Automating a robot cell welding process

Bachelor thesis at SWEP International AB

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Problem formulation

Today, the importance of sustainable and effective energy usage is rapidly growing. SWEP International AB leads the manufacture of brazed plate heat exchangers that offer effective heating and cooling applications used in a wide range of systems and industries. In their manufacturing process, stud bolts are manually welded onto the heat exchanger surface. A project to fully automate this process using an industrial robot has already begun at SWEP to increase the process productivity, quality, and repeatability. The intention of this bachelor thesis was to continue their project of creating a fully automated solution.

Brazed plate heat exchangers from SWEP

Methodology

The continuation of their automation project was achieved by first analyzing and studying their existing semi-automated solution, and then further developing the project by performing quality analysis for automated welds, analyzing and improving the original program algorithms in ABB RobotStudio, implementing a control structure to operate the robot program using a PLC via PROFINET, and creating an automated solution by programming an HMI in Siemens TIA Portal.

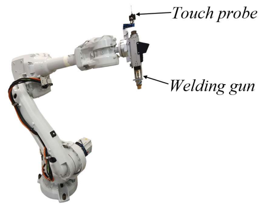
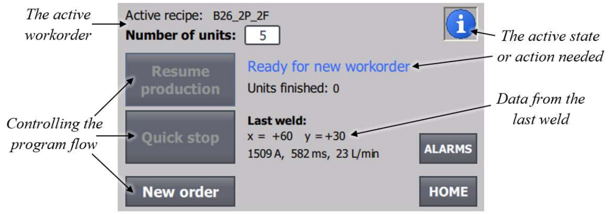


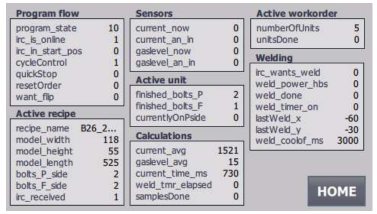
ABB industrial robot with tools

Results

The result was an extended automated solution where the HMI could be used to create work orders, create and save bolt configuration recipes, control the robot welding program, and monitor the process. All initially planned control features were implemented, and the master PLC program was operating the process as intended. The quality analysis resulted in further knowledge of how the weld parameters affect the weld quality, and an optimal weld parameter configuration was determined. Accuracy tests of the original program algorithms showed that the positional bolt tolerances were not being met. However, after added improvements, the final accuracy was put well within tolerances, and the best algorithm to use was concluded.



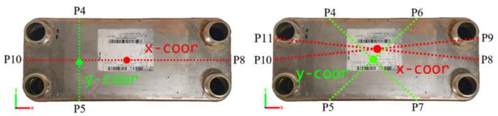
The HMI "Operator view"



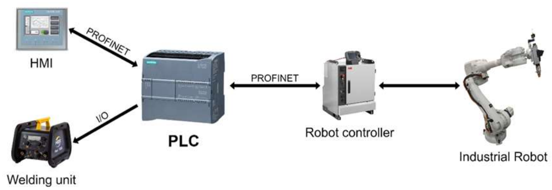
The HMI "Monitoring view"

Analysis

The first objective was to study their existing semi-automated solution and perform quality analysis by testing different amounts of current, weld time duration, and shielding gas flow. A bend test, torque test, and visual inspection were then performed to understand how each weld parameter affects the weld result. From this, an optimal set of parameter values were determined. The positional accuracy of two different methods for calculating the center reference point was then measured. In these accuracy tests, it was seen that the tolerances were not being met. Improvements were made to both methods to increase their accuracy. Lastly, it was concluded which method should be used in the automated welding process. The welding unit that supplies the current and gas flow was then set up to measure and monitor the weld parameters to create a fail-safe system that stops the process if any parameter is measured outside its tolerance. A control structure was then implemented to operate the original robot program via PROFINET. A PLC and HMI were programmed in Siemens TIA Portal, and additions were made to the robot program in ABB RobotStudio.



The two methods for calculating a center reference point



Control structure of the robot program, using a PLC and HMI

Discussions

After improvements to the program algorithms had been implemented and tested, and it was seen that the two methods of calculating the center reference point then had equally good tolerance (both well within the target tolerance of 1mm), the drawn conclusion was that the first method should be used in the welding process as it needs significantly less time for measurements. It was concluded that the extra measurements in the second method, not used in the first method, did not increase the accuracy, which was the initial prediction.

This thesis work has further developed the already begun project at SWEP of creating a fully automated solution to replace the manual bolt welding station in the factory. Even though most of the process is now automated from the PLC and HMI, there still needs to be an operator present to flip over some units, fill the bolt tray with bolts, as well as loading and unloading each new unit. To automate the process even further, these events could be automated as well. There are also other needed considerations that were outside the scope of this thesis. For example, if an incorrect model of heat exchanger is placed on the workstation, whose dimensions differ from the chosen recipe, the touch probe could get damaged, or the measuring algorithm could fail to find the surface or sides. A possible solution to this would be to not include the model dimensions in the recipe, but instead use separate distance sensors mounted around the workstation to automatically measure and confirm that the correct model is being used.

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