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CLOSED CIRCUIT TELEVISION
WELDING ALIGNMENT SYSTEM

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CLOSED CIRCUIT TELEVISION WELDING ALIGNMENT SYSTEM

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Closed circuit television (CCTV) weld targeting systems were developed to provide accurate and repeatable positioning of the electrode of an electronic arc welder with respect to the parts being joined. A sliding mirror electrode holder was developed for use with closed circuit television equipment on existing weld fixturing. A complete motorized CCTV weld alignment system was developed to provide weld targeting for even the most critical positioning requirements.

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SUMMARY

Electronic arc welding processes require accurate and repeatable positioning of the welding electrode with respect to the parts being joined. As the size of the welded parts decreases and accurate positioning becomes more important, the use of conventional microscope viewing for electrode alignment becomes inadequate. In addition to alignment errors caused by microscope viewing angles, eye fatigue can result from long term microscope use. To alleviate these problems, a closed circuit television (CCTV) alignment system was developed.

Initially, a CCTV system with a microscope viewing adapter and a monocular microscope with an internal light source were acquired for development of the optical alignment system. Several limitations were encountered with this system, including its large size, a lack of viewer depth perception, inadequate lighting, and exposure of the television camera to the welding arc flash.

To eliminate some of these problems, a 10X angled optical system was substituted for the microscope. Fixturing was developed to allow this device to be mounted in place of the microscope used on existing weld positioning fixtures. Although this system relieved some of the previous limitations, inadequate depth perception and camera vulnerability were still present.

Development of a welding electrode holder incorporating a precision slide mechanism upon which the electrode and a 45-degree mirror are mounted has eliminated the depth perception and camera vulnerability problems. A telephoto lens along with photographic extension tubes were incorporated into this system to replace the magnifying optics. This resulted in relatively long variable focal lengths and variable magnification levels. The system is designed to be used with existing weld positioning fixtures.

A complete CCTV alignment system has been developed for use with a motor driven weld positioning system. The telephoto camera system with a cross hair reticle is positioned to view straight down. The parts to be welded are aligned while in view on the monitor and are subsequently automatically indexed into position under the welding electrode by using the precision slide motor controls of the positioning system. The system provides accurate weld alignment and has the potential for manual or computer controlled multi-weld configuration alignment.

DISCUSSION

SCOPE AND PURPOSE

This project was designed to develop a closed circuit television (CCTV) viewing system to be used for visual alignment of welded parts during miniature electronic arc welding operations. Development work included selecting optical equipment to interface with the television, and designing and evaluating fixtures for mounting the optical equipment onto weld positioning equipment. This system was developed to permit precise alignment of small critical weld configurations.

ACTIVITY

When miniature parts are electronically pulse arc welded, precise alignment of the parts with respect to the welding electrode is required for correct molten metal flow and subsequent fusion. As welded configurations get smaller, or when the material combination melting temperature difference is significant, precise alignment becomes critical. Electrodes are usually aligned by the production operator who views the parts through a stereo microscope mounted at the front of the weld positioning fixture (Figure 1). Critical part positioning is difficult because of depth perception problems caused by viewing the parts from an angle. Prolonged microscope viewing also causes operator eye fatigue. A CCTV optical alignment system was developed to alleviate these problems.

A Sharp Model IT-21 CCTV system with a microscope adapter and an Olympus Model MJ monocular microscope with an internal light source were acquired for development of the viewing system. The camera and microscope were mounted on a universal microscope stand to facilitate their orientation (Figure 2). The system magnifications were found to be 60X, 50X, and 45X at 12.7 mm (0.5 in.), 44.45 mm (1.75 in.), and 25.4 mm (1.0 in.) focal lengths respectively.

The proximity of the microscope lens to the work pieces, because of short focal lengths, created working space limitations, the system's magnification was too great for meaningful visual interpretation of the work parts, and the internal light source of the microscope could not supply the required illumination of the weld area, as did conventional external light sources. In addition, the system lacked necessary depth perception because of the monocular microscope, and resulted in inaccurate part positioning.

Figure 1. Microscope Viewing on Weld Station
Fixturing

Another problem associated with this system as well as any other system where the camera is exposed to the weld arc is the camera's vulnerability to intense light. The camera's vidicon tube, its image gathering device, must be protected from intense light. As a result, the microscope-camera assembly had to be removed during each weld operation.

Angled Optics System

To eliminate problems encountered with CCTV viewing through the microscope, a Bausch and Lomb 10X angled optical viewer was substituted for the microscope. Although restricted to a fixed magnification of about 25X, the use of this arrangement alleviated several of the limitations found with the microscope system.

Fixturing was developed for the angled optic viewer using a rack and pinion microscope stage which replaced the standard stereo microscope used on existing weld positioning fixtures (Figure 3). Because of the system's reduced size and increased focal length, more operating room was left around the work parts. Less lighting was required on the weld area with this system (a larger lens diameter was used on the optics), which permitted the use of standard illumination equipment.

Figure 2. CCTV Microscope System

Although the angled optics system relieved several of the previous drawbacks, depth perception inadequacies and camera vulnerability were still encountered.

Sliding Mirror-Electrode Holder

At this point in the project, a new concept was pursued. Viewing the work parts directly from above eliminates depth perception considerations. Since it is impractical to mount the camera directly above the weld position, a precision slide electrode holder assembly was developed (Figure 4). The electrode and a 45-degree mirror were mounted on a slide detented for two positions. In one position, the electrode is over the work pieces and in the other position the mirror is over the work parts. The fixture is designed to replace a standard pulse arc electrode holder.

A telephoto camera lens and photographic extension tubes were acquired for use with the CCTV camera (Figure 5). This equipment

Figure 3. Angled Optics Fixturing

provides a longer focal length and also provides variable magnification by varying the combination lengths of the extension tubes. With the light gathering capacity of the 75 mm f1.5 telephoto lens, ambient lighting is adequate for most part viewing.

The mirror-electrode holder allows the CCTV camera with the telephoto lens and extension tubes to be positioned at the side of the weld fixturing, out of the work area. When parts to be welded are aligned, the mirror is positioned over the parts and they are viewed through the CCTV camera on the 45-degree mirror. They are aligned by coordinating a reference marker in the camera-monitor system with the detented electrode position over the weld piece parts. After the parts are aligned, the electrode is moved into position over the weld target. This also blocks the camera's view of the weld area and protects the camera from the welding arc flash.

The sliding mirror-electrode holder can be used to accurately position the welding electrode over the weld target, eliminating

Figure 4. Fixturing for Sliding Mirror-Electrode Holder

Figure 5. Telephoto Lens Extension Tube System

Figure 6. Error Resulting From Incorrect Alignment Height

the previous limitations. However, one problem was noted with this system. If the mirror is not precisely 45 degrees from vertical or if the camera system is not exactly horizontal, then the height of the fixture above the parts to be welded becomes critical (Figure 6). This problem can be overcome by proper part fixturing and by incorporating a vertical position reference point on the weld position fixturing. This will assure that the part alignment will be performed with the camera-mirror system at the same distance from the weld target each time.

Motorized CCTV Alignment System

A previously developed motorized weld positioning system was used to develop a complete CCTV welding alignment system for precision weld targeting (Figure 7). The motorized fixturing consists of a three-axis motorized slide arrangement. Each slide is driven by a stepping motor which is controlled by a stepping pulse generating presetable indexer. The indexers allow a pre-determined number of stepping pulses to be supplied to the slide motors,

Figure 7. Motorized Alignment System

Figure 8. Camera Mounting Fixture

resulting in precision position control of the slide. The indexers also provide free running and one-step jogging modes. In addition to the standard operating features, the indexers were modified to provide two speed operation.

The CCTV telephoto lens system and a 1:1 optical relay lens which superimposes a cross hair onto the televised image were mounted on the side of the vertical axis slide member (Figure 8). The camera fixturing includes slide adjustments for final camera positioning. The camera assembly is aligned so that it views directly downward a calibrated distance away from the welding electrode along the lateral x-axis. Parts are positioned while being viewed on the CCTV monitor. When the cross hair is aligned on the desired weld target, the part to be welded is indexed automatically into position under the welding electrode.

This alignment system provides accurate positioning capabilities with none of the previously encountered limitations. In addition to accurate single target alignment, this system provides the potential for manual or computer controlled multi-weld configuration alignment.

ACCOMPLISHMENTS

Two successful closed circuit television welding alignment systems have been developed. The first utilizes a sliding mirror electrode holder that can be used on existing weld position fixturing. This system works quite well when fixture alignment and fixture to piece part distance are maintained. The second system uses three-axis motorized positioning fixturing calibrated to coordinate camera and electrode positioning by preset indexing methods. This system provides accurate positioning capabilities as well as potential multiweld position programming. Although more costly, this system is recommended over the sliding mirror electrode fixture when accurate positioning is very critical.

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