Test Validated

CASE STUDY

Multi-Scale Modeling and Validation
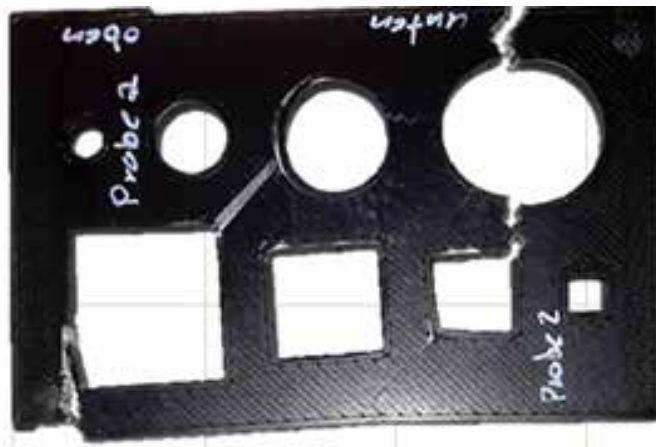
for Additive Manufactured Hole Plate

BOSCH

Challenge

BOSCH, a leader in the manufacturing of electronic components, was interested in reducing trial and error costs of Additive Manufacturing fabrication and assess part in-service performance of a hole plate housing for specialty products **(Figure 1)**.

BOSCH AM Hole Plate

![AlphaSTAR]

Solution

BOSCH utilized AlphaSTAR's GENOA 3DP, an ICME toolset, for AM process simulation and build optimization. BOSCH chose a BASF ABS polymer, Terluran, with a continuous matrix and finely dispersed butadiene rubber particles. The polymer did not include reinforcements. Initial material properties were taken from a Terluran datasheet and ABS non-linearity data published on the BASF website. It was assumed that voids would be cylindrical with an aspect ratio of 4% and the AM material would have a void volume ratio of 22%.

First, with the usage of AlphaSTAR's MCQ software, which predicted material properties data including temperature dependent mechanical properties, BOSCH was able to build a virtual material model for AM simulation. Coupons with various print orientations were fabricated to validate the material model.

Next, AlphaSTAR's GENOA 3DP tool path error capability was used to assess the G-code, tool path assessment, and build simulation. GENOA 3DP identified gaps associated with the build that ultimately would affect structural performance **(Figure 2)**.

Further, transformation of the G-code including build parameters into an FEM mesh for the full hole plate revealed potential concerns associated with gaps, voids, and bald spots that would be an outcome of the deposition process **(Figure 3)**.

FIGURE 2

First Indication of Build Anomalies
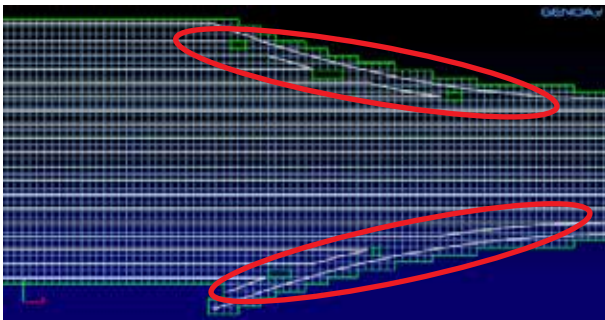
FIGURE 3

Toolpath and Build Defects
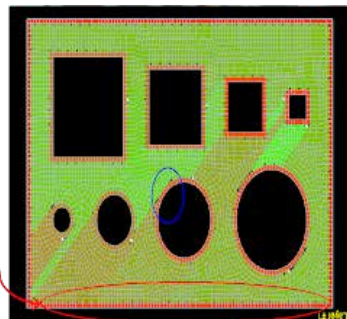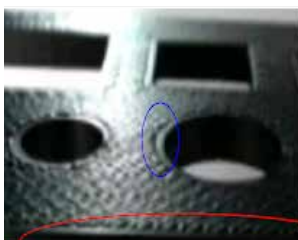
Solution (Cont.)

Continuing with the simulation, GENOA 3DP was able to predict accumulated residual stresses as a function of the build. Information related to S11, S22 and S12 residual stresses are shown in **Figure 4** which eventually leads to damage initiation and propagation during service loading.

The final component in this effort involved virtual testing of the AM built hole plate which was subject to service loading and compared against the results of actual physical test data. The AM produced Hole Plate was tested in an MTS(define) servo-hydraulic test fixture and subjected to longitudinal loading under displacement control.

The results depicted failure as would be expected of an unreinforced part. GENOA 3DP accurately:

⟩ Captured the peak load and overall behavior of the load displacement curve associated with the test process **(Figure 5)**.

⟩ Identified the point of damage initiation and propagation leading to failure.

FIGURE 4

Accumulated Residual Stress in All Three Directions at Final Layer of AM Build

a) S11   a) S22   a) S12

FIGURE 5
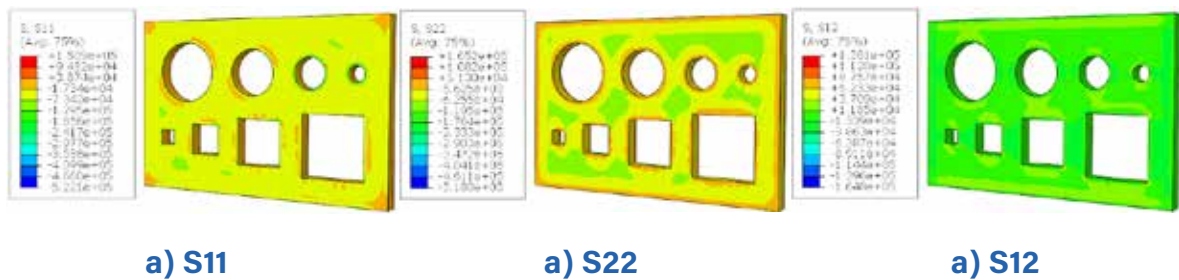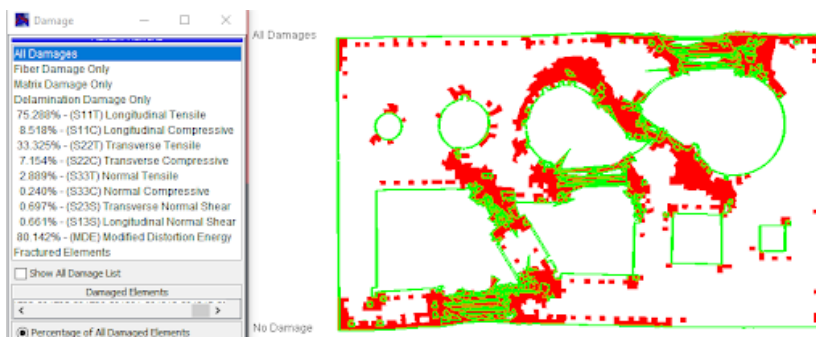
Test Versus GENOA 3DP Simulation
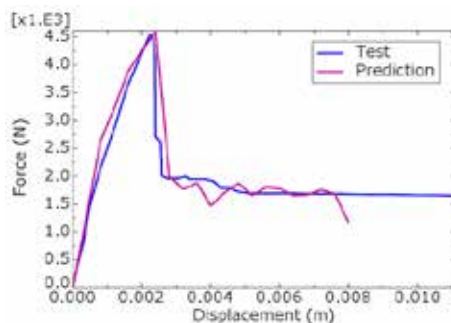
Solution (Cont.)

The full benefit of GENOA 3DP's multi-scale progressive failure analysis includes an explanation of why, when, and where failure occurs, including percentage contribution of individual failure criteria during the service loading process **(Figure 6)**.

FIGURE 6

Cause and Contribution of Failure

Result

Successful and Accurate simulation of the AM build process for an unreinforced ABS polymer hole plate.

GENOA 3DP simulation identified potentially serious manufacturing anomalies and residual stress. The case study highlighted the benefits of AM simulation; further sensitivity studies and process optimization can be used to improve build quality and part performance.

AlphaSTAR

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