RESEARCH ON THE PRECISION OF 3D SCANNING FOR AUTOMOTIVE PARTS

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***Abstract**: The paper presents, both in a general context and with applications in the automotive industry, the use of 3D scanning technologies for the analysis and dimensional verification of additive manufactured parts. The study focuses on a component manufactured through additive manufacturing material extrusion process using PLA filament, which was subsequently scanned with a CR-Scan Ferret Pro (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China)*

The main objective is to compare and evaluate the dimensional differences between the initial virtual model (CAD), the physically printed part, and the model obtained through 3D scanning. This approach highlights the role of 3D scanning in quality control, process optimization, and the identification of dimensional deviations, which are critical aspects especially in the automotive industry, where precision and part conformity are essential.

Keywords: 3D scan, automotive, precision measurement, additive manufacturing, portable scanner

1. INTRODUCTION

In recent literature, 3D scanning is treated as a core technology for rapid digitization of physical objects, geometric reconstruction, dimensional inspection, and integration into reverse engineering and additive manufacturing workflows. Contemporary research focuses on structured-light, time-of-flight (ToF), and RGB-D systems, with emphasis on improving point cloud fidelity, reconstruction accuracy, and robustness under real conditions [1], [2], [3]. In this context, the practical value of 3D scanning extends beyond model generation to the evaluation of dimensional deviations between physical components and their nominal CAD geometry [4], [5], [6].

In industrial applications, including the automotive sector, 3D scanning is driven by the need for rapid inspection, reverse engineering of legacy parts, and integration with additive manufacturing. Optical scanning systems are commonly used for point cloud–to–CAD comparisons, while accuracy is influenced by factors such as surface reflectivity, lighting conditions, calibration, and data processing methods [4], [7], [8]. Review studies confirm that 3D imaging technologies are widely adopted across domains such as industrial inspection, medical applications, and cultural heritage digitization, demonstrating their maturity and versatility [9], [3].

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A key research direction concerns the identification of factors affecting scanning quality. Studies show that parameters such as surface texture, geometric complexity, resolution, and acquisition strategy directly influence reconstruction errors, alongside post-processing operations such as smoothing and simplification [6], [1], [2]. Additionally, research on RGB-D and low-cost sensors highlights the importance of noise modeling and compensation for improving measurement reliability in engineering applications [8], [10].

In parallel, research on additively manufactured parts highlights the presence of dimensional deviations between CAD models and physical components due to process parameters, material behavior, and measurement techniques. Comparative evaluation using 3D scanning, contact measurements, or CMM systems is essential, as results depend on the measurement method and evaluation protocol. Optical inspection studies show that deviations are more pronounced in areas with fine features or complex geometries [11], [12].

For PLA-based components, the literature focuses on correlating the nominal CAD model, the manufactured part, and the scanned geometry. PLA is widely used for prototyping due to its accessibility and stable processing behavior. Structured-light scanning is considered suitable for both offline measurement and quality control when acquisition and alignment procedures are properly managed [11], [1].

Within this context, the present study focuses on the Grill Intake Adapter, a component designed in CAD, manufactured via additive manufacturing using a Creality K1C (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China) printer and PLA filament, and subsequently scanned using a CR-Scan Ferret Pro (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China) (Figure 1). The objective is the comparative analysis of dimensional deviations between the CAD model, the printed component, and the scanned model. This approach aligns with current research directions integrating 3D scanning for inspection and reverse engineering with additive manufacturing and comparative evaluation methodologies [4], [7], [11].

Overall, current research supports the use of 3D scanning not only for geometric reconstruction but also for dimensional validation of additively manufactured parts, contributing to quality control, rapid prototyping, and optimization of geometric reproducibility [5], [6], [8].

Figure 1. CR-Scan Ferret Pro (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China)

The CR-Scan Ferret Pro is a portable structured-light 3D scanner designed for rapid digitization of small to medium-sized objects.

It operates using optical projection and camera-based reconstruction, enabling non-contact acquisition of geometric data with moderate accuracy suitable for engineering applications.

Offering two distinct modes, the device ensures both accuracy and speed. High-Quality Mode boasts up to 0.1mm accuracy, capturing even the smallest details.

The scanner integrates both mobile and PC-based software for real-time processing, but its performance is influenced by surface properties, lighting conditions, and object complexity.

2. ADDITIVE MANUFACTURING, SCANNING AND MEASUREMENTS

Figure 2 shows the 3D modeling of the "Grill Intake Adapter" part using CATIA V5 (Dassault Systèmes), followed by export to STL format for slicing in preparation for additive manufacturing via Material Extrusion (MEX).

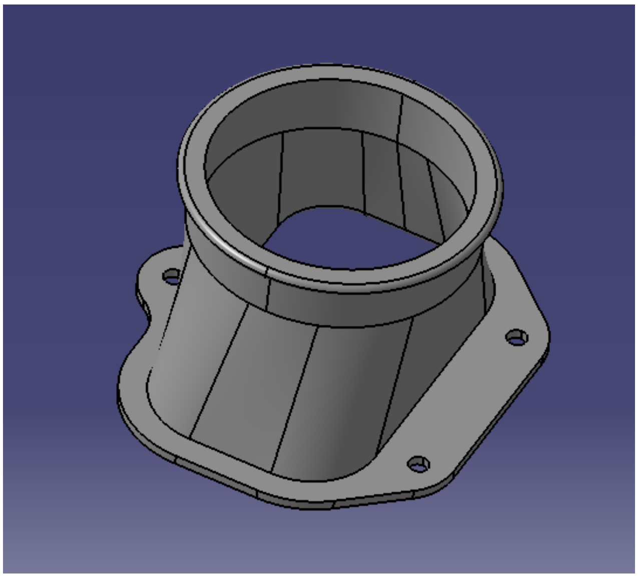

Figure 2. 3D modeling of the "Grill Intake Adapter" part using CATIA V5

Figure 3. shows the execution drawing for the Grill Intake Adapter defines five critical dimensions (D1–D5), selected to represent:

-overall length (D1)

-height (D2)

-internal and external diameters (D3–D5)

These dimensions enable a structured comparison across different geometric features.

The Creality K1C (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China) printer is a high-speed FDM 3D printer (Figure 4) is designed for rapid prototyping and functional part fabrication, featuring CoreXY kinematics for improved motion efficiency.

It supports high printing speeds (up to several hundred mm/s) and high accelerations, enabling reduced production time while maintaining acceptable dimensional accuracy.

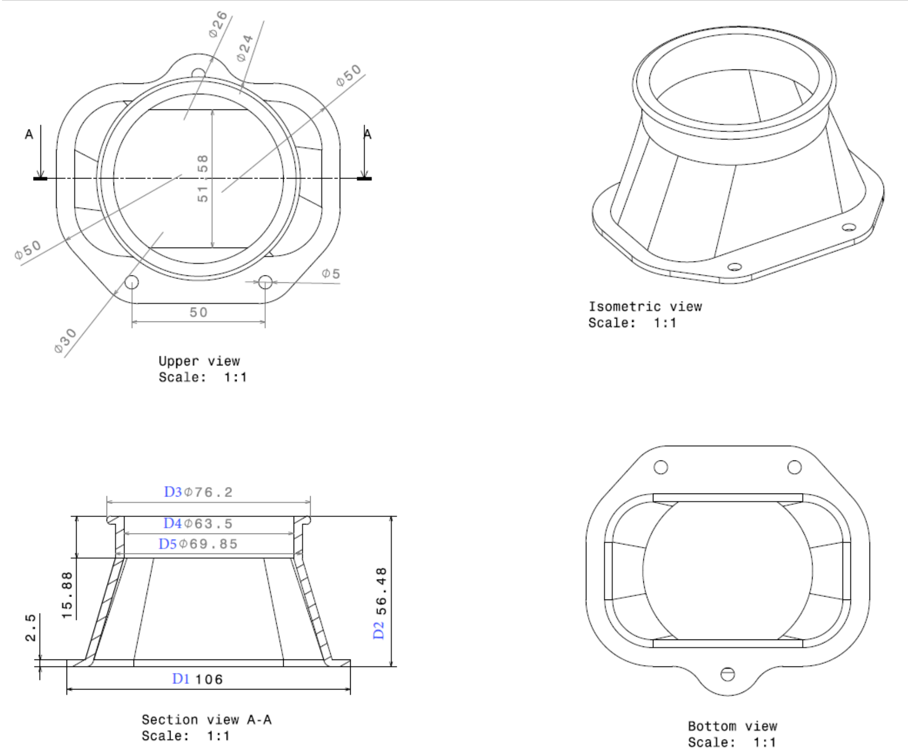

Figure 3. Execution drawing - Grill Intake Adapter.

The system is compatible with standard 1.75 mm filaments such as PLA and incorporates automated features for stable extrusion, making it suitable for engineering and automotive applications.

Figure 4. 3D printer Creality K1C (Shenzhen Creality 3D Technology Co., Ltd., Shenzhen, China)

The 3D slicing modeling of the "Grill Intake Adapter" part, performed for the Material Extrusion (MEX) additive manufacturing process, using the slicing software Creality Print (version 6.2.0, Creality), is shown in Figure 5. Figures 6 and 7 present the slicing parameters specific to the MEX process for the "Grill Intake Adapter" feature.

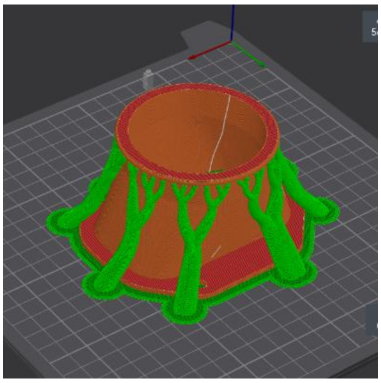

Figure 5. 3D slicing modeling of the "Grill Intake Adapter" part, using the slicing program, Creality Print (version 6.2.0, Creality)

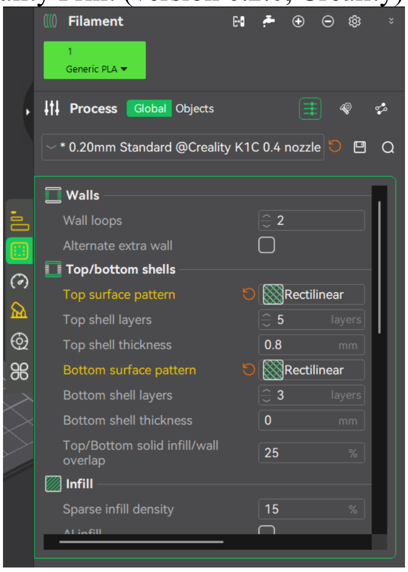

Figure 6. The slicing settings of the " Grill Intake Adapter" using Creality Print (version 6.2.0, Creality)

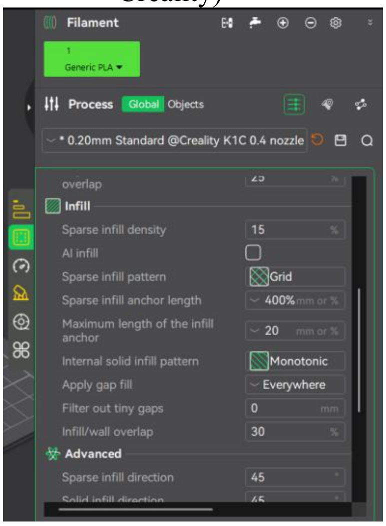

Figure 7. The slicing settings of the " Grill Intake Adapter " using Creality Print (version 6.2.0, Creality)

The main slicing settings for the "Grill Intake Adapter" feature, in Creality Print V6.2.0., were as follows:

0.20mm Standard @Creality K1C 0.4 nozzle
Filament: Generic PLA
Layer height — 0.2 mm
First layer height — 0.2 mm
Line width (Default) — 0.42 mm
Line width (First layer) — 0.5 mm
Flow ratio — 1
Top surface flow ratio — 1
Infill/wall overlap — 30%
Wall loops — 2
Top shell layers — 5
Bottom shell layers — 3
Sparse infill density — 15%
Sparse infill pattern — Grid
Outer wall speed — 200 mm/s
Inner wall speed — 300 mm/s
Acceleration (Normal) — 10000 mm/s²
Acceleration (Outer wall) — 5000 mm/s²
Jerk (XY) — 20 mm/s
Travel speed — 500 mm/s
Seam position — Aligned
Slow down for overhangs — Enabled

The 3D printing of the "Grill Intake Adapter" took 1 hour and 38 minutes. and consumed 51g of PLA filament.

Figure 8 shows the "Grill Intake Adapter" part, 3D printed using PLA filament on Creality K1C printer.

Figure 8. "Grill Intake Adapter" part, manufactured using PLA filament on Creality K1C

3. EXPERIMENTAL RESULTS

Figure 9 illustrates the set of scanning parameters configured within the software Creality Scan 4 (V1.6.15, Creality), which directly governs both geometric resolution and tracking robustness during the acquisition process. In structured-light 3D scanning, parameter selection is not merely procedural but determinative for data fidelity: resolution settings control the spatial density and precision of the reconstructed mesh, while tracking-related parameters influence the scanner's ability to maintain consistent alignment across successive frames.

Improper calibration can lead to drift, noise accumulation, or partial data loss, particularly in geometries with low feature variation or reflective surfaces. Therefore, the chosen configuration reflects a balance between high-detail capture and stable frame registration, optimized for the specific morphology and surface characteristics of the Grill Intake Adapter.

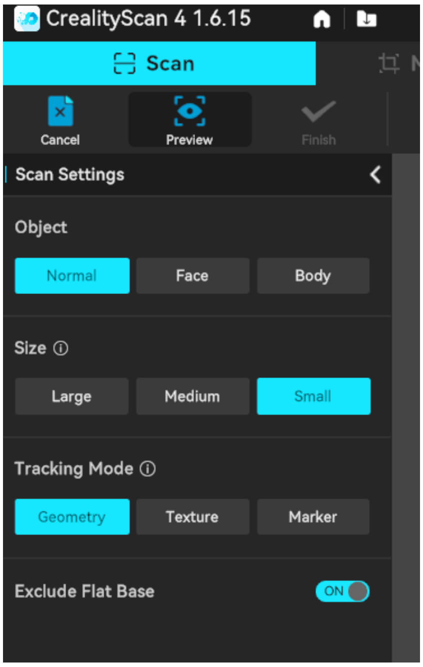

Figure 9. Setting used to scan the Grill Intake Adapter

Figure 10 shows the 3D scanned part with CR - Scan Ferret Pro.

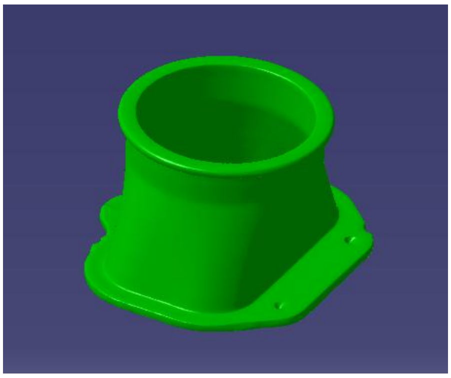

Figure 10. The STL result of the scanned part.

Figure 11 illustrates the alignment and overlay of the CAD model with the scanned STL, enabling a direct geometric comparison between the nominal and digitized representations of the part.

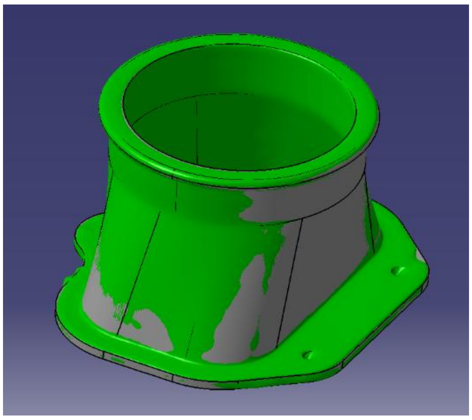

Figure 11. The CAD model (STL) aligned and overlaid with the scanned STL for comparison.

Figure 12 shows the dimensions of the scanned part.

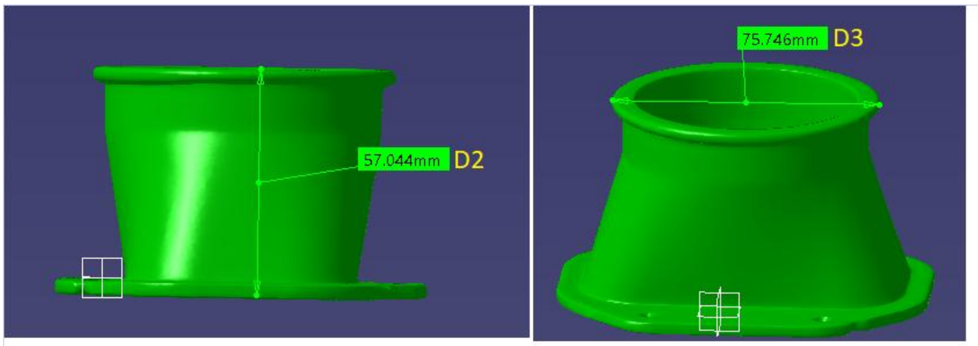

Figure 12. Dimensions of the scanned part.

Table 1 shows the deviations of the printed part and the scanned part are evaluated relative to the nominal CAD values.

Table 1

Table 1. Dimensional deviations

	CAD model (STL)	Printed part	Scanned part	Δ CAD–Printed (%)	Δ CAD–Scanned (%)
D1	106	105.39	105.79	0.58%	0.20%
D2	56.48	56.7	57.04	-0.39%	-0.99%
D3	76.2	75.6	75.74	0.79%	0.60%
D4	63.5	63	62.72	0.79%	1.23%
D5	69.85	69.56	69.6	0.42%	0.36%

The “Dimensional Deviations” chart in represented in figure 13, shows percentage differences between the CAD model and both printed and scanned parts for D1–D5.

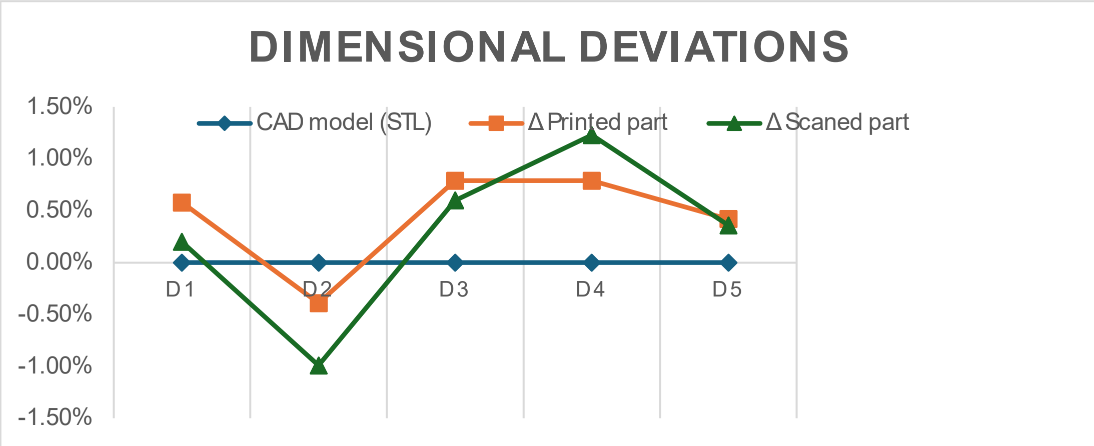

Figure 13. Dimensional deviations chart.

4. CONCLUSIONS

The comparative dimensional analysis between the CAD model, the printed part, and the scanned model indicates that the CAD–manufacturing–inspection workflow produced generally consistent results, but with different error sources in each stage.

For the printed part manufactured on the Creality K1C using PLA, the deviations from the CAD model remained low, between 0.39% and 0.79%. Most dimensions are slightly smaller than the nominal values, indicating a consistent tendency toward dimensional contraction. This behavior is typical for the material and process, where cooling effects lead to minor shrinkage.

The scanned model shows deviations between 0.20% and 1.23% compared with the CAD model. These values are close to the printed-part deviations, but the distribution is less uniform. The CR-Scan Ferret Pro has a nominal accuracy of approximately 0.1 mm, but this value is achievable only under favorable conditions. In the measured results, some deviations exceed this nominal tolerance, which indicates that the final scan accuracy was affected not only by scanner precision, but also by surface visibility, meshing, alignment, and reconstruction.

The weakest results are associated with internal features, especially holes. These areas are more difficult to scan accurately because the optical scanner has limited access inside cavities, and the reconstruction algorithm may smooth or partially close edges. As a result, holes and internal diameters are less reliable than external dimensions. This explains why the scanned model does not follow the same consistent deviation pattern as the printed part and why localized errors, such as the higher deviation observed for D4, can occur.

Overall, the printed part demonstrates better dimensional repeatability than the scanned model. The manufacturing stage produced controlled and predictable deviations, mainly linked to PLA shrinkage, wall generation, line width and the absence of X–Y compensation. The scanning stage reproduced the general geometry correctly, but introduced additional variability, especially in holes and less accessible regions.

5. REFERENCES

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