DEVELOPMENT OF POWDER DENSITY CONTROL L-PBF METHODS FOR TUNGSTEN POWDER

Chiyen Kim*[1], Ho Lee[2], Philip Morton[3], Ryan B Wicker[4]

*[1]Department of Mechatronics Engineering, Korea Polytechnics College, Cheungju, South Korea 28590
[2]Department of Smart Mobility Engineering, Kyungpook Nat'l University, Daegu, South Korea 41566
[3]P.M. Technologies LLC, El Paso, TX 79905
[4]W.M. Keck center for 3D innovation, University of Texas at El Paso, El Paso, TX 79968

Abstract

Numerous studies and developments have been carried out on metal 3D printing technology with respect to the various metals. However, for refractory metals with high melting point materials, such as tungsten or molybdenum, there hasn't been much advancement in additive manufacturing technology. Even when the powder and base have been heated up, a major crack will still be created if the LPBF method is used because the refractory metal has a very high sintering temperature and there is an excessive temperature difference between the melting pool and the surrounding area. This study proposed methods for laser fusion of densified powder after compressing it to increase density, based on conventional powder metallurgy. Experiments were carried out on tungsten powder at various compression densities and pressures, gradually increasing to a green density.

1. Introduction

The traditional method of manufacture of tungsten products is powder metallurgy(PM). PM is a technique used to compress powder particles together, minimizing the gaps between them to ensure maximum contact between their surfaces. This allows for the formation of ingots or products through a process called chain sintering, even at temperatures below the melting point.

The particle form or size determines the varying green density. Usually in the industrial fields, a density of more than 17.8 g/cm3 generates products at 1800 to 2000 degrees Celsius. Based on the master sintering curve model, a 40 nm tungsten powder under 2560MPa generates an approximately 900 degrees tungsten ingot theoretically [1].

The present study considers the application of the PM method as a way to solve several problems that arise when layering tungsten materials in an additive manufacturing manner of the current L-PBF method. In the L-PBF printing method, this work hypothesize that it would be possible to put pressure on the powder recoating process to create a high-density powder and to reduce the sintering temperature when printing with pattern scanning on it to solve the brittleness problems. The study proposed the L-PBF method of the powder pressure process and conducted a study on the effect by pressure and the determination of proper parameters experimentally.

2. Proposed powder recoating system

As illustrated in Fig. 1, this paper developed a method that includes a compressing process during recoating in order to increase the density of the powder for sintering.

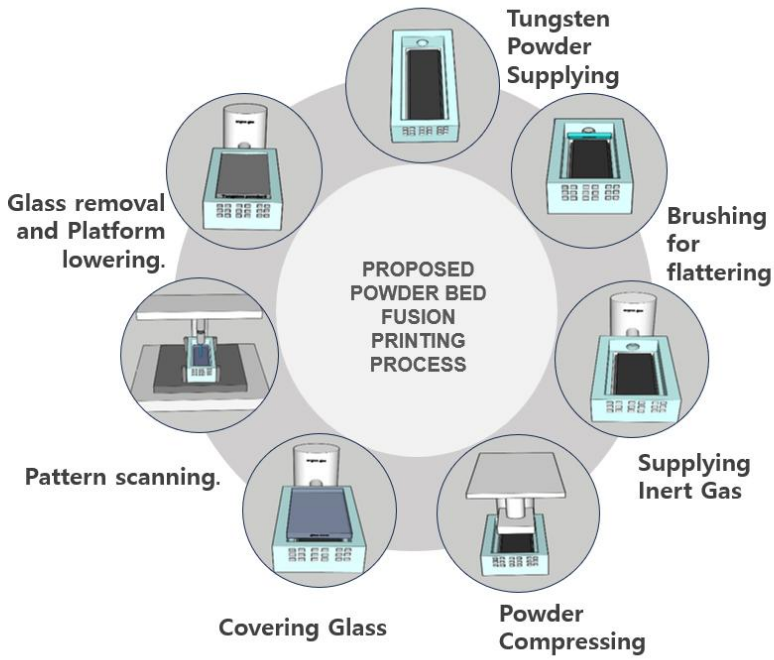

Figure 1: Proposed recoating method compromising powder compressing.

3. <u>Experiment preparation</u>

To implement the proposed method in this paper, it is necessary to control the compression pressure of the metal powder and to remove the oxygen contained within the powder. Figure 2 shows the internal structure of the powder compression device used in this experiment, as well as the actual experimental setup. To prevent metal oxidation, argon gas is injected internally during the compression stage to remove oxygen, and laser scanning is performed using an inert gas chamber, as is typical with traditional methods.

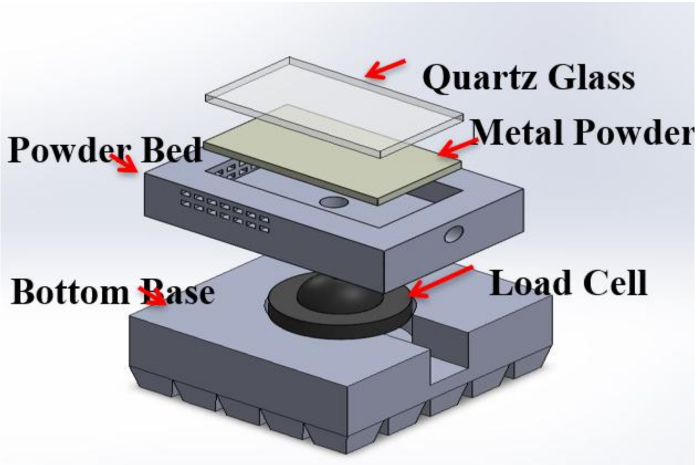

Figure 2: Internal structure of the powder compressor(left) and experimental device(right)

Table 1: Specifications for powder compression components

Item	Model & spec
Pressor	J03-0.7(Daju Hitech, Seoul Korea) 1 Ton
Load Cell	MNC-2T(CASE Korea ,Seoul Korea) 2 Ton (255Mpa)

4. Experiment Test

The experiment was implemented by setting the laser and process parameters as shown in Table 2. In this study, the powder was compressed at four stages of pressure, ranging from 25 MPa to 100 MPa, and tungsten metal printing was carried out.

Table 2: Experimental system parameter

PARAMETER	VALUE
LASER	Fiber laser
LASER WAVELENGTH	1030 nm
LASER POWER	600W
METAL POWDER	Tungsten powder 99.9% (1.8~5um)
LAYER THICKNESS	100um
PRESSURE	25MPa, 50Mpa, 75Mpa, 100Mps
SCAN SPEED	80 mm/s

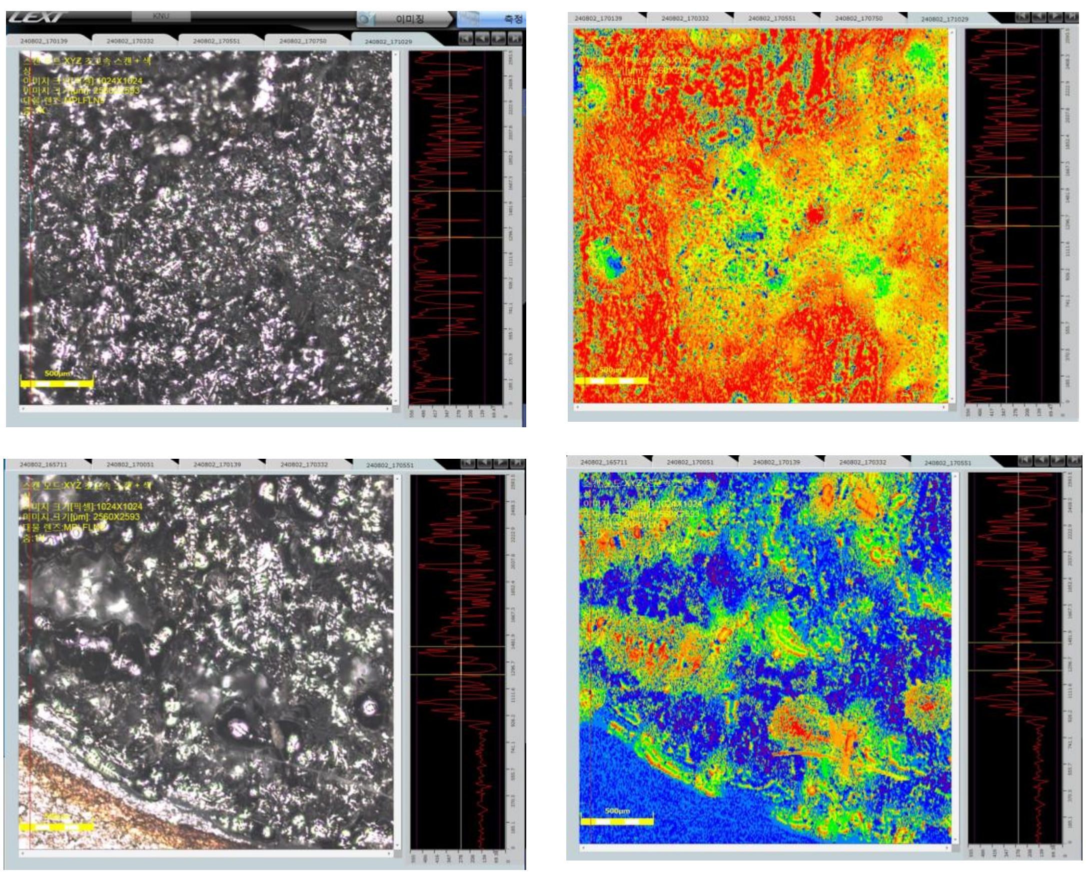

Figure 3: 25 MPa(up) and 50 MPa(down) condition optical image(left) and surface scan mapping image(right)

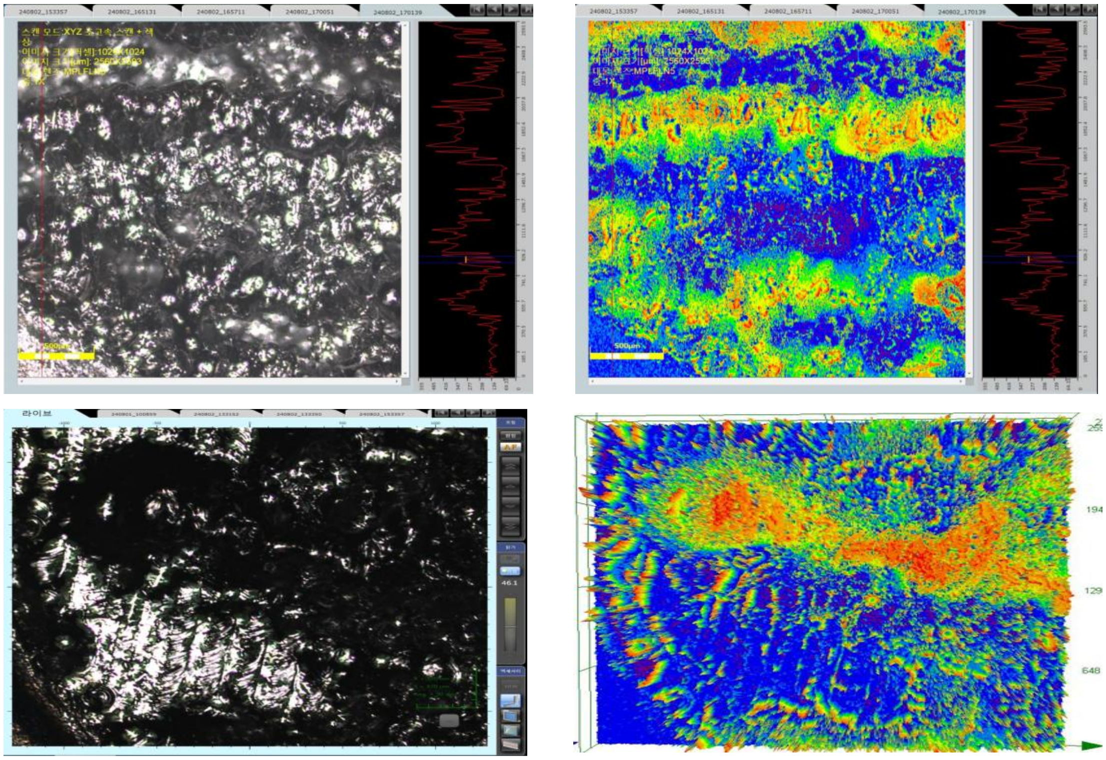

Figure 4: 75 MPa(up) and 100 MPa(down) condition optical image(left) and surface scan mapping image(right)

5. Conclusion

The study aims to combine the conventional PM technology of tungsten into the tungsten additive manufacturing technology. The proposed method is to press each layer powder to raise the powder density, so reducing the sintering temperature and preventing flaws resulting from fast cooling. The following findings were validated from a basic study carried out in this paper to identify changes according to density.

1) The 50 MPa powder pressure did not reveal any cracks in the laser pattern path.
2) When the powder was subjected to high pressure, it had a tendency to thicken and rise along the laser pattern path.
3) Compared to the beginning, the middle point now shows a stronger trend.

The following are the issues identified in this study and the solutions that were proposed.

1) The powder that was adhered to the press surface had a problem. Thus, the next work will identify and utilize the press surface lubrication technology.
2) The issue of sub-heating with the uniform laser power supply resulted in an increase in the sintering volume close to the center. The following study will control the melting size by varying the laser power profile.
3) Multilayer building suffered from the unequal height variations. It will keep investigating the parameter optimization for tall part building and high density manufacturing.

Acknowledgement

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Reference

[1] A.Talignani, R. Seede, A. Whitt, S. Zheng, J. Ye, I. Karaman, and Y.M. Wang, “A review on additive manufacturing of refractory tungsten and tungsten alloys,” *Additive Manufacturing*, 2022, doi:10.1016/j.addma.2022.103009