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The Future Deep Underwater Space Station

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Abstract: The purpose of the study is to provide an idea of developing an underwater space station. Though the ocean covers about 71% of the surface of the Earth and holds tremendous amount of resources, it is still an unknown field for human beings. With the depletion of natural resources on the land, there is an urgent need to explore and exploit the ocean, but this process is constrained by the ocean engineering equipment and technology. The study proposed a sketch of a deep sea space station, which is similar to the International space station. The station can applied to observe the ocean environment, generate power from the ocean energy, manage to mine resources, control underwater factories and underwater vehicles, be habitable for staff, making another space for human.

Keywords: Ocean exploration and exploitation, ROV, underwater factory, underwater living, underwater space station

INTRODUCTION

The twenty-first Century will be a century of ocean, which can not only provide human with living space, food, minerals, transport and water resources, but play an important role in the development of new energy sources. What' moiré, the oceans are crucial for the regulation of the earth's climate.

The total area of the Earth is about 500 million square kilometers. The land area is about 149 million square kilometers, accounting for only 29% of the surface of the earth and the sea area is about 361 million square kilometers, constituting about 71% of the Earth's surface, as described by Domingo (2012). It is a huge blue treasury. The oceans hold the largest amount of species, up to hundreds of thousands of plants and animals, about 80% of the total species on the Earth, a large portion of which are yet unknown to man. Under the condition that the ecological balance is not disrupted, the edible aquatic resources from oceans can be exploited about 3 billion tons yearly. Oceans contain vast quantities of materials that presently serve as major resources for humans (Water Encyclopedia, 2012). It is mined for minerals, like salt, sand, gravel and some manganese, copper, nickel, iron and cobalt can be found in the deep sea. All minerals on the land can also be found in oceans. It has been drilled for crude oil, coal and natural gas.

The ocean plays a critical role in removing carbon from the atmosphere and providing oxygen. It regulates Earth's climate and moderates the Earth's temperature by absorbing incoming solar radiation. The ocean is an increasingly important source of biomedical organisms with enormous potential for fighting disease. These are just a few examples of the importance of the ocean to life on land. Explore them in greater detail to understand why we must keep the ocean healthy for future generations (Marinebio, 2012).

Ocean is the familiar environment for us. It not only provides ample natural resources, but also is used for transportation and a treasured source of recreation. The research and development of underwater world are processing gradually during recent decades, but the extreme conditions, such as high water pressure, invisibility and non-oxygen become great barriers for human to access directly (Yao and Wang, 2012). Because of the awful operational environmental, the technologies and equipments for ocean exploration and exploitation should meet special requirements and some of them have been developed and put into underwater operation.

The growing interest in the fields of offshore natural resources, military and ocean scientific investigation has resulted in the development of many new approaches for improving the underwater working capability and underwater technology. Underwater manipulators are important equipments for many underwater vehicles and they play a crucial role in underwater applications. Mohan and Kim (2012) researched an autonomous underwater vehicle-manipulator system (UVMS) with six degrees of freedom (DOF) underwater vehicle and a 3-DOF underwater manipulator. Boyer and Lebastard (2012) proposed a solution to the underwater exploration of

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objects using a new sensor inspired from the electric fish. Hwang and Seong (2012) studied a simultaneous localisation and mapping scheme which can be applicable to small military unmanned underwater vehicles. Autonomous under water sensor networks can be deployed to perform collaborative monitoring tasks in oceanic environment to communicate with each other via acoustic signals, report the geographical origin of events, data tagging, assist in target tracking, geographic aware routing, node tracking and to administer the sensor network and evaluate its coverage (Naik and Nene, 2012). Underwater welding is an important tool for underwater fabrication works to repair failures of offshore structures, such as oil drilling rigs, pipelines, platforms (Wang *et al*., 2009). Several underwater welding methods have been successfully applied. Underwater cutting methods are also developed to maintain and repair underwater pipelines. Such equipments and techniques are underwater diamond wire saw (Cao, 2008)**,** guillotine pipe saw (Gong *et al*., 2009)**,** laser cutting technique (Jain *et al*., 2010), explosive cutting (Yan *et al*., 2000).

The scope of undersea exploration includes the physical and chemical properties of seawater, all manner of life in the sea and the geological and geophysical features of the Earth's crust. Underwater exploration near the surface and near the shore is an ancient form of earning a livelihood and enjoying the pleasures of the water**,** but the deep-sea exploration is a recent phenomenon, because technological developments have been essential to the survival of human beings in deeper water. Advances in the technology of oceanography and greatly increased interest in the vast and virtually untapped resources of the ocean floor led to use the seabed as a new environment for military installations. For further exploration and exploitation of the ocean to make it better serve the human beings, it is necessary to build a deep underwater space station, similar to the International Space Station (ISS). In the study, the functions of each part of the underwater state space are described and the structure of such an underwater state space is proposed.

INTERNATIONAL SPACE STATION

The ISS is undoubtedly and particularly well suited as a reference for developing a deep-sea space station. The ISS (Fig. 1) was intended to be a laboratory, observatory and factory in space. It was also planned to provide transportation, maintenance and act as a staging base for possible future missions to the Moon, Mars and asteroids (NASA Report, 2009). Recently, the ISS was given additional roles of serving commercial, diplomatic and educational purposes. The ISS is the largest, most complex international scientific project in human history and our largest adventure into space to date (Jacobs, 1996). As a research outpost, the station is a test platform for future technologies and a research laboratory for new, advanced industrial materials, communications technology, medical research and so on.

Fig. 1: A photograph of the international space station

The ISS is a habitable artificial satellite which is maintained at an orbital altitude of between 330 km (205 mi) and 410 km. The ISS serves as a microgravity and space environment research laboratory in which experiments in biology, human biology, physics, astronomy, meteorology and other fields can be conducted (John, 2008; Gary, 2006). It is suited for the testing of spacecraft systems and equipment required for missions to other planets. The ISS is composed of pressurized modules, external trusses, solar arrays and other components (John, 2008), which have been launched by America and Russia. The ISS programme is a joint project between five participating space agencies: NASA (National Aeronautics and Space Administration), the Russian Federal Space Agency, JAXA (Japan Aerospace Exploration Agency), ESA (European Space Agency) and CSA (Canadian Space Agency) (Gary, 2006). The station is divided into two sections: the Russian orbital segment and the United States orbital segment, which is shared by many nations. The critical systems of ISS are the atmosphere control system, the water supply system, the food supply facilities, the sanitation and hygiene equipment, fire detection and suppression equipment and communication system (Wikipedia, 2012a).

FUNCTIONS OF DEEP UNDERWATER SPACE STATION

The deep underwater space station is a kind of manned deep-sea vehicle equipment not influenced by high winds, waves, currents, severe storms, can directly operate working tools and equipments in deep-sea under all weather to carry out underwater engineering, exploration and exploitation of resources and marine scientific research in long period. The development of a deep underwater space station has great significances to the exploitation of deep-sea resources, the improvement of equipment techniques of deep-sea engineering, the detection of deep-sea ecology and environment as well as the potential military application.

- **The exploitation of deep-sea resources:** The deep-sea resources mainly consists of oil and natural gas including natural gas hydrate, deep-sea minerals and biological resources in deep-sea, among which the oil, the natural gas and the minerals in deep sea are considered as a reliable sources for human race to get rid of the increasingly serious energy risk. It is estimated that the reserve of oil and gas located in deep water and minerals buried in ocean floors can supply all factories on the earth for several centuries (Fang *et al*., 2000). The increasing population and the exhaustion of readily accessible terrestrial deposits undoubtedly will lead to broader exploitation of marine resources and increasing extraction directly from ocean. This will be an important direction of the development of deep water economy.

Deep sea creature refers to those organisms that live below the photic zone of the ocean. These creatures must survive in extremely harsh conditions, such as hundreds of bars of pressure, small amounts of oxygen, very little food, no sunlight and constant, extreme cold (Wikipedia, 2012b). Because of their living environment, they form its unique creature structures and metabolic mechanisms so. The active substances in their bodies have wide application prospects in such fields as food processing, medicine and so on. At the same time, the ocean plays an important role in scientific research to discover the origin and evolution of life and the adaptability of creatures to special environment.

The current exploitation of deep sea resources is always affected by geographic location and hampered by technological constraints. The process is difficult as deep sea resources are not easy to bring up to the surface, but it will probably become a huge industry once technology evolves to solve the logistical problem. A deep sea space station can supply a platform for the exploitation of marine resources.

- **The development of offshore engineering equipment technology:** The ocean environment is different from the land environment, for it has special environment, like complex ocean topography, high pressure, strong absorption of electromagnetic wave by water, low acoustic positioning precision, little sunlight, seawater density change. A wide variety of mineral resources have been found on the seafloor. These resources can be divided into four general categories: granular sediments, placer minerals, hydrothermal deposits, hydrogenetic minerals. Granular sediments are transported to the sea by rivers and glaciers and are sorted according to size by wave action on the coastline (Ocean Energy and Minerals: Resources for the Future, 2012). They have different distribution states and contain different minerals. It is difficult to mine the deep sea resources.

In recent years, owing to the slash on the exploitation cost of offshore resources, offshore fields have been built by different countries. This boosts up the demand on ocean engineering equipment and drives attention to the exploration and exploitation of offshore natural resources. The energy industry, military and marine navigation fields require ocean engineering skills. The invention of thousands of oceanographic instruments and devices, including computer and satellite linked buoys and floats, sediment traps, ocean seismometers, underwater video equipment, acoustic measuring devices and underwater vehicles, such as submersibles and remotely operated vehicles, has changed the way we study and exploit the ocean. Because technology is central to the field of ocean engineering, the high-end equipment manufacturing is playing an important role in deep sea resources exploitation. The need for production capability in deeper water depths further offshore has pushed the industry to develop new and better equipment and techniques. The ocean exploitation has become one of the major national projects for many countries. As a result, the ocean engineering equipment market has emerged to be a booming business.

- **Detection of deep sea ecology and environment:** The ocean environment is a vital part of natural environment. Pollution, over-harvesting and general habitat destruction are seriously impacting the vast, yet extremely fragile, marine environment. It occurs during the ocean exploitation. Without considering the capacity of marine environment, mining the ocean can be devastating to the natural ecosystems. The ocean floor climate, a kind of marine climate and similar to the continent climate, changes with time and location. It has special influence on oceanic climate, especially the harsh weather conditions formed by tsunami caused by ocean volcanoes and cliffs.

Creatures that live hundreds or even thousands of meters deep in the ocean have adapted to the high pressure, lack of light and food source and low temperature. Since at such deep levels, there is little sunlight, photosynthesis is impossible as a means of energy production and not enough oxygen to support a fish living at higher levels. To survive, these creatures have much slower metabolisms and therefore can survive using little oxygen.

Though the exploration of human on ocean is less than 1%, the ocean environment has been seriously destroyed, especially the impact of pollution, ocean exploitation and climate change on marine creature habitats. With the development of technologies, ocean natural resources can be mined; millions of tons of fish will be captured. In addition with the climate change, those make the ocean confronted a great and urgent challenge.

The deep sea space station provides scientists with a mobile platform, which can be used to observe the mysterious ocean world, making scientists enable to study the link between global warming and the ocean, investigate the deep sea creature, research on ocean ecosystem and monitor the marine environment.

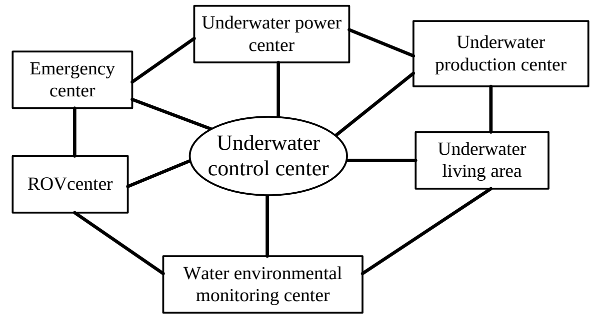

Fig. 2: The configuration of deep sea space station

THE CONFIGURATION OF DEEP UNDERWATER SPACE STATION

A deep sea space station can be used to exploit marine resources, monitor ocean environment, as well as life and emergency. Its configuration, shown in Fig. 2, is mainly composed of underwater power center, underwater production center, underwater living area, underwater environmental monitoring center, ROV center, emergency center and underwater control center, to achieve resources exploitation and exploration, ecosystem and environment detection, underwater production and monitoring, personal settlement.

- **Underwater power center:** The ocean contains vast amount of energy in forms of thermal energy, mechanical energy and salinity. They are all renewable energy. Thermal energy comes from solar radiation and mechanical energy from the waves, tides and currents. The most distinct form of ocean energy is the energy from ocean surface waves, which are generated by wind action. The tidal energy is produced by height changes in sea level, caused by the gravitational attraction of the moon, the sun and other astronomical bodies on oceanic water bodies. The rise and fall of the tide offers the opportunity to trap a high tide, delay its fall behind a barrage or fence and then exhaust the potential energy before the next tidal cycle. Tides cause kinetic movements; that is, the movement of ocean water volumes, creating tidal current energy. The ocean thermal change can also be used to produce electricity. For salinity power, the chemical difference generates a voltage, converting this energy into electricity (Ocean Energy Systems, 2012).

  The underwater uses the tremendous amount of energy in the ocean to generate electricity to supply the whole system.
- **Underwater production center:** The center is based on automated factories whose production is controlled by computers. It generates heat, high pressure air and fresh water for the space station and is responsible for mining the ocean floor for diamonds, gold, silver, metal ores like manganese nodules and gravel mines. Other resources exploitation is also carried out in the center. The task of the center includes mine, process, transportation and storage.
- **Underwater living area:** The living area provides the staff working in the underwater space station with a space for their lives including diet, daily rest, health, fitness, entertainment, solving their logistical supply.
- **Underwater environmental monitoring center:** The center monitors ocean climates and creatures, sea floor volcanoes, seawater temperature, changes of seawater density and salinity in real time. All those information are essential for the space station and are provided to other centers.
- **ROV center:** ROV (Remotely Operated Vehicle) is regarded as the most important basic technology in the exploitation of marine resources. It is a tethered underwater vehicle commonly used in deepwater industries and linked to the space station. They usually equipped with manipulator arms and additional equipments, including sonars, magnetometers, cameras, a manipulator or cutting arm, water samplers and instruments that measure water clarity, light penetration and temperature, are added to expand the vehicle capabilities. They can do many tasks that human can not do.
- **Emergency center:** Emergency center aims to solve unexpected events and improve the space station public security, maximizing the reduction and prevention of sudden incident and the resulting damage and ensuring the safety of life and property of the space station. It is responsible for environmental emergency, communication notice and emergency alarm. It also investigates serious environmental pollution and construction accidents, evaluates the losses of accidents.
- **Underwater control center:** The underwater control center is the core component of the whole

space station, working with other centers and monitoring the whole system via communications. Its functions mainly include: to coordinate, manage, control and monitor other parts with reliably signals transmission; to be responsible for the communication between underwater and the surface; to control and operate the ROVs, automated factories other remote control working tolls. All data from other centers will be collected and analyzed in the center. At the same time, the control center feedback useful information for other centers.

CONCLUSION

The deep sea is now still a mysterious field for human to exploit. However, it is an important resource for human beings. Like outer space exploration, the deep sea exploitation and exploration has great attraction and challenge.

For China, during its 12^{th} and 11^{th} Five-year Plan, some researches on deep sea space station have been carried out. Unmanned submersible vehicles, acoustic control, docking technology and surface supporting ship have been studied. China will continue to carry out small deep space station research.

The Jiaolong, China's manned submersible named after a mythical sea dragon, reached 7,020 meters below sea level during its dive into the Mariana Trench in the western Pacific Ocean. The Jiaolong enabled China to join the ranks of deep-sea faring countries. The United States, Japan, France and Russia currently lead the world in the development of deep-sea exploration technology, each possessing their own submersibles and support bases.

In China Beijing International High-Tech Expo, a model of small scale deep-sea mobile workstation was debuted on May 23, 2012. The workstation will be finished during the 12^{th} Five-year Plan. It can work in long period under all weather at 1000 meters beneath the sea surface to provide a platform for scientific research on ocean and its resources exploitation.

The increasing need for natural resources to meet the economic development in China urges China to develop deep-sea engineering. In 2011, China imported 250 million tons of crude oil and 28.18 billion cubic meters of natural gas. The external dependences are 55.2% and 21.56%, respectively. The contradiction between energy supply and consumption is becoming serious. However, the South China Sea has been proved to hold huge oil, gas and mineral reserves beneath its seabed. The great challenge to mine those resources is the deep-sea engineering equipments and technologies.

The ocean is playing a vital role in competition among countries. The deep-sea space station, as a forefront and core technology of ocean engineering, reflects the level of science and technology and economy of a country. Since developing such an underwater space station is an immensely complex system, it can take international cooperation like the ISS. It will enable human to further know about the ocean and exploit the ample resources for human beings.

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