Prosthetic Technology

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What is Prosthetic Technology? Prosthetic technology is used by those who have lost limbs, and can regain limb use, control, and typical motion by means of these artificial limbs. Why are engineers (bioengineers) spending so much time, effort, and money improving old prosthetics? Existing prosthetic arms are so clunky that many amputees do not even bother with them. Some work by flexing a back muscle to bend the arm, using a series of cables and pulleys, while flexing the bicep can close the hand. New technology provides benefits such as a greater range of motion and utilizing electronic impulses from the human brain to control prosthetics.

To fully understand the benefits of new prosthetic technology, one must get a general understanding of the parts and materials that comprise this new technology. A measurand is a physical quantity that a system measures. In the case of artificial limbs, the accessibility is external because it's an electric pulse on the end of a limb. The book calls this "electrocardiogram potential." However, the measurand could be internal in other cases. Sensors convert this physical measurand to an electric output. It responds to only the form of energy present in the measurand and it ignores all other kinds to prevent interference[1].

How do engineers do it? In the following example, we'll discover how a prosthetic limb would be applied to the upper body (i.e. an arm). Nerves from the arm are attached to chest muscles, whose movements amplify the nerve signal. Sensors placed over the new locations on the chest pick up impulses from the brain and transmit them to the prosthetic arms, a process called 'targeted muscle reinnervation.[4]' Therefore, the patient *can* indeed control prosthetics with only their thoughts. Students at the University of Rhode Island got to experiment with similar tasks when they designed and built the cricket car[5] (more information on the URI website and outside the classroom in Kelley Hall).

What differences has this made for patients? Aside from facilitation of these limbs, and addition of motions, the new technology has improved response time and reflexes. According to studies, flexing or rotating the wrist took about 0.22 seconds for the amputees versus 0.16 seconds for the controls. Completing a task took 0.11 seconds *longer* for amputees than the controls[2].

Bioengineers are behind the entire process. A team led by the Johns Hopkins University Applied Physics Laboratory developed the first fully integrated prosthetic arm that could be controlled naturally and allows for eight degrees of freedom. It was developed for the Defense Advanced Research Projects Agency Revolutionizing Prosthetics Program, is a complete limb system that also includes a virtual environment used for patient training. APL is already hard at work on a second prototype that will have more than 25 degrees of freedom and the strength and speed of movement approaching the capabilities of the human limb[3].

The focus of my presentation is on the materials going into the production of these products. Specific materials are important for the fabrication and creation of these limbs for two reasons; comfort of the socket, and strength. There is no one universal material that suits all amputees. Their lifestyle and physical characteristics need to be evaluated for engineers to know which materials to use and to avoid.

Plastic Polymer Laminates begin as a liquid mixed with a catalyst. This combination, under a vacuum pressure to make it lightweight and strong, creates a lamination. By adjusting the resin and fabric, you can make the device more flexible or more rigid. Examples of the laminated include acrylic, epoxy, and polyester. But with any and all materials, they have their benefits and disadvantages. On the positive side, the prosthetisis has good control over the strength and thickness, but the material is difficult to heat and remold if the device is uncomfortable over the socket[6].

Reinforcement textiles are fabrics used in a laminate for strength. These textiles include fiberglass, nylon, Dacron, carbon fiber, and Kevlar. The disadvantage is that most are very thin and relief areas cannot be ground into the materials. One example of this material is carbon fiber, which is brittle, so perhaps a stronger material like Kevlar or fiberglass could be used, because those materials will bend rather than break[6].

The process of putting these materials together to form a prosthetic limb begins with the saturation of the reinforcement textiles with a plastic polymer resin and put under vacuum pressure, as mentioned before. The socket is custom designed and put over the residual limb is made of plastic. But besides just being strong, it needs to connect the body to the artificial limb via electrodes, so electrode dummies are built into the socket. After making a plaster cast of the limb, a polyvinyl alcohol film is applied to separate from the plastic resin. The aforementioned 'reinforcement textiles' are applied along with whatever needs to connect the sockets and the electrical components[6].

References:

[1]John, Webster G. Medical Instrumentation. Danvers, MA: John Wiley and Sons, 1997.
[2]http://articles.latimes.com/2009/feb/14/science/sci-arm14
[3]http://www.jhuapl.edu/newscenter/pressreleases/2007/070426.asp
[4]http://www.medgadget.com/archives/2009/02/targeted_muscle_reinnervation_improves_prosthetic_control.html[5]http://www.ele.uri.edu/~diceccoj/cricket_car_NEBC.pd[6]http://www.amputee-coalition.org/inmotion/sep_oct_98/matinprs.html