RELIABILITY ASSESSMENT OF STAINLESS STEEL SAFETY BURSTING DISCS FOR USE IN PWR

S. GARRIBBA
CESNEF, Istituto di Ingegneria Nucleare, Polytechnic Institute of Milano,
Via Ponzio 34/13, I-20133 Milano, Italy

E. SILVESTRI
NIRA, Piazza di Carignano 2, I-16128 Genova, Italy

G. VOLTA
EURATOM JRC, I-21020 Ispra (Varese), Italy

SUMMARY

Safety bursting discs may be used in PWR's pressurizer relief tank to meet certain design requirements as a support to safety valves. The required performances of these bursting discs are that they must rupture within a narrow range of pressures under any operating circumstance. The behavior depends upon a number of factors: geometry, material characteristics, assemblage and load history. All factors may be affected by significant variability. In this respect, a study of reliability appears worthy and helpful. It can be noted that pressure discs are a comparatively simple and repeatable structural component. Thus a number of experiments can be planned in order to verify how well theory may interpret the real behavior of the structure.

When used as pressure-relief devices, bursting discs may fail to operate in two ways. They may undergo spurious failures (safe failure), or fail to operate when required (unsafe failure). In this work structural reliability is evaluated for an AISI 304 LC, 1 in discharge diameter, 0.28 mm thick safety diaphragm. Bursting experiments have been made for a range of operating conditions. Additional information is provided by tensile tests on the same material sheet as that from which discs were manufactured. Bursting experiments show that assemblage plays a negligible role. The significant conditions affecting variability in burst pressures are fatigue and possible change of mechanical properties of the metal.

In their normal condition discs rupture in the region of the pole. The failure model which appears to predict satisfactorily burst pressure is essentially the one proposed by Weil, J. Appl. Mech. 26 (1959) 621. However, when discs undergo a certain number of loading cycles, one observes transition from rupture at the pole to rupture at the edge. With severe fatigue conditions a lower burst pressure pertains to this type of failure. In reliability evaluation the two rupture patterns are assumed independent and transition is treated statistically. Overall reliability is computed in terms of crossing probability of stochastic processes. Loads indeed develop as a stochastic process in time. On the other hand, residual strength can be considered as the result of a mechanism of cumulated effects where damage is determined by corrosion and random fatigue.

The application of reliability to structural mechanics is not new. However, in the knowledge of authors, there are few cases where theoretical models were supported by experimental evidence. With regard to this, scope of the paper has been to present a theory and its direct use in a practical problem. Finally, methods and approximations that have been developed seem transferable to a wide class of alike situations.