Fundamental of Materials Science Homework 3

1. List three items (in addition to those shown in Figure 1.8 of Chapter 1 in the e-text I uploaded) made from metals or their alloys. For each item, note the specific metal or alloy used and at least one characteristic that makes it the material of choice.
2. Classify each of the following materials as to whether it is a metal, ceramic, or polymer. Justify each choice:
3. alumina;
4. brass;
5. cast iron;
6. Plexiglas®;
7. boron carbide (B4C)
8. polychloroprene.
9. Select one or more of the following modern items or devices and conduct an Internet search in order to determine what specific material(s) is(are) used and what specific properties this(these) material(s) possess(es) in order for the device/item to function properly. Finally, write a short essay in which you report your findings.

Cell phone/digital camera batteries

Cell phone displays

Solar cells

Wind turbine blades

Fuel cells

Automobile engine blocks (other than cast iron)

Automobile bodies (other than steel alloys)

Space telescope mirrors

Military body armor

Sports equipment

Soccer balls

Basketballs

Ski poles

Ski boots

Surfboards

Golf clubs

Golf balls

Kayaks

When preparing your report, you should consider that many of the devices combine multiple materials to provide the properties/functionality of the device. Thus, you should consider more than one material and its properties. How would this problem help you with respect to materials selection in a future job? I have enclosed a sample investigation report (Appendix 1) at the end of the homework for Lightweight Bicycle Frames. Don’t forget to list the References in your essay.

***Appendix 1***

**A Sample Investigation Report for Lightweight Bicycle Frames**

The item selected for studying is the lightweight bicycle frame. In fact, several different materials can be used for bicycle frame featuring lightweight, and there is no consensus on which one is the best. This short essay will discuss the most common materials used for this purpose and their properties.

Lightweight bicycles generally require that the frame material has low density, while achieving high strength and durability. Steel was the most conventional material for bicycle frames decades ago. It is nowhere near ideal for lightweight bikes, since the density of various types of steels usually ranges between 7,750 and 8,050 kg/m3 [1]. This is nearly twice as heavy as the common lightweight materials to be discussed below.

The first material common for lightweight bicycles is aluminum. Since its introduction as a material bicycle frame material about 30 years ago, aluminum is now the most common material, thanks to its low density and stiffness, as well as affordability [2]. With the density only 1/3 of the steel, the aluminum results in significantly lighter frames. Besides, the stiffness is also lower, leading to improved machinability compared with steel [3]. However, lower strength is a problem for pure aluminum, so an aluminum alloy is generally used, of which the 6000 series aluminum alloy is a common choice because of the excellent machinability and decent strength. While the 7000 series aluminum alloy is stronger, it is much harder and therefore the machinability is poor [4]. In order to achieve enough strength, however, the tubes have to be made in larger diameter compared with steel, which reduces the advantage of lower density.

Titanium is a potentially good choice for lightweight bicycle frames due to its combination of strength and low weight. The stiffness and density (about 4.43g/cm3) of titanium alloys are about half of those of steel. An additional desirable characteristic of titanium is its resistance to corrosion. The family of titanium alloys offers a wide spectrum of strength and combinations of strength and fracture toughness [5]. Today, most titanium bicycle frames use the 3Al/2.5V alloy (3% aluminum/2.5% vanadium). Nevertheless, titanium frames are expensive to make not only due to the high material costs of titanium, but due to the welding of titanium tubes being demanding [2].

Carbon fiber is becoming the most preferred lightweight bicycle frame material. It is known for both its low weight and its ultra-high strength, stiffness, and durability. Carbon fiber consists of non-metallic graphite fiber cloth that is layered together with a high strength epoxy resin to form a matrix, which arranges the individual fibers to form a strong structure. The fatigue life of carbon fiber is almost infinite, unlike its metal counterparts [6]. Another unique feature of carbon fiber composites is that they can be molded and tuned to orient the strength wherever necessary. Therefore, it is almost ideal for high performance lightweight bikes due to its customizability in strength orientation. Although carbon fiber is expensive, it is still the most popular lightweight material for performance and racing bicycles nowadays.

In summary, a number of materials are available for lightweight bicycle frames. Each of them has unique properties that enable them to stand out.

References

1. Elert, Glenn. "Density of Steel". Retrieved 04/23/2009.
2. “Which frame material is the best?”, [http://bigshark.com/articles/which-frame-material- is-the-best-pg531.htm.](http://bigshark.com/articles/which-frame-material-) Retrieved 08/24/2016.
3. Wikipedia “Aluminum”, <https://en.wikipedia.org/wiki/Aluminium>. Retrieved 08/24/2016.
4. Wikipedia “Aluminum Alloy”, <https://en.wikipedia.org/wiki/Aluminium_alloy>.

Retrieved 08/24/2016.

1. <http://www.rtiintl.com/Titanium/RTI-Titanium-Alloy-Guide.pdf>. Retrieved 08/24/2016.
2. <http://cyclingtips.com/2015/08/what-is-the-lifespan-of-a-carbon-frame/>. Retrieved 08/24/2016.