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SOLUTIONS

Application Note

Creating a Forming Limit Curve in VIC-3D

VIC-3D 9

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Creating a Forming Limit Curve in VIC-3D

Introduction

Forming is the process of mechanically deforming an object through reshaping without adding or removing material, so the mass remains constant. Forming is commonly used in the automotive industry as a fast, reliable, and repeatable method to manufacture vehicle components such as body panels. However, creating a strong part using the least amount of material is an essential study that saves millions of dollars in material cost. To solve this problem, engineers perform a series of experiments using various geometrical configurations of a material to create a forming limit diagram or curve (FLD/FLC). The FLD creates a clear understanding of how the process is deforming the material, and how to improve the process using less material. Determining this can be extremely challenging using traditional measurement methods such as applying strain gauges, because the strain gauge location is finite and the fracture location is unknown.

Digital Image Correlation (DIC) has proven to be an excellent non-contact measurement technique due to its robustness and its full-field surface deformation and strain measurement capability. DIC is perfect for forming applications as it identifies critical areas of the material during the process. Displacements and strains are measured and extracted at the precise locations. Furthermore, recent developments in the VIC-3D software from Correlated Solutions allow the user to generate an FLC utilizing data from multiple DIC tests. This user friendly software module is an essential solution for engineers to understand the behavior of a material undergoing significant plastic deformation caused by the forming process. This document outlines the analysis procedure of the VIC-3D FLC module.

VIC-3D Forming Limit Curve (FLC) Procedure Guide

1. Acquire image pairs during the forming process using the VIC-3D system.
2. Define an area of interest, and perform a DIC analysis with the VIC-3D software as usual.
3. After the entire test image sequence is analyzed and the strain computation is complete, in VIC-3D, select **Data - > Postprocessing tools - > Forming limit curve**.
4. In the FLC dialog VIC-3D automatically displays the data from the last image in the sequence, and locates the peak major strain e1 (green point in figure 1), and the peak dome height Z value (red point in figure 2) in the image pair before failure.

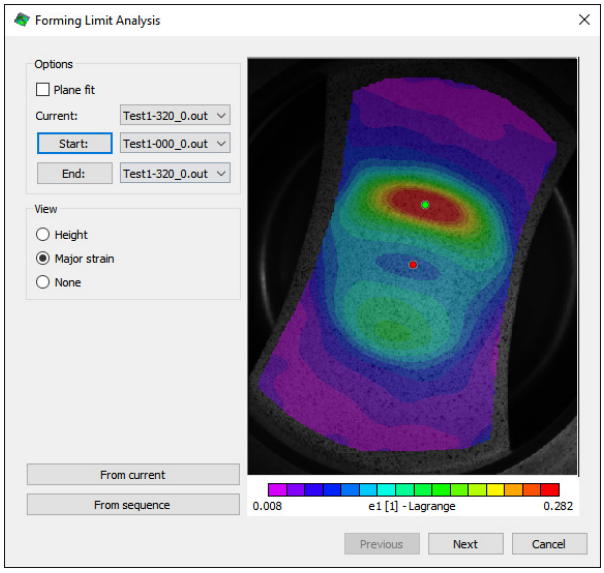

Figure 1.
Forming limit window displaying e1

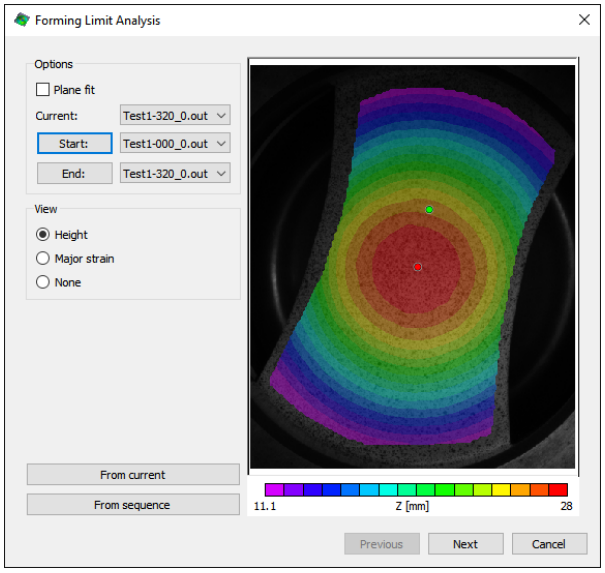

Figure 2.
Forming limit window displaying Z

5. The user can manually move these points to any desired location in the image.
6. After the user clicks **Next**, the e1 vs time graphs are shown for the two points. The software automatically attempts to determine the correct point in the time sequence for strain extraction based on a change in slope of the extraction point as shown in figure 3. However, the user can change this point by dragging the white dot on top of the vertical bar left and right.

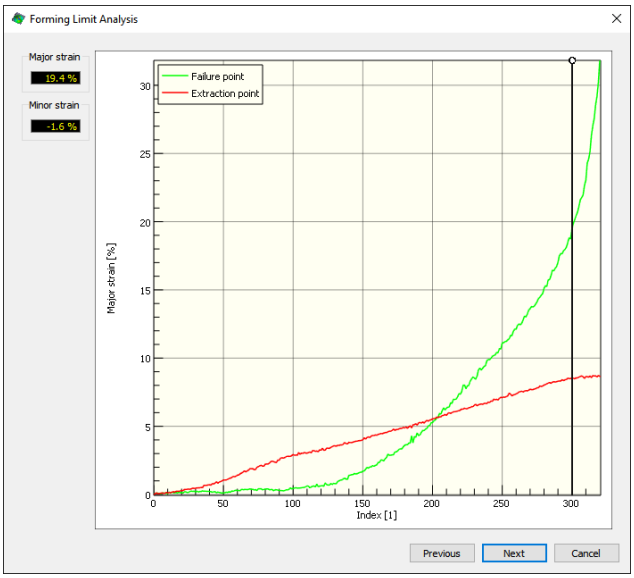

Figure 3.
Graph of e1 vs image number of the failure and extracted points

7. After the user clicks **Next**, the e1 & e2 values at the selected failure point are shown in the FLD as displayed in figure 4. The software automatically loads a database (*.flc file) from the parent directory if it exists. It is recommended that all tests for the FLC are kept as sibling directories of a common parent directory in which the database is stored.

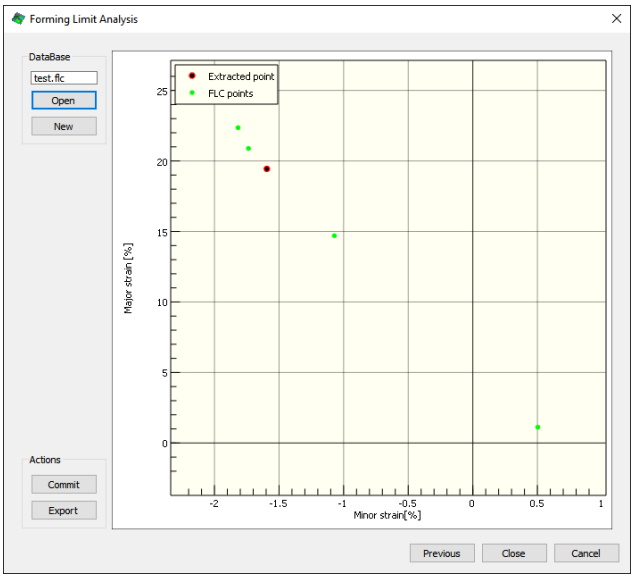

Figure 4.
The FLD points shown from multiple DIC tests

8. If no database is found, the user can create one by clicking **New**. It is recommended to save this database in the parent directory.
9. After all the forming tests are performed, the user will end up with one common graph that includes all the data points as shown in figure 4.
10. This data can then be exported to a CSV file, and a curve can be fitted to the data points.

NOTE: It is recommended not to include any images after fracture in the project, as this typically creates some severe outliers that can interfere with the automated extraction algorithms.

Support

If you have any questions about this document or any other questions, comments, or concerns about our software, please contact us at support@correlatedsolutions.com, or visit our website at support.correlatedsolutions.com.