Leishman, Levi
Zeltner, Darrel

Pegleg Crutch

Faculty Mentor: David Fullwood, Mechanical Engineering

The progress of a cheap, simple and practical substitute for the common crutch for us has had many design improvements and successes in this year. We were able to meet with medical, educational, and engineering professionals who were all able to input their criticisms and advice. We have decided on a final design that is not the best design for use, but the best when considering cost. See figure 1 for a visual of the final design.

Some of the major improvements on our design have been major, while others are minor. The materials and manufacturing processes are a major consideration, although the optimum process is yet to be determined. The main shaft that holds the person up we have replaced, going from a curved composite to a used portion of the common crutch. This change is for cost, making a vast difference. The spring that the bend provided had to be substituted with something else, and after a few ideas, we decided upon a rubber pad which would be placed on top of the shaft and inserted into a cavity in the bottom of the knee platform. A simple hinge now connects the shaft to the foot, allowing rotation only front to back.

Min K Chung, professor in the Division of Mechanical and Industrial Engineering at the Pohang University of Science and Technology, published a study which determined what people found to be the most comfortable postures for sustaining loads in the peer-reviewed International Journal of Industrial Ergonomics. Without padding, people are generally 70.4% comfortable in a kneeling position[1]. With padding and contour this comfort rating would go up significantly.

Another consideration is safety in weight sustained in the kneeling position. For this verification I will refer to Dr. P R Davis of the Department of Human Biology and Health at the University of Surrey. Davis published a standard for safe levels of loading in the one-knee kneeling position[2]. The maximum amount of load safely applied in this position is 60 pounds, which is around the body's center of mass, as shown in figure 2[3].

This is not exactly the posture a person will hold while using the Pegleg crutch, but a simple experimental survey was done to show the difference. To do this, we compared a subject's total body weight to the weight placed on the knee while in this posture. Through this comparison, we found the percent body weight that was placed on the knee was between 67% and 73% of the subject's total body weight.

While in stride using the Pegleg crutch the entire body weight is placed on the knee, with the exception of the weight of the lower leg, in periodic impulses. According to Davis, a 100 lb. user would not only walk safely but also have space to wear a backpack or carry other items up to around 30 pounds. This crutch is also safe for a 200 lb. user. Again, this is all assuming there is

[1] Chung pp 26
[2] Davis pp 33
[3] Davis pp 35

no padding on a flat surface. The Pegleg greatly reduces the pressure with a curved surface and padding.

We also performed preliminary stress and strain analysis to confirm if the design and product itself will sustain use. The method we used was to break down the Pegleg crutch and analyze each part as an individual member. Each member has its own material and yield strength, which was used to compare the results of the analysis. Each part was analyzed with an accurate representation of the forces that it can see during use. From this, we concluded that each part is structurally sound for use in the Pegleg crutch. Using a safety factor of 2, each part was analyzed using the student version of Unigraphics NX5 Nastran solver. An example of the results is shown in figure 3.

Future research has to confirm comfortable use with our prototype that has recently been made, see figure 4, as well as padding analysis for closed-cell padding to confirm safe levels of loading onto the knee. Then manufacturer's quotes for producing and marketing the product must be analyzed to know the actual cost to the consumer.

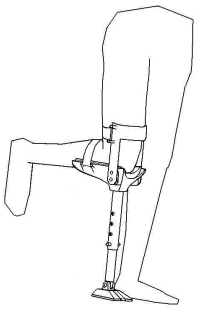

Figure 1 – Final design of the Pegleg crutch with figure of legs as would be used

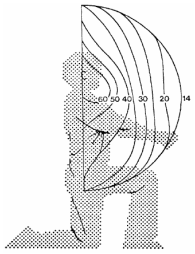

Figure 2 – Position for max load of 60 lbs. over center of kneeling knee.

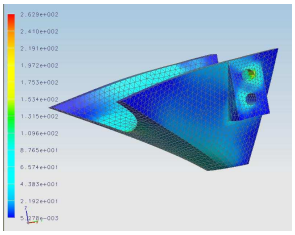

Figure 3 – Nastran solution for the knee platform part of the Pegleg crutch.

Figure 4 – Initial Prototype that will be used in testing the usability and comfort supplied to the user.

Bibliography

Min K Chung, Assessment of postural load for lower limb postures based on perceived discomfort. *International Journal of Industrial Ergonomics.* 2003;31:17-32.

PR Davis, Safe Levels of Manual Forces for Young Males EM Dash 3. *Applied Ergonomics.* 1978;9:33-37.