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CAUSES FOR CRACK APPEARANCE IN THE WELDED JOINT OF THE SHIP WINCH FRAME DURING THE FAT TEST

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Abstract

Sip winches are one of the most important parts of the ship equipment. They perform the most responsible tasks on different types of ships. Considering the responsibility of their tasks, ship winches must fulfill the strictest requirements in regards to functionality, reliability and working life span. Ship winches are in the majority of cases welded structures. In order for the high reliability requirements to be fulfilled, integrity of the welded joints of the winch's individual parts have to be investigated prior to their imbedding into the winch. After those tests are performed and the parts are built-in the winch, factory acceptance test (FAT) must be performed. During that type of tests almost all the flaws that can occur during production should be visible.

In this paper is described an appearance of a crack in the ship winch frame that occurred during the FAT. The possible causes for such a crack to appear are discussed. In the closing, certain measures were proposed for reducing such cracks to a minimum. Some possible directions for future research oh this problem are proposed, as well.

Key words: *winches, factory acceptance test (FAT), welded structures, welded joint, integrity assessment.*

1. Introduction

Ship winches belong into a group of the most important ship equipment. They perform very responsible tasks on all kinds of ships. Winches' working tasks range from winches for catching fish to winches that are lowering into the sea or the ocean extremely expensive research equipment. They are mainly welded structures. Difference between the experimental investigations and analytical calculations should not exceed 10 %. Very high standards are applied for sizing of the winches' elements (SAA – Standard Association of Australia, DNV – Det Norske Veritas, etc.). In that way is ensured that if any flaw occurred in the manufacturing phase, the failure should occur immediately. If that should happen, eliminating the failure is far less costly on land than at open sea. Very important factor during investigations is maintaining the constant pulling force during the variable test conditions [2]. In that way the winch is tested for variable conditions during the open sea operations.

In paper [3] is presented testing of the welded corner joint, which appears in about 50 % of cases of the welded joint on winches. The crack usually appears in the heat affected zone (HAZ). In paper [4] is presented investigation of the V-notch of the S355JR steel (Č0561), which is the most frequently used material for manufacturing the winch frame. Specimens taken from the welded joint sample were from the base metal zone, HAZ and weld metal zone. Investigations have shown that the best characteristics in regard to crack opening have the weld metal. In works [5-7] are presented investigations of corner joints subjected to different varying loads. All the flaws and cracks that were created, or appeared during investigations, or were artificially created, point to the fact that the most critical places causing the welded structures failure are within the heat affected zone.

In this paper is presented an exactly opposite phenomenon. During the factory acceptance test cracking of the welded joint occurred right in the middle of the weld. This was

so puzzling and unexpected, that authors tried to find causes for such an uncommon behavior of this welded joint. The procedure of investigation is explained as well as crack appearance and the possible causes for this phenomenon are presented. At the end, the conclusions are drawn why this type of flaw occurred and measures proposed are for preventing its reoccurrence.

2. Factory acceptance testing

Factory acceptance testing (FAT) represents investigation of the winch prior to building-in the ship in conditions similar to real ones. Test is done in such a way that winch stand is being welded onto the platform, identically as it is imbedded on the ship. After that, the systems for proper winding up the winch are being tested. Testing of the load carrying capacity of the winch is done so that it is loaded maximally, together with + 10 % of the variable load above the maximal one. Then the pulling force is being checked, as well as the braking force. In Figure 1 is presented a sketch of the FAT station.

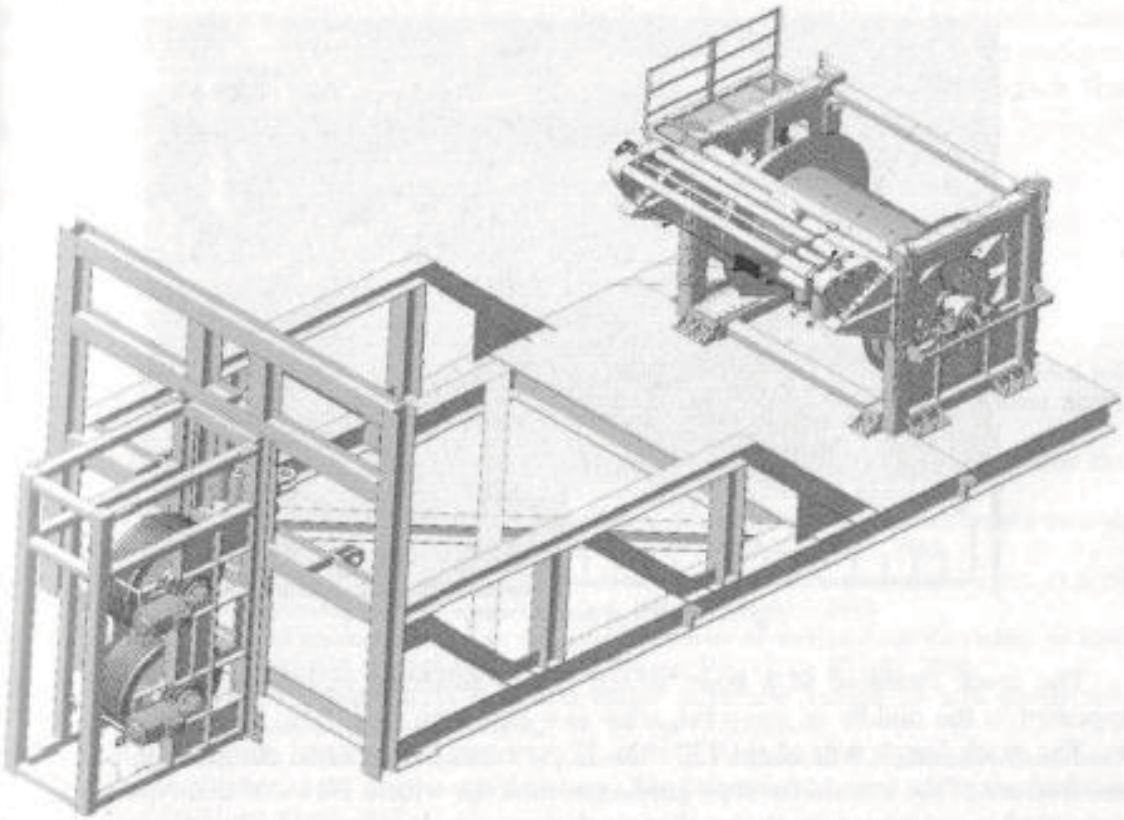

Fig. 1. Factory acceptance test station

During this test, all the flaws that can appear during construction and manufacturing of the winch can be noticed visually. Then each of the welded joint is being loaded in conditions which are more strenuous than the real working conditions, and any flaw, even the smallest one, can surface. This type pf testing is very dangerous and presence of workers at a distance smaller than the safe one is not allowed. The safe distance is being defined taking into account the size of the winch. This test is done according to the DNV standard, [8].

3. Failure during the factory acceptance test

Material, the tested winch is made of, is steel Č0561 (S355JR). This is a steel of unwarranted chemical composition, with tensile strength 500 – 590 N/m^2, carbon content

of 0.24 %, maximal content of sulfur and phosphorus of 0.06 %. Percentage of the V-welds on the tested winch frame was 40 %, while the corner joints were about 50 %; the rest of the welds were prepared as the U and X welds. The applied welding procedure was MAG, protective gas was Co_2. The wire used for welding was VAC (mark by "Jesenice" ironworks). Its chemical composition is: C 0.1 %, Si 0.9 %, and Mn 1.5 %. This wire is used for welding thin sheets and profiles of the ship equipment for steels with tensile strength up to 590 N/mm^2. Welding was done after operations of thin sheets and frame profiles cutting by gas cutter, cleaning of the cut positions, preparation of grooves for welding, stapling (pre-welding joining of parts) and sand blasting. After the welding was finished the heat treatment of welds normalizing was skipped. Then the penetrating test was performed. No flaws were detected with this probe. Finally, the finishing protection and painting of the frame were done. Final operation of the FAT was mounting of the winch. During the testing a crack was noticed at the place where the carrying plate is connected to the device for proper winding-up of the rope (Fig. 2.)

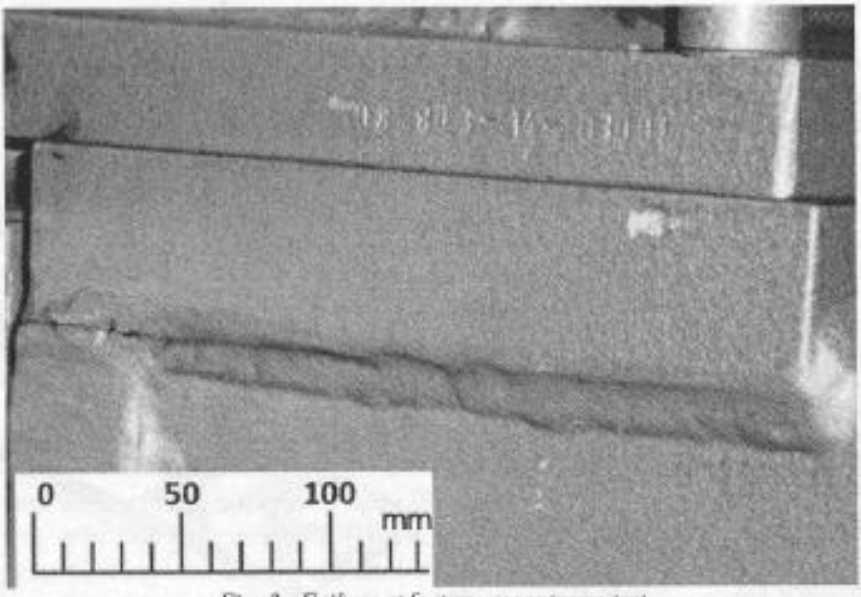

Fig. 2. Failure at factory acceptance test

The crack appeared at a point which is not subjected to maximum load intensity. It appeared in the middle of the weld, what is a very rare case, both in exploitation and in tests. The crack length was about 120 mm. If the crack was opened completely, that would cause fracture of the system for rope guiding around the winch. Flaws of this type could lead to catastrophic consequences during the winch operation at open seas. Due to appearance of this crack, the safety of the winch operator would be automatically compromised, as well as pulling up or lowering down the cargo and the total failure of the winch would be immanent.

4. Discussion and conclusion

Appearance of such a crack could be caused by several reasons. Specifically in this case of a crack on the winch frame, the highest influence was imposed by the following factors:

1. insufficiently cleaned surfaces prior to welding;
2. lower pressure of the protective gas and
3. poor quality of the welding wire.

Insufficient and improper cleaning of surfaces prior to welding a possibility was created for appearance of impurities in the weld metal. Those impurities cause inhomogeneity

of the weld metal appearance of eventual inside cracks. At lower loads those cracks propagate and connect with each other and form a large crack.

Wire that was used for welding is completely adequate for this purpose, according to characteristics provided by the manufacturer's catalogue. However, it is the most probable that an error occurred and that this wire was replaced by the wire that does not possess adequate characteristics, necessary for executing good welded joint.

It is also possible that the welder played a partial role in appearance of this flaw – crack. However, due to previously stated reasons, that role would be negligible.

In order to avoid appearance of such cracks in the future, it is necessary to introduce the following measures:

1. cleaning of surfaces prior to welding and their degreasing at the highest quality level;
2. checking of the protective gas bottle and pressure of the gas in it and
3. changing of the welding wire supplier.

By introducing the listed measures, flaws like the discussed one, could be reduced to minimum. Appearance of the combination of the three factors mentioned as possible causes for flaw, is highly improbable. However, if they coincide and if the FAT is not performed, consequences could be catastrophic and would result in fast appearance of winch frame failure immediately after the first crack appearance.

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