

Submersible conceptual design using computer aids

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Abstract

Submersible design algorithm has been analysed in details. As result a program named DVCAD is proposed. It aids designer work in most creative phases of its work. While intended principally for submersibles, the approach can be adopted for work with other complex systems which can be described as well known in principles but of arrangement difficult to define. This would however require changes in expert procedures and component database. Paper describes principal problems which must be solved to balance requirements for high flexibility, easy to read graphical interface, real time operation and software as well as hardware limitations.

1. Introduction

Our long term goal is constant development of submersible design procedures. Final expression of this work is a computer program named DVCAD. It is generally an expert program were our experience as well as information available from other sources are offered to a designer in various forms. The procedure has been developed with the following assumptions in mind:

- a submersible is designed to fulfill separately defined mission tasks,
- it is composed of several hierarchically dependent subsystems,
- the subsystems are designed using information regarding existing well proven products and principles, non existing components or additional parameters are evaluated physical phenomena and dedicated design methods and reference products,
- the algorithm structure is to be open to allow design procedure to be customized,
- arrangement of components in three dimensional space and evaluation of external shape is a final step of design iteration.

As underwater technology develops permanently thorough the years, the DVCAD program as a design tool will never be finished but it greatly improves our design capabilities in every stage of its development.

2. Design procedure

The approach to design process of a submersible craft is illustrated by diagrams presented on Fig 1. and Fig 2. Generally an objective is detailed design in conceptual phase. While Fig 1. illustrates the whole algorithm. For the purpose of this procedure, a hypothetical submersible has been broken down to 36 subsystems. From functional and structural point of view they were grouped into 6 groups as listed in Table 1.

Design of a craft begins with definition of its mission task and mission profile. This allows to evaluate mission timing and later calculations of power requirement. Than it is recommended to design subsystems from the top to the bottom of the list. However, in which step a particular system will be designed is always a designer choice. It is also his decision which subsystems a craft will be composed of.

3. Subsystems

To design a subsystem, for its characteristics required, parameters of components are to be calculated and adequate components found. Fig 2. describes one of base tasks in design process which is selection of components. These can be selected from among devices available on the market or devices known from other sources that can be used as a reference. Both types of components are listed in the program database. Alternatively this element can be created by a designer itself and introduced to the project as a "black box".

Selection of components can be substantially aided by means automatic or semiautomatic procedures, which present designer well proven solutions.. For most of subsystems, several standard solutions were defined. This can be illustrated by variable ballast which is offered in different versions for water oil and solids used as ballasting material (Fig 3.) Standard solution offered is usually composed of diagram schematics and list of minimum number of components required for subsystem to operate properly. An example is shown on Fig 4..

4. Vehicle general arrangement and graphics

While selection of subsystems can be aided to very extend, creation of a craft arrangement is purely designer`s task. Using graphical screen he locates components in three dimensional space according to his imagination or/and external limitations. However, even in this phase his work is efficiently aided by real time calculations of weight, buoyancy, centers of weight and buoyancy as well as resultant inclination angles. Calculated values of these parameters are instantly displayed on graphical screen.

From design "technology" point of view we try to find optimum methods of graphical presentation of results and interaction between computer and designer. Main problem is to find balanced compromise between graphical presentation of an element particulars and computer processing performance. The latter being expressed as hardware price. From the beginning program has been equipped with its own graphics. This graphics is greatly simplified to reduce processing time. This allows real time presentation while changing element location. Real drawback of this solution is the need for adequate drafting program for ready to use document generation. Beginning from the low end we had evaluated suitability of Autodesk`s AUTOCAD but without success. It is not really three dimensional and communication with our program proved to be difficult. At the moment, Parametric Technologies`s PRO ENGINEER is being evaluated. DVCAD program itself, developed initially for PC AT technology is being transformed to Windows environment now. While we would like to make the program to be platform independent, the PC, Windows and Pro Engineer worlds must be cleared first. For this reason we concentrate on subsystem design procedures development now.

5. DVCAD and present projects

Current projects, such as characterized by L. Matuszewski in his paper presented on this conference, are excellent the "test beds" suitable for permanent development of DVCAD program. This time the submersibles are comparatively simple in function, with limited number of subsystems. This allows us to concentrate on selected areas such as energy source, propulsion and control components. Again, to illustrate our approach to submersible design please find that, for example, we are not actually designing software functions of AUV control system. Instead, within DVCAD procedure, we try to find what hardware is required to accomplish the task.

This calls for evaluation of the following parameters:

- Number of separate control tasks that requires separate CPUs
- Number of digital inputs/outputs
- Number of analog inputs/outputs
- Multiplexing compatibility

- Processing power in separate tasks
- Memory requirements

While these parameters are calculated or found other way, a reference hardware can be selected. With commercially available range of cards, it is than possible to find suitable bus, number of slots required and create list of boards and ancillary components. Finally, parameters important to design of other subsystems such as energy consumption, heat generation, weight and volume can be calculated. These parameters can be used in conceptual design of related subsystems and the craft itself.

As with other subsystems, semiautomatic design procedure is of great value for a designer as this offers significant reduction of time required to create initial design. The approach is feasible because, even in the case of rapidly developing electronics, many components such as I/O, signal conditioning, board sizes and cable terminations evolves slowly.

Table 1. Submersible subsystems break down

Group 1. Submersible work systems and instrumentation

- 1.1. Observation equipment
- 1.2. Manipulators
- 1.3. Hydroacoustic space Visualization equipment
- 1.4. Oceanographic instrumentation
- 1.5. Communication equipment
- 1.6. Navigation equipment
- 1.7. Emergency equipment

Group 2. Diving and personnel transportation

- 2.1. Divers and transferred personnel
- 2.2. Tools
- 2.3. Diver life support
- 2.4. Diving chambers
- 2.5. Mating skirts

Group 3. Control system and crew

- 3.1. Control system
- 3.2. Crew
- 3.4. Control panels
- 3.5. Isobaric compartments life support system
- 3.6. Pressure vessels for crew and controls

Group 4. Motive

4.1. Surface buoyancy

4.2. Variable ballast

4.3. Trim

4.4. Propulsors

4.5. Hydroplanes

4.6. Anchors

Group 5. Energy supply

5.1. Main secondary sources of energy (batteries)

5.2. Main primary sources of energy (Heat engines, fuel cells nuclear)

5.3. Umbilicals

5.4. Emergency sources of energy

5.5. Power distribution and energy transformers

Group 6. External

6.1. Frame

6.2. Fairing

6.3. Bumpers

6.4. Floats

6.5. Ballast