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An improved multiaxial rainflow algorithm for non-proportional stress or strain histories

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Non-proportional multiaxial fatigue damage occurs when the principal stress directions vary during the loading induced by several independent forces, such as out-of-phase bending and torsion. Uniaxial rainflow counting techniques cannot be reliably applied in this case. The objective of this work is to develop a simple multiaxial rainflow algorithm that allows the proper calculation of multiaxial damage in non-proportional histories.

Two approaches can be followed to perform a multiaxial damage calculation. The first is based on a critical plane approach, where several candidate planes must be studied. The stress/strain history on every candidate plane must be rainflow counted to find the one that experiences the largest damage [1]. This method is not efficient for very large non-proportional loading histories.

The second approach is to use a truly multiaxial rainflow algorithm, such as Wang-Brown's (WB) method [2]. Such algorithm, however, has a few idiosyncrasies that can lead to non-conservative predictions, incorrectly filtering out significant events within a multiaxial loading cycle.

An improved multiaxial rainflow algorithm is proposed in this work. It has two main improvements over the WB algorithm. First, the criterion to choose the point where the count is started is modified. Examples are shown that prove that the original criterion can overlook the most damaging event from the history, as opposed to the modified version.

And second, the algorithm implementation is significantly simplified when formulated on the reduced five-dimensional Euclidean space defined in [3]. Under plane stress conditions, the algorithm is further simplified using a three-dimensional Euclidean space based on the deviatoric stresses or strains. A simple pseudo-code is presented (see Fig. 1) to efficiently implement the multiaxial count, allowing the calculation of fatigue damage in long non-proportional histories. Experimental results are used to validate the proposed algorithm.

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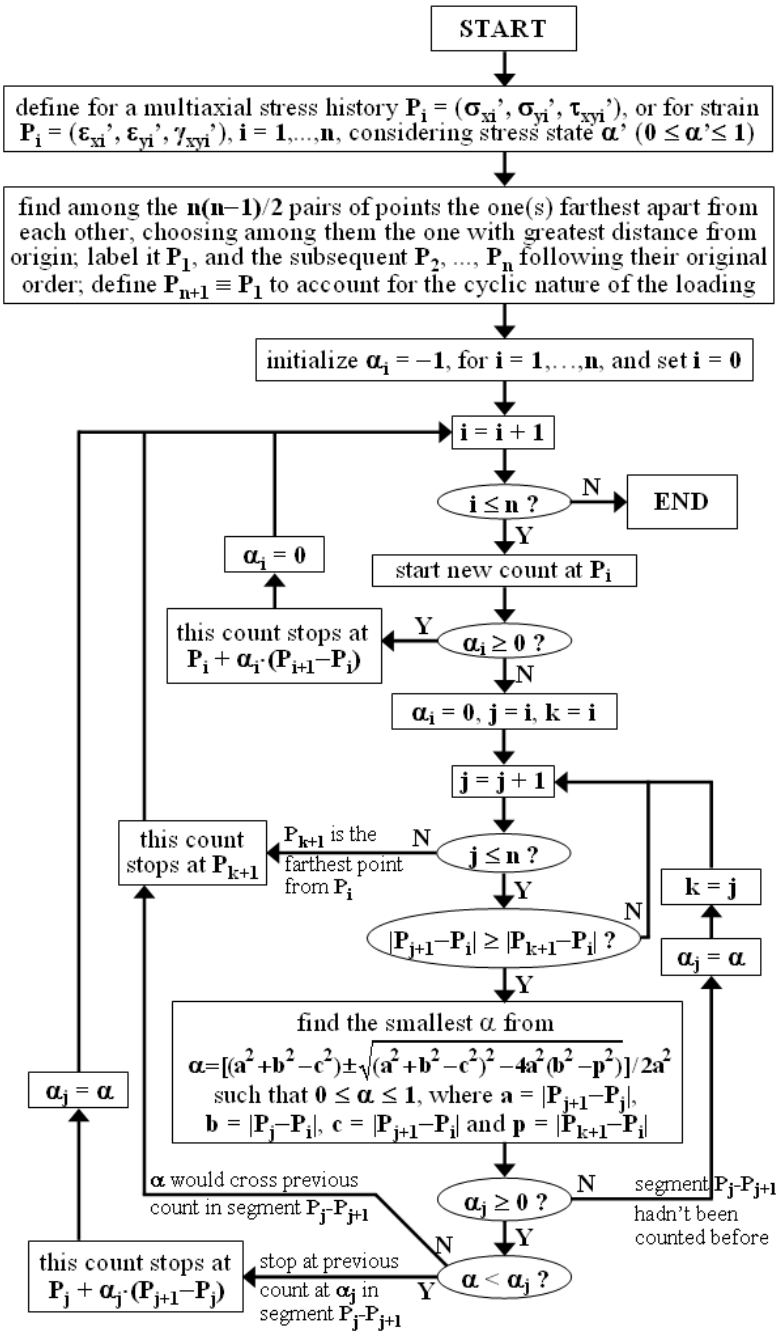

Fig. 1. Flow chart of the proposed modified Wang-Brown multiaxial rainflow algorithm

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