UNIVERSITI TEKNOLOGI MARA

CHAINED MANUFACTURING PROCESS FOR PRODUCT QUALITY USING FINITE ELEMENT METHOD (FEM) WITH EXPERIMENTAL VALIDATION

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ABSTRACT

The purpose of this research is to conduct the investigation for product quality using Finite Element Method (FEM) – based simulation or virtual manufacturing (VM). Understanding the VM process will significantly assist the production to minimize defects, reduce manufacturing cost of new product development and improve quality of the finished products being produced by several continuing processes. FEM - based VM approach is used to predict final dimensional change in both forming and welding processes through the utilization of specialized manufacturing software Simufact.Forming and Simufact.Welding. This research consists of case studies which are aimed on chained process from stamping to welding. The first case study is to practice FEM simulation and experimental investigation on distortion of butt-joint welding with defined clamping force for verification purpose. Experimental butt-joint welding was joined by means of robotic welding system (ABB IRB 2400/16) and advanced power source (KEMPPI ProEvolutionProMig) with mixed shielding gas 80% Ar/ 20% CO2 as well as filler wire ER70S. It was also demonstrated that VM shows good agreement during the experimental verification. In the second case study, investigation of chained process quality for product design with the purpose to demonstrate the accuracy in predicting final geometry in chaining processes where the physical properties from the first process serves as the initial condition of the second process. The parameters for simulation study were obtained from manufacturing companies with sheet metal material of low carbon steel SPH440, thickness of 2 mm, Young Modulus of 210 MPa and Manganese composition of 1.1%. The third case study dealt with FEM analysis of chained process from stamping to welding. The stamping effect of distortion behaviour will be continued in fourth case study with welding process. Through this research, the impacts of chained process could be predicted and Taguchi Method was used for optimization. In the first case study of FEM simulation and experimental investigation on distortion of butt-joint welding, the error range of the comparison result on distortion yields the value of 11.331% in average. In the second case study, the error range on final geometry in chaining processes is found out to be 4.42% in average. In the case of chaining processes Stamping-to-Welding in case study 3, the percentage of difference between chaining and unchaining are 37.7% which provides an overview of a difference between these two processes. Finally, the fourth case study shows that the distortion in chained process is closer to real distortion than unchained process with percentage of difference of 72.6%. It can be concluded that the VM method can be applied at manufacturing industries to improve the product quality by predicting defects in design phase before the actual manufacturing process due to commence. As further recommendation, the application of FEM as one of the ninth pillars of Industrial Revolution (IR) 4.0 can be enhanced in advanced materials, other coupled processes and geometries as well as other conditions.

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