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MODERN WELDING AND ASSEMBLY TECHNOLOGIES ENSURING HIGHER MANUFACTURING QUALITY OF SHIP HULL STRUCTURES

Mikhail V. Aleksandrov, Valeriy M. Levshakov, Pavel L. Lyamin, Mikhail N. Zelenin

Among others, the shipbuilding industry is rather conservative. However, implementation of modern technologies is mandatory for development of promising high-performance projects. JSC "Shipbuilding & Shiprepair Technology Center" (JSC SSTC) is a leading state scientific center of Russian Federation focusing on development and implementation of modern technologies for manufacturing of surface ships and submarines and increase of production precision and quality.

Mounting of structures, mechanisms and special equipment

Measuring system accepted in Russian shipbuilding industry is based on linear dimensions and angular position of object planarity in relation to natural datum – vertical Earth reference. Acquisition of volumetric measurement information requires complicated plotting and calculation.

Imperfections of measuring devices hinders development of technologies and equipment for assembly and installation of ship structures and mechanisms. Fitting works in shipbuilding industry form up to 40% of total labor intensity.

Measuring equipment is now experiencing a technical breakthrough such as implementation of digital 3D measuring aids capable to issue high-precise digital volumetric data on large dimensional structures in online mode.

Shifting to three-dimensional measuring aids in shipbuilding gives the following advantages:

- Computer-aided manufacturing of ship blocks and assemblies using virtual drawings and excluding hard copies of drawings, templates and certain part of technical preparation;
- Adjustment of assembly jigs as per virtual drawings;
- Simplification of assembly stands due to

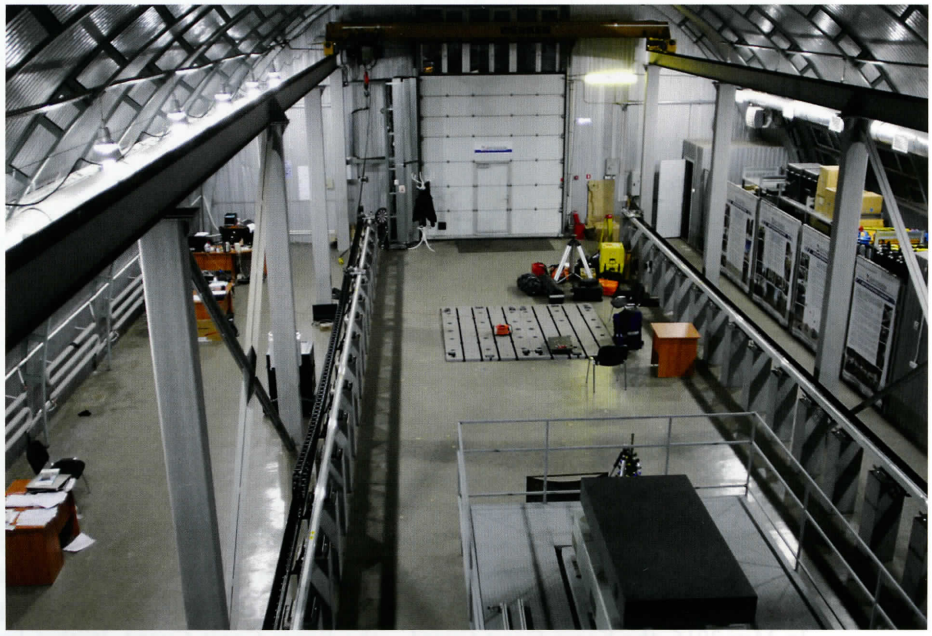

Fig. 1. Measuring center of JSC SSTC

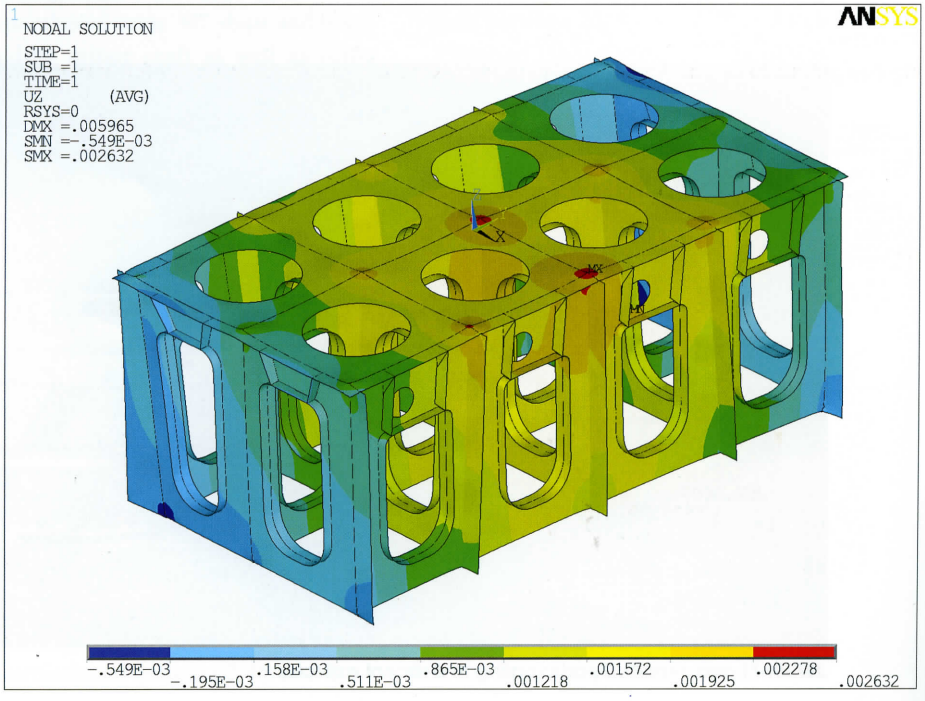

Fig. 2. Sample of calculation of expected welding deformation rate for welded ship's foundation.

exclusion of: stationary measuring datum points, and their adjustment, alignment of ship structures in reference to stand's measuring base and construction of scaffolding to perform measurements;

- High planarity of ship assembly joints and high precision of components layout inside the joint to ensure their assembly without fitting works;
- Shifting to virtual check of large-dimensional blocks of ships and offshore rigs to be assembled afloat allows to exclude: respective facilities for checking blocks assembly, blocks transportation and fitting works;
- Decreased labor intensity and enhanced manufacturing accuracy of ship blocks and irregular shaped articles;
- Establishment of database for computer-aided pipe routing;
- Template-free marking of ship foundation holes;
- Capability to recover drawings of ships being in operation for a long time or newly acquired ships (during repair/retrofit).

Implementation of new measuring aids shall reduce quantity of fitting works during assembly of blocks and ship as a whole even without robotizing. This approach shall ensure application of industrial zonal and modular methods for shipbuilding. Labor intensity is expected to decrease by at least 25%.

In order to implement the abovementioned goals JSC SSTC established the measuring center (fig. 1).

This center is equipped with nearly all types of 3D measurement aids, unique system of measuring rails, zero class surface plate made from hard rock, mirrors for reference azimuth directions, assembly plate for placing equipment to be checked and 1.5t crane.

Fig. 3. Overall view of equipment for low-frequency vibratory stress relief

At presence, specialists of measuring center perform large scope of works at shipbuilding enterprises using 3D measuring aids.

Reducing welding deformations and ship hull deformations

High level of residual welding stress in hull structures negatively affects their strength and operational performance. Therefore, welding and assembly technology must ensure low stress and deformation rate. This is particularly significant for ship hull structures, since they are subject for extremely high demands.

Accordingly, development of welding and assembly technologies ensuring minimum welding stress requires knowledge of stress occurrence and development factors. This allows to define expected deformation rate when designing the structure of developing production technology for the same.

JSC SSTC developed unique method for calculation of expected deformation rate. This method combines advantage of analytical approach and numerical calculation method: shortening of welding seams is defined on basis of heat passage theory and thermal plasticity as per analytical dependencies, while structural deformations are defined with finite elements method. Fig. 2 indicates sample of calculation using the abovementioned approach.

Definition of expected welding deformations for various welding and assembly patterns allows to select optimal operational sequence and to ensure minimum deviation of shape and dimensions of structure to be welded. However, structural stress rate may remain high. This issue can be solved by different methods. One of them is low frequency vibratory stress relief (VSR).

VSR method involves initiation and induction of small amplitude low-frequency vibration into the structure. This leads to reduction and re-distribution of residual stresses in metal structure and increases creep-rupture and fatigue strength, corrosion resistance together with stabilization of structure's shape and dimensions. VSR technology excludes expensive thermal structural processing which is impossible for structures composed of different steel types or alloys.

When applying VSR, energy dedicated for residual stress relief gets transferred into the structure by forced oscillations. This is performed with special-purpose equipment indicated on fig. 3, 4.

Fig. 4 indicates results of modal analysis indication oscillations of beam structure during low frequency (110 Hz) vibratory stress relief.

JSC SSTC is continuously advancing technologies on assembly, welding and installation of hull structures of various ships. We are ready for cooperation with foreign partners.

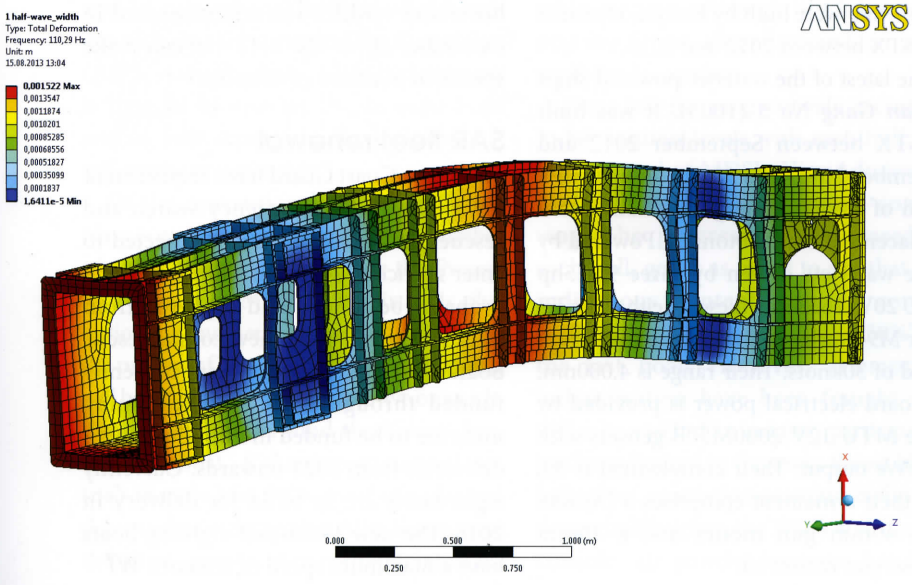

Fig. 4. Oscillation of beam structure under 110 Hz vibration frequency

JOINT STOCK CORPORATION
SHIPBUILDING & SHIPREPAIR
TECHNOLOGY CENTER

JSC "Shipbuilding & Shiprepair Technology Center"
7, Promyshlennaya Str., 198095, Saint Petersburg, Russia
Phone: +7 (812) 786-26-10
Fax: +7(812)786-04-59
E-mail: inbox@sstc.spb.ru