RESEARCH OF MAIN DIMENSIONS OF NEW GENERATION SUBSEA CONSTRUCTION VESSELS AND INVESTIGATION OF INFLUENCE OF CHOICE OF DIVING COMPLEX AND REMOTELY OPERATION VEHICLES ON CONCEPT DESIGN STAGE

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Abstract

The mobile diving complexes and remotely operated vehicles available to companies operating offshore in the Caspian Sea are described, along with their proposed installation on subsea construction vessels. Based on research, methods for selecting the main dimensions of subsea construction vessels are presented, utilizing a database of vessels with similar functions and taking into account the installation of the described mobile diving complexes and equipment. The optimization of the main dimensions of subsea construction vessels is carried out using various methods, considering the parameters of the diving complexes and remotely operated vehicles. The main dimensions of the proposed subsea construction vessel are determined according to the parameters of the installed diving complexes and remotely operated vehicles.

Keywords: Subsea construction vessel (SSCV), Remote Operation Vehicle (ROV), Diving complex, The vessel main dimension, Optimization model, The vessel modeling

I. İntroduction

This study describes the mobile diving complexes and remotely operated vehicles (ROVs) available to companies working offshore in the Caspian Sea, as well as their proposed installation on Subsea Construction Vessels (SSCVs). Based on previous research [1 - 6], methods for selecting the main dimensions of SSCVs are proposed, utilizing a database of vessels with similar functions and considering the installation of the described mobile diving complexes and ROVs. The optimization of SSCV dimensions is carried out using various methods that take into account the parameters of the diving complexes and ROVs. The main dimensions of the proposed SSCV, based on the parameters of the installed diving complexes and ROVs, are simulated. Additionally, the study outlines future research opportunities and potential applications. For example, the designed vessel could serve as a carrier for manned submersibles, as described by researchers such as Rahul Bharti, Bhaskaran Pranesh, Dharmaraj Sathianarayanan, Manickavasagam Palaniappan, & Gidugu Ananda Ramadass [7] in relation to offshore operations in the Caspian Sea.

Types of the installation mobile diving complexes and ROV on SSCV.

In the development of a sea oil field, diving complexes and ROVs are widely used for deep-water and technical operations. Considering their application offshore in the Caspian Sea, companies require vessels optimally designed to carry mobile diving complexes and ROVs. The operators working offshore in the Caspian Sea have access to the mobile diving complexes and ROVs illustrated in Figure 1 and described in Tables 1 and 2.

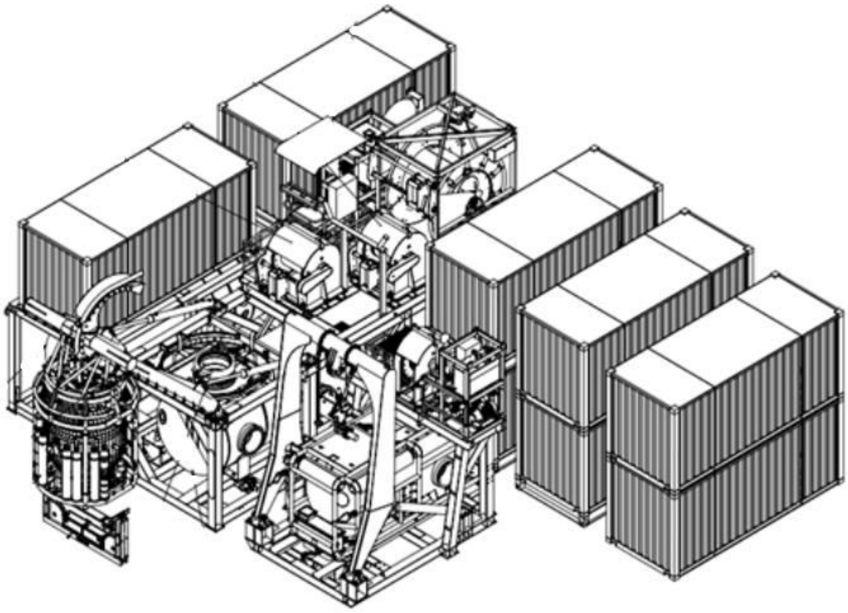

Figure 1: *Mobile diving complex MDDK-200*

For the safe and efficient operation of mobile diving complexes and equipment, it is necessary to design and construct SSCVs according to the requirements of the described mobile technology. In particular, the main dimensions, ship structures, devices, and systems must ensure safe operation at sea. To accommodate mobile complexes and equipment, it is proposed to design a subsea vessel that can also perform technological operations by installing the appropriate mobile technology (such as a mobile drilling complex, pipe-laying, or cable-laying equipment). Thus, an SSCV equipped with mobile technology will be capable of performing the full range of operations typically conducted by specialized vessels, such as diving, drilling, pipe laying, or cable-laying vessels.

Table 1: *The main dimension of the mobile diving complexes installation on SSCV*

MDDK-200		MDK-60	
The deep-water diving module with approximate dimension, m	14×16	The davits dimension, with diving basket, m	2,5×6
Reclaim Bag Container, m	2,5×6	Chamber, м	2,5×6
Power module (diesel generator, air compressor) – 2piec., m	2×2,5×6	Power module (diesel generator, air compressor), m	2,5×6
Compressed air cylinders packed	25×50*l*. 10piec.	Compressed air cylinders	16×50*l*. 6piec.
Workshop, m	2,5×6	Workshop, m	2,5×6
Store, m	4×2,5×6	Store, m	2,5×6
Staff, man.	56	Staff, man.	15

Table 2: *The main dimensions of the mobile ROV, installation on SSCV*

ROV complexes «COUGAR XT»	
ROV module, m	2,5x6
Control post module, m	2,5x6
Workshop module, m	2,5x6
Store container, m	2,5x6

Methods of the select of the main dimension of vessels in parameters of mobile diving complexes and ROV.

Considering the above, the main dimensions projected for the described complexes and SSCV hardware are determined using the nomogram developed by the author (Abdullayev O.M., 2024), as shown in Figure 2. At the same time, the main dimensions of the projected SSCV are defined as the sum of the areas of the open deck, the area occupied by mobile technology equipment, and the area necessary for servicing and performing technological operations, as expressed by Equations (1), (2), and (3). As a result, the main dimensions obtained according to the nomogram in Figure 2 and the formulas (1), (2), and (3) lead to the selection of optimal dimensions based on the optimization models (4), (5), (6), and Table 3.

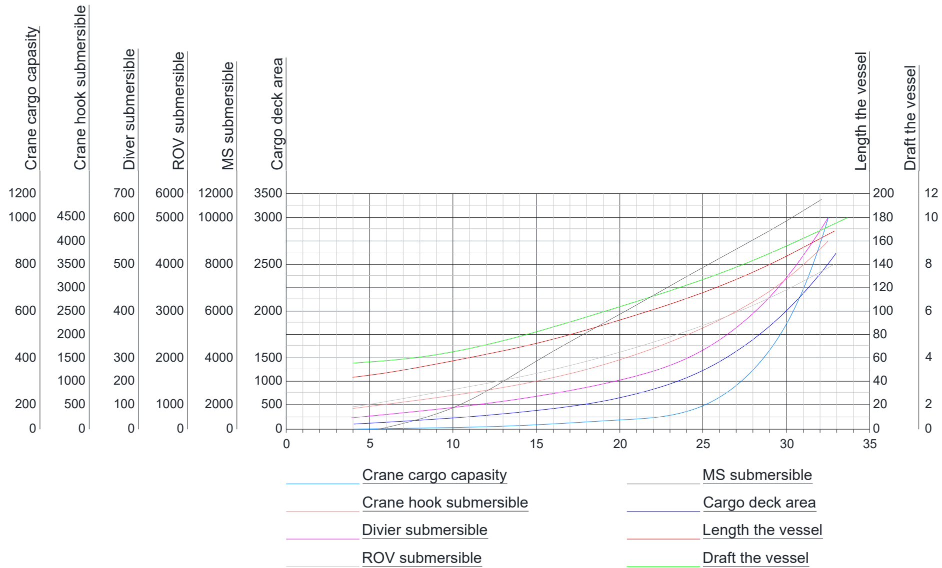

Figure 2: *Nomogram of definition of the main dimension of vessels of definition of subsea and technical operations*

Determination of the main dimensions according to the nomogram is carried out in the following sequence:

1. The vessel width is selected based on the required technological and design parameters reflected in the vertical scales on the left side of the nomogram:

– the required value of the technological or design parameter specified in the vessel design conditions (specified on the left side of the nomogram) is selected;

– a horizontal line is drawn until it intersects with the curve of the corresponding name;

– a vertical line is drawn downwards from the point of intersection of the horizontal line and the corresponding curve until it intersects with the horizontal scale;

– the point of intersection of the vertical line and the horizontal scale indicates the desired vessel width.

2. The largest value of the vessel width is selected:

– having carried out actions for all the technological and design parameters required for a specific vessel design, independently of each other, we obtain a group of width values for the designed vessel;

– from the obtained width values, the largest one is selected for the designed vessel.

3. The length of the vessel is selected:

– from the selected value of the vessel's width on the horizontal scale, draw a vertical line to the intersection with the vessel's length curve marked in red;

– from the point of intersection of the vertical line and the vessel length curve, a horizontal line is drawn to the right to the vertical scale on the right side of the nomogram reflecting the vessel length;

– the point of intersection of the horizontal line and the vertical scale of the vessel length reflects the length of the designed vessel.

4. The vessel draft is selected:

– from the selected value of the vessel width on the horizontal scale, a vertical line is drawn to the intersection with the vessel draft curve;

– from the point of intersection of the vertical line and the vessel draft curve, a horizontal line is drawn to the right to the vertical scale on the right side of the nomogram reflecting the vessel draft;

– the point of intersection of the horizontal line and the vertical scale of the vessel draft reflects the draft of the designed vessel.

Width of SSCV is determined by a formula (1) that is the sum of width of a diving complex, ROV width (at estimated joint installation) and width of passes for service.

$$B = b_{D.C} + b_{SERV.} + b_{ROV} \quad (1)$$

Here:
$b_{D.C}$ – width of a mobile diving complex, (Table 1);
$b_{SERV.}$ – pass width for service (~ 1-2m);
b_{ROV} – width of a mobile ROV complex (Table 2).

Length of the cargo deck for installation of diving complexes and apparatus, is determined by a formula (2) that is the sum of lengths of a diving complex, ROV and the necessary serving part of the deck.

$$L_{C.D.} = l_{D.C} + l_{ROV} + l_{SERV.} \quad (2)$$

Here:
$L_{C.D.}$ – length of a cargo deck;
$l_{D.C}$ – length of a mobile diving complex (Table 1);
l_{ROV} – length of a mobile ROV complex (Table 2);
$l_{SERV.}$ – length of a service part of the cargo deck (~Σ $l_{D.C}$, l_{ROV}).

Square of the cargo deck for installation of diving and ROV complexes, is determined by a formula (3) that is the sum of the spaces occupied by diving complexes, ROV and the serving part of the deck. At the same time the received sum of the areas has to be approximately equal to the work of length of the cargo deck and width of the designed vessel.

$$S_{C.D.} = (S_{D.C} + S_{ROV}) + S_{P.SERV.} \approx L_{C.D.} \times B \tag{3}$$

Here:

$S_{C.D.}$ – square of the cargo deck;

$S_{D.C}$ – square occupied by the mobile diving complex;

S_{ROV} – square occupied by the mobile ROV complex;

$S_{P.SERV.}$ – squre of the service part of the cargo deck (~Σ $S_{D.C}$, S_{ROV}).

Optimization of the main dimension of Subsea Construction Vessel got in parameters of diving complexes and ROV.

Counting dimension of SSCV by types and structure of the established diving complexes and apparatus, with use of models of optimization (4), (5) and (6), we form criteria of optimization:

$$L_{(X)} = \mathrm{C}f\left(\sum_{n=1}^{n} X_L\right) \rightarrow \mathrm{L}_{mid} \tag{4}$$

$$\mathrm{B}_{(X)} = \mathrm{C}f\left(\sum_{n=1}^{n} X_B\right) \rightarrow \mathrm{B}_{max} \tag{5}$$

$$d_{(X)} = (\mathrm{C} + B)f\left(\sum_{n=1}^{n} X_d\right) \rightarrow \mathrm{d}_{min} \tag{6}$$

here:

C – constant values of a problem of optimization;

L – rated length of the vessel, m;

B – rated width of the vessel, m;

d – rated draft of the vessel, m;

X_L, X_B, X_d – the varied elements participating by optimization of overall dimensions of the vessel respectively;

L_{mid} – average dimension of length of the vessel;

B_{max} – maximum dimension of width of the vessel;

d_{min} – minimum dimension of the draft of the vessel.

Definition of optimum main dimension it is reflected in an optimization matrix, (see table 3). The specified main dimension the immersions of divers and the area of the cargo deck received on a formula (2) determined by formulas (1), (2), (3) and received according to the nomogram (fig. 2) taking into account depth, we define optimum main dimension of SSCV for safe and quality operation of diving complexes and ROV.

Table 3: *Matrix of optimization of the main dimension of SSCV*

Methods of the received dimension	**L**	**B**	**d**
On formulas (1), (2), (3)	110	23	4
On depth of immersion of divers (fig.2)	90	20	3
On square cargo deck. On formulas (3) and fig.2	85	18	3
The received main dimension	**90**	**23**	**3**

Formation of the main dimension of the Subsea Construction Vessel, received in parameters of diving and ROV complexes.

Relying on the received values of the main dimension of SSCV, length, width and draft, with use of dependence of the cubic module (which is the work of length, width and draft of the vessel) and displacement, received from values of the database of relatives to destination of vessels, we define required for operation of diving and ROV complexes, the displacement of the designed vessel.

Key parameters of the offered SSCV and parameters of the diving and ROV complexes installed on the vessel are reflected in table 4.

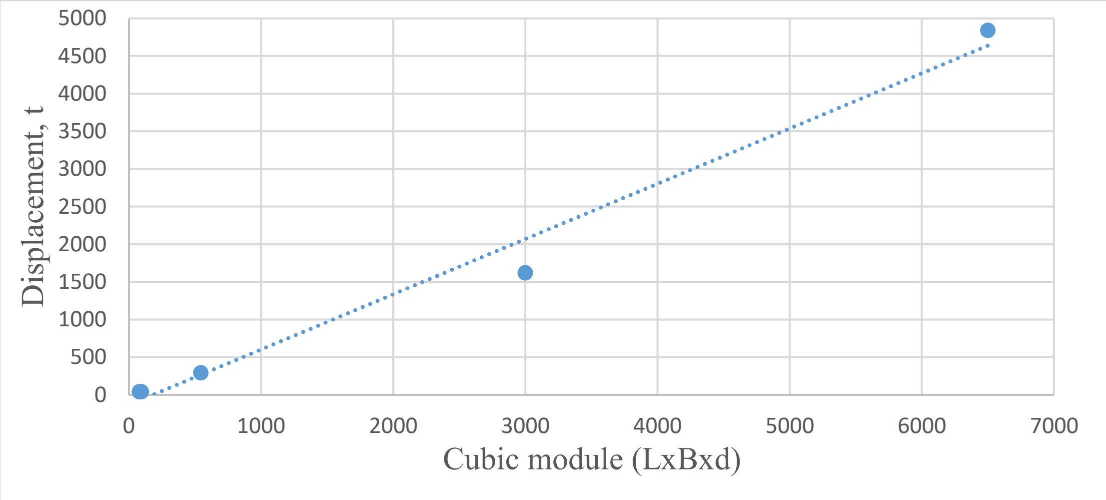

Figure 3: *Ratio cubic module (L×B×d) and displacement of diving vessels.*

Table 4: *Main parameters of the offered SSCV, in parameters of a diving and ROV complex*

Main dimensions of offered SSCV	
Length, m	90
Width, m	23
Draft, m	3
Square of cargo deck, m³	440
Displacement, t	4500
Block coefficient, C_b	0.72
Bath for service staff	90
Main parameters of mobile diving complex MDDK-200	
Working depth, m	200
Type of respiratory mix	Helium-oxygen
Volume of the respiratory mix, m^3	8000
Power of the power station, kVt	800
Service staff, man.	60
Main parameters of mobile diving complex MDK-60	
Working depth, m	60
Type of respiratory mix	Compressed air
The sum volume compressed air, m^3	600
Power of the power station, kVt	400
Service staff, man.	15
Main parameters the mobile ROV complex	
The ROV class	Working
Working depth, m	2000
Type of the power	Hydraulic
Service staff, man.	10

Considering that the kind of work of SSCV, consists in collaboration of technology equipment installed on it, each of them, postpones the print when forming the main dimension of the offered vessel. At the subsequent stages of a research, it is supposed to consider influence of the installed mobile technology equipment on the main dimension of the Subse Construction Vessel and to remove optimum values of the main dimension. It is separately possible to consider the possibility of perspective use of the offered vessel as the carrier of manned submersibles, for a research of a sea side of the Caspian Sea.

II. Conclusion

The types of mobile diving and ROV complexes available to companies operating offshore in the Caspian Sea are described. The method for selecting the main dimensions of SSCVs based on the parameters of the applied diving and ROV complexes is presented. A model for optimizing the main dimensions of SSCVs has been created. Using the optimization model, the main dimensions of SSCVs have been determined, and a type of vessel designed to ensure deep-water and technical operations for the safe and effective operation of the described mobile diving and ROV complexes is proposed. Expected subsequent research on the subject is also outlined.

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