Tolerances of Studio System parts

knowledge.desktopmetal.com/hc/en-us/articles/360019594154-Tolerances-of-Studio-System-parts

Tolerances obtained in your part are affected by all three stages of the BMD process (printing, debinding, and sintering). While some sources of tolerance error are beyond control of the user, many sources of error can be avoided and/or mitigated by proper part placement in printing, debinding, sintering, as well as the selection of slicing parameters in certain cases.

In this article, we address common questions related to tolerance:

- the tolerances achievable in the BMD process
- sources of inaccuracy across printing, debinding, and sintering
- specific steps that may be taken to improve the dimensional accuracy of your part.

The specification of tolerance in the BMD process

The tolerance of features in BMD parts depend upon the size of the feature. Desktop Metal specifies an error tolerance for parts fabricated using the standard printing profile; 95% of measured features should follow the specified error tolerance. This is shown graphically in the following figure.

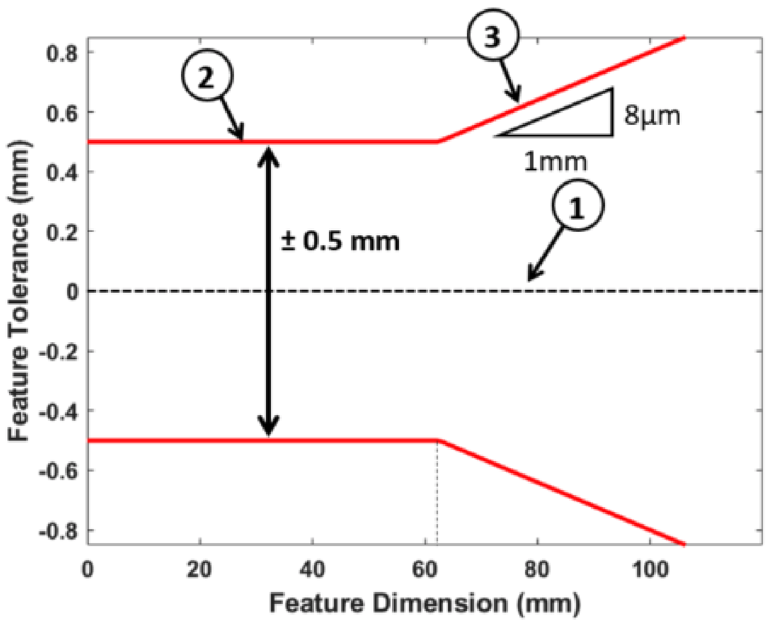

Figure 1: Definition of feature tolerances in the BMD process. The anticipated part tolerance is shown in red, and depends upon the size of the feature being fabricated.

In Figure 1, a perfect part would have zero tolerance, as indicated by the dashed line (1). When the feature dimension is small (less than about 60 mm), the feature has a tolerance of +/- 0.5 mm (2). As the feature becomes larger, the expected tolerance in the part grows with the size of the feature (3), at a rate of ±8 μm of error per 1 mm of feature size.

Why does the feature tolerance vary with feature size?

There are three main factors that impact tolerance in BMD fabricated parts:

(1) slicing/toolpathing related artifacts,

(2) variance induced by the printer during material deposition

(3) variance induced by sintering.

1. Slicing/toolpathing artifacts

Slicing/toolpathing artifacts arise most prominently at interior features, such as holes. These artifacts will be nearly identical to what you would expect in the 3D printing of plastic parts. Typically, these artifacts produce holes and bores which are tighter than the intended design.

2. Variance induced by deposition

Variance induced by the printer will be most severe in regions where the velocity of the motion system or extruder changes, such as corners, or other sharp curves. This variance typically does not depend upon the size of the feature being printed.

3. Variance induced by sintering

During sintering, the part shrinks to its final size. In the furnace, parts undergo a thermal debind step as polymer binder burns out. The furnace temperatures then increase to just below the melting point of the metal, causing the metal particles to fuse together. During this stage, the part shrinks in size by closing voids created during binder removal. Forces opposing the shrinkage force will depend upon part size, feature type, and part orientation. Gravity is the primary driver of part distortion, and this is typically a source of variance for larger parts.

Each artifact and source of variance will depend differently on the size of the part being fabricated, and will vary to some degree upon the slicing parameters used. It is important to keep in mind that modifying the print settings using Advanced Settings may impact tolerance. **Desktop Metal guarantees tolerance for the standard printing profile only.** Tolerances for the other printing profiles have not yet been characterized.

My part is larger than 60mm, but has small features. What should I expect?

Specific feature tolerances will depend upon the size of the feature, and the relation of the feature to the overall part. As a general rule, the tolerance of a given feature depends upon the size of the feature of interest.

In parts where the maximum dimension is larger than 65 mm, but a local feature (a post for example) is smaller than 65 mm, the tolerance on the smaller, local feature will have a constant error tolerance. The figure below shows an example case in further detail.

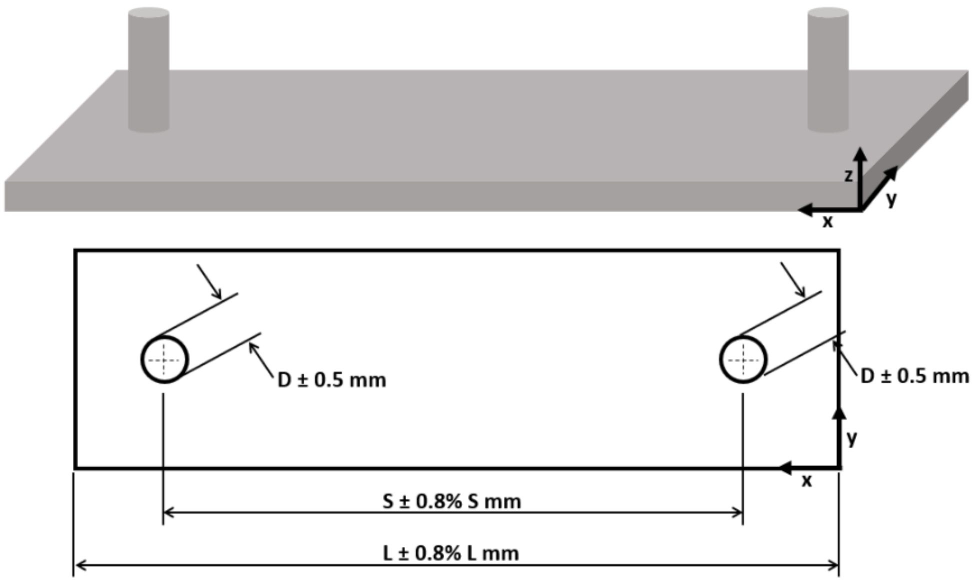

Figure 3 - A long part with small, isolated, posts. The uppermost view is an isometric rendering, the lower view presents the X-Y plane of the part with specific dimensions indicated. Here, S and L are both greater than 65 mm. The post diameter D is less than 65 mm.

In figure 3, a part of length L>65 mm has two posts spaced at a distance S>65 mm. Each post has a diameter D<65 mm. In this example, the overall part length L and post separation distance S will exhibit a tolerance that varies with each dimension. In contrast, even though the overall part dimension is larger than 65 mm, the diameter of the posts will have a fixed tolerance of D +/-0.5 mm.

Dimension	Label	Part/feature size	Tolerance
Diameter of the posts	D	< 65 mm	± 0.5mm
Length of the part	L	> 65 mm	± 0.8% L mm
Distance between posts	S	> 65 mm	± 0.8% S mm

Is this tolerance guaranteed for every part and set of processing parameters?

No, tolerance is only guaranteed for parts which follow the design guidelines and parts which are sliced with the standard profile. You should expect parts with features that disobey the design guidelines to be severely out of tolerance.

How will part tolerance vary as I change slicing parameters?

The tolerance is only specified for parts sliced in the standard profile. You should expect part tolerances to vary with slicing parameters. The precise variation of tolerances will depend upon the exact slicing parameters changed and the particular part and feature geometries of interest.

Prior to changing slicing parameters, ensure that the part orientation is best suited for the features of interest. Fabricate's auto-orientation feature will help ensure the part is oriented for full process success. In general, parts should be oriented to minimize friction and gravitational sagging. (See the design guidelines for additional information).

How can I improve feature tolerances?

Specific improvements will depend upon the feature of interest. Always ensure your features obey the BMD design guidelines.

For part attributes like interior holes and slots, which are typically undersized, strategies from FFF plastic printing may be used. Here, such interior features with characteristic dimensions between 2 and 8 mm can be enlarged by about 400 um to achieve the appropriate tolerance.

Other features are better considered on a case-by-case basis, although selecting part orientation such that critical features experience minimal gravitational sagging can help reduce part deformations and deviations from nominal dimensions.

As a final strategy, a part may be printed, debound, sintered, and its dimensions characterized. The deviations of the measured part from the intended dimensions can then be built into the part model and then the part re-processed. This is typically a last resort, as it is the most time-consuming option. However, this approach can make it possible to achieve much tighter tolerances than specified in Figure 1.