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Nenad Petrović[1]
Strahinja Milenković[2]
Živana Jovanović Pešić[3]
Nenad Kostić[4]
Nenad Marijanović[5]

DETERMINING 3D PRINTED HOUSING DIAMETERS FOR PRESS-FITTING STANDARD BALL BEARINGS

ABSTRACT: This research paper considers an experimental approach to determining 3D printed housing diameters for press-fitting standard ball bearings. The housing was 3D printed using Fused Deposition Modelling (FDM) technology with DevilDesign PET-G filament. Printed bearing seats were made with a 0.2 mm resolution for two nominal bearing sizes: 13 mm and 26 mm. The bearing seats had three varied nominal measurements: one matching the size of the bearing being installed, another 0.1 mm smaller, and a third 0.2 mm smaller. The experiment was carried out on a series of samples, focusing on analysing both the required compression force and the assembly force between the bearing and the housing. The goal was to evaluate the interaction between the bearing and the 3D printed housing, ensuring proper fit and mechanical stability during the press-fitting process.

KEYWORDS: PET-G, 3D printing, Fused Deposition Modelling (FDM), press fit

INTRODUCTION

PET-G (Polyethylene Terephthalate Glycol) is a thermoplastic polymer commonly used in 3D printing due to its favourable properties, including high impact resistance, good chemical resistance, and ease of processing. Unlike its predecessor PET, PET-G is modified with glycol, which enhances its clarity and reduces brittleness. These properties make PET-G an excellent choice for applications requiring durability and strength [1].

PET-G is widely utilized in 3D printing for its balance of strength, flexibility, and ease of use. It is known for producing parts with a smooth finish and high dimensional accuracy. The material is less prone to warping compared to ABS (Acrylonitrile Butadiene Styrene) and typically requires lower printing temperatures, which reduces the risk of thermal distortion [2]. PET-G also has good layer adhesion and can be printed with minimal odour, making it suitable for both professional and hobbyist applications.

[1] *Nenad Petrović, Assistant Professor, Faculty of engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, npetrovic@kg.ac.rs*
[2] *Strahinja Milenković, Research Assistant, Institute for Information Technologies, University of Kragujevac, 34000 Kragujevac, bb Jovana Cvijića Street, Serbia, strahinja.milenkovic@fink.rs*
[3] *Živana Jovanović Pešić, Teaching Assistant, Faculty of engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, zixi90@gmail.com*
[4] *Nenad Kostić, Associate Professor, Faculty of engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, nkostic@kg.ac.rs*
[5] *Nenad Marijanović, Full Professor, Faculty of engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, nesam@kg.ac.rs* (CA)

Press fitting is a technique for assembling parts without the need for adhesives, screws, or welding. This method involves applying pressure to create a secure and stable connection between components, resulting in strong and durable joints in manufacturing and machining. To achieve optimal performance in press-fitted assemblies, it is crucial to ensure adequate strength and precise dimensional and form accuracy. Rashed et al. investigated the deformations and shape inconsistencies caused by press-fitting a thick cylinder into a square housing with a circular inner hole, utilizing finite element analysis (FEA) [3]. This technique is widely used across various industrial sectors, including the automotive [4], railway [5], hydraulic and pneumatic systems, metal processing, and medical industries [6, 7].

The study aimed to investigate the impact of varying fit tolerances on the assembly and integration of ball bearings within 3D-printed housings. To this end, two sets of samples were created, corresponding to nominal bearing sizes of 13 mm and 26 mm. Each bearing seat was designed with three different nominal diameters: one matching the bearing size precisely, another 0.1 mm smaller, and a third 0.2 mm smaller. This variation was intended to assess how these fit tolerances influence the press-fitting process and the overall performance of the assembled components.

MATERIALS AND METHODS

PET-G filament (1.75 mm diameter; DevilDesign purple PET-G) was used for FDM 3D printing of samples at Creality Ender 3 printer. The 3D printing parameters are provided in Table 1.

Table 1 3D printing parameters

Parameters	Values
Nozzle Temperature	235 °C
Platform Temperature	70 °C
Printing Speed	60 mm/s
Wall line Count	3
Top Layers	3
Bottom Layers	3
Infill Density	20%
Infill Pattern	Gyroid
Resolution	0.2 mm

Two sets of samples were created for the two nominal bearing sizes: 13 mm and 26 mm. The bearing seats were designed with three different nominal measurements: one exactly matching the size of the bearing being installed, a second that was 0.1 mm smaller, and a third that was 0.2 mm smaller. This variation in measurements aimed to assess the impact of different fit tolerances on the performance and integration of the bearings within the housing. All samples are shown in Figure 1.

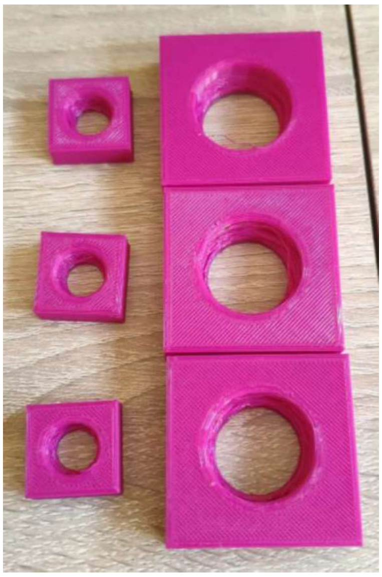

Figure 1 3D printed samples

The Brookfield CT3-50kg Texture Analyser was utilized to measure the force required for assembly as a function of depth. This advanced analyser features a load capacity of up to 50 kg (5000 N) and provides a high level of precision with a load resolution of 5 g and an increment resolution of 0.1 mm. Additionally, it offers an accuracy of 0.1 mm. The data is continuously read and recorded digitally in real-time, allowing for precise and immediate analysis [8]. This capability ensures accurate measurement of the forces involved in the assembly process, contributing to a thorough understanding of the interactions between the bearing and the housing. Figure 2 illustrates the experimental setup used for the assembly process. In this setup, each 3D printed bearing seat was individually subjected to assembly tests to determine the optimal diameter of the housing. This procedure aimed to evaluate how well each bearing seat fit with the corresponding bearing, thereby identifying the ideal dimensions needed to achieve a precise and secure assembly. The results from these tests are crucial for refining the design specifications and ensuring the effective integration of the bearings into the printed housings.

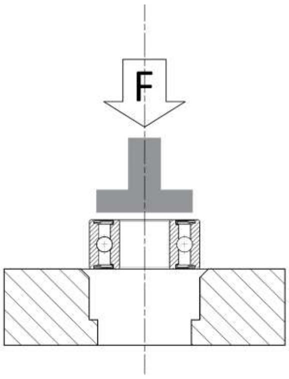

Figure 2 Schematic representation of the experiment setup for assembling

RESULTS AND DISCUSSION

All bearing seats were subjected to the assembly process to evaluate their fit and determine the required force for proper integration of the bearings. During the assembly, the interaction between the bearing and the printed housing was carefully observed to assess any variations in the press-fit due to differences in the nominal diameters. The goal was to identify the optimal conditions that ensure a secure and stable assembly. The appearance of the press-fitted assembly, highlighting the final positioning and alignment of the bearings within the housing, is shown in Figure 3. This visual representation provides insight into the quality and precision of the press-fitting process across different sample sets.

Figure 3 Appearance of the press-fitted bearing assembly within the 3D-printed housing

The force-displacement diagram for the 13 mm, 12.9 mm, and 12.8 mm bearing seat sizes during the press-fitting process is presented in Figure 4. This diagram illustrates the relationship between the applied force and the displacement of the bearing as it is inserted into the housing. By comparing the three different bearing seat sizes, the diagram highlights how variations in the nominal diameter affect the required press-fitting force and overall assembly performance. Analysing these force-displacement curves provides valuable insights into the optimal fit tolerance, ensuring a balance between ease of assembly and secure retention of the bearing within the housing.

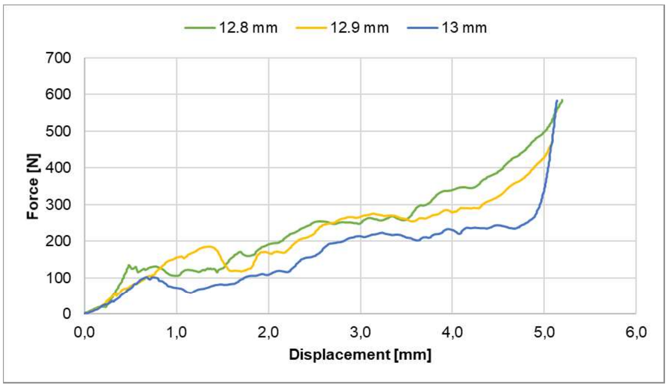

Figure 4 Force-displacement diagram for press-fitting bearing seats with sizes 13 mm, 12.9 mm, and 12.8 mm housing

Figure 5 presents the force-displacement diagram for the 26 mm, 25.9 mm, and 25.8 mm bearing seat sizes during the press-fitting process. This diagram shows how the applied force correlates with the bearing's displacement as it is pressed into the housing. By comparing the different bearing seat sizes, the diagram reveals how slight variations in nominal diameter influence both the force required for assembly and the overall performance of the fit. Examining these force-displacement curves offers key insights into determining the ideal fit tolerance, ensuring a proper balance between ease of assembly and the secure positioning of the bearing in the housing.

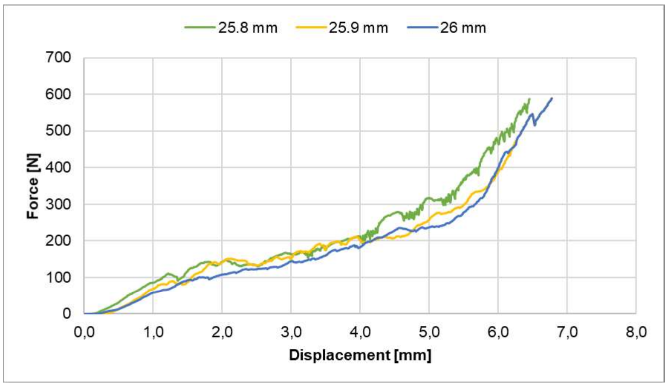

Figure 5 Force-displacement diagram for press-fitting bearing seats with sizes 26 mm, 25.9 mm, and 25.8 mm housing

Figure 6 shows the appearance of the housing after the press-fitting and subsequent disassembly of the bearing. The image highlights any potential deformation or wear that occurred during the assembly and disassembly process, providing insight into the impact of press-fitting forces on the 3D-printed housing material.

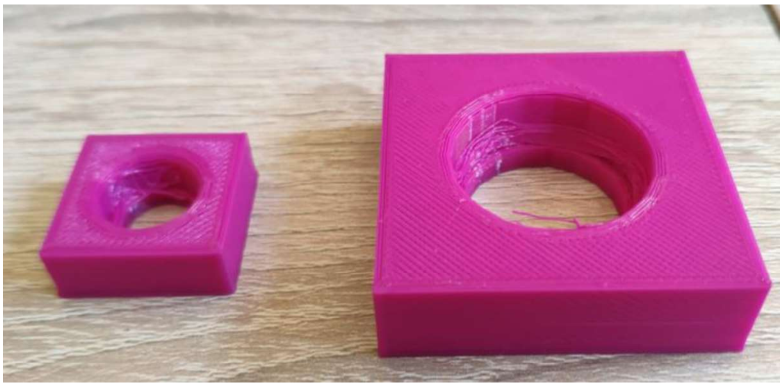

Figure 5 Appearance of the housing after press-fitting and disassembly of the bearing

CONCLUSIONS

Press-fitting metal parts into 3D-printed components is a common requirement in various mechanical assemblies. The aim of this research was to determine the forces necessary for press-fitting ball bearings into 3D-printed housings and evaluate the assembly performance. The study focused on two frequently used bearing sizes, 13 mm, and 26 mm, with typical 3D printing resolutions applied to the PET-G material. While this research provides valuable insights, future work should include experiments with other commonly used 3D printing materials such as ABS and PLA to develop comprehensive guidelines for press-fitting in 3D-printed assemblies.

In this study, three different diameters were tested for each bearing size, with 0.1 mm and 0.2 mm undersized seats designed to create a press-fit condition directly within the 3D model.

Based on the analysis of the force-displacement diagrams, it can be concluded that the greatest force was required to press-fit the bearing into the housing with a 12.8 mm seat diameter, reaching 583 N, as shown in Figure 4. Similarly, from the data presented in Figure 5, the maximum force required for the press-fitting process in the 25.8 mm bearing seat was 588 N. These findings indicate that smaller bearing seat diameters demand higher assembly forces, underscoring the importance of carefully selecting the fit tolerance to ensure both ease of assembly and secure retention of the bearing within the housing.

REFERENCES

[1] Lakshman Sri, S.V., Karthick, A., Dinesh, C.: "Evaluation of Mechanical Properties of 3D Printed PETG and Polyamide (6) Polymers." Chemical Physics Impact, vol. 8, June 2024, pp. 100491. https://doi.org/10.1016/j.chphi.2024.100491.

[2] Hsueh, Ming-Hsien, et al.: "Effect of Printing Parameters on the Thermal and Mechanical Properties of 3D-Printed PLA and PETG, Using Fused Deposition Modeling." Polymers, vol. 13, no. 11, May 2021, pp. 1758, https://doi.org/10.3390/polym13111758.

[3] Rashed, A.F., Damir, M.N.H., Cherif, A.S., Afifi, M.A.: "Study of deformation and form error due to press-fitting a thick cylinder into a square outer housing". Wear. 60, 339–347, 1980. https://doi.org/10.1016/0043-1648(80)90232-X

[4] Khubchandani, A., McCullough, M., Deporter, W.: "A Comparative Study of Bearing Press Fit Contact Modeling Techniques with Current Finite Element Analysis Tools". SAE Technical Paper 2011-01-1049, 2011, https://doi.org/10.4271/2011-01-1049.

[5] Benuzzi, D., Donzella, G.: "Prediction of the press-fit curve in the assembly of a railway axle and wheel". Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit. 218, pp. 51–65, 2004. https://doi.org/10.1243/095440904322804439

[6] Natali, A.N., Carniel, E.L., Pavan, P.G.: "Investigation of viscoelastoplastic response of bone tissue in oral implants press fit process". Journal of Biomedical Materials Research Part B: Applied Biomaterials. 91B, pp. 868–875, 2009. https://doi.org/10.1002/jbm.b.31469

[7] Weißmann, V., Boss, C., Schulze, C., Hansmann, H., Bader, R.: "Experimental Characterization of the Primary Stability of Acetabular Press-Fit Cups with Open-Porous Load-Bearing Structures on the Surface Layer". Metals. 8, 839, 2018. https://doi.org/10.3390/met8100839

[8] Palić, N., Slavković, V., Jovanović, Ž., Živić, F., Grujović, N.: "Mechanical Behaviour of Small Load Bearing Structures Fabricated by 3D Printing". Applied Engineering Letters. 4, pp. 88–92, 2019. https://doi.org/10.18485/aeletters.2019.4.3.2