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Finite Element Analysis of Composite Leg and Optimization

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ABSTRACT

In this paper, an effort has been made to carry out the analysis of "Composite Leg" for the identification of possible failure situation, any flaws in the design stage can be identified and rectified in the analysis stage. The stress developed can be understood by maximum and minimum stresses acting on the component and suitably reduce it using a better material through optimization methods.

In optimization analysis was performed on a Leg. Pre-processing and solving procedures were performed using Catia and Hypermrsh. Initially GFRP is used and von Misses stress and deflection on the Leg ware found as it is showing more FOS on few parts. So optimization is carried out on those. The analysis resulted in mass reduction and the processes involved.

The final section of the documentation deals with the comparison of results obtained from the use of analysis software, with the results obtained after optimization if feasible and a brief idea of the future scope of analysis using software for the Artificial Composite Leg.

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I. INTRODUCTION

In today's world, it is important to maintain balance in life – getting work done and maintaining contact with friends. The composite leg is ready for these challenges. Today's modern world presents new challenges daily. In this fast-changing environment, it is essential that we try to maintain a balance in our daily life – going about our work, pursuing daily activities, and keeping in touch with friends and family, with the composite leg, ideally equipped to meet daily challenges.

II. LITERATURE REVIEW

S. Blumentritt, et al, 2009, studied that the static alignment of the knee joint and foot component did not vary between the groups. The distance between the load line and trochanter major was smaller compared with the group with moderate to long residual limbs. This means the prosthesis of the short residual limb group was marginally more secure in terms of alignment. Time-distance parameter: The amputees with short residual limbs walked more slowly at all three walking speeds, the prosthesis side stride was shorter and the stride length on the contralateral side was equal in both groups. The prosthesis side stance phase duration is independent of the residual limb length, but on the sound side it is longer among amputees in the short residual limb group. [2]

According to J Prosthet Dent, et al, 1998, fiber-reinforced composite materials can be used to make metal-free prostheses with excellent esthetic qualities. By using various matrix materials and fibers, a number of fiber-reinforced composite formulations were evaluated with the goal of creating a system with optimized mechanical properties and handling characteristics. Fiber-reinforced composite based on a light-polymerized BIS-GMA matrix has been used clinically to make 2-phase prostheses comprised of an internal glass fiber-reinforced composite substructure covered by a particulate composite. The clinical and laboratory procedures required for the fabrication and use of reinforced composite fixed prostheses are described for laboratory-fabricated complete or partial coverage fixed prosthesis and chairside prosthesis. [3]

S. L. Evans, et al, studied that Composite materials have been widely promoted as possible orthopedic biomaterials but to date have found few successful commercial applications, due to the many challenging problems presented by their design, fabrication and testing. The range of possible composite biomaterials is reviewed, together with the possible methods of fabrication and the limitations that these place on the design of composite components. The use of composite materials allows many new design possibilities, but this freedom of design requires a clearer understanding of the objectives and constraints on the design process.The interaction of composite materials with the body is more complex than that of the component materials, and the prediction of their long-term mechanical performance also presents many intractable difficulties. However, despite these challenges composite materials are likely to prove invaluable in the future development of orthopaedics. [9]

According to D. Puppi, et al, Current strategies in scaffold-guided tissue engineering approach, involving the most employed biodegradable polymers, either of natural or synthetic origin, will be reported underlying the role played by both material structure–property relationship and scaffold architecture. While there are many polymeric materials that may be employed for the regeneration of bone and cartilage tissue, we will focus specifically on those that have been more extensively applied, showing promising outcomes. Commonly exploited and innovative processing techniques for the fabrication of advanced tissue engineering scaffolds will be explored, highlighting theoretical principles and their potential in creating micro-nanostructures suitable for tissue regeneration applications. [5]

III. ANALYSIS AND DISCUSSION

A. Analysis of the parts as follow:

3.1. The Foot Base made up of GFRP**:**

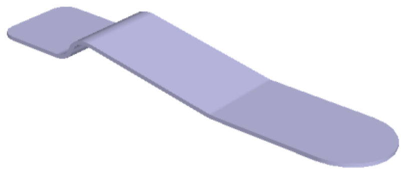

Fig. 3.1: Modelling View of Foot Base

3.2 Boundary Conditions:
The Foot Base is constrained as shown and applied 1225 Load on FE Model.

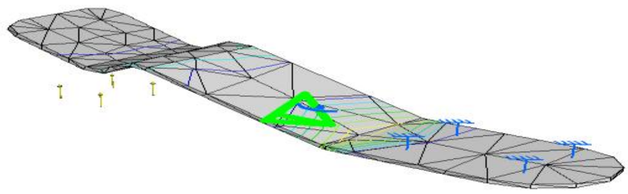

Fig. 3.2: The Foot Base:

3.3Stresses Induced in the Foot Base
805e7N/m2 Von mises Stresses induced in Foot Base.

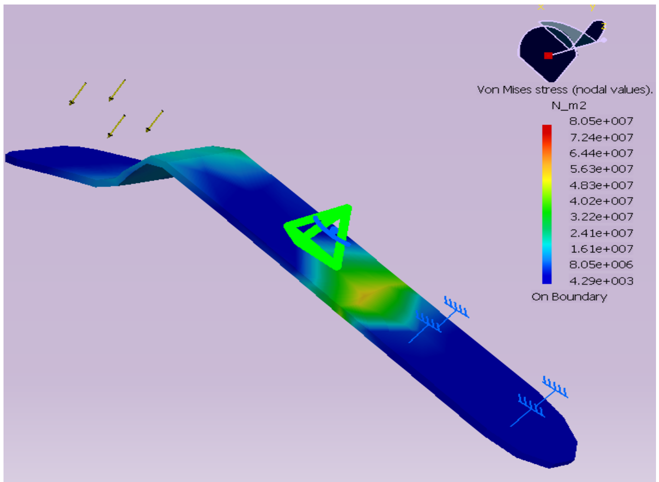

Fig. 3.3: Stresses induced in the Foot Base

3.4. The Foot Top made up of GFRP:

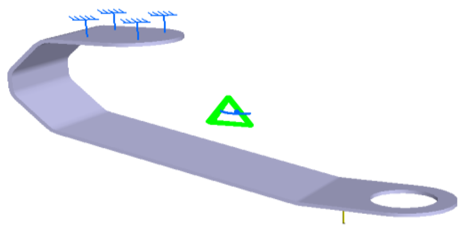

Fig. 3.4: Modelling View Foot Top.

3.5. Boundary Conditions:

The Foot Top is constrained as shown and applied 1225 N Load on FE Model.

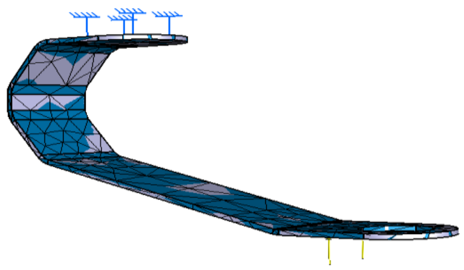

Fig. 3.5: The constrained Foot top**.**

3.6. Stresses Induced in the Foot Top:

1.1e8 N/m2 Von mises Stresses induced in Foot Top.

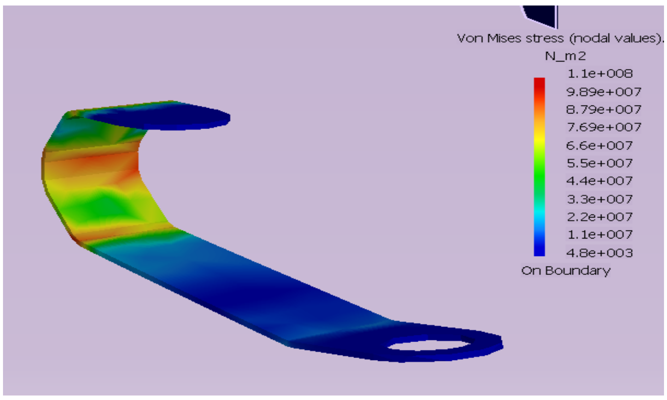

Fig. 3.6: Stresses induced in the Foot Top

3.7. The Foot Top Tube up of GFRP:

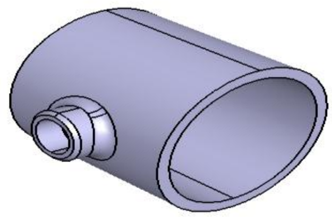

Fig. 3.7: Modelling View Foot Tube

3.8. Boundary Conditions:

The Foot Tube is constrained as shown and applied 1225 N Load on FE Model.

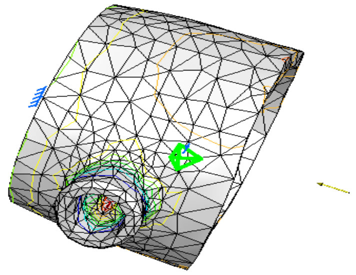

Fig. 3.8: The constrained Foot tube.

3.9. Stresses Induced in the Foot Tube:

8.65e6N/m2 Von mises Stresses induced in Foot tube

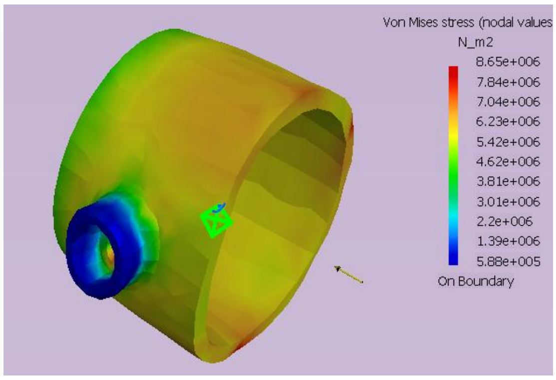

Fig. 3.9: Stresses induced in the foot tube

3.10. The Foot Stem made up of GFRP:

Fig 3.10: Modelling View Foot Stem.

3.11. Boundary Conditions:

The Foot stem is constrained as shown and applied 1225 N Load on FE Model.

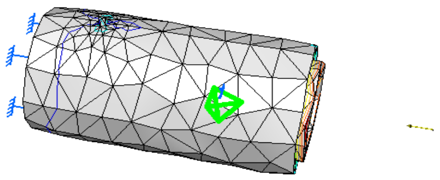

Fig. 3.11: The constrained Foot stem.

3.12. Stresses Induced in the Foot Stem:

1.2e7N/m2 Von mises Stresses induced in Foot Stem.

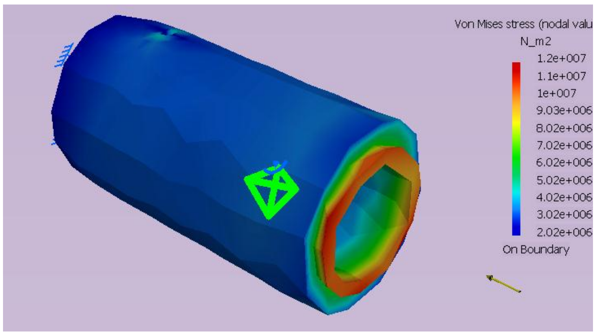

Fig. 3.12: Stresses induced in the Foot Stem

3.13. The connector made up of GFRP:

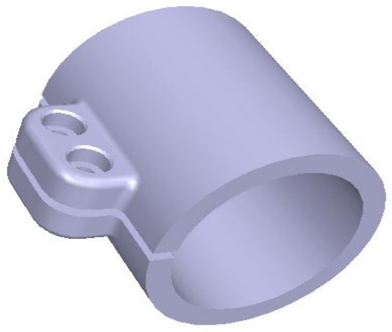

Fig 3.13: Modelling View connector

3.14. Boundary Conditions:

The connector is constrained as shown and applied 1225 N Load on FE Model.

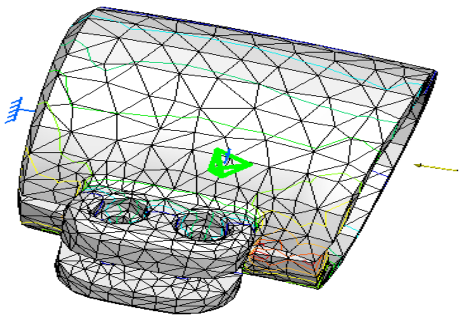

Fig. 3.14: The constrained connector.

3.15. Stresses Induced in the Connector**:**

1.28e7N/m2 Von mises Stresses induced in connector.

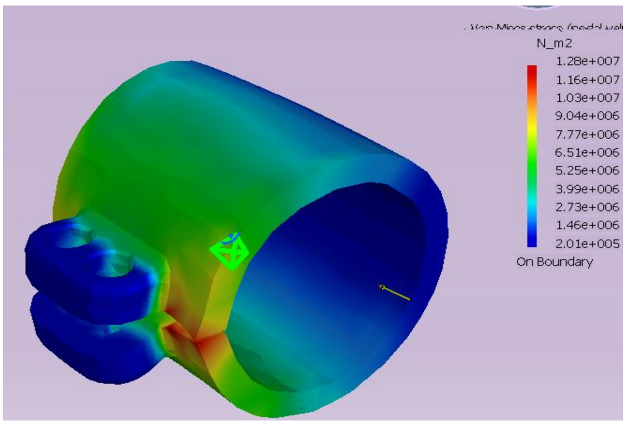

Fig. 3.15: Stresses induced in the connector

3.16. The Lower App made up of GFRP:

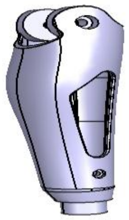

Fig 3.16: Modelling Lower App.

B. Results Obtained:

The Result obtained from the analysis.

1 The Maximum 8.05e7 N/m2 Von mises Stresses induced in the Foot base
- The Maximum 80 N/mm2 Von mises Stresses induced in the Foot base is bellow Yield stress 125 N /mm2 FOS = 1.5
- The factor of safety is 1.5 as the Foot base is safe no optimization is required.

2 The Maximum 1.1e8 N/m2 Von mises Stresses induced in the Foot top.
- The Maximum 110 N/mm2 Von mises Stresses induced in the Foot top is bellow Yield stress 125N /mm2 FOS =1.1
- The factor of safety is 1.1 as the Foot top is safe no optimization is required.

3 The Maximum 8.65e6 N/m2 Von mises Stresses induced in the Foot tube.
- The Maximum 8.65 N/mm2 Von mises Stresses induced in the Foot tube is bellow Yield stress 125 N /mm2 FOS = 14.4
- The factor of safety is 14.4 As the Foot tube is safe. As FOS is too high so optimization will be carried out.

4 The Maximum 1.2e7 N/mm2 Von mises Stresses induced in the Foot stem.
- The Maximum 12 N/mm2 Von mises Stresses induced in the Foot stem is bellow Yield stress 125N /mm2 FOS = 10.4 As FOS is to high so optimization will be carried out.

5 The Maximum 1.28e7 N/mm2 Von mises Stresses induced in the connector.
- The Maximum 12 N/mm2 Von mises Stresses induced in the connector is bellow Yield stress 125 N /mm2 FOS = 10.4
- As FOS is high so optimization will be carried out.

6 The Maximum 4.96e7 N/mm2 Von mises Stresses induced in the Lower app.
- The Maximum 49.6 N/mm2 Von mises Stresses induced in the Lower app is bellow Yield stress 125 N /mm2 FOS = 2.5 As FOS is too high so optimization will be carried out.

7 The Maximum 1.49e7 N/mm2 Von mises Stresses induced in the Cylinder.
- The Maximum 14.9 N/mm2 Von mises Stresses induced in the Cylinder is bellow Yield stress 500 N /mm2 FOS = 33.5

As FOS is too high so optimization will be carried out.

8 The Maximum 1.48e7 N/mm2 Von mises Stresses induced in the Piston shaft is bellow Yield stress 500 N /mm2 FOS = 33.7

As FOS is too high so optimization will be carried out.

9 The Maximum 1.44e7 N/mm2 Von mises Stresses induced in the Joint top is bellow Yield stress 125 N /mm2 FOS = 8.6 As FOS is to high so optimization will be carried out.

A conclusion section is recommended as it helps the readers to check the relevance. Conclusion may the scope of the work presented in the paper.

IV. CONCLUSIONS

An attempt was made to analyze and optimize the Artificial Composite Leg using CATIA software. The project work carried out is successfully analyzed to meet the requirements as per the constraints. The Composite Leg is carefully analyzed and cross checked where it does meet the requirements. Composite Leg is designed using optimum material in order to avoid the larger weight by using GFRP. The factor of safety is Between 1.3 to 2.7. As the composite leg is safe and the cost of manufacture can be brought down. We are able to get finish product. Cost of composite leg and time for manufacturing can be brought down. As the density also less compared to Metal alloy the Leg weight also low. Volume of Leg brought down. We can bring down cost of the Leg by 30% to 40% in mass production.

As we have used here the free meshing to get a better result map machine can be used and also with some advance materials

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