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A Proposal of Using Fiber reinforced Foamed Urethane as Structural Material for a Robot

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Fiber reinforced Foamed Urethane (FFU) is a kind of artificial wood and is made of the plastic foamed urethane resin reinforced by long glass fibers. Due to excellent weather resistance, good machinability , lightweight and cost effectiveness, FFU is used as a synthetic sleeper. This paper proposes to use FFU as structural material for building a robot. Initial machining tests are also shown.

1 Introduction

High strength material is always pursued to improve a robot physical capability. Light weight material is also desirable especially for a mobile robot because the weight of the robot directly governs to overall performance of the robot.

Carbon Fiber Reinforced Plastic (CFRP) is one of the best material so far for robot structural parts and is utilized for high speed pick-and-place robot [1], legged robot [2] and aerial robot [3] to reduce weight and inertia of the robot.

However, its usage is rather limited because off-the-shelf CFRP materials are basically sheets or pipes. It requires extremely high cost when we design custom made parts which have arbitrary curved structure because it needs molding in an autoclave.

In this paper, we propose to utilize Fiber reinforce Foamed Urethane (FFU) [4] which is originally developed for a building material. FFU has light weight, ease of machining, excellent weather resistance, suggesting morphological stability in an outdoor environment. To the best of our knowledge, this is a first trial to utilize FFU to build a robot.

2 Characteristics of FFU

Material developer [5] describes FFU as follows. "FFU is the thermosetting resin foam reinforced by continuous glass fibers. The continuous glass fibers are homogeneously dispersed up to the mono-filament condition, and the foam maintains completely closed cell." Since FFU is made of foamed urethane, it contains a lot of air inside and consequently becomes light weight. Mechanical strength is reinforced by long glass fibers. Basic characteristics are listed as follows.

- Light weight (0.4-0.74 g/cm^3)
- High strength compared with natural wood
- Low cost
- Good machinability
- Non-water absorbency
- High chemical resistance
- High morphological stability

The density of FFU is 2/3 of ABS plastic and 1/2 of POM plastic, and FFU can float on water. Strength is not superior to CFRP because FFU utilizes grass fibers. However, FFU is better than natural wood. FFU is also cost effective which is approximately 1/3 of POM. The most distinguished feature of FFU is good machinability. Machine works are easily applicable. Thus, there is a possibility to make various light weight parts by using conventional machining such as drilling, milling and lathe.

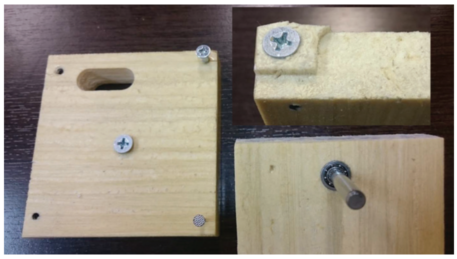

Fig. 1 Machining tests

FFU is mainly used for sleeper for railway, indicating excellent weather resistance. Therefore this material can be used for field robots.

3 Initial Machining Tests

In order to evaluate FFU for a robot structural part, we carried out initial tests such as 1) drilling, 2) milling and 3) using nails and wood screws. Figure 1 shows the results of these tests. As for drilling, the cutting force was almost same as natural wood and very easy to make a hole. Two ball bearings were inserted to make it a shaft holder. The shaft rotated quite smoothly without a play. As for milling, we succeeded to make a oval hole. However cutting surface became fluffy when the milling surface was orthogonal to the fiber axis. Nail and wood screw fixing were quite good even when the 3 mm wood screw screwed to the point where only 5mm away from the edge of the test material. However, if the screw screwed parallel to the fiber axis, the material easily tore, suggesting that we have to be careful to choose fiber direction and principle force direction.

4 Conclusions

In this paper, we propose to utilise FFU for a material of structural parts of a robot.

References

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