CHAPTER – 4

GEOMETRIC MODELING AND RAPID PROTOTYPING

4.1 Geometric modeling for non-contact analysis

The geometric modeling of the knee joint was done using the modeling features of ANSYS 8.1 software. During geometric modeling, two dimensional diagrams of femoral and tibia components of 40, 50 and 60mm sagittal radius were generated first and were extruded in Z-direction for the flexion angles 0, 20 and 40 degrees. Fig 3.1 shows the dimensions of femur and tibia considered during the modeling.

Fig. 4.1 2D view of tibia and femoral components
4.2 Geometric modeling for contact analysis

The geometric modeling of the knee joint was done using PRO E software. During geometric modeling, two dimensional diagrams of femoral and tibia components of 40, 50 and 60mm sagittal radius were generated first and were extruded in Z-direction for the flexion angles 0, 20 and 40 degrees [Ansaurullah LAWI et al., 2008, Stephen J. et al., 2001]. Fig 3.2 and 3.3 shows the dimensions of femur and tibia considered during the modeling for contact analysis.

Fig 4.2 Dimensions of femur in mm

Fig 4.3 Dimensions of tibia in mm
Fig. 4.4 Three dimensional models of prosthetic femoral/tibia joint for different sagittal radius in mm and flexion angles in degrees
4.3 Rapid prototyping

Rapid prototyping using stereo lithography is a fairly new process of generating 3D prototypes from a liquid polymer without the use of traditional tools and/or molding techniques. Initially, a 3D model is created in the computer. Each layer of this 3D model is then written using a laser beam onto a liquid photopolymer. Each layer can be anywhere from 0.05 mm to 1 mm. The laser beam polymerizes the resin and the unexposed part is removed prior to the exposure of the next layer. A resin prototype of the computer model is thus generated.

A solid model of femorotibial joint (Fig.3.4) is created on a computer, which is converted into a format dubbed the ‘STL’ (*.stl) file format which originates from 3D systems. The STL file format approximates the surfaces of the model by polygons. Highly curved surfaces must employ many polygons which mean that STL files for curved parts can be very large. A computer program analyzes a STL file that defines the model to be fabricated and ‘slices’ the model into cross sections. The cross sections are systematically recreated through the solidification of liquids to form a 3D model.

The Eden 500V -3D Printing System is used to print a prototype model shown in the figure (3.5). Based on Objet’s innovative PolyJet™ technology, Eden 500V provides an
easy to use, fast and clean solution for the precise building of any geometry. Models produced on the Eden 500V have smooth and durable surfaces with exceptionally fine details and an outstanding surface finish.

The Eden 500V offers high resolution in the Y-axis of up to 600dpi with no difference on print speed. A choice of high speed or high quality printing mode gives maximum flexibility to achieve the quality.

Outstanding features of Eden 500V

- Horizontal layers of 16µm.
- The highest resolution in the market, with identical X and Y resolution of 600 dpi; enables models with fine features in Y direction with no loss of speed.
- Eliminates the stair effect common to complicated curved surfaces built in lower resolution.
- Produces ultrafine details usually available with high cost 3D printers.
- Thin walls down to 0.6mm.

VeroWhite FullCure830 is the member of the well known Vero family of opaque model materials. This material provides excellent dimensional stability, great detail visualization and surface quality. In addition, it provides all the benefits of the Vero family. Vero White is supported by all Eden family printers. Vero White also offers excellent flexural strength 75 MPa and flexural modulus along with tensile strength of 50 MPa making it ideal for engineering simulation and structural testing. With a superb surface quality and detail visualization of the opaque rigid Vero White material, models look and feel like molded plastic parts. The other popular material is fullcure720 which has tensile strength of 60 Mpa and flexural strength of 76 Mpa. The 3D models of femorotibial joint (40mm sagittal radius and 0 degree flexion) manufactured form the Eden 500V is shown in Fig.3.6 and Fig. 3.7. The models produced form the Eden 500V 3D printer is further used for verification of physical aspects and the contact between the femur and tibia in the present work.
Fig. 4.6 Prototype model of femorotibial joint (FullCure830 material)

Fig. 4.7 Prototype model of femorotibial joint (FullCure720 material)