

Optimisation of Lattice Parameters for Selective Laser Melting Process Using DOE-FEM Approach

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Abstract

One of the highly promising and advanced Additive Manufacturing (AM) methods capable of directly fabricating functional metallic parts is Selective Laser Melting (SLM). SLM, a type of Laser Powder Bed Fusion (LPBF) AM, involves creating metallic components from CAD data by layer-by-layer fusion of metallic powders using a laser energy source, producing 3D metal materials. Lattice parameters such as unit cell size, cell thickness, and solid wall thickness were studied by utilising a numerical-based design of experiment (DOE-FEM) approach to plan and conduct the experiment systematically to gain optimal lattice parameters for the application of metallic lattice components. This study simulates a Ti-6Al-4V rectangular block with a gyroid lattice structure, aiming to analyse and compare the results of residual stress and distortion between DOE combinations and an optimised lattice parameter. The lattice structure is generated using nTopology software, and the SLM simulation is carried out with various input parameters using Simufact Additive software to analyse the impact on the lattice structure and final product. The optimisation of lattice parameters in the SLM process is performed through a numerical simulation using a DOE-FEM approach with Minitab software. These findings provide valuable insights into the behaviour of Ti-6Al-4V gyroid lattice structures and highlight the importance of considering lattice parameters, including overall dimensions, when designing standard specimens to analyse residual stress and distortion.

1. Introduction

Additive Manufacturing (AM) is a sophisticated method utilised to produce intricate shapes and structures by adding material in layers based on three-dimensional 3D model data directly from CAD software [1,2]. AM technology's special abilities make it a great option for producing parts with lattice structures [3]; as a result, lattice structures that were impossible to produce with previous manufacturing methods can now be easily created using AM technologies [4].

SLM is a Laser Powder Bed Fusion (LPBF) form of AM where metallic components are fabricated from CAD data by the layer-wise fusion of metallic powders using a laser energy source [5] for the production of 3D

metal materials, employing micron-sized spherical powders as the raw material. These include streamlining the production processes by reducing the number of steps involved, optimising material utilisation and achieving a higher strength-to-weight ratio [6] and enabling the direct fabrication of the final version of the part.

DOE is a statistical approach that facilitates systematic analysis of process parameters and their interactions which to determine an optimal combination of parameters [7], while FEM is used to solve complex engineering problems, and it allows for the analysis of stresses and deformations in structures, as well as additional physical phenomena [7]. This method uses FEM simulations to forecast the behaviour of the SLM process under various parameter settings and statistical approaches to construct tests and analyse the data collected from the experiments.

A lattice structure is an architecture formed by an array of spatial periodic unit cells with edges and faces, A lattice structure is defined as a space-filling unit cell that can be tessellated without any gaps in between the cells along any axis to form a lattice [8]. With its high-strength mechanical qualities, the lattice structure is a useful way to minimise the material used in manufactured products [4]. Several methods can be used to measure lattice structure strength, such as tensile, bending, and compression tests, which are common methods of testing [7].

Many overhanging areas are developed because of the geometry that cannot be constructed with support structures [9]. Unfortunately, support structures have several limitations that can increase construction time, post-processing, and the possibility of parts damage [10]. These deviations can greatly affect the mechanical characteristics of the lattice structures. They could be partially eliminated by minimising the used layer thickness and modifying the laser process parameters during SLM manufacturing of lattice structures [9], where they can result in significant changes in mechanical parameters.

There are three parameters have been investigated in this study, such are cell size, cell thickness and solid wall thickness and based on DOE, it will be designed and tested on the numerical simulation. Using the DOE-FEM approach, a combination of input parameters for lattice structure will be applied to optimise the lattice parameters. Simufact Additive software has been utilized to run an SLM simulation to predict the lattice structure behaviour, such as residual stress and distortion of the additively manufactured Ti-6Al-4V Gyroid specimen, which has been developed with the lattice-based structure using numerical software, nTopology.

2. Methodology

The application of DOE and FEM approaches to optimise the lattice parameters by achieving the desired mechanical performance, residual stress and distortion of the additively manufactured Ti-6Al-4V Gyroid specimen, which has developed with a lattice-based structure using nTopology software. According to input parameters, the SLM simulation process runs with various input lattice parameters to analyse how these parameters affect the lattice structure and final part properties possible for optimising the SLM process to achieve the required mechanical performance.

2.1 Minitab Software

Each level of run has different value input parameters of lattice structures related to the dimension of the lattice box, which depends on the cell size and thickness of the lattice structure that has been designed, as shown in Table 1. DOE-Taguchi method required to run the L9 array for three factors and three levels of Taguchi orthogonal array design can be seen in Table 2, which matches the number of control factors and levels by using the Minitab software for minimising the number of experiments required to optimise the product or process parameters.

Table 1 List of input lattice parameters [7, 11, 12]

Gyroid	Lattice Parameters		
	Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)
G-1	3	0.8	15
G-2	4	0.9	10
G-3	5	1.0	5

Table 2 L9 array for input lattice parameters

DOE	Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)
1	3	0.8	15
2	3	0.9	10
3	3	1.0	5
4	4	0.8	10
5	4	0.9	5
6	4	1.0	15
7	5	0.8	5
8	5	0.9	15
9	5	1.0	10

2.2 nTopology Software

Developing the geometry for rectangular block specimen was designed using nTopology software with specific dimensions and type of lattice structure. Table 3 lists the three variations in the dimensions of the rectangular block specimen for the lattice box, specifically focusing on changes in its length and width, with the height of the block specimen remaining constant. The illustration of the lattice box dimension can be seen in Fig. 1.

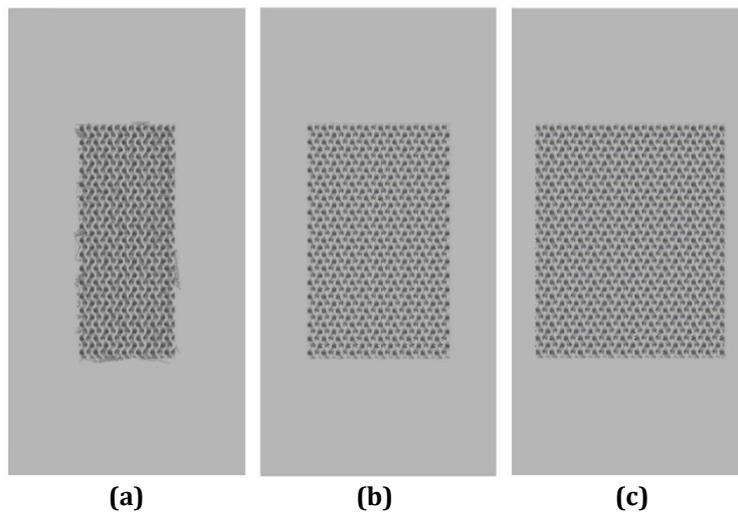


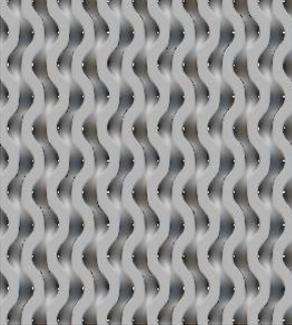
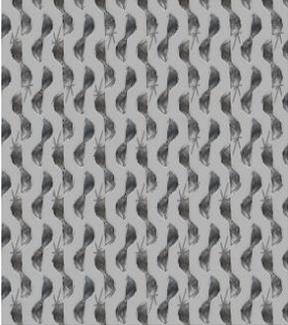
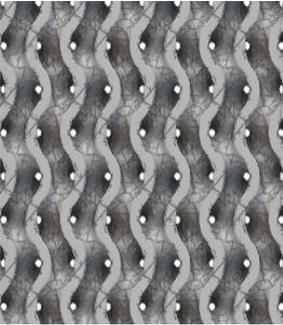
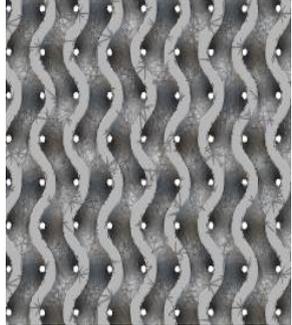
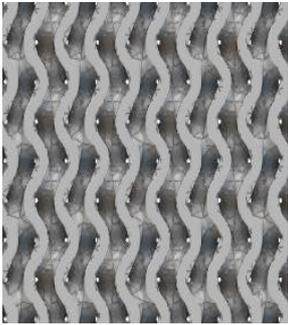
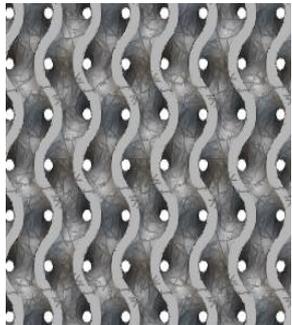
Fig. 1 Lattice box dimensions illustration ($L \times W \times H$) (a) 50 mm×20 mm×15 mm; (b) 50 mm×30 mm×15 mm; and (c) 50 mm×40 mm×15 mm

Table 3 Dimension of lattice box

Variables	Dimension (mm)		
Cell Thickness	0.8	0.9	1.0
Length	50	50	50
Width	20	30	40
Height	15	15	15

In addition, Table 4 shows the illustration of three different sizes and thicknesses of cell size of gyroid lattice structures that have been designed by using nTopology software for this study. These cell sizes and thicknesses were integrated into the rectangular block specimen with 0.5 mm of tolerance and 0.25 mm of minimum feature size in nTopology under the meshing element.

Table 4 Cell size and thickness of gyroid lattice structure illustration

Cell Size (mm)	Cell Thickness (mm)		
	0.8	0.9	1.0
3			
4			
5			

2.3 Simufact Additive Software

To simulate the LPBF process in order to optimise metal part manufacture. Table 5 outlines the general properties of the machine. The material properties for the rectangular block specimen, detailed in Table 6, specified the use of Ti-6Al-4V powder imported from the Simufact Material database.

Table 5 *Simufact Additive setting parameter*

Variables		Properties	
Machine			
Machine Type	Renishaw RenAM 500M		
Build Space (X, Y, Z) (mm)	X 248	Y 248	Z 350
Base Plate	Shape	Rounded Corners	
Critical Surface Angle (°)	0		
Method	CADS Additive		
CADS Support Parameter Type	Rod		
Shell Thickness (mm)	0.3		
Analysis			
Surface Mesh	Part Base Plate	Default Setting	
	Mesh Type	Default Setting	
	Voxel Size (mm)	Uniform	
Voxel Mesh	Part:	2	
	Plate:	4	
	Meshing Type	Manual Meshing	

Table 6 Mechanical material properties of Ti-6Al-4V powder at 20°C

Parameters	Constant Values
Poisson's ratio (-)	0.26
Thermal Expansion Coefficient (J/K)	8.84024×10^{-6}
Ultimate Strain (%)	15
Yield Strength (MPa)	1140
Tensile Strength (MPa)	1290

2.4 Geometrical Modelling

The dimensions of the rectangular block specimen are 100 mm in length, 50 mm in width, and 15 mm in height. Due to this study requiring modifications to the thermal process parameters, the thermo-mechanical method was used in the parametric analysis to obtain the residual stress and distortion analysis. The main parts of the SLM process, such as the substrate plate, component, and support structure, were included in the simulation that was run, as seen in Fig. 2. The support structure method was categorised as "Materialize" and described in accordance with the component. It generates block supports with 0.3 mm of shell thickness. The angle of surfaces from which support structures are constructed is determined by 0° critical surface angle.

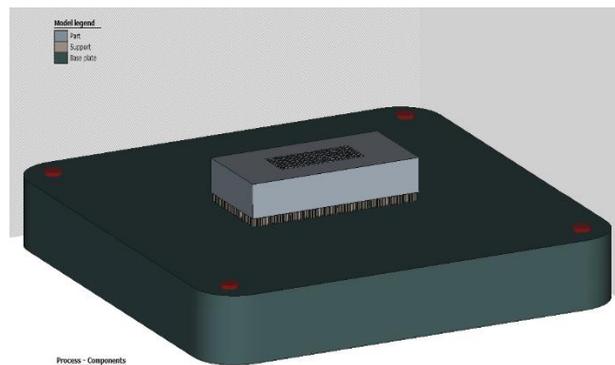


Fig. 2 Simulation of rectangular block Ti-6Al-4V specimen on substrate plate in Simufact Additive

3. Results and Discussion

The lattice box has been designed with three different dimensions, each corresponding to different cell thicknesses as shown in Table 3. All three designs have the same length and height dimensions. The development of a lattice-based structure specimen for this study used a TPMS lattice structure, which is a gyroid lattice structure. Ti-6Al-4V was selected as the material of the specimen. Due to its outstanding mechanical properties with excellent corrosion resistance and high specific strength [13], it was commonly used in the SLM process. Simufact Additive software material database was utilised to extract the main mechanical, thermal, and physical characteristics of the Ti-6Al-4V powder used in this study, as shown in Table 6.

3.1 Residual Stress and Distortion Analysis

After the SLM process has been conducted, referring to the equivalent stress data, the residual stress on the specimen can be evaluated by identifying the highest and lowest values of stresses that affect the lattice specimen. Besides, the stress distribution within the part can be seen through the application of a colour contour map in the simulation. Higher stress levels are usually represented by the red region. The colours can be correlated to specific stress levels, and the visualisation helps identify areas of high-stress concentration. This evaluation is important in this study to understand the residual stress and distortion created during the manufacturing process, which might affect the integrity of the structure and productivity of the part.

3.1.1 Residual Stress and Distortion on G-1 Lattice Structure

G-1 lattice structure represents DOE 1-3. Lattice-based structure on the specimen with 3 mm of cell size and 0.8 to 1.0 mm of cell thickness. The dimensions of the lattice box are 50 mm×20 mm×15 mm for DOE 1 had been run in the SLM process to identify the residual stress and distortion.

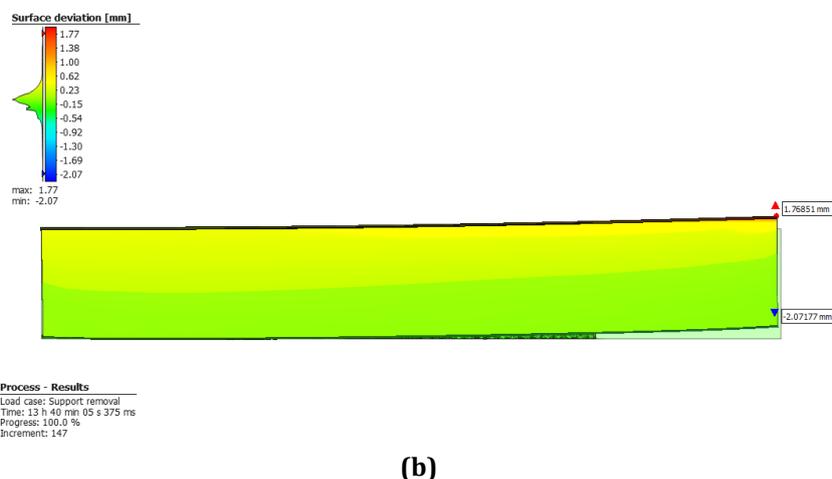
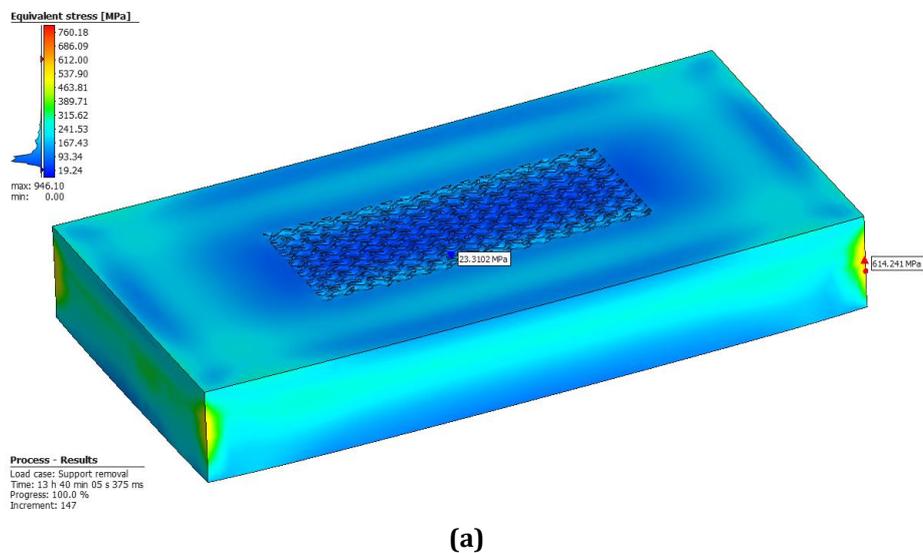


Fig. 3 Result of DOE G-1 (a) Residual stress; and (b) Distortion

Based on Fig. 3(a) shows that the yellowish regions on the right and left edges of the specimen indicate areas of higher stress concentration along the edges. Due to the stress not escaping from the build, there is a higher stress at each edge of the specimen. As the specimen gets closer to the heat source and the temperature keeps changing, the thermal gradient can lead to residual stress [14]. The edges become stressed due to residual stress developed in each layer, as each layer is stacked on top of the one before it. Furthermore, the central part of the specimen exhibits a bluish colouration, as shown in Fig. 3(a), indicating a lower residual stress of 23.310 MPa. Besides, the solid wall thickness shows low residual stress at the edges of the specimen, indicating that low residual stress is present between the gyroid lattice surfaces. The gyroid lattice structure's surface area has lower residual stress compared to a solid surface. The gyroid lattice surface's intricate structure enhances heat distribution, which in turn reduces the residual stress. Additionally, the solid surface area is larger compared to the surrounding air, resulting in uneven cooling and heat buildup on the solid surface.

Referring to the surface deviation seen in Fig. 3(b), which represents the distortion of the specimen, the maximum distortion value is 1.768 mm, which led to different dimensions compared to the actual dimensions of the specimen after the specimen had been printed. The distortion parts are focused on the right edge of the specimen, where the red arrow indicates the maximum distortion. Deformation on the specimen occurs due to additional stresses when rapid temperature changes for each layer develop during the SLM process, causing insufficient stress relief. The maximum residual stress for DOE 1 run is 614.241 MPa, with a maximum residual stress reading of 1.768 mm. DOE 1 exhibits the highest residual stress among the nine runs designed using the DOE-Taguchi method.

Table 7 Residual stress and distortion for cell size 3 mm

DOE	Cell Thickness (mm)	Residual Stress (MPa)	Distortion (mm)
1	0.8	614.241	1.768
2	0.9	568.484	0.807
3	1.0	568.295	0.788

3.2 DOE-FEM Approach

By conducting the experiments based on the numerical simulations of lattice parameters using the DOE-FEM approach, this study had achieved to reduce the number of simulations required to run in the SLM process using Simufact Additive software, analysed residual stress and distortion of Ti-6Al-4V gyroid lattice structure specimen on various lattice parameters. The combination parameters of DOE-Taguchi have been developed using Minitab software to optimise the product or process parameters, which are used to analyse the interactions between factors that influence the response variable, while the effects help in identifying the optimal levels of the factors that produce the maximum signal-to-noise ratio (S/N ratio).

3.2.1 Taguchi Analysis

The input lattice parameters were combined with responses obtained from the SLM process in Simufact Additive software. A DOE-Taguchi approach was applied to analyse the influence of three factors in this study: cell size, cell thickness, and solid wall thickness. In total nine input parameters were built with three different values for three factors assigned. The analysis hence possesses three factors and three levels for the Taguchi L9. Table 8 lists the summary of all the combinations analysed and the simulated residual stress and distortion.

Table 8 L9 array combinations lattice parameters

DOE	Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)	Residual Stress (MPa)	Distortion (mm)
1	3	0.8	15	614.241	1.768
2	3	0.9	10	568.484	0.807
3	3	1.0	5	568.295	0.788
4	4	0.8	10	599.769	2.327
5	4	0.9	5	597.058	2.560
6	4	1.0	15	562.579	1.380

7	5	0.8	5	596.287	2.701
8	5	0.9	15	596.925	1.728
9	5	1.0	10	595.887	1.820

As seen in Table 8, the G-1 lattice structure represents DOE 1-3, DOE 4-6 are categorized in the G-2 lattice structure, and DOE 7-9 are classified under the G-3 lattice structure. Based on this study, each category corresponds to different cell size values. Firstly, for DOE 1-3, which have a cell size of 3 mm and a cell thickness ranging from 0.8 to 1.0 mm, DOE 1 exhibits the highest residual stress and distortion, with values of 614.241 MPa and 1.768 mm, respectively. In contrast, DOE 3 has the lowest residual stress at 568.295 MPa and a distortion of 0.788 mm. Compared to DOE 1, DOE 3 demonstrates better lattice parameters for a cell size of 3 mm. Next, the G-2 lattice structure encompasses DOE 4-6, with a cell size of 4 mm and a cell thickness varying from 0.8 to 1.0 mm. The optimal lattice parameters for the G-2 lattice structure are found in DOE 6, with residual stress and distortion values of 562.579 MPa and 1.380 mm, respectively. DOE 5 exhibits the highest residual stress and distortion within this category, with values of 597.058 MPa and 2.560 mm. DOE 6, on the other hand, shows the lowest residual stress and distortion values. Besides, DOE 7-9 are categorized under the G-3 lattice structure, with a cell size of 5 mm and a cell thickness ranging from 0.8 to 1.0 mm. DOE 8 exhibits the lowest residual stress and distortion values at 596.925 MPa and 1.728 mm, respectively, whereas DOE 7 shows the highest residual stress at 596.287 MPa and distortion at 2.701 mm. These findings highlight DOE 8 as having the best lattice parameters.

Based on the analysis of these combination parameters, it can be seen that input lattice parameters have an influence on the geometry dimensions, especially for the cell thickness and solid wall thickness that can lead to residual stress and distortion of the Ti-6Al-4V gyroid lattice specimen. Referring to L9 array combination parameters in Table 8, the similarity in results obtained from referring to the highest and lowest values of residual stress and distortion can be attributed to the narrow range of lattice parameters influencing the outcomes.

3.2.2 Signal-to-Noise Ratio (S/N Ratio)

The S/N Ratio was determined using the Taguchi relationship in order to verify the patterns of behaviour that were seen. In general, signal-to-noise analyses the noise (errors) ratio to signal (obtained data). This ratio displays the precision of the measurement and computation for every test set [12]. For the objective function, smaller is better aimed at obtaining the minimised response for this study. Fig. 4 gives the optimum parameter combination to get a smaller value of residual stress and distortion. Based on the main effect plot of the S/N ratio, the selection of optimized parameters was given, and when the response is influenced by different levels of each part, the analysis of the main effects becomes important.

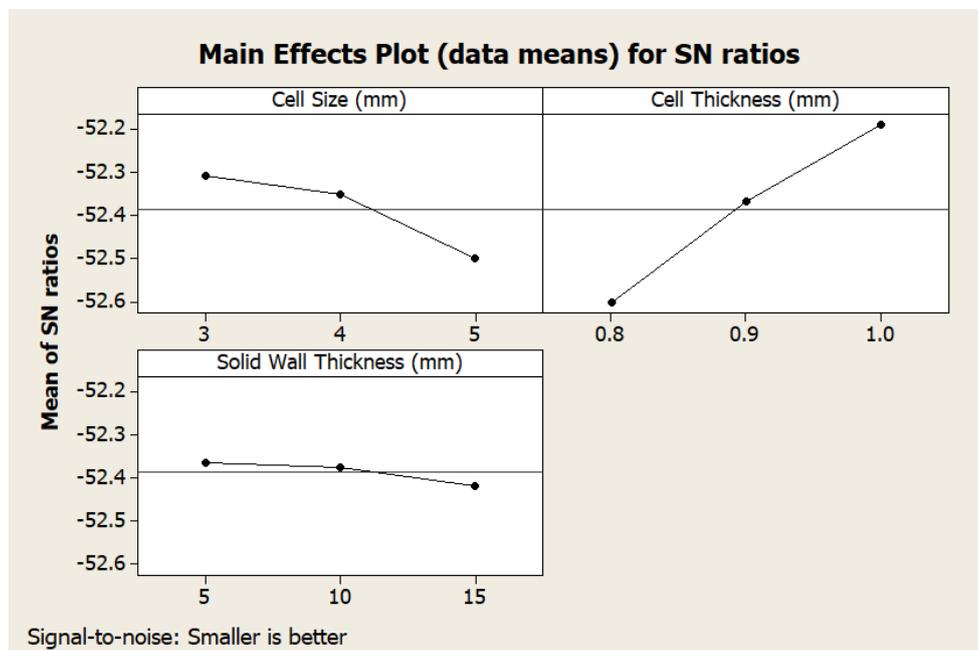


Fig. 4 Main effect plot for S/N ratio

Table 9 shows the ranking for all three factors of lattice parameters by using smaller is better method. The difference between the maximum and minimum average from all levels are used to calculate the delta after the average response for each factor has been determined at each level and the factors are ranked based on the largest to smallest delta.

Table 9 Response table for S/N ratios of small is better

Level	Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)
1	-52.31	-52.60	-52.36
2	-52.35	-52.37	-52.38
3	-52.50	-52.19	-52.42
Delta	0.19	0.41	0.06
Rank	2	1	3

The result for the response S/N ratio, as seen in Table 9, shows the cell thickness was in the first rank as the most effective parameter, where it can be seen at every level of the S/N ratio, the response was increased consistently compared and has the highest value of delta with 0.41 compare to the cell size and solid wall thickness. This indicates that cell thickness has the greatest influence on the structure of the gyroid lattice specimen. Cell size is the second most significant factor in minimizing residual stress and distortion, while solid wall thickness ranks third. Both cell size and solid wall thickness obviously consistently decreased at every level and had the lowest value for delta, which is 0.19 for cell size and 0.06 for solid wall thickness. The ranking of the S/N ratio values indicates that the cell thickness has the greatest influence on variability.

The optimal levels of the lattice parameters can be obtained from Figure 4, indicated by the levels which produce the lowest S/N ratio values, which seem the objective function is smaller and better. For cell size, the points for 3 mm, 4 mm and 5 mm became steeper, starting from -52.31 to -52.50. This indicates that the optimal cell size is 5 mm. Besides, the point for cell thickness increased drastically, where the point starting from cell thickness of 0.8 mm with -52.60, -52.37 for 0.9 cell thickness and -52.19 for cell thickness of 1.0 mm. However, the optimal cell thickness chosen based on the slope data using the DOE-FEM approach is 5 mm. As can be seen in Figure 4.4, there is a slight decrease in the slope of 5 mm, 10 mm and 15 mm of solid wall thickness. The range of differences in the point is only 0.02 to 0.04, with the values for 5 mm being -52.36, -52.38, and -52.42 for both 10 mm and 15 mm. This concludes that a solid wall thickness of 15 mm is the optimal level achieved.

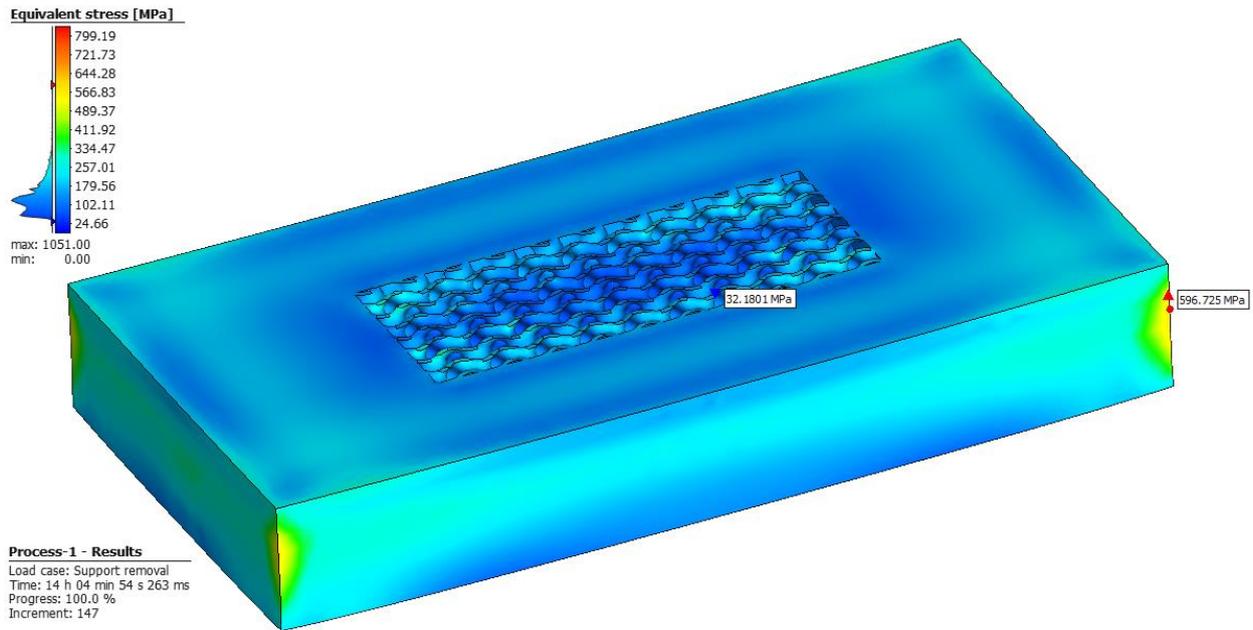
Furthermore, all the optimal lattice parameters data have been gathered using the DOE-FEM approach. The optimized lattice parameters were produced, with 5 mm of cell size, 0.8 mm of cell thickness, and 15 mm of solid wall thickness, as shown in Table 10. These lattice parameters have not been utilized in DOE-Taguchi as seen in Table 10.

Table 10 Optimized lattice parameters

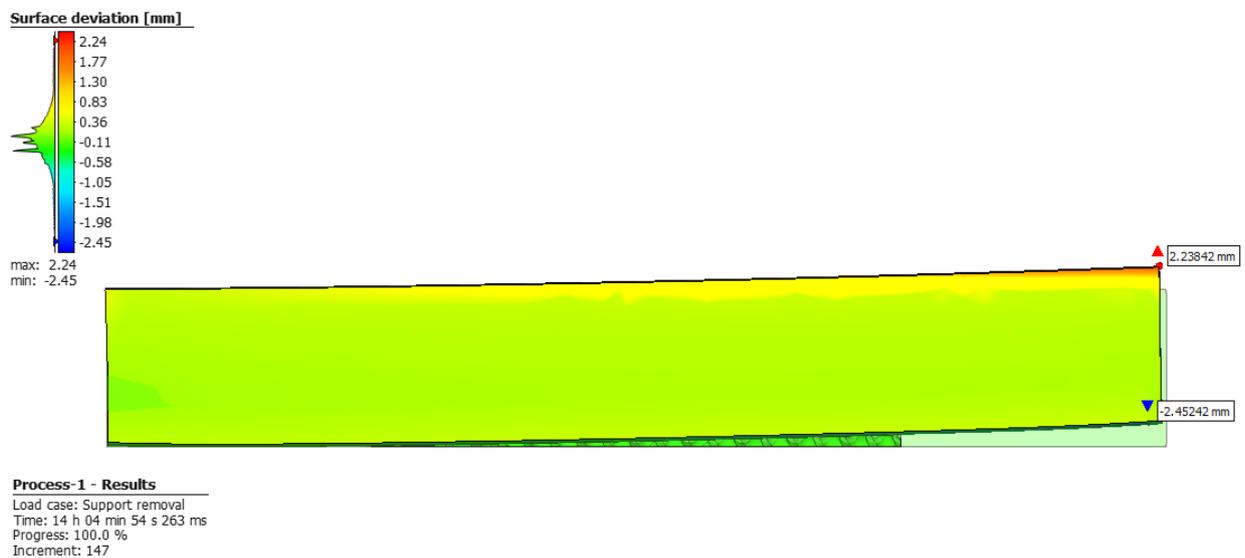
Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)
5	0.8	15

3.2.3 Optimized Lattice Parameter Geometrical Model

Fig. 5 shows the full geometrical model of the optimized lattice parameter obtained from the DOE-FEM approach using Minitab software. The residual stress of this lattice structure seen in Fig. 5(a) appears to be averaging close to 320 MPa. The highest residual stress seen along the edges of the structure is close to 650 MPa. The centre of the lattice box structure is found to have an equivalent stress in the range of 100 to 200 MPa. The last residual stress is found along the top surface and at the centre of the lattice structure in the rectangular block specimen. Since building the lattice structure can take hours, the thermal gradient affecting each layer is not as pronounced as in other parts of the lattice geometry, resulting in lower residual stress in this area [15].



(a)



(b)

Fig. 5 Result of optimized lattice parameter (a) Residual stress; and (b) Distortion

As illustrated in Figure 5(b), the highest surface deviation on the right edges of the structure is 2.238 mm. The green shadow indicates the specimen's original dimensions. This distortion alters the shape, causing it to be distorted upward, which results in dimensions that differ from the intended dimensions of the specimen after printing. The structural geometry also significantly influenced its distortion, and it was discovered that long section lengths and thin existing parts compromise dimensional accuracy, as indicated by a high level of distortion [16]. Additionally, adding powder can increase substrate distortion compared to substrates without powder [17]. The optimal lattice parameters are found in DOE 10 as seen in Table 11, with residual stress and distortion values of 596.725 MPa and 2.238 mm, respectively.

Table 11 Residual stress and distortion for optimized lattice parameters

DOE	Cell Size (mm)	Cell Thickness (mm)	Solid Wall Thickness (mm)	Residual Stress (MPa)	Distortion (mm)
10	5	0.8	15	596.725	2.238

3.2.4 Comparison between DOE Combinations and Optimized Lattice Parameter

Based on the L9 array combination parameters presented in Table 8, DOE 7-9 are categorized under the G-3 lattice structure, characterized by a cell size of 5 mm and cell thicknesses ranging from 0.8 to 1.0 mm. The optimized lattice parameters have been determined, specifying a cell size of 5 mm, a cell thickness of 0.8 mm, and a solid wall thickness of 15 mm, as detailed in Table 10. The comparison between DOE combinations and optimized lattice parameters is based on measured residual stress and distortion values. Specifically, DOE 7 exhibits a residual stress of 596.287 MPa and a distortion of 2.701 mm. DOE 8 shows residual stress and distortion values of 596.925 MPa and 1.728 mm, respectively. DOE 9 has a residual stress of 595.887 MPa and a distortion of 1.820 mm. Meanwhile, DOE 10 has residual stress and distortion values of 596.725 MPa and 2.238 mm. It can be concluded that DOE 8 exhibits the lowest values of residual stress and distortion, recorded at 596.925 MPa and 1.728 mm, respectively, whereas DOE 7 demonstrates the highest residual stress of 596.287 MPa and a distortion of 2.701 mm. Although DOE 10 is an optimized lattice parameter, these findings still highlight DOE 8 as possessing the most optimal lattice parameters.

Additionally, within the G-3 lattice structure, DOE 7 displays the highest residual stress at 596.287 MPa and distortion of 2.701 mm, while DOE 8 shows the lowest residual stress and distortion values, recorded at 596.925 MPa and 1.728 mm. Residual stress in fabricated parts can sometimes be attributed to the geometric structure and performance characteristics. Specifically, materials with higher thermal expansion coefficients tend to generate higher levels of residual stress. The residual stress data taken at various points in the lattice structure exhibit a wide variation, indicating that the stress values are inconsistent or uniform throughout the structure. Instead, revealing significant differences in stress levels across different areas of the structure. Hence, it is important to understand the temperature variations accurately throughout the produced part during manufacturing to manage the internal stresses and deformations in a manufactured part.

4. Conclusion

This study simulates a Ti-6Al-4V rectangular block with a gyroid lattice structure, focusing on analyzing and comparing residual stress and distortion results between DOE combinations and an optimized lattice parameter. Using nTopology software, the lattice structure is generated, and the SLM simulation process is conducted with various input parameters using Simufact Additive software to evaluate their impact on the lattice structure and final product. Numerical simulation, DOE-FEM approach for optimization of lattice parameters in SLM process using Minitab. Based on the result of L9 array combination parameters, DOE 7-9 are classified under the G-3 lattice structure, with a cell size of 5 mm and cell thicknesses ranging from 0.8 to 1.0 mm. DOE 7 displays the highest residual stress at 596.287 MPa and distortion of 2.701 mm, while DOE 8 shows the lowest residual stress and distortion values, recorded at 596.925 MPa and 1.728 mm. The optimal lattice parameters are found in DOE 10, with residual stress and distortion values of 596.725 MPa and 2.238 mm, respectively. Although DOE 10 is an optimized lattice parameter, these findings still highlight DOE 8 as possessing the most optimal lattice parameters. According to the results of this study, the following conclusions and viewpoints emerged:

- i. Utilizing numerical simulations of lattice parameters with the DOE-FEM approach greatly reduces the number of simulations needed to optimize the SLM process using Simufact Additive software. This method helps identify the most impactful factors on the mechanical performance of lattice structure and accurately predict outcomes during SLM process development.
- ii. Printed components' residual stress and distortion values were analysed using various parameter combinations. The study investigated how the gyroid lattice structure's cell size, cell thickness, and solid wall thickness affected a Ti-6Al-4V rectangular block specimen. The results showed that these factors significantly influence the performance and reliability of the materials.
- iii. Numerical simulations compared the outcomes of residual stress and distortion between DOE combinations and optimized lattice parameters. Each level of lattice parameters produced different residual stress and distortion values, highlighting how various lattice parameters distinctly impact the geometric structures after the SLM process.

Overall, it can be concluded that the residual stresses and distortion that occurred during the LPBF process may significantly impact the mechanical performance of complex gyroid lattice structure geometries. These findings offer valuable insights into the behaviour of Ti-6Al-4V gyroid lattice structures and emphasize the importance of

considering lattice parameters, including overall dimensions, when designing standard specimens to analyse the residual stress and distortion.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

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