# Design and Development of a Portable Spot Welding Machine for Joining Metal using HCT

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***Abstract:***

*The project aims to spot weld the battery terminals without influencing the battery life. In view of accessibility of materials on neighborhood choice of different metal strips can be spot welded on the battery terminals. The high C rating of the battery builds the thickness of the metal strip to be utilized henceforth high thickness metal strip up to 0.7mm can be welded without influencing the battery life. This builds the battery existence with great contacts of metal strip is guaranteed. The current from the transformer is constrained by appropriate postpone timing of hand-off utilizing microcontroller. This decreases the super-hot spot of metal strips during welding.*

***Keywords:*** *Arduino, Spot welding, lithium ion battery, HCT.*

## 1. Introduction

The electric vehicle relies upon a lithium particle battery packs which has high limit and light weight. The lithium particle batteries can be made joining increasingly number of 3V volt lithium particle batteries as indicated by the necessary rating for high proficient and less warmth. This can be conceivable by utilizing the spot welding machine that can associate the metal strips with the battery terminals by utilizing a high present transformer (HCT) where the essential side is associated with supply and auxiliary side is associated with copper cathode. The opposition welding expel oxidized on metal strip and make it a decent lead between the batteries. The temperature sensor is utilized alongside spot welder to screen the battery temperature while welding. They lessen the temperature over the battery and increment the battery life.

### *1.1 Analysis of discussed spot welding system proposed*

The proposed system is to weld the battery pack easy and safety. The spot welder made helps the technicians to weld and connect the battery terminals properly and makes sure contacts are strong. The high current is supplied through high current transformer to weld the contacts. The high current transformer or step down transformer is driven through relay. The Arduino Uno ATMEGA32p controls the relay timing by proper delay. If the temperature of the battery increases the beyond certain limit it shuts down the transformer and allows the battery to cool down. A hand held press button is given to control the action of welding by the user. The spot welding of battery terminals using metal strips holds the battery pack tightly and conducts the current properly. This spot welder can be used to weld 0.1mm to 0.75mm thickness metal strips without increasing the battery temperature. The various metal strips can be spot welded such as nickel, stainless steel, copper based on their availability and capacity of battery pack produced. This will help in the production of high capacity with a crating battery packs. The lithium ion batteries are used in e-bike for their light in weight and high discharge. But the battery terminals are difficult to connect because of their flat surface and impossible to solder. The battery terminals should be connected in such a way. So, that the contacts should not be broken while vehicle running. The battery life should not be affected while connecting the battery terminals also the contact made between the terminals should be able to conduct high current instantaneously without any loss. The following block diagram of Fig.1 is shown.



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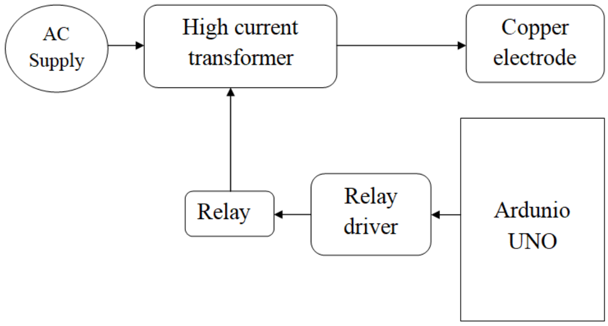


**Fig.1** Block Diagram

To make it possible spot welding is used to make weld the metal strips between the battery terminals. While increasing the C-rating of the battery the thickness of the metal strip should be increased. In existing spot welding machines, the high thickness metal strip cannot be welded the maximum thickness is 0.5mm in existing machines. The transformer is designed in such a way able to give its maximum power in duration of milliseconds. It is possible only if the transformer has higher power rating. Hence, by increasing the power rating the maximum power can be provided in milliseconds.

## 2. Methodology

### *2.1 Resistance Spot Welding*

The spot welding (RSW) which was developed by Elihu Thomson in 1877. It is one of the most broadly utilized assembling forms for joining sheet metals. RSW is where at least two metal sheets are welded together through the use of an electrical flow and weight between two cathodes. The electrical obstruction of the material at the interface brings about the age of warmth and melts the materials together without the utilization of filler material or gases. When welding with batteries, stray flows may emerge from the battery. This current neutralizes the applied present and should along these lines be represented with a higher applied introductory current. Excessively high of an applied current may anyway prompt anode staying. The strategy regularly utilizes a double heartbeat. The primary heartbeat takes out defilements and oxides, and the subsequent heartbeat welds the work sorts out. The temperature increments in the influenced territory, the interface, and inevitably arrives at the material's liquefying point. A weld piece shapes in the influenced zone in the wake of cooling. This is a little volume of the material which has softened and afterward melded.

RSW is the most established and a generally utilized welding technique in the car business. One of the focal points with RSW is that it doesn't require filler materials or gases and is effectively computerized for mechanical applications. It is a moderately modest and joining process in accomplished as must as brisk quick simultaneously a decent degree of value control can be accomplished. Flimsy sheets can be consummately joined yet nonetheless, RSW experiences issues creating enormous nuggets. A burden with the technique is that it isn't as helpful for exceptionally conductive materials and has hard to join multiple layers. The characteristics of the welds are too frequently difficult to research because of the weld's area being between the welded material and the weld quality may fluctuate from weld to weld because of commotion, inconstancy and blunders that emerge. Cathode staying is likewise a typical issue for RSW where the material may adhere to the terminal tip while welding. The physical marvel abused in obstruction spot welding to accomplish attachment between materials is called as electrical opposition. The obstruction is characterized as voltage to the current through a substance or material.

$R = \frac{V}{I}$……….. (1)

Where, V is voltage, R is resistance, I is current.



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At the point when electrons are avoided in a material they can be diverted either intelligently or incongruously. Intelligible avoidance infers the electron dissipated against an inflexible nuclear grid imperfection and didn't move any of its vitality to the deformity. Indistinguishable diversion infers the electron moved a portion of its vitality to the deformity. Exclusively cognizant redirectors may bring about a quantifiable opposition R, yet just muddled deformities offer ascent to vitality scattering and warmth age. The neighborhood heat age at the surface interface is ordinarily generally higher in light of the fact that there are increasingly incomprehensible imperfections there. In this way bringing about a more noteworthy warmth age between the surfaces of battery and metal strips.

### *2.2 Heat generation and dynamic resistance*

When watts and warmth are regarded as synonymous, an improvement of Ohm's Law could be made. The electrical obstruction of the channel to the flow stream will produce heat at the point where the flow goes through a conduit. The critical heat age recipe could be expressed as

$H = I^2R$........ (2)

Where, H = Heat The heat, $I^2$ = Welding Squared Current, R = Stamina.

The auxiliary bit of the welding circuit of an obstruction location, including the sections to be welded, is really a defensive progression. This electrical obstruction's all-out added material estimate affects the flow yield of the opposition spot welding machine and the circuit’s warm age. In all parts of the electrical circuit, the flow esteem is the equivalent, the opposition esteem will change dramatically at different focuses in the circuit. The induced warmth at any time in the circuit corresponds directly to the obstruction.

## 3. Electrode tip geometry

### *3.1 Flat electrode tip*

The welding electrode with off-center flat tip design is the easiest shape to manufacture due to its simple geometry; it does not produce effective weld results. Not only does the relatively large tip diameter yield inadequate deformation on work-pieces. But also contributes to a ring shape of current density distribution along the edge of electrode tip. There is higher current density along the outside edges of electrode tips where more reaction force (pressure contact) from the positive cap are presented causing uneven heat generation. Excessive diameter of electrode tip also conducts heat dispersion in the region between two welding, which results in a poor weld contact quality. Hence, this electrode shape is not suitable for spot welding on this battery cell.

### *3.2 Tapered electrode tip*

The tapered electrode tip, small welding points can be formed between work-pieces surfaces which contribute to higher current density flow at the welding point. Consequently, higher temperature can be generated developing a stronger welding contact. Although the tapered shaped electrode tips promote a better weld contact quality, it happens that the electrode tips get worn away quickly after several welding processes.

### *3.3 Round electrode tip*

From trial welding experimentation, it appears that the round-shaped electrode tips with small flat tip diameter offers similar spot weld results when compared to the tapered-shaped electrode tips, but with a moderate wear of electrode tips after the number of welding processes. Thus, it is more preferable than tapered electrode tips for mass production spot welding. However, the round-shaped tips are relatively more difficult and required more time to make them manually by hand. Accordingly, for a mass production spot welding, it is recommended to manufacture the welding electrodes with the CNC (Computer Control) machining to obtain a uniform geometry of electrode tips.

### *3.4 Connecting strip design*

There are flows of current along the upper layer of work pieces (connecting tab). Moreover, the current also shatteringly flows around two welding electrodes. These flow behaviors results in a dispersing of heat on the connecting tab, as a consequence a desired maximum temperature cannot



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reach. Thus, a higher input current is required in order to attain a melting temperature of material creating welded spots. Alternatively, connecting tabs with slot at the middle are being used in the market in favour of controlling the current flow paths to pass through small electrode tips down to the contact points between connecting tab and battery terminal without flowing along the middle region between two weld spots.

As a result, the welded spots are easier to obtain due to small region of heat are being generated and a higher maximum temperature can be reached. However, it can be noticed that there are also some current flows around the slot contour due to insufficient resistance along the path, this can be avoid by a modification of slot geometry to increase the resistance. For connecting tabs with thickness higher than 0.15 mm, higher input current is required. Other than using connecting tab having slot, they could easily promote small spots of current concentration. As a result, a decent weld contact can be formed at a lower input voltage current setting and the electrode life can be prolonged. With the same amount of current supply, using a connecting tab having slot at the middle would yields a better weld contact than the one without slot.

In other words, to equally achieve decent welded contacts strength, the connecting tab with slot required less input current than the normal one. Nevertheless, creating slot on the connecting tab required additional manufacturing process, consequently higher production time.

### *3.5 HCT*

The present transformer's basic concept is the same as that of the control transformer. The new transformer also comprises a main and a secondary winding, as does the new transformer. An alternating magnetic flux is produced whenever an alternating current flows through the primary winding, which then induces an alternating current in the secondary winding. The load impedance or 'burden' is very minimal in the case of current transformers. Therefore, under short circuit conditions, the existing transformer works. The current in the secondary winding also does not rely on load impedance, but relies on the current in the primary winding flowing instead. Basically, the present transformer consists of an iron core on which wounds are made of primary and secondary windings. The transformer’s primary winding is linked to the load in series and carries the actual current flowing to the load, while the secondary winding is linked to a measuring system or relay. The number of secondary turns is proportional to the current that flows through the primary; that is, the greater the amount of current that flows through the primary, the greater the number of secondary turns. The ratio of primary current and secondary current is referred to as the CT’s current transition ratio. The current CT transformation ratio is usually high. The secondary grades are usually in the order of 5 A, 1 A, 0.1 A, while the primary grades range from 10 A to 3000A or more. Far less power is managed by the CT. The rated load may be specified on the secondary side of the CT as the product of current and voltage. It is calculated in volt ampere (VA). When current is flowing in the primary, the secondary of a current transformer should not be isolated from its rated load. As the primary current is independent of the secondary current, when the secondary current is opened, the entire primary current functions as a magnetizing current. This results in a deep core saturation that cannot return to its normal state, so the CT can no longer be used. Fig 2 indicates the welded position that is used for connecting the batteries.

**Fig.2** HCT Welded Spot



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## 4. Experimental Procedures

A critical component in every electronic product design is the Power Supply Unit (PSU). Most electronic household goods, such as smartphone chargers, Bluetooth speakers, power banks, smart watches, etc., require a power supply circuit that can convert the AC power supply to 5V DC to operate them. In this project, with a 10W power rating, we will create a similar AC to DC power supply circuit. That is, the 220V AC mains will be converted to 5V by our circuit and provide up to 2A maximum output current. This power rating should be adequate to power most 5V running electronic devices. In electronics, the 5V 2A SMPS circuit is also very common since there are several microcontrollers operating on 5V. Arduino Uno is an 8-bit ATmega328P microcontroller based microcontroller board that is connected to the top power supply. In addition to the ATmega328P, the microcontroller is provided by other components such as the crystal oscillator, serial communication, voltage regulator, etc. There are 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue input pins, a USB link, a power barrel jack, an ICSP header, and a reset button. The relay is powered by this.

A +5V DC supply to one end of the coil and the other end to ground via a switch is used for the relay with a 5V trigger voltage. This switch can range from a small transistor to a microcontroller that can perform operational switching. It was also found that this diode is called the Fly Back Diode, a diode connected across the coil of the relay. The typical pin can be connected to one end of the load and the other end is either connected to NO or NC. If connected to NO, the load remains disconnected before the signal, and the transformer remains connected for 10ms when connected to NC.

A high current is a transformer, a system that transforms one voltage or current to another using the principles of electromagnetism. It consists of a pair of wounds around a magnetic core of insulated wire. The winding to which the voltage or current to be converted is connected is called the primary winding and the secondary winding is called the output winding. By heating the copper, the high current transformer (2.5KW) is used to weld the battery via the copper electrode.

The electrode attaches to the secondary transformer terminals. When the transformer 's high current is applied to the electrode, it welds the metal strips to the battery terminals. The copper electrode is used for high current and temperature resistance.

## 5. Conclusion

To improve efficiency and safety of batteries in electric vehicle, this paper proposed a better way by multiplying number of batteries according to requirement of the rating. The proposed spot welding can reduce percentage of risk of life of a battery while welding. Where this eliminates the use of soldering that may lack of connection due to external factors like climatic conditions and rough insipid.

## 6. Future Work

The present thesis includes knowledge regarding the process planning of Spot Welding. The results from this also identified future work for research in controlling the temperature that may affect the battery. The machine can be interfaced with the human by a display device that builds a bridge to fetch information and current status of machine. The IOT can also be implementing where the massive production of battery packs in plant for electric vehicle can connect with computer for fetching data to identify machine status and production in efficient way. They can have a data of battery pack with which time it is being produced and analysis purpose.

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