BY DAVID BELLISH

Q: Our company has only used manually operated pneumatic PED welding machines in the past. However, due to increased production requirements, we are currently in the process of designing a new robotic cell with servo weld guns. I have heard there are different philosophies on how to handle the equalizing on servo robotic guns. Can you explain?

A: Servo robotic guns have been around for more than 15 years, and the methods used for equalizing have changed along with the weld gun's evolution. To make the best choice in regard to the method for equalization, it is best to have a good understanding on what equalization is and why it is necessary in the first place.

Before servo guns were introduced to the market, weld guns were operated with pneumatic or hydraulic cylinders, or occasionally a combination of both. Since the accuracy of the robots, weld guns, fixtures, and clamping devices was poor, robotic weld guns had to have some way of compensating for tip wear, gun arm deflection, and workpiece variations. As a result, they were designed to have an "equalizing" assembly that would allow the weld tips to move relative to its stationary mount to make the necessary electrode position adjustments. This movement would allow the robot programmer to set the gun in a rough location next to the panel, and then as the weld tips closed, the gun could "float" into the correct welding position. There are several factors that influence the amount of equalization from spot to spot:

- **Tip wear:** Electrodes continually wear down during the welding process due to the heat generated and mechanical forces applied at the weld.
- **Tip dressing:** To maintain quality, some users will dress the face of the electrode to maintain a certain spot face size. The amount of material removed will vary depending on the dressing time and force applied to the electrode during dressing.
- **Gun arm deflection:** The gun arms will bend under force. So, the weld gun must compensate for this bending to prevent panel deformation — Fig. 1.
- **Sheet metal location:** Most panels have

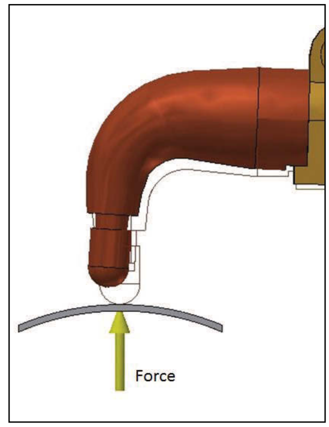

Fig. 1 — As gun force is applied, compensation for arm deflection is required.

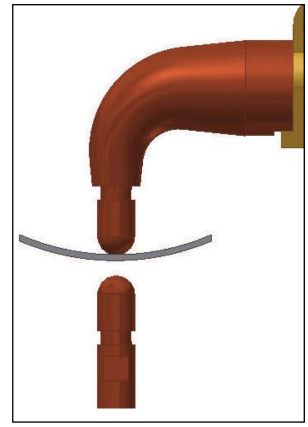

Fig. 2 — Part is out of position relative to fixed side causing panel deformation and additional stress on the gun arm.

some dimensional variation from part to part. If the panel is not in the expected position, excessive expulsion, inferior welds, or additional stresses on the gun arm will occur — Fig. 2.

- **Robot programming:** Positioning the weld gun in the proper location for each spot can be time consuming, so equalization allows some variation to help speed up line installation.

Traditional pneumatic weld guns had a few different types of equalizing assemblies. The type utilized was mainly user preference based on their experience or particular application. The main types are as follows:

• **Springs only:** This is the simplest method. During the welding process, the body of the weld gun is free to move relative to the stationary mount, or robot bracket, and its movement is aided by springs. As the robot moves from spot to spot, the weld gun is locked in place by some type of mechanical system to prevent unexpected movements from the robot inertia changes. Occasionally, some type of damper system is added to help prevent these unexpected movements. Since the amount of weight acting on the springs changes as the weld gun rotates in relation to the floor, this type of design is limited to one floor position, or only small angles of rotation.

• **Springs with air locking cylinder:** This design is based on the first method, but adds a pneumatic cylinder that prevents the gun from floating when the robot is moving. Since there is an additional pneumatic cylinder on the weld gun, it requires a solenoid valve to allow air flow to the locking cylinder. This valve is wired to the robot controller that allows coordination between the air flow to the cylinder and the robot's movement. This type of equalization is also floor-position dependent since it relies on the springs for the equalizing movement.

• **Pneumatics only:** As pneumatic controls became more precise, some users chose a pure pneumatic system. The main advantage of removing the springs and using only pneumatic control was to allow for welding in all positions relative to the floor. The floor position in relation to the weld gun could now be accounted for by adjusting the air pressure to the cylinders. Without going into too much detail, there are a few types with minor differences, but all of them work with the same general principles. Air flow is regulated to the cylinder, which controls the movement of the weld gun in relation to the robot. Depending on the type, the controls portion can be quite complicated and expensive. However, with the added features and cost, the positional accuracy control is improved.

Early servo guns introduced another

type of equalizing option. A second servo motor and drive were added to the servo gun that was used to control the position of the "fixed" side of the weld gun. This additional servo allowed a more precise position control due to the servo feedback. However, adding this second servo required an additional servo controller, so costs were much higher than previous equalizing systems.

As servo control evolved and the tolerances in the robots, weld guns, and clamping devices were reduced, the equalization functions were moved to the robot controller. With this type of system, the entire weld gun is fixed to the gun mount bracket, and the equalizing parts are removed. Tip wear and tip dress are accounted for by the servo feedback loop within the drive motor and controller. At any time, the weld tips can be closed, and the amount of material removed by tip wear or tip dress can be determined. The amount of wear or dress between fixed side and movable side can then be estimated by a set percentage, or by using a more precise method, referencing a known "zero" location, which is usually a steel gauge plate of known thickness placed near the robot. To compensate for the gun arms bending, deflection data are usually provided for each gun by the weld gun maker, which allows the robot to synchronize the position of the fixed tip and the force buildup in the gun. Compensating for the sheet metal position is a little more involved.

It is critical to have consistently repeatable panel positions through the use of jigs, positioning pins, clamps, and proximity sensors. If the part location can be controlled, and the part or robot can absorb this small amount of variation, then there should not be any issues. However, if there are large variances in panel position, or the part is very rigid, then this type of application would probably require some type of equalizer on the weld gun. Some robot manufacturers have been experimenting with controls that can adjust for panel positions during each weld, although this usually adds cycle time since doing this quickly and accurately in all orientations with different payloads and different robot arms is extremely difficult. Typically, this is only performed on a periodic basis as a maintenance function to limit the cycle time increase.

There are also some regional differences on the best equalization method on servo robotic guns. Asian manufacturers rely on robot equalization almost 100%. North American companies have also gravitated in that general direction, with some minor differences on pedestal-mounted weld guns. European manufacturers have been somewhat resistant to this trend. Some European manufacturers prefer to keep the equalizing on the weld gun like a traditional pneumatic weld gun. Their opinion is that it results in better control, especially with thicker panel welding. Keeping the equalizing on the weld gun makes the adjustments easier to see visually as well, so some prefer this over the robot control, which can be more difficult to see during line operation. Another advantage of keeping the traditional method is that the initial robot teaching time is reduced since the programmer can be less diligent in their initial tool center point setup.

However, removing the equalization from the weld gun clearly has some advantages.

- **Air is no longer required at the weld gun:** Removing the air equalization and using servo-operated weld guns removes any need for an air supply to the gun and all of the associated pneumatic control equipment.
- **Less maintenance:** The weld gun has fewer parts and is easier to maintain. Some equalizing systems are quite involved and maintenance can be quite time consuming.
- **Less weight:** Traditional equalizer systems can add up to 10~15 kg to the overall weight of the gun.
- **Independent of floor position:** Although some gun equalizing systems can account for the change in floor position, it is much simpler using the robot controls.
- **Weld gun cost:** Removing the equalizing assembly from the weld gun reduces the initial weld gun cost by roughly 10%.

As servo control continues to improve over time, it appears that the trend is moving toward using all of the functions with the robot controller to maintain weld tip position. In the end, the final decision would come down to user preference based on the above factors. Future developments from the weld gun makers and robot manufacturers will have some influence on this decision as well. Both suppliers are continually advancing their technologies to help the end user create a better weld.

Many thanks to the contributors of this response: colleagues, weld gun end users, and robot manufacturing companies.♦

DAVID BELLISH is senior technical coordinator, Obara Corp. USA, Warren, Mich. He has 20 years of experience in weld gun design, and is an applicant member of the AWS D8D Subcommittee on Automotive Resistance Spot Welding. Send your comments and questions to him at david.bellish@obarausa.com, *or by mail to David Bellish, c/o Welding Journal, 8669 NW 36th St., #130, Miami, FL 33166.*