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MAMAGEMENT OF OVERALL PRODUCTIVITY IN SPOT WELDING CARRIED OUT IN WELD DIVISION OF A LIMITED COMPANY

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ABSTRACT
In the highly competitive nature of the automotive industry there is always demand for improvements and increased precision engineering in the area of spot welding. The present experimental study addresses the issue of management of overall productivity in spot welding process used in the weld division of automobile limited company. By studying the weld division area for a stipulated period, and having obtained an understanding of the working methods, it was observed that there was more spatter formation during the spot welding process in the weld division which required immediate addressing as it adversely affected the productivity of the company by creating unsafe working environment for the operators and inturn affecting the morale & overall performance of them, causing weld defects due to weld separation and spot burr which in turn increased the cost of rework and scraps. Thus, to overcome the above problems, the spatter reduction activity was carried out to improve overall productivity. The management came forward in implementing the countermeasures which resulted in improved working conditions, reduction in defects and rework time by 33%, reduction in Defects per Vehicle (DVP) by 29%, reduction in rework cost by 66% and reduction in safety gears consumption by 11% hence increasing the overall productivity and the managerial aspects of the company.

KEYWORDS
Spatter, Spot welding, jig, Cause and Effect Diagram, Spot burr, Hanare Defects.

INTRODUCTION
Spot welding is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat generated by the resistance to the flow of electric current through work pieces that are held together under force by two electrodes, one above the other below overlapping sheets. The normal welding parameters considered for spot welding are current-9000-15000 A., Time-10-25 cycles and pressure-200-400 KPa. Spot welding process finds extensive application in automobile and aircraft industries because of its advantages like; low cost, dependability, high speed welding, high uniformity of products and no edge preparation required over other welding processes. Spot welding gun is one of the most important equipment in spot welding process. Gun handle, trigger, Pneumatic cylinder, gun yoke, tip shank & tips involved are the major parts of a welding gun. There are different types of guns with different shapes based on the requirements such as C and X guns' guns are used to weld horizontal panels whereas X guns are used for vertical panels. The power transmission in spot welding is done using a step down transformer .power is transmitted by using aid cables which are made up of many strands of fine copper wire twisted into ropes which in turn are twisted together to form the body of the cable. A neoprene dipped cotton braid protects the cable. The cables are equipped with internal cooling system which flows between the insulated cable and cotton wire in order to cool the tip and the gun from the large amount of heat generated during the welding process. The electrodes used in spot welding possess good mechanical strength and hardness at high temperatures. The tip of the electrodes are usually made from copper alloys and are of 3 types i.e.; pointed, domed and flat tip. Electrode tip maintenance plays a vital role in determining the quality of the weld since the tip is the main component of the spot welding that comes in contact with joining metals and determines the area over which current and pressure are distributed. The defects caused in spot welding due to various parameters such as improper gun, varying welding parameters, usage of improper gun tips and impurities on welding surface are as follows; Spatter, spot hanare, pin hole, spot hole, spot burr, spot miss and pitch NG. Spatter is the metal particles blown away from the welding spot, which create an unsafe working environment to the workers on the shop floor and damages the safety gears. Hanare is a Japanese word meaning separation. After welding, a part or panel getting separated from the welded point is called as spot hanare or hanare defects. These defects in turn affects the overall productivity by decreasing the strength of the spot weld, increasing rework or MUDA, causes damage to the equipments and safety gears, causes injuries to the operators and eventually the company's quality reputation.

METHODOLOGY
Methodology is a description of process, simple set of methods or procedures, concepts or ideas that relate to a particular discipline or field of inquiry. In the proposed study the methodology planned is as listed below;
- Preliminary Observation
- Construction of cause and effect diagram
- Model Area Selection
- Implementation of Countermeasure
- Jig wise spatter analysis
- Evaluation

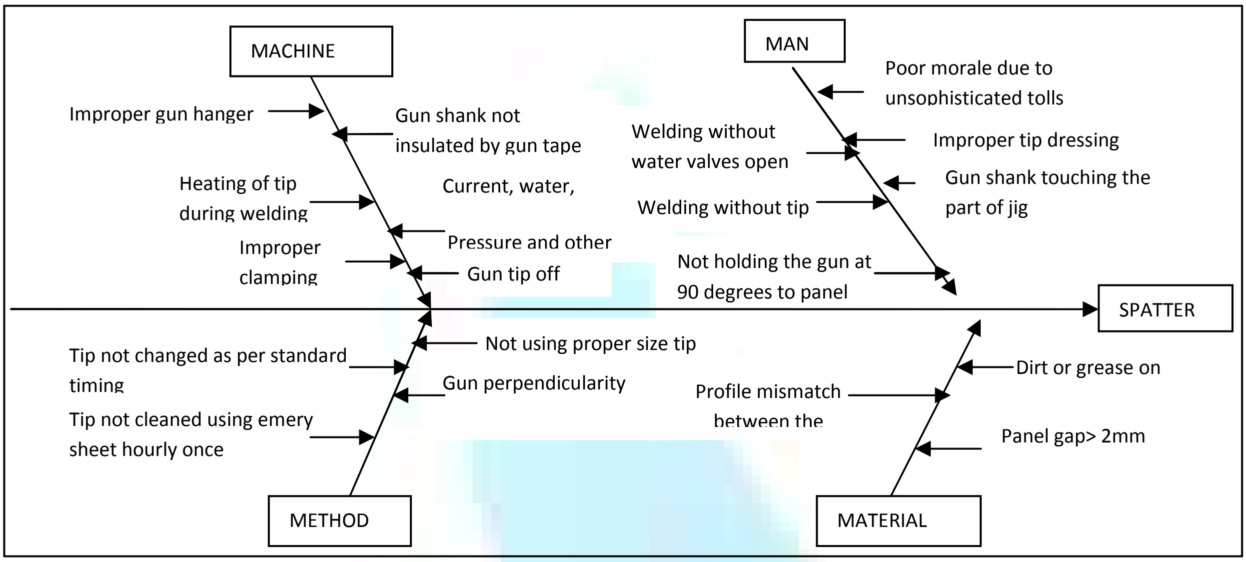
PRELIMINARY OBSERVATION
During the initial observation period in the weld section line it is noted that there is more spatter formation during welding which caused inconvenience for the operators, which inturn lead to more number of defective pieces. A spatter analysis was carried out in order to analyse the intensity of spatter formation in all

jigs of the weld line. Each gun in the line was observed for the length and intensity of spatter, and all the guns were rated on average length and intensity of the spatter formed at each gun. The guns producing high intensity spatter of length more than 3 meters were rated A, the guns with low intensity spatter of less than 1 meter was rated as D and others were rated in between as B & C.The jig wise spatter analysis was carried out for four processes namely; main body (9 jigs), under body (9 jigs), side member (26 jigs) and cowl sub assembly (8 jigs).

CONSTRUCTION OF CAUSE AND EFFECT DIAGRAM

The possible factors causing spatter were noted down during the preliminary observation period with reference to 4M's- Man, Machine, Method & material after which a fish bone diagram was constructed to analyse the causes and their effects on spatter formation as shown below in Fig.1.

FIG.1: CAUSE AND EFFECT DIAGRAM



From the above cause and effect diagram, it is analysed that the following factors were the causes for spatter formation;

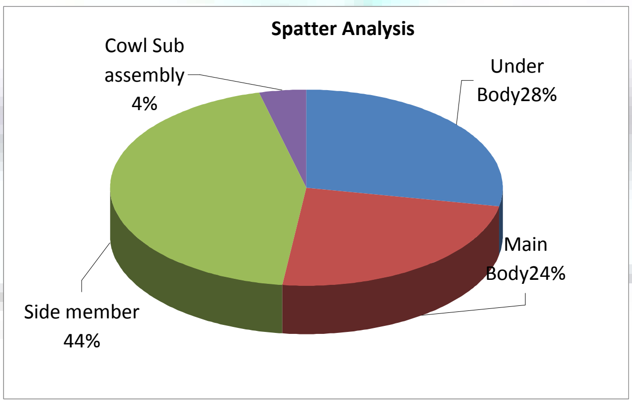
- Improper jig Layout
- Improper gun handing(non perpendicularity of the gun to panel surface)
- Excessive gap between the panels
- Presence of impurities on panel surfaces
- Tip offset beyond the surface limit
- Improper alignment of gun hanger
- Improper gun guide
- Kick-less cable position.
- Poor morale of the operators due to unsophisticated tools

MODEL AREA SELECTION

The next step in the study was to select a model area for the implementation of the countermeasures. This was done by collecting spatter formation in various groups of the weld shop and identifying the group where maximum spatter is being produced. The management selected a model area for the implementation of the activity using a pie chart as shown in fig 2. Here the data from the jig wise spatter analysis is used to identify the area with high intensity of spatter to implement the activity.

By the analysis of the pie chart, it was noted that the side member area of the weld line had a high intensity of spatter and hence it was selected as the model area for the implementation of the activity.

FIG.2- SPATTER ANALYSIS PIE CHART



IMPLEMENTATION OF COUNTERMEASURES

Once the model area was selected, the causes for spatter formation was analysed and the countermeasures were determined to reduce spatter formation. The countermeasures were implemented in the side member section and are as follows;

1) MODIFICATION OF JIG LAYOUT : THE PREVIOUS JIG LAYOUT

Was not ergonomically designed and hence was hindering free movement of gun making it difficult for the operator to perform welding on both jigs and to maintain perpendicularity.Therefore the layout was modified ergonomically to enable easy workability for the operator, which improved the overall productivity in the shop floor. The previous and improved layout conditions are shown in Fig-3(a&b)

FIG.3A PREVIOUS LAYOUT

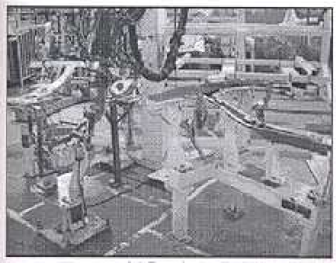
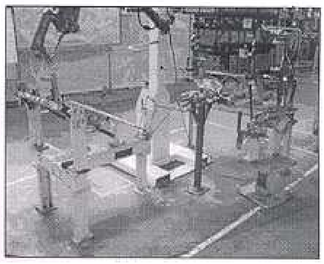


FIG.3B IMPROVED LAYOUT



2) IMPROVED GUN HANDLING: DUE TO IMPROPER ALIGNMENT

Of the aid cables and the gun hanger of the jig, the operator was not able to move the gun freely to maintain gun perpendicularity with the panel resulting in spatter formation. Therefore the positioning of the aid cable and the gun hanger balance were modified to facilitate free gun movement as shown in fig 4(a&b) & 5(a&b)

FIG.4A PREVIOUS AID CABLE

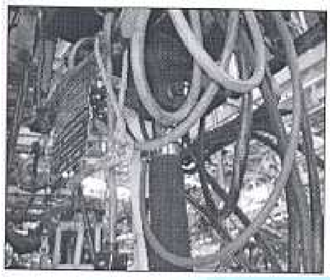


FIG.4B IMPROPER GUN HANGER

FIG.5A IMPROVED AID CABLE

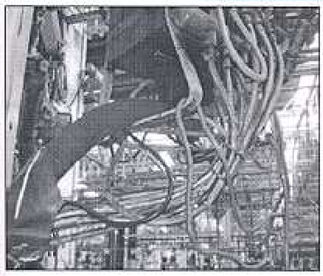


FIG.5B IMPROVED GUN HANGER

3) REDUCING THE GAP BETWEEN PANEL: THE GAP BETWEEN

The panels in the jig was noted to be more than 2mm.It is very important to ensure that the gap Between the panels to be welded is minimized as much as possible in order to avoid spatter formation and defective weld. Hence a 2mm shim was added in the jig as temporary clamping to minimise the gap. The previous and improved conditions are as shown in fig 6&7.

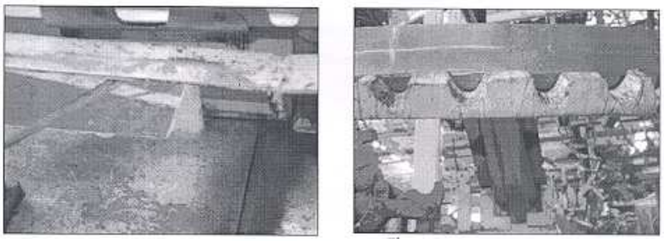
FIG.6 MORE GAP BETWEEN PANELS

FIG.7 INSERTION OF 2MM SHIM AND IMPROVED CLAMPING

4) INSTALLATION OF NEW GUN GUIDE:

It was observed that there was no gun guide in the previous jig because of which the operator was not able to maintain perpendicularity with the panel surfaces. Hence a new gun guide was installed to enable easy gun handling as shown in fig 8.

FIG.8 JIG WITHOUT GUN GUIDE AND JIG WITH GUN GUIDE



RESULTS AND DISCUSSIONS

A. *JIG WISE SPATTER ANALYSIS*

Jig wise spatter analysis of all the jigs in the side member line was carried out after the implementation of the countermeasures. By comparison with the previous conditions and the implemented countermeasures, there was a reduction in rank A & B spatter formation guns and also no spatter guns were considerably increased. There was an increase of No spatter guns by 14.2%.The observation summary is as shown below in table.1.

TABLE: JIG WISE SPATTER ANALYSIS

Before Activity					
Spatter Intensity	>3 mtrs	2-3 mtrs	1-2 mtrs	<1 mtrs	No spatter
No.Of Guns	3	8	21	21	3
After Activity					
Spatter Intensity	>3 mtrs	2-3 mtrs	1-2 mtrs	<1 mtrs	No spatter
No.Of Guns	2	5	13	28	8

B. *REDUCTION IN HANARE*

After the implementation of the countermeasures there was a noticeable reduction in hanare occurrence. Here is the 6 month hanare data of the side member line where in we can see the reduction in hanare defects after implementation of countermeasures which is 33% below average number of hanare cases per month.Hanare data of past 6 months is as shown in table.2.

TABLE I: HANARE DATA OF PAST 6 MONTHS

Month	No.of hanare
September	4
October	7
November	8
December	5
January	6
February	**2**

C. *REDUCTION IN REWORK TIME DUE TO HANARE*

The approximate time taken to carry out a 1 hanare check is estimated to be 1 min. If hanare occurs in the weld line then the upcoming ten bodies and front ten bodies are checked, hence a minimum number of cars checked if a hanare occurs will be 20 bodies and therefore the total time lost due to 1 hanare occurs will be 20 mins. After implementation of countermeasures rework time 33.3% less than average rework time is achieved. Time lost due to hanare in last 6 months is shown below in table III.

TABLE II: TIME LOST DUE TO HANARE IN LAST 6 MONTHS

Month	Time lost (mins)
September	80
October	140
November	160
December	100
January	120
February	**40**

D. *REDUCTION IN SPOT BURR*

Spatter formation leads to spot burr, which inturn leads to other surface defects. So the reduction in spatter helps to reduce defects per vehicle (DPV).After the implementation of countermeasures DPV less than 29% of average DPV per month is achieved which is shown in the table IV.

TABLE IV: DPV DATA OF PAST 6 MONTHS

Month	DPV
September	0.2
October	0.15
November	0.23
December	0.2
January	0.21
February	**0.14**

E. *REDUCTION IN REWORK COST*

There is a considerable cost associated with rework due to hanare, which can be approximately calculated without taking into account the loss due to reduced productivity and depreciation costs.

1) Cost estimation for rework due to hanare

Total welding cost =Labour cost + Welding Consumables + Power cost

Labour cost per job

$$\text{Labour cost} = \frac{\text{(total meters o weld)*(labour and overhead charges/hr)}}{\text{(Welding speed in m/hr)*(operating factor)}}$$

Operating factor % = $\frac{\text{Arc Time*100}}{\text{Arc Time + Down Time}}$

Considering salary of technician as Rs.10,000/month

The labour cost per hour= $\frac{10,000}{8*25}$ = Rs.50/hr=Rs.0.833/min

Power cost per min is estimated to be Rs.0.0312

Therefore the total cost per hanare rework is estimated to be Rs.2.422.After the implementation of countermeasures, the rework cost was reduced to 66.6% below the average rework cost.

F. *REDUCTION IN SAFETY GEARS CONSUMPTION*

Safety gears are very much essential for the workers during welding process, also it accounts for a major part of the cost. After the implementation of countermeasures, it was evident that there was reduction in safety gears consumption by 115 below the average. The data for safety gear consumption pattern for past 6 months is shown in tableV&VI

TABLE V: COST OF SAFETY GEARS

Sl .No	Part Name	Cost(Rs/Unit)
1.	Overcoat	149
2.	Arm cover	27.3
3.	Wrist support	14.7
4.	Cotton gloves	7.2
5.	Ear plug	11
6.	Mask	30.3
7.	Safety goggle	110
8.	Leg guard	100
9.	Safety shoes	750

TABLE VI: SAFETY GEAR CONSUMPTION DATA

Month	Safety Gears Consumption(in Rs)
September	16357
October	17183
November	17672
December	16324
January	18526
February	**15308**

CONCLUSION

The present paper outlines the study of the factors causing spatter formation in spot welding process and implementation of countermeasures taken by the management. Reduced spatter formation aids in improved workability with modified jig layout, improved working conditions making it safer for the workers on the shop floor, average hanare defects and average rework time is reduced by 33% per month, average DVP per month is reduced by 29%, average rework cost and safety gear consumption is reduced by 66% and 11% per month respectively, There by increasing the over all productivity. The above paper emphasizes the importance given to the operator, which projects the managerial skills of the management of the limited company.

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