INFLUENCE OF ELECTROPOLISHING ON THE IMPACT CHARACTERISTICS OF PRESSURE VESSEL STEELS

Ph. Van Asbroeck*, J.-L. Puzzolante*, A. Hennen*

Determination of relevant toughness values for pressure vessel material requires, before or after Charpy V notch (CVN) testing a microstructural characterization of the test specimen. Electropolishing can be used for this purpose without interfering with the dimensional requirements of ASTM standard E-23. The objective of the present work is to determine if the Charpy V notch characteristics of 18MND5 type steel are not affected by electropolishing.

Three kinds of CVN specimen surface conditions were considered : machined, completely electropolished before notch machining and laterally electropolished after notch machining. Electropolishing was carried out as described in the previous study. The instrumented impact tests were carried out on three sets of CVN specimens corresponding to the three surface conditions. The results are presented in Table 1.

Table 1 : Influence of electropolishing on the instrumented impact characteristics of 18 MND5 steel (average values)

Characteristics	Ref. Condition	Electropolished Laterally	Electropolished Completely
CVN energy (J)	102	113	123
SFA (%)	24	31	28
Lat. exp. (mm)	11.6	11.6	11.8
Gen. yield (kN)	13.6	14.2	13.3
Max. load (kN)	18.3	18.4	18.2
En. at max. (J)	80	77	80
En. at u.c.p.(J)	90	103	114

u.c.p. : unstable crack propagation;

* C.E.N./S.C.K.; B-2400 MOL; Belgium

A statistical method was used to detect a possible influence of electropolishing on the CVN specimen properties. The method is based on significance tests. This technique gives the probability to observe differences of measurements for a given characteristic, assuming this characteristic is effectively not different for the various samples (null hypothesis). Two types of significance tests were used : a parametric test assuming normal distribution and a non-parametric test, which is a distribution-free test. Agreement between non-parametric and parametric significance tests implies that a normal distribution cannot be rejected. In that case the likelihood ratios of null to alternative hypothesis may be estimated and give an idea of the odds of the "no effect of surface condition" hypothesis with respect to the "effect of surface condition" hypothesis.

Good agreement between the non-parametric and the parametric significance tests was observed which validates the use of the likelihood ratios. For the general yield load, differences become statistically significant at a 5 % level only. Regarding machined and laterally electropolished specimens the level of significance was not sufficient to draw a conclusion. Under these circumstances a small effect on the general yield load can not be excluded. But this has little practical consequences, as the difference at stake is small : an increase of about 0.7 kN (5 %). The situation was similar when machined and completely electropolished specimens were compared : odds were equal, implying a maximum possible increase of about 0.2 kN (2 %).

However, lateral electropolishing after notch machining increases the general yield load relatively to complete electropolishing before notch machining. In this case, the level of significance is 1 % and the odds support the hypothesis of an effect, i.e. a general yield load decrease of about 0.9 kN (6 %). Possible explanation could be a small change in geometry, the surface condition (cold-worked layer) or a change of friction characteristics between anvil and specimen. Finally, it was found that total polishing decreases the scatter of all results by a factor of about 2.

It should finally be noted that, although the observed differences of the CVN energy and the energy at u.c.p. of machined and completely electropolished specimens are not significant (Table), an improvement of these properties by complete electropolishing can not be rejected. This improvement could be caused by a later initiation of unstable crack propagation.

The following conclusions can be drawn from the systematic instrumented impact testing of base material steel CVN specimens in the transition zone :

- lateral electropolishing of CVN specimens after notch machining has no practical effect on the instrumented impact test properties,
- complete electropolishing before notch machining can increase the total energy for rupture and the energy at unstable crack propagation. On the other hand, it can also improve reproducibility by a factor of about 2.