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February 5, 2016



Solid Models and Dimensional Tolerances

Solid models have improved steel casting design. The ability to create a complex shape using computer solid modeling has allowed designers to be more creative and effective. A solid model can be used to evaluate the performance of design concepts using finite element analysis (FEA) for complex shapes and loads. The solid model can be used to test fit and assembly using other software tools. Designers use castings to make parts with free-form geometry to gain the maximum performance.

Traditional design used orthogonal drawing views with uniform sections as these were easy to draw and materials for production were readily available.. These designs were analyzed for performance using simplified geometries that allowed manual calculations. Dimensional tolerances for these traditional designs involved specifying the size of part features. These dimensions were verified by manual measurements. Once the part design was verified and approved, there were only audit checks or gauging of critical features for fit and function. Some dimensions might not even conform with the drawing having been modified in the tooling for production or performance without the drawing being changed to reflect the parts supplied. As long as the parts supplied from the pattern tooling worked, little effort was made to ensure compliance with the drawing.

For functional dimensioning of parts used, designers adopted Geometric Dimensioning & Tolerancing (GD&T). Instead of isolated feature measurements, the location and size of critical features were defined in a nominal geometry and its acceptable variation. **According to the ASME Y14.5-2009^[1] standard, the purpose of GD&T is to describe the engineering intent of parts and assemblies.**

The use of Coordinate Measuring Machines (CMM) and concerns about liability and quality required that castings now fully comply with the drawing tolerances. Photo and laser scanning technology coupled with software to weave the images together, created another means to dimensionally inspect parts. The ability to represent the actual part dimensionally through a point cloud or series of images enables the direct comparison back to the solid model. Deviations of the part from the solid model are not necessarily non-conformances but must be evaluated based on the tolerances.

It is now more important than ever to understand Form Fit Function (FFF) and the effect of dimensional tolerances. Inspecting a casting with scanning technology requires a solid model with GD&T. Inspecting a casting to a nominal tolerance everywhere does not provide for FFF. Features that are fit-to-air or non-critical could scrap the part, force machining, or increase cost or delay delivery of the casting.

Guidance for appropriate tolerances using ISO 8062 is available in SFSA's Steel Casting Handbook Supplement 3 (<https://cdn.sfsa.org/wp-content/uploads/2021/10/s3.pdf>). Model-Based Definition (MBD) enables the foundry to know what needs to be manufactured. The designer and purchaser should work with the foundry to establish dimensioning for the part to provide FFF.

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