

WEAR-RESISTANT AND CORROSION-RESISTANT IRON-BASED ALLOY POWDER FOR LASER CLADDING AND LASER CLADDING LAYER THEREOF

FIELD

- 5 **【0001】** The present disclosure relates to the field of metal materials, and specifically relates to a wear-resistant and corrosion-resistant iron-based alloy powder for laser cladding and a laser cladding layer thereof.

BACKGROUND

- 10 **【0002】** Laser cladding technology is a surface strengthening process technology, which refers to the addition of selected cladding materials on the surface of the substrate through different filler methods, and the high-power density laser beam is used to fuse the very thin layer on the surface of the substrate at the same time, and quickly solidify to form a surface cladding layer with dense structure, extremely low dilution, and metallurgical bonding with the substrate, thereby significantly improving the wear resistance, corrosion resistance, heat
15 resistance, oxidation resistance and other characteristics of the base layer surface, and the application range is very wide. Laser cladding stainless steel materials can endow substrates with good corrosion resistance; it is a common process method to replace hard chromium electroplating. Compared with electroplating, it has the characteristics of green and clean, high strength and long life.

- 20 **【0003】** The conventional high Cr stainless steel cladding layer has a low content of C element and less hard strengthening phases in the structure of the cladding layer, resulting in the hardness of the cladding layer is generally less than HRC55, and the wear resistance is not high. Increasing the C content will cause a large amount of Cr₂₃C₆ to precipitate at the grain boundaries. On the one hand, it dilutes the Cr content in the structure and reduces the
25 corrosion resistance and intergranular corrosion resistance of the cladding layer. On the other hand, the accumulation of brittle Cr₂₃C₆ at the grain boundary increases the risk of intergranular cracking and reduces the strength of the cladding layer.

- 30 **【0004】** With the increasing requirements for cladding efficiency and the urgent need to reduce the use cost, there is an urgent need to develop high-strength wear-resistant and corrosion-resistant iron-based alloy materials.

SUMMARY

(1) Technical problems to be solved

【0005】 The present disclosure provides a high-strength wear-resistant and corrosion-resistant iron-based alloy powder. The cladding layer formed by the iron-based alloy powder has good wear-resistant and corrosion-resistant properties, high strength and toughness, and excellent welding performance. The prepared cladding layer is dense and crack-free, and can overcome the chilling cracking problem caused by high cladding rate.

(2) Technical solutions

【0006】 The present disclosure provides a wear-resistant and corrosion-resistant iron-based alloy powder for laser cladding, comprising the following components in mass percentages: C: 2.5-3.0%, Cr: 29-31%, Ni: 8.3- 8.5%, V: 7.5-8%, Ti: 1.6-1.8%, Fe balance.

【0007】 Further optionally, the sphericity of the iron-based alloy powder is greater than or equal to 90%, the particle size distribution is 15-65 μ m, and the fluidity is 32-41s/100g. Good fluidity and suitable powder particle size range can ensure the quality and stability of the cladding layer. On the one hand, fine powders with a particle size distribution of less than 15 μ m will agglomerate, and the smaller the sphericity of the powder, the easier the fine powder will agglomerate. The two work together, resulting in poor fluidity and prone to powder blocking during the cladding process, which affects the process stability. On the other hand, under high cladding rate, the laser action time is short, the molten pool solidifies quickly, and the energy transferred to the powder per unit time is relatively small. The powder with a particle size distribution greater than 65 μ m cannot obtain enough energy to completely melt, and then remain in the cladding layer, forming cracks, pores and other unfused defects.

【0008】 In the above solution, optionally, the content of the C element is 2.5-3.0%. C in the eutectic composition range inhibits the formation of ferrite in the cladding layer, and avoids the loss of Cr, V, Ti alloying elements caused by ferrite formation, and ensures that as much austenite is converted into martensite in the cladding layer during the chilling process; at the same time, the chromium carbide, vanadium carbide, and titanium carbide in the alloy can refine the particles and effectively improve the strength and hardness of the cladding layer. But the content of C needs to be matched with the content of V and Ti elements, to ensure that as much C can be combined with V and Ti, and to avoid combining with Cr to precipitate

Cr₂₃C₆ at the grain boundary, to damage the corrosion resistance and cracking resistance of the cladding layer. Too high C content requires more V and Ti content to match, resulting in waste of resources and increased costs.

【0009】 In the above solution, optionally, the content of the Cr element is 29-31%. High Cr content can increase the corrosion electrode potential of the cladding layer, prevent the occurrence of corrosion, and improve the corrosion resistance; at the same time, high Cr content can reduce the dilution effect of the C element and avoid the deterioration of corrosion performance. But as a ferrite forming element, too high Cr content will promote the formation of ferrite in the cladding layer, which will lead to the loss of Cr, V, Ti alloy elements.

【0010】 In the above solution, optionally, the content of the Ni element is 8.3 to 8.5%. On the one hand, the presence of Ni element can improve the wettability and ductility of the cladding layer, and on the other hand can improve the corrosion resistance of the cladding layer.

【0011】 In the above solution, optionally, the content of V is 7.5-8%. V is a strong carbide forming element. Compared with Cr element, V element preferentially combines with C element to form vanadium carbide. On the one hand, it refines the particles and improves the strength and hardness of the cladding layer. On the other hand, the precipitation of Cr₂₃C₆ at the grain boundary is reduced, thereby improving the pitting resistance and intergranular cracking resistance of the cladding layer. Within the preferred C and V content ranges, the vanadium carbide of the eutectic component can be uniformly distributed in the cladding layer structure, which improves the overall strength and hardness of the cladding layer.

【0012】 In the above solution, optionally, the content of Ti is 1.6-1.8%. Ti element is an extremely strong carbide forming element. Compared with V and Cr elements, Ti element preferentially combines with C element to form titanium carbide, reducing or avoiding the precipitation of harmful Cr₂₃C₆, thereby improving the strength and corrosion resistance of the cladding layer. If it exceeds the preferred range, excess Ti element will combine with Ni element to form Ni₃Ti and precipitate along the grain boundaries, resulting in a sharp decline in the toughness of the cladding layer.

【0013】 In the above solution, the cladding layer formed by the iron-based alloy powder has good wear resistance and corrosion resistance, and at the same time has high strength and

toughness, excellent welding performance, and the prepared cladding layer is dense and crack-free, and can overcome the chilling cracking problem caused by high cladding rate.

(3) Beneficial effects

【0014】 Compared with the prior art, the present disclosure has the following beneficial effects: (1) The cladding layer formed by the iron-based alloy powder of the present disclosure has good wear resistance and corrosion resistance, and at the same time has high strength and toughness, excellent welding performance, and the prepared cladding layer is dense and crack-free, and can overcome the chilling cracking problem caused by high cladding rate.

【0015】 (2) The hardness of the cladding layer formed by the iron-based alloy powder of the present disclosure is 61HRC~63HRC, according to GB/T6461-2002 "The rating of samples and test pieces of metal and other inorganic coatings on metal substrates after corrosion tests", the corrosion resistance of the neutral salt spray test cladding layer reaches the level of 9 and has good wear and corrosion resistance.

【0016】 (3) The cladding layer formed by the iron-based alloy powder of the present disclosure has good strength and toughness, excellent cladding performance, and the yield strength of the cladding layer reaches 1700~1900MPa.

DETAILED DESCRIPTION OF THE INVENTION

【0017】 The present disclosure provides a wear-resistant and corrosion-resistant iron-based alloy powder for laser cladding. Before laser cladding, it is necessary to configure and prepare raw materials and powders according to the design composition, and the preparation method of the powder raw materials can use water atomization, gas atomization or mechanical ball milling alloying method, etc., these powder preparation methods and techniques are familiar to professionals, and will not be repeated here. The technical solution of the present disclosure is further detailed below through examples, but the scope of protection of the present disclosure is not limited to the content.

【0018】 According to the powder composition of Examples 1 and 2 and Comparative Examples 1 and 2 shown in Table 1, the following laser cladding process and steps were used to cladding the iron-based alloy cladding layer on the 9Cr2Mo shaft of $\phi 110\text{mm} \times 1200\text{mm}$.

【0019】 (1) Screening and purifying iron-based alloy powder.

【0020】 (2) Grinding is used to remove oxide layer and oil on the surface of the shaft workpiece, and the cladding area of the workpiece is 0.414m².

【0021】 (3) The cladding layer is prepared by using laser cladding on the surface of the workpiece in step (2). The laser used is a semiconductor laser. The process parameters are:
5 laser power 2100W, spot diameter 1mm, scanning line speed 55m/min, powder feeding rate 35g/min.

【0022】 (4) The workpiece obtained in step (3) is finalized on the five-axis CNC machine tool according to the part drawing.

【0023】 Statistical and performance tests were performed on the workpieces cladding by
10 the method described in the present disclosure, and the results are shown in Table 1. The powder composition of Example 1 and Example 2 are both within the preferred range, and the cladding layer obtained at a scanning line speed of 55 m/min has excellent performance, and has good hardness and yield strength. However, the powder composition of Comparative
15 Example 1 and Comparative Example 2 is not within the preferred range, and the cladding layer obtained in Comparative Example 1 has low hardness and poor wear resistance at a scanning line speed of 55 m/min. However, the yield strength of the cladding layer obtained in Comparative Example 2 was low, and the cladding layer cracked at high linear speeds, and both of them did not meet the requirements for use. The powder composition of Comparative
20 Example 3 and Comparative Example 4 is the same as that of Example 1, but the sphericity, particle size distribution, and fluidity are not within the preferred ranges. The sphericity of Comparative Example 3 is low, and there are more fine powders below 15μm, resulting in poor fluidity and the phenomenon of powder blocking during the cladding process is serious, and stable cladding cannot be achieved. In Comparative Example 4, there are many coarse
25 powders with a particle size of 65μm or more. Although the hardness of the cladding layer reaches the same level as that of Example 1, due to the existence of a large number of unmelted particles, the cladding layer has unfused defects such as pores at high cladding linear speeds, and neither of them meets the requirements for use.

【0024】 Table 1 shows the components, sphericity, particle size distribution and fluidity of the specific examples and comparative examples.

serial number	C%	Cr%	Ni%	V%	Ti%	sphericity	particle size distribution	D50	fluidity
example 1	2.9	30.2	8.1	7.2	1.8	91%	15~64μm	33μm	34s/100g
example 2	2.6	29	8.3	8.2	1.6	92%	15~62μm	32μm	33s/100g
comparative example 1	2.1	26	7.5	5.4	1.3	91%	15~65μm	34μm	36s/100g
comparative example 2	3.3	34	11.2	10	2.2	90%	15~64μm	32μm	32s/100g
comparative example 3	2.9	30.2	8.1	7.2	1.8	87%	10~53μm	24μm	56s/100g
comparative example 4	2.9	30.2	8.1	7.2	1.8	91%	15~88μm	41μm	31s/100g

【0025】 Table 2 shows the performance of the cladding layer and the quality of the cladding layer in specific examples and comparative examples.

serial number	cladding layer hardness (HRC)	yield strength (MPa)	cladding layer quality
example 1	62.5	1773	not cracked
example 2	61.4	1821	not cracked
comparative example 1	56	1725	not cracked
comparative example 2	64	1461	cracking
comparative example 3	—	—	blocking powder
comparative example 4	62.5	1710	large amounts of unmelted and defects

【0026】 The above are only preferred specific implementations of the present disclosure, but the scope of protection of the present disclosure is not limited to this. Any changes or substitutions that can be easily conceived by those skilled in the art within the scope of the technology disclosed in the present disclosure shall be covered by the scope of protection of the present disclosure. Therefore, the scope of protection of the present disclosure should be subject to the scope of the protection of the claims.

CLAIMS

1. A wear-resistant and corrosion-resistant iron-based alloy powder for laser cladding,
comprising the following components in mass percentages: C: 2.5-3.0%, Cr: 29-31%, Ni:
5 8.3- 8.5%, V: 7.5-8%, Ti: 1.6-1.8%, Fe balance, the total mass of each component is 100%.

2. The iron-based alloy powder according to claim 1, wherein
a sphericity of the iron-based alloy powder is greater than or equal to 90%, a particle size
distribution is 15-65 μ m, and a fluidity is 32-41s/100g.
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3. The iron-based alloy powder according to claim 1, wherein
a content of the iron-based alloy powder C is 2.5-3.0%.

4. The iron-based alloy powder according to claim 1, wherein
15 a content of the iron-based alloy powder Cr is 29-31%.

5. The iron-based alloy powder according to claim 1, wherein
a content of the iron-based alloy powder Ni is 8.3-8.5%.

20 6. The iron-based alloy powder according to claim 1, wherein
a content of the iron-based alloy powder V is 7.5~8%.

7. The iron-based alloy powder according to claim 1, wherein
a content of the iron-based alloy powder Ti is 1.6~1.8%.
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8. A wear-resistant and corrosion-resistant laser cladding layer, prepared by using any one of the iron-based alloy powders of claims 1-7, and comprising:

(1) screening and purifying the iron-based alloy powder, a sphericity of the iron-based alloy powder is greater than or equal to 90%, a particle size distribution is 15-65 μ m,

and a fluidity is 32-41s/100g;

(2) grinding used to remove oxide layer and oil on a surface of shaft workpiece, and a cladding area of the workpiece is 0.414m²;

(3) laser cladding used to prepare the cladding layer on the surface of the workpiece

in step (2), the laser used is a semiconductor laser, process parameters are: laser

power 2100W, spot diameter 1mm, scanning line speed 55m/min, powder feeding rate 35g/min; and

(4) performing final finishing on the workpiece obtained in step (3) on a five-axis CNC machine tool according to a part drawing, to obtain a wear-resistant and corrosion-resistant laser cladding layer.

9. The laser cladding layer according to claim 8, wherein

the laser cladding layer has a corrosion resistance up to level 9 of the national standard

(GB/T6461-2002), a hardness of 61HRC $\sim$ 63HRC, and a yield strength of 1700 $\sim$ 1900MPa.