Case Study: Sinterline® prototyping by Solvay

Ultimate strength prediction of a plenum under pressure produced by selective laser sintering

Summary

Solvay, a global leader in advanced polyamide solutions, is the principal material sponsor for the Polimotor project, who aims at opening the way for a technological breakthrough in the automotive sector by replacing up to 10 metal parts by plastic materials in the engine Polimotor 2 engine.

Among the manufactured plastic parts, the Polimotor 2 engine will feature a 3D printed plenum chamber produced through selective laser sintering (SLS) using a Sinterline® Technyl® polyamide 6 (PA6) powder grade reinforced with a 40 percent loading of glass beads.

The target is to demonstrate that the plenum plastic part manufactured with those technology and material can perform with the same reliability as its injection-molded counterpart.

Polimotor 2 Plenum printed with Sinterline®

Challenge

Due to the fact that parts are built of layer superposition without the need of support materials, laser sintering can quickly produce components that integrate complex internal features and functions. However the direction in which the part is built greatly affect the printed part strength. Although the printed material behavior is not affected by the building direction, its ultimate strength is reduced in the stacking direction. This issue is inherent to additive manufacturing processes, as successively deposited layers are not perfectly bound together.

The impact of the produced part orientation in the build chamber of SLS devices, and AM processes in general, must not be neglected and this new parameter influence must be evaluated.

Here, the plenum has been printed in a peculiar direction due to the limited space available in a building chamber: this will be taken into account while predicting the ultimate pressure load it can sustains.

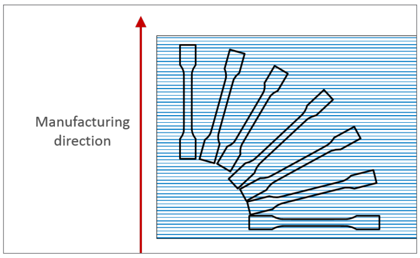

Figure 1: Manufacturing direction vs. various tensile samples

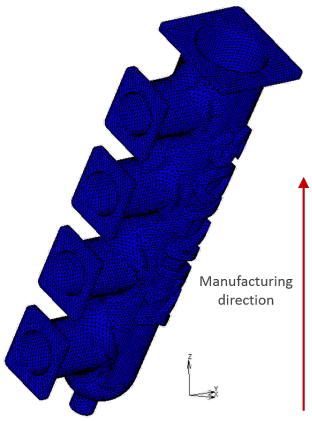

Figure 2: Manufacturing direction of the plenum

Solution

- Create and calibrate the material behavior using the appropriate constitutive law. The glass beads are modelled using an elastic law while the pressure-dependent Drucker-Prager model is well suited to catch the matrix behavior.
- Fully characterize the failure surface using the appropriate failure criterion. The failure surface shape, specific to 3D printed material, can be well fitted with a generalized version of the Tsai-Wu transversely isotropic failure criterion.
- Perform a coupled MSC Marc/Digimat calculation to establish the ultimate pressure load the part is able to withstand.

Results/Benefits

- Precise description of the material behavior and failure surface
- Study sensitivity of the part strength to its orientation in the build chamber
- Avoid producing parts that do not meet the strength requirements by taking into account the specificity of 3D printing processes

Key Highlights:

Digimat:
Digimat-MF, Digimat-CAE

CAE Technology:
MSC Marc

Industry:
Automotive

Application:
Failure prediction

Performances:
Structural strength

Results Validation

The maximum pressure load sustainable has been numerically predicted to 9.1 bars, whereas 3 bars has been experimentally applied without failure in the same environmental conditions. The designed plenum should sustain the working load conditions and may be redesigned by topology optimization in order to lighten the structure while taking advantage of the 3D printing technology.

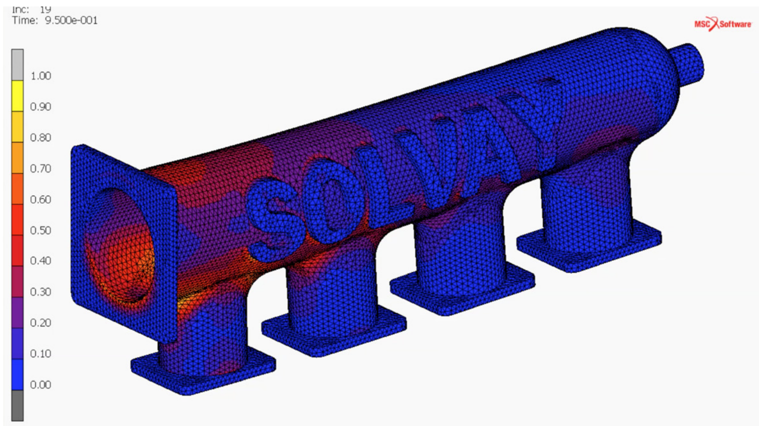

Figure 3: Failure indicator distribution before ultimate failure of the plenum under pressure

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