R E V I E W

of PhD Thesis of
Konstantin Iliev Chterev

Remotely operated vehicle for a continental shelf
a dissertation for the degree of Doctor of Philosophy

Member of the Scientific Jury, by order of
Scientific Secretary of the Institute of Oceanology BAS No.301/09.12.2019

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Doctoral and dissertation information

Konstantin Iliev Chterev graduated at the Technical University of Varna and received his Master's degree in Computer Science in 1990.

Konstantin Iliev Chterev has been enrolled as a PhD student in independent training in the scientific specialty: Higher education field: code 4. "Natural sciences, Mathematics and Informatics", Professional direction: code 4.4. Earth Sciences; Doctoral Program in Oceanology, Department of Marine Geology and Archeology (Order No. 91/24/2016). The topic of the thesis is Remotely operated vehicle for a continental shelf. Following the completion of the doctoral program by a decision of the Scientific Council, protocol No.6/ 19.04.2019, he has been deducted with the right of defense.

K. Chterev's career path is as follows: 1991-1995: IT engineer, Design Ltd. Varna; 1995-1995: Honorary Assistant, Technical University, Varna; 1996-1997: hardware and software engineer, Institute of Hydro and Aerodynamics, Varna; 1997-2016; smart card industry consultant Gemini 2000 Ltd, UK.

Relevance of the dissertation

The study and exploration of the offshore shelf is a topical topic, determined by the interests and needs of geology, archeology, navigation, shipbuilding and construction. In doing so, each of these areas sets different tasks and uses different methods.

The tasks of the mentioned areas are solved by different means. Remote and direct means are used. Autonomous (unmanned) and cable controlled (tether) submarines are most commonly used. Various problems are solved using unmanned submarines, mainly due to lower price and safety.

Available publications on the topic of the dissertation are in the field of navigation, hydrodynamics, stability and autopilots. There are not too many papers about the overall technical solutions and design.

There are and are using different types of submersibles with different uses and characteristics. The main disadvantage of the devices used is their high cost. The dissertation aims to develop an apparatus that is twice cheaper than the model accepted for the pattern. This implies the development of innovative solutions for the creation of the device, which, while maintaining or improving the characteristics of the device, are much cheaper.

All of the above proves the relevance of the thesis.

Degree of knowledge of the state of the problem and creative interpretation of the literary material

The PhD student is very familiar with the information available on the topic of the dissertation. There are 123 sources cited - all in English, indicating that there are no publications in Bulgarian.

It should be noted that the dissertation has a systematic character, i.e. tasks from different areas of technical science are researched and solved, which requires comprehensive knowledge and information. The reference list of used literature shows that K. Chterev has studied these areas very well.

Correspondence between the chosen research methodology and the formulated purpose and tasks of the dissertation

The dissertation work is systematic. Research and solve problems related to power, communication, rope connection, propeller, electric drive, projector lighting, camera.

The research, selection, design and operation and control of each of the above parts is carried out in a competent manner, the optimal solution is always sought, and each of these activities is justified. I believe that the chosen design and research methodologies are consistent with the goals and objectives of the dissertation and the PhD student has chosen the optimal solution.

Brief analytical characteristics and evaluation of the reliability of the material on which the contributions of the dissertation are built

In the *First introductory Chapter*, a classification of submarine drones is made. The main functions and characteristics of existing devices are given. Various parts of submersible vehicles are also considered. It is emphasized that the submarine vehicle is a complex system and the design, as well as its construction, is a complex interdisciplinary and optimization problem.

The main goal of the dissertation is set: research and creation of the optimal submersible apparatus with its requirements and creation of a workable specimen. To achieve this goal, the basic tasks have also been set: the use of a systematic approach in which the apparatus is considered, investigated, designed and manufactured as consisting of separate systems connected in a hierarchical system; design and manufacture of individual components and subsystems; testing and analysis of the test results obtained.

In *Chapter Two*, the power supply system is developed. A major problem with remote source power supply is the large drop in supply voltage. The dissertation proposes a non-trivial solution to the problem by compensating for this drop. For this purpose, an analysis of the equivalent power supply circuits (direct and alternating current) was carried out, on the basis of ensuring stable operation the basic parameters of the compensator were selected.

The *Third Chapter* deals with the basic issues of communication between the submarine vehicle and the surface operator. Two communication channels are used: high speed for video image and low speed for commands and telemetry.

The high-speed network is standard, with improvements needed for underwater applications.

An innovative communication protocol for the low-speed channel has been developed that has a number of advantages over existing networks: high flexibility; parallel high and low speed networks; low price; small number of wires, connectors; standard components; simple configuration; open to development.

The Open System Interconnection (OSI) interaction model was selected, which plays an important role in network development. The OSI model uses 7 layers, the interaction between some only between adjacent levels. Because the processor performs network management and communication, the separation of functions can be performed through a network adapter or through an interface converter.

Chapter Four elaborates and studies the cable (tether) connecting the submersible vehicle and the operator and containing power wires, which are also used for communication (twisted pair), enhancing the mechanical strength of the fibers, the addition of buoyancy control, the protective outer shell. The wave resistance of the cable is determined to provide communication.

In *Chapter Five*, the propulsion system of the submersible apparatus, consisting of a propeller and a brushless DC motor, is developed. The control of the electric propulsion of the submersible apparatus, consisting of a three-phase inverter, controlled by pulse-width modulation, has also been developed. The system for speed control and protection is also designed.

The propeller is designed for the geometry of the blades, their number and the angle of pitch. The project was made using tables, setting the angle of pitch, which was selected depending on the required device.

In *Chapter Six*, the projector lighting is designed. LED lights have been selected to be the most efficient and easy to operate in underwater operations, with the power and color required.

In the *Seventh Chapter* for video transmission, a camera based on the video stream and channel bandwidth is selected.

Chapter Eight summarizes the results of the design, testing and operation of the submarine. The operation of the individual systems of the apparatus,

the testing methodology, the results obtained and how they are set are described.

All the parameters and characteristics of the individual submarine components are given in detail. These results prove the correctness of the innovative engineering solutions adopted.

Scientific and applied scientific contributions

I agree with the main contributions made:

- An underwater power model has been created, with an equation for maximum power transmitted.
- Transfer function of series connected power units is obtained.
- A network information model and an innovative command protocol have been created to minimize delay and synchronize command flow.
- A two-wire connecting cable has been created with a twisted pair for power and communications operating up to 650 meters.
- An algorithm for controlling a brushless DC motor has been created and implemented.
- A specialized propeller was created.
- The effectiveness of an LED floodlight in water has been investigated and its color temperature has been selected.
- A camera with the necessary bandwidth capacity of the network channel has been selected and tested. The minimum bandwidth for a camera with HD quality is displayed.
- An underwater vehicle has been built and tested in marine conditions.

All these contributions belong to the group "proving with new means existing scientific fields and problems".

Results and authorship of the results obtained

On the preliminary presentation of the dissertation K. Chterev demonstrated the wholesale model of the submarine apparatus, which showed all the possibilities and characteristics stated in the dissertation. Video signal transmission over the mains was demonstrated and underwater videos were made.

The results of the dissertation are documented in detail. In the annexes of the dissertation the complete design documentation is placed, with the help of which serial production of submersible vehicles can be started.

Three publications reflect the main achievements of the dissertation:

P. Dimitrov, D. Dimitrov, V. Peichev, K. Slavova, Hr. Smolenov, Hr. Mihai-hunt, **K. Shterev**, A. Vassilev, Ancient Black Sea coastlines and conditions for human presence - Expeditions "No-2009" and "No-2011", Proceedings of the Union of Scientists - Varna, 2011, p.3-18.

Konstantin Shterev, Remote Methods for Exploring the Shelf and the Ancient Black Sea Coastlines, News of the Union of Scientists - Varna, January 2012, p.15-28, ISSN 1314-3379.

Konstantin Shterev, Remote Sensing Methods for Shelf and Ancient Black Sea Coastlines, Oceanology, Varna, 2012, Chapter 21, p.402-418 DOI: 10.13140 / RG.2.2.26406.

I believe that these publications reflect the results of the dissertation and are sufficient.

The presentation of the dissertation and the answers to the questions asked give me reason to accept that the dissertation developed is a personal work of the doctoral student.

Summary of a doctoral thesis and author's summary of the results

The Summary is 37 pages long and reflects the main content of the dissertation. It is illustrated with a sufficient number of figures and tables presenting the most important research results.

Using the results of the dissertation work developed in scientific and social practice

The obtained scientific and applied results (models, methodologies, control algorithms, underwater apparatus) were used for carrying out archeological, oceanological and geological studies in the Black Sea. It is a very good achievement to reflect the achievements of the thesis in foreign and our media.

Media appearances on the topic of the thesis:

1. 2012 National Geographic: Ancient X-Files: Great Flood and Scottish Mystery;
2. 2016 TV +: Demonstration of the functions of the Sea Turtle remote control;
3. 2017 Black Sea Newspaper: Varna Oceanologists: Made a two-day robot to explore the seabed;
4. 2017 Black Sea Newspaper: A surface drone made in Varna follows in the wake of the Flood.

Opinions, recommendations and observations

In my long-standing practice as an evaluator and reviewer, I have not encountered such a well-structured dissertation, reflecting what has been done and presenting the results obtained.

I think the greatest achievement of the thesis is the creation of an underwater vehicle with parameters and characteristics corresponding to world-wide assignments.

Conclusion

The dissertation presented is a completed scientific work, the main parts of which are published, i.e. he went through a test run. The scientific research methods used are adequate and the scientific results obtained are reliable. The main achievement is the created underwater vehicle. The dissertation contains the scientific and applied contributions necessary for the acquisition of scientific degrees. In summary, it can be concluded that the dissertation submitted meets the requirements of the Academic Staff Development Act in the Republic of Bulgaria, the Rules for the Implementation of the Academic Staff Development Act in the Republic of Bulgaria and the Law on Higher Education and Internal Affairs Academic Regulations and Criteria, adopted by the National Assembly of the Academy of Sciences of BAS, Varna, therefore I recommend to the scientific jury to award the educational and scientific degree **Doctor of Philosophy** of **Konstantin Iliev Chterev** Higher Education field "Natural Sciences, Mathematics and Informatics", professional direction: "Earth Sciences".

15 February 2020

Member of the Scientific Jury:
(prof. DrSc N.F. Djagarov)