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STUDY AND ANALYSIS OF KNEE IMPLANT IN HUMAN BODY

GAJANAN D. MANDAVGADE

Assistant Professor, of Mechanical Engineering, IBSS COE-Amravati. (MS)

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Abstract: Aim of this work is to study & analysis Knee implant in human body. The study is divided in three steps. First step is the measurement of the shape and size of the knee implant using commercial implant available in market. Second step is drafting of the implant using CAD (Computer Aided Design) software. Next step is analysis the CAD model of knee implant by importing it into Finite Element Analysis (FEA) software. After setting up various boundary conditions, the implant is analyzed and the stresses developed in the implant are obtained.

Keywords: Abrasive jet machining, Erosion Rate, Peening, Fluidized bed, Machining Removal Rate.

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Corresponding Author: MR. GAJANAN D. MANDAVGADE

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INTRODUCTION

In human body there are various joint but knee joint are important in human body.

1.1 Knee joint

The knee joint is one of the largest as well as one of the most complex joint in human body. Because knee is made up of several bones and ligaments such as Femur, Tibia, Patella, ACL & PCL (anterior & posterior cruciate ligaments) It is able to withstand extensive strain and injury; also risks in everyday and occupational life as well as in sports. Normal age related process and excess weight, as well as physical inactivity, can lead to wear and tear on the joint. [1]

1.2 Anatomy and physiology

The round femoral knuckles or lie on the flat tibial plateau, this joint is bent or extended as its rolling or gliding every time. This occurs only if the cartilage layer is intact; the function of cartilage layer is to continuously lubricate a gliding surface by synovial fluid. A thin fibrous cartilage between a surfaces of joint secure firmly outwards and inward on the tibial plateau.

The ligament stabilizes the joint; in order to prevent the femur and tibial plateau from the outward or inward bending under normal condition. The anterior and posterior crcuiate ligaments provide additional stabilization, so that the tibial plateau is also firmly secure in place to prevent it from slipping too far to the front or back. [2]

Fig.1.Normal Anatomy

There are many type of arthritis that affect the knee but most common are as fallows-

Osteoarthritis- It's a wear and tear condition that occurs when all the cartilage which lines the bone in knee and natural cushioning deteriorates, thus bone rubs against adjacent bone and patients often experience pain, stiffness, and disability. These severe cases are more commonly treated with knee replacement rather than cartilage restoration. [3]

Healthy knee joint Osteoarthritis

Rheumatoid arthritis- Rheumatoid arthritis is an autoimmune arthritis in which immune system mistakenly attack & destroy healthy body tissue, muscles, joints etc. it may result in abnormal growth of organ & change organ function. Although rheumatoid arthritis is a chronic disease. The process of rheumatoid swells the cartilage, muscles, tendons and ligaments which can misshape the joints, erode the cartilage and eventually lead to destruction of bone. [4]

Traumatic injury to the knee-

The knee can be injured in any number of ways, including during sports, a fall or a collision. The quick and unexpected twisting or reposition of the joint can damage the cartilage or ligaments. In many cases it is possible to repair this damage by repairing, restoring or replacing the cartilage.

2.0 Metallic Biomaterials

The materials that are used as biomaterials include ceramics, metals, polymers and composites. The main metallic biomaterials which are used for fabricating implants are Stainless steels, cobalt alloy, and titanium alloys, because this material has important property of biocompatibility, followed by corrosion resistance. The metals used as biomaterials include titanium and its alloys, cobalt-chromium alloys, stainless steels, gold, silver and platinum. Out of those metals, the SS 316L is one of the most commonly used biomaterial. [5]

2.1 Stainless Steel

The reason that SS 316L serves as a good biomaterial is that firstly, material. The implants made of SS 316L with stand to high load because it is a very strong. Secondly, chemical composition of material such as molybdenum gives greater hardness and helps maintaining a cutting edge, carbon content improves the corrosion resistance and minimizes sensitization, chromium gives the scratch-resistance and corrosion resistance. The nickel provides a smooth and polished finish. [6]

2.2 Titanium Alloy

Titanium alloys are more widely used for biomedical application, such as fabricating an artificial hip joint, artificial knee joint, etc because Titanium alloy is light in weight, having high specific strength, low elastic modulus and good biocompatibility properties, but titanium has poor shear strength. This characteristic makes it less desirable for bone screws and plates. It also tends to affect suddenly when in sliding contact with itself or other metals.

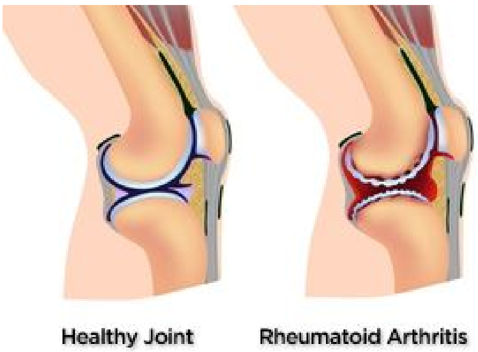


Fig.3.Rheumatoid Arthritis Knee[8]

However, titanium has low wear and abrasion resistance because of its hardness.

3.0 SOLID MODEL

In this study a modelled of knee joint is design from commercially available joint and contact stress in the same is analysed by using CAD (Computer Aided Design) Software, such as CATIA, PRO/E, Hyper mesh, etc. In recent years, solid modelling has been used extensively in medical applications for creating solid models of hip prosthetics, Knee prosthetics etc.

PRO/E software is used for developing a model of knee prosthetic because it offers several different approaches to develop a solid model of prosthetics part design, surface design etc. In study 3D model was developed from the existing the real implant by following two steps. Firstly the measurements of the individual components were measured using the measurement device, and a solid model was created using Pro-E 4.0. Then all the modelled components were taken into the assembly module of Pro-E 4.0 and it was assembled to get a complete assembly of the standard artificial implant. [7]

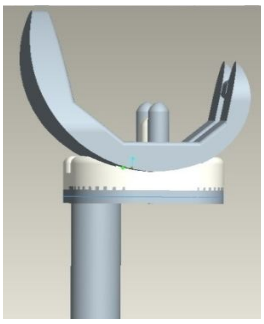


Fig.4. Metallic Knee implant Fig.5. CAD Model of knee Implant

Table 1 Analysis Results for Knee Implants (SS 316L)

Load (N)	Deformation (max) mm	Shear Stress (max) mpa	vonmises Stress (max) mpa
500	0.00014118	0.35564	4.269
1000	0.00028236	0.71128	8.538
1500	0.00042354	1.0669	12.807

Table 2 Analysis Results for Knee Implants (Co-Cr-Mo)

Load (N)	Deformation (max) mm	Shear Stress (max) mpa	vonmises Stress (max) mpa
500	0.00015142	0.19835	1.1002
1000	0.00030284	0.39669	2.2004
1500	0.00045427	0.59504	3.3006

Table 3 Analysis Results for Knee Implants (Titanium alloy)

Load (N)	Deformation (max) mm	Shear Stress (max) mpa	vonmises Stress (max) mpa
500	0.00009553	0.19938	1.1094
1000	0.00019107	0.39876	2.2187
1500	0.00028661	0.59814	3.3281

4.0 FEA

Finite element analysis is a technique which is widely used to analyze stress-strain states in various biomedical devices and in prosthetic bone joints.

In Knee implant analysis first import a knee

model in ANSYS software in .sat file format then material is select for knee implant, after selecting material an implant divided into a small number of solid finite elements, these processes know as meshing. A load (500N, 1000N,1500N) is applied on implant by fixing its one end and then behaviour of each element is analyzed, following table 1 shows the result of analysis for knee implant of Ss 316L. Same procedure is repeated for Co-Cr-Mo and Titanium alloy results are displayed in table 2 and 3 resp.

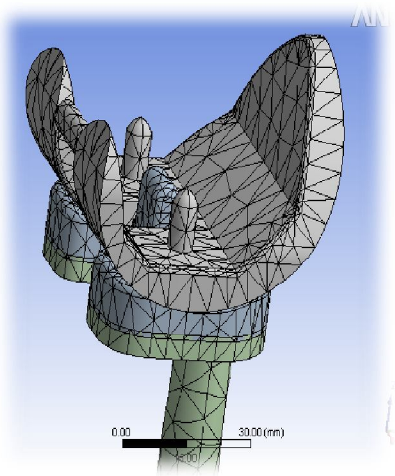


Fig.6. Meshing model of Knee Implant

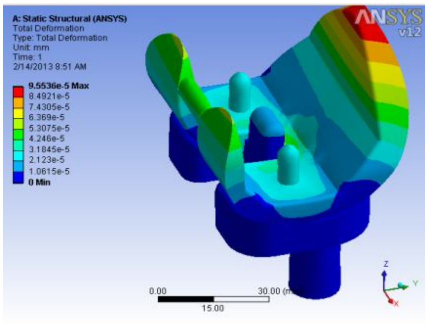


Fig.7 Deformation (500N)

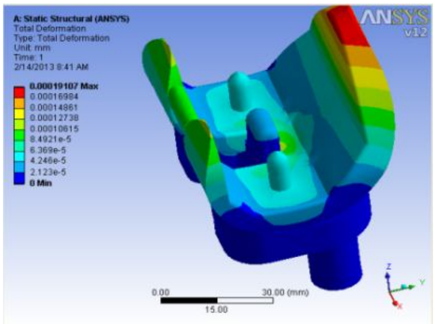


Fig.8 Deformation (1000N)

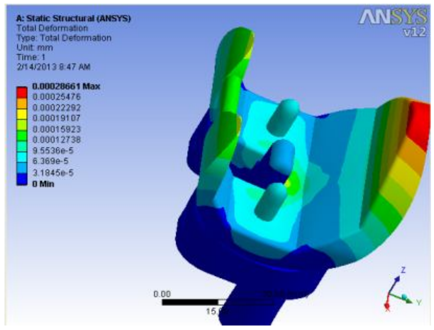
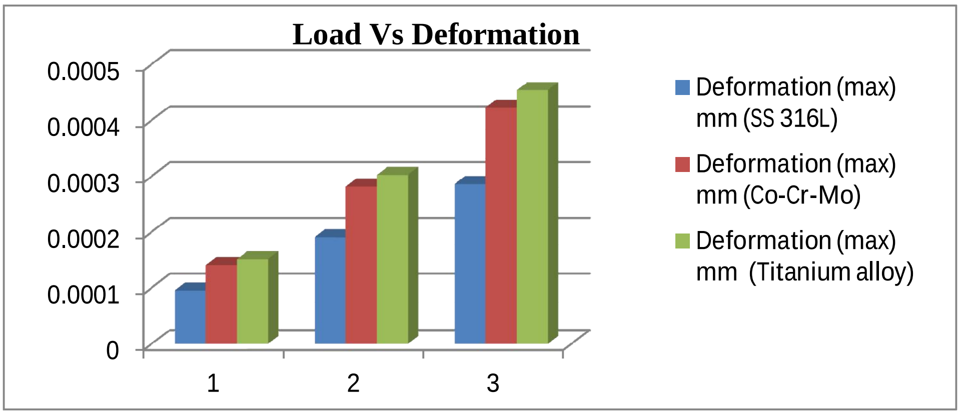


Fig.9 Deformation (1500N)



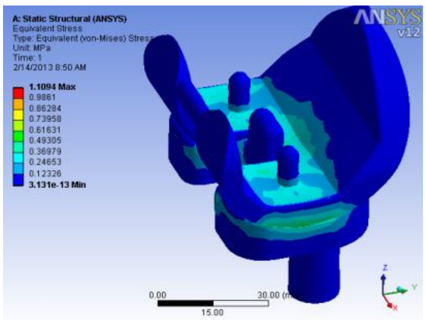


Fig.10. Von mises Stress (500N)

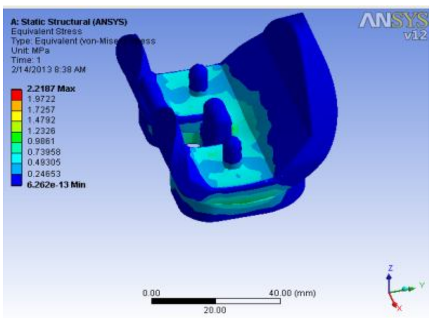


Fig.11. Von mises Stress (1000N)

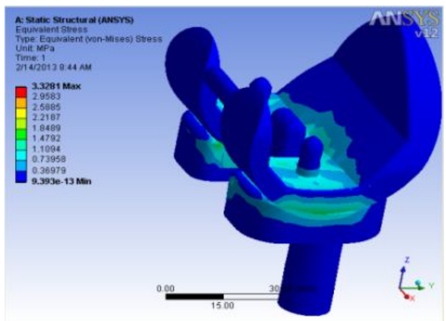
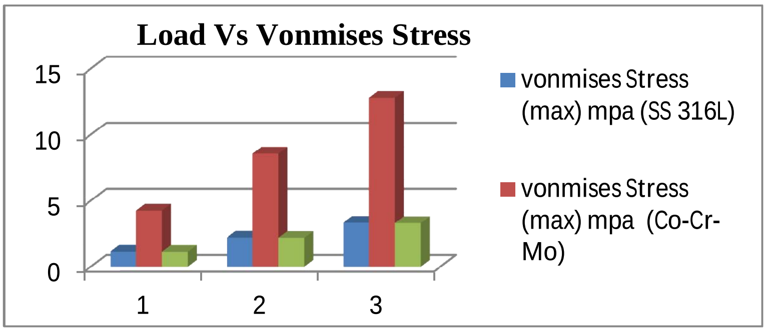


Fig.12. Von mises Stress (1500N)



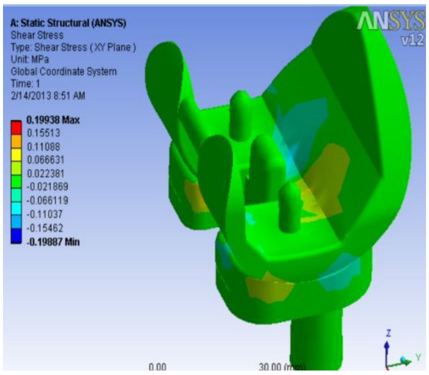


Fig.13. Shear Stress (500N)

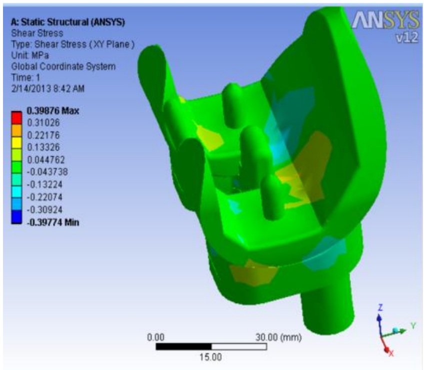


Fig.14. Shear Stress (1000N)

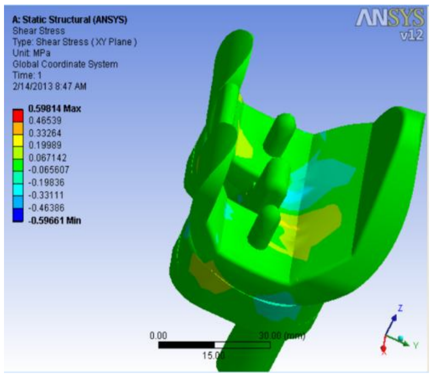
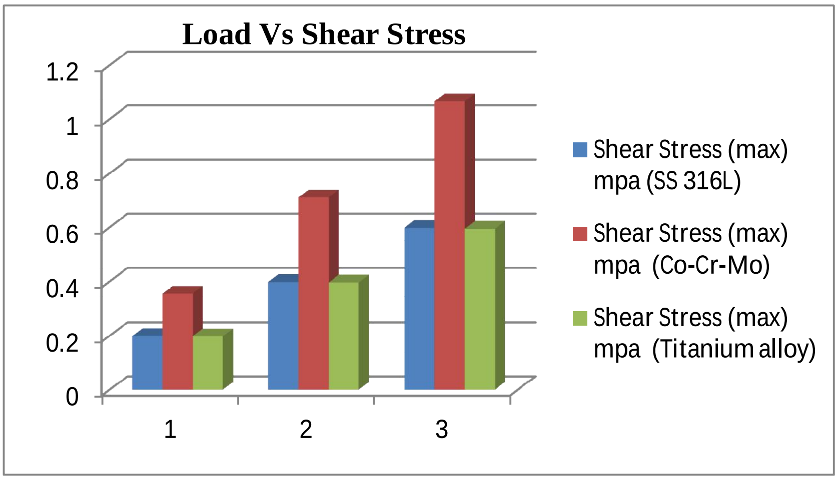


Fig.15. Shear Stress (1500N)



CONCLUSION

The aim of this study is successfully achieved

SS 316-L has excellent bio-compatible properties along with physical properties which makes it an ideal implant material for surgeries.

While manufacturing an implant achieve good internal properties, including strength, toughness and fatigue resistance. However, a special attention must be paid while choosing the material, because Titanium and Cobalt chromium alloys are more difficult to machine than SS -316L.

Deformation in titanium alloy is more as compare to SS 316L & Cobalt chromium molybdenum. This contributes significantly in reducing the problem of implant loosening which can lead to total failure of the impact functioning.

The maximum values of von mises stresses for Knee implants of SS 316L ranges from 1.1094 to 3.3281 MPa is much lower when compared to the yield strength of SS 316L (690 MPa).

The results we have obtained are amazingly satisfactory and validate the relevance of use of SS 316L for implants.

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