HÖGSKOLAN VÄST

Feedback Control of Robotic Friction Stir Welding

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AKADEMISK AVHANDLING

som med tillstånd av Forsknings- och forskarutbildningsnämnden vid Högskolan Väst för vinnande av doktorsexamen i ”Produktionsteknik” framläggs till offentlig granskning.

Fredag 25 april 2014 kl. 10:00 i sal C118, Högskolan Väst

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Abstract

Title: Feedback Control of Robotic Friction Stir Welding

Keywords: Friction stir welding; Process automation; Temperature control; Force control; Deflection model; Robotics

The Friction Stir Welding (FSW) process has been under constant development since its invention, more than 20 years ago. Whereas most industrial applications use a gantry machine to weld linear joints, there are applications which consist of complex three-dimensional joints, requiring more degrees of freedom from the machines. The use of industrial robots allows FSW of materials along complex joint lines. There is however one major drawback when using robots for FSW: the robot compliance. This results in vibrations and insufficient path accuracy. For FSW, path accuracy is important as it can cause the welding tool to miss the joint line and thereby cause welding defects.

The first part of this research is focused on understanding how welding forces affect the FSW robot accuracy. This was first studied by measuring path deviation post-welded and later by using a camera and laser distance sensor to measure deviations online. Based on that knowledge, a robot deflection model was created. The model is able to estimate the tool offset during welding, based on the location and measured tool forces. This model can be used for online path compensation, improving path accuracy and reduced welding defects.

A second challenge related to robotic FSW on complex geometries is the variable heat dissipation in the workpiece, causing great variations in the welding temperature. Especially for force-controlled robots, this can lead to severe welding defects, fixture- and machine damage when the material overheats. First, a new temperature method was developed which measures the temperature at the interface of the tool and the workpiece, based on the thermo-electric effect. The temperature information is used as input to a closed-loop temperature controller. This modifies primarily the rotational speed of the tool and secondarily the axial force. The controller is able to maintain a stable welding temperature and thereby improve the weld quality and allow joining of geometries which were impossible to weld without temperature control.

Implementation of the deflection model and temperature controller are two important additions to a FSW system, which improves the process robustness, reduces defects and allows FSW of parts with highly varying heat dissipation.