Investigations Offatigue Test & Corrosion Test ONSS316L Used As Orthopaedic Implant Material

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Abstract- *This research paper constitutes the study of fatigue test as per ASTM A240 and corrosion tests for SS316L (readily available) material for orthopedic implant. In medical field SS316L material has been used as a medical implant due to its high strength and its mechanical properties. In this for fatigue tests, we have prepared the specimen as per required dimensions to conduct fatigue tests. As Human skeleton plays an important role for giving support to the muscles and decides the structure of body. Mechanical properties of whole bone or bone tissues and bone implant material interfaces are equally important as their morphological or structural aspects. Hence we suggest this material to be used for femur bone prosthesis. From the corrosion test material is corroded partially and we get pH value very nearer to 7 hence it indicates that material is neutral, hence we suggest this material for femur bone prosthesis*

Keywords- SS316L, Fatigue test, Immersion tests

I. INTRODUCTION

Generally SS316L material is a readily available material with low cost. In this project work existing material SS316L selected for investigations of fatigue tests for femur bone. There are around 300 different types of bones in human body (i.e) hard and soft bones. In this we have selected femur bone for fatigue test because human being is busy with other activities like cycling and with other different sports. So, the fatigue load will be applied on bone (i.e) femur bone, therefore due to uncertain accidents the bone will get fracture, so for that bone we are replacing or inserting the SS316L material. So we are conducting fatigue test on SS316L material and compare with femur bone in human body. Before implanting this material into human body corrosion tests also need to be carried out with use of artificial saliva as human body contains saliva. These tests are carried out to check whether material gets corroded or not.

Fig1: SS316L material

II. LITERATURE SURVEY

Human skeleton plays an important role for giving support to the muscles and decides the structure of body. Mechanical properties of whole bone or bone tissues and bone implant material interfaces are equally important as their morphological or structural aspects [1].Post processing of materials is necessary to suit them for the intended requirements. The properties of stainless steel of Grade 316L cannot be influenced with further processing such as hot working.[2] Silvia Suner Moreno proposed a theory on ultra-high molecular weight polyethylene for joint replacement. He observed that the material gives the good performances with biological and mechanical stabilities. This journal provides the concept of carbon based composites for the joint replacement [3].Basquin relation was used to verify how accurate the model is in predicting fatigue life. The result shows that the lifetime of prediction curve is slightly lower than the experimental data by 23 percent. The fatigue limit was successfully characterized and found to be 160.69 MPa.[4]
The experimental data for strain controlled symmetric low cycle fatigue have been generated for first 30 cycles (beyond saturation) for different strain amplitudes.[5]The Femur is the longest and strongest bone in the skeleton is almost perfectly cylindrical in the greater part of its extent.[6]

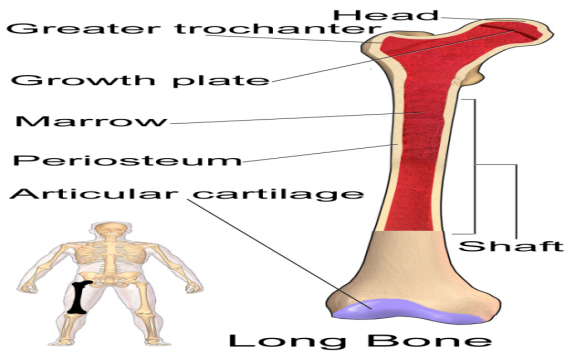


Fig. femur bone mechanical properties

Table 2.1 shows the femur bone mechanical properties

SPEED (RPM)	LOAD IN (kgf)	LOAD IN (N)	No of cycles	Stress (N/mm^2)
3500	20	1000	40280	31.58
3500	16	800	52350	25.26
3500	14	700	60998	22.10
3500	12	600	124169	18.95

Mechanical Tests	≤ 30 Years	31 – 50 Years	51 – 70 Years	≥ 70 Years
Tensile Strength MPa	43.44 ±3.62	39.82 ±4.29	33.16±6.43	30.16±7.09
Compressive strength MPa	155.8 ±9.53	142.37±12.12	124.44± 15.40	115.29±12.94
Bending strength	84.03 ±9.91	75.22 ±11.6	61.89±10.81	43.57±11.74
Fracture toughness	1760 J/m^2			

III. EXPERMENTIAL DETAILS

Specimen is subjected to both specific load and irregular load and the number of cycles is recorded after material fails. Generally, the test is repeated with identical specimens and with different changeable loads. Loads may be applied axially, in torsion, or in flexure. Standard and sub size fatigue specimens of plate type were designed to the specifications of ASTM E 466,12) as shown The dimensions of a sub size specimen, thickness of2.6mm and gage length of 10.4 mm, were in the lower limit of the specifications. The overall length of a standard specimen was 190mm and that of the sub size 67 mm. Before fatigue testing, all specimens were polished as per there commendations of ASTM E 466. High-cycle fatigue tests, at room temperature and 300_C, were performed on a 100 KN.[7]In daily life as human has many activities to be carried out like, walking, running, few exercises etc. many humans have accidents every year to which it leads to bone fracture especially like femur bone. Due to this implantation of SS316L material may be used. Fatigue generally calculates the maximum strength of the material it withstands.

2.1 EXPERMENTIAL PROCEDURE:

- Initially stainless steel material is taken and is machined to desired dimensions for fatigue test to be carried on as shown in fig 1 and fig1.1
- The specimen is fixed into the specimen holder and is clamped well as shown in fig1.2
- Load is been applied as necessary.
- Set the RPM as necessary using the controller as shown in fig1.4

Results obtained

- Turn on the machine and note down the reading
- Till the specimen breaks.

Repeat the process with different specimens and with different loads.

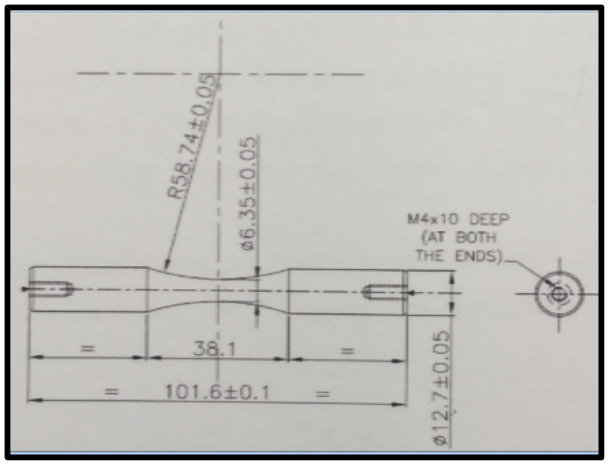


Fig1.1:Dimension for fatigue test

Fig1.3: SS316L material

Fig: 1.2: Fixing the specimen

Fig1.4: controller

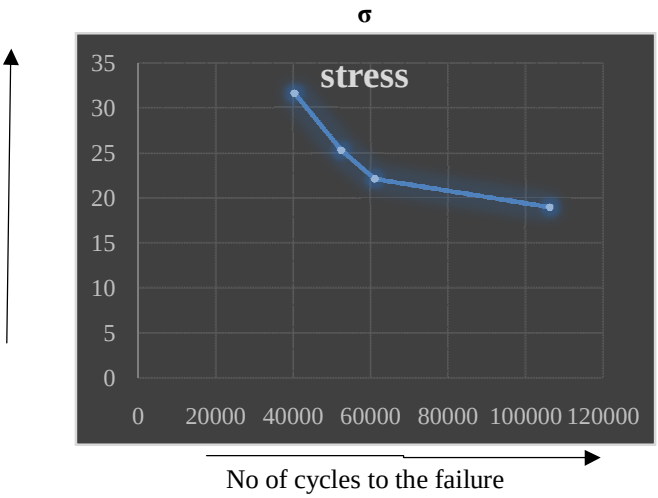
2.3 CALCULATIONS:

1kg=50N (RATIO 1:5)
From above data calculating area (a).
$A=\pi/4\times d^2 = A=\pi/4\times 6.35^2$
$A=31.66mm^2$
σ =Load/area

σ = 1000/31.66

σ = 35.37N/mm^2

2.4 GRAPH OBTAINED



III. EXPERMENTIAL DETAILS: IMMERSION TEST

Immersion test by using electrolytic method by ASTM G-31. This test is been conducted to check whether the metal gets corrode or it doesn't. And if it does what is the pH value.

This test is carried out to check whether the metal gets corroded or not. After implantation of SS316L material into human body, the human body contains saliva in it where the metal gets corroded, to avoid corrosion in human body after implantation corrosion tests are carried out.[8]From literature surveyas the world's populations increaseand age, there is a parallel increase in the number of medical procedures addressed to bone related in- juries. It is estimated that approximately 1 mil- lion of orthopedics implant surgeries in association with total joint replacements are needed every year.

3.1ARTIFICIALSALIVA PREPARTION[9]

The composition of artificial saliva: grams (per litre)

Methyl-p-hydroxybenzoate 2.00
KCL 0.62
Sodium carboxymethyl cellulose 10.00$CaCl_2.2H_2O$ 0.16
$K_2HPO_4$0.80
KH_2PO_4 0.32
$MgCL_2.6H_2O$0.05
The pH of artificial saliva was adjusted to 6.75

3.2 Experiential Procedure:

- A circular specimen of about 38mm (1.5in) diameter is a suitable shape for corrosion tests. With thickness approximately 3mm (0.125in) and an 8mm dia hole for mounting these specimen.

- These specimens are kept inside the apparatus in a solution with required chemical composition.
- These specimens are kept in the setup for nearly 48hrs.
- Every now and then the temperature is checked, whether there is a rise or fall in temperature.
- Generally in summer the average temperature will be around 40˚C.
- So the temperature is set to around 40˚C.
- The specimens are kept inside the setup in an artificial saliva with required chemical composition with adjustable pH value of saliva.
- From the above results we can get to a conclusion, whether the implant material SS316L would be successful into human body or not.

3.2.1 TEST SETUP PHOTOS

Fig1.5: Corrosion test setup

3.3 Specimens Before and After Tests

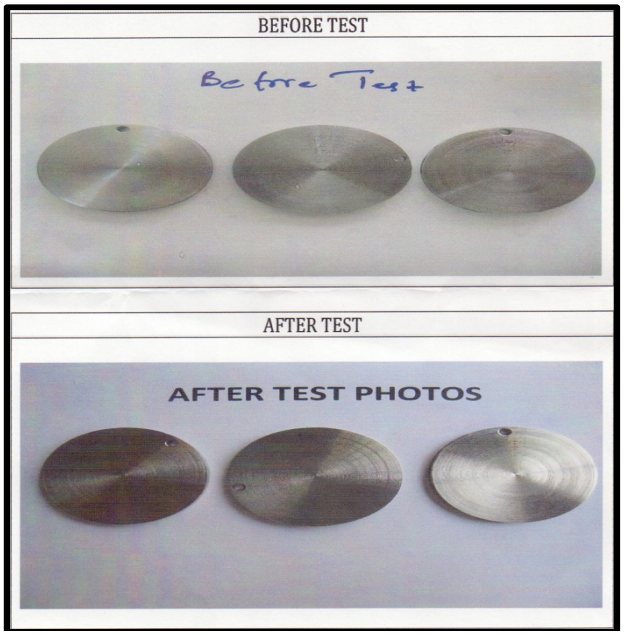


Fig1.6: Specimens Before and after tests

3.3.1 Specifications

- These specimen dipped in that solution is kept for 48hrs, with temperature set to,
  - Max temperature : 42 degree Celsius
  - Min temperature :40 degree Celsius
  - Average temperature : 41 degree Celsius

Size, shape and area of specimen,

- Diameter: 38.3mm
- Thickness: 3.11mm
- Area : 374mm^2

3.4 RESULTS OBTAINED:

- Corrosion rate, µm/y 68 Average
- pH of the saliva (after test) 6.8

From the above results the pH value of the saliva after the test is approximately equal to 7, hence we can say that it's neutral.

IV. CONCLUSION

Generally in medical field, low cost material will be suggested due to the interest of economical one, when compared to the other alloy material. SS316L is the low cost material and its property will be so close and better when compared to femur bone mechanical properties. Hence we suggest that this material to be used in medical field applications.

And also we have carried out corrosion tests on SS316L material for a duration of 48hrs, and we have found that little amount of corrosion took place on existing material. From the above results the pH value of the saliva after the test was found to be approximately equal to 7, hence we can say that it's neutral. Hence this material can be implanted for biomedical field as the pH value is nearly neutral.

V. FURTHER WORK

Hydroxyapatite Coating is required to avoid corrosion and to get bio-compatibility, FEA analysis is required

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