International Scientific-Technical and Production Journal

The Paton WELDING JOURNAL

December 2012 # 12

English translation of the monthly «Avtomaticheskaya Svarka» (Automatic Welding) journal published in Russian since 1948

Founders: *E.O. Paton Electric Welding Institute of the NAS of Ukraine*
International Association «Welding»

Publisher: *International Association «Welding»*

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URL: www.rucont.ru

State Registration Certificate
KV 4790 of 09.01.2001

Subscriptions:
$348, 12 issues per year,
postage and packaging included.
Back issues available.

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CONSIDERATION OF PORE FORMATION AT ESTIMATION OF LIMITING STATE IN ZONE OF PRESSURE VESSEL WALL THINNING DEFECT

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The tough fracture models allowing for pores forming in plastic flow either at non-metallic inclusions or in matrix from the microcracks that do not propagate by cleavage mechanism provide for the corresponding algorithms of growth of the pore due to plastic strains and respective redistribution of the stress-strain state. At present, the interest in these models is determined by growth of the scope of prediction and expert estimates for the welded structures, based on calculation estimation of the limiting state. In a number of cases, in view of the trend to utilization of high-strength and sufficiently ductile materials in the welded structures, the limiting state occurs under the tough deformation conditions at the rigid stressed state, which contribute to the pore formation. Fracture as a result takes place at relatively small plastic strains that rapidly reduce deformation capacity of corresponding welded assemblies before fracture.

Keywords: *steel pressure vessels, development of plastic flow, limiting state, pore formation, fracture zone, criteria of fracture involving pores, spontaneous fracture*

Operational defects of wall thinning in current welded pressure vessels are the most widely identified defects of long-term service structures (main pipeline, oil and gas storages, tank cars etc.). At periodic technical diagnostics of such structures the identified defects are estimated from point of view of safe operation of the structure for a period at least up to the next technical diagnostics. Specific rules based on corresponding calculation and experimental investigations are applied at that. These rules are improved according to accumulation of facts of their application, change of operation conditions for specific type of structures, development of calculation models of loading (fracture) as well as methods of realization of these models.

Observed significant progress in computer engineering, deformation and fracture mechanics of structural materials, respectively, provides for realization of the more complex physical models. It is a good basis for development of more detailed models of behavior of structural material at deformation (in stage close to fracture) as well as at fracture to certain extent. This makes the calculation approaches to prediction of a limiting state for complex cases of deformation sufficiently suitable to that is observed in experiment allowing reducing the scope of expensive experiments. Such an approach is connected with attraction of additional physical and mathematical models for development of information related with the coming of limiting state. Work in this direction is actively performed in different countries. Works of scientists of Siberian school of Prof. V.E. Panin in scope of new scientific direction, i.e. physical mesomechanics of materials [1], are worthy of notice among the current investigations. Deformation of material on mesolevel, i.e. considering significant physical discontinuity determined by presence of different interfaces (for example, gain boundary) with further estimation of reaction of material on macrolevel by means of average of characteristics of stress-strain state along representative mesovolume is considered in scope of this direction. Primitive example of inelastic material behavior according to [1] is a «shear + rotation» that allows preserving continuity condition up to fracture. The latter is a final stage of material fragmentation on macrolevel when global shear buckling takes place.

Pore formation in many cases is an important phase of material deformation before fracture stage. The pores are formed in plastic flow at non-metallic inclusions or in matrix from the microcracks that do not propagate by cleavage mechanism, i.e. being almost essential attribute of material tough fracture. It is not surprising that a great attention is paid to the issue of formation and growth of pores at tough fracture of materials [2–4]. Initial dimensions of appearing pores are not large around 1 μm as a rule. Therefore, their influence on deformation processes and fracture can be considered in scope of mesolevel