IASDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH THE HONG KONG POLYTECHNIC UNIVERSITY 12TH TO 15TH NOVEMBER 2007

AN ARTIFICIAL KNEE HAVING A FIVE-JOINT MULTI-LINK SYSTEM USING ELASTIC MATERIAL

Fumio Terauchi[1], Mitsunori Kubo[1] and Hiroyuki Aoki[1]

[1]Department of Design Science, Graduate School of Engineering, Chiba University, Chiba, Japan, ftera@faculty.chiba-u.jp

ABSTRACT:

An artificial knee consisting of two elastic joints, three normal joints that rotate freely and five rigid arms was investigated in order to develop a simple and light artificial knee. This artificial knee is designed to assist people who have problems with their knees to walk naturally in the same manner as people who have healthy knees do. The elastic joint is composed of three housing layers and six elastic components that are installed at the interfaces between the three housing layers, which simultaneously function as suspension and shock absorbers. A five-joint multi-link system was proposed and examined numerically to assess its potential to be used as an artificial knee.

KEYWORDS: Artificial Knee, Gait, Numerical Simulation

1. THE ELASTIC JOINT OF THE ARTIFICIAL KNEE

1. 1. THE STRUCTURE OF THE ELASTIC JOINT

The elastic joint is a major component of the artificial knee, which is able to rotate around its central axis (Fig.1). This joint supports the axis elastically and absorbs the dynamic energy that is produced when the joint rotates. The hatched sections are the housings and the six small colored sections that have trapezoidal-like shapes are the elastic components that deform under stress. The deformation and the friction between the three housings or between each housing and each elastic component absorbs the rotational energy transferred to the joint through the central axis.

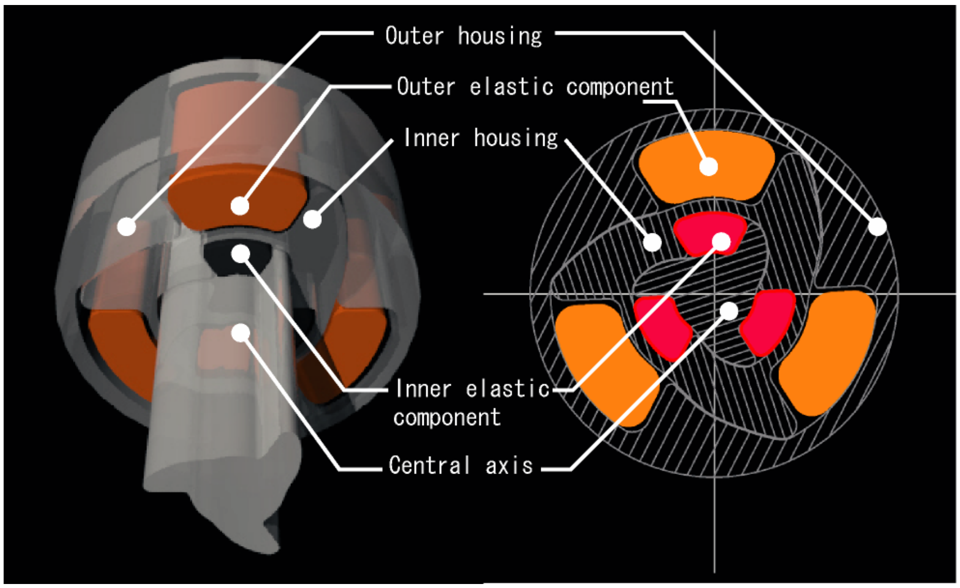

Figure 1: Structure of the elastic joint

1. 2. TWO GAIT PHASES AND TWO KINDS OF ELASTIC JOINT

The gait is generally subdivided into two phases on the basis of distinct dynamical differences; one phase is the stance phase and the other one is the swing phase (Fig. 2). In this study, two kinds of the joints have been proposed to properly reproduce both gait phases (Fig. 3).

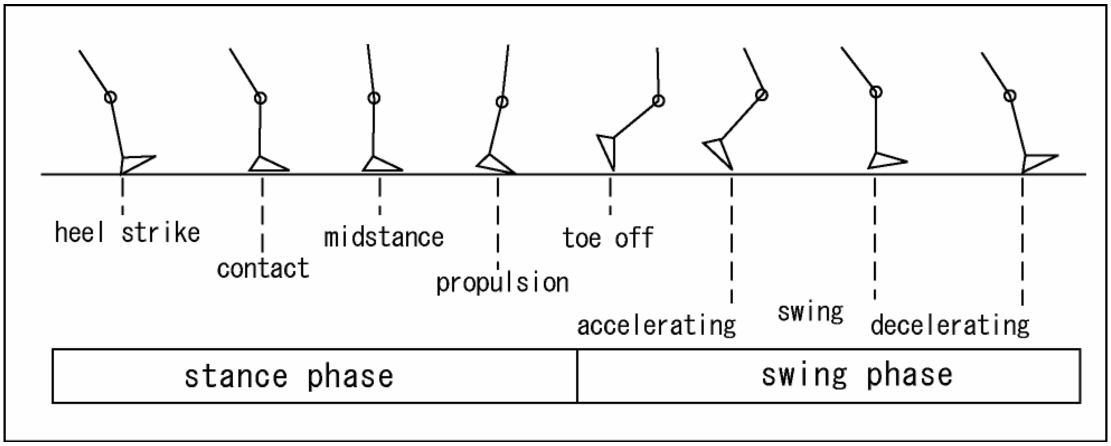

Figure 2: Two gait phases

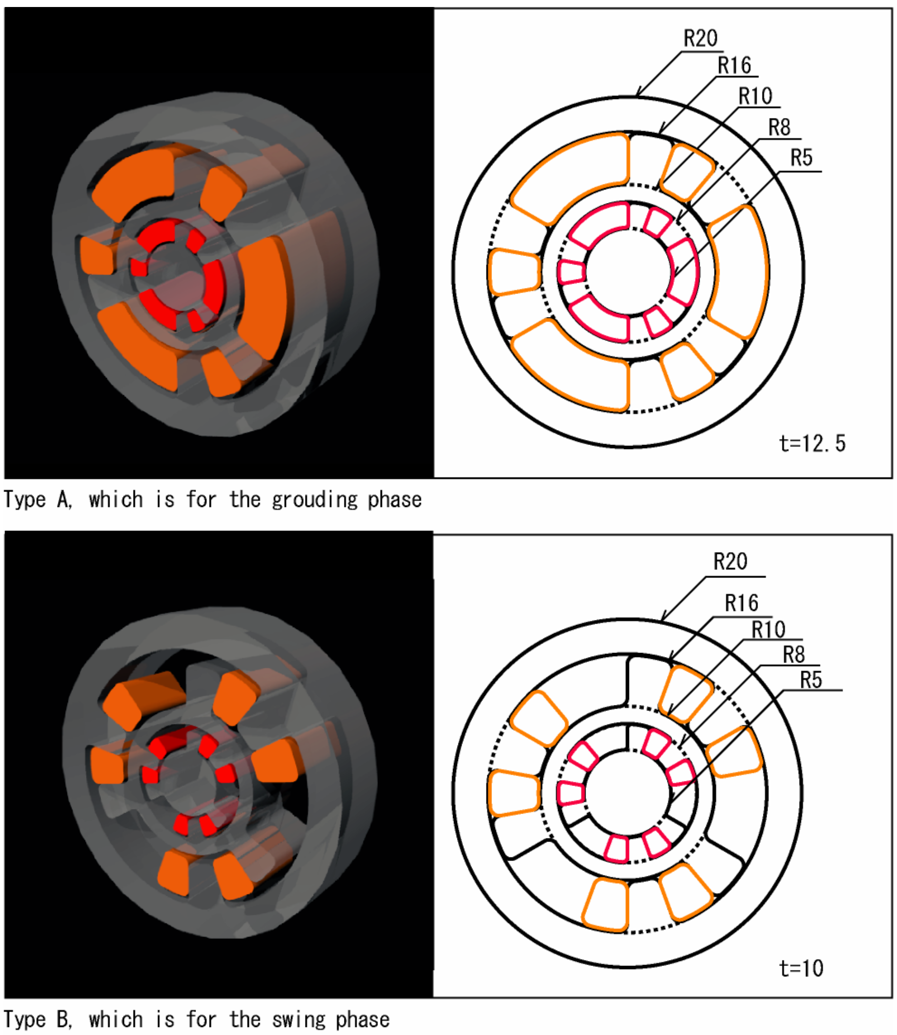

Figure 3: Two joints using the elastic components

2. ARTIFICIAL KNEE

The artificial knee consists of two elastic joints, three normal joints and five rigid arms (Fig. 4). Figure 4 shows a schematic model of the artificial knee. It was also used as the basis for the gait simulation numerical model.

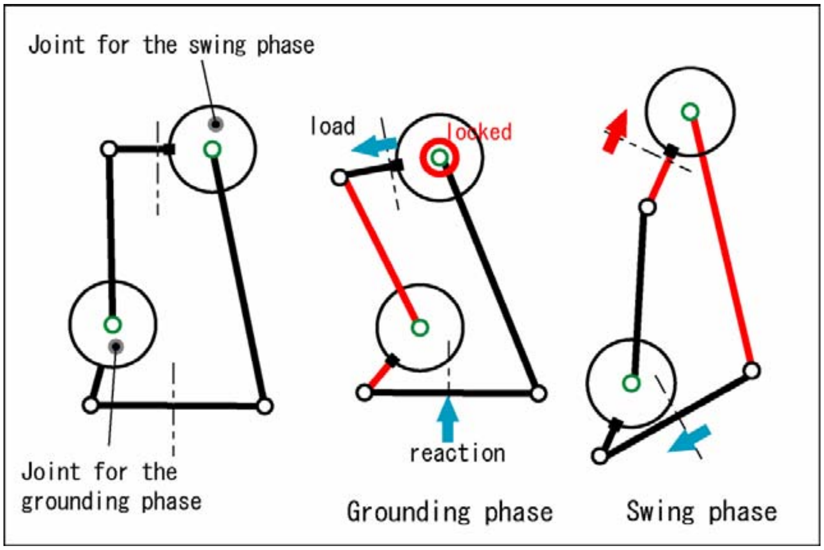

Figure 4: Artificial knee consisting of the two elastic joints

A simplified leg was defined to numerically simulate the behaviour of the gait with the artificial knee. The dynamic behaviour of the numerical leg was investigated using the simulation, which was developed using visualNastran 4D and MATLAB/Simulink (Fig. 5).

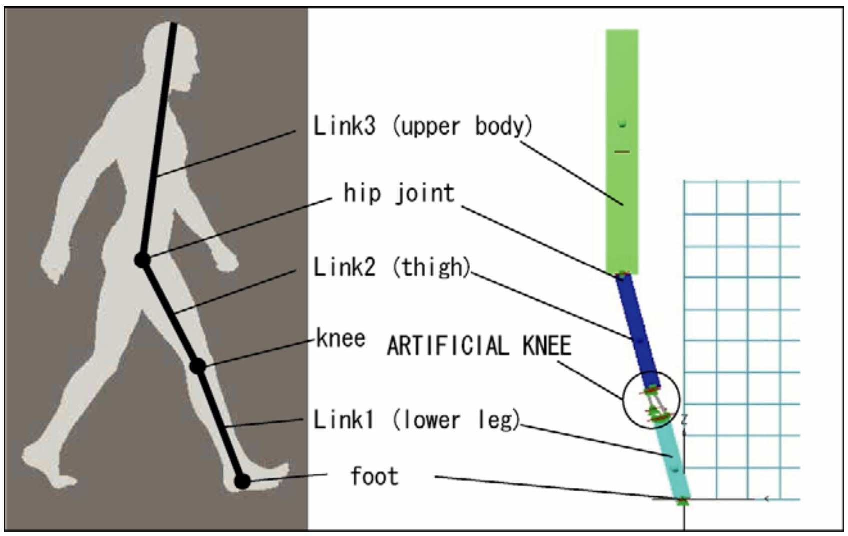

Figure 5: Numerical leg with the artificial knee

3. FIVE-JOINT MULTI-LINK SYSTEM

The characteristics of the two kinds of elastic joints were adjusted by matching the gait reproduced in the simulation with the actual gait that was observed at the hip joint (Uchida 2001) to obtain the natural gait. Finally, a five-joint multi-link system that reproduces the real two gaits on computer was proposed (Fig. 6).

Figure 6: External form of the artificial knee

REFERENCE:

Uchida, Shibata, Zheng and Ito (2001) An Adjustment Method of Visco-elastic Parameters for Above-Knee Prosthesis based on Mechanical Models, Journal of the Society of Biomechanisms, Vol.25, No.2, pp.81-86.