3D cavitation instabilities using a non-quadratic anisotropic yield function

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ABSTRACT

For a single void in an infinite elastic-plastic material cavitation instabilities have been found for cases where a constant remote stress level is so high, that the stored energy drives continued void expansion [1]. Recently, the authors have studied cavitation instabilities in a full 3D setting accounting for plastic anisotropy represented by the classical anisotropic Hill-48 quadratic yield function [2,3]. The two different anisotropies studied have shown that an initially spherical void develops into a spheroidal void that differs significantly from the initial void shape. An extremely small void volume fraction is needed in order to see cavitation instabilities, i.e. 5·10^-7 is adopted here.

The present work extends the previous 3D analyses to account for plastic anisotropy represented by the non-quadratic Barlat-91 yield function proposed by Barlat et al. [4]

\[ \Phi = [S_1 - S_2]^m + [S_2 - S_3]^m + [S_1 - S_3]^m \]

where \( S_i \) are the principal values of the modified stress deviator and \( m \) is the exponent, typically larger than two [5]. Similar to the quadratic Hill-48 yield function, the non-quadratic Barlat-91 yield function requires six coefficients of anisotropy, but additionally the exponent \( m \) is required. For the six coefficients being unity and the exponent equal to two \( (m=2) \) the isotropic Mises yield surface is recovered. However, for large exponents (typically \( m > 20 \)), the Barlat-91 represents an isotropic Tresca-like yield surface with rounded corners. It is found, that the stress level required for cavitation instabilities to occur using Tresca is reduced by approximately 3% compared to Mises-plasticity.

In order to see the effects of adopting the different yield functions two different plastic anisotropies are used to calibrate the coefficients of anisotropy involved for Hill-48 and Barlat-91. However, the exponent is set to \( m=8 \) for Barlat-91, in order to represent the FCC crystal structure of aluminium [5]. Only minor effects on the overall stress level is observed when adopting Barlat-91 over Hill-48, but one anisotropy seems to have a significant effect on the predicted void shape evolution.

REFERENCES