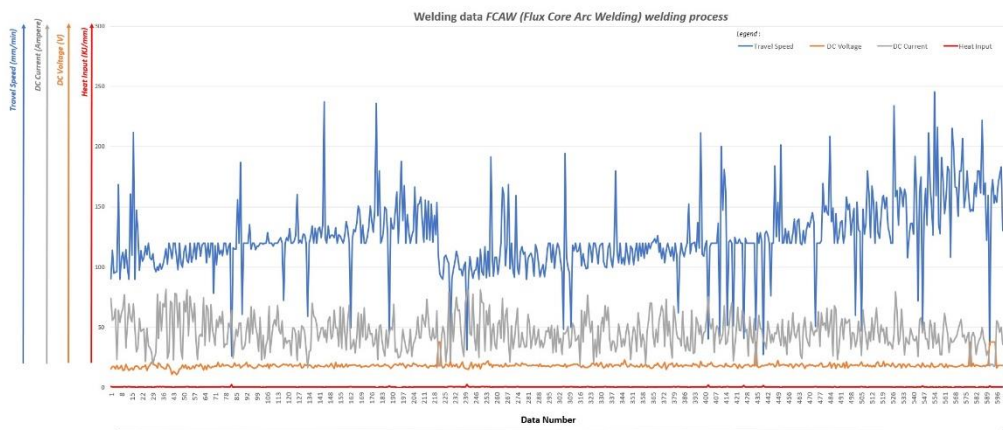


Figure 4.1 Graph of FCAW (Flux Core Arc Welding) welding parameter values displayed by the prototype.

4.1.1 Supporting analysis of test data results.

The author performs several supporting analyzes for each parameter value other than the main parameter (Heat Input).

4.1.1.1 Welding Travel Speed

- a) There are some data that show less / more than the welding procedure specification limit.

Table 4.1 Supporting analysis for Travel Speed parameter values.

No.	Number of Data	Date and Time	Mode	Travel speed (mm/min)
1	70	19/04/2022 11:52	DC	78,23
2	82	19/04/2022 11:59	DC	26,05
3	89	19/04/2022 12:01	DC	60,57
4	117	19/04/2022 12:10	DC	72,35
5	133	19/04/2022 12:15	DC	58,9
6	144	19/04/2022 12:18	DC	237,15
7	162	19/04/2022 12:23	DC	49,63
8	179	19/04/2022 12:30	DC	235,91
9	188	19/04/2022 12:33	DC	44,91
10	229	19/04/2022 13:39	DC	39,64
11	240	19/04/2022 13:42	DC	31,36
12	305	19/04/2022 14:04	DC	48,45
13	310	19/04/2022 14:05	DC	50,1
14	382	19/04/2022 14:30	DC	62,11
15	402	19/04/2022 14:36	DC	40,27
16	410	19/04/2022 14:38	DC	42,94
17	415	19/04/2022 14:39	DC	51,74
18	419	19/04/2022 14:40	DC	51,33
19	426	19/04/2022 14:41	DC	40,94
20	434	19/04/2022 14:43	DC	47,75
21	439	19/04/2022 14:46	DC	27,64
22	444	19/04/2022 14:47	DC	76,34
23	474	19/04/2022 14:54	DC	50,99
24	501	19/04/2022 15:04	DC	59,84
25	505	19/04/2022 15:05	DC	46,99
26	527	19/04/2022 15:21	DC	233,77
27	543	19/04/2022 15:21	DC	71,86
28	546	19/04/2022 15:31	DC	51,14
29	554	19/04/2022 15:33	DC	245,23
30	591	19/04/2022 15:46	DC	35,28

There are 30 data deviations from the welding procedure limit, after analysis, there is no consecutive welding time (the value is not sustainable). We can see this in the travel speed graph in the form of a sharp spike (peak value) but not sustainable.

So it can be concluded that this incident occurred at the beginning of welding and at the time of welding interruption.

The value that is out of the limit of the welding procedure for the travel speed parameter is not the main reference in making decisions for the relevant departments to accept / not accept the results of the welding performed. The main reference for the analysis is the value of the Heat Input parameter.

b) There are data anomalies such as continuous value shifts as shown in Figure 4.1

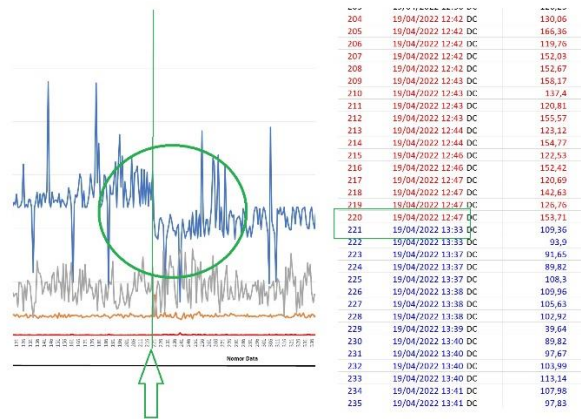


Figure 4.2 Analysis of travel speed parameter values (shift values on the travel speed parameter value graph)

Analysis of Figure 4.2 shows that there is a difference in welding time, meaning that this data was stopped and unsustainable (2 different welding's). The author analyzes this in relation to the ability of the welder, meaning that welding is carried out by different welders where abilities are also different or the welder takes a break so that he returns to his prime when working again. There is nothing strange in the parameter value because it is still stable and the value is within the limit of the welding procedure.

4.1.1.2 DC Voltage

There is an anomaly in some of the voltage value data (V) where this value exceeds the capability of the prototype. This prototype is designed at a maximum capacity of 30V with a voltage divider system on the ESP32-32S microcontroller.

Table 4.2 Supporting analysis for DC Voltage parameter values.

No.	Number of Data	Date And Time	Travel speed (mm/min)	DC Voltage (V)	DC Current (A)	Heat Input (KJ/mm)
1	221	19/04/2022 13:33	109,36	37,91	17,71	0,37
2	222	19/04/2022 13:33	93,9	37,91	17,82	0,43
3	434	19/04/2022 14:43	47,75	37,91	18,46	0,88
4	578	19/04/2022 15:39	145,99	37,91	17,82	0,28
5	591	19/04/2022 15:46	35,28	37,91	17,94	1,16

No.	Number of Data	Date And Time	Travel speed (mm/min)	DC Voltage (V)	DC Current (A)	Heat Input (KJ/mm)
6	592	19/04/20 22 15:47	158,59	37,91	19,33	0,28
7	593	19/04/20 22 15:47	172,58	37,91	19,16	0,25
8	594	19/04/20 22 15:47	153,06	37,91	17,47	0,26
9	595	19/04/20 22 15:47	159,28	37,91	18,34	0,26

DC voltage generally tends to be stable; this is proven in this prototype test. And welding generally uses a voltage value below 30V even with the use of high currents.

In table 4.2 there are 9 total data recorded at a value of 37.91V. The author performs the following analysis:

- 1) This data anomaly proves that there is an error in the ESP32-32S microcontroller itself because the voltage value should have damaged the microcontroller but in fact nothing happened to the microcontroller.
- 2) The data anomaly occurs at the same numerical value, namely 37.91V (there is no variation in other values). A total of 600 data have been carried out, the highest value of the voltage is 22.9V (there is a very significant difference in value).

Based on the two analyzes above, the authors conclude that there is an error in reading the voltage value by the ESP32-32S microcontroller.

4.1.1.3 DC Welding Current

In the DC current analysis, there are 70 data that are below the minimum limit of 30A or about 12% of the total 600 data. Low DC current can be caused by several factors, including:

- 1) Uncalibrated welding machine (tends to produce unstable DC current).
- 2) The distance between the welding wire and the workpiece (filler metal stick out / torch length) is too far. The closer the torch length is, the higher the current is and vice versa, the farther the torch length is, the lower the current generated. So, to maintain the desired current, special skills from a welder are needed.
- 3) The level of cleanliness of the workpiece surface (surface cleanliness) affects the level of stability of the welding current so that the welding is not optimal (the welding current tends to work at low currents).

Low current strength is still acceptable as long as the final value of the Heat Input is still within the limits specified in the welding procedure specifications.

4.1.2 Main analysis of test data results.

The main analysis on the test results is the value of the Heat Input parameter. The Heat Input value is analyzed based on the limit values that have been determined in the WPS (Welding Procedure Specification) where the acceptable Heat Input value is 0.2 KJ/mm – 1.2 KJ/mm.

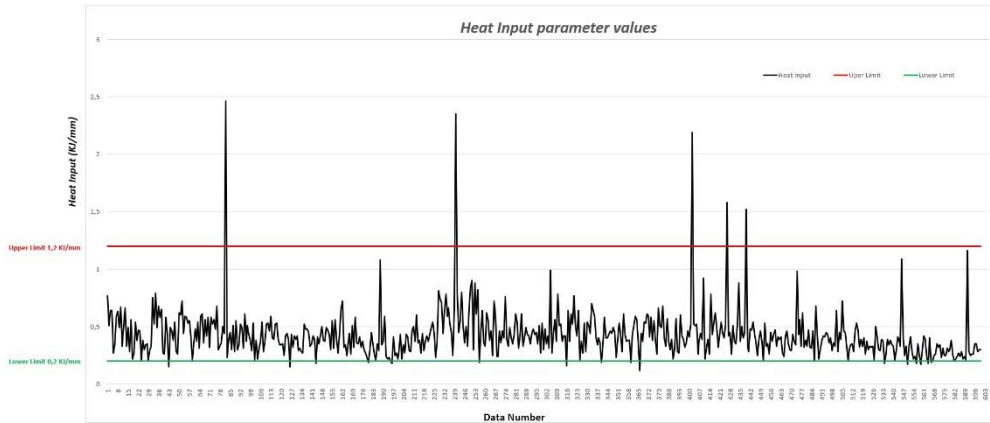


Figure 4.3 Graph of FCAW (Flux Core Arc Welding) Welding Input Heat parameter values displayed by the prototype.

Table 4.2 Fault analysis of the Heat Input Values (Out Of WPS parameter value)

Number Data	Travel Speed	DC Voltage	DC Current	Heat Input	Fault analysis
43	119,76	13,2	22,81	0,15	DC Voltage and Current is too low
82	26,05	16,7	64,05	2,46	Welding wire speed (Travel Speed) is too low. This occurs at the start of welding.
126	160,14	17,83	22,64	0,15	DC Current Value is too low. The welding technique of the Welder is not good.
144	237,15	16,9	41,6	0,18	The Heat Input value is too low.
180	142,63	19,23	23,22	0,19	DC Current Value is too low. The welding technique of the Welder is not good.
196	187,8	18,57	30,7	0,18	The Heat Input value is too low.
240	31,36	15,38	79,77	2,35	Welding wire speed (Travel Speed) is too low. This occurs at the start of welding.
256	191,29	19,54	30,99	0,19	The Heat Input value is too low.
316	119,76	17,86	18,17	0,16	DC Current Value is too low. The welding technique of the Welder is not good.
340	179,64	18,72	29,65	0,19	DC Current Value is too low. The welding technique of the Welder is not good.
360	119,76	19,71	19,39	0,19	DC Current Value is too low. The welding technique of the Welder is not good.
366	123,74	18,56	33,83	0,12	The Heat Input value is too low.
402	40,27	19,5	75,36	2,19	DC Current Value is too low. The welding technique of the Welder is not good.

Number Data	Travel Speed	DC Voltage	DC Current	Heat Input	Fault analysis
426	40,94	17,96	59,99	1,58	DC Current Value is too low. The welding technique of the Welder is not good.
439	27,64	18,05	38,82	1,52	DC Current Value is too low. The welding technique of the Welder is not good.
534	164,68	18,72	26,87	0,18	DC Current Value is too low. The welding technique of the Welder is not good.
550	211,27	18,12	32,15	0,17	The Heat Input value is too low.
556	215,83	17,52	37,95	0,18	The Heat Input value is too low.
559	191,08	19,66	27,22	0,17	DC Current Value is too low. The welding technique of the Welder is not good.
564	179,64	18,25	29,19	0,18	DC Current Value is too low. The welding technique of the Welder is not good.
566	215,31	17,91	37,53	0,19	The Heat Input value is too low.

These Heat Input parameter data are evaluated by the relevant team and it can be decided that the welding from the data is not acceptable so the results of the welding must be corrected.

4.2 Conclusion

After testing with a data range of 600 data, it can be concluded that the tool made is in accordance with the final purpose of writing this journal.

- (a) According to the title of this journal, the tool can read the welding parameter values properly, namely Voltage Value (Voltage), Strong Current (Amperes), Welding Wire Speed (Travel Speed) and Heat Input.
- (b) This tool can display welding parameter values wirelessly via ThingSpeak, Blynk media and stored data via MySQL database storage media.
- (c) The data displayed wirelessly can be accessed by interested parties (Production, Quality department & Management representative) in the welding process to evaluate the ongoing welding process.
- (d) Relevant parties / departments (Production, Quality department & Management representative) can make decisions regarding acceptable or not the results of welding carried out based on evaluation of actual data.

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