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Umbilical cord winch for a remotely operated vehicle (ROV) system

SUMMARY

The umbilical cord winch for a remotely operated vehicle system is presented. The winch is non-typical as the umbilical cord used to the ROV system is the cable-line comprising, apart from electric cables, a co-axial optical fibre bundle. The optical fibres were assumed not to have any movable connector, which made it necessary to design a special winding mechanism fitted inside the winch drum.

The design was elaborated by a team of the Faculty of Ocean Engineering and Ship Technology, Technical University of Gdańsk.

The paper was presented at the IV Conference on Port Technology and Ship Deck Equipment held in Międzyzdroje on 3 to 5 June 1998.

INTRODUCTION

Along with the fast developing new marine techniques and different underwater vehicles and facilities, special deck equipment for them is also developed. The line, cable and cable-line winches belong to this equipment. They make it possible to lower and lift as well as to tow and supply with energy, in a controllable way, such underwater objects as diving bells, underwater vehicles, sonars etc. Transmitting information and control signals between an underwater object and assisting ship is also possible with the use of the cable and cable-line winches. Yet not long ago the signals were sent by electric wiring. Quality of so transferred information depended on many factors, among which immersion depth of the cables, transmission speed and quality of cable connectors, especially the movable ones, were the most important. Unsufficient quality of so transmitted information was a serious obstacle for development of the novel underwater vehicles equipped with many measuring systems.

New promising possibilities have emerged for the area along with developing the optical fibre technique. Applying optical signals to long umbilical cord systems is especially advantageous. Quality of optical fibre connectors passing from the „wet" (movable) state to „dry" (on-deck, stationary) state is a difficulty to be overcome. At present three following methods of solving the problem are at disposal :

- ❖ to convert the optical signal into electric one inside the line drum and then transmit it through a rotating electric connector with sliding rings
- ❖ to apply a rotating, multi-channel optical connector
- ❖ to install a special mechanism for winding the optical fibre bundle, inside the winch drum.

Converting the transmitted signals and fitting the electronic systems inside the winch drum is required to use any of the two first methods. However any of them does not yet guarantee obtaining a high quality of fast transmitted information.

Only the third method makes it possible to avoid the movable connectors and signal converters and thus to transmit the signals in both directions through the integral optical fibre bundle connected to a laser, at its one end, and to a receiver at its other end. However this can be achieved in expense of a highly complex winch design and possible hazards due to difficulties in ensuring small, constant stresses in the optical fibres. Nonetheless the method is considered as the most promising for solving the problem in question.

Therefore in 1997 an original design of the umbilical cord winch based on the last method, was elaborated by a team of the Faculty of Ocean Engineering and Ship Technology, Technical University of Gdańsk.

In the paper the most important design assumptions of the winch as well as its constructional and operational features are presented.

DESIGN ASSUMPTIONS

The following assumptions, apart from the above mentioned ones, have been deemed the most important :

- ➢ the rated pull $F_n = 350$ N
- ➢ the line heaving speed $V = 0 \div 2.5$ m/s
- ➢ the drum capacity $L_c = 400$ m
- ➢ electric drive (in consequence of assuming an electronic system of stepless control of the winch within a broad range of its working parameters, which decisivcly influenced the choice of a type and reduction ratio of the applied mechanical gear)

- ensuring an adjustable, automatically maintained tension of the umbilical cord (which, together with application of a brake-fitted electric motor, made the winch drum brake unnecessary)
- demanded relatively large bending radius of the umbilical cord and optical fibre bundle (deciding to a large extent upon transverse dimensions of the drum and winding roller, and hence of the entire winch)
- broad changing range of the angle of the umbilical cord running onto the winch :
  - a_0 = -80÷80° - at the plane parallel to the drum axis
  - a_p = 0÷85° - at the plane perpendicular to the drum axis which together with the preceding assumption made it necessary to design the umbilical cord loop layer of a special construction
- compact, modular construction to be placed inside a portable framework
- low weight.

DESCRIPTION OF THE WINCH CONSTRUCTION

The winch (without its electronic equipment) is presented in Fig.1. It consists of the following units : the winch framework (1), umbilical cord drum (2) together with the winder fitted inside it, umbilical cord loop layer (3), loop-layer gear (4), drum driving gear (5) and electric motor (6).

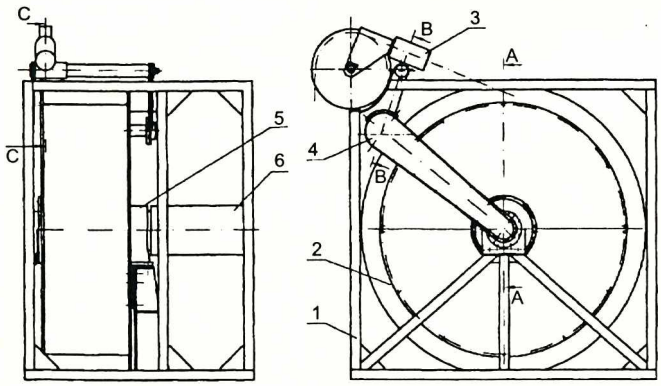

Fig.1. General arrangement of the umbilical cord winch for an underwater vehicle (The item numbers are explained in the text)

Winch framework

The winch framework is made of GRP box profiles of square cross-section filled with polyurethane-foam core. This structural solution was applied to obtain the framework weight as low as possible and to maintain its stiffness sufficient for the assumed working pull and expected loadings. The outer form of the framework is close to a rectangular prism, and all units of the winch, except for the loop layer, but together with the electronic control unit (not shown in Fig.1), are practically accommodated inside the prism. It secures to a large extent the units against possible damages especially during transporting the winch.

Inside the middle part of the framework a foundation plate is provided to fix the gear (5), and on the left-hand side of the framework (acc. Fig.1) a rack of the drum shaft bearing sectional casing. The solution makes it possible to fix easily the drum and gear units connected in advance, to the winch framework, entering to it from the top.

Umbilical cord drum together with winding mechanism

The umbilical cord drum of a relatively large diameter is intended for containing five layers of the cable-line. The large diameter of the drum resulted from the necessity of accommodating the optical fibre winder inside it. The mechanism is schematically shown in Fig.2.

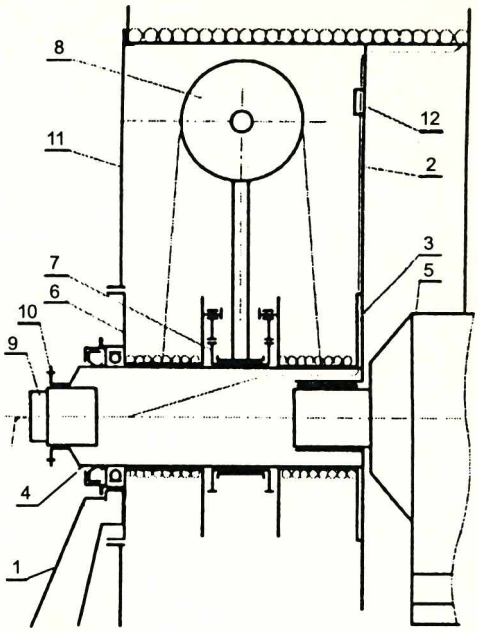

Fig.2. A scheme of the optical fibre winding mechanism (The item numbers are explained in the text)

The frame (1) and umbilical cord drum (2) are made of GRP. The outer face of the drum facing toward the gear, is fast connected to the winder rotating drum (3) and the quill shaft (4). The shaft is fitted at one end onto the gear pin (5), and at the other end, supported by the sliding bearing installed in the winder stationary drum (6) fixed to the winch framework (1).

On the shaft between the winder drums the latch wheel (7) is slide-wise fitted together with the optical fibre winding roller unit (8) fitted onto it and connected to it by friction.

The umbilical cord beneath the element (12) which fastens it to the drum, is fagged out and so arranged as to keep the optical fibre bundle separated from the electric cable bundle further inside the drum.

The optical fibre bundle of the fagged-out umbilical cord is partly reeled onto the rotating drum of the winder, then it reels around the roller and the next part of it is reeled onto the stationary drum from which it directly goes to the apparatuses, with no further manipulation. During laying-out operation of the umbilical cord by using the winch the rotating drum revolves and makes the optical fibre bundle wind onto it with simultaneous winding-out the bundle from the stationary drum. The bundle reeling around the roller makes the entire roller unit rotate around the shaft in compliance with the drum motion, but with an appropriately lower speed. During heaving operation of the umbilical cord the optical fibre bundle winds onto the stationary drum and winds out from the rotating one. The circumferential motion of the roller unit results from operation of the latch mechanisms and frictional contact. The axial force in the wound optical fibre bundle can be controlled by changing the frictional contact torque.

The cable bundle for transmitting the electric signals is introduced into the shaft interior and led up to the rotating connector (9) placed inside the chain wheel hub (10) of the loop layer and fixed at the left end of the shaft.

The interior of the umbilical cord drum is closed, at its left face, by means of the sectional cover (11) , in result the winding mechanism accommodated in it is secured against atmospheric influences, and easy access to it is simultaneously ensured.

Umbilical cord loop layer

In the winch design in question the umbilical cord loop layer is of an non-typical construction. To fulfil the earlier described demands it was necessary to elaborate an own original design. In Fig.3 and 4 the cross-sections of the loop layer are presented whose positions can be identified in Fig.1.

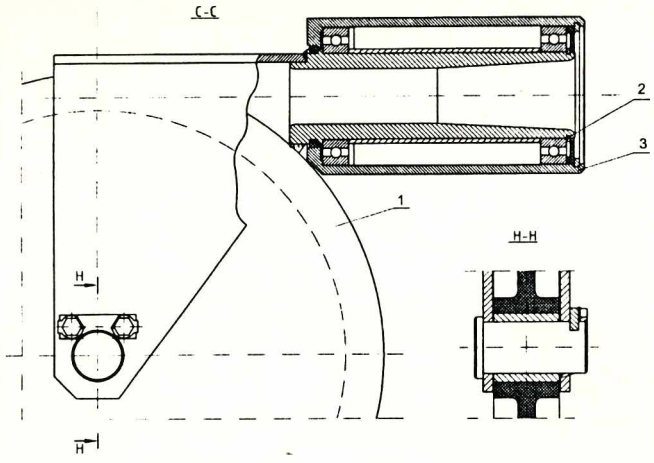

Fig.3. Attachement of the leading roller of the umbilical cord loop layer (Position of the cross-section C-C is shown in Fig.1. The item numbers are explained in the text)

The large diameter leading roller (1) was applied because of a relatively large umbilical cord bending radius. It is pivotably supported by two rolling bearings (2) placed within the sleeve (3) of the carriage of the umbilical cord layer.

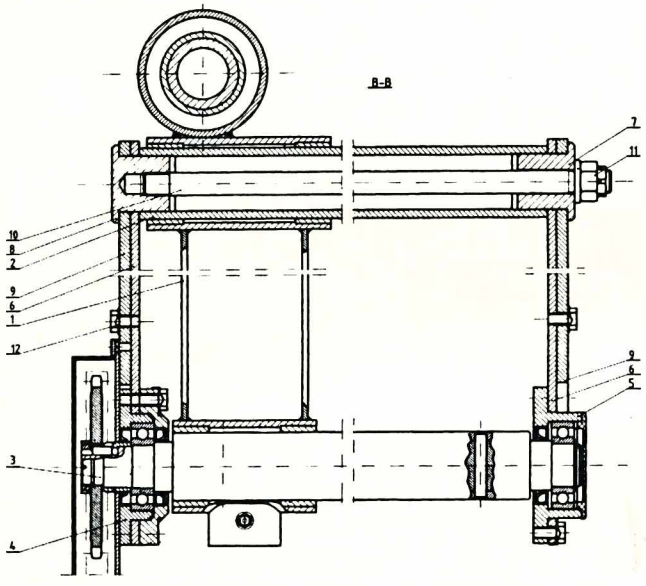

Fig.4. Umbilical cord loop layer unit (Position of the cross-section B-B is shown in Fig.1. The item numbers are explained in the text)

The roller's location shown in Fig.1. makes it possible to obtain the greatest change range of the angle of the cable-line running onto the winch. Due to installation of the winch by the assisting ship side the umbilcal cord is let to go almost vertically out from the roller which is then located over the ship's railing, down into water, without rubbing against the ship side.

The loop layer carriage (1) shown in Fig.4 is slide-wise fitted on the tubular slideway (2) as well as on the cylindrical surface of the guide screw (3). The screw is supported by the rolling bearings fitted in the casings (4) and (5) firmly connected to the arms (6). Both arms are swing-wise fitted onto the pins (7) and (8), directly between the plates (9) of the winch frame, and connected to them with the use of the screw (10) placed in the slideway, and of the screw bolts (12). To tighten the gear chain an angular displacement of the arms together with the guide screw, in respect of the slideway axis and within the assumed clearance limits, can be effected by loosing the nut (11) and bolts (12).

The solution also makes assembling and dis-assembling the entire loop layer unit and some of its elements fitted at the winch frame relatively easy and irrespective of the drum unit.

Winch drive

An asynchronous, squirrel-cage motor with brake and electromagnetic release was applied to drive the winch, and supply it through a vectorial inverter to ensure stepless control of winch parameters and stop the winch at given pull. The motor is fixed with the use of flange connection to a multiple reduction toothed gear of high reduction ratio. The gear's output pin is directly connected to the drum shaft. At the other end of the gear shaft the chain wheel of the gear of the umbilical cord loop layer is fitted.

A one-step gear with single roll-chain was sufficient due to the required low reduction ratio and transferred loading.

FINAL REMARKS

The presented design solution of the winch contains, especially in its winding mechanism, several original features which are registered for patent assignment.

A prototype of the winch was constructed. Stand and preliminary tests of it were completed with positive results at the laboratory of the Underwater Technique Department, Faculty of Ocean Engineering and ShipTechnology, Technical University of Gdańsk. Also, during sea trials the expected operational features of the winch were confirmed.

Appraised by Lech Rowiński, Assoc.Prof.,D.Sc.

BIBLIOGRAPHY

1. Roy A.: „Sidewinder – for ROVs, VDS, and Towed Arrays". Sea Technology. July, 1992

Conference

TEMPUS SEMINAR on DEVELOPMENTS IN OFFSHORE INDUSTRY

The seminar associated with a TEMPUS project obtained by Prof. W.Penney, the Maritime Faculty, Southampton Institute, was held on 12 November 1998 at the Faculty of Ocean Engineering and Ship Technology, Technical University of Gdańsk.

During the seminar the following papers were presented :

- „Developments in Offshore Industry, Offshore Ring Decommissioning" - by Prof. W.Penney, Southampton Institute
- „Certification Aspects of Decommissioning of Offshore Structures" - by Mr A.D.Muncer, Lloyd's Register (Poland) Ltd
- „Safety Estimation During Offshore Rigs Decommissioning" - by Dr. M.Gerigk, Technical University of Gdańsk.

The presented papers triggered off an interesting discussion. The seminar was attended not only by the scientific workers but also a number of students of the host faculty.