

Development of New Pressure Vessel With New Material for Underwater Vehicle

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ABSTRACT

We are developing several underwater vehicles. There is development of pressure vessels by new material as one of the element technology to develop underwater vehicles. In the case of electronics to use underwater, defer from when they used in the land, they need solid pressure vessels. The reason is because it has to protect electronics from water and water pressure. Particularly, water pressure is increasing according to depth, so the pressure vessels need to make strong. But strong vessels are very heavy weight. It is not good at treatment. Especially, a heavy pressure vessel makes energy efficiency worse for a deep and long cruising type vehicle. So we started research and development of magnesium alloy to apply as a new structure material to lighten of pressure vessels. Our development target is stronger than Titanium alloy (Ti-6Al-4V) of ratio strength (tensile strength/specific gravity) as strength of a pressure vessel. The Ti-6Al-4V is usually used lightweight and strong material for pressure vessel.

In this paper, we report several results of estimation tests. We carried out estimation test about test pieces. And we made a small pressure vessel and carried out estimation tests about strength about this pressure vessel.

KEY WORDS: New Material, Magnesium, Pressure Vessel, Underwater Vehicle

INTRODUCTION

Recently, many underwater vehicles and underwater observation machines are working on all over the sea. All of them are controlled by electronics. However, every electric elements cannot work in the sea to short-circuit, and many electronic elements are broken by high pressure. So, solid pressure vessels are necessary to use electronics in underwater. The pressure vessels are required strong as endurance for high water pressure, lightweight, endurance for corrosion, keep from rust and so on. Particularly, water pressure is increasing according to depth, so the hull of pressure vessel needs to increase thickness to make strong. But strong pressure vessels became heavy weight. It is not good with an aspect of energy efficiency for a deep and long cruising range underwater vehicle. Therefore light and strong structure material is important.

There is a plan to construct a new deep and long-long cruising range type underwater vehicle (Aoki et al) in JAMSTEC. Usually, Titanium alloy, Aluminum alloy and High Tensile Strength Steel are used as a material of

pressure vessel. However, we decide to develop a new pressure vessel by using lighter and stronger another material. The reason is because it is necessary to lighten weight to cruising in a long range as far as a long cruising type vehicle by limited energy. Thus lighter and stronger material is need than conventional materials. Our development target is 1.3 times stronger than Titanium alloy (Ti-6Al-4V) at ratio of (tensile strength)/(specific gravity) as strength of a pressure vessel.

In this paper shows results of development about two kinds of material.

ESTIMATION OF TEST PIECES (FIRST STEP)

At first, we prepared standard material (Ti-6Al-4V) and two kinds of new materials as test pieces. Then we carried out mechanical tests for characteristic of these materials. We show these materials which carried out mechanical tests below.

- 1) Standard Material : Ti-6Al-4V (Titanium alloy, forging)
- 2) Test Material 1: Ti-V-Fe- (Titanium alloy, forging)
- 3) Test Material 2 : Mg-La- (Magnesium alloy, casting)

The test piece of titanium alloys such as Ti-6Al-4V and Ti-V-Fe- were cut out from a board. Titanium alloy boards are shown in figure 1. The test pieces of magnesium alloy was cast each. Because the magnesium alloy that we used by this development was still an initial stage of a study (Kawamura et al), so we were able to cast only size of test peaces. The test pieces of magnesium alloy are shown in figure 2. The reason why we chose Magnesium: 1) Magnesium is the most lightweight material. 2) We want to make new pressure vessel by using new material not Titanium, Aluminum and high tension steel that usually use for underwater. 3) The Japan Steel Works Ltd. is a maker of magnesium alloy, and they developed new magnesium alloy that has high strength at very small test piece level at the beginning stage. So, we decided to challenge to use the magnesium alloy for underwater.

Three kinds of materials were carried out two tests such that tension test and Charpy impact test. The estimation tests was minimum course , because we have few budgets for development.

-Tension Test

The test that a test piece is pulled and broken, then strength and ductility are estimated. 0.2% proof stress, tensile strength, elongation and reduction of area are measured. In this study, aim is developing materials of high ratio strength, so we assumed the value of 0.2% proof stress and tensile strength contrast of comparison. Figure 3 shows a state at tension test of titanium