



TECHNICAL BRIEF

Repeatability and Accuracy of the microArch S240 in HT200

Introduction

The rapid advancement of additive manufacturing technology has revolutionized various industries, enabling the production of intricate and customized objects with unprecedented ease. As this technology continues to mature, ensuring repeatability and reliability becomes increasingly critical. Repeatability, defined as the ability to produce consistent results when printing the same object multiple times, is a fundamental characteristic that directly impacts the quality and usability of printed parts.

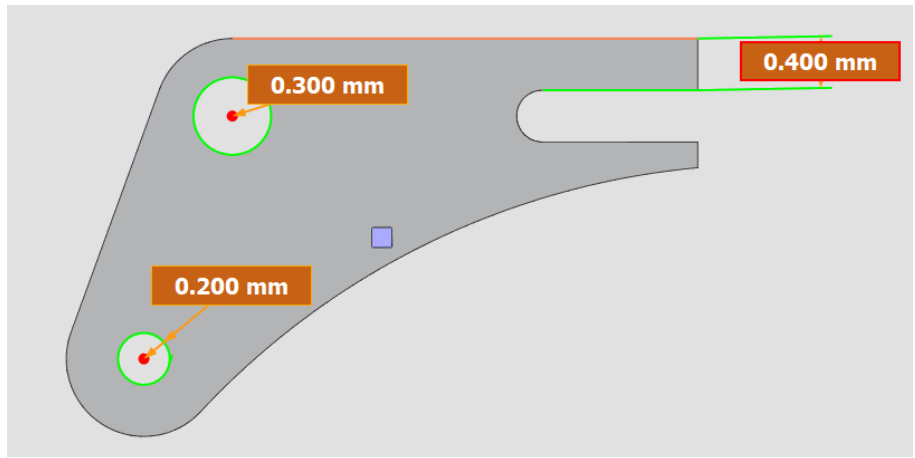
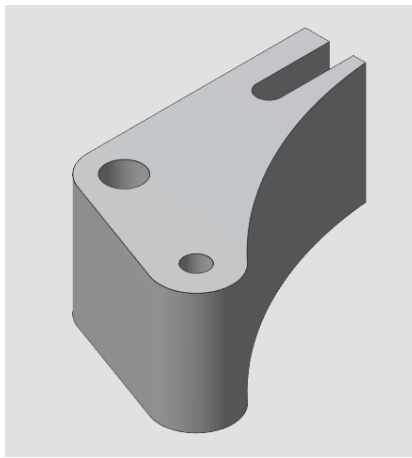
This study aims to investigate the repeatability of the BMF microArch S240 10 μ m system by examining the variability in printed objects produced using the same printer, material, and parameters. By assessing the consistency of printed dimensions, we can gain insights into the inherent variability of this system and identify factors that contribute to deviations between repeated prints.

Methodology

In this study, we employ a systematic experimental approach to evaluate the repeatability of 3D printing. We control various factors, such as printer calibration, print orientation, and printing parameters to isolate their effects on repeatability. Through a comprehensive analysis of printed parts, we aim to provide valuable insights and guidelines for achieving consistent and repeatable results.

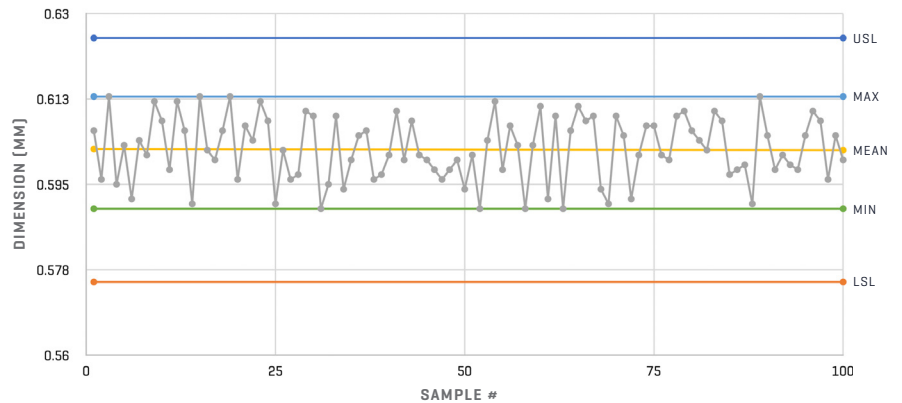
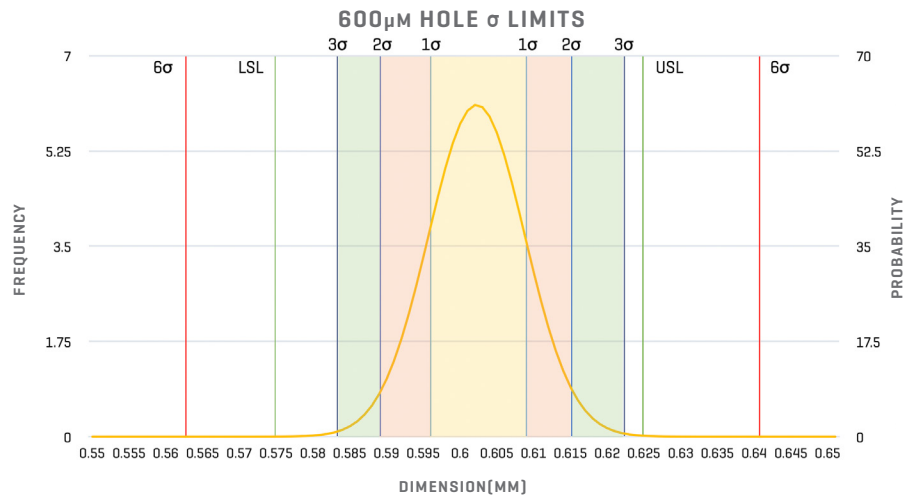
Three different features were measured on the target part to assess repeatability over different feature types, both positive and negative. The features included a 600 μ m diameter through hole, a 400 μ m diameter through hole, and a 400 μ m thin wall feature, pictured below.

All parts were measured after fully cleaning and post-processing the parts to ensure accurate results with a final product. All measurements were made using a Keyence measurement system

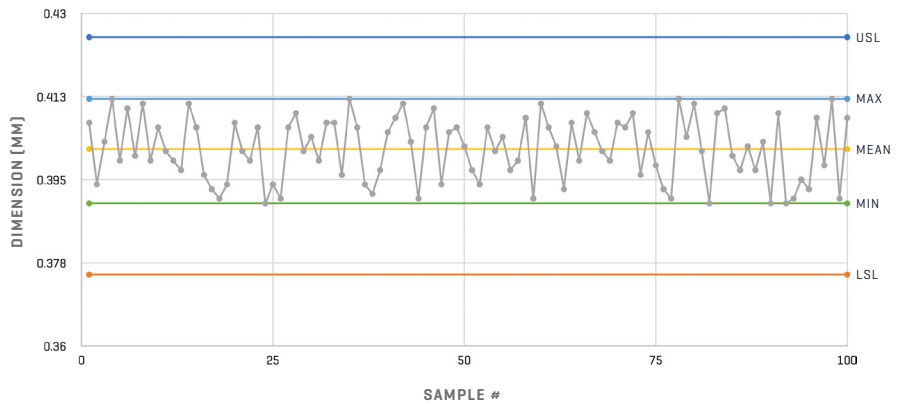
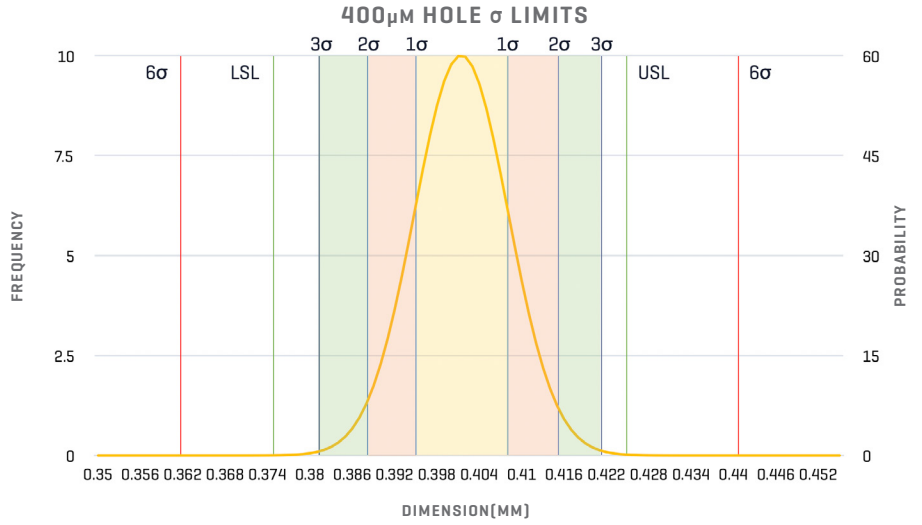


Results

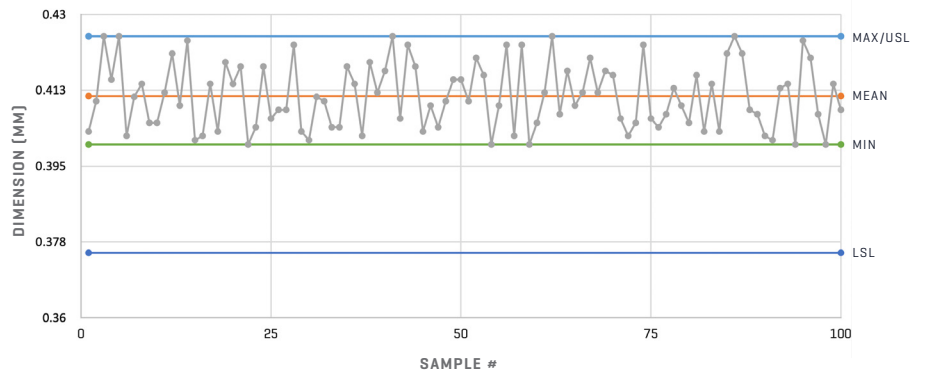
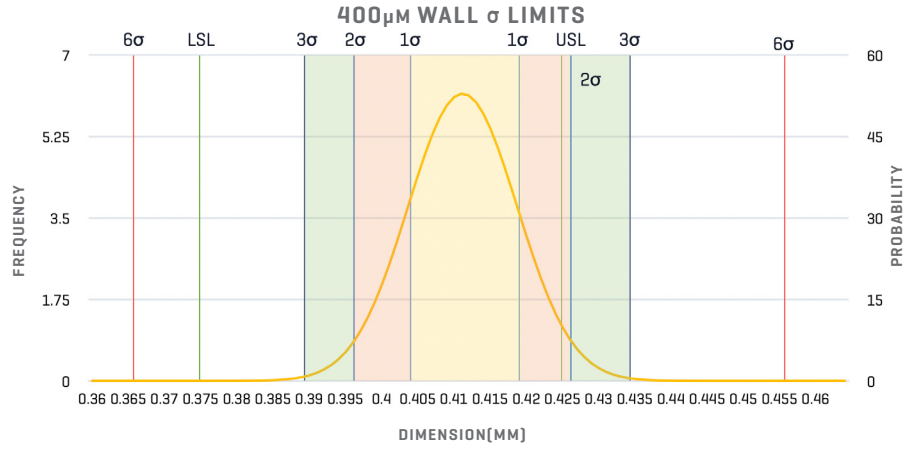
| 600µM HOLE | | |
|---------------------------|------------|--------|
| N | 100 | |
| Mean | 0.60224 | |
| Std Dev | 0.006541 | |
| USL | 0.625 | |
| LSL | 0.575 | |
| Upper 6σ | 0.6415 | |
| Lower 6σ | 0.5630 | |
| Max Vertical Axis | 7 | |
| Cpk | 1.159787 | |
| CP | 1.273931 | |
| PwithinTol1mil | 999733 | 99.97% |
| PPM [Parts outside limit] | 267 | 0.03% |



| 400μM HOLE | | |
|---------------------------|------------|--------|
| N | 100 | |
| Mean | 0.40143 | |
| Std Dev | 0.006644 | |
| USL | 0.425 | |
| LSL | 0.375 | |
| Upper 6σ | 0.4413 | |
| Lower 6σ | 0.3616 | |
| Max Vertical Axis | 10 | |
| Cpk | 1.182469 | |
| CP | 1.25421 | |
| PwithinTol1mil | 999771 | 99.98% |
| PPM [Parts outside limit] | 229 | 0.02% |



| 400μM THIN WALL | | |
|---------------------------|------------|--------|
| N | 100 | |
| Mean | 0.41118 | |
| Std Dev | 0.007543 | |
| USL | 0.425 | |
| LSL | 0.375 | |
| Upper 6σ | 0.4564 | |
| Lower 6σ | 0.3659 | |
| Max Vertical Axis | 7 | |
| Cpk | 0.610722 | |
| CP | 1.10478 | |
| PwithinTol1mil | 966536 | 96.65% |
| PPM (Parts outside limit) | 33464 | 3.35% |



| | 0.600MM HOLE | 0.400MM HOLE | 0.400MM THIN WALL |
|-----------------------|--------------|--------------|-------------------|
| Nominal | 0.600mm | 0.400mm | 0.400mm |
| Mean | 0.602mm | 0.401mm | 0.411mm |
| Distance From Nominal | +0.002mm | +0.001mm | +0.011mm |
| Std Dev | .006mm | .007 | .008 |
| CP | 1.274 | 1.254 | 1.104 |
| Cpk | 1.160 | 1.182 | 0.611 |
| PPM | 0.03% | 0.02% | 3.35% |
| DPMO | 267 | 229 | 33464 |
| Measured Tolerance | +/-0.012mm | +/-0.011mm | +/-0.014mm |

Discussion & Conclusion

For this specific resin on the microArch S240, the data shows a repeatable process with tight controls, as CP > 1.0. CP measures the spread of the process without accounting for centering of the data, while cpk accounts for the spread. Looking at the data above, this is why the cpk values for the two hole features are higher, as they are centered much closer to nominal. Cpk values over 1.0 are also considered repeatable with tight controls, and a cpk of 2.0 is considered the gold standard, as this indicates a six sigma process. When centered around nominal, current processes show 3σ limit capability, with 99.7% or greater measurements falling within specified tolerance band of +/-25μm. Measured tolerance with HT200 resin on S240 was even better than stated tolerance, with measured tolerance within +/-14μm at the largest spread. Based on all the collected data, the estimated failed parts are at 3% or lower for production processes, with failures estimated at 0.03% or less for properly centered data. These parts were made using a general set of parameters for this resin, but dimensional accuracy and tolerances can be improved even further by additional tuning, control of environmental factors, and finer calibration of the printer. Identifying the optimal print parameters for a given application and consistently using them can enhance the repeatability of 3D prints. With tighter tuning and control, the cpk values can be improved by centering the data closer to the nominal dimensions as well as reducing the variation of measurements between sample parts.

In conclusion, this study highlights the significance of repeatability and provides valuable insights into the factors influencing repeatability, including machine calibration, material properties, and print parameters. By understanding these factors and implementing appropriate measures, the repeatability of 3D prints can be significantly improved.