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Mathematical modeling of the processes occurring in gas mixtures used in hyperbaric facilities

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Abstract

Diving is one of the domains in which humans are facing a totally different environment from that in which they live normally. Depending on the purpose of the underwater mission and the diving depth to be reached, some special installations and breathable gas mixtures are used to sustain life in such an environment. Diving chambers are hyperbaric facilities used for forming, training, testing and in unfortunate circumstances rescuing divers. The paper deals with the mathematical modeling of the phenomenon taking place in a hyperbaric facility during the compression and decompression phases of a saturation diving. For this purpose the authors of the present paper have conceived a mathematical model with which, the values of the main quantities forming a breathable gas mixtures delivered to the divers are established for each diving depth during the entire mission.

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1. Background and aims

One of the domains using hyperbaric facilities is the diving area. The hyperbaric processes are those developed at pressure values higher as the normal one (atmospheric pressure). Regardless if professional divers are operating in scientific, industrial or military field they are periodically trained and tested in high pressure conditions. For accomplishing safely any mission, the deep diving procedures impose the necessity of using hyperbaric equipment like the diving (hyperbaric) chambers (figure 1).

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For professional diving missions air, which is used mostly for recreational scuba diving, is replaced with other breathing mixtures made from two (binary mixtures) or three (ternary mixtures) gases. One of the gases is oxygen and the others are inert gases. The role of the inert gases in the mixture is to counteract the neurotoxic effect of oxygen breathed at high pressure values.

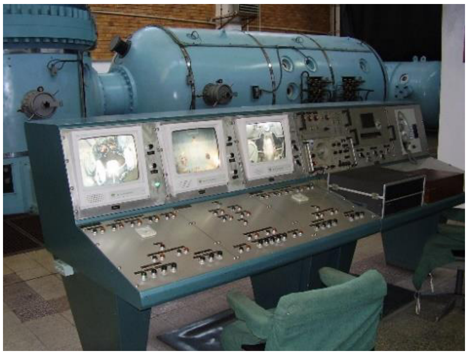


Fig. 1. The diving chamber and the associated control panel owned by the Dive Center of Constanța

The major problems using gas mixtures for deep diving are related to the purity of the compound, the ratios between the components, the effect of oxygen breathed at high pressures and as a consequence, the decompression procedure. Thus, breathing mixtures are made in diverse ratios of the constituent gases. Their amount is in close relationship with the diving depth and thus, with the partial pressure of the gases.

The common inert gases used for deep diving are nitrogen and helium. Their role is to dilute oxygen and together to form a binary breathing mixture called NITROX (NITRogen - OXigen) respectively HELIOX (HELIum - OXigen) or all three together a ternary mixture named TRIMIX.

The amount of each gas that from the mixture is close related to the characteristic quantities of each of the gases and the diving depth.

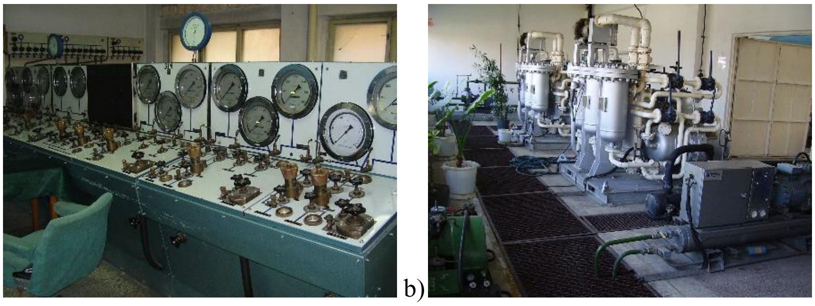
a)  b)

Fig. 2 Hyperbaric laboratory equipment. (a) pressurization/decompression command panel of a diving chamber system; (b) air treatment plant.

A major role in operating any hyperbaric facility plays the diving technology which is linked to the mission particularities. Manufacturing of breathing mixtures is a very complex process which must be done very carefully and following a series of precise rules.

The processes related to the compression and decompression phases for a unitary saturation diving are achieved by a rigorous monitoring of the procedures concerning the breathing gas mixtures composition present in the hyperbaric chamber and the compression and decompression phases at different moments.

The authors of the present paper have conceived a mathematical model in order to simulate the compression and decompression procedures of any saturation diving mission. Thus, based on this mathematical model the phenomena taking place in a hyperbaric facility (diving chamber) during a deep diving mission can be theoretically simulated.