Study Program: Mechanical Engineering

Course Title: Materials for 3D Printing

Instructor: Živić T. Fatima

Course Status: Elective course within the *Production Engineering* module

ECTS Credits: 6

Prerequisites: None

Course Objective

The main objective of the course is to familiarize students with the importance and characteristics of new materials for 3D printing, as well as their selection, production methods, applications, behavior during exploitation, and techniques for characterizing 3D printed parts. Students will also be introduced to the application of 3D printing materials in various fields and the development directions of new materials.

Learning Outcomes

Students should understand and become familiar with the basic types of materials used in 3D printing, their characteristics, and potential applications. Based on the acquired knowledge, students will be qualified to independently and correctly choose and apply materials for specific practical uses. They should also learn to analyze the applicability of sustainable materials, identify types of finishing processes and testing methods for 3D printed parts, and apply them in quality control.

Course Content

Theoretical classes

Overview of 3D printing materials (FDM, SLA, SLS). Thermoplastic materials: PLA (Polylactic acid), ABS (Acrylonitrile butadiene styrene), PETG (Polyethylene terephthalate glycol), TPU (Thermoplastic polyurethane), PVA (Polyvinyl alcohol), and polystyrenes. Photopolymers: standard, flexible, high-temperature resins, and castable resins. Powder materials: metal, ceramic, and polymer powders. Composites: carbon fiber-reinforced filaments, glass fiber-reinforced, and metal-reinforced materials. Key factors influencing material selection: strength, flexibility, durability, and thermal resistance. Material properties: Mechanical (strength, toughness, elasticity), Thermal (heat deflection temperature, thermal expansion, conductivity), Optical (transparency, UV resistance). Applications in: Industry (prototypes and device components), Automotive (lightweight structures, functional parts), Medical devices (implants, prosthetics), Consumer goods. Surface finishing of 3D printed parts: polishing, coloring, drying, curing, and chemical finishes. Trends in material development: natural materials, composite filaments, smart materials, metamaterials. Material selection criteria: Design and end-use requirements, Balancing cost, performance, and quality, Safety and regulatory aspects. Quality control of 3D printed parts: Testing mechanical and thermal properties, Material quality standards. Material sustainability and recyclability: Biodegradable and eco-friendly materials. Future material developments: Nanomaterials, 3D printed electronics, Flexible materials and wearables. Practical aspects: Storage and transportation of 3D printing materials, Common printing issues (warping, elastic deformation, layer adhesion problems), Material compatibility with various 3D printers.

Study research work: Case studies: material selection and practical examples of applying 3D printed materials in different fields. Laboratory research using primary scientific sources and systematic data analysis. Creating practical case study reports. Practical characterization of materials and 3D printed parts.

Recommended Literature

1. TRAJANOVIĆ, M., GRUJOVIĆ, N., MILOVANOVIĆ, J., MILIVOJEVIĆ, V. Computer-Aided Rapid Manufacturing Technologies. Faculty of Mechanical Engineering, University of Kragujevac, 2008.
2. WICKRAMASINGHE, S., DO, T. and TRAN, P., 2020. *FDM-based 3D printing of polymer and associated composite: A review on mechanical properties, defects and treatments*. Polymers, 12, p.1529. [viewed 29 April 2025]. Available at: https://doi.org/10.3390/polym12071529
3. RAFIEE, M., FARAHANI, R.D. and THERRIAULT, D., 2020. *Multi-material 3D and 4D printing: A survey*. Advanced Science, 7, p.1902307. [viewed 29 April 2025]. Available at: https://doi.org/10.1002/advs.201902307
4. MAZZANTI, V., MALAGUTTI, L. and MOLLICA, F., 2019. *FDM 3D printing of polymers containing natural fillers: A review of their mechanical properties*. Polymers, 11, p.1094. [viewed 29 April 2025]. Available at: https://doi.org/10.3390/polym11071094
5. AHMED, A., ARYA, S., GUPTA, V., FURUKAWA, H. and KHOSLA, A., 2021. *4D printing: Fundamentals, materials, applications and challenges*. Polymer, 228, p.123926. [viewed 29 April 2025]. Available at: https://doi.org/10.1016/j.polymer.2021.123926
6. GOH, G.D., YAP, Y.L., AGARWALA, S. and YEONG, W.Y., 2019. *Recent progress in additive manufacturing of fiber reinforced polymer composite*. Advanced Materials Technologies, 4, p.1800271. [viewed 29 April 2025]. Available at: https://doi.org/10.1002/admt.201800271
7. GONZALEZ-GUTIERREZ, J., CANO, S., SCHUSCHNIGG, S., KUKLA, C., SAPKOTA, J. and HOLZER, C., 2018. *Additive manufacturing of metallic and ceramic components by the material extrusion of highly-filled polymers: A review and future perspectives*. Materials, 11, p.840. [viewed 29 April 2025]. Available at: https://doi.org/10.3390/ma11050840

Number of active teaching hours	Theoretical classes: 30	Practical classes: 30

Teaching methods

The course is conducted through both theoretical and practical instructions. Student performance is evaluated continuously during the year (up to 70 points) and on the final exam (up to 30 points). Points are accumulated cumulatively. Students are eligible to take the final exam if they earn more than 25 points during the course.

Knowledge assessment (maximum 100 points)

Pre-exam Obligations	Points	**Final Exam**	Points
Class participation	**5**	Written Exam	
Study research work	**10**	Oral Exam	**30**
Mid-term exam(s)	**40**		
Seminar(s)	**15**		