

Electrode Dressing Makes a Better Spot Weld

Outlined are why the electrode face changes during welding, strategies for cutting blade selection, advantages of using tip dressers, and future methods

BY HIRO KUSANO

It's essential in automobile body production to perform resistance welding, including nut and bolt, spot, and stud welding. Thousands of spot welds support the quality and reliability of an automobile's body structure.

Technology continues to progress for preventing rust, along with making the auto body's structure lighter and stronger, through better materials. The demand for thin-coated steel has been steadily increasing for the past 20 years. Recently, the demand for high-tension material with rust-preventive coating has increased. Although there have been improvements to these materials, many new obstacles have arisen in spot welding.

This article is not intended to tell you how to weld these new materials, but rather to explain the changing of electrode management when using these materials to achieve better welding quality.

Why the Electrode Face Changes

During the process of resistance welding, two copper electrodes press down and create joule heat inside the steel material to be welded. This process creates a nugget that bonds together the steel material.

In the case of galvanized steel, the gal-

vanized coat melts and permeates on the electrode causing buildup on the electrode face. During this resistance welding process, a layer of alloy, Cu_5Zn_8 (copper and zinc), builds up on the electrode due to high pressure and temperature.

After repeating this phenomenon multiple times, the electrodes will be covered with buildup that eventually causes damage to the electrode, possibly causing the electrode to crack. Some of the alloy layer may come off the electrode and stick to the metal, which can cause cosmetic problems to the automobile body. Even though some of the layer may come off, the majority of the alloy layer remains on the electrode surface. This also causes less current to pass, which leads to weak welding conditions and possibly cold welds. Something has to be done to clean the electrode face so proper welding conditions can be maintained.

In addition to the galvanized material buildup problem, the electrode shape, cooling condition, steel material, coating, or welding gun may cause a deformed or cracked electrode. Current step-up programs are not good for the electrode because higher current softens the cap tip and causes the galvanized material to spread out more on the electrode causing greater buildup on the electrode face.

Analysis of the Electrode Face

To analyze the electrode's alloy layer, the following equipment was used:

- Electrode: CuCrZr material, 16-mm-diameter cap tip (female cap)

- Robot: 150 kg
- Welding gun: C gun
- Steel material: galvanized coated material ($t = 1.0$ mm, $t = 1.2$ mm)
- Welding specification: optimal for welding quality
- Weld time: 100, 300, 400, and 500

Because the dissolved Zn and steel permeated on the cap tip surface, there was a layer of alloy that formed. The alloy layer consisted of 79% Fe, 13% Zn, 6% Cu, 0.8% Cr, and 0.8% Al.

Results

In Fig. 1, the alloy layer steadily increases in size as the number of welds increase. There was a direct correlation found between larger alloy layer sizes and an increasing number of welds. In addition, it was found that with the increase in the number of welds, the alloy layer can cause indentation of the electrode surface. Based on fatigue testing, as the number of welds increase, the nugget can become more oval shaped, which can cause bad or cold welds.

Table 1 explains the correlation between the number of welds with the diameter of the weld nugget if no tip dressing occurs.

In Fig. 2, the black line represents non-coated steel, and the red line represents galvanized steel. The dotted black line represents the standard nugget size wanted when welding. Anything above the dotted line represents a good nugget/weld, and anything below the dotted line represents a bad nugget/weld. When the welds

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Based on a paper presented at the AWS Detroit Section's Sheet Metal Welding Conference XIV, Livonia, Mich., May 12-14, 2010.

Table 1 — Correlation Table between Numbers of Welds to Alloy Layer Thickness

No.	No. of Welds	Alloy Layer Thickness (μm)
1	100	11
2	300	87
3	400	101
4	500	140

increase, the noncoated steel remains above the standard line, and the galvanized steel gets worse as welds increase. As you can see, 1800 welds ($t = 1.2 \text{ mm}$) is the limit of good welds an electrode can make without tip dressing. Therefore, it's essential to remove the alloy layer well before the 1800 weld limit.

What Is the Tip Dresser?

There are several types of tip dressers, but this article focuses on the in-line auto electric motor tip dresser. The unit is used for milling the face of an electrode operated by robotic programming — Fig. 3.

Tip dresser components include a geared motor, floating unit, holder and cutting blade, stand, and switching box (power supply). Additional options consist of an air blower, chip collection and tip verification devices, and a rotation sensor.

Tip Dressing Details

The main purpose of tip dressing is to extend electrode life by milling the electrode's face to its original shape by removing the layer of alloy that has built up on the electrode surface from welding galvanized steel — Figs. 4, 5. This is the most efficient and effective method of electrode management. The quality and economical savings of resistance welding depends on the extension of the electrode's life.

Dressing Time and Amount

The dressing time and amount depends on torque, rev/min of the dressing unit, and the cutting blade. Figure 6 shows the correlation between the dressing amount and gun pressure with 1 s of tip dressing. The most effective condition for tip dressing is also based on the steel thickness, number of welds, current, cycle time, and electrode material. The best condition for tip dressing should be decided under the worst conditions of alloy buildup. Some auto manufacturers use the in-cycle dress method that the manufacturer tip dresses after each job (approximately 25 welds). Because of this method, the manufacturer

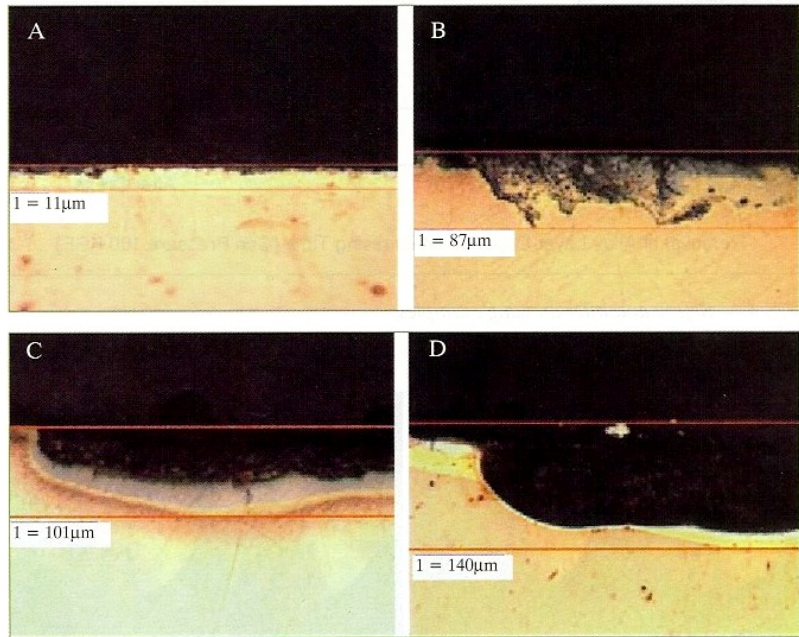


Fig. 1 — Alloy layer buildup visual as welds increase. A — Alloy layer after 100 welds (11 μm); B — alloy layer after 300 welds (87 μm); C — alloy layer after 400 welds (101 μm); D — alloy layer after 500 welds (140 μm).

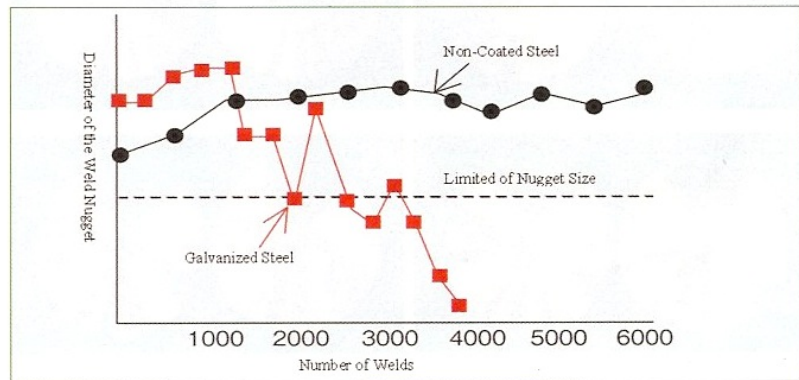


Fig. 2 — Correlation chart for number of welds and diameter of nugget.

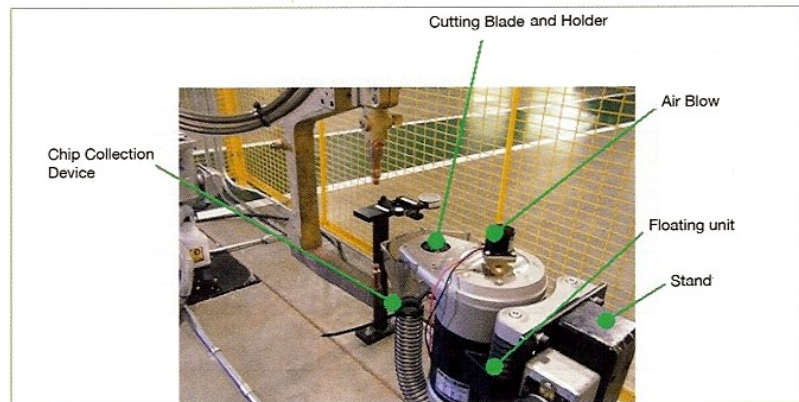


Fig. 3 — Tip dresser with various options.

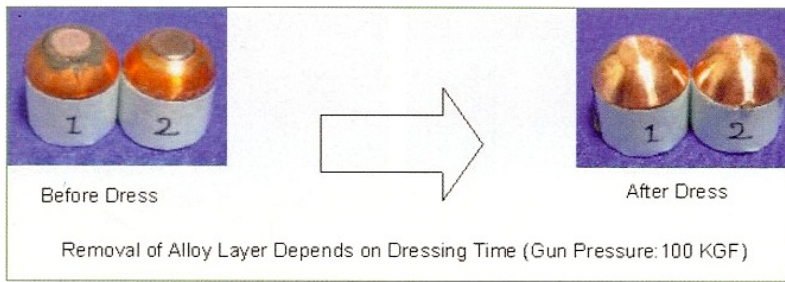


Fig. 4 — Before and after dressing examples.

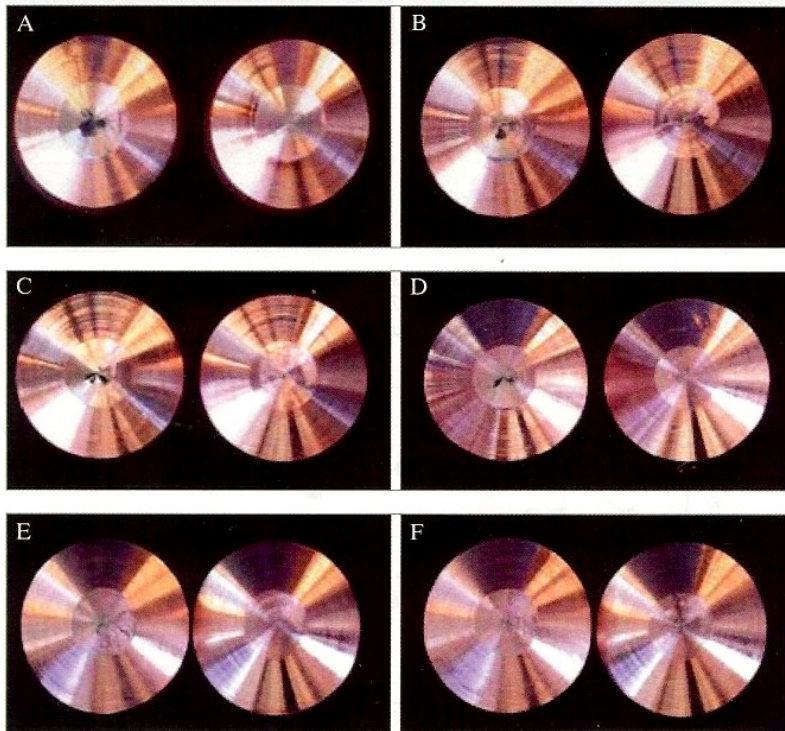


Fig. 5 — Dress conditions after different dressing times. A — 0.5 s; B — 1.0 s; C — 1.3 s; D — 1.5 s; E — 2.0 s; F — 2.3 s.

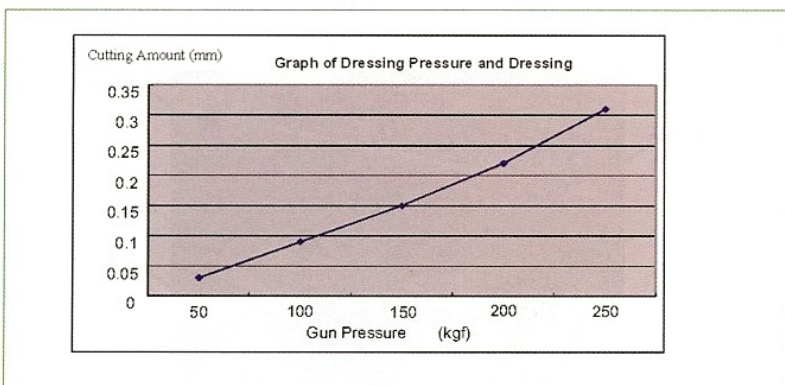


Fig. 6 — Correlation of dress amount and gun pressure chart (per 1 s).

may only have to dress for 0.3 to 0.5 s because the alloy layer didn't build up due to the small number of welds.

This dressing method not only keeps welding quality high, but it also increases the electrode and cutting blade life. The method only removes hundredths of a millimeter each dress depending on the short dressing time. In comparing the in-cycle dress method to not dressing at all (step up), one must look at not only the first weld but also the last weld.

If welding is performed without using a tip dresser, the first weld would have good quality, but weld number 400 will not be the same quality and continually get worse. When using a tip dresser and the in-cycle method, the first weld will have the same quality as the 400th, and the quality stays the same because the electrode face keeps the original form and cleanliness. This allows you to not have to step up nearly as much, which saves time and money as the use of oversized transformers will not be needed.

The Importance of Cutting Blade Selection

Electrodes come in many different shapes and sizes. Therefore, cutting blades must be designed to fit each electrode — Fig. 7. These can come in many blade variations as well, including single, double, four, and reversible. They also come in various materials such as high-speed and carbide steel.

If a manufacturer uses the wrong cutting blade that doesn't match the correct electrode, the electrode's surface could resemble the photos in Fig. 8 (excluding the first image).

Guidelines for Tip Dressing

Following is useful information for tip dressing, including the number of welds and dresses along with optimal conditions, weld parameters, cutting blade life, verification devices, and chips/shavings management.

Number of Welds between Tip Dressing

The number of welds between tip dressing depends on the welding parameters and type of steel. For example, if the steel thickness is 1.0 mm, the maximum number of welds between tip dressing is 400 welds.

Optimal Tip Dressing Condition

The conditions that affect tip dressing are cutting blade shape, rev/min of the tip dresser, gun pressure, and tip dressing

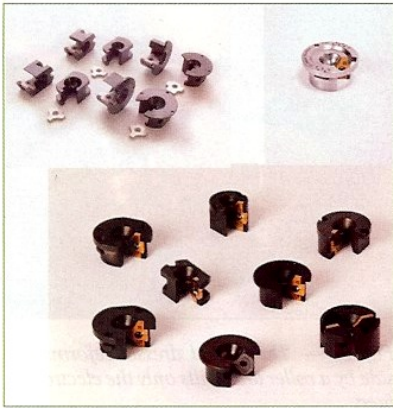


Fig. 7 — Cutting blades and holders come in many variations.

time. The target result for tip dressing is one second of dress time while removing 0.1 mm of material. Choose the correct cutting blade shape, rev/min, gun pressure, and time to achieve this result. If results are unstable, it's recommended you ask your tip dresser manufacturer for the best tip dressing condition for your program.

Weld Parameters

Some users follow a step-up program (2–5% increase) without using tip dressers. With tip dressing, there is no need to increase current.

Number of Tip Dressings

The number of dresses depends on tip dressing parameters. A user can dress up to 50–100 times per cap (depends on weld conditions, including weld gun, electrode shape, dress time, etc.).

Cutting Life

Cutting life is difficult to determine because of welding parameters such as weld gun type, material, gun pressure, and dress time. However, there are two ways to determine this factor. First, change your cutting blade on a periodic basis. For example, some users determined from experience what the shortest life a cutting blade has on an application and then changed these based on the shortest time. The second way is by using a weld face verification device. This allows a user to know if the cutting blade is dressing the electrode properly, and if it's not, it alerts the user that a blade change is needed. Cutting life has steadily improved over the past few years due to new materials and technology in designing the cutting blades.

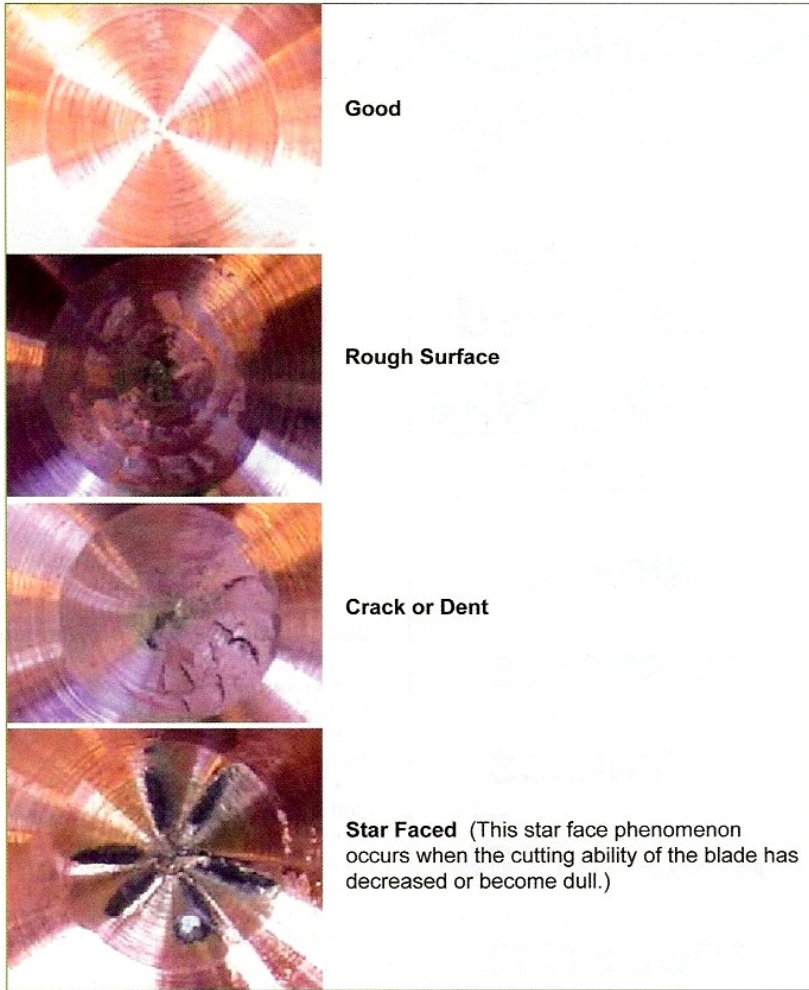


Fig. 8 — The effects of using wrong cutting blade selections.

Verification Devices

There has been new technology introduced over the past few years to help the user with tip dressing. One of the new products is the rotation sensor that allows a user to be sure the motor of their dressing unit is turning. The second is the tip verification device that allows you to know whether or not you are getting a good tip dress.

Chips/Shavings Management

Over the past few years, society has seen a movement to keep the environment clean. Auto manufacturers have also followed in this movement. In the past, manufacturers used air blower units, and copper chips were blown all over manufacturing floors. Now, many manufacturers use devices that allow chips/shavings to be collected into containers for recycling. This keeps manufacturing floors clean and is also eco-friendly by recycling the copper shavings.

What's the Advantage of Using Tip Dressers?

Here's a breakdown of various tip dressing factors, including cost analysis, cap tip cost, and spatter reduction benefits.

Cost Analysis without Tip Dressing

- Number of welding robots: 50
- Time of manual cap tip change: 3 min per robot
- Cost per min: \$0.80
- Number of welds between tip change: 1000
- Cost of cap tip: \$0.50
- Usage of cap tips: 4000 per month
- Number of manual tip changes per month per robot: 40 times (4000/50/2)
- Cost of tip changing: \$57,600 (40 times × 3 min × \$0.80 × 50 robots × 12 months)



Fig. 9 — The servo dresser synchronizes with the robot and servo motor welding gun.

Cost Analysis with Tip Dressing

- Frequency of tip dressing: every 200 welds
- Number of tip dresses per cap: 40 dresses
- Number of welds per cap: 8000 welds (200 welds × 40 dresses)
- Usage of cap tips per month: 500 (based on above calculation, using tip dresser makes cap last 8 times longer)
- Number of tip changes per month per robot: $(500/50 \text{ robots}/2) = 5$ times per robot
- Cost of cap tip change: \$7200 (5 times × 3 min × \$0.80 × 50 robots × 12 months)
- Result: \$50,400 savings

Cap Tip Cost

- $4000 - 500 = 3500$, $3500 \text{ caps} \times \$0.50 = \$1750 \times 12 \text{ months} = \$21,000$
 - Result: \$21,000 savings
- From the above analysis, you can save \$71,400 yearly and \$5950 monthly.

Reduce Spattering

Tip dressing reduces spatter by not having to step up the current. When a manufacturer does not tip dress, it has to step up the current many times, causing massive spatter showers that can lead to cosmetic and weld quality problems. Tip dressing is not only cost effective, it's also a good controller of spatter issues.

Future Method of Electrode Management

The future looks bright for tip dressing in automobile manufacturing as manufacturers continue to cut costs wherever pos-



Fig. 10 — The hybrid dresser reforms the side by a roller and mills only the electrode's face.

sible all while being eco-friendly. Demand for tip dressers is at an all-time high, and new technology continues to increase daily.

Some of the new technology includes a servo dresser that uses an eighth axis of the robot servo motor. This next-generation tip dresser synchronizes with the robot and servo motor welding gun — Fig. 9. The advantage of this tip dresser allows manufacturers to use dressers in various welding conditions. The servo dresser can adjust motor rev/min while tip dressing, adjust the milling amount, and manage how the electrode is wearing as the electrode becomes smaller. This dresser is cost effective for new projects because there is no control box needed — only the dresser and stand.

Another technological breakthrough is the hybrid dresser that's a combination of milling and forming the electrode. This device reforms the side by a roller and mills only the electrode's face — Fig. 10. The amount of milling is 0.01 mm for the hybrid dresser. Test results show that one electrode was able to weld 40,000 times. This hybrid dresser works well, but it needs to have good maintenance and learned to be used. If this takes place, the hybrid dresser can produce good welding conditions with little spatter and long electrode life.

Conclusion

The importance of electrode management in modern body shops is at an all-time high. The uncertain climate that manufacturers are in today cause many engineers to look for ways to save money without risking quality.

Tip dressing is important and necessary because it helps improve economic impacts and provides better welding quality across the automotive manufacturing board. With the new technology previously mentioned, it's felt that tip dressing will be something every automobile manufacturer will have in the near future, and it will dramatically impact costs as well as the environment for years to come. ♦