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Manufacture on marine equipment special repair material—Metalock

Zhelun Shen[1], Yaning Wang[1,a] , Wendong Song[1] ,Lili Ji[1], Lu Cai[1]

[1] Zhejiang Ocean University, Zhoushan, Zhejiang, 316022 China

[a] Corresponding author: wyn198399@126.com

Abstract. As a unique cold repair process,Metalock procedure perfectly solves the problem that cast iron parts are difficult to weld,but it can be welded when the proper procedures are used. The Metalock are the core of this process. However, its preparation technology has always been foreign, that China can only cost high prices from abroad. For the purchase, the wave bond is prepared by the cold pier process, which is mainly divided into four steps of cutting, surface treatment, phosphorus saponification and rolling forming. The subject selected 304 stainless steel with higher hardness, better corrosion resistance and high temperature resistance as the main material, and manufactured Metalock through pressure die and WEDM.

1.Introduction

What is Metalock?The Metalock/Masterlock procedure offers you a unique alternative for repairing castings that can only be welded to a limited extent. It is particularly used in industry and shipping sector.

As it involves a cold process, no thermal stresses result.In no distortion of the component, which can occur in other common repair procedures. And this repair process ensures a high degree of pressure tightness, so that oils and gases can not escape.

In the meanwhile Metalock can carry out repairs on-site while the casting is installed. This does away with disassembly and transport costs for the part needing repair. Further factors that are advantageous for demand-side: This deployment makes system downtimes shorter, while there is no need to procure a new, expensive cast part.

However, the whole maintenance process can not be separated from one thing, that is Metalock. So,the Metalock is the core of the whole technology.

2.Research procedure

2.1 Material selection

The properties of metallic materials are inextricably linked to the content of impurities and the content of C. Many metal alloys contain active elements and are easily reacted with air. Therefore, in order to prevent defects such as pores in the casting process, we generally use vacuum equipment to isolate metal from air contact. Extrusion can effectively improve the mechanical properties of metals, but this process is more complicated, and different parameter settings will have a great impact on the final molding effect. Therefore, it is also a major difficulty to study the characteristics of metals by setting reasonable parameters for different alloys to eliminate the anisotropy and achieve satisfactory results[1].

As far as the preparation of materials is concerned, the following requirements must be met for the Metalock process requirements:

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1).The Metalock procedure riveting process needs to deform the wave bond to fill the entire wave groove, which requires the metal material to have cold work hardening properties. The processing of metal materials at normal temperature or below the crystallization temperature produces strong plastic deformation, which causes the lattice to be distorted and distorted. Such deformation increases the concentration of dislocations which may subsequently form low-angle grain boundaries surrounding sub-grains. it is called cold work hardening, which increases the hardness of the surface layer metal and reduces the plasticity of the surface layer metal deformation. That is, cold work hardening refers to a phenomenon in which the strength index is increased and the plasticity index is lowered when the metal is processed at room temperature. For example, austenitic nickel-chromium steel and low-carbon chromium-manganese silicon steel have good cold work hardening properties[2]. Lightweight alloys do not have this property and cannot be used very well even when processed into wavy bonds.

2). The Metalock also have certain requirements for the strength of metal materials. The strength of the wave button is sufficient to ensure that the repaired machine has sufficient strength and will not easily cause secondary breakage.

3). The material is "soft" and has good ductility and can be rolled and formed by a cold pier process.

4). When repairing cast iron parts working at high temperature, the coefficient of thermal expansion of the material is slightly smaller than the coefficient of thermal expansion of the machine. Nickel-based alloys should be used [3] (Ni36 or Ni42 alloy).

At present, the manufacture materials of the Metalock are mainly selected from 1Cr18Ni9 or 1Cr18Ni9Ti austenitic nickel-chromium steel. The research material selected for this study is 06Cr19Ni10 [4](304 stainless steel). The properties of these three materials are shown in the table below.

Table 1. Performance requirements of 1Cr18Ni9, 1Cr18Ni9Ti and 06Cr19Ni10 materials[5]

	1Cr18Ni9	**1Cr18Ni9Ti**	**06Cr19Ni10**
Tensile Strength（Mpa）	≥520	≥550	≥520
Yield Strength （Mpa）	≥205	≥200	≥205
Hardness	≤187HB ≤90HRB ≤200HV	≤187HB ≤90HRB ≤200HV	≤201HBW ≤92HRB ≤210HV
Elongation（%）	≥40	≥40	≥40
Rate of reduction in area（%）	≥60	≥55	≥60

Table 2. Element contents of 1Cr18Ni9, 1Cr18Ni9Ti and 06Cr19Ni10 materials[6]

Element content(%)	**1Cr18Ni9**	**1Cr18Ni9Ti**	**06Cr19Ni10**
C	≤0.10	≤0.12	≤0.08
Mn	≤2.00	≤2.00	≤2.00
P	≤0.045	≤0.035	≤0.045
S	≤0.030	≤0.030	≤0.030
Si	≤1.00	≤1.00	≤1.00
Cr	17.00 ~ 19.00	17.00 ~ 19.00	18.00 ~ 20.00
Ni	8.00 ~ 10.00	8.00 ~ 10.00	8.00 ~ 10.00
Ti	-	5(C％-0.02) ~ 0.80	-

Stainless steel can meet the requirements of the Metalock manufacture. It can be seen that 304 stainless steel has lower carbon content and therefore has better strength. In addition, it has excellent corrosion resistance and intergranular corrosion resistance. The high temperature resistance is also better than the other two, so it is the object of this study.

2.2 Metalock manufacturing

In the forging of metal, the brittle impurities of the metal are broken, distributed in the form of granules or chains in the direction of metal elongation; plastic impurities are distributed in the direction of elongation along the deformation of the metal, which is the forging flow line of the meta,which is also called flow pattern. With the improvement of the forging process, the distribution of the streamline can also be optimized, and the tensile properties of the metal along the streamline direction are higher, perpendicular to the streamline direction, and the tensile properties are lower. If we can reasonably apply the characteristics of high longitudinal strength of the streamline, we can improve the bearing capacity and corrosion resistance of metal parts[7]. The Metalock is manufactured by a cold forming process (also known as a cold pier process), and the Metalock waveform is rolled because the cut will destroy the metal forging flow line and affect the performance of the part. The cold pier process can not only improve production efficiency, material utilization rate, and save production cost, but also significantly improve the quality of parts, improve strength, and resist fatigue.

The shape of the Metalock is shown in Figure 1.

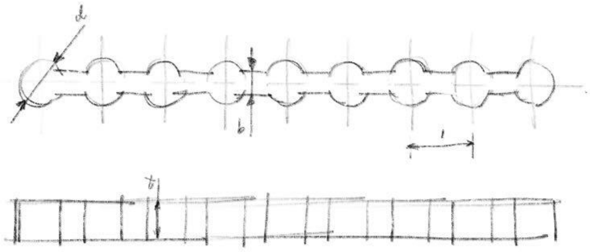

Figure 1. Schematic diagram of Metalock

The main dimensions of the Metalock are neck width b, spacing l, flange d and thickness t. The width of the neck is a basic parameter, and the value ranges from 3 to 6 mm. After determining the value of b, the remaining three dimensions can be determined empirically. In general, d/b=1.4~1.6, l/b=2~2.2, t/b=0.9~1.1, the number of common wave bond flanges is five, seven, nine, eleven and thirteen [8].

There are four main steps in the manufaturing of Metalock:

1). Cutting. The 304 stainless steel was cut into a desired shape with BM800 WEDM at first (20 mm x 5 mm x 6 mm). And then cutting parts were sanded smooth to remove surface impurities and metal debris, eventually cleaned and dried.

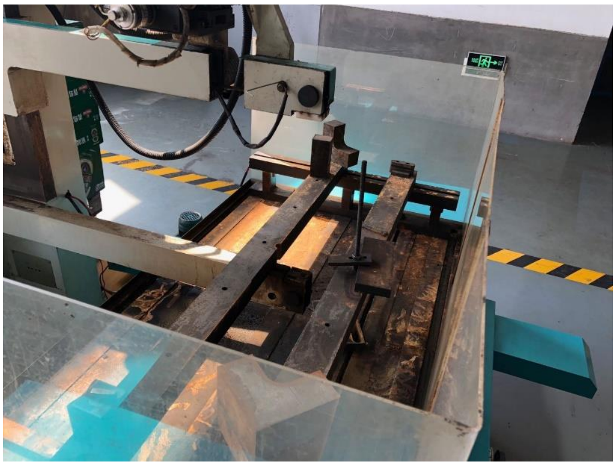

Figure 2. BM800 WEDM

2). Surface treatment. In order to prevent the sticking of the mold, the parts need to be saponified by phosphorus, but the temperature of the cold pier is too high, and the general lubricating film will be damaged. Before that, it is necessary to uniformly coat the metal parts with a layer of copper. As a support surface, reduce friction.

3). Phosphorus saponification. Before rolling, in order to prevent the metal parts from sticking to the mold, it is necessary to coat the surface of the part with a cold forging film, that is, phosphorus saponification (soap powder) to improve the plasticity of the workpiece and facilitate the flow of the metal when it is squeezed.

4). Rolling. The last step, the parts to be processed were placed in a self-made rolling facility and it was formed by pressure rolling at 2.0MPa.

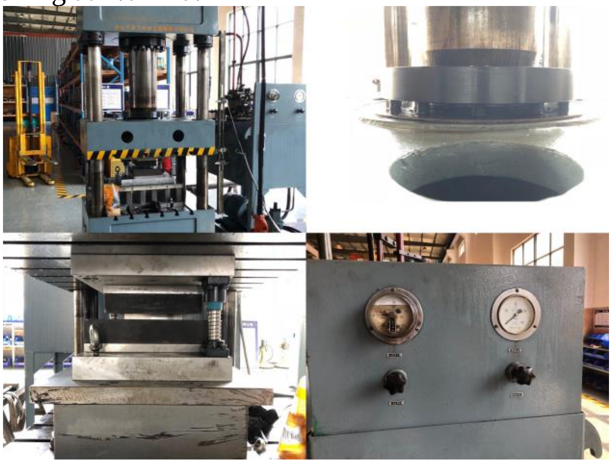

Figure 3. Rolling equipment

According to the requirements of the metal fastening process and the preparation principle of the Metalock, the material of the Metalock needs to have good cold work hardening property, sufficient strength and good ductility, so two kinds of austenitic nickel-chromium steels such as 1Cr18Ni9 and 1Cr18Ni9Ti are commonly used. This research also selected 304 stainless steel with higher hardness, better corrosion resistance and high temperature resistance from the materials satisfying the above conditions.

2.3 Usability tests

Using the Metalock procedure, the hollow broken sphere is repaired by the manufactured Metalock, and test the airtightness is checked by a pressure gauge. Fill the sealed workpiece with a certain pressure of gas, after a period of pressure (2~5 seconds), check whether the pressure drops, observe the calculated pressure change to judge whether the product has leakage (the whole process is 5~25 seconds).

2.4 Microstructure analysis

The initial microstructure of the alloy was characterized using a scanning electron microscope (SEM).

2.5 Metallographic analysis

Since the physical properties of the metal material are determined by the metallographic structure, in order to determine the metallographic structure of the alloy, a metallographic sample is prepared, and then the image is observed by a high-grade metallographic microscope of the Olympus Japan[9].

3.Results and discussion

3.1 Manufacturing results

After many experiments, we finally got the Metalock that meet the requirements of shape and size,as shown in Figure 4. We got the best conditions for making the Metalock: the main dimensions of the Metallock, the neck width is 4mm, the spacing is 7mm, the flange is 6mm, and the thickness is 5.6mm.

Figure 4. Metalock before and after molding

3.2 Pratical operation results

We used the SALT-806 air-leakage test instrument to test the airtightness of the repaired ball. After the test, the calculated pressure did not change, indicating that the sphere has good air tightness.

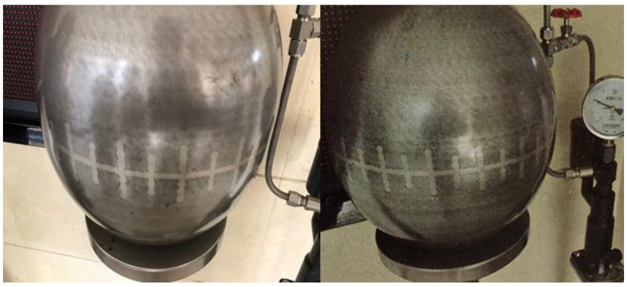

Figure 5. Repaired metal sphere

3.3 Microstructure

Figure.6 shows the surface microstructure of the Metalock at 500 times and 1000 times respectively (the bubble-like part in the figure is caused by corrosion of the corrosive liquid and is independent of the material). As can be seen from the figure, the alloy matrix is austenite, and The thin line marks in the figure are traces of the elongation of the matrix grains in the rolling direction during the casting process, which may be the result of the preferred orientation[10,11].

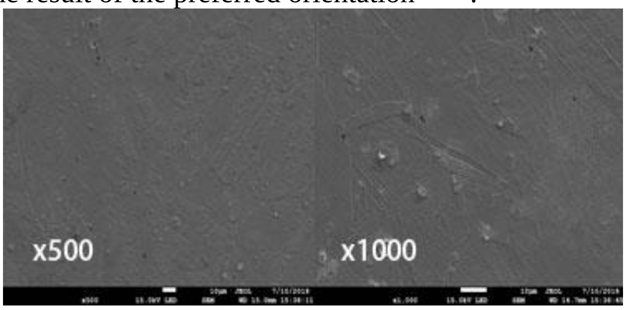

Figure 6. Structure of Metalock samples at different multiples

3.4 Metallographic analysis results

Fig. 7 is a microscopic metallographic diagram of the Metalock.It can be seen from the figure that the alloy matrix is austenite and the metallographic structure is evenly distributed without inclusions.

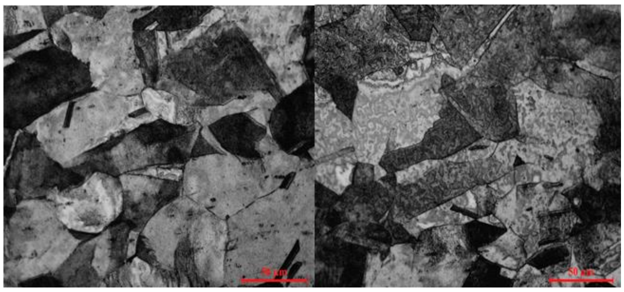

Figure 7. Metallographic micrograph

4.Conclusions

This experiment successfully produced wave bonds using 304 stainless steel. Through the metallographic test and the air tightness test, the wave bond prepared in this study has high practicability and high use value, and fully meets the requirements of the repair operation. If it can be produced on a large scale, the current situation of China's import of wave keys from abroad will be greatly improved, which will save a lot of money and labor costs.

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