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Abstract	In the composition of the composite material, stainless steel powders are 75%, LDPE is 25%. Using composite material, the product was developed in the FDM method, and methods for removing binder polymers from the product were analyzed. Methods of cooking stainless steel powders with polymer annealing, and studies of the structural quality of the product were carried out. Stainless steel powders at 1387 °C, the outer layers of the powders came together and the process of crystallization began. Removal of binders decreased by 90% as a percentage.	
Keywords (separated by '-')	Stainless steel powders - LDPE polymer removal methods - baking - FDM method	



Analysis of the Structure of a Sample Developed from a Composite Material on a 3D Printer

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Keywords: Stainless steel powders · LDPE polymer removal methods · baking · FDM method

1 Introduction

The method of melting materials at a temperature close to the melting point and developing products with layer-by-layer pressing is additive manufacturing [1]. Additive manufacturing, in contrast to traditional technology, is in the use of a complex form and material without waste.

Depending on the physical and chemical properties of the material used in additive manufacturing, approaches to product development are divided into several groups: SLA, SLM, EBM, FDM, LOM, etc. [2, 3].

The EBM method develops products based on layer-by-layer pressing of metal powders with electron beams, creating anisotropic microstructure [4, 5]. And the technology for the development of plastic products is FDM (modeling by layer laying) technology. The mechanism of operation is simple, and is becoming more widespread due to its availability [6].

Analysis of the construction of a product developed using composite material added to stainless steel powders as a binder in simple FDM technology, the main research area of this article is to say.

Based on the method of thermal annealing, polymers can be removed [7, 8]. Also, the furnace at the stage of removal of the binder is directly dependent on the rate of gases

and heating in the atmosphere. If the heating rate is fast, the polymer will accumulate between a certain amount of powder before it has time to completely decompose and the moisture does not dissipate. This affects the appearance of the defect by interfering with the fusion of stainless powders.

At the stage of baking powders, it is necessary to add argon, nitrogen gases and hydrogen with a volume of 25% to avoid oxidation. [9] During the baking phase of the powders, the outer surface of the powder melts and crystallizes together with the next one. In this way, all the powder can be combined to create a product with low roughness. In particular, complex products with composite material using FDM technology, and then remove the binder contained in this product, take a sample made of iron and analyze it.

2 Materials and Methods Characteristics of Raw Materials

In the composition of the composite material, stainless steel powders are 75%, LDPE is 25%. Phase analysis of the composite material with X-ray diffraction was carried out. The product was studied at a step of $1.5408 \text{ \AA}$, 0.02° , using a beam of 2θ between the range of $3\text{--}90^\circ$, $\text{Cu K}\alpha$.

The structure of the sample after firing and cooking methods was studied under a scanning electron microscope, and it was analyzed using the Zeiss Crossbeam instrument. With this method, it will be possible to study how much the binder is removed.

As mentioned above, at the stages of removing the binder, the polymer is moistened. The wet period was studied in infrared spectroscopy. Measured the FTIR spectrometer with the Thermo Scientific Nicolet is10 instrument in the range from 500 to 4000 cm^{-1} .

3 Printing Modes on a 3D Printer with Composite Material

In the 3D printer, the balting temperature of raw materials is 240°C , and the table temperature is 60°C . The pressing speed was 60 mm/s , 100% product filling, and the layer thickness was 0.2 mm . All modes were calculated and analyzed in advance.

3.1 Melting Point Analysis Description

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4 Results and Discussion Composite Material Analysis Results

If we discuss the result with a scanning electron microscope, we can observe stainless iron powders ranging in size from $1.86\ \mu\text{m}$ to $7.37\ \mu\text{m}$. The highest percentage of powders in the composition of raw materials are powders measuring $3\ \mu\text{m}$ (Fig. 1).

The structural state of atoms was studied by XRD. Fe-Cr-Ni austenite alloy tops $2\theta = 44.65^\circ, 64.98^\circ, 82.30^\circ, 98.88^\circ, 116.31^\circ$ can be observed (Fig. 2).

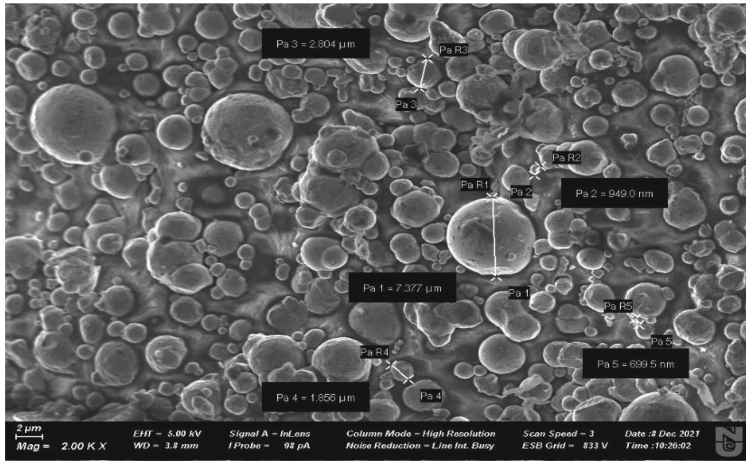


Fig. 1. The result of a scanning electron microscope.

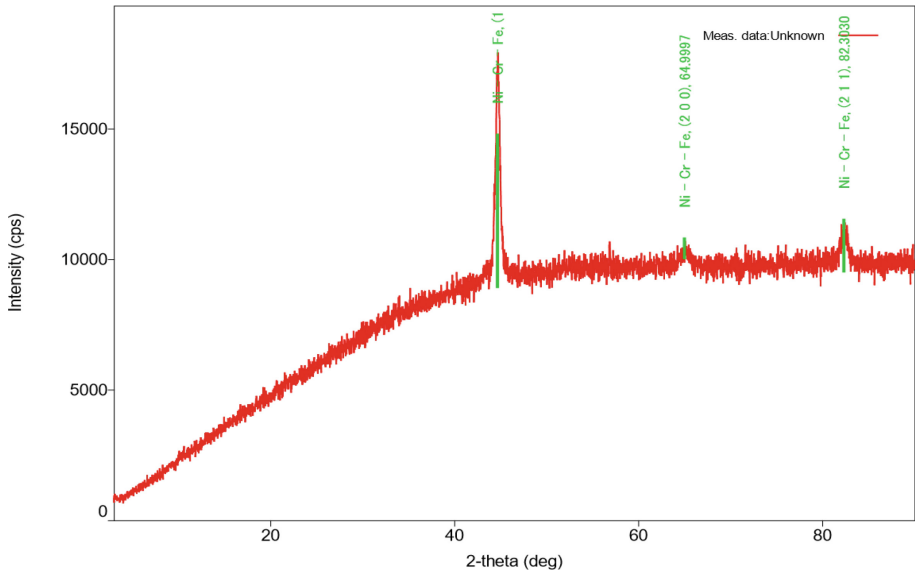


Fig. 2. 2θ , XRD result in the range of $10\text{--}90^\circ$.

In Figure 3, you can see the tensile oscillation of the binder at the peak of 3000 CM^{-1} , and this phenomenon optimizes the printing phase with a 3D printer.

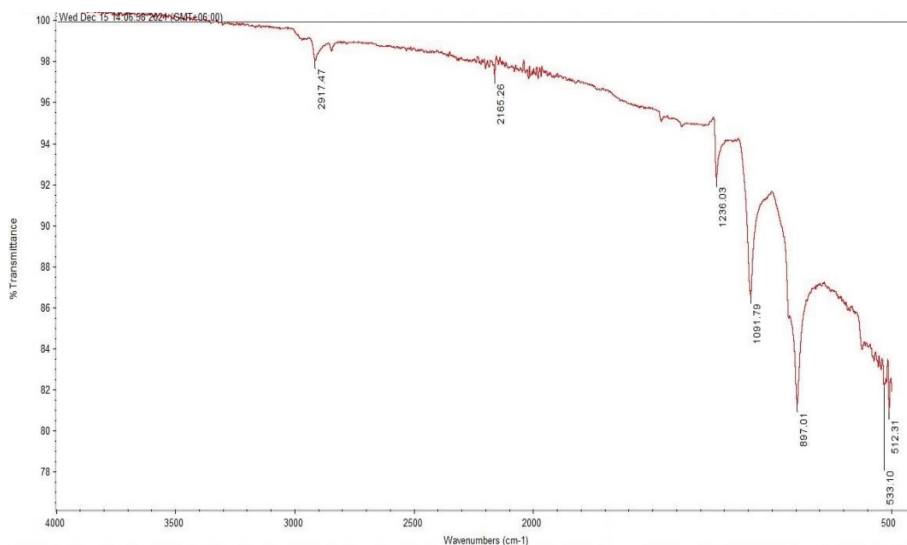


Fig. 3. The result of FTIR Spectra.

5 Results of Studies on the Melting Point of Composite Material

Based on the study, during the period of destruction of the binder, the weight of the material decreased. The absence of an exothermic process was found. An endothermic process was observed at $166.7\text{ }^{\circ}\text{C}$, $396.8\text{ }^{\circ}\text{C}$, $471.2\text{ }^{\circ}\text{C}$, $514.6\text{ }^{\circ}\text{C}$, $766.8\text{ }^{\circ}\text{C}$.

Stearic acid, paraffin, polypropylene were destroyed in the range of $190\text{--}600\text{ }^{\circ}\text{C}$. In conclusion, the weight is reduced by 9.7% from the sample.

6 The Results of the Destruction of Binders and the Fusion of Powders

As is clear in many studies, 100% of the binder is not destroyed. These studies are also proof. If the binders are held for a long time and the gases released from it create a pore in the center of the powder. It can be seen in Fig. 4 that the surface layers of the powder are covered by gases separated from the polymer. But being in small quantities, the percentage of fusion of powders is 90% (Fig. 5).

The volume of defects makes the product unusable, increasing the internal defects of the product.

SEM analysis after combining the powders revealed that 10% of the defects remained. This can be considered a high indicator.

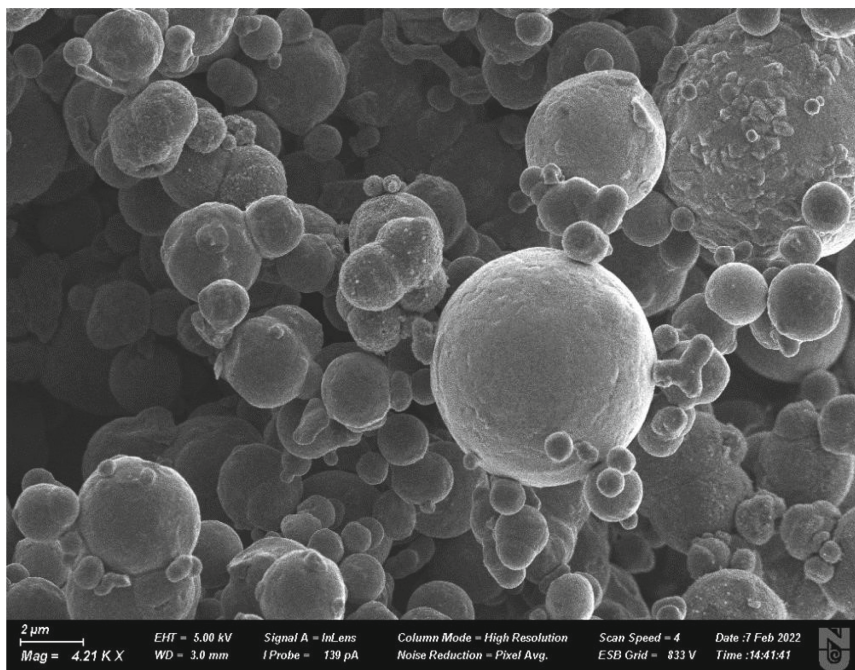


Fig. 4. SEM analysis result after the destruction of binders.

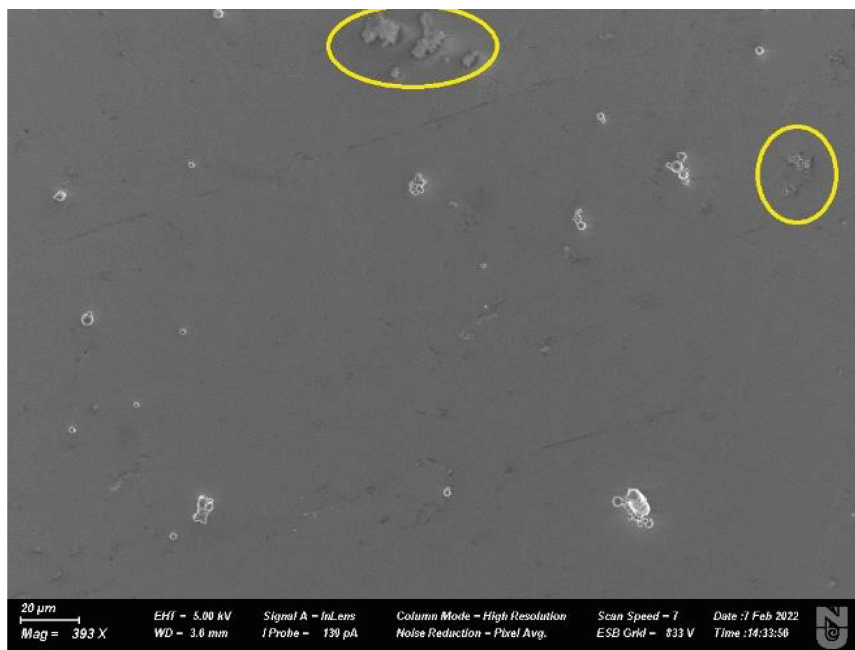


Fig. 5. SEM analysis result after combining the powders.

7 Conclusion

In this work, the sample is made in additive production by introducing the polymer into the metal powder, and the polymer in the resulting sample is removed and the metal powder is combined by baking at a temperature close to the melting point.

Differences in the sizes of metal powders, as well as a 10% polymer residue, as well as the Le Els of firing and baking are factors that directly affect the quality of the resulting sample. It turns out that complex stainless steel models can be made using the simplest technology.

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