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APPLICATION OF VIRTUAL MANUFACTURING USING FEM IN DISTORTION ANALYSIS FOR WELDING, WELDING-FORMING AND WIRE-ARC ADDITIVE MANUFACTURING PROCESS

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ABSTRACT

This master research deals with the application of Virtual Manufacturing (VM) using Finite Element Method (FEM) on manufacturing processes which consist of welding, coupled welding to forming and Wire Arc Additive Manufacturing (WAAM) process. Deformation behaviour caused by the mentioned manufacturing processes are main concern for this research investigated by means of VM and experiments. A series of experiment was conducted in order to verify the result of simulation, whereby materials chosen for this study are low carbon steel and High Strength Low Alloy (HSLA) steel. The material properties taken from experiment, previous researches and software database were implemented into simulation in order to ensure a realistic resemblance. The simulation was carried out by utilizing thermo-mechanical FEM under consideration of non-linear isotropic hardening using specialized and commercial FEM software namely SIMUFACT and MSC Marc/Mentat. The first case study is the investigation of angular distortion induced by T-Joint welding process using FEM software Simufact.Welding and MSC Marc/Mentat. In this case, low carbon steel S235 is selected as material for both simulation and experiment. For verification, experimental T-Joint welding was executed by means of robotic welding machine ABB IRB 2400/16 and power source KEMPPI Pro-EvulutionProMig with shielding gas (80% Ar and 20% CO_2) and filler wire ER70S. The result of FEM-based VM simulation generated by both software would later be compared to analyse the angular distortion. The second case study is an analysis of springback effect caused by coupled process welding to forming using FEM software Simufact.Welding and Simufact.Forming. The final springback occurred at the end of the coupled process is the main concern of this study, in which low carbon steel DC04 is assigned as material. For experimental verification, a robotic welding machine Comau Robotics SMART NS-16-1.65 with power source Fronius TrasmaPuls Synergic 5000 CMT along with shielding gas (80% Ar and 20% CO_2) and filler wire G2Si was assigned for welding process, while sheet metal bending machine VEB WERKZEUG PYE 160s was utilized for experimental forming process. The last case study is the analysis of substrate distortion induced by WAAM process in which FEM-based VM simulation was executed by using MSC Marc/Mentat and two different bead modelling strategies were implemented and compared with S235 as substrate material. The experimental WAAM was conducted by using robotic welding machine similar to first case study with filler material low alloy steel ER80S-Ni. For all three case studies, comparative analysis between simulation and experimental result were compared. The percentage errors range between 11,25% to 22%, 4,54% to 33,1% and 17,3% to 20% for T-Joint, coupled welding to forming and WAAM respectively. It can be concluded that FEM-based VM can produce results which show a good agreement compared to experiment.

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