Introduction

The International Symposium on Mechanical Relaxation of Residual Stresses was convened on April 30, 1987, in Cincinnati, Ohio, with speakers from five countries participating. The objective was to obtain a better understanding of the processes by which residual stresses are relaxed by certain mechanical treatments. This volume presents the peer reviewed and edited proceedings of that specialists' symposium.

One of the interesting adjectives that is often used to describe residual stresses is "insidious." This is because residual stresses are present in virtually every solid material or component but, because we can't see them and because without some careful and complex measurements we don't know how severe they might be, we sometimes tend to forget that they are there. Yet, their effects can be significant, even catastrophic.

In spite of their insidious nature, we do know some basic and important things about residual stresses. We know, for example, that residual stresses and applied stresses are algebraically additive within the elastic range and, thus, residual stresses can be beneficial as well as detrimental. Fatigue damage, crack propagation, and stress corrosion are tensile phenomena and, therefore, tensile residual stresses may contribute to the development of these failure modes. Conversely, compressive residual stresses are beneficial in that they tend to inhibit these occurrences. However, large residual stresses, whether they are tensile or compressive, can cause dimensional instability, either through creep or by their redistribution as a result of machining.

It is, of course, desirable to reduce residual stresses that are detrimental. One means for doing this, which is usually effective and economical, is thermal stress relief. Sometimes, however, this method is not practical because a thermal treatment would be detrimental to other characteristics of the object, or because the object is too large, or for any of a variety of other reasons. In such cases, mechanical stress relaxation is often a viable alternative. Cold working and vibration are two common means for achieving mechanical stress relaxation. When the residual stress distribution in a given object is beneficial, then it is likely that no intentional effort would be made to relieve these stresses. However, depending upon the operational stresses imposed upon the object while it is in service, mechanical stress relaxation could take place anyway, say, by the effects of cyclic loads.

Whether mechanical stress relaxation takes place intentionally or unintentionally it would be very helpful in many applications to understand how it happens and what its magnitude is. In general, this kind of information is sparse. Available knowledge about mechanical stress relaxation is largely qualitative. Very few studies of the mechanical relaxation of residual stresses have involved actual measurements of the reduction in residual stresses as a result of mechanical treatments. On the contrary, most of what is known or believed to be true about mechanical stress relaxation has been inferred from indirect observations of the effects of residual stresses. In other words, changes in fatigue, fracture, or stress corrosion behavior, or in dimensional stability, which follow mechanical treatments of the kinds mentioned, are simply attributed to changes in the residual stresses. Clearly, this kind of knowledge is neither complete nor reliable. Without an understanding of the mechanics of residual stress relaxation and a quantitative grasp of its magnitudes, the designer is unable to rely upon the benefits of beneficial residual stresses nor can he avoid overdesigning to allay the possible detriments of detrimental residual stresses. Similarly, the maintenance engineer and the in-service inspector can never be certain under these circumstances about the continued integrity of a structure or component.

This inadequate understanding of mechanical stress relaxation has developed from the difficulties in measuring residual stresses accurately and reliably. Substantial progress in recent years has mitigated some of these difficulties. Today it is frequently possible to measure residual stresses rapidly and economically as well as accurately and reliably. New standard test methods as well as technological developments have effected this advancement in measurement capabilities. ASTM Standard Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method (E 837-85) and ASTM Standard Method for Verifying the Alignment of X-Ray Diffraction Instrumentation for Residual Stress Measurement, (E 915-85) are noteworthy in this context.

With these new capabilities, Subcommittees E28.11 and E28.13 in ASTM Committee E-28 on Mechanical Testing decided about two years ago that it was now feasible to seek a more definitive understanding of the mechanical relaxation of residual stresses, and plans for an international specialists' symposium on this specific, important, topic were initiated.

Through the efforts of Matt Lieff, then ASTM staff manager for Committee E-28, and his counterpart in ASM International, agreements were reached to hold the symposium immediately following the ASM Conference on Residual Stress in Design, Process and Material Selection. The ASM conference was scheduled for April 27–29 and the ASTM symposium for April 30, 1987, in Cincinnati, Ohio. In view of the relatively general nature of the ASM conference and the narrowly focused scope of the ASTM symposium, no unpleasant competition for papers was anticipated and none developed. On the contrary, the back-to-back timing probably benefitted both meetings by attracting additional attendees to the unusual double feature.

No papers were *invited* for the ASTM symposium since, frankly, the members of the organizing committee were not aware of any recent or on-going research activities that involved actual measurements of residual stress relaxation. Total reliance was placed on an international call for *contributed* papers. Nevertheless, the committee was adamant in its intention to accept only papers that specifically included measurements of the relaxation of residual stresses due to mechanical treatments, or theoretical analyses of this phenomenon. Needless to say, it is always difficult to reject good papers simply because they do not address the intended theme of a symposium or a conference, and that is why it is common to see irrelevant papers on symposium and conference programs. The rejection task was made relatively painless in the case of this symposium because of a fortunate set of circumstances. The chairman of the symposium was simultaneously serving on the organizing committee for the ASM conference and was also arranging a session on residual stress for the 6th International Conference on Pressure Vessel Technology (ICPVT-6). Thus, good papers which were submitted to the ASTM symposium but did not adequately address the very specific theme of that symposium were diverted to one of the other conferences, which had comparatively broad themes. As a result, out of sixteen papers submitted to the ASTM symposium, seven were accepted for presentation and subsequent publication. Three others were accepted for the ASM conference and one for the ICPVT-6.

Although only seven papers were considered acceptable for the symposium, they represented a high-quality, balanced mix. Three of the papers addressed the relaxation of residual stress by the application of cold working, two papers dealt with vibratory stress relief, and two with the relaxation of residual stresses that accompanies cyclic loading. All of these papers are presented in this volume, together with the abstract of a paper which was only presented orally.

To the editor's knowledge, this is the only book specifically devoted to the mechanics of the mechanical relaxation of residual stresses. There is reason to believe that this volume will serve to eliminate many of the misconceptions that have existed regarding the mechanical relaxation of residual stresses and will also help to stimulate its use in applications where such treatments would be desirable. The development of standard test methods for evaluating mechanical stress relaxation may also be feasible now.

It is a pleasure to acknowledge the diligent efforts of the authors of the papers—their cooperation, despite separation by oceans, has been exceptional. Thanks are also due to all of the other people who helped produce this book; the hand-picked, expert reviewers whose evaluations and critical comments immeasurably enhanced the final versions of the papers, and the ASTM editorial staff upon whom we have all come to rely so heavily.

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