

# **Applications of Advanced Weld Modeling Technology in Structure Design and Manufacture**

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## **Introduction**

VFT™ (Virtual Fabrication Technology) modeling software is a state-of-the-art cutting and welding simulation tool developed by Battelle and Caterpillar in the past few years. It can model extremely large and complicated fabrications. Extensive full-scale experiments have validated VFT™ accuracy and predictive power. It can be used to reduce fabrication cost and improve quality by minimizing and controlling distortions. This paper presents the basic physical/mathematical theory of VFT™ weld modeling software as well as its applications in welded structure design and manufacture.

## **Analysis Procedure**

The software consists of a weld-mesh generating tool (CUBIT), a weld graphic user interface (WGUI), a comprehensive-thermal solution procedure (CTSP) and a structural model (UMAT). WGUI is a 3-D graphics user interface program developed for welding process simulation. It provides a visual tool for the user to define welding simulation procedures for CTSP and UMAT. CTSP and UMAT are two main analysis modules for thermal and structural analysis in this software. The CTSP permits most welding features, from weld start/stop effects, multiple passes and base plate cutouts, to trailing heat and cooling sources and moving weld torches on complex structures. The UMAT includes a constitutive law that permits stress relief due to weld melting/re-melting effects, strain hardening effects, large deformation mechanisms and a scheme of virtual element detection (VED) for modeling continuous weld element deposition associated with a moving arc.

The required input data for a VFT analysis is a design solid geometric model of the structure and the proposed weld procedures, jigs, fixtures, and weld sequences. CUBIT is used to generate weld mesh. The graphical User Interface (WGUI) is used to generate CTSP, ABAQUS/UMAT input file based on proposed weld sequences. Then the temperature fields of the weldment can be calculated as a function of time using CTSP and the stress (structure) analysis can be performed with ABAQUS/UMAT by inputting the temperature fields.

## **Applications**

Several VFT™ applications examples in heavy industries, automotive industries, maritime industry and piping industries are presented in this paper. A weld

analysis of a 4-meter-long motor grader drawbar illustrates how to use VFT™ analysis to assist welded structure design and manufacture in heavy industries. A C-channel weld analysis of a car frame demonstrates VFT™ applicability in automotive industries. To further show the efficacy of VFT™ software, an actual ship-structure welding simulation is also presented. The structure is approximately 15-meter long and 7.5-feet wide. Many transverse and longitudinal bulkheads and tee-stiffeners are included in this structure. The purposes of these simulation exercises were to determine the weld sequence that would minimize weld distortion and residual stresses.

## **Conclusion**

A VFT™ weld-modeling software is introduced and its components, CUBIT, WGUI, CTSP, and UMAT are discussed in this paper. The application examples show that VFT™ is applicable for predicting weld-induced distortion in assisting welded structure design and manufacture. Use of this technology offers the industries a methodology to rapidly ascertain effective and efficient weld sequencing to minimize and control weld distortion and residual stresses and thereby reduce costs by eliminating non-value added re-work.