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Catalytic debinding and sintering of 3D printed elements by FDM method

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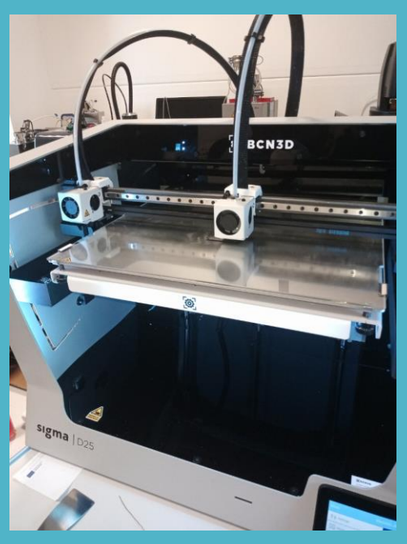
Introduction

Metal Fused Deposition Modeling (MFDM) metal 3D printing technology is one of the methods for additive manufacturing of metal parts. The process begins with preparing a 3D model of the part using specialized CAD software and printing elements in 3D technology. The first stage of post-processing is oxidative degradation conducted in the presence of nitrogen oxides, followed by thermal debinding and the metal powder sintering process.

1. Printing 3D



2. Catalytic debinding

3. Thermal debinding and sintering

4. Final sample

The oxidative degradation reaction of polyethylene (PE):

$$2CH_2\text{-}CH_2\text{-}[\text{-}CH_2\text{-}CH_2\text{-}]_n + 2NO \rightarrow 2CH_2\text{-}CH_2\text{-}[\text{-}CH_2\text{-}CH_2\text{-}]_{n-1} + H_2O + N_2O$$

Invention

The Ultrafuse 316L filament from BASF was used in the research. An innovation developed by the team of scientists from the Nanotechnology and Materials Technology Scientific and Didactic Laboratory was the degradation process of the polymer material in the vapors of nitric acid (V). The vapors of nitric acid (V) consist of nitrogen oxides such as NO_2, N_2O, and NO. This process is called oxidative degradation, which results in the breaking of intermolecular bonds in the polymer. The process was conducted under laboratory conditions in a fume hood. The samples were placed on a platform inside a large beaker containing nitric acid (V). The system was heated to a temperature of 120°C. As a result of heating, nitrogen oxides are released in the gaseous state. In a closed system, the nitrogen oxides react with the polyethylene present in the polymer adhesive of the additively printed samples. The research confirmed that the optimal process time is 30 minutes. The experimental study also demonstrated that the optimal amount of nitric acid used for the degradation of two test samples with dimensions of 45mmx10mmx4mm is $5cm^3$ of nitric acid (V). The optimal time and amount of the reactive substance allow for the removal of the appropriate amount of polymer without compromising the sample's shape. After the oxidative degradation process, the samples should undergo thermal degradation at a temperature of 530°C and the sintering process at a temperature of 1260°C.

Considering that the post-processing of finished prints by BASF is subject to a patent, reproducing this process and achieving high-quality sintered products is undoubtedly a research success. Therefore, the oxidative degradation process developed by the laboratory of the Silesian University of Technology deserves to be recognized as a scientific innovation.