ANSYS

Distortion Compensation

Distortion compensation is an ANSYS exaSIM™ feature that enables additive manufacturing (AM) users to rapidly predict how their parts will distort during the build process and provides a com-pensated model for users to build. Distortion compensation reduces the need for trial and error experimental iterations. In short, exaSIM saves users time and money while making accurate parts.

Figure 2. Simulation and physical build images showing no bulge before top ring is added

What is the hurdle?

Most parts produced using metal laser powder bed AM experience distortion. Even the intuition of experienced users often is not sufficient to understand how a complex part will distort during the build process. When distortion is understood, designers are still faced with the problem of correcting for distortion. ANSYS exaSIM provides a solution to distortion problems by providing a compensated geometry that can be used during fabrication to produce an accurate part.

This tech brief describes the process that Croft Filters (Warrington, UK) went through using exaSIM to correct a “bulge” distortion problem (see Figure 1) and produce an accurate part.

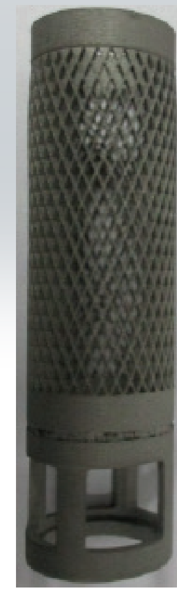


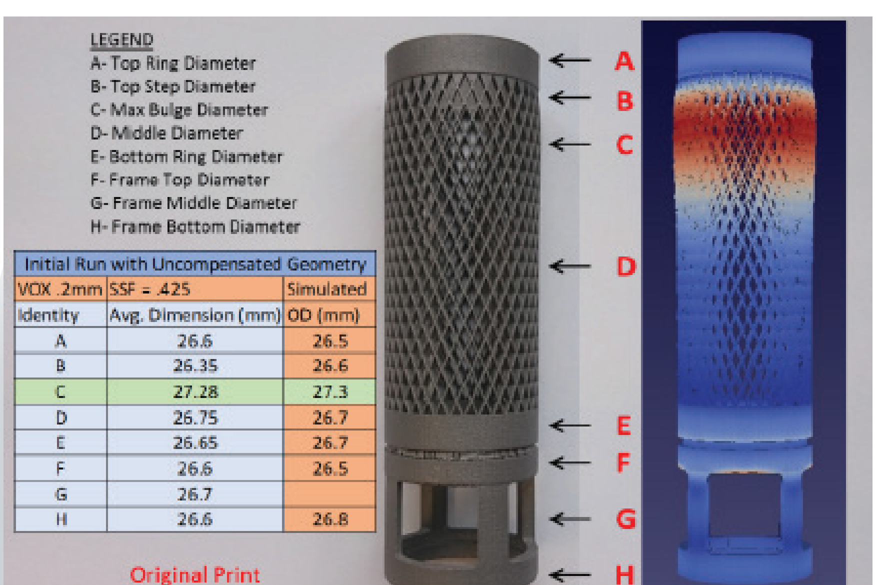
Figure 1. Filter produced by Croft Filters showing bulge on what should have been straight walls

How was simulation used to clear the hurdle?

Croft Filters creates custom metal AM filters; but even with many years’ experience, some geometries still prove problematic. The Diamond Filter shown in Figure 1 was one of these problematic geometries. The original part experienced a bulge in the mesh section slightly below the transition from mesh to a solid ring. In general, mesh structures build accurately, so the question arose as to whether this bulge was a manufacturing anomaly or a predictable artifact of the process.

After analysis, exaSIM showed that this was a predictable behavior for this geometry. A comparison of the physical and predicted filters and their relative diameters is shown in Figure 3. A layer by layer animation of the part distortion, and a build without the top ring, showed that the mesh section was built with very high accuracy up until just before the ring was built (see Figure 2). Shrink-age forces during ring fabrication caused the bulge in the mesh. This was further validated by simulating and building the part inverted to see if the bulge would switch ends in the mesh near the inverted upper portion of the build. The simulation accurately predicted that the bulge would change ends when the filter was inverted (see Figure 4).

Designers using exaSIM can predict how design modifi-cations affect part accuracy. Design modifications can be done manually (in CAD) or using the exaSIM distortion compensation tool. When using exaSIM, the magnitude of distortion compensation can be varied. A distortion compensation factor of 1.0 results in an STL file with a visi-bly large reverse distortion (see Figure 5). The predicted final part shape from the 1.0 compensated STL file will have a slight inward deformation pattern, eliminating the external bulge.



Initial Run with Uncompensated Geometry		
VOX .2mm	SSF = .425	Simulated
Identity	Avg. Dimension (mm)	OD (mm)
A	26.6	26.5
B	26.35	26.6
C	27.28	27.3
D	26.75	26.7
E	26.65	26.7
F	26.6	26.5
G	26.7	
H	26.6	26.8

Figure 3. Simulation results compared to measured results of original geometry

Since distortion and stress accumulation are highly dependent upon the input geometry, using a distortion compensation factor of 1.0 may not be the best solution. An iterative approach, where a user utilizes a lower compensation factor for two or more iterations, is easy using exaSIM. Figure 6 shows that two iterations, each with a distortion compensation factor of 0.5, result in a part that will build extremely close to the originally intended design shape.

Figure 4. Simulation accurately predicted that the bulge in an inverted filter will occur in a different portion of the mesh region, just below ring.

Figure 5. (Left) Distortion compensated STL file at 1.0 magnitude. (Right) Predicted final shape after build of distortion-compensated geometry.

Were the users able to create a compensated part without the bulge?

The results of physical builds showed that exaSIM accurately predicts different effects of filter design modifications and build orientations. Using the exaSIM distortion compensation functionality, a part that was completely free of external bulge was created in a single iteration (see Figure 7).

With the rapid growth of metal AM, the demand for skilled AM designers and machine operators is greater than the supply. Using exaSIM, even inexperienced designers and machine operators can quickly predict geometry changes due to distortion and the effects of build orientation on the accuracy of critical features. This enables companies to build parts successfully without needing to find designers/operators with years of experience. The Diamond Filter had been problematic for Croft Filters for several months. Using exaSIM, a first-year engineering student was able to generate a successful geometry that provided a viable path forward for building a part with no external bulge.

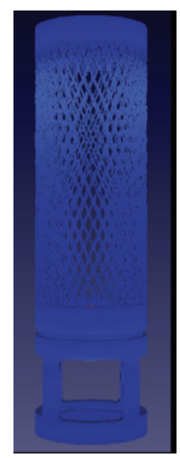


Figure 6. Simulation results of two iterations of distortion compensation at a factor of 0.5.

Figure 7. Physical build of 1.0 magnitude distortion-compensated file showing no external bulge and nearly vertical walls.

Conclusion

Croft had an as-built part that was not conforming to their design intent. Multiple manual iterations to the design resulted in only minor improvements. ANSYS exaSIM accurately predicted part distortion and automatically created a distortion-compensated file. After building the compen-sated part, the external bulge was eliminated. Croft Filters demonstrated how 3DSIM users can significantly reduce the time and cost to develop high quality components.

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