Abstract:

The 1985 Corvette manufactured by General Motors contained a beam in the driver's side door to resist penetration and protect the driver. The beam was supported by seven spot welds at the hinge in the door frame. During an accident, the welds were unable to withstand the proper load bearing and separated upon impact and indirectly caused the driver to sustain fatal head injuries. If the welds were properly joined the beam would have remained intact and would have been able to bear the load caused by the accident.

Introduction:

In Berlin, Germany on May 15, 1993, Joyce A. Poliseno and her husband Michael Kuhlbars were driving through a residential area during a rainstorm. The couple was driving a 1985 Corvette they purchased only a few months before. Due to the wet roadway, the Corvette hydroplaned and slid sideways off the road, jumped a curb on the right and became wedged between a retained wall and a tree.

The car was severely damaged along the left side. The windshield and the driver's side window had shattered. The driver's side door had pocketed and the tree protruded 20 inches into the drive's side compartment.

The passenger, Poliseno, received only a minor laceration while the driver, Kuhlbar, was unconscious with severe head injuries. Kuhlbar was rushed to the hospital were he died on June 3, 1993. Kuhlbar had died from the severe head injuries he suffered from the accident.

The door's structure and frame was designed to sustain a certain amount of side impact force before bending into the passenger's compartment. The accident was described as moderate and not severe given that the Corvette was traveling a mere 17 miles per hour. The Federal Motor Safety Standard No. 214 states when a stationary vehicle is side impacted by a force with a velocity of 33.5 miles per hour, the occupants must sustain only minor lacerations. It was concluded that the door should not have been protruded by the tree given the minor severity of the accident.

Body:

After an analysis of the car, it showed that the beam in the driver's side door had not remained intact during the accident. The high strength, low alloyed steel beam inside the door was used to increase rigidity and help buffer passengers from side impact (Figure 1). The beam was made to absorb a lot of energy and therefore reducing the amount of energy transferred to the occupants.

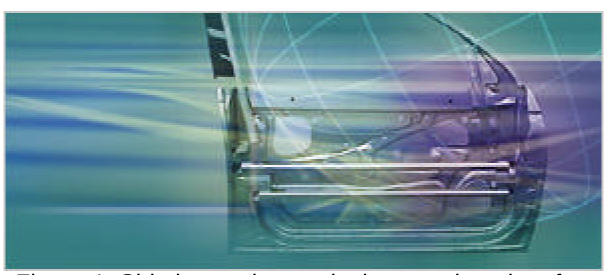

Figure 1: Side impact beams in the complete door frame.

The beam was joined to the hinge on the door frame by seven spot welds. Spot welding is a form of Electric Resistant Welding that is used to join thin sheet metal parts. Spot welding consists of two electrodes clamped on either side of the material to be welded. Pressure is applied to the electrodes while an electric current flows through the electrodes and the material. The resistance of the material to be welded is much higher than that of the electrodes causing heat to generate and thereby melting the material. The pressure on the electrodes forces the melted material in the two pieces of metal to unite and the pressure is held constant after the current stops flowing long enough for the metal to solidify (Figure 2).

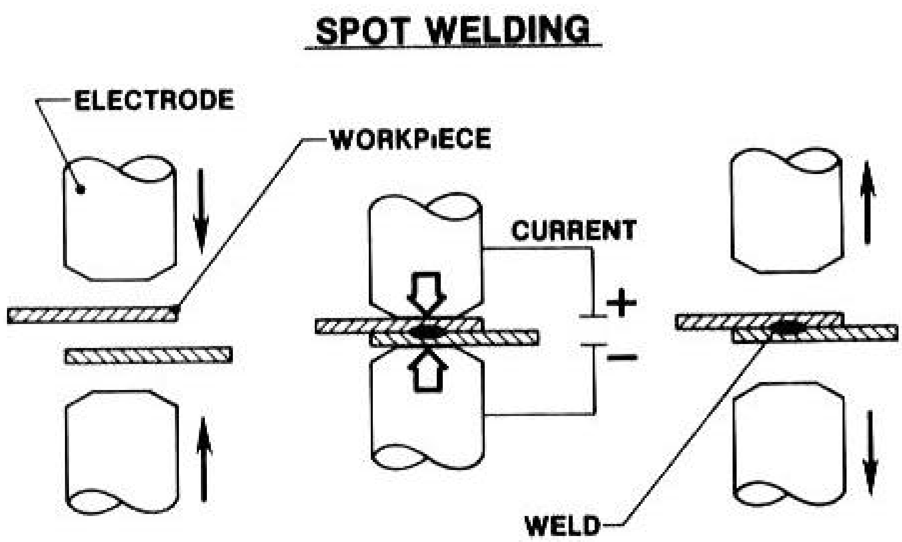

Figure 2: Spot welding Process

The welds that had connected the driver's side door beam to the internal structural components of the door had separated during the accident. The welds had deviated from several of the weld standards and were therefore concluded to be defective. If the welds had been properly joined the beam would have remained intact. The safety beam would have been able to bear the load of the quick blow from the tree and the tree would have only intruded approximately five inches into the driver's compartment. Therefore, Kuhlbars would have only received a minor laceration.

Automotive structures contain between 4000-6000 spot welds and approximately 80% of automotive body durability problems are associated with spot welds. Uncertainties in the quality of the weld result from the erosion of the electrode's tip, preparation errors, the quality of the electrical contact, and the variance in the surface quality of the material to be welded. Production quality is determined by the porosity, penetration thickness, and the size (diameter) of the weld (Figure 3).

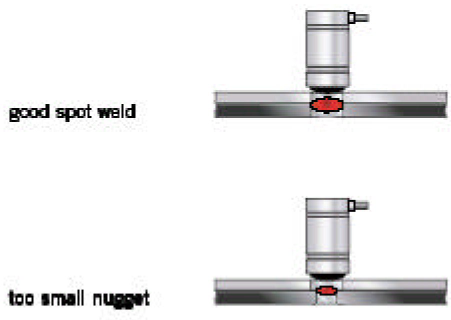

Figure 3: Good weld vs. defective weld

The defective spot welds in the door of the Corvette should have been prevented with proper inspection. Systematic testing of spot welds assist in the assurance of quality. This has been carried out using a hammer and chisel and performing tension-shear, cross tension, twist, and peel tests on randomly selected welds (Figure 4). The nuggets (welds) were extracted and the defects were spotted using the trained eye. This was time consuming and expensive because the part was unable to go to market once it was tested.

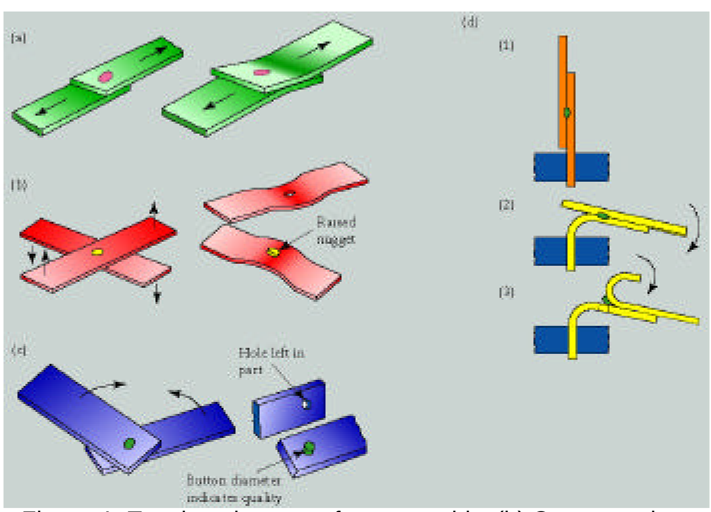

Figure 4: Tension-shear test for spot welds. (b) Cross-tension test. (c) Twist test. (d) Peel test.

In 1989 (after the manufacturing of the 1985 corvette) a new ultrasonic form of testing was made available. This method is based on the different intensities of the sound wave energies traveling through the weld. This is a nondestructive form of testing which allowed the part to go to market after it was tested. This test can detect the porosity, size, and penetration depth of the weld and is very accurate. If this test was available and properly used in the production of the 1985 corvette, the accident could have greater probability of being prevented.

The beam was made out of a high strength, low alloy steel which is considered to have good weldability. High carbon or high alloyed steels tend to form hard, brittle welds that have higher chances of cracking. If the material was made out of low-carbon steel, the weldability would increase but the material properties would decrease, reducing the hardness and toughness of the beam. Therefore the high strength, low alloy steel welding material is the most suitable.

Laser welding is a technology that is spreading through the automotive industry. Laser welding is a non-contact process that concentrates energy from a laser into a small area. The output energy ranges from 2-10 kW producing power levels of 10^3-10^5 Wmm^{-2} on the surface of the part. The laser beam forms a small hole approximately 1 mm in diameter of liquid steel. The liquid steel solidifies behind the traversing beam, leaving a small weld while the surrounding material remains unaffected.

Laser welding has many advantages over spot welding. Laser welding allows the joining of dissimilar materials with small heat effected zones. This technology can weld in difficult, hard to reach areas. They produce very narrow, very deep welds with minimal heat input while running at high welding rates (Figure 5). Because the weld is so small, there is no need for surface finishing and this further reduces costs.

Laser welding proves to be a great alternative to spot welding. With laser welding, there are no uncertainties about corrosive electrode tips, variance of surface quality of the welding material, or the quality of the electrical contact.

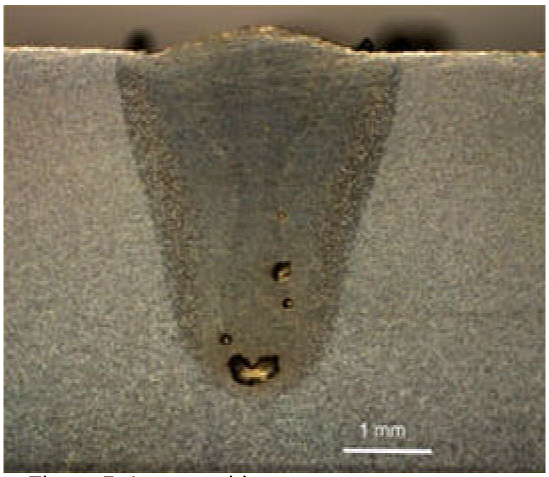

Figure 5: Laser weld

The one disadvantage of laser welding is the part is limited by the thickness of the welding area. Laser welding is designed for thin sheet metal. Quality of the weld is reduced with thicker portions.

This case is very relevant to this manufacturing course. It demonstrates the consequences of improper use of manufacturing techniques and the importance of process control. Michael Kuhlbar had paid the ultimate price of a manufacturing defect. If the manufacturers were more cautious and inspected the parts more carefully and more frequently, Michael Kuhlbar would still be driving his Corvette today.

Conclusion:

Laser welding would have been a good alternative to spot welding the Corvette's safety beam to the structural components of the door. Laser welding proves to facilitate high production rates with great strength and high formability. In 1985, this process was not well known in the automotive industries but is now beginning to be accepted.

If the manufacturer's conducted their inspections more frequently and/or with more precision the safety beam would have remained intact and effective. A more innovated and accurate approach for inspection of welds would be to use ultrasonic testing, but this wasn't available till 1989 (after the manufacturing of the 1985 Corvettte).

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