RESEARCH ARTICLE

DESIGN A TECHNICAL PROCESS OF THERMAL SPRAY APPLIED TO THE CRANKSHAFT REHABILITATION OF SHIP

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ARTICLE DETAILS

ABSTRACT

The metal spraying was discovered very early. The important uses of this method are the processing and restoration of damaged machinery-parts that are corrosion or incorrect. Material which only needs a small amount compared to the whole of new parts that must be reproduced, used in the restoration. In some cases, restoration of the machinery-parts will have quality and the long-life higher than the new parts. This report presents a study that is about the design of combust-spaying and the heat treatment process.

KEYWORDS

metal spraying, heat treatment, crankshaft rehabilitation, ship

1. INTRODUCTION

The metal spraying technology is invented from the early 20th century by Max Ulrich who is an engineer of the Swiss. The principles of this technology are used heat-source (arc, combust-gas, plasma) which is melt metal. Then, the liquid-metal is blown by compressed gas to disperse the particles (mist) which are very small, hit on the surface-parts which is prepared. The creating a metal-coating has the required thickness [1]. So far, metal spraying has become a field of science and technology as like a technology of handling surface. Another way, it is like new technology in manufacturing [2,3]. The metal spraying technology is also used in many fields for various purposes such as anti-rust protection, anti-corrosion in atmospheric environment, soil and water environment; creates a conductive layer on a non-conductive surface, used for decoration of technical works; Restoration of worn machinery-parts; Repair defects for castings or defects occurring during mechanical processing, save precious metals.

Currently, in general, the metal spraying technology and methods of gas-spraying is still new compared to other technologies, but it has been widely applied in many industries [4-8]. Especially, in mechanical engineering, transportation, oil, air...and has become an indispensable technology in the process of restoring worn parts [9]. The spraying of the high-speed gas heaters (HVOF) is the preferred method for coating with low porosity and high adhesion. In the process of spraying high-speed gas HVOF, fuel and oxygen are taken into the combustion chamber along with powder spray which generates high temperature and pressure in the chamber through the nozzles that create an ultrasonic flow of gas. Flame temperatures range from 2500°C to 3100°C, depending on the fuel, gas/oxygen ratio and gas pressure and depend on the design of the spray gun structure of the high-speed gas injection system HVOF [10].

Because of its advantages over other methods which have adhesion and porosity, the high-speed gas heater spraying technology is constantly being developed and expanded in scale; Improvement in coating quality has been widely applied in many industries. The report presents the method
Preparation of the base surface must select the appropriate method to ensure the required adhesion of the coating. The nature of the undulation will be different in each case of preparation. Cleaning methods consist of: Use organic solvents and solutions which contain components; Clean by electrolysis; Soak the metal.

Making roughness on the surface is an important process. This process ensures the durability and adhesion of the coated metal which has a covered surface. The parts after roughing and rinsing should be sprayed immediately, as soon as possible, if the time is too long, the surface will be oxidized, affects the spray quality. This time should not exceed 1-2 hours [15-18]. For parts which is rounded shape, They are clamped on the lathe, and the nozzle is mounted on the knife. At that time, the spinning parts and the spray gun move along the shaft to create a uniform spray adhesion of the spray and part is best achieved if a sufficient spraying time is required. If the thickness is large, we have to spray in many turns. At this time there will be a small layer of dust in the spraying-layers, which will reduce adhesion [19-22]. During the process of spraying, it is necessary to keep the temperature of the components hotter than 70-80°C because if the temperature is too high will change the microstructure of the parts and reduce the hardness of the spray. When spraying parts with sudden transitions such as axes, it should be sprayed this position from 45 to 75 degrees. After spraying a thickness of about 1/3 - 1/2 of the spraying thickness, it starts to other stages.

3. Calculation of spray process

3.1 Material

3.2 With the spray-powder tested the main parameters such as grain level, shape, flow. The shape is examined by a microscope, flow-rate is determined by the standard.

<table>
<thead>
<tr>
<th>Chemical composition</th>
<th>Ni</th>
<th>Cr</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>% mass, max.</td>
<td>75-68</td>
<td>22-23</td>
<td>+ 0.15</td>
</tr>
</tbody>
</table>

Spray-powder must be prepared in advance. The preparation of spray-coating powder consists of steps: powder drying and grading. Normally sprayed metal powder is dried at 120-150°C for 1-3 hours. For ceramic powder, the drying temperature is higher than 700-800°C and the drying time is 4-5 hours. Particle grading of spray powders often uses sieve wire with size less than 100 mm.

3.3 Compressed air pressure

The compressed air pressure required to blow the droplets into a small beam and maintain the arc's stability and the flight of the metal particles to the surface of the parts. Atmospheric pressure also provides for the energy metal-particle necessary to deform violently on the surface of the particle to adhere to it. Air pressure also affects the wear resistance of the coating, to the loss of spraying-metal.

3.4 The rotation speed of parts and amount of spray head movement

For circular surfaces, the rotational speed of the part and velocity of the coating gun-head to create a steady spray., It also doesn’t cause overheating on the surface. With different sizes so moving mode in table 2.

<table>
<thead>
<tr>
<th>Diameter [mm]</th>
<th>Number of revolutions of parts [rpm]</th>
<th>Movement speed of spray gun [mm/r]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 30</td>
<td>160</td>
<td>2.5</td>
</tr>
<tr>
<td>31 - 60</td>
<td>80</td>
<td>1.7</td>
</tr>
<tr>
<td>61 - 100</td>
<td>60</td>
<td>1.7</td>
</tr>
<tr>
<td>101 - 200</td>
<td>30</td>
<td>1.2</td>
</tr>
<tr>
<td>201 - 300</td>
<td>15</td>
<td>1.2</td>
</tr>
<tr>
<td>301 - 400</td>
<td>10</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Moreover, this rate is proportional to the current intensity when spraying.
the wire. This speed must be such that the spraying wire is pushed to the spray gun head. For gas nozzles with acetylene and oxygen, the appropriate flame type should be chosen because the gas flame affects the quality of the coating. Medium flame: \( \text{O}_2/\text{C}_2\text{H}_2 = 1.1 - 1.2 \) is used for metal spraying.

### 3.5 Spray Technique

The metal injection can be done by hand or machine. But when spraying, it is necessary to pay attention to the factors that affect the spraying process and the spraying requirements. To achieve steadily coating thickness. The surface can be divided into several parts and spraying is so convenient for tracking. For flat surfaces, we often spray from the outside and gradually into the inside. Round surfaces (outside or inside) are usually sprayed on the lathe. The metal-coated object will rotate to ensure even coverage. Depends on the required thickness of the coating. Spraying can be carried out one time. The rotational speed of the part ensures that the surface speed of the base surface for spraying is about 6 to 20 rpm to ensure the coating thickness, but it can also be sprayed in multiple layers. It depends on the level of heating the coating and the cooling capacity needed for them, but it is best to cover once.

As analyzed above, the large shrinkage of the spraying metal will lead to the appearance of dangerous cracks in the coating. Especially when coated with low carbon steel. Preliminary heating or heating of the surface before spraying is a measure to reduce the relative shrinkage between the spraying-metal and the preheating before spraying metal. It is usually carried out in furnaces or flames for heating. Sometimes use other specialized equipment. Preheating temperature in the range of 100, but some things to note is that after the pre-heating usually occurs the oxidation of the coating surface, so after the heating need to clean by ball spray. When spraying metal onto the surface of the part, It is often necessary to protect the overlapping parts such as lace, screw, For axial surfaces with keyway. When restoring the surface with a metal spray, it is also necessary to protect the keyway to avoid damaging the surface. The fastest method is to coat with plastic, paint on the place to protect. When preparing the axial surfaces and keyway, soft or hardwood overlaid is used.

### 4. Result and Discussion

With the coating's anti-wear properties combined with the superiority of spray coating technology; Ni-Cr coatings are increasingly used in the manufacture and restoration of machine parts. The application of the spray applied to real life which helps improve the life of the product.
4.1 Hardness

Through hardness analysis we recognize: The coating hardness value before heat treatment is low. This low value is explained by the fact that the alloying phase of Fe with Cr and Ni as well as the carbides of this layer have not yet been achieved so that the hardness value is low.

Figure 6: Sample hardness value after heat treatment

The sample has a relatively uniform distribution of the mantle; bonding layer and metal background. Moreover, by using microhardness measurement method as well as the microstructure observation, there is the emergence of the intermetallic phases. This process has created a good adhesion after diffusion; Inside the microstructure receives the metallic bonding phases of Fe; Cr and Ni. This improves the durability and abrasion resistance of the parts.

4.2 Adhesion of coat spraying

Analysis of adhesion levels shows that pre-heat treated samples have the adhesion higher than non-heat-treated samples. The degree of adhesion reduction is due to the heat treatment due to the very thin coating which has been oxidized to the degree of bonding to the very strong substrate so that the adhesion decreases rapidly.

Table 3: The result of adhesion

<table>
<thead>
<tr>
<th>Sample</th>
<th>Before heat treatment, MPa</th>
<th>After heat treatment, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample M1</td>
<td>15.42</td>
<td>8.38</td>
</tr>
<tr>
<td>Sample M2</td>
<td>24.26</td>
<td>25.94</td>
</tr>
<tr>
<td>Sample M3</td>
<td>25.08</td>
<td>25.98</td>
</tr>
<tr>
<td>Complete sample</td>
<td>26.61</td>
<td>28.98</td>
</tr>
</tbody>
</table>

Thus, with the post-spray treatment method, the coating will create a complete layer to increase the ability to work for parts. This result accurately reflects the organization of the sample that has been diffused to form a complete coating that increases adhesion on the part. So that, regarding the mechanics and microstructure of the prior sample, after heat treatment there is the microstructure and mechanical correlation of the part.

4.3 Analyze the wear of samples before and after heat treatment

As a result of the analysis of the wear intensity, the same abrasion test pattern before the heat treatment of the average wear intensity is much greater than the sample after heat treatment. This is explained due to the low level of adhesion between the coating and the base metal before heat treatment; the coating easily removes the rapid wear and tear (after the shear coating test). When the heat treatment has made the element diffusion from the mantle into the floor creates a strong bond between the base metal and the mantle, significantly improving the anti-wear quality.

Table 4: The value of wear intensity

<table>
<thead>
<tr>
<th></th>
<th>Wear intensity (kg/N.m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before heat treatment</td>
<td>5.87.10^6</td>
</tr>
<tr>
<td>After heat treatment</td>
<td>1.89.10^6</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Science and technology for treatment processing machine parts, mechanical structures, works is a strongly developing field. The achievements of surface science and technology contribute to significantly improving the efficiency of use of products both regarding life and reliability. In surface science and technology, spraying technology is a method with many advantages and high applicability. Therefore, the research on spraying technology applied in protecting and restoring machine parts and metal structure is of great significance in both theory and practice. The article clearly stated the technological parameters of the metal spraying process including:

(i) Surface treatment before spraying,
(ii) Method of creating adhesion of the coating,
(iii) Parameters of heat treatment technology: Spray temperature, spray pressure, spray speed, metal grain level when spraying,
(iv) Handling after spraying: diffusion annealing.

REFERENCES


