K. D. Hardikar, D.J.Nidgalkar, Dr.K.H. Inamdar/ International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp.1609-1613

"PREDICTION OF WELDING SEQUENCE FOR MINIMUM POSSIBLE DISTORSION OF AN ASSEMBLY LIKE B-PILLAR OF A CAR, WITH EFFECT OF PARAMETERS ON DISTORSION WHILE WELDING"

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ABSTRACT:
The aim of this paper is to achieve thespot welding sequence for minimum distortion of a sheet metal assembly and to optimise the parameters of welding which insures minimum distortion for the optimised sequence. The distortion of the assembly involving number of spot welds is different for different sequences of welding The assembly consists of sheet metal components which are joined by using various welding sequence schemes. The components are manufactured in quantity and welding with various sequences. After welding the distortions in an assembly due to welding sequence change are worked out and compaired.The temperature distribution along B-pillar is also analysed while deciding optimum sequence of welding. The sequence with minimum distortion is suggested a solution for the quality manufacturing with minimum distortion induced in it. The various parameters like weld timing or current, convection film coefficient are optimisedfor the sequence giving minimum distortion.
Keywords: Spot Welding**,** Weld Sequence, Distortions

1. INTRODUCTION:
The body in white of a car consists of hundreds of sheet metal parts that are joined together and thousands of spot welds to join them together. During the joining process many factors affect the final geometrical quality. One of the many geometrical factors affecting the final geometrical outcome of the sheet metal assembly is the spot welding sequence used when the parts are welded together. It is of course desirable to choose a welding sequence that minimizes both variation and deviation in critical dimensions of the final assembly. During the welding process the sequence by which the welding is carried out is of important. For deciding the sequence with minimum thermal distortion the assemblies are welded with the different welding schemes and distortions are worked out from the physical results. The technique involving sequence which yields the minimum distortion is the technique for optimization of spot welding sequence. The parameters like weld timing or current, convection film coefficient, Temperature are varied and their effect on distortion is analysed for optimisation. The assembly selected is an sample assembly having a cross section like B-Pillar of passenger car. The assemblies are welded with 7 different sequences of welding by spot welding process and then compaired for the distortions induced. The sequence which yields minimum distortion will be the optimized way of welding the assembly and is suggested as a solution.

2. SAMPLE ASSEMBLY:
The assembly selected is an assembly having a cross section like B-Pillar of passenger car.Standard cross sections of a car body are as shown in the Fig.1.

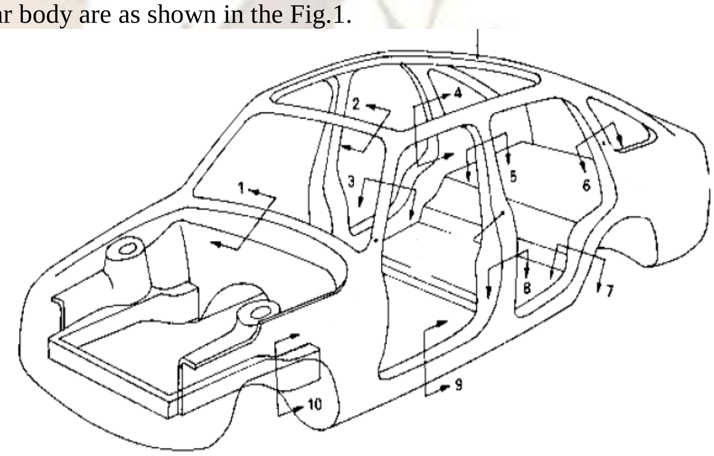

Fig. 1 Standard Cross-Sections of B-pillar of a passenger car

Standard cross section of B-pillar of a car is as shown in Fig.2 below,

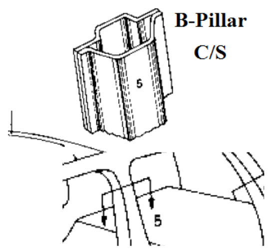

Fig. 2 B-Pillar C/S of B-pillar of a passenger car

The B-pillar of a vehicle is the second pillar of the passenger compartment, after the A-Pillar. The B-pillar plays a key role providing strength to the midsection of the vehicle. They also play an important role in protecting the occupants in roll-over incidents.

2.1 Modelling: Modelling of B-Pillar is carried out by using CATIA V5-R18 software. Modelling is done for 1mm sheet of material AISI 1045 Steel Sheet which is used for manufacturing of components of assembly.

1. Total available span over which weld spots are distributed is 500mm.
2. Upper B-pillar width is 80 mm while at the bottom it is 100mm.
3. Perpendicular inter-distance between 2 components of a sample B-Pillar is 69.062mm.

3. SPOT WELD LOCATIONS AND SEQUENCE OF WELDING:

The weld spots are located on the flange are as shown below in Fig. 3

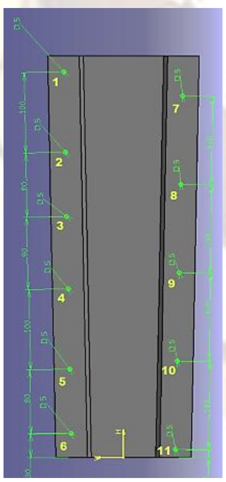

Fig.3Spot welds and their locations

On the right flange 6 weld spots are located with inter distances as (All distances specified are cumulative distances from free upper edge of sample B-pillar)1st – 30 mm ,2nd – 110 mm, 3rd – 210 mm, 4th – 300 mm, 5th - 380 mm, 6th – 480 mm as shown I the Fig. above.On right flange 5 weld spots are located with inter distances as (All distances specified are cumulative distances from the free upper edge of pillar)1st – 10 mm, 2nd – 120 mm, 3rd – 230 mm, 4th – 340 mm, 5th - 450 mm.

3.1 Actual welding Sequences for spot welding of components: (With reference to Fig. 3).

1. (1-2-3-4-5-6-11-10-9-8-7)
2. (1-2-3-4-5-6-7-8-9-10-11)
3. (4-3-5-2-6-1-9-8-10-7-11)
4. (1-7-2-8-3-9-4-10-5-11-6)
5. (1-6-11-7-2-3-4-5-10-9-8)
6. (1-6-11-7-2-3-4-5-8-9-10)
7. (1-6-11-7-2-8-3-9-4-10-5)

Spot weld made in two sheets, each 1 mm in thickness, would generate a nugget 5 mm in diameter. The weld time is measured in cycles of line voltage as are all timing functions and hence in a 50 Hz power system. So total welding time is 80ms for each weld and 110VAC, 30A input power system is used for welding.

The snapshot of actual welding is as follows in Fig.4,

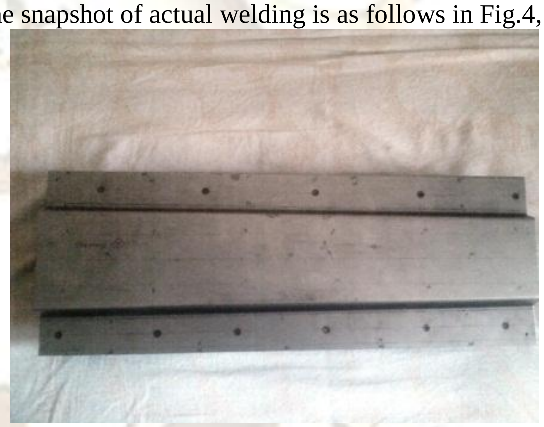

Fig.4 Actual assembly after welding

4. MARKINGS FOR THE MEASUREMENT PURPOSE

(The markings are made on the manufacturing components (7Nos.) as shown in Fig. 5, so that the distortion can be predicted by measuring those points for all the components with the particular sequence of welding.)

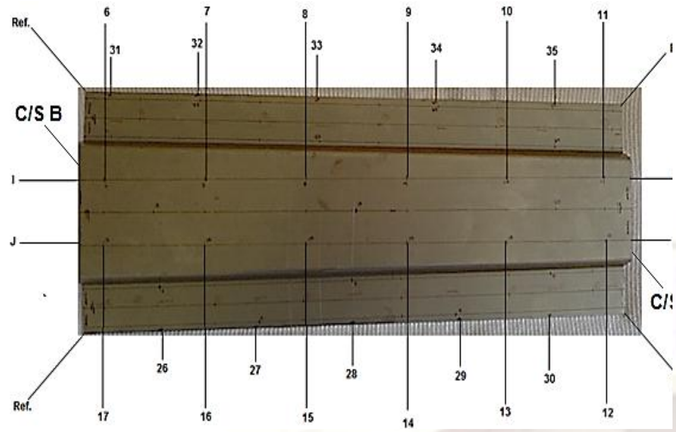

Fig. 5Markings for the measurement

4.1 Deflections considered :-

1. Bending in a horizontal plane. (For this,points 26-35 are measured on the side edge from a ref. point).

The measurements are done by Trimos. The componentsare welded according to the various sequences. The various timings are recorded for welding time and cooling time as per the sequence of welding. The welding time being constant taken as 80ms for each weld. The timings in between two spots i.e. cooling time is taken from physical welding constraints. The spot temperature on flange i.e.1550^{0}C.

The uniform reference temperature provided is 30^0 for the complete analysis shown in Fig.6.

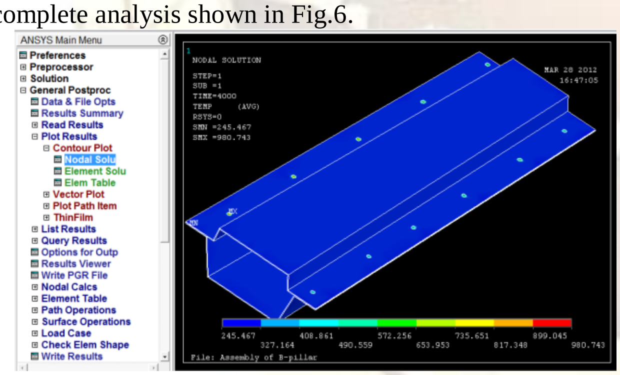

Fig. 6 Sequence analysis for spots

The overall minimum and maximum deflections and stress are worked out for all the sequences from which deflections at the marking locations can be found out. The values of distortions are also found at the nodes located at the location of marked points.

5. SOFTWARE AND PHYSICAL ANALYSIS FOR DISTORTIONS INDUCED:

5.1.BENDING IN A HORIZONTAL PLANE:

For this,points 26-35 are measured from a ref. point. From these physical measurement readings the graphs are then plotted for prediction of the optimum sequence of welding and compared with the software results.

(a) Analysis of Actual Results:

The graph is plotted with physical measurements for the comparison purpose and is as follows in Fig.7,

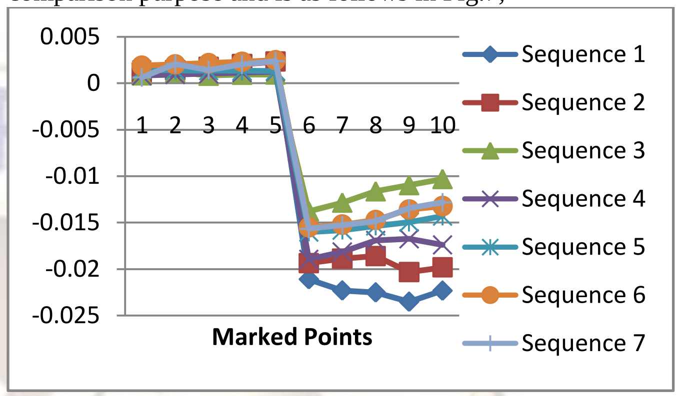

Fig. 7 Graph for actual deflection

(b) Analysis of Software Results:

The graph is plotted with software measurements for the comparison purpose and is as follows in Fig.8,

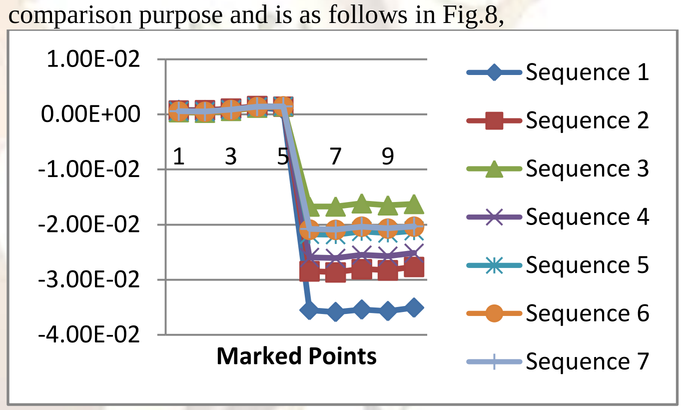

Fig. 8 Graph for Software deflection

(c) Comparison between Actual and Software Distortions at marked points:

The comparison graph is also plotted to compare the results obtained from physical measurements and the software measurements of distortions as shown in the Fig. 9.

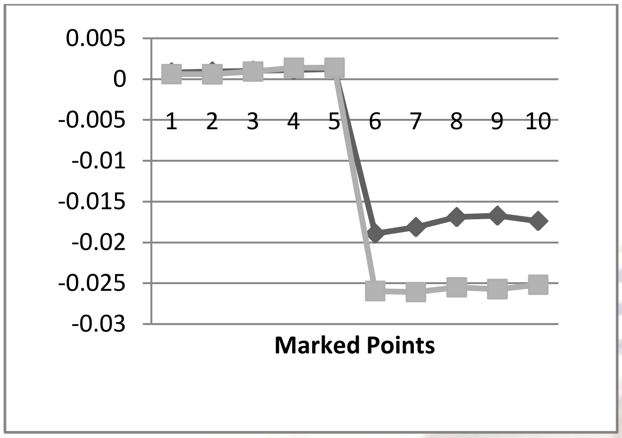

Fig. 9Graph for comparison of actual and software deflection

From the graphs above the optimised sequence of welding is Sequence No.03 i.e. firstly welding the centre spot on left flange i.e. 4th, then welding spots alternately and centre spot on right flange i.e.9th, then welding the spot alternately on side flange (Sequence as 4-3-5-2-6-1-9-8-10-7-11).

The temperature distribution along the B-pillar is also worked out for 7 sequences of welding. The Sequence No. 03 gives the uniform temperature distribution along the B-pillar and the comparison of temperature distribution for different sequences is as shown in the Fig. 10 below,

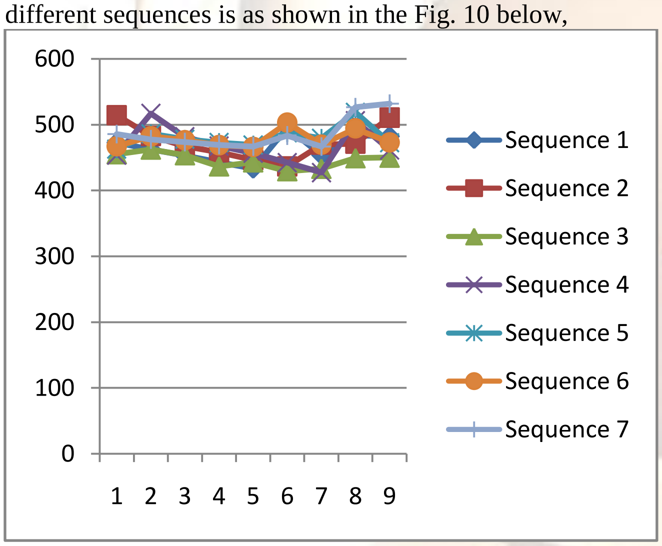

Fig. 10 Graph for Software deflection

6. EFFECT OF WELDING PARAMETERS ON DISTORTION FOR SEQUENCE NO.03:

The parameters considered are Weld time and Convection Film Coefficient for optimised Sequence No.03and effect on distortion by variation in those is analysed for optimisation.

6.1 Weld Time:

The 3 weld timings 70ms, 75ms, 80ms are taken to study effect of it on distortion. The results are as shown in the Fig.11 below,

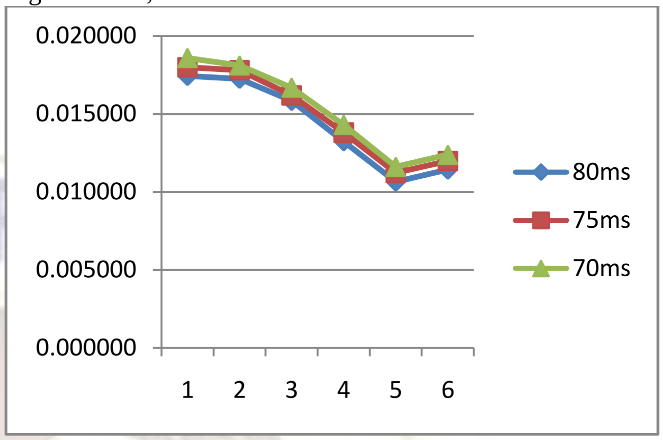

Fig. 11 Distortion variation with weld timings

6.2 Convection Film Coefficient:

The Convection Film Coefficient is varied in between 6-10 W/m^{0}K to study its effect on distortion. The comparison is as shown in the Fig. 12 below,

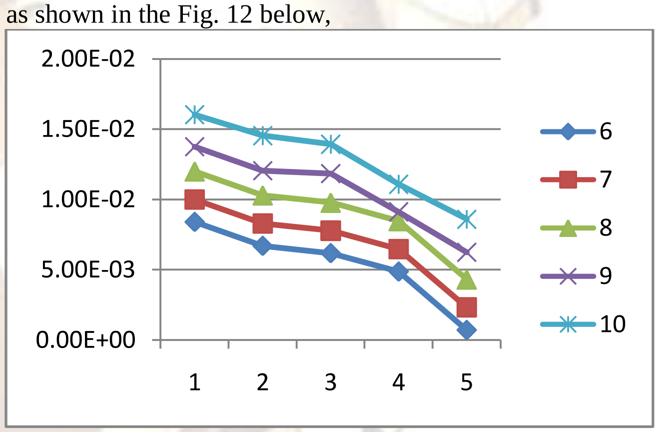

Fig. 12 Distortion variation with Convection Film Coefficient

7. CONCLUSION:

1. From various field visits with car shops it is found that selecting the proper welding methodology and welding sequence is of prime importance. Also the distortion of assembly will reduced drastically by choosing proper sequence.
2. Sequence no. 3 i.e. firstly welding the centre spot on left flange i.e. 4th, then welding spots alternately and centre spot on right flange i.e.9th, then welding alternately. i.e. (Sequence as 4-3-5-2-6-1-9-8-10-7-11) is the best possible minimum possible solution for welding the B-Pillar assembly and is validated by both physical as well as software analysis.

3. Welding the centre spot on the flange first yields the even distribution of heat induced due to welding, which gives the best thermal distribution plot along the B-pillar and hence reduced overall distortions.

4. Welding time of 80ms yields the minimum distortion that the 70ms and 75ms so it is interpreted that the temperature application should be gradual and welding should be done with the minimum possible current setting. The welding with lower current also yields the best quality of weld spots.

5. The Convection Film Coefficient of $6W/m^0K$ will give the minimum possible distortion than others which interprets that the spot should be cooled uniformly at atmosphere conditions uniformly. Abrupt cooling of it yields more distortion like in quenching process.

6. The deviation in the physical and software analysis results is due to following reasons:

a. The welding and cooling cycle timings for the software analysis are taken by doing time study of physical welding. Calculating the time in seconds and mili-seconds introduced an error in the software measurements.

b. Tongs pressure while welding is not considered for software analysis which exits in case of welding physically.

8. REFERENCES:

[1] F.W. Brust, Paul Scott, “Weld distortion control methods and applications of weld modeling,” Transactions, SMiRT, Toranto, August 2007, paper #B05/1.

[2] Lin, Echele, Shi, “Effect of welding sequence on welding induced alignment distortion in butterfly laser diode module,” University of California, eScholarship, 02-01-2005.

[3] Scott E. Zilincik and Wm. Jeffrey DeFrank, Ernie Monroe and Salman Khan, “A new approach to evaluating spot welds for automotive durability,” Society of Automotive Engineers, Inc., 982277.

[4] Dr.R.M.Warkhedkar, M.S.Mukhedkar, “Optimization of spot welding using taguchi method,” International Conference on Sunrise Technologies, 13th – 15th Jan 2011.

[5] Dongyul Lee, Ki Eak Kwon, Jaeyeol Lee, HaeseongJee, SeongWook Cho, Jong-Gye Shin, Gyubong Lee, “Tolerance analysis considering weld distortion by use of pre-generated database,” Journal of Manufacturing Sciences and Engineering, August 2009, Volume131/ 041012-1.

[6] C.L.Tsai, S.C. Park, W.T.Cheng, “Welding distortion of a thin plate panel structure,” Welding Research Supplement, 156-s/May1999.

[7] Kathleen Hoffman, FadilSantosa, “A simple model of sheet metal assembly,” Society for Industrial and Applied Mechanics, 2003, Vol.45, No.3, pp. 558-573.