6440 DWT RIVER-SEA NAVIGATION TANKER WITH RUDDER-PROPELLERS

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ABSTRACT: Within last years the Marine Engineering Bureau (Odessa) carries out regular scientific researches and practical development on providing reliability and raise of efficiency of existing ships of the mixed river-sea navigation operated by shipowners of Ukraine and Russia.

The concept of the new generation tanker «Armada Leader» type has been formulated as follows: the tanker with full usage of Volga-Don river channel gabarits, greatest possible block coefficient from positions of providing of propulsive quality, increased capacity of tanks at minimally possible depth; the raised maneuverability in the constrained conditions, in locks, channels and on a shallow water; the substantiated operational reliability of ship’s hull constructions at optimum metal consumption the last. In total ten vessels were built in the series.

Marine Engineering Bureau (Odessa) conducted systematic scientific researches and practical developments on maintenance of reliability and increase of efficiency of the existing ships of mixed river-sea sailing area (SMSA), controlled by the Shipowners of Ukraine and Russia. The gained results and analysis of international experience have allowed to obtain an authentic estimation of the positive and negative sides of the existing SMSA and to proceed with creation of a new generation of domestic SMSA, differing both from the existing ones, built on the basis of river vessels, and from the standard European ships of coastal shipping, having insufficient cargo capacity at draughts about 3,40-3,60 m (see Fig. 1).

In August 2002 the shipyard SELAH (Touzla, Turkey) has delivered to the Customer – the shipping company (SC) “Palmali” (Russia) a head tanker – product-carrier of the mixed river-sea sailing area "Armada Leader". The ship is designed on class KM LU1 1 II A1 oil tanker (ESP) of Russian Maritime Register of Shipping (RS) and is the first ship, built under the project and author supervision of the Marine Engineering Bureau.

In total it is build a series of ten ships.

SC “Palmali” owns oil carrying ships of mixed sailing area of the projects P77, 621, 0201L, 19612, 550A. Ships are used for carrying cargoes of the companies LUKOIL and British Petroleum from the regions of Volgograd, Astrakhan, Turkmenbashi, Aktau to ports Neka (IRAN), Makhachkala, Kerch and on other routes up to ports of Turkey, Greece, Italy, Israel etc., including on route ports of the Caspian sea - ports of the Mediterranean sea. Main are the spring-summer transportations of boiler oil, diesel fuel, other petroleum of the Volgograd OPP and crude oil from the ports of Volga river to the oil-storage ship in the region of Kerch and to port Neka with a restricted passing draught. In the winter season ships operate in the Caspian, Black and Mediterranean seas, participating in transportations of petroleum, including gasoline, furnace fuel, and also vegetable oil. The basic characteristics of ships are adduced in the Table 1.

On routes through the Volgo-Don river channel (VDRC) there are used ships, built in 1981-1997 on classes of the Russian River Register (RRR) M, M-pr, M-SP, of “Lenaneft” type (pr. P77, 621) and of “Volgoneft” type (pr. 550A). In 1998-2002 years hulls of these ships were reinforced under the projects of Marine Engineering Bureau on the RS class IIISP.

“Lukoil” type (pr. 0201L) and “SFAT-1” type (pr. 19612) ships were built on the RS class I in 1999-2003 years, are applied basically for sea transportations due to insufficient cargo capacity at draught 3,40 m, single-screw propulsion plant (pr. 0201L), and also surplus overall dimensions (pr. 19612) for VDRC.

An analysis of exploitation of the existing tankers of mixed sailing area (see table 1), that operate successfully through VDRC, and which were obtained by the hull reinforcements from river ships, allowed to determine their main lacks [4, 5, 7]. These are:

– insufficient fatigue and wear durability of hulls under sea conditions (especially for pr. 550A/1577, P77);
– insufficient capacity of cargo spaces (pr. 621, 621.1, 630);
– insufficient power of main engines and related to this considerable speed losses when sailing in rough seas.
### Table 1. The comparative characteristics of tankers of pr. 0201L, 19612, P77, 550A and 005RST01

<table>
<thead>
<tr>
<th>N.os</th>
<th>Data</th>
<th>pr. 0201L</th>
<th>pr. 19612</th>
<th>pr. P77</th>
<th>pr.621</th>
<th>pr.550A</th>
<th>pr.005RST01</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Length maximum, m</td>
<td>129.3</td>
<td>141.0</td>
<td>108.5</td>
<td>122.83</td>
<td>132.6</td>
<td>138.7</td>
</tr>
<tr>
<td></td>
<td>Length between perpendiculars $L$, m</td>
<td>123.2</td>
<td>139.0</td>
<td>105.0</td>
<td>117.8</td>
<td>128.6</td>
<td>132.8</td>
</tr>
<tr>
<td></td>
<td>Breadth $B$, m</td>
<td>16.5</td>
<td>16.6</td>
<td>14.8</td>
<td>14.8</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>Depth $H$, m</td>
<td>6.8</td>
<td>7.4</td>
<td>4.4</td>
<td>5.2</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>Trunk height $h_{tr}$, m</td>
<td>1.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>Cubic module $LBH$, m$^3$</td>
<td>14507</td>
<td>17320</td>
<td>7066</td>
<td>9453</td>
<td>12033</td>
<td>13731</td>
</tr>
<tr>
<td></td>
<td>Overall height up to a upper edge of fixed parts from BL, m</td>
<td>16.7</td>
<td>16.9</td>
<td>14.6</td>
<td>15.4</td>
<td>16.1</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>Draught by SLWL $d_M$ at sea / $d_F$ in river, m</td>
<td>5.01/3.6</td>
<td>5.1/3.6</td>
<td>2.88/2.95</td>
<td>3.48/3.56</td>
<td>3.51/3.59</td>
<td>4.3/3.6</td>
</tr>
<tr>
<td></td>
<td>Deadweight $D_{wr}$, t</td>
<td>6645</td>
<td>7970</td>
<td>2812</td>
<td>3794</td>
<td>4889</td>
<td>6407</td>
</tr>
<tr>
<td></td>
<td>Speed in river / at sea, knots, at % from maximum continuous power</td>
<td>11.0/10.0 (85%)</td>
<td>≈11 (100%)</td>
<td>≈10 (100%)</td>
<td>≈10 (100%)</td>
<td>≈10 (100%)</td>
<td>≈11.5 (100%)</td>
</tr>
<tr>
<td></td>
<td>Volume of cargo tanks, m$^3$</td>
<td>7384</td>
<td>8266</td>
<td>3222</td>
<td>3485</td>
<td>5683</td>
<td>7221</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>KM ★ L3 I A1 Oil tanker (ESP)</td>
<td>KM ★ L3 I A1 Oil tanker (ESP)</td>
<td>KM ★ L4 IIICII Oil tanker (&gt;60°C) (ESP), as built +M-pr 2,5</td>
<td>KM ★ L4 IIICII Oil tanker (ESP), as built +M-SP 3,5</td>
<td>KM ★ IIISP Oil tanker (ESP), as built +M 2,5</td>
<td>KM ★ LU1 II A1 Oil tanker (ESP)</td>
</tr>
<tr>
<td></td>
<td>Admissible wave height of 3%-probability of exceed, m</td>
<td>8.5</td>
<td>8.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Power and type of ME</td>
<td>1750 kW</td>
<td>2×1320 kW</td>
<td>2×515 kW</td>
<td>2×640 kW</td>
<td>2×736 kW</td>
<td>2×1120 kW</td>
</tr>
<tr>
<td></td>
<td>Type of main fuel</td>
<td>HFO (260 cSt)</td>
<td>HFO (380 cSt)</td>
<td>MDO</td>
<td>MDO</td>
<td>MDO</td>
<td>HFO (380 cSt)</td>
</tr>
<tr>
<td></td>
<td>Crew/berths, persons</td>
<td>11/15</td>
<td>12/16</td>
<td>11/15</td>
<td>16/18</td>
<td>15/23</td>
<td>12/14</td>
</tr>
</tbody>
</table>
In connection with increase of volumes of transported cargoes, the customer posed a problem of creation of a new universal tanker with a reliable hull and equipment, which would be economically effective at linear operation on internal waterways of Russia, at restricted draughts in the Azov and Caspian seas (main routes: Volgograd-Kerch and Volgograd or Astrakhan-Neka), and also could be exploited with minimum losses of sea days in sea areas of Europe, including passages through the Bay of Biscay in winter season.

The concept of a vessel was formulated by the author of the present article as follows: a tanker with full usage of overall dimensions of VDRC, greatest possible block coefficient from the stands of performance maintenance, heightened cargo capacity at minimum possible depth; heightened controllability in confined conditions, in sluices, channels and in shallow waters; reasonable reliability of ship hull structures at optimum metal consumption of the latter.

On the basis of the modern approaches to the risk-theory based design it was offered and implemented the following:

- pursuant to expected directions of transportations and estimation of possible losses of sea days from idle times in expectation of weather, select the class RS II, which allows to exploit a vessel on passages around of Europe and in the Irish sea;
- pursuant to gained experience in the Azov and Caspian seas, accept an ice-reinforced category LU1;
- at the expense of increase of the section height (application of a trunk) increase cargo capacity and lower expenditure in domestic ports by module, having ensured sufficient for the selected class total longitudinal strength without increase of thicknesses of the overwhelming majority of structures if compared with the minimum thicknesses of the RS Rules (see Fig. 2);
- basing on model tests conducted in the towing tank of Odessa National Maritime University, outwork a block coefficient up to 0.90, ensuring maximum cargo capacity at restricted draughts (3.40 m in VDRC and 4.20 m – in port of Neka);
- at the expense of application of rudder propellers (RP), ensure a demanded controllability and performance, increase length of a cargo area, reduce approximately by 20% the sizes of ME, reduce costs of mounting and expected costs of repair and maintenance;
- assign identical, whenever possible, wall thicknesses of web and ordinary framing and shelf for maintenance of equal durability by wearing (in application to the given project the idea has received a title "the principle of 9 mm");
- design structures of side, bottom for perception of operational loads, the majority of which are considered till now “not design” (contacts with hydro-facilities, ground, etc.);
- at the expense of rational application of the main and web framing reasonably (providing demanded local strength and stability), preserve thicknesses of platings and skins at a level of minimum; • eliminate framing in cargo tanks (outside framing of an upper deck and trunk, transverse bulkheads with horizontal corrugations);
• for the purpose of increase of actual fatigue life, design “smooth” structures of flanges of an equivalent girder with minimum quantity of technological cut-outs and weld-ups, use rationally executed joints of interception of connections and smooth variation of areas of hull longitudinals lengthwise;
• at the expense of rational distribution of ballast and dry compartments in double sides and double bottom, obtain positive decision under the requirements of the Rule 25A of IC MARPOL 73/78 and remove a longitudinal bulkhead in CL.

Tanker of the “Armada Leader” type (see Fig. 3) represents a steel single-deck with a minimum freeboard, with two rotary RP, with superstructures 2.5 m in height and trunk of width 0.82B, extending over the entire length (forecastle of length 0.08L, poop of length 0.14L and trunk between them), without deck sheer, with aft deckhouse and ER, with a double bottom of height B/15 in CL (with rise to sides) and double sides of width 0.09B in a cargo area.

In a fore end with a high for the given type of ships forecastre there are located forecast, emergency fire pump, log and echo sounder trunk, boatswain’s and paints store, and also bow auxiliary thrust device of power 230 kW.

In an after end of the vessel are arranged ER and developed high poop deckhouse. A two-tier aft deckhouse with service and living accommodations for crew members – 12 persons (14 places) is designed with account of ensuring of the limited air draft of the ship (13.2 m at a draught 3.00 m).

Hull lines of the ship, designed by I.A. Ilnitsky, have a parallel middle-body of the length 0.65L. The bulb, area of which makes 2.9% from the area of a middle frame, of length 0.0045L, will be used for increase of relative fullness of a fore end and meeting the requirements of IC MARPOL 73/78 without change of geometry of cargo space. It is not designed for decrease of a wave resistance, since at $Fr \approx 0.15$ the given problem is not actual. The special shape of an after end, close to the “sleigh-like”, is optimized for arrangement of RP.

Advance and steering of the ship are provided with the aid of two after fully-revolving RP of the Schottel company, of SRP-1010FP type, with fixed-pitch propellers of diameter 1950 mm in nozzles. The drive to BPK from propulsion diesel engines is implemented through the mechanical Z-transmission.

In a cargo area are arranged 6 cargo and 2 settling tanks. Refusal from the longitudinal bulkhead in CL has allowed to reduce by 2.8% mass of a structural steel hull and to reduce practically twice the mass of pipelines and fittings of a cargo piping system. Indirect effect of the given solution was decrease of design heel angles at emergency damages effecting cargo tanks.
Transition from the poop deck to the forecastle is implemented via a catwalk, displaced from the CL of the ship towards the portside. The hydraulic crane of flame-safe construction is applied for operation with cargo hoses in the region of manifolds and gangways installation of lifting capacity 2 t with radius of a boom 12 m of GD-HK 2/12 type, manufactured by the GÜRDESAN company.

Outgoing from results of tests, for the main propulsive plant two mid-speed diesel engines of 6L20 type, manufactured by Wärtsila company, each with the specification maximum continuous power 1120 kW, are selected. Main engines operate on heavy fuel, with viscosity up to 380 cSt.

For heating of the cargo and heavy fuels, in Engine Room there are installed two vertical steam generators of the TT Boilers company, each having productivity 1,50 t/h, working on heavy fuel with viscosity up to 380 cSt at the temperature of 50 °C. Besides this, there are two exhaust-heat boilers with productivity by steam up to 0,50 t/h at pressure 1,1 MPa.

The cargo system of the tanker can provide simultaneous operation with three kinds of petroleum of density 0,72-1,015 t/m³ without limitation on flash point and provides a closed method of taking cargo by shore means with output up to 1200 m³/h.

Six fixed centrifugal submerged pumps of the Hamworthy KSE company with explosion-proof electric drives provide intensity of unloading up to 900 m³/h. The regulation of operation of cargo pumps is made from the control panel for cargo handling, arranged on the bridge, through the frequency converters, ensuring smooth regu-
lation of frequency of rotation of pumps. This allows to perform a high-quality stripping of tanks from residues of cargo by the pipeline of small diameter at the expense of decrease of productivity. There is envisioned also a stand-by control of a cargo handling from the converters compartment.

The cargo system envisions segregation of tanks into 3 groups (each group for a definite kind of cargo). The fore group includes cargo tanks No. 1 and No. 2, mean – No. 3 and No. 4, aft – No. 5 and No. 6. Each group of tanks has the manifold ensuring acceptance and issue of cargo on both sides. The productivity of submerged cargo pumps provides discharging of cargo for 7 – 9 hours, depending on its viscosity.

There is foreseen a capability of discharge from each group of tanks at failure of one pump. For maintenance of inflow of cargo to a working cargo pump the bypass valves, manually-controlled from the main deck, are installed. The shutters are mounted on transverse bulkheads between the cargo tanks of one group and are remotely driven.

On the vessel the pipeline cargo heating installation is applied. It provides maintenance of temperature of the transported cargo during a voyage up to the temperature not above + 60 °C (at the temperature of ambient air – 5 °C). The condensate from coil pipes is removed through the condensate discharge pipelines from each section independently into a common main of a condensate in ER and further comes into a condensate observation tank.

For each tank the gas-extraction system, equipped with high-velocity automatic gas-discharge valves with speed of ejection above 30 m3/s.

Collecting of gases evaporating from cargo tanks, and transfer them to the shore is implemented through the special pipeline integrating gas outlets, and manifold. The control over vapors of gases by pressure with the signaling on a minimum and maximum on the cargo handling control panel (CHCP) is foreseen.

At exploitation in summer season with a high temperature (over 25 °C) of outside air for the purpose of reducing of vaporization of transported petroleum and pollution of the environment the water cooling system of the trunk deck by an overboard water is envisioned. For watering in the region of CL on the trunk framework the trunk deck by an overboard water is envisioned. For washing of a ballast system at negative temperature of an environment the watering system of the ballast system is foreseen. The time of a ballast cycle is not more than 7 hours. The system is served by two submerged ballast pumps with productivity Q = 100 m3/h and 12 fixed washers (two in each tank) Q = 9,2 m3/h, and also 2 portable sets Q = 20 m3/h each are installed. The system provides a sequential washing of each cargo tank. The drop of washing waters from the slop tank is envisioned by the pump of the slop tank in the regions of allowed drop through the Oil Discharge Monitoring and Control System or through the manifold of the slop tank ashore. The feasibility of shore means with a simultaneous washing of all tanks and pumpdown of a washing water by the ship cargo pumps through manifolds into the shore purification facilities is envisioned. Taking from the shore of a detergent water is implemented through the settling tank manifold from any side at a head 0,8-1,0 MPa and temperature up to 80 °C.

Beside this, for a pollution prevention of environment there are installed on the tanker the oily bilge waters collecting and cleaning system with the separator SKT/S 0,5 of RWO company, with output 0,5 m3/h, and tank for collecting of oily waters of volume 15,5 m3. There is a system for collecting and treatment of sewage with the plant MSO II/20 for a bio-cleaning of sewages, of the Holland Marine Service company, with productivity 1,6 m3/h, in set with the vacuum installation for collecting of sewages from the toilet jet30MB-D, fecal tank of volume 15,9 m3 and bilge tank of volume 40,3 m3.

The deck areas in the region of manifolds are equipped with enclosures for collecting of possible leakages of petroleum and deleting them by hand pump into the slop tank by the separate pipeline. All deck in the region of cargo area is fenced with a coaming averting overflow of petroleum.

The conducted sea trials have shown an exclusive maneuverability of the ship and good performance qualities (ahead speed at usage of 100 % of a maximum continuous power 11,5 knots, astern speed – 9,0 knots).

The gained experience and economical results of exploitation on transportations of boiler oil, furnace fuel, diesel fuel, crude oil, vegetable oils of the first two ships of a series have completely confirmed the new decisions, made at development of the concepts.

Despite of their overall dimensions and considerable block coefficient, ships of project 005RST01 were well controlled in confined conditions of VDRC, reducing duration of a round voyage Volgograd - Kerch on the average by 7-9 % as contrasted to the existing ships, transporting transportations of larger amount of cargo than ships of pr. P77 and 621 and loss-free of sea days on a marine site (in expectation of favorable forecast), as ships of pr. 550A, having the least standard of total strength of all the considered ones.

The reasonably chosen power of main engines and developed superstructure of the forecastle have ensured seaworthiness in conditions of rough sea with a wave height of 3-5% probability of exceed 7,0 m. The speed loss in such conditions did not exceed 0,8-1,2 knots.

Cargo tanks washing system is made by the closed cycle with clearing of the cleaning fluid by a two-stage flowing deposit in slop tanks. For system operation the centrifugal submerged pump with productivity Q = 100 m3/h and 12 fixed washers (two in each tank) Q = 9,2 m3/h, and also 2 portable sets Q = 20 m3/h each are installed. The system provides a sequential washing of each cargo tank. The drop of washing waters from the slop tank is envisioned by the pump of the slop tank in the regions of allowed drop through the Oil Discharge Monitoring and Control System or through the manifold of the slop tank ashore. The feasibility of shore means with a simultaneous washing of all tanks and pumpdown of a washing water by the ship cargo pumps through manifolds into the shore purification facilities is envisioned. Taking from the shore of a detergent water is implemented through the settling tank manifold from any side at a head 0,8-1,0 MPa and temperature up to 80 °C.

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Thus, the known problem of imbalance of hulls of SMSA in respect of strength and seaworthiness was resolved.

Being based on successful exploitation of tankers of the 005RST01 project, having obtained practical approval of the concept of “risk-oriented design”, the Marine Engineering Bureau has elaborated a series of projects of dry-cargo ships of mixed river-sea sailing with rudder propellers, with hulls, similar to that of the m/s “Armada Leader” (see Fig. 5).

Fig. 5. Tankers of the 005RST01 project in exploitation

REFERENCES