

Optimization of SLS forming parameters in the dimensional accuracy of formed parts

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Abstract: In selective laser sintering powder forming, the performance and dimensional accuracy of the formed part are affected by the process parameters. Different materials have different process parameters, and there is still no reference standard for PA materials. To solve this problem, in response to this problem, PA2200 material was selected, and the influence of scanning interval and scanning speed on the dimensional accuracy of the formed part was analyzed. Through theoretical analysis and experiments, the optimal process parameters were obtained. The best combination of parameters is a scanning speed of 4000mm/s, a scanning interval of 0.5mm, and the size of the molded part has a X-axis deviation -0.35%, a Y-axis deviation -0.4%, and a Z-axis deviation -0.25%.

1 Introduction

Selective Laser Sintering (Selective Laser Sintering, SLS) is currently a mainstream technology of 3D printing, which is formed by laser sintering powder. During the forming process, it has the advantages of no need to add support, can be formed into any shape, low processing cost and high material utilization rate. It is widely used in aerospace, automobile, mold and other fields^[1].

The forming process parameters are the core of SLS technology, which will affect the performance and accuracy of the formed parts. Unreasonable process parameters will cause the formed parts to warp, deform and have poor performance^[2]. The forming process parameters mainly include: laser power, scanning rate, scanning distance, preheating temperature and scanning layer thickness, etc. In practical applications, the process parameters are often adjusted through the experience of engineers. At present, there is no quantitative characterization. Therefore, it is of great significance to study the process parameters of selective laser sintering^[3].

In recent years, scholars at home and abroad have done a lot of research. For the selective laser sintering of PS powder, Bo Fuxiang^[4] analyzed the influence of laser power, scanning distance, scanning rate, heating temperature and printing layer thickness on the molded parts, and obtained the best combination of process parameters and the importance of the influence of each process parameter. Li Xiaorong^[5] used PA6 powder to carry out SLS forming experiments, and analyzed the effects of preheating temperature, laser power and scanning speed on the forming accuracy and upper surface roughness of the formed parts, and obtained the optimal combination of process parameters. Yang Laixia^[6] analyzed the PS powder test piece and studied

the influence of laser power, filling speed, powder layer thickness and scanning distance on dimensional accuracy.

At present, the research work on the process parameters of SLS is relatively simple, and no universal law can be obtained. There are few reports on the research on the process parameters of PA forming parts. In view of the above problems, PA2200 powder was selected as the research object, and the dimensional accuracy of the formed part was used as the evaluation index to study the influence of scanning distance and scanning speed on the dimensional accuracy of the formed part, and the optimal combination of process parameters was obtained by orthogonal experiment^[7].

2 Experimental part

2.1. Experimental Materials

PA powder: PA2200, the average particle size is 60 μ m, the appearance is white powder, Germany EOS Optoelectronics Technology Co., Ltd. (EOS), the mixing ratio of new and old powder is 1:1.

2.2. Laboratory equipment

Selective laser sintering rapid prototyping machine: EOS P396, Germany EOS Optoelectronics Technology Co., Ltd. (EOS); High-Speed mixer: XHS-50KG, Ningbo Beilun Tongsheng Machinery Manufacturing Co., Ltd.; Sieving Machine: Auspack-und Siebstation P1/P3, Germany EOS Optoelectronics Technology Co., Ltd. (EOS); Sandblasting Machine: 9070, Ningbo Yinzhou Wuxiang Xinzhe Machinery Factory.

2.3. Sample preparation

The test piece is determined according to the plastic tensile specimen standard GB/T1040-2006, and the standard type 1B sample piece (as shown in Figure 1) is used. The sample size^[8] is shown in Table 1.

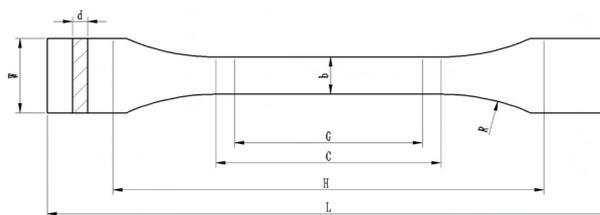


Figure 1. Tensile sample structure.

Table 1. The sample size.

Symbol	Name	Size/mm	Symbol	Name	Size/mm
L	Total length	150	W	End width	20
H	Distance between fixtures	115	d	Thickness	4
C	Length of middle parallel part	60	b	Width of middle parallel part	10
G	Gauge length (or effective part)	50	R	Radius	60

Use selective laser sintering rapid prototyping machine to print, preheating temperature 168°C; printing layer thickness 0.12mm; laser power 40W; scanning interval (unit: mm) choose 0.3, 0.4, 0.5, 0.6 four levels; scanning speed (unit: mm/s) choose: 3000, 4000, 5000 three levels. The scanning interval and scanning speed adopt the orthogonal experiment method, a total of 12 sets of data, 5 samples are printed in each set.

2.4. Sample test

The total length (L=150mm), end width (W=20mm) and thickness (d=4mm) of the sample are measured with a digital vernier caliper, and the average value of 5 samples in each group of data is taken.

3 Results and discussion

3.1. The influence of scanning interval on the dimensional accuracy of formed parts

The distance between the centers of two adjacent laser scanning lines is called the scanning interval. The diameter of the laser spot determines the size of the scanning interval (that is, the larger the laser spot diameter, the larger the scanning interval). The size of the scanning interval determines the coincidence of two adjacent laser lines (that is, the smaller the scanning interval, the higher the coincidence).

Figure 2 shows the influence of the scanning interval on the X, Y, and Z dimensional accuracy of the formed part (the blue line, the red line and the black line represent the scanning speed of 3000mm/s, 4000mm/s and 5000mm/s, respectively). It can be seen from the figure that when the spacing increases between (0.3mm, 0.4mm), the dimensional accuracy deviation gradually decreases. When the power increases between (0.4mm,

0.6mm), the dimensional accuracy deviation gradually increases.

3.2. The influence of scanning speed on the dimensional accuracy of formed parts

The scanning speed determines the time for the laser to scan and heat the powder, as well as the time for the workpiece to be formed. When the scanning speed is high, the powder melting sintering molding time is insufficient and the effect is poor; when the scanning speed is low, the powder melting sintering molding has good compactness and high dimensional accuracy, but the heating time is long.

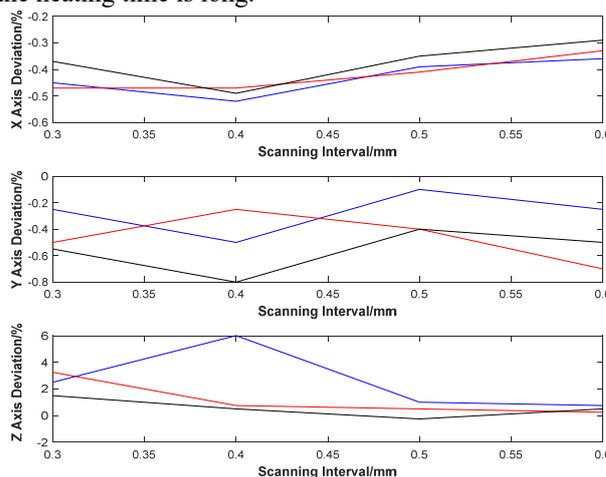


Figure 2 The influence of scanning interval on X, Y, Z dimensional accuracy.

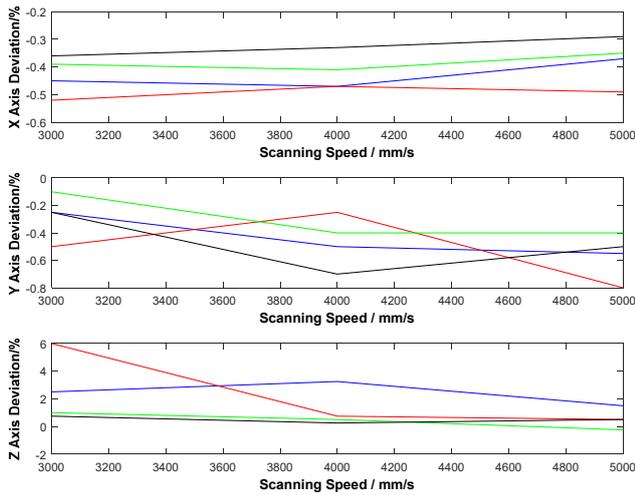


Figure 3 The influence of scanning speed on X, Y, and Z dimensional accuracy.

Figure 3 shows the influence of the scanning speed on the X, Y, and Z dimensional accuracy of the formed part (the blue line, red line, green line and black represent the scanning distance of 0.3mm, 0.4mm,

0.5mm and 0.6mm respectively). It can be seen that when the laser speed increases between (3000mm/s, 4000mm/s), the dimensional accuracy deviation gradually decreases; when the laser speed increases between (4000mm/s, 5000mm/s), the dimensional accuracy The deviation gradually increased.

3.3. Optimization of process parameters

Using the orthogonal experiment method, 12 sets of experimental data composed of two variable factors of scan interval and scan speed, when each set of variables are changed by the controlled variable method, analyze the X, Y, and Z dimensional accuracy deviations. Then select several groups of data with smaller average and smaller variance and then optimize the parameters. Table 2 and Table 3 show the situation when the scan rate and scan pitch are changed in sequence. Table 4 shows several parameter combinations with the smallest dimensional accuracy deviation.

Table 2. When the scanning speed changes.

Serial number	Scanning Speed/ mm/s	Proportion of dimensional accuracy deviation (%)					
		X direction		Y direction		Z direction	
		average value	variance	average value	variance	average value	variance
1	3000	-0.43	0.06	-0.28	0.17	2.56	2.42
2	4000	-0.42	0.06	-0.46	0.19	1.19	1.40
3	5000	-0.38	0.07	-0.56	0.17	0.56	0.72

Table 3. When the scanning interval changes.

Serial number	Scanning Interval/mm	Proportion of dimensional accuracy deviation (%)					
		X direction		Y direction		Z direction	
		average value	variance	average value	variance	average value	variance
1	0.3	-0.43	0.05	-0.43	0.16	2.42	0.88
2	0.4	-0.49	0.03	-0.52	0.27	2.42	3.10
3	0.5	-0.38	0.03	-0.3	0.17	0.42	0.63
4	0.6	-0.33	0.04	-0.48	0.23	0.5	0.25

Table 4 Several sets of parameter combinations with the smallest deviation of dimensional accuracy.

Serial number	Scanning Speed/ mm/s	Scanning Interval/mm	Proportion of dimensional accuracy deviation (%)		
			X direction	Y direction	Z direction
1	3000	0.6	-0.36	-0.25	0.75
2	4000	0.5	-0.41	-0.4	0.5

3	4000	0.6	-0.33	-0.7	0.25
4	5000	0.5	-0.35	-0.4	-0.25
5	5000	0.6	-0.29	-0.5	0.5

It can be seen from Table 2 and Table 3 that the scan speed is 5000mm/s and the scan distance is 0.5mm, which is the optimal parameter combination. It can be seen from Table 4 that the group with the smallest size deviation is the scan rate of 5000mm/s, the scan distance of 0.5mm, the X-axis deviation accounts for -0.35%, the Y-axis deviation accounts for -0.4%, and the Z-axis deviation accounts for -0.25 %.

4 Conclusion

Comprehensive analysis shows that the scanning interval and scanning speed in the selective laser sintering process will have an impact on the dimensional accuracy of the formed part. The increase in the scanning interval and scanning speed will reduce the deviation of the dimensional accuracy first and then increase, so the optimal parameter combination will Will achieve the highest dimensional accuracy, while also considering cost and processing cycle. According to theoretical and experimental data analysis, the best combination of parameters is the scan speed 4000mm/s, the scan interval 0.5mm, the X-axis deviation accounts for -0.35%, the Y-axis deviation accounts for -0.4%, and the Z-axis deviation accounts for- 0.25%. The obtained optimal parameter combination can provide a basis for the study of PA material SLS forming, and can also provide solutions for improving the dimensional accuracy of PA forming parts.

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