SERBIATRIB '25

19th International Conference on Tribology

14 – 16 May 2025, Kragujevac, Serbia

PROCEEDINGS

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Serbian Tribology Society

University of Kragujevac
Faculty of Engineering

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EDITOR: Slobodan Mitrović

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ISBN: 978-86-6335-128-8

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Publisher:	**Faculty of Engineering, University of Kragujevac** Sestre Janjić 6, 34000 Kragujevac, Serbia
For the Publisher:	**Slobodan Savić** Faculty of Engineering, University of Kragujevac
Technical editor:	**Dragan Džunić, Živana Jovanović Pešić** Faculty of Engineering, University of Kragujevac
Printed by:	**Inter Print** Jurija Gagarina 12, 34000 Kragujevac, Serbia
Circulation:	200 copies

The publication of this Proceedings was financially supported by the Ministry of Science, Technological Development and Innovation, Republic of Serbia.

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Research paper

DOI:10.24874/ST.25.205

INFLUENCE OF PRESS-FIT DIMENSIONS ON REPEATED ASSEMBLY OF BALL BEARINGS INTO 3D PRINTED HOUSINGS

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Abstract: *This study investigates the mechanical behaviour of 3D printed PET-G housings designed to accommodate steel 6000-2RS ball bearings, a common component in hobbyist and rapid prototyping applications. Two housing variants were manufactured using identical printing parameters and material, differing only in internal diameter—undersized by 0.2 mm and 0.1 mm, respectively, since it is impossible to include tolerances in this form of additive manufacturing. The goal was to simulate interference fits and assess how repeated assembly and disassembly cycles affect fit integrity and material deformation. Each bearing was press-fitted into its respective housing and removed across five consecutive cycles using a texture analyser, an advanced device capable of applying and precisely measuring forces up to 5000 N. Insertion and removal forces were recorded throughout the experiment. Dimensional measurements of the housings were taken both before and following the cycles to evaluate permanent deformation or loss of tolerance. The results highlight differences in required assembly and disassembly forces between the two under-sizing approaches, providing practical insights for design tolerances in 3D printed assemblies where repeated mechanical interfacing is expected. These findings contribute to best practices in additive manufacturing design for mechanical fit components.*

Keywords: *3D printing, press-fit, assembly, surface, ball bearings*

1. INTRODUCTION

The additive manufacturing process of 3D printing polymer materials has seen widespread adoption across industrial, hobbyist, and rapid prototyping sectors due to its flexibility, cost-effectiveness, and capacity for fast iteration. In industrial settings, 3D printing enables on-demand production of complex geometries with minimal material waste, while hobbyists benefit from increasingly affordable desktop printers and accessible design software. Rapid prototyping, in particular, leverages the technology to accelerate product development and functional testing. Advances in material science, printer resolution, and mechanical properties continue to expand their capabilities, bridging the gap between prototype and end-use functionality.

In 3D printing applications, it is common to integrate standardised industrial components, such as bolts, nuts, bearings, metal shafts, rods, and pins, into printed assemblies. These components are combined with printed parts to form systems capable of mechanical interaction. Integration methods vary depending on the application and performance requirements. Commonly used thermoplastics include PLA, ABS, and PET-G, selected for their mechanical properties, printability, and application suitability.

PET-G, a glycol-modified form of polyethylene terephthalate (PET), exhibits enhanced clarity, flexibility, and reduced brittleness compared to its predecessor [1]. These modifications make it easier to process and less prone to cracking under stress, making it ideal for strength-focused applications. PET-G also offers excellent chemical resistance, withstanding exposure to various substances without significant degradation [2]. Its low shrinkage and minimal warping ensure dimensional accuracy and reliable print quality, making it well-suited for 3D printing [3]. Additionally, its transparency, flexibility, and recyclability have led to increased use in manufacturing, packaging, and medical sectors, where both mechanical and aesthetic performance are valued [4].

Press-fitting is a widely used assembly technique that joins components without adhesives, screws, or welding. By applying controlled pressure, it forms durable connections, which are particularly useful in manufacturing and machining contexts. The reliability of such joints depends on material strength and the precision of dimensional tolerances. Press-fitting ball bearings into PET-G parts has been studied to assess the effects of single press-fits and disassembly [5–7]. This study focuses on the interaction between standardised steel 6000-2RS bearings and 3D printed PET-G bearing seats through repeated press-fit cycles. By examining changes required assembly forces, the research aims to inform best practices for achieving reliable, reusable fits in additive manufacturing applications.

2. TEST MODELS

The 3D models used for designing the bearing housing were made according to the dimensions given in Figure 1. This design represents a section of a housing in which a bearing would be press-fit. The models were made in Autodesk Inventor Professional 2020 and exported as high-resolution .STL files for slicing, using default high-resolution settings. This is done to achieve the circular hole of the shape, which is as close as possible to a perfect circle.

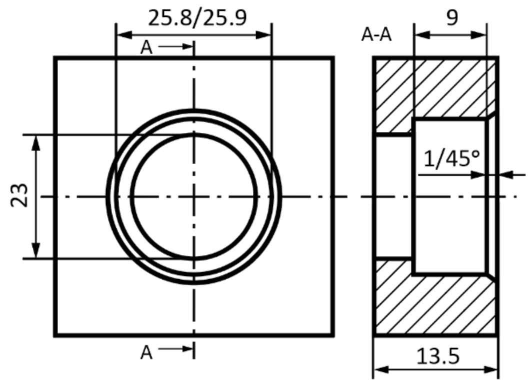


Figure 1. Geometry of the modelled bearing seats.

The two models' internal diameters are undersized by 0.2 mm and 0.1 mm, respectively, from the 6000-2RS's outer diameter of 26mm. The ball bearings in question are produced to a tolerance of 0/-0,009 mm.

The slicing was done using Bambu Studio 2.0.3, with the printing parameters detailed in Table 1.

Table 1. 3D printing parameters

Parameters	Values
Layer height	0.2 mm
Wall line count	3
Top/Bottom layer count	3
Z-seam alignment	Random
Infill density	20%
Infill pattern	Gyroid

All specimens were fabricated on a commercially available Bambu X1E printer. The material used was DevilDesign PET-G filament (purple), with a nominal diameter of 1.75 mm.

Printing temperatures were 235 °C for the nozzle and 75 °C for the bed.

The process of press-fitting and disassembly was done on a Brookfield CT3-50kg Texture Analyser, capable of measuring up to 500 N of force since it provides a 5g load resolution and 0.1 mm accuracy, enabling accurate analysis of press-fit interactions. Force and displacement were recorded in real-time as each part underwent five press-fit and disassembly cycles.

3. RESULTS

The printed bearing seats were measured before and after all test cycles using Vernier callipers with a dimensional accuracy of 0.02 mm. Measurements were taken along two axes corresponding to the flat sides of the part. For both parts, dimensions in each direction remained consistent throughout the five press-fit cycles, recorded as 25.86 mm and 25.78 mm, respectively. Figure 2 shows the press-fitting forces, while Figure 3 shows the disassembly forces for all five iterations on the 25.9 mm seat.

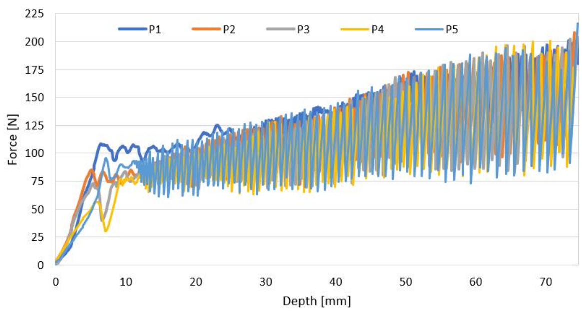


Figure 2. Press-fitting forces for the 25.9 mm seat for each iteration(P1-5)

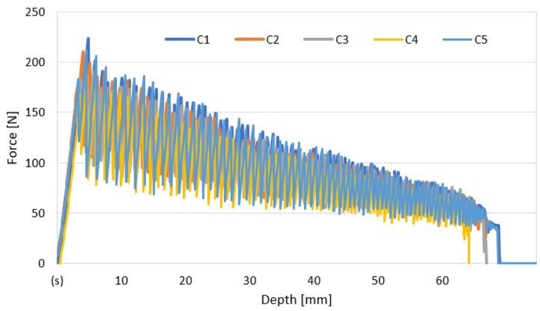


Figure 3. Disassembly forces for the 25.9 mm seat for each iteration (C1-5).

Figures 4 and 5 show the press-fitting and disassembly forces, respectively, for all five iterations on the 25.8 mm seat.

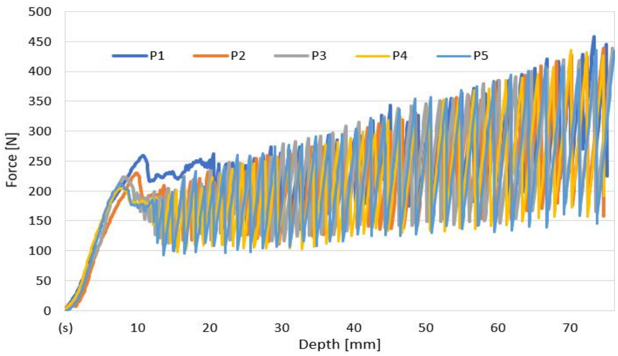


Figure 4. Press-fitting forces for the 25.8 mm seat for each iteration (P1-5).

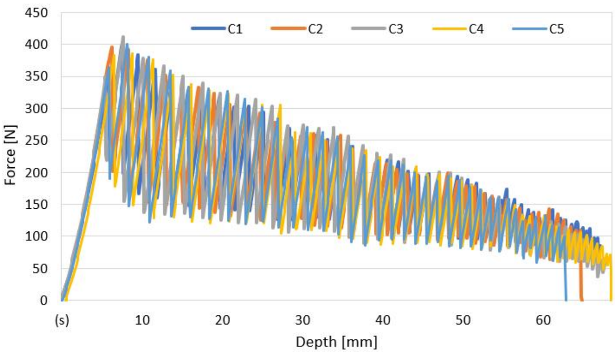
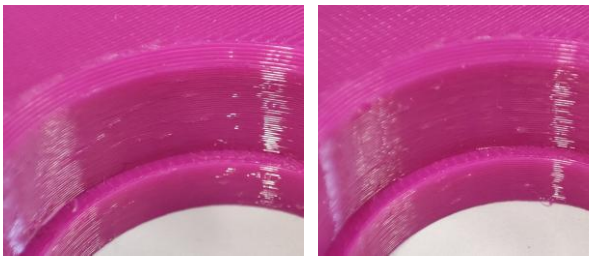


Figure 5. Disassembly forces for the 25.9mm seat for each iteration (C1-5).

Figures 6a and b show a close-up view of the bearing seat before and after the experiment, respectively, on the 25.8 mm hole model.



a) b)

Figure 6. Seat surface a) before and b) after the experiment.

4. CONCLUSION AND DISCUSSION

This study examined the press-fit behaviour of standardised 6000-2RS steel ball bearings inserted into 3D printed PET-G housings, with particular focus on the mechanical and dimensional response of the polymer parts during repeated assembly and disassembly cycles. Two variations of bearing seat dimensions were tested, featuring undersized diameters of 0.1 mm and 0.2 mm, respectively. The results provide insight into the reliability and repeatability of such interference fits in polymer-based additive manufacturing applications. Force measurements showed that the 0.1 mm interference fit required ~200 N for assembly and ~225 N for disassembly. In comparison, the 0.2 mm fit demanded significantly higher forces, ~450 N for assembly and ~415 N for disassembly. Despite the elevated forces involved, both part variants exhibited minimal wear and no visible structural damage after five complete assembly-disassembly cycles. The dimensional analysis confirmed that the bearing housings largely returned to their original form after each cycle, with no significant permanent deformation observed. Only slight surface smoothing was detected, likely due to localized contact stresses during insertion and removal.

These findings suggest that PET-G can maintain dimensional integrity and functional performance under repeated press-fit operations, even at higher interference levels. For applications requiring modularity or reusability, a 0.1 mm interference appears optimal, balancing sufficient holding force with low risk of deformation or material fatigue. In contrast, the 0.2 mm fit offers a tighter, more secure connection, but at the cost of substantially higher insertion force, which may be impractical in applications requiring frequent disassembly or where component longevity is critical.

Overall, this work contributes to the understanding of mechanical interfacing between 3D printed polymer parts and industrial components, offering design guidance for achieving reliable, repeatable fits in functional additive manufacturing assemblies.

ACKNOWLEDGEMENT

This paper results from research conducted under the author's contract No. 451-03-137/2025-03/200107, dated February 4, 2025 and scientific research work 451-03-136/2025-03/200378.

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