

Reviewer 2 Open Review

Comments and Suggestions for Authors

The paper investigated the mechanical responses of the small punch creep test by a series of finite element modeling and experimental comparison. The influences of key parameters such as the friction coefficient on the test results were discussed, and the results can provide helpful guidance for the recently published SPC standard. The manuscript is well structured and could be accepted for publication in Metals after the following issues are addressed.

- (1) Page 4 Line 130, the authors adopted a phenomenological creep model i.e. Eq.(3). Was the model proposed by the authors or others?

Reply: Yes it was proposed by us and described in some more detail in [32]

- (2) Page 2 Line 90, The authors used the “Design data” from RCC-MRx for the calibration of the model. What is the difference between design data and experimental data from RCC-MRx? The lower bound or some safety factors were adopted to guarantee the conservatism?

Reply: The data in RCC-MRx is based on processed data from large experimental test programmes by experts. This is Design Code Data. Since there is not creep curve data between the minimum creep rate and rupture we construct a creep curve between the values using the Logistic Creep Strain Prediction. This is the “Processed” part of the Design Code Data.

The creep curves equation in the RCC-MRx code (primary and secondary) represent average values. The rupture stress values in Table are also average values. Thus no safety factor or lower bound. We have stressed design code data (line 90 and 144) as design data may imply lower bound (e.g. fatigue curves) and that we use average values (line 91 and 138 & 139). The phenomenological models and how it is calibrated to the RCC-MRx data is described in more detail in [32].

- (3) The general creep model is strain-based, so what’s the corresponding failure criterion for creep failure? That is, how to determine the creep rupture life? Whether it is related to creep ductility? The stress state of the sample for SPC test is not uniaxial, so how to consider the multiaxial effects in the creep model? The authors should clarify this point, because they compared the rupture lives in the subsequent numerical analysis.

Reply. The phenomenological that is implemented for the numerical analysis describes the strain rate as function of the accumulated creep strain and true stress. Thus it does not include a creep failure criterion. From microstructural analyses it has been observed that the failure is usually preceded by the formation of cracks typically at the edge of the contact zone between the semi-spherical indenter and the disc resulting in a very large increase in the deflection rate. To model this would require a damage models and a specific criterion (e.g. crack density, crack initiation, critical crack size). Using

the phenomenological model results in a very drastic increase of the deflection as seen in Figure 6 (also seen in the experiments) and the strain as indicated in Figure 12 due to the increasing true stress effect and power-law dependence of the creep strain rate as function of the true stress. In the analysis we define that failure occurs when the creep strain becomes so large so there is no convergence. As seen in Figure 12 the peak creep strain is then of order 1. Failure occurs probably at lower strains and thus time to rupture is overestimated.

The deformation and stress field are of course multi-axial in both the test and in the analysis. Understanding the role of multi-axiality is paramount to fully understand and fully exploit the SPC test, and in particular relate it to the uniaxial test (as is done in the Standard). We mention in the discussion the importance of looking at the strain components rather than the effective strain. The whole issue of multiaxiality is very complex and cannot be addressed in this paper. It is our intention to address this topic in future work by comparing uniaxial and SPC creep.

(4) Besides, how to obtain the rupture life of the sample from the simple Norton model? It is a little bit obscure, because this is a creep model for secondary creep

Reply: the true stress effect and accelerated deflection rate in the final stage applies to the pure Norton models as well.