NSRP Panel Project Final Report

Nelson Test Report 2012-3

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110V Stud Welder

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Executive Summary

This Panel Project evaluated a new power storage and conversion concept, and led to the development of a drawn arc stud welding power source capable of being powered from common 110VAC outlets in shipyards. This could greatly speed up ship construction schedules by simplifying the logistics in moving stud welders among multiple work sites, without the need for a certified electrician to connect to high voltage 3-phase power. It also enhances workplace safety by reducing workers' risk of both electric shock and arc flash. Weld quality should also be improved by the use of the drawn arc process to replace the capacitor discharge process currently used for insulation pins.

1 Introduction

In the construction of U.S. naval ships, millions of studs have been applied using stud welders that are powered from a high voltage power supply. Stud welding is a simple process which takes a fraction of a second to complete, and does not require a certified welder. However, up to 30-40% of the studs on Navy ships are manually arc welded, simply to avoid the cost and time delay of moving a conventional stud welder, which often requires a crane, and then finding and connecting the unit to 3-phase 480V industrial power, which requires a qualified electrician. But, manually arc welding a stud then takes a certified welder several minutes to accomplish, and produces an inferior strength weld.

Safety is another major concern with the use of 480V power. This is especially true for ships in the water to be outfitted. A ship under construction is a hazardous work environment with sharp objects such as scaffolding, rails, edges, tabs and stiffeners that can easily damage the insulation on high voltage power cables. Development of a 110V drawn arc stud welder would reduce the risk of both electric shock and arc flash, and reduce the number of OSHA recordable injuries.

Single phase 110V input stud welding power sources currently exist only for the capacitor discharge (CD) stud welding process. The CD process it is not as reliable as the drawn-arc or short cycle welding processes, for a number of reasons. The CD process is sensitive to the studs' timing tip geometry, base metal surface conditions, gun perpendicularity, resistance of the chuck, ground clamps, and connectors, as well as overall weld cable length and cable routing.

The CD weld is literally an explosion that blows away most of the molten weld metal. This makes visual inspection of the CD welds unreliable. In the last decade, many applications have changed from CD to the drawn-arc and short cycle welding process. Increasing performance requirements driven by increasing levels of shock testing and fatigue testing will likely drive more process change from CD to drawn arc.

The welding power supplies which have been developed from this project will combine the convenience of the existing CD units operating on 110V input, with the high reliability and more predictable weld quality of the drawn-arc stud welding process. These welders will provide a precisely regulated weld current, suitable for drawn-arc stud welding, and powered by 110 volt single-phase input power, at a reasonable cost.

The diameter of the studs to be welded will influence the size and weight of the welder. A welder capable of welding up to 3/16" diameter pins, using the converter concept we have developed, will weigh about 65 pounds. The welder capable of welding 3/8" threaded (reduced base) studs will weigh approximately 100 pounds.

2 Welding Equipment Development

2.1 Definition Stage

The definition stage for this welder was performed with the input of key stakeholders in the participating shipyards to help define key features and requirements.

A first conceptual design was built based on the premise of slowly drawing energy for stud welding from the single phase 110V input power, storing the energy using a high capacity electrical storage system, and then releasing the energy to the output quickly, but in a precisely controlled manner, using advanced buck converter technology.

A technical specification was drafted outlining key performance criteria. This spec was circulated and discussed at various shipyards, including 5-6 staff members at Ingalls, and in Austal shipyard. It was also developed cross-functionally with Nelson's technical service, production and sales representatives for BIW, NNS, EB, NASCCO, MMC, Bollinger, etc.

Specifications for two models were drafted: The N400c, for welding up to 3/16" diameter insulation pins, and the N550c, for welding up to 3/8" diameter pitch base threaded studs.

The initial proposal for a rechargeable battery version was not pursued, because a portable AC generator will be a more cost-effective solution where grid power is absent. Also, current battery technology would produce a relatively heavy design, with a lower power output/weight ratio than would satisfy the portability goals.

2.2 Prototype Stage

Prototypes were built to verify the conceptual design. Power supply components, controls and test chasses were designed and built. Four units of each model were assembled. One N550c unit was provided to Ingalls Shipyard at Pascagoula, Mississippi. A second N550c unit was provided to Newport News Shipbuilding. Other units were electrically, thermally and mechanically tested in the lab at Nelson.

One of the first N550c prototypes went to the Navy Day on Sept 27, 2012 in Washington DC. An improved N550c prototype was later demonstrated at the All Panel Meetings in Charleston, SC, April 23-25, 2013, as shown in photo below.

Jeff Krupp of Nelson Stud Welding demonstrates N550c prototype at NSRP All Panel Meeting, April 23-25, 2013.

3 Shipyard Testing

Testing was done at Ingalls Shipyard and Newport News Shipbuilding. Each shipyard used the equipment as they were able, while working in production schedules.

3.1 Ingalls Shipyard

One N550c unit was provided to Ingalls Shipyard at Pascagoula, Mississippi. This unit was returned without welding. Operators believed that the size & weight of the machine made it a second choice to Nelson's lighter N800i inverter.

In this case, the operators chose the smaller and lighter option, and were willing to trade off portability versus lower voltage power supply. Nelson will continue to offer inverters for customers who will prefer this same tradeoff.

3.2 Newport News Shipyard

One N550c unit was provided to Newport News Shipbuilding, in Newport News, Virginia. This unit was used by operators for welding 3/8" pitch base steel studs. Operators were very satisfied with the smooth arc and high quality welds.

The unit failed during the tests, when a minor flaw in a newly designed PC board manifested itself. The flaw was easily found, and the next iteration of PC boards will eliminate this problem. This is a good example of why Nelson invests in field trials for new designs, just as our shipbuilding customers hold sea trials, to find and fix minor problems.

Again, the operators believed that the size & weight of the machine made it a second choice to Nelson's lighter N800i inverter, hence trading off portability versus lower voltage power supply. Nelson will continue to offer inverters for customers who will prefer this same tradeoff.

4 Conclusions

Here are summarized conclusions from the field trials:

These welders are heavier and volumetrically larger then inverters of the same power output rating. This is a known tradeoff of the 110V converter design. Some users were not receptive to the concept due to this tradeoff. Nelson's position is that this "apples-to-oranges" comparison does not reduce the particular value of a 110V-powered design. Other stakeholders at the shipyards have consistently supported this concept, attaching significant value to the cost savings and safety improvements that this concept will deliver. Simply put, where all the benefits of low voltage supply power are desired, this is the unique solution.

The wheeled undercarriages will be improved to be more durable and compact. We believe we can achieve reasonable portability.

A minor control board failure occurred at Newport News. It was easily remedied, and it will be corrected in the next design iteration. That kind of failure is welcome at this stage, where one of the explicit goals is to find the weak links, and fix them quickly.

These machines weld very well. Their welding performance will be comparable to Nelson's popular inverters.

Field trials with other non-shipyard customers are ongoing, as of the date of this report.

5 Future Work

Nelson is moving forward with the development of these two models. Both welders are being fitted into alpha stage sheet metal, and a wide range of mechanical, thermal, loading, and other stress testing will be conducted on the alpha units.

CAD rendering of "alpha" stage N550c shown here. Alpha stage follows prototype stage, and incorporates more actual production features.

Goals for final production versions include:

- Sheet metal enclosures that are more similar to existing Nelson welders, which are widely accepted in the shipyards.
- User interfaces similar to existing Nelson welders, which should greatly reduce training costs.
- Very durable designs, ready for rough, salt water environments.
- Compatible with existing Nelson guns, cables and accessories.

Current Production Target: 2nd Quarter, 2014.

Disclaimer:

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