WARSHIP TECHNOLOGY

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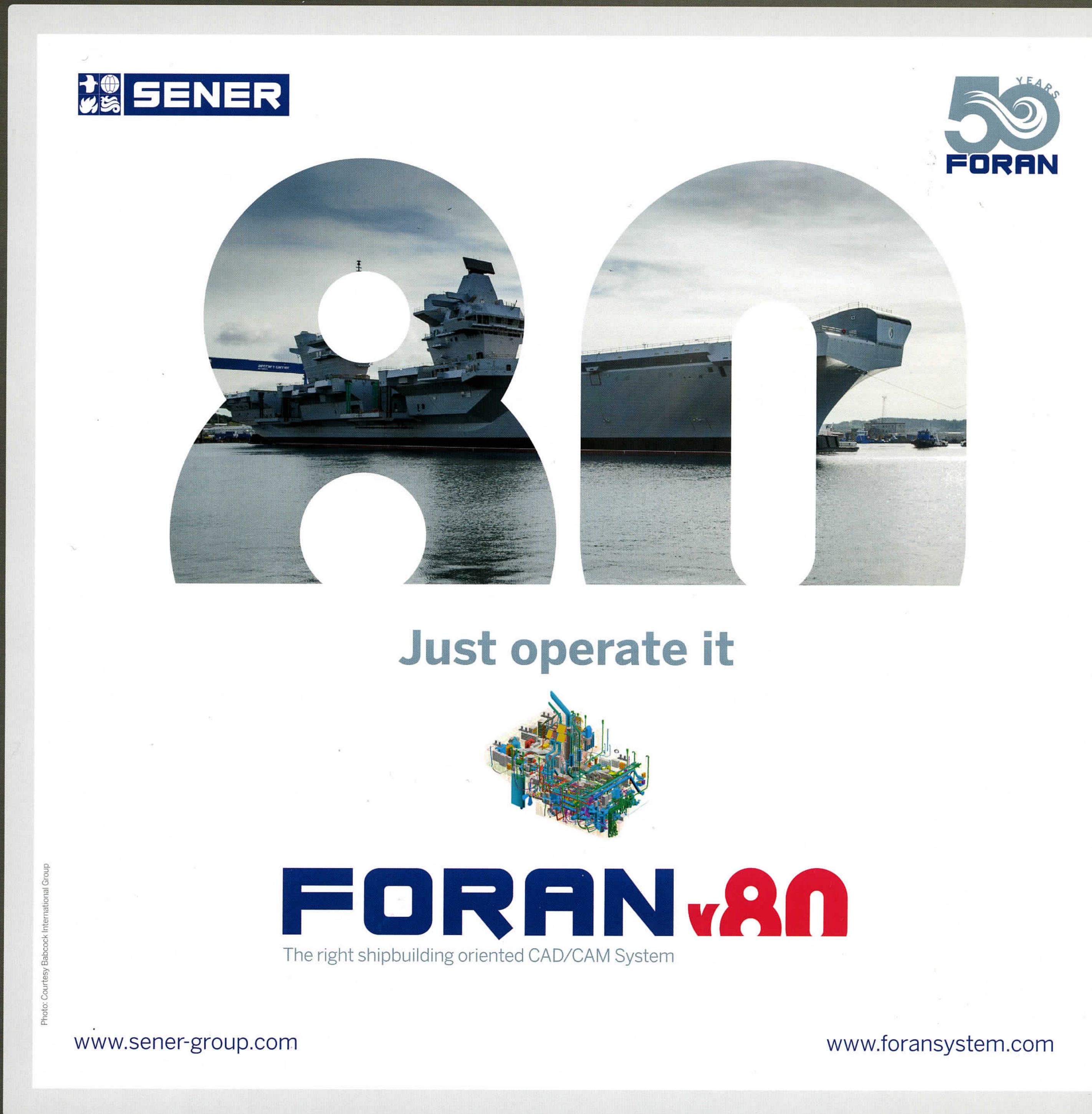

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MECHANIZED TECHNOLOGIES FOR COMPOSITE SHIPBUILDING

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Specific feature of structures made from composite materials is simultaneous shaping of material and structure – the same defined lead role of technology, integrating results of researches from the field of material science, design and structural analysis.

Demand in polymer composites in shipbuilding is based on rare combination of outstanding performance characteristics, providing following advantages in comparison with conventional materials:

– High specific strength, comparable with specific strength of steel and exceeding similar parameter of aluminum in almost two times;

– Low density; the same is lower, than density of steel in 4.7 times and in 1.7 times lower, than density of aluminum;

– Low heat conduction;

– Application of composites allows making hull structures of irregular shape;

– High corrosive resistance;

– Low operational costs and easy repair of composite structures.

Composite hull structures can be manufactured in different manners – depending on their type, purpose and carrying capacity.

Presently, main manufacturing procedures are:

– Vacuum shaping;

– Winding.

Vacuum shaping allows manufacturing of composites with higher strength characteristics – in comparison with contact molding, decreasing time of fiberglass parts manufacturing, reducing weight and supporting better environment in production area. For this reason in recent years this procedure is applied in shipbuilding more and more often for constructing hulls of fishing vessels, ships, yachts and boats.

In recent years, construction of LNG carriers is an issue of growing interest in Russia. JSC SSTC carried out researches, targeted on development and manufacturing of composite tanks, including manufacturing of material samples, thorough investigation of the same as well as manufacturing of three-layered tank wall with T-beam.

The sample was manufactured using infusion procedure. Test results confirmed principal possibility of composite tank manufacturing, combining functions of load carrying structure and thermal insulating material.

Wet winding

Casings of tanks, operating under external pressure, are traditionally manufactured from metal alloys. Casing weight can be reduced by application of polymer composites.

Rotation body is an efficient shape of structures, subjected to external hydrostatic pressure. The only procedure of manufacturing such structures from composites is rowing with continuous fiber (roving, thread).

For use under relatively low pressures – up to 3-4 MPa – optimal are casings of closed design, supported by framing, providing rigidity of the same. In case of high external pressure – when rigidity of casings is supported by their significant thickness – structures without framings are used.

When manufacturing casings, one faces such problem as initial components selection, tank designing, calculation of material specifications for specified operation conditions, calculating technological parameters of winding, selection of thermal processing mode, excluding loss of thick-walled casings containment under the influence of shrinking stresses.

Selection of filament reinforcement, content and orientation of the same determine technological parameters of casing shaping and have decisive influence on composite properties and carrying capacity of tank. Highly advertised spherical fore part, having higher theoretical value of critical pressure than isotensoid, doesn't show the same in practice due to technological features of reinforcement structure shaping, and also due to impossibility

Fig. 1 – Part of LNG carrier's tank wall

to wind the same simultaneously with cylindrical section. Even best variants with included compounds are less efficient, than single structure of cylinder and isotensoid.

Casing of tanks, being a cylinder with ellipsoidal (isotensoid) fore part, is an efficient solution, combining high requirements to mass ratio, strength and containment.

In case requirements to casing weight are higher, instead of plastic, reinforced by fiberglass, plastic, reinforced by aramid fiber can be used. Casing weight can be 20 – 30 % less in case aramid fiber based on organoplastic is used (with density of 1,35 g/cm^3 instead of fiberglass with density of 2,0 g/cm^3); mechanical characteristics of both materials are similar.

Aramid fibers have clearly defined anisotropy of elastic and strength properties. Fibers have high breaking strength along fiber axis, but their longitudinal tension index is relatively low. This particularity is related to structure of organic fibers, which looks like supermolecular features (fibrils) packed along fiber axis. Fibrils consist of linear macromolecules, connected among themselves with relatively weak hydrogen bridges – the same shall be

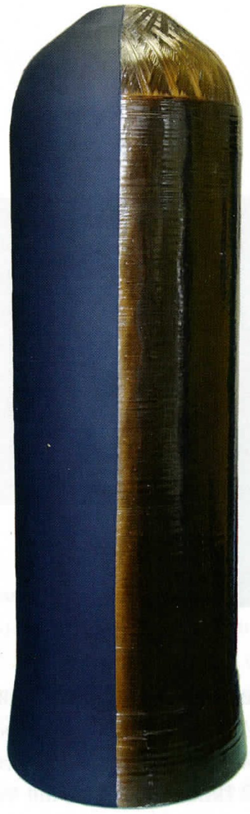

Fig. 2 – Casing hull

considered when designing structures.

Strength and rigidity calculation was made using finite elements model. Rigidity was calculated for fiberglass and organoplastic casings with thickness of 9, 11, 13 and 15 mm.

When calculating casings strength, test pressures, equal to one and half of operating pressures, were applied as design pressures.

In accordance with calculations results, the stress level acting inside the casing under pressures, corresponding to design pressures, that are equal to long-lasting critical pressures, is in 2-3 times lower than values, equal to strength of fiberglass and organoplastic. Hence proper strength of casings is provided.

In order to check design characteristics, experimental casings were manufactured and tested with external hydraulic pressure.

Casings were manufactured on NC winding machine. Winding programs were calculated basing on correlation of bottom thickness in toroidal part and cylindrical casing thickness, correlation values were 0.4 and 1, correspondingly.

Cylindrical section of casing consists of alternating packets, containing layers; each of the layers is laid under calculated angle.

In accordance with results of casing's hydraulic tests, when casings were subjected to external pressure, fiberglass and organoplastic casings were destroyed under pressures, being close to calculated critical load values; the same confirmed correctness of manufacturing procedures selected.

Wet winding was also applied for making dielectric insulation devices.

Insulation devices are applied in cryogenic systems, cooled by gas or fluid cryogents (helium, hydrogen, nitrogen, etc.) in temperatures range of 4.2-300 K and pressure up to 30 MPa.

Insulation devices are required for electrical insulation of cryogenic system from HV buses and magnets windings. Cryogenic system must be insulated, because superconductive cable is located in metal tube, connected with loop, purposed for supercritical helium circulation.

Insulation devices are a coaxial structure with internal and external casings, providing containment and strength and consist of fiberglass cylinder, equipped with channels for cryogents and end fittings from stainless steel.

All manufactured insulating devices were successfully tested and accepted by the Customer.

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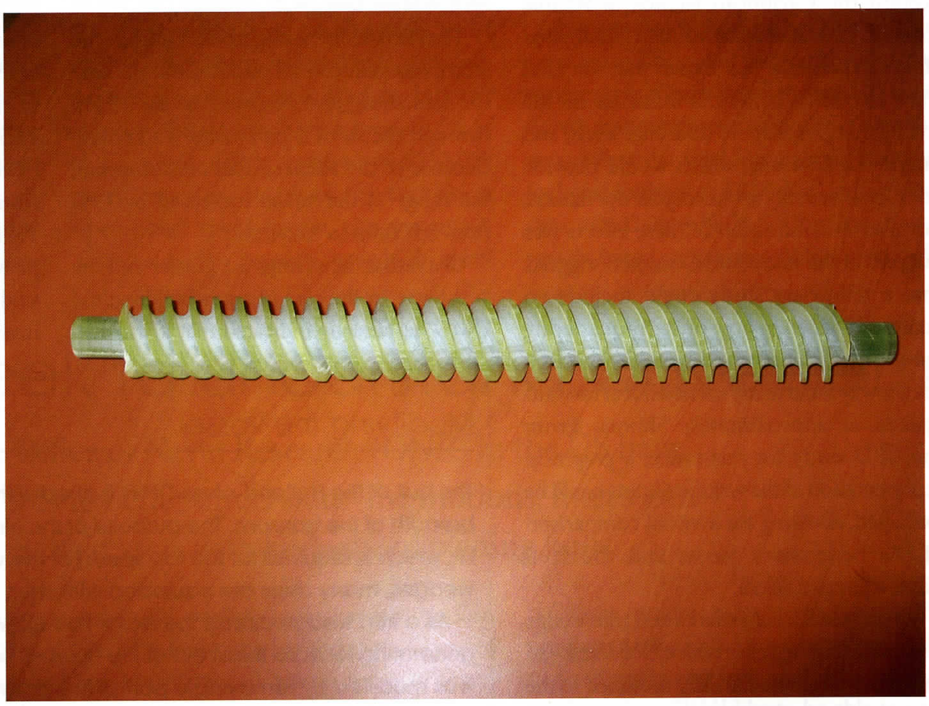

Fig. 3 – Fiberglass rod

Fig. 4 – Insulation device with channels