Effects of the Use of the Guided-Bend Weld Test on Attainment of Selected Arc and MIG Welding Competencies

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Arc welding has been an important agricultural skill since the widespread mechanization of agriculture. Because the newer MIG welding process is cost effective under many conditions, its adoption rate in the field of agriculture is steadily growing. Welders are now needed, especially in industry, that are specialized in MIG welding.

The importance of fusion welding to those engaged in the field of agriculture is apparent. Agricultural machinery and equipment are constructed in industrial settings and in farm shops. Repair of machinery and equipment takes place on the farm and in commercial shops. Regardless of where it is constructed and repaired, quality welds are of great importance.

It has been noted that welds which pass a visual examination sometimes fail a destruction test. This is due to the fact that internal porosity, slag inclusions, and excess grain growth do not always reveal themselves at the surface of the weld. A student welder making errors which cause these unseen characteristics remains unknowing of the fact that the welds thus produced are inferior in strength and reliability. Furthermore, the student has no indication that a problem exists and, therefore, makes no progress toward correction of the mistakes causing it.

Purpose of the Study

The following null hypotheses were formulated for purposes of this study and tested at the .05 level of significance:

Ho_1: There is no significant difference between the proficiency scores of subjects who receive arc welding instruction incorporating the guided-bend weld test and the proficiency scores of subjects who receive arc welding instruction incorporating visual examination of welds.

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Ho_2: There is no significant difference between the proficiency scores of subjects who receive the MIG welding instruction incorporating the guided-bend weld test and the proficiency scores of subjects who receive MIG welding instruction incorporating visual examination of welds.

Procedures

This study was conducted using the agricultural mechanics laboratory at the Department of Agricultural Engineering, University of Missouri-Columbia. Two Agricultural Engineering 20 - Welding sections taught by the same instructor were identified for use in the study. Random assignment was used to identify one section as a control or visual weld examination group and the second section as an experimental or guided-bend weld test group.

All steel used was hot rolled mild steel (HRMS) obtained from Armco Steel of Kansas City and was of three-eights inch thickness. All practice plates were three inches wide and four inches long and all pretest and posttest plates were four inches wide and four inches long. All included angles were 60 degrees and were produced by cutting the plates at a 30 degree angle on a horizontal band saw. Plates for arc welding were further prepared by the investigator utilizing a stationary abrasive disc sander/grinder to produce a root face of one-eighth inch. Plates for MIG welding were left without a root face. Cold rolled mild steel strips of one-sixteenth inch thickness were used for back-up strips for the MIG welding.

Thirteen subjects were randomly selected from each of the two sections of the course to participate in the study. One group received arc and MIG welding instruction utilizing the guided-bend weld test as a teaching aid and the other group received arc and MIG welding instruction utilizing visual examination of welds and did not use the guided-bend test.

Each group received a pretest and a posttest. The pretest and posttest, which were identical, consisted of one specimen arc welded and one specimen MIG welded from each of the three following positions: flat, horizontal, and vertical. All joints were butt joints.

Following the pretest and prior to the posttest, each of the three skill activities for both arc and MIG welding were performed eight times for practice. During this practice time, the instructor was available and provided instruction to the control group through visual inspection of the practice welds. Students in the experimental group received this instruction but also performed a bend-test on each practice weld after it was completed and allowed to slow cool to room temperature. Based on the bend-test results, recommendations were made to students of the experimental group by the instructor. One instructor was employed to teach both sections utilizing standardized teaching material prepared by the investigator.

Upon completion of the practice welding, a posttest was administered. This posttest was identical to the pretest. That is, butt joints were welded by each student by both the arc and MIG welding techniques in each of the following positions: flat, horizontal, and vertical. This test was administered to each group during a two hour block of time and on the same day.

All pretest and posttest weld specimens were then prepared and tested utilizing the guided-bend weld test. To prepare the specimens for the test, both faces of the plates were first ground flat and with grinding marks made parallel to specimen edges utilizing a right angle grinder. Two one and one-half inch wide coupons were then sawed from the center of each specimen, utilizing a horizontal band saw. A maximum radius of one-sixteenth inch was next filed by hand on all four edges. Following these preparatory steps, all coupons were subjected to the guided-bend test, using one coupon per specimen for the root-bend test and the remaining coupon for the face-bend test.

Following the bend test, all coupons were scored independently by three judges. Scores assigned to coupons by the judges were on a scale of zero to 100 points and reflected the judges' opinion of the quality of the weld test as based on a scoring standard (Morton, 1982) modified by the investigator from its original form as used in studies by Shinn (1971), Harrell (1972), and Drake (1981).

Statistical Procedures

At the conclusion of the welding portion of the study, there were 288 pretest coupons and a like number of posttest coupons for a total of 576. Each coupon was scored by three judges which resulted in a total of 1,728 observations.

Students entering the Agricultural Engineering 20 - Welding course represent varied backgrounds, may or may not have been exposed to previous welding training, and are of different levels of intelligence. Since it was impossible to pair subjects in a university classroom/laboratory setting, the control of these variables became important in choosing the method of data analysis. Analysis of covariance was chosen as the tool of analysis with significance tested at the .05 level of confidence.

Findings

Effects of the Guided-Bend Weld Test on Results of Arc Welding Instruction

The following hypothesis was subjected to statistical analysis to determine the effects of the use of the guided-bend weld test on the results of arc welding instruction.

Table 1

Analysis of Covariance Between Groups for Face-Bend Proficiency Scores in Arc and MIG Welding

Source	df	ss	F
Pretest	1	1299.516	2.16
Position	2	1720.329	1.43
Type welder	1	1977.033	3.29*
Position-type welder	2	1798.115	1.49
Group	1	600.540	1.00
Position-group	2	115.089	0.10
Type welder-group	1	552.093	0.93
Position-type welder-group	2	40.816	0.03
Error	131	78829.101	

Note. $p < .10$

Ho_1: There is no significant difference between the proficiency scores of subjects who receive arc welding instruction incorporating the guided-bend weld test and the proficiency scores of subjects who receive arc welding instruction incorporating visual examination of welds.

The null hypothesis was not rejected. There were no significant differences between the experimental group and the control group for either the face-bends or the root-bends (see Tables 1 and 2). Also, there were no significant differences among positions of welding for either the face-bends or the root-bends (see Tables 1 and 2). No interactions were significant.

Descriptive Results of the Study

Least square means of groups for proficiency scores in arc and MIG welding are reported in Table 3. With arc and MIG scores considered together, there were no significant differences between groups for either face-bend or root-bend scores. The experimental group had somewhat better scores than the control group for face-

Table 2

Analysis of Covariance Between Groups for Root-Bend Proficiency Scores in Arc and MIG Welding

Source	df	ss	F
Pretest	1	1885.174	2.16**
Position	2	14.132	0.02
Type welder	1	22569.423	52.84***
Position-type welder	2	86.556	0.10
Group	1	448.215	1.05
Position-group	2	495.177	0.58
Type-welder-group	1	493.311	1.15
Position-type welder-group	2	97.186	0.11
Error	131	55955.900	

Note. $^{**}p < .05$, $^{***}p < .01$

Table 3

Least Squares Means for Groups for Proficiency Scores in Arc and MIG Welding

Group	Face-bend	Root-bend
Group 1 - Experimental	55.065	49.986
Group 2 - Control	50.953	53.554

bends. However, the control group had somewhat better scores than the experimental group for root-bends.

Perhaps the most noteworthy differences found in this study were those associated with type of welder. As reported in Table 4,

Table 4

Least Square Means for Type Welder for Proficiency Scores in Arc and MIG Welding

Type welder	Face-bend	Root-bend
Arc	49.086	38.598
MIG	56.932*	64.943***

Note. $*p < .10$, $***p < .01$

MIG welds were superior to arc welds for both face-bends and root-bends. MIG face-bend scores were reported to be significantly higher than arc face-bend scores at $p < .10$ level and MIG root-bend scores were reported to be significantly higher than arc root-bend scores at $p < .01$. The root-bend is primarily a test of the degree of weld penetration. Because the MIG welding process has a higher current density than arc welding, this variable could be the reason for the difference in scores. Conversely, the lower current density of arc welding could be the variable causing lower arc welding scores. Another possible explanation for the difference in scores is that electrodes utilized for arc welding had a tensile strength rating of 60,000 pounds per square inch as opposed to the MIC welding wire which had a tensile strength rating of 70,000 pounds per square inch.

Conclusions

The following conclusions were formulated as a result of the findings of this study:

1. The guided-bend weld test, as used in this study, does not in itself produce knowledge of results that would be necessary to significantly improve the quality of arc and MIG welding.

2. The MIG welding process provides the student with an easier process of producing higher quality welds.

Recommendations

Based on the findings and conclusions of this study, the following recommendations were developed:

1. The guided-bend weld test can be used to provide a criterion on which to judge student achievement for arc and MIG welding and in so doing, initiates students to industrial standards; it's use is recommended.

2. Arc and MIG welding instruction should be balanced so as to provide students with skill levels in each welding process at acceptable standards.

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