NUMBER OF SPOT ASSURANCE IN VEHICLE BODY SPOT WELDING

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Abstract

The project title indicates that to assure the correct number of spot welds on the vehicle body parts as per the design, which is coming out of the Innova under body welding section. In Toyota, there are more than 1366 spots in the Innova vehicle body spot welding process. Spot welding process carried out by operators and main problem is missing of spots during the process. Welding of multi spots at same point on the body parts is also happening during the spot welding process. These two problems lead to the strength deterioration and quality issue problems in the vehicle body. Once the vehicle body came out with defect or less number of spots as per design, it is difficult to find the problem in the next section. But at the end of spot welding process, if any vehicle body found defective, then the whole body send to rejection or rework. This project suggested the different spot assurance techniques with detailed drawings and circuit diagrams. All the technique suggested for assuring the correct spots according to the specification of the part in spot welding process and also avoiding multispot at same weld points during the spot welding process. Feasibility study of making equipment for spot assurance technique also completed. Out of ten suggested ideas, Toyota maintenance team selected most economical three ideas for implementation..

Keywords: Spot welding, Toyota, Deterioration, Multi spot etc.

1.Introduction

Spot welding is a type of resistance welding process in which overlapping sheets are joined by fusion at one or more points by generating heat due to the flow of electric current through the work pieces that are held together under the force by two electrodes. The major parameters in spot welding process are welding current, welding time and welding pressure. There are more than 1366 spots in the Innova vehicle body spot welding process. The main problem is missing of any spot during the process and also the welding of multi spot at the same weld point. It leads to the strength deterioration and quality issue problems in the vehicle body. Mainly the spot welding operation is performed by manually. So the chances of error or missing of spot is common. Currently they are counting and marking the spots with marker for assuring the correct number of spots has been welded during the spot welding process.

This projects aim to make a suitable equipment for assure the correct spots according to the specification of the part in spot welding process. And also make it automatically assure the spots and if there is any variation in number of spots, the equipment warns the operator about the missing of spots. Challenge of this project is implementation of the equipment in actual working condition

without any losses and interruption in the current set up of spot welding process. As the missing of spots is a main problem of vehicle body strength deterioration and quality issue, assuring of correct number of spot in the spot welding parts is very important. By doing this project it is assure that the parts will not come out from the welding shop without correct number of spot welding. It also aims to improve the quality of weld and avoid the waste time for marking the number of spots manually.

2. Methodology

Before discussing the methodology section, the main problems to be consider in this project are

    a. Spot missing during the spot welding operation
    b. Welding multi spot at same point in spot welding
    c. Unwanted welding gun triggering of operator during operation
    d. Rough handling of spot welding gun

So the methodology should design according to these factors. Methodology suggesting for these problems are, using the help of sensors, we can monitor the spots during spot welding operation. Monitoring of spots include the counting of spots on specified jigs and programming the spot counter according to the spot weld requirement of jig. Then according to the sensor output of spot counting correct number of spots can ensure. And for avoiding multi spots at same point, use a position sensor which detects current position of electrode or spot and if the operator try to weld multi spot at the same point, the sensor detects the operation and will inform that operator welded multi spot at same point using any indicator or alarm. This position sensor works in correlation with the spot counting sensor. Both this sensors should program according to their requirements.

Input for the spot counting sensor will be the vibration of the spot welding gun. It means, for each spot welding operation after forming the nugget, there is a vibration produced in the tip of electrodes and it transmit to the gun frame. So when the vibration of this range is produced, it means the nugget or spot weld is formed. So by sensing this vibration through the frame, we can accurately count the number of spots during spot welding operation.

If the spot counting sensor and position sensor can correlate and find solutions for spot missing and multi spot welding at same point. The installation of sensors on the gun is very important and finding a suitable place on the spot welding gun reduces the risk of failure of sensors due to rough handling of spot welding gun by the operator while performing spot welding process. The sensor for counting weld spots should sense vibration of the frame, that too in specified range. Piezoelectric and accelerometers are best for sensing the vibration. Piezo resistive sensor is also best for sensing vibrations. Proximity sensor can be used as the position sensor for avoiding multi spot at same point.

Installations of sensors are also very important. Vibration sensor should place at end of gun frame, so that it can detect the vibrations very easily and at that point the intensity of vibration is very high. Position sensor should place at tip of the spot welding gun. That area is suitable for its efficient operation. Program the sensor circuit and spot welding counter according to the requirements. Take utmost care while installing the circuit on the spot welding gun. Power needs to run the circuit can take from the existing power supply for the gun. Space requirement for the whole circuit is less, so that the new change in the spot welding gun will not interrupt normal working of gun.

7.2 Spot Assurance Techniques

1. Use of vibration sensor (Piezo electric sensor) for number of spot counting in spot welding operation.
2. Use signal from the weld timer at the time of welding for counting the number of spots.
3. Combination of vibration sensor on spot welding gun and three proximity sensor on gun hanger moving rails for counting number of spots in spot welding and to avoid multispot at same point.
4. Using one proximity sensor on spot welding gun hanger joint and two proximity sensors on gun hanger moving rails for counting number of spots in spot welding and to avoid multispot at same point.

5. Combination of using weld timer signal and three proximity sensors on gun hanger moving rails for counting number of spots in spot welding and to avoid multispot at same point.
6. Combination of vibration sensor on spot welding gun and position sensor on spot welding gun handle for counting number of spots in spot welding and to avoid multispot at same point.
7. Combination of signal from weld timer and position sensor on spot welding handle for counting number of spots in spot welding and to avoid multispot at same point.
8. Combination of vibration sensor on spot welding gun and three proximity sensors on spot gun hanger moving rails with mini compact Programmable Logic Controllers (PLC) for counting number of spots in spot welding and to avoid multispot at same point.
9. Combination of position sensor on spot gun handle and vibration sensor on spot welding gun with mini compact Programmable Logic Controllers (PLC) for counting number of spots in spot welding and to avoid multispot at same point.
10. Combination of using weld timer signal and three proximity sensors on gun hanger moving rails with mini compact Programmable Logic Controllers (PLC) for counting number of spots in spot welding and to avoid multispot at same point.

There are ten number of project ideas suggested. All those ideas are described below:

1. Using vibration sensor
2.

Vibration sensors are used in this method to detect the vibrations. During the weld nugget formation of spot weld, high magnitude vibration is producing inside the gun handle and it is transmitting through the gun handle. So it is possible to count the number of spot weld from this vibration as input. This method is using only for the number of spot weld counting.
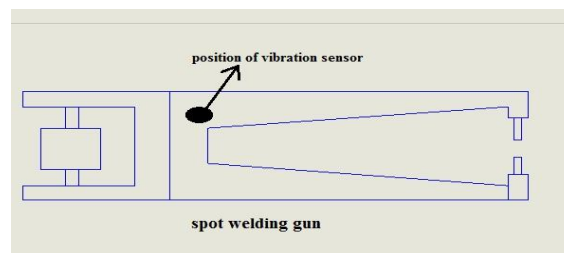

Figure 1: Position of vibration sensor

Position of vibration sensor and its attachment is shown in the figure. The circuit diagram for this method is shown below.
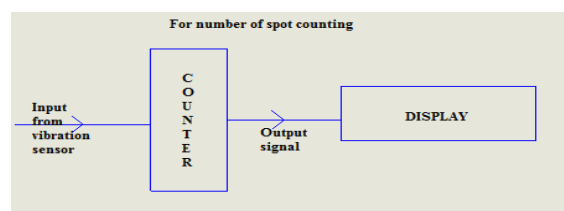

Figure 2: Circuit diagram for number of spot counting

2. Using weld timer signal as input

In this case the aim is to count number of spots in spot welding operation. No sensor is used in this method. Weld timer is an electronic circuit associated with resistance spot welding gun and it controls the welding operation. It is placed separately from spot welding gun. Weld timer controls the current and time of resistance spot welding process. So whenever spot is form, current is passed from the weld timer only. So by taking this as the input for spot counting, it is possible to count number of spot in spot assurance technique and the operation will be accurate. Multisport at same point cannot be avoided with this method. Circuit diagram for this method is shown below:
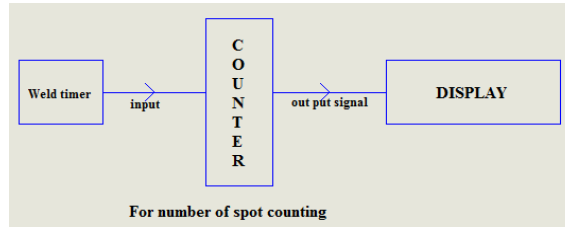
Figure 3: Circuit diagram for number of spot counting

3. Combination of vibration sensor and proximity sensors on gun hanger moving rails

This method is the combination of vibration and proximity sensor. It is suitable for counting number of spots and to avoid multispot at same point. Vibration sensor is attached to the gun handle. But the three proximity sensors are attached to the gun hanger moving rails. The arrangements are shown in the figure:
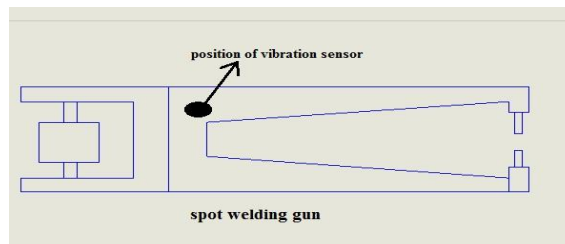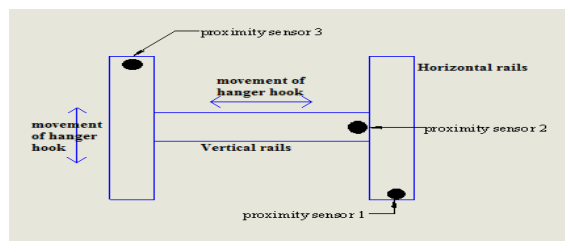

Figure 4: Position of vibration sensor

Figure 5: Position of proximity sensors on gun hanger moving rails

The circuit diagrams corresponding to the arrangements are shown below:
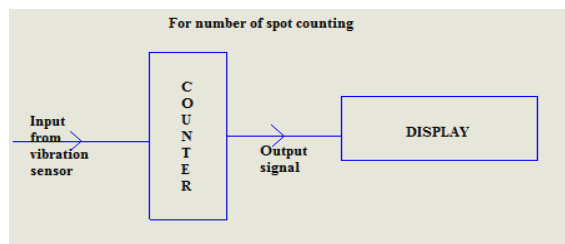
Figure 6: Circuit diagram for number of spot counting
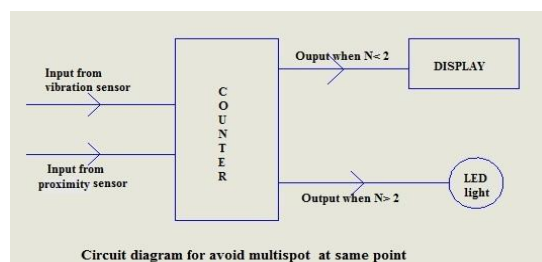
Figure 7: Circuit diagram for avoid multi spot at same point

There is separate counter for counting the number of spots and also separate counter for multispot counting circuit. In multispot counting circuit, both the input signals are given to the counter. And the output there is two options if the operator welds the two or more spot at same point, LED light will blink and if the operator did the correct weld it will show in the display.

4. Using proximity sensor in gun hanger joint and hanger moving rails with vibration sensor

This method is the combination of vibration and proximity sensor. It is suitable for counting number of spots and to avoid multispot at same point. Vibration sensor is attached to the gun handle. But the two proximity sensors are attached to the gun hanger moving rails and one proximity sensor is attached to the gun hanger joint. The arrangements are shown in the figure:
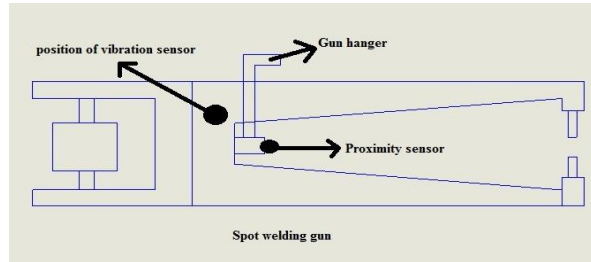

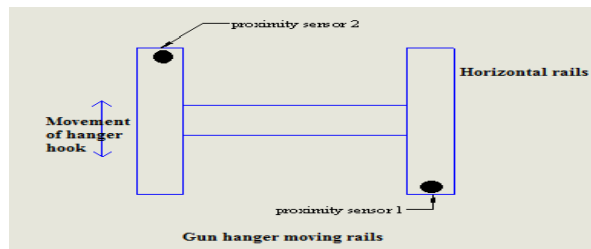Figure 8: Position of vibration and proximity sensor

Figure 9: Position of proximity sensors on gun hanger moving rails

Circuit diagrams for these arrangements are shown below:
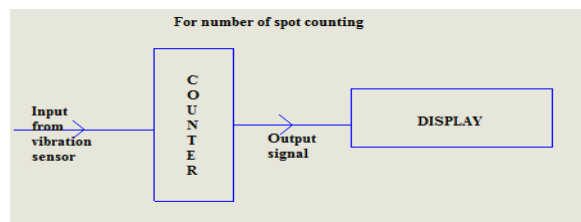

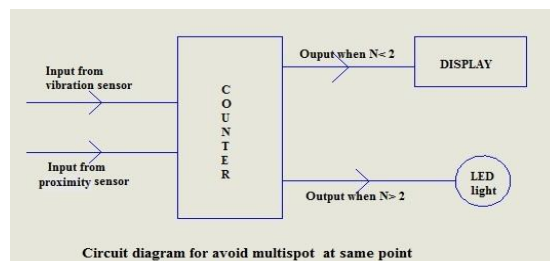Figure 10: Circuit diagram for number of spot counting

Figure 11: Circuit diagram for avoid multi spot at same point

Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

5. Combination of weld timer and proximity sensor on the gun hanger moving rails

In this combination weld timer is used to count the number of spots as well as to avoid multispot at same point with the help of three proximity sensors on the gun hanger moving rails. No sensor is used for the number of spot counting but for avoids multispot at same point; three proximity sensors are placed on the gun hanger moving rails. The arrangements are shown in the figure:
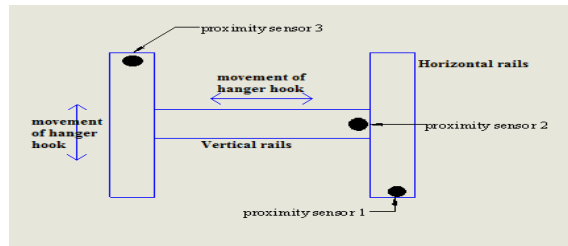

Figure 12: Position of proximity sensors on the gun hanger moving rails

Proximity sensors on the horizontal rails will give the change in position of the gun moving in horizontal direction. And operator moves the spot welding gun in vertical direction, sensor on the vertical rail will measure the change in position. Commonly two counters are using for both the operation.

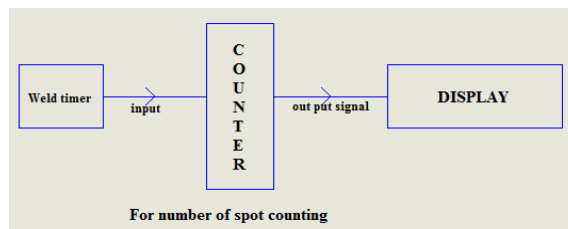Circuit diagrams corresponding to weld timer and proximity arrangement are shown below:

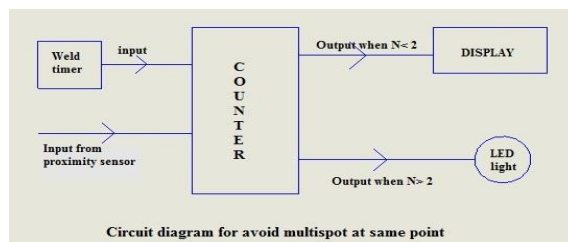Figure 13: Circuit diagram for number of spot counting

Figure 14: Circuit diagram for avoid multi spot at same point

Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

6. Combination of vibration and position sensor on gun handle

This design is also count the number of spots and to avoid multispot at same point. For counting number of spot welds vibration sensor is using and to avoid multispot at same point combination of vibration and position sensor is using. Position sensor is placed near to the shank of the gun and vibration sensor is attached to the other end of spot welding gun as shown in the figure:
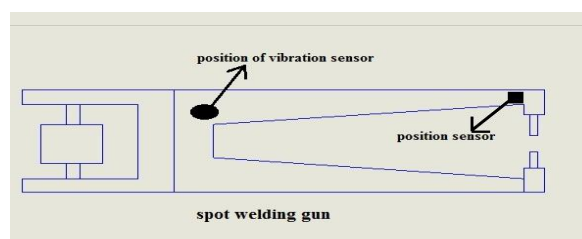

Figure 15: Location of vibration and position sensor on the spot welding gun

During the weld nugget formation of spot weld, high magnitude vibration is producing inside the gun handle and it is transmitting through the gun handle. So it is possible to count the number of spot weld from this vibration as input. Combining the vibration sensor output and position sensor output, it is possible to avoid the multispot at same point. When the operator weld more than one spot at same point, then the system will alarm about this faulty operation.

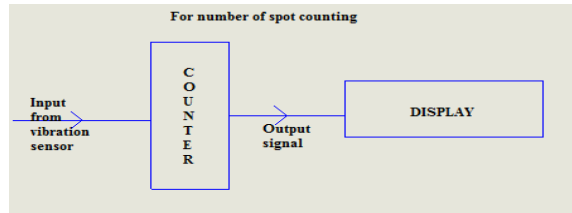Circuit diagrams of the arrangement of vibration and position sensors are shown below:

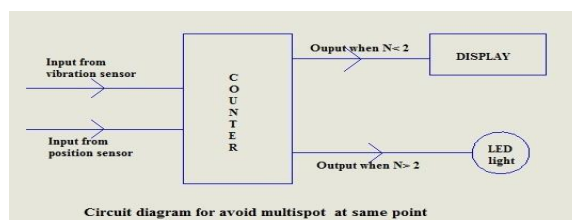Figure 16: Circuit diagram for number of spot counting

Figure 17:Circuit diagram for avoid multi spot at same point

Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

7. Combination of weld timer and position sensor in gun handle

This design is using only one sensor and weld timer signal as input. It is suitable for number of spot counting and to avoid multispot at same point. Position sensor is covered with plaster to protect it from spatters during the spot welding operation. And this is the point where it can operate well and will not damage while the operator rough handle the spot welding gun. The arrangement is shown in the figure:
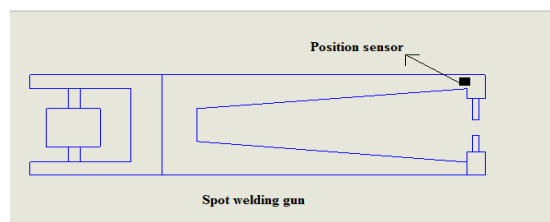

Figure 18: Location of position sensor on the gun handle

Position sensor attached to the gun handle is for trace the position of spot gun electrode. Whenever operator changes the position, position sensor output will also change. And when operator keeps the gun at same point it will detect that position until the spot gun moves from that position. This idea is behind the spot assurance technique in this section. When operator weld more than one at same point, two output form weld timer and position sensor goes to the counter, there it compare with the conditions and as per conditions one output will come out from the counter.
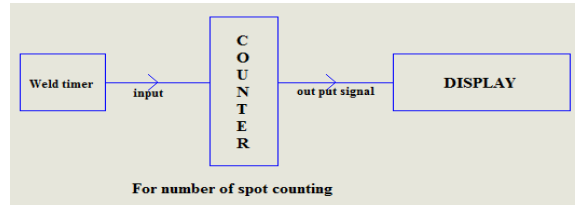
Circuit diagrams are shown below:

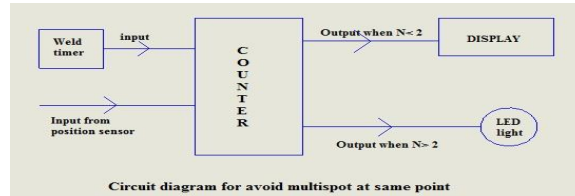Figure 19: Circuit diagram for number of spot counting

Figure 20: Circuit diagram for avoid multi spot at same point

Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

8. Combination of vibration and proximity sensors on gun hanger moving rails with programmable logic controller (PLC)

In this method instead of counters, programmable logic controller (PLC) is using. While in counter circuit, separate counters are used for counting the number of spots and multispot counting operation. In this case only one PLC is using and it reduces the complexity in circuit design. The arrangements are shown in the figure:
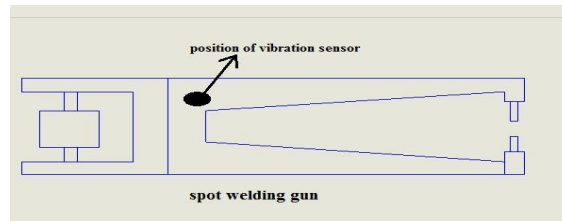

Figure 21: Position of vibration sensor
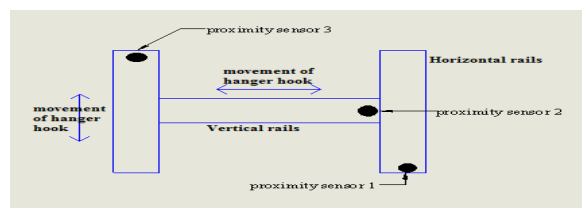
Figure 22: Position of proximity sensors on gun hanger moving rails

Proximity sensors on the horizontal rails will give the change in position of the gun moving in horizontal direction. And operator moves the spot welding gun in vertical direction, sensor on the vertical rail will measure the change in position. Commonly two counters are using for both the operation.

Circuit diagram of vibration and proximity sensors with programmable logic controller is shown below:

Figure 23: Circuit diagram for spot counting and multispot checking

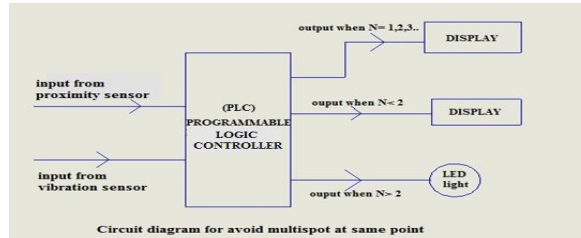In this combination instead of counter, PLC is using. So it not complicated like counter circuit. First the PLC should program as per the requirement using ladder logic. Then connect the sensors as per circuit diagram. While working for counting number of spots, circuit have separate one display and for avoid multispot at same point, one display and LED light is using. Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

9. Combination of position and vibration sensor with programmable logic controller (PLC)

In this the position sensor is attached near to the shank of spot gun. Vibration sensor is attached to the rear part of the gun or near to the triggering switch in the spot gun. The setup is shown below:
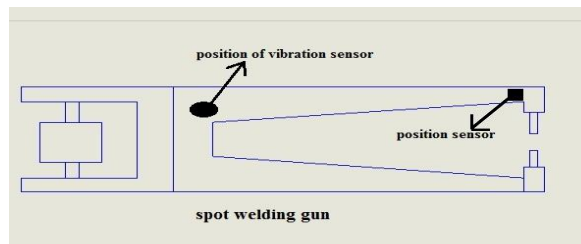

Figure 24: Location of vibration and position sensor on the spot welding gun

During the weld nugget formation of spot weld, high magnitude vibration is producing inside the gun handle and it is transmitting through the gun handle. So it is possible to count the number of spot weld from this vibration as input. Combining the vibration sensor output and position sensor output, it is possible to avoid the multispot at same point. When the operator weld more than one spot at same point, then the system will alarm about this faulty operation. In addition to this set up one programmable logic controller in included for controlling the spot counting operations.The circuit consist only one programmable logic controller, which avoid the use of counters. Total two circuits are integrated to one circuit by the use of programmable logic controller (PLC).

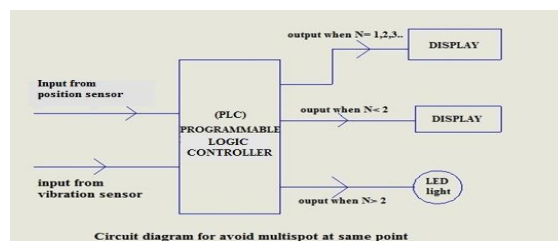Corresponding circuit diagram is shown below:

Figure 25: Circuit diagram for spot counting and multispot checking

In this combination instead of counter, PLC is using. So it not complicated like counter circuit. First the PLC should program as per the requirement using ladder logic. Then connect the sensors as per

circuit diagram. While working for counting number of spots, circuit have separate one display and for avoid multispot at same point, one display and LED light is using. Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

10. Combination of weld timer input and proximity sensors on gun hanger moving rails with programmable logic controller (PLC)

In this design the proximity sensors are attached to the gun hanger moving rails. Weld timer input is using for spot counting and to avoid multispot at same point with the help of proximity sensors. The setup for the idea is shown below:
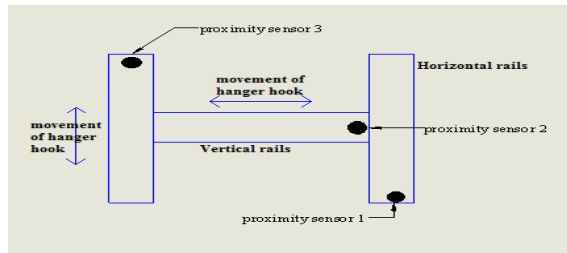

Figure 26: Position of proximity sensors on gun hanger moving rails

Proximity sensors on the horizontal rails will give the change in position of the gun moving in horizontal direction. And operator moves the spot welding gun in vertical direction, sensor on the vertical rail will measure the change in position. Commonly two counters are using for both the operation. Weld timer signal is used for to count the number of spot during the resistance spot welding operation. Both the input from weld timer and proximity sensors are using for to avoid multispot at same point.
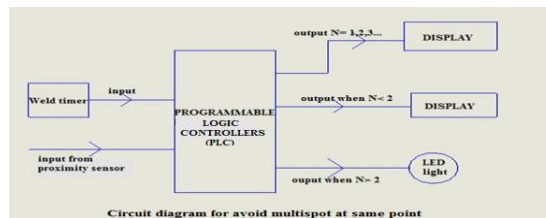
Corresponding circuit diagram is shown below:

Figure 27: Circuit diagram for spot counting and multispot checking

In this combination instead of counter, PLC is using. So it not complicated like counter circuit. First the PLC should program as per the requirement using ladder logic. Then connect the sensors as per circuit diagram. While working for counting number of spots, circuit have separate one display and for avoid multispot at same point, one display and LED light is using. Circuit diagram for avoid multi spot counts shows that whenever the operator weld more than one spot at same point output will goes to the LED light and the light will lit. It shows the clear indication of multispot at same point.

Ladder Logic

[7]Ladder logic is the programming language for programmable logic controllers that represent a program by graphical diagram based on circuit diagram of relay logic hardware. Based on the similarity to the ladders, with two vertical rails and series of horizontal rungs in between them, the program is known as ladder logic.

There are other PLC programming software's also. But ladder programming is the simplest one. It can be used for simple systems, critical control systems or reworks old hardwired relay circuit. It is also using for very complex automation systems. By learning this simple program, technicians can develop software without the help of high end programming languages such as FORTRAN or any other languages. The implementation of ladder logic having its own characteristics. They are sequential execution and support for control flow features.

Programmable logic controller manufactures also provide associated ladder logic programming. But ladder logic program from two different manufactures will not be compatible. So ladder logic is actually a set of closely related programming languages rather than one language. And different models in the same family of plc's may have different ladder notations, so that the programs cannot be interchanged between models. Ladder logic is a rule – based language and rung in the ladder represents a rule. When ladder logic program is implemented in a PLC, software execute the rules sequentially in a continuous loop.

3.RESULTS

Totally ten number of spot assurance techniques have been suggested with detailed design and description. All these ideas are based on the thorough observation and study of resistance spot welding, operator behavior, spot welding parameters and spot welding jigs. Feasibility study of the all the spot assurance techniques have been completed. Out of ten techniques, three of them are very economical, accurate spot counting, avoid multispot at same point and will not make any problem for the current set of spot welding gun during installations. They are:

1) Combination of vibration sensor on spot welding gun and three proximity sensor on gun hanger moving rails for counting number of spots in spot welding and to avoid multispot at same point.

2) Using one proximity sensor on spot welding gun hanger joint and two proximity sensors on gun hanger moving rails for counting number of spots in spot welding and to avoid multispot at same point.

2) Combination of using weld timer signal and three proximity sensors on gun hanger moving rails with mini compact Programmable Logic Controllers (PLC) for counting number of spots in spot welding and to avoid multispot at same point.

4.CONCLUSIONS

The solutions for spot assurance techniques we have presented in front of maintenance team of Toyota because maintenance team is responsible for the implementation of any new ideas in the existing machines or instruments in the shop floor. Maintenance team is approved the three techniques as mentioned in the result and discussion part of this project report. But they need time for installation and want to conduct a study from their side also. Then maintenance will submit that report to the higher officials, if they approve the project then only they can implement these spot assurance technique in actual working condition. But as a part of study from maintenance department, they can do the trial run of this spot assurance solution. But meantime the project duration got over and we couldn't be the part of trial run of spot assurance techniques before implementing the actual working situation in shop floor.

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