THE NEED FOR ANALYTICAL/EXPERIMENTAL ORCHESTRATED APPROACHES TO SOLVE RESIDUAL STRESS PROBLEMS IN REAL STRUCTURES

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ABSTRACT

This paper discusses the need for analytical/experimental hybrid approaches to solve residual stress problems in real structures. Analytical models are used as the basis, and experimental data obtained on selected locations are used to calibrate the analytical models and to improve their accuracy. By properly combining recent analytical and experimental techniques, it is possible to significantly improve the state-of-the-art of studying residual stresses and distortion and their effects on service behaviors of welded structures.

INTRODUCTION - PROBLEMS AND POSSIBLE SOLUTIONS

This paper discusses the need for analytical/experimental hybrid approaches to solve residual stress problems in real structures. Today, welding is widely used for fabricating many structures including aerospace structures, bridges, pipelines, pressure vessels, and ships. However, welded structures are by no means free from problems. One of the major problems associated with welding is related to residual stresses and distortion. Due to localized heating by the welding arc, a weldment always contains residual stresses. The maximum value of the stresses in regions near the weld is as high as the yield stress of the material. Various types of distortions also occur. The residual stresses and distortion cause complex effects, most of which are harmful to the integrity of a welded structure. For example, transient thermal stresses and metal movement during welding may cause weld cracking and joint mismatching. High tensile residual stresses in areas near the weld may cause premature fractures of the
welded structures. Distortion and compressive residual stresses in the base metal may reduce the buckling strength of a structural member subjected to compressive loading.

Because of their significant, mostly adverse, consequences, considerable research has been carried out on residual stresses and distortion since the 1930's. Also studied have been their effects on the service behaviors of welded structures. Results have been reported in numerous publications. One of the most comprehensive sources of information regarding these problems is a recently published book by Masubuchi1. This book, which can be useful to designers and fabricators of welded structures, presents a systematic summary of knowledge on residual stresses and distortion in welded structures. The information presented in this book can be regarded as a "first generation" or "pre-computer age" system for analyzing these problems.2

Figure 1 shows schematically a system for analyzing residual stresses and distortion in welded structures, and how it may be used by practicing engineers. The system is composed of two parts, Analysis 1 and Analysis 2. Analysis 1 is to predict residual stresses