The Quality Inspection and Defect Repair for Marine Anchors

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Abstract. Aim at the surface defects found in the quality inspection of marine anchors, structural features of anchors and factors affecting the forming process were analyzed, the typical defects found in the quality inspection of ship anchor were mainly studied, including cracks, blowhole, shrinkage hole, slag, sand casting residual stress and etc., the reasons of various surface defects were analyzed base on an example of stockless anchors, and several aspects of defect repairs focused on are pointed out.

Introduction

A marine anchor is the main part of ship anchoring equipment. A marine anchor is a metal structure on special shape. When working, an anchor is thrown into water, the fluke could hold the bottom of water with great griping force, so as to moor ships or other floating structures on a certain water area through anchor chains. The safety of ships is mainly depended on the griping force when mooring. The feature and quality of anchors are closed related with ship safety[1]. So anchors are also called the 2nd lifesaving appliance. To ensure the quality of marine anchors and prevent the quality defects happening in anchor’s process and lead to the construction cycle of the ship delayed. In this article, the typical defects found in the quality inspection of ship anchor are mainly studied, the reasons of various surface defects are analyzed, and several aspects of defect repairs focused were pointed out.

Structural Features and Process Molding

Structural Features

According to anchor’s different categories, the anchor’s structure characteristic appears different. Different classification method could be lead to different classification results. According whether there is a cross bar, it can be divided into stock anchors and stockless anchors. Similarly, according whether the flukes can turn round, anchors can be divided into fixed fluke anchors and swinging fluke anchors. At present, anchors are commonly classified four categories as stock anchors, stockless anchors, high holding power anchors and special anchors, altogether dozens anchors[2].

![Figure 1. Admiral anchor structural diagram.](image1)

![Figure 2. Hall’ anchor structural diagram.](image2)
Stock Anchors. The stock anchors are also called admiral anchors, as shown in Figure 1. The flukes and anchor stocks are cast a whole, and there is a cross bar perpendicular to the fluke plane. When stock anchors working, a fluke is grasped into the deep bottom with a great gripping force. The structure of stock anchors is simple, great in grip weight ratio, good in stability of gripping bottom, but inconvenient in safekeeping, so it is used in small ships mostly.

Stockless Anchors. Hall’s anchors and Speke’s anchors are most common used stockless anchors, as shown in Figure 2. A Hall’s anchor comprise anchor shackle, anchor stock, fluke, anchor arm and anchor crown. The anchor arm, fluke and anchor crown were cast into one whole.

The anchor stock and anchor arm in one stockless anchor are cast respectively. The fluke, anchor crown and anchor arm are cast into a whole, the anchor stock is inserted into a rectangular hole in anchor crown, so as to turn around for the anchor stock, the fluke could turn 45° along the forth and back of anchor stock. Stockless anchors are widely used as head anchors in inland commercial ships.

Process Molding

The shape of the anchor is special. Nowadays, anchors are mostly made of forged steel or cast steel. Generally, anchors are made by manual sand casting. The quality of foundry goods through mold casting is effected by different factors, such as the structural rationality of foundry goods, the rationality of casting technique, the smell quality of molten steel, the performance of mold sand, including strength, refractoriness and gas permeability, etc., temperature, heat treatment. Any factor mentioned above would produce defects, even be declared worthless. Climate also affects The casting quality is also affected by climate, for example, the defects as blowhole in casting could be generated because the high humidity with more rain in summer.

Marine anchors are mostly produced by order. The carbon content of casting steel for marine anchor is relatively low(C ≤0.23%) with high pouring temperature, as it could be as high as 1560°C. So that some defects must exist more or less during anchor’s steel casting manufacture.

Typical Surface Defects and Causes

Cracks and Causes

Crack Defects Found on Site Inspection. The various crack defects were found in the workshop of anchor’s manufacturer, they were shown as Figure 3 to Figure 12.

Figure 3. Surface hot crack on the fluke root arc on an anchor. Figure 4. Inner hot crack polished on the fluke root arc.

Visual Features and Causes for Crack Defects. The hot cracks seemed irregular curves, the inner surface looked rougher and dark brown with iron oxide. The cool crack line was relatively straight and the inner surface cracks appeared clean and metallic luster.
The reasons for cracks produced in Figure 3 and Figure 5 were due to the shrinkage stress of the casting in the solidification process of the molten steel. The visual features of Figure 8 were hot cracks.
caused by slag inclusion, the reasons for cracks was that the mold sand fell into the mold cavity when closed with no cleaned. The reason for cracks found in Figure9 was the resistance of sand due to molding sand during solidification. The defect in Figure8 was caused by the root arc of the flash groove was too small or the casting box was opened too early. The main reason for the surface cracks produced in Figure 11 was improper size of process reinforcement or the casting box was opened too early. The main reason appeared in Figure 12 was that the casting stress did not eliminated.

**Blowhole, Shrinkage Hole and Causes**

The visual features of blowhole defects appeared circular, the inner wall was smooth with oxidation tint, as shown in Figure13. There were many reasons to cause the defects. The blowhole defect as shown in Figure13 was caused by that molten metal wrapped with bubble in the pouring system flow into the molded cavity. The visual features of shrinkage hole defects appeared irregular in shape and the inner surface seemed as a dark blown empty hole with iron oxide, as shown in Figure14. The main reasons were that the height of flash groove or the level for molten steel pouring did not satisfied, or the pouring speed was too fast.

![Figure 13. Surface blowhole on shaft boss of a steel casting.](image1)

![Figure 14. Shrinkage hole on the flash groove at an anchor stock.](image2)

**Slag Inclusion, Abscess and Causes**

The visual features of a surface slag inclusion defects was oxide inclusion with low melt point and vitreous silicate inclusion, as shown in Figure 15. The main reason of defects shaped was that during the ladle pouring process with bottom pouring style for casting, the non-metal slag inclusion inside the molten steel did not floated in time or the slag inclusion in pouring system got into the casting mould once again, and during solidifying process for steel casting, the slag inclusion was afloat up to the upper surface on the steel casting. The surface abscess defect on a steel casting was shown in Figure 16.

![Figure 15. Surface slag inclusion defect on a processed steel casting.](image3)

![Figure 16. Surface abscess defect on a steel casting.](image4)
The Repair to Defects
In generally, the raw and processed materials of steel casting for marine anchor was low in carbon content, good in welding performance, the weld up was allowed on the defects. The quality control of weld up was mainly related with carbon equivalent of casting material, the welding area, the notch depth, the size of electrode used, and furthermore, with the repair capacity of the manufacture. The defects repair of steel casting of marine anchors should be focused in the following several aspects.

Approval to the Repair Technique
The process approval about anchor steel casting defect repair should be carried out for marine anchor manufacturing enterprises. It would be one of the necessary condition for anchor steel casting manufacturer to approve the process technique and to survey the anchor steel casting, otherwise, the production capacity for the manufacturer seems dissatisfy. As mentioned above, there are always some casting defects unavoidable or more or less during the processing of steel casting, if the quality for defect repair of steel casting is not satisfied the criterion, there is no guarantee for the quality of the steel casting.

Surface Defects Grade
Evaluate the grade to surface quality defects of anchor steel casting according to minor defects and critical defects, and work out the corresponding repair process technique, then report to the relative classification society for approval.

Quality Control to Important Parts
During the repair to important part of an anchor, the important ring should be witnessed, mainly including follows.

Quality of Groove and Preheat. Be sure to clean the defects up, keep the surface a metallic luster, the groove’s size is easy to weld up. When using gas flame, blaze must not be concentrated, heating from periphery to center welding area well distributed, preheating area should be no less than two times the area of the welding up area. The temperature gradient inside preheating zone should be flat, to avoid producing cracks by local rapid heating.

Quality of Inter-pass Temperature and Inter-lamination Welding up. In particular, when using the CO₂ gas shielded welding, it is necessary not only to prevent the inter-pass temperature up to high for continuously welding up, but also to prevent the current going up too large to produce cracks. During the inspection, it was found that since the current was too large in the welding up process of the CO₂ gas shielded welding, filamentous crack appeared when stopping welding up.

Testing after Defects Repair
The repaired anchor shall be kept a heat treatment and crack detection testing once more. The minor defects could be tested again by magnetic powder inspection after repaired and cooled 24 hrs. The critical defects must be tested again by magnetic powder inspection after repair, heat preservation and cooled 48 hrs. Whether the ultrasonic flaw detection on a marine anchor steel casting after heat treatment is performed depends on the control to the welding up process and condition after post-weld heat treatment.

Summary
Through a great deal of collection and practice, based on the analysis results to the existed causes of surface defects on marine anchor steel castings, four aspects that must be paid attention to in defect repair are presented. It has practical guiding significance for actual production of marine anchor steel castings, and gets good use effect.
References
