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Analysis of Influence of the Cable Lay Equipment on the Main Dimensions of Subsea Construction Vessel

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Abstract

The study proposes to determine and justify the required main dimension of the subsea construction vessel (SCV) using the database method. Using the database of cable-laying vessels, dependencies were developed and mathematically described that reflect the influence of the parameters of the cable-laying equipment on the main dimension of the vessel. Using the dependencies, the previously developed nomogram for determining the main dimension of the (SCV) was supplemented. Taking into account the parameters of cable-laying operations in the Caspian Sea and relying on the developed dependencies and nomogram, the necessary special (SCV) were created to perform work on laying and repairing underwater cable lines.

Keywords: subsea operation, subsea construction vessel, supply vessel, cable lay vessel, technology equipment, special vessel, the vessel main dimension.

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Sualtı texniki təminat gəmisinin əsas ölçülərinin müəyyənləşdirilməsində kabel düzmə avadanlıqının təsirinin analizi

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Xülasə

Məqalədə, verilənlər bazasından istifadə edərək, sualtı texniki dəstək gəmisinin (STDG) tələb olunan əsas ölçülərinin təyin edilib əsaslandırılması təklif edilir. Kabel düzən gəmilərin verilənlər bazasından istifadə edərək, kabel düzmə avadanlığının parametrlərinin gəminin əsas ölçülərinə təsirini təsvir edən asılılıqlar tərtib edilib. Asılılıqlardan istifadə edərək, əvvəlcədən tərtib olunmuş STDG-nin əsas ölçülərini müəyyən edən nomoqramm, kabel düzmə parametrləri ilə təkmilləşdirilib. Xəzər hövzəsində istifadə olunan kabel düzmə əməliyyatlarının parametrlərini nəzərə alsaq və tərtib edilmiş asılılıqlar və nomoqrama əsaslanaraq, STDG-nin, kabel düzmə və təmir əməliyyatlarının icrasını təmin edilməsi məqsədi ilə, tələb olunan STDG-nin əsas texniki verilənləri tərtib edilib.

Açar sözlər: sualtı texniki işlər, sualtı texniki işləri təminat gəmiləri, kabel düzən gəmilər, texnoloji avadanlıqlar, ixtisaslaşmış gəmilər, gəminin əsas ölçüləri.

Анализ влияния кабелеукладочного оборудования на главные размерения судов обеспечения подводно-технических работ

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Аннотация

В статье предлагается определить и обосновать необходимые главные размерения судна обеспечения подводно-технических работ (СОПТР) методом базы данных. Используя базу данных кабелеукладочных судов, были разработаны и математически описаны зависимости, отражающие влияние параметров кабелеукладочного оборудования на главные размерения судна. С использованием зависимостей было дополнена разработанная ранее номограмма определения главных размерений СОПТР. Принимая во внимание используемые параметры кабелеукладочных операций в бассейне Каспийского моря и опираясь на разработанные зависимости и номограмму, были сформированы необходимые технические данные СОПТР для выполнения работ по прокладке и ремонту подводных кабельных линий.

Ключевые слова: подводно-технические работы, суда обеспечения подводно-технических работ, кабелеукладочные суда, технологическое оборудования, специализированные суда, главные размерения судна.

Introduction

In the Caspian Sea, cable-laying operations have been successfully carried out for a long time by a support vessel with mobile cable-laying equipment installed on the cargo deck. Given the closed nature of the Caspian Sea and the frequency of cable-laying operations, the need to use a special cable-laying vessel due to downtime between projects is impractical. In this paper, it is proven that a subsea construction vessel (SCV) with the appropriate equipment can be used as a cable-laying vessel.

The major factor in the solution of the tasks connected with development and service of the sea oil field objects [1] is their uninterrupted supply with electric energy. For high-quality and accident-free performance of laying and repair of sea cable routes, the corresponding vessels are necessary [2 – 5]. Considering the Caspian Sea as the closed sea, in the present work the problem of justification of use of the multipurpose Subsea Construction Vessel (SCV) is solved with the cable lay equipment installed on it, instead of the specialized cable lay vessel.

For the solution of an objective, within the research the system analysis is carried out with development of the block diagram of influence of parameters of the cable lay equipment on formation of the main dimension of SCV and the criterion function reflecting influences of the cable lay equipment on the main dimension of SCV is developed.

In the abstract, the main dimension of SCV the using cable lay equipment, with application of the database method is created and proved. For the solution of a task, was created the database of twenty-five cable lay vessels of the world fleet, reflecting in themselves key parameters is created. Using the database, dependences are and assessment of the impact of the cable lay equipment on the main dimension of SCV is carried out. Also with use of the received dependences, the nomogram [6, 7] of definition of the main dimension of SCV developed earlier, with addition of data on the cable lay equipment was added. Using the nomogram and dependences, the SCV necessary parameters for use of the cable lay equipment were created.

Research objective

Using the database of cable lay vessels, having made dependences of influence of the cable lay equipment parameters on the main dimensions of the vessel and having added the nomogram developed earlier, to determine the SCV necessary parameters for performance of cable lay operations.

Problem definition

To create necessary main dimensions of SCV for performance of cable lay operations, investigating influence of parameters of the cable lay equipment on the main dimension of the vessel with use of the database of cable lay vessels parameters.

System analysis and mathematical model of influence of the cable lay equipment on the main dimension of the subsea construction vessel.

Within the research the block diagram, (Figure 1) reflecting interference of parameters of the cable lay equipment designed vessels and the nature of influence of these parameters on the main dimension of SCV was developed. Mathematical model of influence of the cable lay equipment on the main dimension of SCV being based on the offered block diagram of (Fig. 1), it is reflected by criterion function (1).

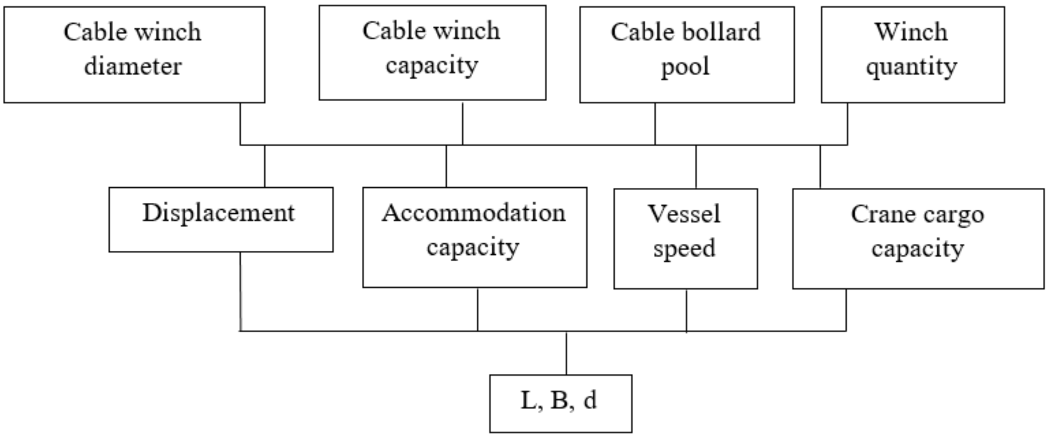

Figure 1 – Block diagram of influence of parameters of a cable lay complex on formation of the main dimension of SCV (L – the vessel length; B – the vessel width; d – the vessel draft)

$$L, B, d = S_{C.L.} f(D, S_{Ac.}, v, P_C), \quad (1)$$

here: $S_{C.L.}$ – SCV cable lay equipment elements, (D_{Winch}, V_C, P_C, n_W, D, $S_{Ac.}$, v, P_C); D_{Winch} – diameter of the winch; V_C – cable winch capacity; P_C – cable lay bollard pool; D – displacement; $S_{Ac.}$ – accommodation capacity; v – the vessel speed; n_W – winch quantity; P_C – cargo crane capacity.

Leaning on criterion function (1), dependences (see Fig. 3 – 16), influences of parameters of the cable lay equipment on technical data of SCV were developed.

Cable lay operation on the Caspian Sea and their prospects

At a sea oil field development, for providing the uninterrupted electric power, trade cable lay operations are made infield inside. Besides, are carried out laying of interstate trans-Caspian cable lines also and in process of development of the wind electric power on the Caspian Sea, there is a prospect of laying and repair of cable lines for objects of wind power industry. Long time when carrying out cable lay operations, were used the mobile cable lay equipment installed on the cargo deck of the supply vessel [5].

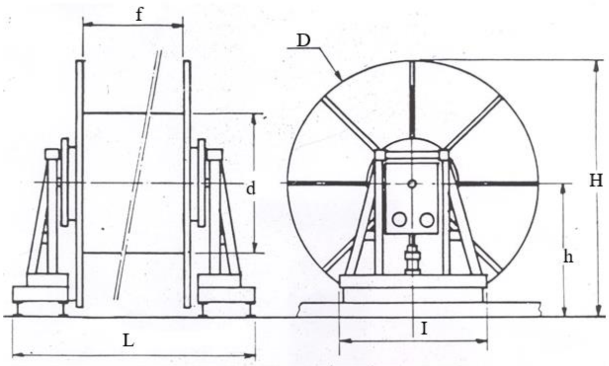

Figure 2 – The winch used when cable laying in the Caspian Sea

Lower in (Fig. 2), the appearance of the used winch is shown. The key technical data of the cable reel and the main brands of the cables which are applied when laying a subsea cable are specified in table 1 – 2.

The provided data reflected in (Fig. 2), and tables 1 and 2 act as introductory information for research of problems of formation and justification of the main dimension of SCV at use of the cable lay equipment.

Table 1 – Technical data of the cable winch

Power, kW		90.0
Speed, rpm.		0 - 1
Dimension, m		
Winch height	H	8.115
Distance from a center of the winch to the basis	h	4.215
Maximum winch diameter	D	7.8
Minimum winch diameter	d	4.4
Basis width	L	9.3
Foundation length	I	5.2
The winch utility width	f	5.0
Winch capacity, t		200
Moments, m		60000
Light weight, kg.		45000
Tension, V		380
Frequency, Hz		50

Table 2 – Brands of the cables used in the Caspian Sea

Brands of the cables	Cable sections, mm^2	Cable diameter, mm	1km cable weight, kg
ПК-6	3×70	55	6300
ПК-6	3×95	65	7600
ПК-6	3×120	75	8800
ПЭПК-35	1×70	54.45	6108
ПЭПК-35	1×95	56.2	6623

Assessment of the impact of the cable lay equipment on the main dimension of subsea construction vessel

For definition of the main dimensions of SCV, with use of the cable lay vessels database, dependences of factors of the cable lay equipment and the vessel were made and described by a formula (2) (see Fig. 3 – 16).

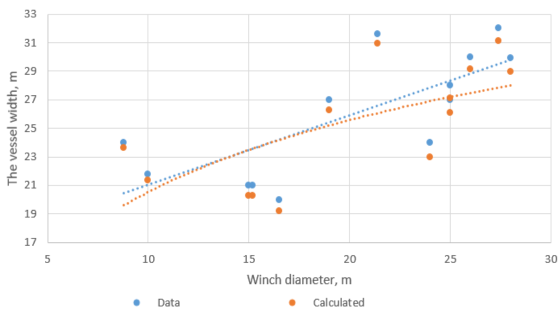

Figure 3 – Dependence of the vessel width and cable lay vessel winch diameter

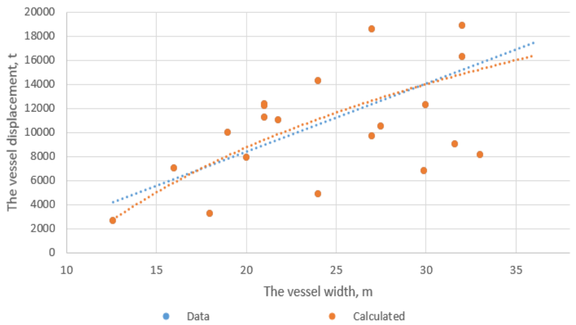

Figure 4 – Dependence the vessel width and cable lay vessel displacement

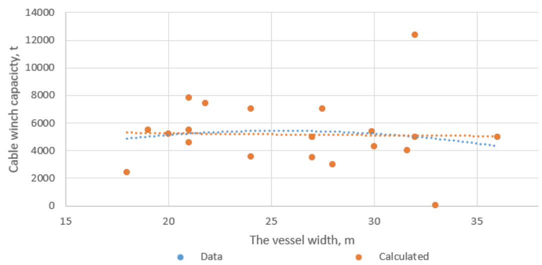

Figure 5 – Dependence the vessel width and cable winch capacity

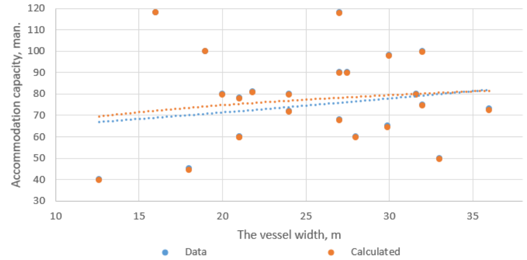

Figure 6 – Dependence the vessel width and accommodation capacity

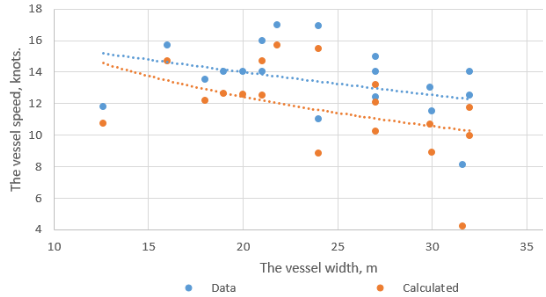

Figure 7 – Dependence the vessel width and speed

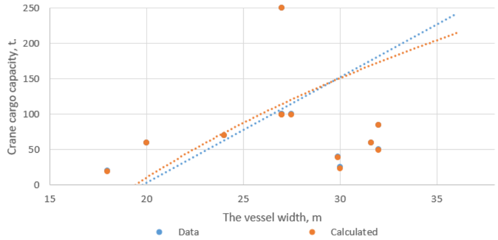

Figure 8 – Dependence the vessel width and crane cargo capacity

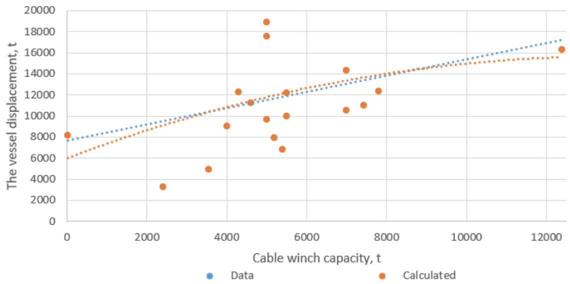

Figure 9 – Dependence the vessel displacement and cable winch capacity

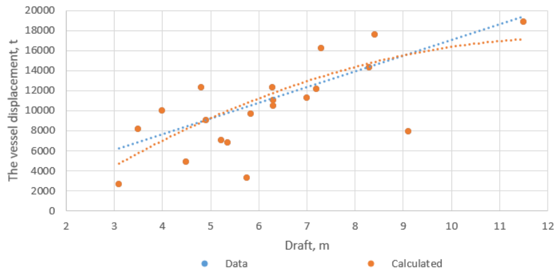

Figure 10 – Dependence the cable lay vessel displacement and draft

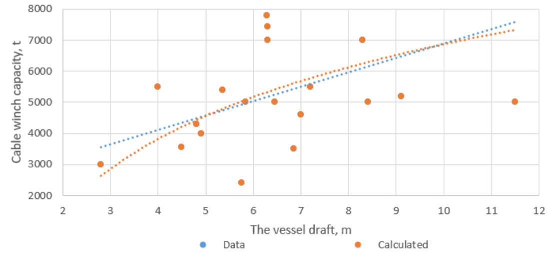

Figure 11 – Displacement the cable winch capacity and vessel draft

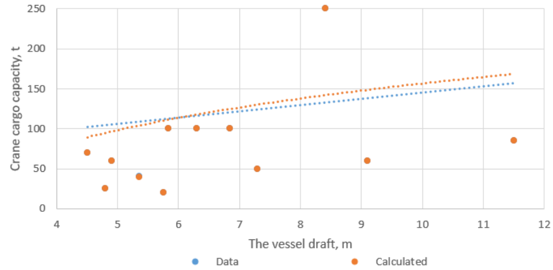

Figure 12 – Dependence the crane cargo capacity and the vessel draft

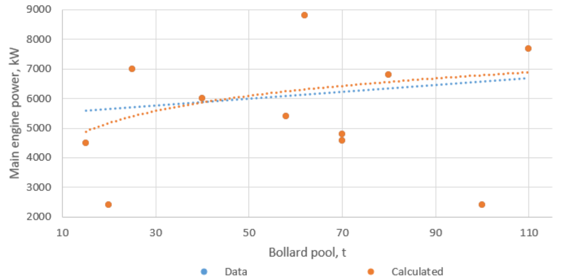

Figure 13 – Dependence the cable lay vessel main engine power and bollard pool

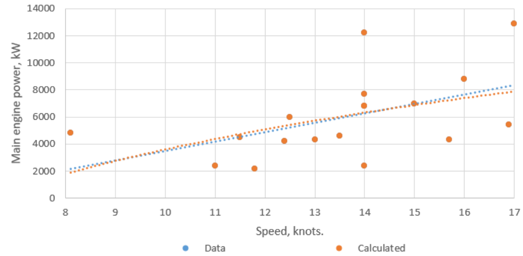

Figure 14 - Dependence the cable lay vessel main engine power and speed

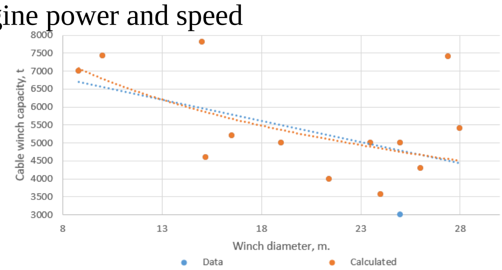

Figure 15 – Dependence the cable winch capacity and diameter

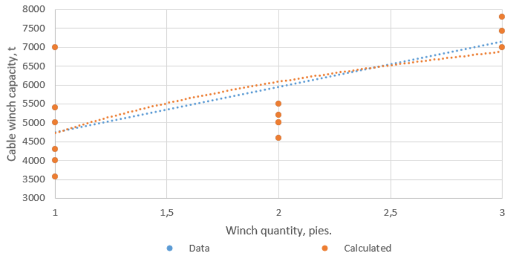

Figure 16 - Dependence the cable winch capacity and winch quantity

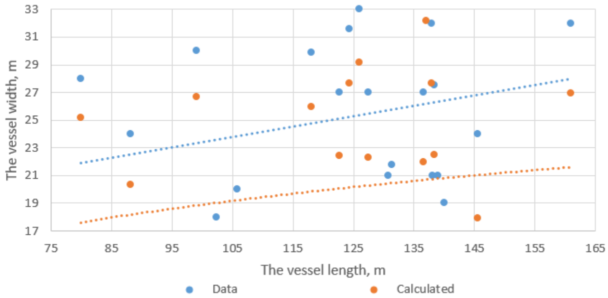

Figure 17 – Dependence the cable lay vessel length and width

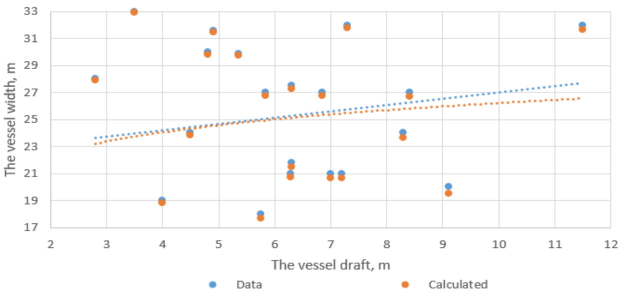

Figure 18 – Dependence the vessel draft and width

Also, with use of the database ratios of the main dimension of cable lay vessels (see Fig. 17 were created - 18), necessary for definition of the main dimension of SCV on which use of the cable lay equipment is offered.

$$C_n = b * S_{\text{C.L.}} - {}^{C_n}/_{S_{\text{C.L.}}} \qquad (2)$$

here: C_n – research parameters, (L, B, d); b – correlation coefficient the considering regularity of the considered ratios determined by a formula (4); ${}^{C_n}/_{S_{\text{C.L.}}}$ – dependence the research and measured parameters.

Thus, the ratio investigated and the measured parameters it is described by expression (3):

$$ {}^{C_n}/_{S_{\text{C.L.}}} = \sum_{i=1}^{n} C_i - b * \sum_{i=1}^{n} S_{\text{C.L.}} \qquad (3)$$

At the same time, the correlation coefficient, is described by expression (4):

$$b = \frac{\sum_{i=1}^{n} ({}^{C_n}/_{S_{\text{C.L.}}} - \overline{{}^{C_n}/_{S_{\text{C.L.}}}})(C - \overline{C_i})}{\sqrt{\sum_{i=1}^{n} ({}^{C_n}/_{S_{\text{C.L.}}} - \overline{{}^{C_n}/_{S_{\text{C.L.}}}})^2 \sum_{i=1}^{n} (C - \overline{C_i})^2}} \qquad (4)$$

Formation of the main dimension of subsea construction vessel on parameters of the cable lay equipment

Using the conducted researches, earlier developed nomogram [6, 7], was added with the cable lay equipment parameters.

Definition of the main dimension according to the new nomogram, in (Fig. 19), is made in the listed below sequence:

1. The select of width of the vessel in the presence of the cable lay equipment in parameters reflected in horizontal scales in the bottom of the nomogram: is select the value added to the nomogram of diameter of the cable lay winch set in the conditions of design of the vessel (set in the lower part of the nomogram); we draw a vertical line before crossing from a curve the corresponding name up; from a point of intersection of the vertical line and the rossing with a vertical scale of width of the vessel to the right; the point of intersection of a horizontal line and vertical scale indicates vessel width size.
2. Determination of diameter of a cable lay winch with value of capacity of a winch: is select the value added to the nomogram, capacity of the cable lay winch set in the conditions of design of the vessel;

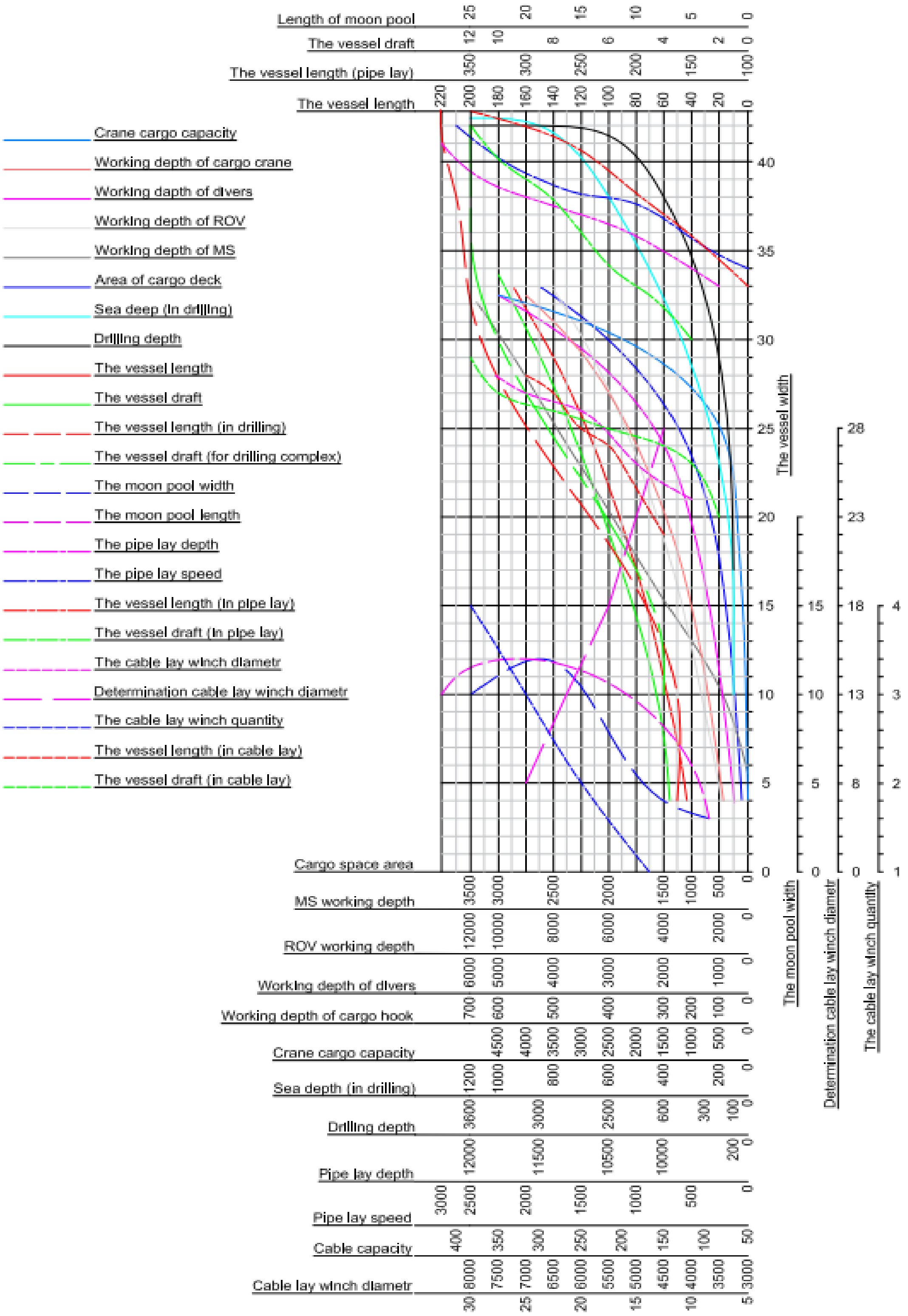

Figure 19 - The nomogram of the main dimension definition of SCV added with the cable lay equipment

we draw a vertical line before crossing from a curve of determination of diameter of a winch up; from a point of intersection of the vertical line and the corresponding curve it is drawn a horizontal line before crossing with a vertical scale of determination of diameter of a winch to the right; the point of intersection of a horizontal line and vertical scale indicates the size of diameter of a winch.

3. Determination of quantity of winch of a cable lay: select the value added to the nomogram, capacity of the cable lay winch set in the conditions of design of the vessel; draw a vertical line before crossing from a curve of quantity of winch up; from a point of intersection of the vertical line and the corresponding curve it is drawn a horizontal line before crossing with a vertical scale of determination of quantity of winch to the right; the point of intersection of a horizontal line and vertical scale indicates the size of diameter of a winch.

4. Select of length of the vessel: from the received value of width of the vessel on a vertical scale, we draw a horizontal line before crossing from the curve length of the vessel with the cable lay equipment; from a point of intersection of a horizontal line and the corresponding curve length of the vessel, we draw a vertical line to a horizontal scale in the top part of the nomogram reflecting vessel length up; the point of intersection of the vertical line and horizontal scale of length of the vessel, reflects necessary value of length of the designed vessel.

5. Select of draft of the vessel: from the received value of width of the vessel on a vertical scale, we draw a horizontal line before crossing from the curve draft of the vessel; from a point of intersection of a horizontal line and the corresponding curve draft of the vessel, we draw a vertical line to a horizontal scale in the top part of the nomogram reflecting vessel draft up; the point of intersection of the vertical line and horizontal scale of draft of the vessel reflects necessary value of draft of the designed vessel.

Using the algorithm of design of SCV which developed earlier, the nomogram of (Fig.19) and dependence of (Fig. 3 – 18), we obtain preliminary main specifications of SCV in parameters of the cable lay equipment (see Table 3) [8, 9]. Considering that the kind of work of SCV, consists in collaboration of the established technological complexes (diving, drilling, pipe laying and cable laying modules), each of them influencing on forming the main dimension of SCV.

Table 3 – Main data the SCV with the cable lay equipment

Length, m	90
Width, m	22.0
Draft, m	3.0
Displacement, t	4500
Service speed, knots.	12.0
Cable winch capacity, t	6500
Cable winch diameter, m	12.0
Cable winch quantity, pies.	2.0
Cable lay bollard pool, t	15
Cargo crane capacity, t	50.0
Main engine power, kW	5000.0
Accommodation capacity, man.	75.0
Winch rotate speed, rpm.	1.0

At the subsequent stages of a research [10], it is supposed to perform optimization of influence of the established mobile technological complexes on the main dimension of SCV and to define optimum main dimension of SCV.

Conclusion

The system analysis is made and criterion function of influence of the cable lay equipment on the main dimension of SCV is created. The cable lay operations which are carried out in the Caspian Sea their prospect, the equipment and types of the used cables are described. Dependences of influence of the cable lay equipment on the main dimension of SCV are developed. The nomogram of definition of the main dimension of SCV is added and the minimum main dimension of SCV necessary for performance of cable lay operations are created.

Conflict of Interests

The authors declare there is no conflicts of interests related to the publication of this article.

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