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The mode is used for the estimation of the technical condition for the boat hull from composite materials for exploitation.

ANNOTATION

The subject of this article is about the marine technology especially the technical exploitation of the boats. The development of the high-speed shipbuilding especially the fibreglass boats demands of an application of the modern objective mode of the estimation of the technical condition of the fibreglass boat hull today. The modes, which used until recently are not objective. The rules of the state agency about that are unnecessary hard. This article is telling about the mode of the estimate techniques condition of the fibreglass boat hull. This mode is based on a search of the inside exploitation defects type the lamination in the fibreglass boat hulls with non-destructive testing. After that, defects is measured and compared with the utmost dimensions. This dimensions of the defects calculated on condition that fibreglass boat hull is indestructible. This mode had been patented.

Key word: High-speed shipbuilding, boat hull, Mode of the estimation of technical condition, Inside exploitation defects type lamination, Impedance and impact testing methods, Boat hull is indestructible.

The control of the dynamics of the progress of the different defects in the boat hulls for the exploitation is appeared one of the other reliable criterions of the estimation of the technical condition of these hulls with the practice of the world shipping. The progress of the defects in the hull's construction reduces its quality of the safety. In addition to brings down the faculty to the resist unfavourable influences for the exploitation.

As a rule the size of the defect is, define with the changes of the geometry dimensions of the cross-section of the boat hull elements. These changes bring to the decrease of the mechanical descriptions (the area of the cross-section and the inertia moment and others) for boat hulls, which were making of the steel or the aluminium.

The stresses that function in the construction are bigger than the breaking points if the size of the defect exceeds the limit size.

In such a case, the construction can collapse for the rated speed. In addition to the zone of the emergency destruction is able to have the disproportionately big size in the supernumerary situations for the exploitation.

The boats that have the hulls of the compositions materials especially the fibreglass boats are biggest part of the world small fleet now. The fibreglass shipbuilding is the especially branch of the industry which develop quickly. Its progress provide with the successes of the air-space industry.

Picture 1. The modern boat which has the hull from the composition materials.

In addition to the large chemical corporations, work out the special complexes of the materials and the equipment for the production and the repair of the fibreglass goods in particular boats.

It is known that the reinforced plastics are the compound materials that have two components. There are the matrix and the reinforced material.

The reinforced composition materials for example the fibreglass have the properties that their components have not. The reinforced fibres are strong but they are flexible and permeable. The connecting resins are not strong but they keep a form and they stable to the influence of the surroundings. The unification of these components is the new material as a matter.

It is able to have strength as the metal at the appointed conditions. However, it has considerable less compact than the metal.

The fibreglass boats in Russia have the term of guarantee from the producers for one year about the constructive integrity. In addition to they have the term of guarantee for five years about the osmosis.

The state agencies that have supervision about these boats must estimate its technical condition independently after that.

The fibreglass does not change the appearance and the sizes for the exploitation during many years. It differ this properties from other shipbuilding materials for the boat hull. However the inside exploitation defects type lamination arise there. The fibreglass that has these defects does not differ from the new material outwardly. Therefore, the analysis of the changes of the geometry dimensions of the cross-section of the fibreglass construction makes no sense.

The hull of the high-speed fibreglass boat is the envelope that has the necessary strength. The dynamics loud operates on this hull for the exploitation.

The lower section of the fibreglass boat hull without the section of the deck and the section of the deck without the lower section of the hull have not the necessary strength.

The sections of the hull and of the deck have the necessary strength afterwards that as they join between them. The fore-and-aft and cross bulkhead place between sections and keep the form of the all boat hull. The every surface of the hull has one’s own set of the mechanical descriptions that change on the all surface and along the length of the boat and through the thickness of the planking

The inside defects which can arise in the composition construction make worse its exploitation qualities and shorten the period of the work of the boat hull.

The period of the work of the fibreglass boat hull is determines with its stableness to the influence of the mechanical loading and of the water and of the heat and of the frost and of the ultra-violet rays of sunny light also the emergency loading. All this factors are the origin of the exploitation inside defects.

The state agencies estimate of the technical condition of the fibreglass boat hull by sight now.

The estimation of the technical condition of the fibreglass boat hull is unsatisfactory by the rules of Russian River Register if this hull has inside defects type the lamination.

The observation with the dynamics of the progress of the inside defects type the lamination in the composition boat hulls for the exploitation with the special testing methods allows to have the information about change of the technical condition of this hull for the all period of the work.

The special testing methods especially the non-destructive testing discovers the inside defects of the composition materials for example of the fibreglass boat hull on the different stages of its progress.

The complete set of the documents about the discovery of the inside defects in the composition boat hull by the acoustic methods were work out for Russian River Register.

The more seventy fibreglass boat hulls from the different countries were investigating in 2007 – 2009 years especially the boats that make in the USA and EU. These boats have the term of work more five years. Some boats got into the shipwreck.

The control of the composition boat hull by the non-destructive testing methods was making in the slipway or on the ground near the bank of the rivers or lakes. The boat hulls were on the supports. The access to the outward surface of the boat hull was ensuring except the zones of contact between the planking of the boat hull and the supports. The submarine part of the boat hull was clean.

The non-destructive testing methods discover the inside defects type the lamination in the different parts of the composition boat hull on the different depth. The displays of the osmosis fix in the final stage only when it acquire the look of the inside defects type lamination.

The all-outward surface of the boat hull receives the control near the variable water line and near the lines between the sides and the bilge or the stern. In addition to the all-outward surface of the boat hull receives the control under the foundations of the main engines and under the fore-and-aft and cross framework and around the place of the situation of the propellers and rudders and others. In addition, to the control makes near the cuts in the freeboard. The control makes all outward surface of the boat hull that has osmosis or had emergency contacts. The one-third part of the submarine surface and the one tenth of the freeboard of the boat hull and the one tenth of the superstructure receive the control too. The control makes from the outside and on the inside of the boat hull if it is possible. Other elements of the composition boat hull control if it is possible.

The impedance and impact testing methods are use for the control of the composition boat hull. The portable flaw detector with the acoustic scanner and the impedance and impact reformers are use for that.

The most effective results of the control of the composition boat hull turned out when the impedance and impact testing methods combine in the work. The portable flaw detector with the acoustic scanner allows fixing the co-ordinates of the inside defects type lamination and measure their areas. In addition to the acoustic scanner allows receiving the image of defect in the graphic form on the display. The conditions of the turning without the standard are use in the work.

The choice of the testing method makes for every part of the all-outward surface of the boat hull. The impact testing method makes for the control of the surface with the big area that has the lower position or the inclined position. In addition, this method makes for the search of the inside defects which is on the big depth (not more 30 mm).

The impedance method with the acoustic scanner uses for the search of the inside defects which is on the depth more 3 mm and for the measuring of their area.

The composition boat hull has many different combinations of the constructive elements and the different reinforced layers and the different compositions materials.

The constructions, which have the inside elements by the foam plastic are control up to this elements.

The axis of the vibrators of the portable flaw detector by the control is perpendicular for the all-outward surface of the boat hull during the work. The control of the outward surface makes every 500 mm. The control makes every 250 mm in the place where the elements of the boat hull unite.

Some hundred inside defects type the lamination for the exploitation fix in the every boat hull by the control. The majority of the boats have not more 200 hours for the year or not more 1000 hours for the five year. The all this boat hull is unsatisfactory by the rules of Russian River Register.

Therefore, the rules of Russian River Register about the estimation of the technical condition of the compositions boat hull for the exploitation are unnecessary hard. Therefore, it is being in need of the modern objective mode of the estimation of the technical condition of the compositions boat hull that bases on the other criterions.

This mode of the estimation of the technical condition of the compositions boat hull for the exploitation bases on the search of the inside defects in the boat's compositions constructions by the impedance and impact testing methods and on the measuring of their parameters. Then the results correlate with the criterions of the strength and of the durability.

The estimation of the change of the strength with the inside defects type the lamination that arise for the exploitation is the criterion of the strength and of the durability for the composition boat hull for the exploitation.

The estimation of the change of it's strength is the comparison of the strength of the construction which calculate by the norms of the project for the new boat hull and the strength of this construction which calculate with the presence of the inside defects type the lamination for the exploitation which have the definite size.

The two principal criterions are the change of the strength near the inside defect type the lamination and the size-limit of the inside defect attached to its rise can begin.

The size-limit of the inside defect type lamination in the composition construction fixes for the construction integrity for the all exploitation. In addition to the size-limit of the inside defect fixes for the construction strength and for its steadiness and for its durability.

The limit of the reduction of the construction strength determines the inside defect type the lamination if the stresses in the construction exceed the permissible limits attached to that.

The limit-size of the inside defect type the lamination determines of the conditions when the defect increases attached to the stresses that act in the construction.

The limits of the strength of the fibreglass attached to the tension and to the shear are the dangerous stresses. They decrease in accordance with the factors of the exploitation.

The dangerous stresses for the composition boat construction fix differently. It depends from the conditions of the work of the different elements of the boat hull. The norms of the dangerous stresses take into account the duration and the nature of the action of the load.

The rated models represent elements of the boat hull. The rated modes for these models corroborate for the practice.

This rated models work out on the grounds construction and the reinforced structure of the composition materials and the technological processes for making them.

The base for the rated models served the construction of the composition boat hull by Scientific Centre "CSKB "Progress" from Samara city and patterns of the outward surface of the boat hull which was take from the different boats.

The parts of the outward surface of the boat hull in the rated models are the plates that hard fasten on the supporting contour. The supporting contour is keel and lines between the bottom and the sides and the deck and the line between the bottom and the stern of the boat.

The anisotropy of the composite takes into account.

The layer of the fiberglass construction which has make of the spray lay-up process is isotropic.

The all constructions of the boat hull offer as the three principal rated models:

- The absolute hard plate with two layers;
- The absolute hard plate with three layers and the middle light filer;
- The absolute hard plate with three layers and the middle stiff layer;

The macro-defects share from the micro-defects by the results of the flaw detection.

It arise by the means of the accumulation of the micro-defects on the front where the macro-defect forming.

The velocity of the accumulation of the micro-defects depends on the local stresses. The nature of the increase of the macro-defect depends on the distribution of the micro-defects in the environment of its front.

There are the two typical situations when the defect increases is continued or by great advance on condition that.

The increase of the defect is considered by continued when it is the increases sizes are less than the technical important sizes. The increase of the defect is steady when the parameters of the lamination meet the criterion by Griffiths or Irvin.

Then the stresses in the zone of the defect reach the critical value.

There is the thin end-line zone near the front of the defect where the all not elastic effects by the model of Leonov- Panasuk- Daedal.

The critical stress is considered by constant within this zone. It is analogous as the limit of the fluidity of the material.

The macro-defect increases by great advance after the short duration incubation when the micro-defects unite on the front of the macro-defect. The increase of the macro-defect is completed when the defect get across to the part of the matrix which it has the little damage.

The micro-defects continue to accumulate on the front of the macro-defect when the load acts on the composition. Then the macro-defect increases by great advance again.

The weakening or the disappearance of the tie between the next layers in the zone of the defect relaxes the mechanical description of the construction.

This weakening can reach down to four times by the experiment.

The lowering of the mechanical description of the construction excites the increase of the stresses within the zone of defect.

The increase of the stresses above the appointed value give raises the further progress of the defect.

Then the size of defect is down to the values when it influences on the strength of the construction strongly.

So the macro-defect begin to influence on the redistribution of the stresses in the composition construction from the outward load when the defect reach the appointed sizes

The value of the stress is call critical when the defect is begun to increase. The defect increase if the value of the potential energy which free oneself attached to the increase of the defect is less then the work of the destruction by the conception of Griffiths. The formula of the critical stress has the form:

$$\sigma_c = [\frac{\gamma E}{\pi L(1-\nu^2)}]^{1/2} \qquad (1)$$

where , σ_C –the critical stress;

γ- the specific work of the destruction;

E - the module of the elasticity;

ν - the coefficient by Poisson;

L- the size of the defect;

The value of the specific work of the destruction can define by the formula of the criterion of Irvin:

$$\gamma = \frac{K_{1c}^2(1-\nu^2)}{E} \qquad (2)$$

where, E –The module of the elasticity;

γ –the specific work of the destruction;

K_{1c} –The critical value of the coefficient of the stress intensity;

The formula of the critical stress by the criterion of Irvin has the form:

$$\sigma_c = K_{1c}[\frac{1}{\pi L}]^{1/2} \qquad (3)$$

The defect has the complicated configuration so the size of the defect can offer in the form:

$$L=(S_Д)^{1/2} \qquad (4)$$

where, $S_Д$ – the area of the defect;

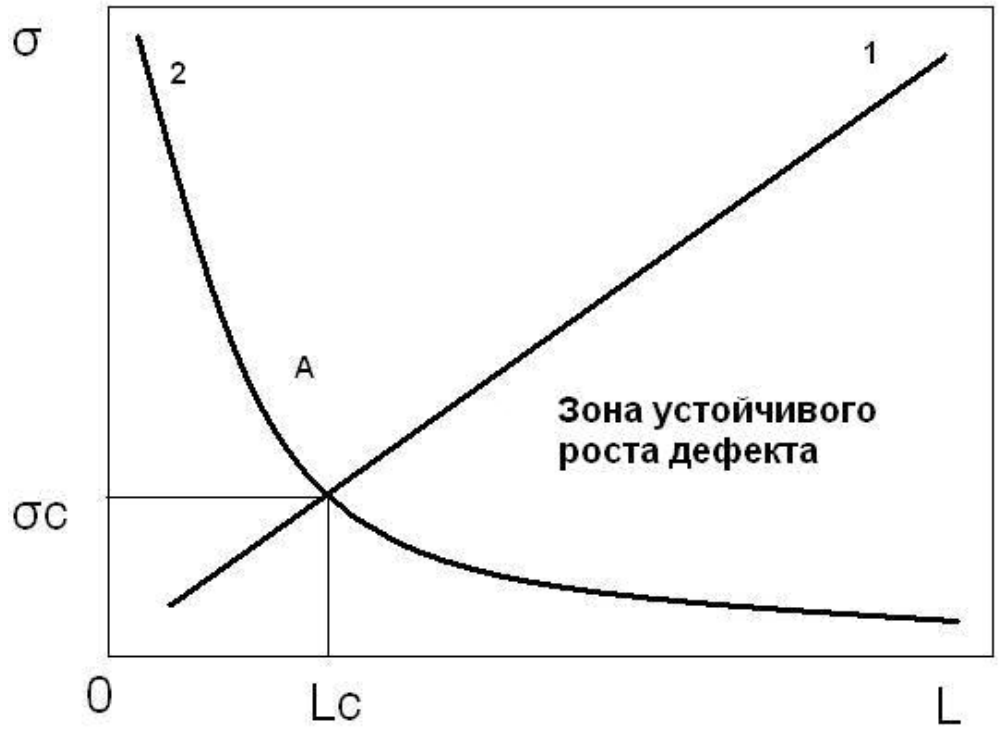
Therefore, the formula of the critical stress by the criterion of Griffiths has the form:

$$\sigma_c = [\frac{\gamma E_{np}}{\pi(S_Д)^{1/2}(1-\nu^2)}]^{1/2} \qquad (5)$$

Therefore, the formula of the critical stress by the criterion of Irvin has the form:

$$\sigma_c = K_{1c}[\frac{1}{\pi(S_Д)^{1/2}}]^{1/2} \qquad (6)$$

It can see that the value of the critical stress is inversely proportional to the area of the defect. The lowering of the strength of the composition takes place if the lamination develops when the stress in the construction is bigger then the critical stress by the experiment.



Picture 2.

The qualitative nature of this dependence imagine on the picture number 2 on graphic air.

The line number 1 shows the changes of the stresses. The action of the outward load cause for them. The line number 2 shows dependence between the critical stresses and the size of defect (by the criterion of Griffiths). The point of intersection of these lines allows defining the size of the defect that corresponds to the critical stress with the appointed outward load.

The zone is found to the right of the point $A\ (\sigma_C;\ L_c)$ and between lines number one and two is the zone where the defects have the stable increase.

Consequently, it can define the area of the defect that corresponds to the critical stress and on the contrary, the value of the critical stress defines the maximum area of the permissible defect.

As a rule the maximum opening of the lamination is neither more than 0,3 mm. Its value is negligible little in comparison with the thickness of the boat hull that usually has the value about 10-50 mm. So it can neglect of the value of the opening of the lamination when the calculation of the strength of the lamination construction makes.

The size of the defect that corresponds to the critical stress by the formula (4) can offer as:

$$L_c = (S_C)^{1/2} \qquad (7)$$

Where, L_c – the size of the defect which correspond to the critical stress;

S_C - the area of the defect which correspond to the critical stress;

The stress for the element of the boat hull in the form of the absolute rigid plate defines as:

$$\sigma^i = \frac{M^i_{изг} E_{пр} (z - z_0)}{D^i} \quad (8)$$

Where $M^i_{изг}$ - the bend's moment on the center of the plate or on the bearing;

$E_{пр}$ – the reduction module of the elasticity;

z – the half of the space between the middle surfaces of the layers of the plate;

z_0 - the displacement of the neutral surface from the middle surface of the plate

D^i – the cylindrical rigid of the plate for bend.

All this values calculate on the methods of the building mechanics of the ship.

The degree of the influence of the defect on the change of the mechanical characteristic of the element of the composition boat hull with the bend values by the increase of the stresses. The bend's moment makes this increase of the stresses in the zone of the lamination in comparison with the safe part. This increase of the stresses takes place because of the lowering of the cylindrical rigid of the plate for bend.

Accordingly, the stress from the bend stresses in the zone of the lamination of the absolute rigid plate can define as:

$$\sigma^i_{pac} = \frac{M^i_{изг} E^i_{пр} (z - z_0)}{D^i_{pac}} \quad (9)$$

The condition of the strength for the safe construction can define as:

$$\sigma^i \leq \sigma_0 \quad (10)$$

Where σ^i - the stress which acts in the safe construction;

σ_0 – the limit of the strength.

Then the condition of the strength for the construction in the zone of the lamination can define as:

$$\sigma^i_{pac} \leq \sigma_0 \quad (11)$$

Where σ^i_{pac} - the stress which acts in the zone of the lamination.

If the condition of the strength (10) not implement then the construction is not stable in the zone of the lamination.

The maximum area of the defect when it increases attached to the load for the element of the composition boat hull can define.

The condition when the defect not increases can define as:

$$\sigma^i_{pac} \leq \sigma_c \quad (12)$$

This condition by the criterion of Griffiths has the form:

$$\sigma^{i}_{pac} = \frac{M^{i}_{изг} E^{i}_{пр} (z - z_0)}{D^{i}_{pac}} \quad \sigma_c = [\frac{\gamma E_{пр}}{\pi (S_Д)^{1/2} (1 - \nu^2)}]^{1/2} \quad (13)$$

This condition by the criterion of Irvin has the form:

$$\sigma^{i}_{pac} = \frac{M^{i}_{изг} E^{i}_{пр} (z - z_0)}{D^{i}_{pac}} \quad \sigma_c = K_{1c} [\frac{1}{\pi (S_Д)^{1/2}}]^{1/2} \quad (14)$$

The choice of the criterion depend from that which one of the two values γ or K_{1c} are well known. If the conditions (13, 14) are not implemented then defect increase.

The mode of the estimation of the technical condition of the composition boat hull for the exploitation with the control by the impedance and impact testing methods and next after that the measuring of the defect and the comparison it's value with the utmost dimensions has been patented.

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