Experimental Research on Fabrication of Iron Based Alloy and Nano-Al_2O_3 powder parts by Laser Sintering

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Abstract

Experiments on selective laser sintering of Iron Based Alloy and nano-Al_2O_3 Ceramic Bulk Materials are carried out and effect of sintering parameters on t he process is analyzed systematically. A reasonable selective laser sintering technique which can be used to fabricate parts wit h free shape is obtained and verified wit h a multilayer sintering experiment. The component and t he microstructure of t he sintering production is tested. The influences of parameters and the amount of nano-Al_2O_3 on microstructure and microhardness of the sintering parts are studied. Laser sintering iron-based alloy experiments show that: microhardness has been noticeably improved. It is indicated that with the selective laser sintering technique obtained above, nano-alumina can be processed to manufacture three-dimension parts with free shape. With the addition of Al_2O_3 and the increase of composite parts of the grain gradually thinning, microhardness gradually improved nanocomposite parts for the microstructure of the dendrite skeleton-shaped crystal and the plane together, the internal Al_2O_3 dispersion organizations to strengthen the implicit crystal martensite and ferrite mixed organizations.

Introduction

Rapid Prototyping (RP) can be defined as a group of techniques used to quickly fabricate a scale model of a part or assembly using three-dimensional computer aided design (CAD) data. Rapid Prototyping has also been referred to as solid free-form manufacturing; computer automated manufacturing, and layered manufacturing. RP has obvious use as a vehicle for visualization. In addition, RP models can be used for testing, such as when an airfoil shape is put into a wind tunnel. RP models can be used to create male models for tooling, such as silicone rubber molds and investment casts. In some cases, the RP part can be the final part, but typically the RP material is not strong or accurate enough. However, most of the commercially available materials such as photo-polymers, powders, paper, wax, plastic materials, and even rubber, are only for the application of concept models, visual prototypes, and limited functional prototypes. The physical properties of these materials are not suitable for functional prototypes or tooling applications[1-3]. Amongst these materials, only powder sintering has great potential applicability for functional prototypes and it even has potential applicability for direct tooling fabrication. Hence, several researchers have concentrated on the development of the direct laser sintering of metals [4-,6], alumina with polymer binders [7], and metal with polymer binders or with low-melting point components[8,9]. LENS (laser-engineered net-shaping) is the only current commercial direct metal fabrication system .Jet technology is another important process for RP systems. By using a nozzle to squeeze low-melting point alloys or a powder binder mixture, metallic or ceramic parts can possibly be fabricated for the application of functional prototypes or tooling.

The objective of laser cladding is to fuse an alloy onto the surface of a substrate with minimum dilution of the substrate. Areas are usually clad by overlapping single clad tracks [12]. Laser cladding was originally developed for surface treatment to modify surface wear or corrosion properties. A new material was clad on the substrate with metallurgical bonding and low dilution [13]. Usually, only one layer was fused on the substrate in the conventional laser cladding processes. In fact, laser cladding can be considered as one type of material ingress manufacturing technology, if multiple layers and any designed pattern cladding are possible. A theoretical investigation of the influence of the process parameters on laser cladding's geometrical properties was conducted using thermal modeling and computer simulation. High power laser diodes were coupled with fiber optics to fabricate solid freeform parts from metal powder.

For the hybrid processes presented in this paper, metal powder was directly delivered into the laser generated melted pool rather than sintered on the powder bed, and the surface or the edge of the clad mold is further machined to achieve the expected accuracy by milling. Hence, the layer manufacturing technology is employed to build up the material of the part.

1. Experimental Procedure

The design and construction of the hybrid processes of SLC and milling is shown in Fig. 1.

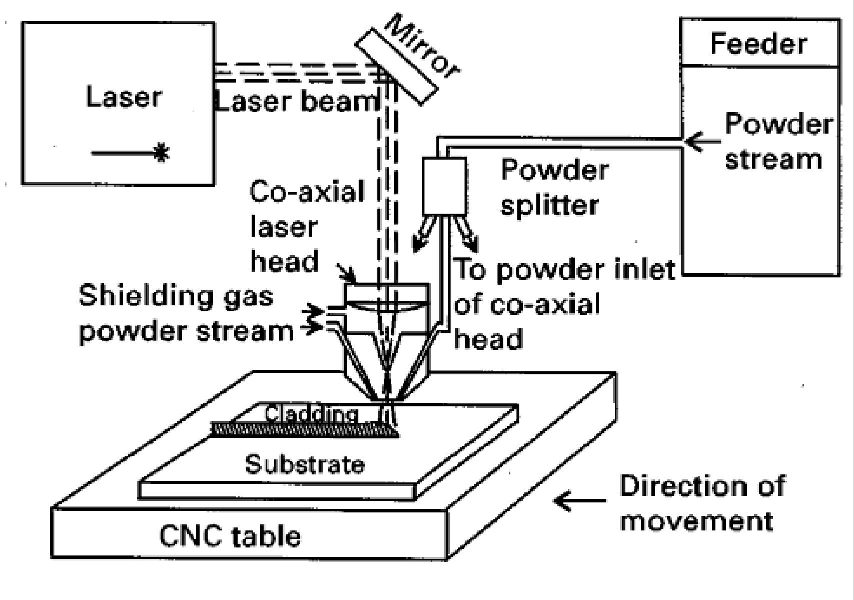


Fig. 1 CO_2 laser cladding schematic drawing

A 3000W CO_2 laser was employed in the SLC system as the power resource for the laser cladding process. A four axial PC-based controller was used to position the work piece XY table, laser focused lens, and milling head. The focused lens and milling head were moved up layer-by-layer.

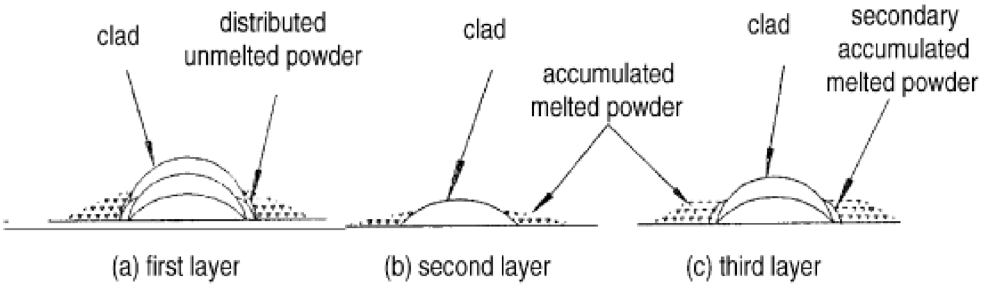


Fig 2 Layer cladding

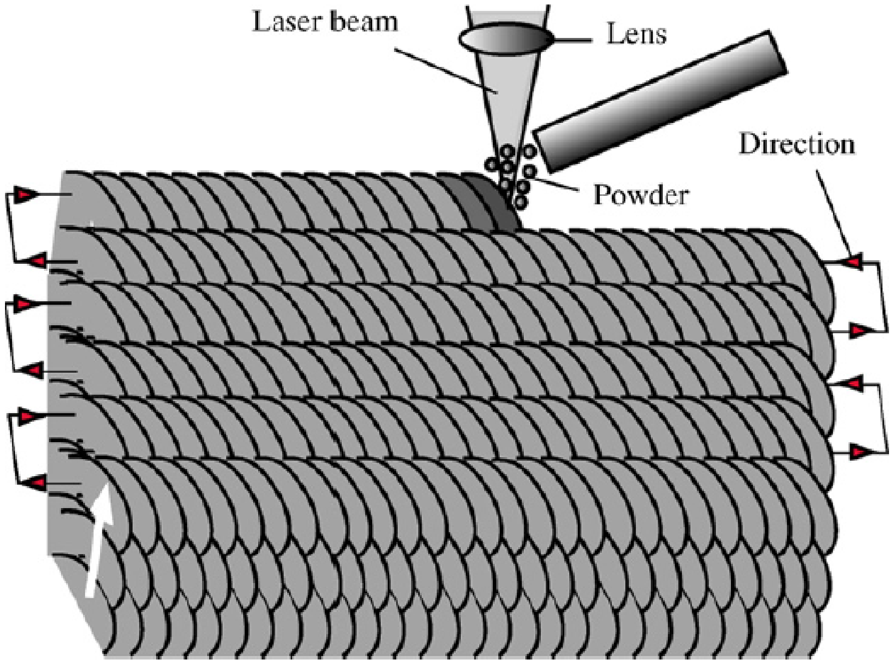


Fig 3 Scan Path of SLC

Nano-Al_2O_3 and iron powder were used in this test. Beside of the diamond, Al_2O_3 has a highest hardness. Nano-Al_2O_3 reinforcement ceramic or rubber is several times higher than conventionalAl_2O_3 particles, in particularly, to improve the density of ceramics, finish, cold and heat fatigue, fracture toughness is particularly significant. This study used the nano-particle size for alumina 50 ~ 180 nm, purity ≥ 99.99%, specific surface area of 14±5m2 /g, phase α, α- Al_2O_3 has some special properties, such as stability, high hardness, stability size. Table 1, 2 shows the experimental parameters.

Table 1 The composition of powder (WT%)

Fe	Nano-Al_2O_3	Ni	Cr	B	Si	C	Mo
85.5	1.5	3	2	1	1	0.3	5.7

Table 2 Laser processing parameters

Laser Power (kW)	Scanning Speed (mm/min)	Beam Diameter (mm)
1.6	350—600	4
3.0	350—600	4

In order to reduce the building time of the part, the layer thickness of the fabrication parameters was set at 0.5 mm, and then the layer profile of the cladding path was calculated according to the design of the part. The layer profile of the cladding path is presented in Fig. 4. As shown in this figure. Fig.5 shows the fabricated part

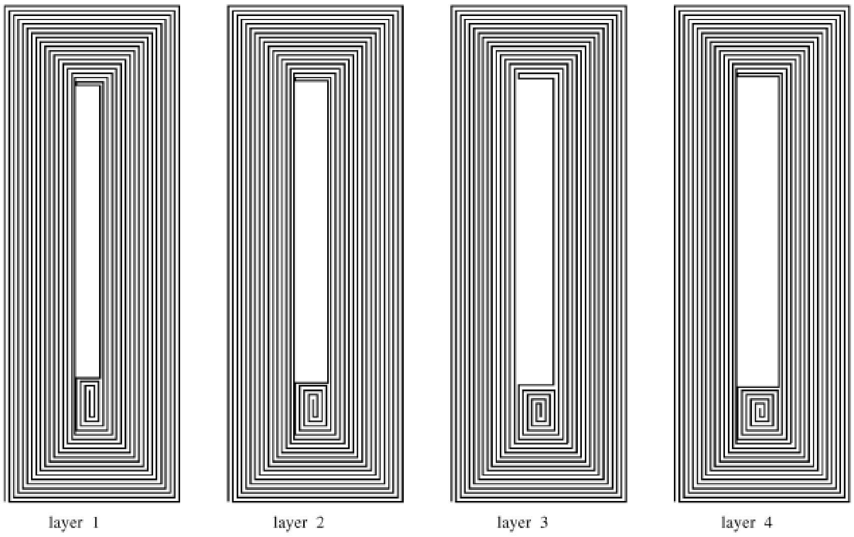


Fig. 4 Layer profile of the cladding path for the part.

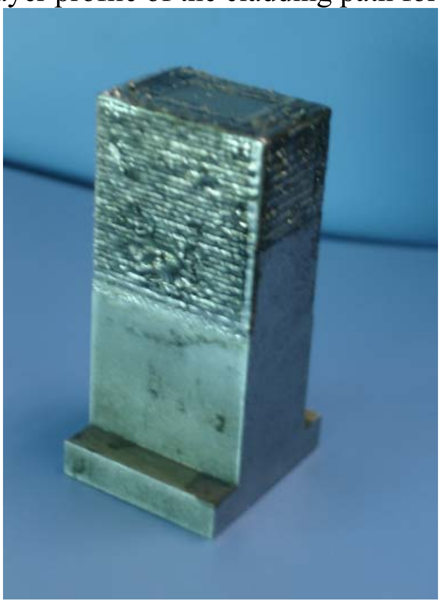
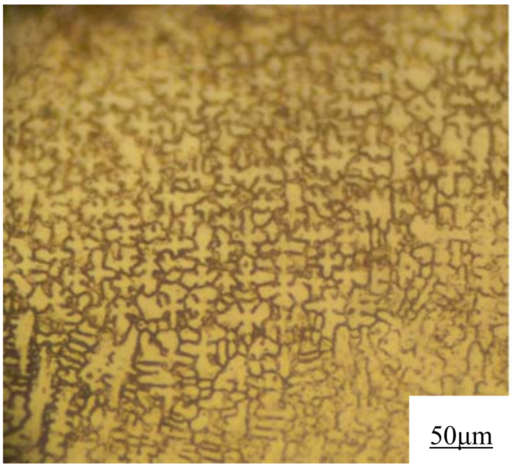


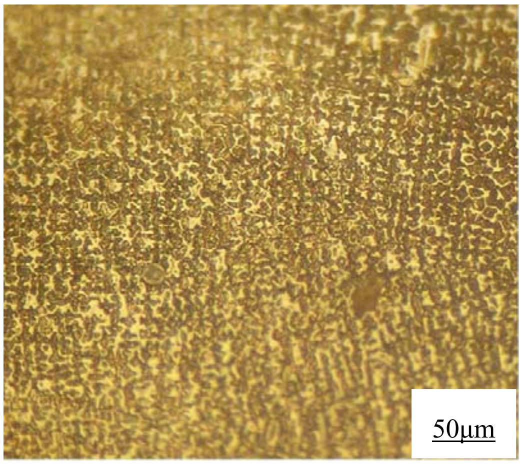
Fig 5 Fabricated Parts

2 Microstructure of Part

The central part of the cladding layer microstructure with 3.0 kW laser power, different scanning speed and Al_2O_3 content are shown in Fig.6. Fig.6 shows the morphology of cladding layer in different Al_2O_3 content. The equiaxed grains with 0.5% Al_2O_3 (in fig. 3a) are coarse. The grains size of cladding decrease with the increasing of the content of Al_2O_3. Figure 6a is the equiaxed, Figure6b is the dendrite, the microstructure of the sample in the erosion of corrosion is very clearly, and Figure 6c is the combination of dendrite and cell-like crystals.



(a)



(b)

(c)

Fig.6 the morphology of indifferent Al_2O_3 content
(a) 0.5% Al_2O_3 (b) 1.0% Al_2O_3 (c) 1.5%Al_2O_3

Fig 7 is the SEM photo of nano composite coating of 1.5 percent Al_2O_3; The experimental results show that the grain size is very fine: the primary dendrite spacing is 3 um, the secondary dendrite arm spacing is 6 um. the grain size of alloy is apparently refined. Nano-Al_2O_3 distributed in the dendrite arm stem and dendrites, while nano-Al_2O_3 in part has certain level aggregate phenomenon.

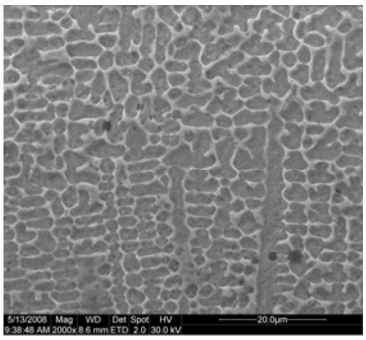


Fig.7 SEM photo

Fig.8 shows the micro hardness of part. From Fig, the average micro hardness of cladding layer is Hv700, laser cladding processing effective enhance the hardness of the matrix.

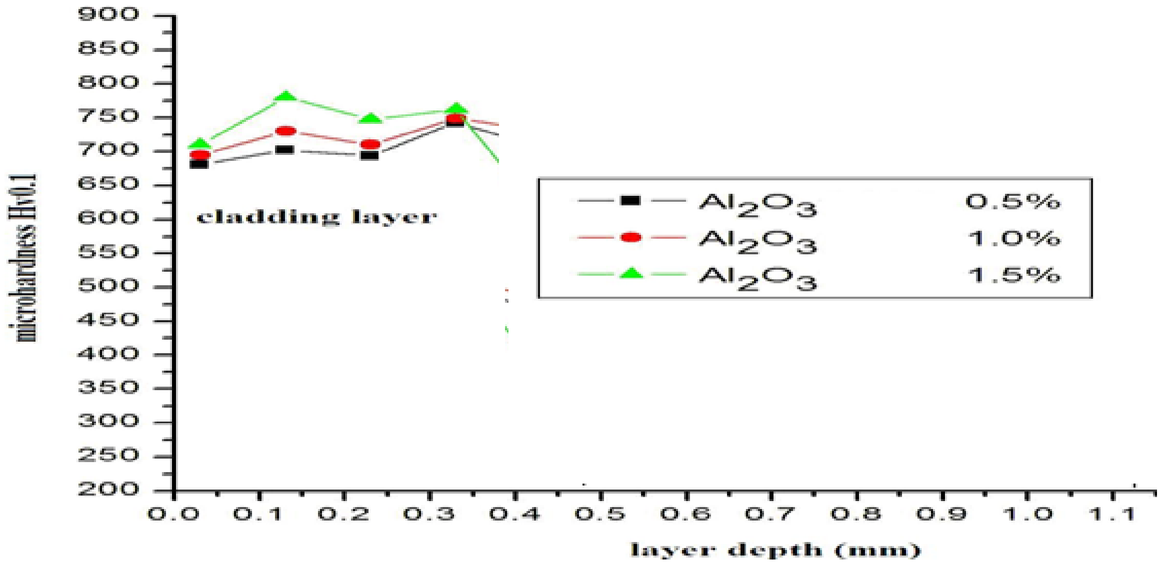


Fig. 8 micro hardness of cladding layer

CONCLUSIONS

Use layer laser sintering processing, A nano component part was obtained by high power laser. And the hardness of part is increased.

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