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Scientific Work

PLA Additive Manufacturing Chassis Parts for Small Scale Rovers

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Contents

1 Abstract

In the context of the Canadian International Rover Challenge, teams made up of students from universities from diverse countries must build a prototype rover to simulate what it would be like as an early colony on an extraterrestrial planet. The rovers will be faced with completing various tasks that future rovers will be expected to perform. These include traversing varying terrain, autonomous operations, operating a dexterous arm and much more!

The chassis of each rover is a critical component that must be robust and reliable and must be of easy manufacture, as the teams have limited resources and time to build their rovers. Due to the prototypical nature of the rovers, a lot of custom parts are needed. Traditional manufacturing methods such as milling and turning can be used to produce these parts, but are time-consuming and require expensive machinery, which is not always available to student teams.

3D PLA printing parts with "hobby grade" 3d printers is a great way to prototype small batches of parts, but the produced parts are sometimes considered fragile, or precise enough due to the nature of the production process. However, modern-day 3D printers have come a long way, and the quality of the parts produced by these machines has improved significantly. Research is needed to determine if such a workflow is a viable option for the production of rover parts for such a project, or if indeed, more traditional manufacturing methods are still better suited for such an application.

2 Introduction

3 Results

Research Findings: This section has been split into nine sections to simplify the comparison of the different materials, and the respective manufacturing workflows associated with them, as well as the properties of the materials themselves. The nine sections are as follows:

- Tensile Strength
- Elasticity
- Surface Quality
- Thermal Properties
- Precision
- Cost
- Time Consumption
- Complexity in Manufacturing Process
- Environmental Impact

3.1 Tensile Strength

A key attribute that determines a material's capacity to resist pulling forces without breaking is its tensile strength. A number of differences were found when 3D-printed PLA (polylactic acid) and 6061-T6 aluminum were compared, emphasizing the distinctive mechanical properties of each material.

PLA is a bioplastic composed of renewable resources like corn starch and from a technical data sheet made by BCN3D Technologies, an ultimate tensile strength of 70 MPa was reported from them. The value shown is the highest possible stress PLA can withstand before breaking down to tension. Due to PLA has a relatively lower tensile strength, being a polymer and having a layer-by-layer deposition while 3D printing, can result in the formation of weak areas along the contact points. Despite its lower tensile strength compared to metals, PLA can be used in situations where mechanical strength is not as important and instead can be used when specified components have to be made. Examples of what components were made through 3D printing are shown below.

On the other hand, according to a material data sheet published by ASM International , 6061-T6 aluminum, a commonly used alloy in several industrial applications, showed a significantly greater ultimate tensile strength of 310 MPa. The composition of the alloy and the T6 tempering process, which includes heat treatment and artificial aging to improve the mechanical properties of the alloy, is responsible for its high tensile strength. For structural components and applications that need high amounts of strength, 6061-T6 aluminum is the ideal material due to its better tensile strength. A good example can be the motor-wheel shaft which transmits torque from the motor to the wheel hub and from the wheel hub to the wheel. In addition, there is the motor cover which supports the weight of the rover. This can be shown below.

The wide range in tensile strength between PLA and 6061-T6 aluminum shows the need for choosing a material according to the particular requirements of a given application. PLA has advantages in terms of manufacturing and environmental impact (mentioned in Section ….), but its mechanical limits restrict its application to less demanding structural tasks. Whereas, when mechanical strength is crucial, 6061-T6 aluminum's durability and reliability make it essential. This comparison emphasizes how important it is for engineering and industrial projects to consider both mechanical qualities and application requirements when choosing materials.

3.2 Elasticity

The Young's Modulus and Elasticity between PLA and 6061-T6 aluminum showed differences when compared to one another, which suggests their different uses and stress resistance.

Based on BCN3D Technologies' datasheet o PLA (link), the material has a Young's modulus of 3120 MPa (or roughly 3.2 GPa). The fact that PLA is a semi-crystalline polymer that was intended to be flexible and simple to produce can be seen in its low modulus score (link). The elasticity of PLA was moderate, meaning that it could deform under stress and return to its former shape when the load was released.

However, with certain components, the 3D-printed PLA could make it brittle. Therefore, it was appropriate for low-stress applications and prototyping where high rigidity was not a requirement. Elasticity in a material helped so that it could absorb some impact without permanent deformation, making it useful for lightweight and less structurally demanding parts. 6061-T6 aluminum had a much greater Young's modulus of 68.9 GPa (link). Compared to PLA, 6061-T6 aluminum was stiffer and had a smaller chance to deform under stress, as shown by its higher modulus.

The material was applicable in instances where rigidity and endurance were required due to its decreased elasticity, which allowed it to bear larger loads without experiencing significant deformation. The contrast in elasticity and Young's modulus between PLA and 6061-T6 aluminum showed the different uses for which each material was appropriate. PLA was made for the use of rapid prototyping and scenarios where it required some flexibility because of its lower modulus and increased elasticity. Whereas with 6061-T6 aluminum's higher modulus and low elasticity, it made it useful in high-stress situations where strength and durability were expected.

3.3 Surface Quality

For 3D printed PLA, the noticeable layer lines on the surface were a result of the layer-by-layer deposition used in FDM (Fused Deposition Modelling) technology (link). The print resolution determined how smooth the surface was; surfaces with thinner layers at higher resolutions were smoother while at lower resolutions, layer lines were more apparent. To smooth and minimize roughness, post-processing methods like coating and sanding (link) were used. Despite these initiatives, 3Dprinted PLA had rougher surfaces than machined metals. Next, components were made of 6061-T6 aluminum, which had a smoother surface and very little roughness (commonly at Ra 0.4 μm). The components were produced with a certain degree of surface consistency and homogeneity due to the machining process. Moreover, surface quality could be improved by applying anodizing and polishing treatments, which would add a layer of protection and improve the appearance. 6061-T6 Aluminium has a glossy natural finish and could possibly be polished even more to get a mirror- like surface, which makes it appealing and ideal for higher-end applications. In terms of aesthetics, 3D printed PLA parts could have had a matte to semi-glossy appearance, and depending on the filament used, there were a wide range of color options available, from typical white or transparent to several different colors available on the market. However, the components that were made from 6061-T6 aluminum had a silver-grey, natural glossy finish. This could have also had the possibility to be anodized in several colors, increasing the component's adaptability (get a link from MS chapters). If necessary, aluminum can be polished to a shinier finish which could increase the visual attractiveness and enable it for uses where performance and aesthetics are equally important.

4 Discussion

5 Conclusion