Introduction

The R-curve approach has a basis in fracture mechanics and, when coupled with new hypotheses pertaining to R-curve characteristics, can be used for instability condition predictions. To be sure, some of the hypotheses can be reasonably challenged, and the need for some additional fundamental studies is apparent. It is intended, therefore, that the contents of this publication will serve to stimulate new involvement in R-curve research work. In particular, help is needed in extending the method to lower strength, high toughness materials, and examples are needed to demonstrate the predictive capabilities of the method.

In reading these papers, it will be apparent that a variety of specimen types and test techniques are available to draw upon, all arriving at a common method of data presentation: toughness development as a function of crack extension. The introductory paper reviews the development of R-curve technology from the early and somewhat misleading model of 1954 to the present model which is believed to be suitable for making instability predictions. Other authors present methods of test, and, in some cases, the fundamental concepts of R-curve technology are presented, tested, and evaluated.

An interesting feature of R-curve concepts is that they contradict the widely held belief that a singular K_c-value can be used to define instability conditions in all types and sizes of sheet specimens. Conversely, it recognizes the role that specimen configuration and dimensions play in controlling the instability event. Early efforts of the Special Committee on Fracture Testing of High Strength Materials, now ASTM Committee E-24 on Fracture Testing of Metals, were aimed at the determination of a K_c-value. Although R-curve principles were fairly well established at that time, the R-curve approach was not accepted generally as a useful tool for materials evaluation. Several laboratories carried out expensive programs in wide panel testing, attempting to arrive at the rather elusive constant K_c-value. An apparently constant value was oftentimes obtained with panels up to 48 in. wide, but experimental difficulties in defining the instability event eroded confidence. Because of these problems and the urgency of fracture toughness evaluation of thicker materials, Committee E-24 turned its attention to the plane strain, K_{Ic}, analysis, which was believed to be more manageable. Here, determinations are made under conditions where little to no stable crack growth is present. Also nearly constant K_{Ic}-values could be determined using relatively compact specimens. This change in emphasis proved productive, and a standard practice, E 399, Test for Plane-Strain Fracture Toughness of Metallic Materials, has resulted. However, many commercial materials in the typical thicknesses provided are not amenable to K_{Ic} analysis. Interest, therefore, is returning to the plane-stress fracture problem.

A recommended standard, E 338, Test for Sharp-Notch Tension Testing of High-Strength Sheet Materials, has been available from E-24 activities for sheet toughness testing using standard size center cracked and edge notched specimens. The notch strength is determined. Interest in such an approach has been sustained, and further developments can be expected. However, the results of this type of procedure offer little prospect of component failure prediction capability. Its primary usefulness is in ranking of materials according to toughness. In application, the need for judgment based on built-up experience is not eliminated. On the other hand, R-curve technology utilizes fracture mechanics concepts and hence offers the prospect of critical fracture stress and flaw size determinations for untested configurations. Presently, the surface has just been scratched on applications for R-curves, and the need for new and original work is great. Low-strength high-toughness materials provide the more challenging testing problems. New ideas will have to be introduced in order to extend the present concepts developed from testing high-strength sheet materials to the common grades of structural plate materials.

D. E. McCabe

Senior research metallurgist, Research and Technology, Armco Steel Corp., Middletown, Ohio 45042; symposium chairman.