The Research of the Processing Parameters in the Selective Laser Sintering Technology

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Abstract. In terms of selected laser sintering rapid prototyping technology, laser power and scanning speed has a very important influence on forming quality. This article mainly analyzes the stain-less steel parts, sintered under different laser power and scanning speed. By measuring the warping values, the best parameter values can be drawn.

1. Introduction

At present, the rapid prototyping technology, originally used to make the casting model and the prototype parts, has been widely used in machinery manufacturing, aerospace, automobile making, building, medical and other fields. In European and American countries, a variety of RP technology have been developed, including the stereo lithography apparatus (SLA), the fused deposition modeling (FDM), the laminated object manufacturing(LOM), the selected laser sintering(SLS) and the three dimensional printing(TDP) technologies, etc.

It is widely accepted that the selected laser sintering technology provided the following merits:

1. A variety of materials can be applied.
2. Manufacturing process is simple.
3. High precision
4. High material utilization,
5. Low cost.
6. The support structure is not necessary.

At present, How to improve the precision of parts of RP is a hotspot in this field. This paper mainly studied the impact of the laser scanning speed and laser power on the precision of parts.

2. The basic principle of SLS

Rapid prototyping technology is based on discrete or accumulation formation theory. Firstly, a three-dimensional digital model is constituted by computer. Secondly, by the application of rapid prototyping software, it is sliced hierarchically. The direction of the slice can be choosed according to the needs and processing convenience. Every slice is composed of various points of 2 d contour information .Finally, all layers of slices are stacked up in a certain order to form three-dimensional entity. Unlike the traditional machining product ,which is obtained by gradually removing excess material and raw materials, and in which material utilization rate is not high, the RP technology product are formed step by step. In this technology the complex three dimensional are translated into simple 2 d slice. So the cost reduce greatly. The utilization rate of raw materials sometimes is close to 100%. Moreover, RP does not have to use traditional machine tool and die, consumes only 30% - 50% of the time of traditional machining, and can directly produce the required entities [1].

Laser sintering technology is based on the general principle of rapid prototyping. On the work table, a layer of powder material is put with a roller. Above them radiation heater make powder material preheat temperature below the melting point. Then in accordance with section contour information, the laser beam, under the control of the computer, scan the powder .The temperature of the powder is near to the melting point. So the particles are bonded each other, and a layer of contour chip is acquired.

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Meanwhile the power outside light area is still melting. After one layer is completed, the workbench down the height of a layer, then the next layer of powder is sintered. Each layer are sintered together at the same time. Eventually three-dimensional artifact is formed. It is evident that other support structure is not necessary.

SLS can used a lot of powder such as plastic powder, wax powder, resin-bonded sand, metal powder, ceramic or metal powder mixed with binder, etc[2,3].

3. Laser scanning speed and laser power influence on the precision of parts

Sintering process parameters of SLS mainly include laser scanning speed, laser power, sintering spacing, thickness of single layer and scanning mode [4,5].Thereinto, Laser power and scanning speed determine the laser sintering temperature of powder materials. So they are the main factors influencing the precision of fabrication. On the premise of 0.165mm sintering spacing, 0.1mm thickness of single layer and scanning mode for two-way line, the influence of scanning laser power and scanning speed on the precision of parts are studied.

3.1Materials and equipment

1) Test material: German stainless steel powder,a kind of spheroidal particle. Its size is about 200-300 mesh.

2) Testing equipment: German EOS M270 metal laser sintering system, which maximum forming size is 250 mm x 250 mm x 215 mm,adopting Yb-fibre generating laser, with 200w maximum power and with the highest Scanning speed of up to 7 m/sec.

3.2 Experimental method

when the other parameters, a 0.165 mm sintering spacing, a thickness of 0.1 mm single layer, a two-way line scanning mode has been selected, a total of twenty of 30 mm x 30 mm x 30 mm metal parts are sintered under different laser power such as 75watt, 77watt, 79watt and 83watt respectively .In each power group five parts are sintered. Table 1 shows a comparation between the volume of parts sintered under different power. Data are analysed by using analysis of variance of SPSS software.

As well, under different scanning speed（15s, 17s, 19s, 21s）, the parts volume of all are showed in table 2. All data are imported into computer and analysed by SPSS software using analysis of variance. It is well known that the smaller the volume change, the higher the accuracy of fabrication.

3.3 The results of variance analysis

Under different laser power, the parts volume are significantly different. P value is Sig. 0.002＜ 0.05. Using S - N - K inspection,1, 2, 3 groups have no significant difference according to two-comparison results, but comparation between group 4 and 1, 2, 3 groups had significant difference.

Sintered under different scanning speeds ,the volume of product have significant difference, according to the pairwise comparison results of the S - N - K inspection, there was no significant difference between2, 3, 4 group , but group 1 and the rest of the group have significant difference

Table 1. The volume of the parts under different laser power

Laser power(W)	The volume of fabricaton(mm^3)
75	28.90 28.85 29.00 28.16 28.83
77	27.78 27.55 27.39 27.96 28.05
79	27.07 26.97 27.48 27.15 27.13
83	26.00 26.01 25.85 26.02 26.12

Table 2. The volume of the parts under different scanning speed

Scanning speed(mm/s)		The volume of fabricaton(mm^3)
15		26.01 25.85 26.00 26.06 26.03
17		27.04 27.05 27.10 27.26 27.11
19		27.87 28.17 27.88 27.85 27.95
21		29.10 29.61 28.85 29.17 28.99

4. Discussion

When the laser power, under the condition of definite other parameters, reaches a certain value, the surface of the metal powder partially absorbed energy, reaches its melting state, and completes the sintering. In this experiment, the powder melting point of the stainless steel are around 1150 centigrade.

Laser power determines the energy given to the powder material. If the power of laser is inadequate, the energy input is low. As a result, powder were melted and bonded insufficiently. Because the liquid phase is less and the solid phase more, the strength of sintered parts is low. In addition, combination is not dense, so increase volume.[6]If the laser power is too low, parts easily broken and can't be molded.

The experimental results show that, when the laser power is 75 watts, the energy Input just can make the powder melted, bonded and molded. The parts have a certain strength. When the laser power increases, the temperature of the powder is higher. At this very moment, the liquid phase is more and the Solid phase low. So the density of parts is strong. At the same time, the volume shrinkage of parts also increase. If the power, however, is too high, nodulizing phenomenon occurs easily. As a result, the surface of parts is of roughness. When power is more than 83 w, the accuracy of fabrication decrease.

Laser scanning speed is one of the important factors that determine the energy density. It determines the laser energy heating time for powder. Under the same laser power, the higher scanning speed, the shorter laser heating time for powder, the less heat transmission. On the contrary, the lower scanning speed ,the longer laser beam irradiation time , the biger the heat output , the better density of sintering. But too lower scaning speed will make surface temperature of the metal powder too high, also can make the parts, exposured under the stronger heat, warping seriously. As a result, influence forming quality is influenced seriously. The results show that when the scanning speed is 15 mm/sec, energy is higher, volume is smaller, parts are denser. When the scanning speed is adjusted to 17 mm/s, the forming quality is better, and when more than 21 mm/sec, the energy is too low, the volume of parts get wider, and precision of parts get falling.

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