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Design and Strengthening of Limb with Numerical Analysis Using Glass Fibre Reinforced Material

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ABSTRACT

In this paper, numerical analysis of "Artificial Limb" carry out. Advantages of numerical analysis in reaction-diffusion are being able to use an arbitrary domain and the ease with which can specify flux boundary conditions. As from numerical analysis total stress produced and the suitable material can be calculated and checked. In optimization analysis was performed on a limb. Pre-processing and solving procedures were performed using Pro-E and Ansys. Glass Fibre Reinforced Polymer Material chooses considering its unique properties like cost, lightweight, chemical and moisture resistance. So by using numerical analysis and considering this material scope of Artificial Limb discussed. This result are useful to make artificial limb lighter weight, to make smooth foot rollover, to adapt composite leg on various walking speeds and on uneven surfaces, to make Attractive and functional foot cosmetic, making it suitable for moderate activity, to adapt Modern design for manufacturing

***Keywords*— Numerical Analysis, Glass Fibre Reinforced Material, Stress- Strain Analysis**

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I. INTRODUCTION

In today's world, it is important to maintain balance in life – The FEA is a numerical procedure for analyzing structures of complicated shapes, which otherwise would be difficult by classical analytical methods. Analytical solution is a mathematical expression that gives values of desired unknown quantity at any location in a body or a structure and it is valid for an infinite number of locations in body or structure. But analytical solutions can be obtained only for simple engineering problems. It is extremely difficult and many a times impossible to obtain exact analytical mathematical solutions for complex engg, problems. In such cases FEM is used which gives approximate solution. .

II. LITERATURE REVIEW

The Numerical Analysis (finite element method) is a numerical procedure for analyzing structures and continua for obtaining approximate solutions to wide engineering problems". The limitations of the human mind are such that it cannot grasp the behavior of its complex surroundings and creations in one operation. Thus the process of subdividing all systems into their individual components or 'elements', whose behavior is readily understood, and then rebuilding the original system from such components to study the behavior is a natural way in which the engineers and scientists proceeds.
The finite element method is a powerful tool for the numerical procedure to obtain solutions to many of the problems encountered in engineering analysis. From structural, thermal and heat transfer, fluid dynamics, fatigue related problems, electric and magnetic fields, the concepts of finite element methods can be utilized to these engineering problems. In this method, the domain over which the analysis is studied is divided into a number of

finite elements. Interpolating functions are used to reduce the behavior at an infinite field of points to a finite number of points. These points define the finite elements. The elements are interconnected by nodes. All the elements are assembled together and the requirements of continuity and equilibrium are to be satisfied between neighboring elements. A unique solution can be obtained to the overall system of linear algebraic equations, provided the boundary conditions of the actual system are satisfied. Solution of these equations gives us the approximate behavior of the continuum. To obtain an accurate solution in the region of rapidly varying variables, more number of smaller elements must be used. [3]

An analytical solution is a mathematical expression that gives the values of the desired unknown quantity at any location in a body, and as a consequence it is valid for an infinite number of locations in the body. For problems involving complex material prosperities and boundary conditions, the engineers resort to finite element methods that provide approximate, but acceptable, solutions as the problem addressed is too complicated to be solved satisfactorily by the classical analytical methods. [5]

FEA works on the principle of divide and rule, that is, it transforms a physical system having infinite unknowns into small finite elements having finite number of unknowns. The unknowns are called degrees of freedom. Degree of freedom is the number of independent coordinates which must be specified to define all displacements. Instead of solving the problem for the entire body in one operation, the solutions are formulated for each constituent unit and combined to obtain the solution for the entire body i.e. going from part to whole Thus in FEM, body or structure is divided into finite number of smaller units known as elements. This process of dividing the body into finite number of elements is known as discretization. The assemblage of elements then represents original body or structure. Physical problem involves an actual structure subjected to certain loads and constraints. The material properties and the governing relationships are considered over the elements and expressed in terms of unknown values at element corners. An assembly process duly considering the loading and constraints, results in a set of equations. Solution of these equations did by FEM gives us the approximate behaviour of the continuum.

Bakelite was the first fiber-reinforced plastic. Dr. Baekeland had originally set out to find a replacement for shellac (made from the excretion of lace beetles). Chemists had begun to recognize that many natural resins and fibers were polymers, and Baekeland investigated the reactions of phenol and formaldehyde. He first produced soluble phenol-formaldehyde shellac called "Novolak" that never became a market success, and then turned to developing a binder for asbestos which, at that time, was molded with rubber. By controlling the pressure and temperature applied to phenol and formaldehyde, he found in 1905 he could produce his dreamed-of hard mouldable material (the world's first synthetic plastic): Bakelite. He announced his invention at a meeting of the American Chemical Society on February 5, 1909

According to R. M. Williams, et al, 2006, in none of the cognitive performance tests were any significant differences revealed between the two knee joint systems. Nor were there any statistically significant differences in the self-selected walking speed (1.06 ± 0.06 m/s with the C-Leg vs. 1.03 ± 0.06 m/s with the Mauch SNS). However, differences between the knee joint systems were identified in terms of subjective cognitive load. The C-Leg requires less attention during walking, which is why the subjective cognitive load is lower when using this knee joint. The author outlines that the use of a microprocessor-controlled prosthetic knee joint requires less attention even in the easy-tomanage situations investigated in this study, according to the subjective assessment made by the amputees. According to the author, this subjective experience was not consistent with the neuropsychological test results and the measured walking speed. Although a microprocessor-controlled prosthetic knee joint is an adequate fitting for the majority of amputees, further studies are required to identify which groups. [4]

According to T.H. Brodtkorb, et al, 2008, using a modified Markov decision analysis model, costs and fitting outcomes are to be estimated for the C-Leg and non-microprocessor prosthetic knee joints. For a defined C-Leg lifecycle of eight years, the additional cost of fitting such a system amounted to EUR 7,657.00 (according to the euro cost base in 2006) while QALY efficiency increased by a factor of 2.38 in the same period. This results in an additional cost of EUR 3,218.00 per QALY for the C-Leg. In comparison with non-microprocessor controlled prosthetic knee joints, the C-Leg, with a simultaneous increase in health-related quality of life, can be considered economical. The authors state that a cost-utility analysis is an additional key piece of information for health insurers and reimburses, and should thus be used as a decision-making aid, particularly for high-priced medical products. They also mention that the approach described in the article would become even more significant if detailed interviews and parameters that can be measured.

III. ANALYSIS AND DISCUSSION

A. OPTIMIZATION

3.1. Stresses Induced in the Foot Tube:

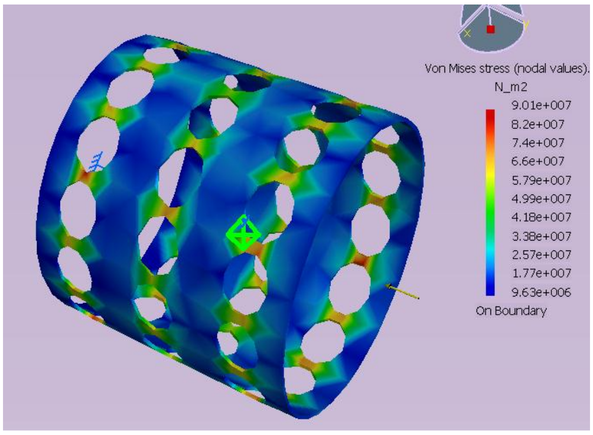

Fig.3.1: Stresses induced in the Foot tube

3.2 Stresses Induced in the foot stem:

4.59e7N/m2 Von mises Stresses induced in Foot

Stem

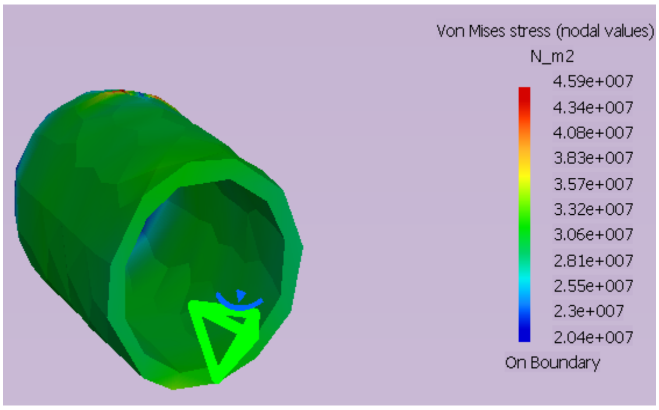

Fig. 3.2: Stresses induced in the Foot Stem:

3.3Stresses Induced in the Connector:
7.77e7N/m2 Von mises Stresses induced in connector

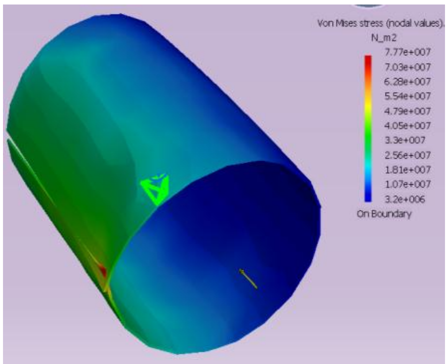

Fig. 3.3: Stresses induced in the connector

3.4. Stresses Induced in the Cylinder

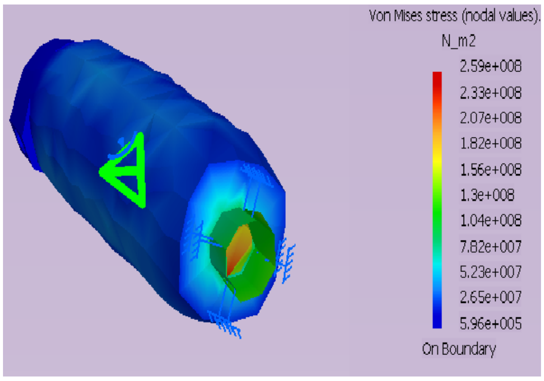

Fig. 3.4: Stresses induced in the Cylinder.

3.5 Stresses Induced in the Piston Shaft: The 2.23e8 N/m2 Von mises Stresses induced in Piston Shaft.

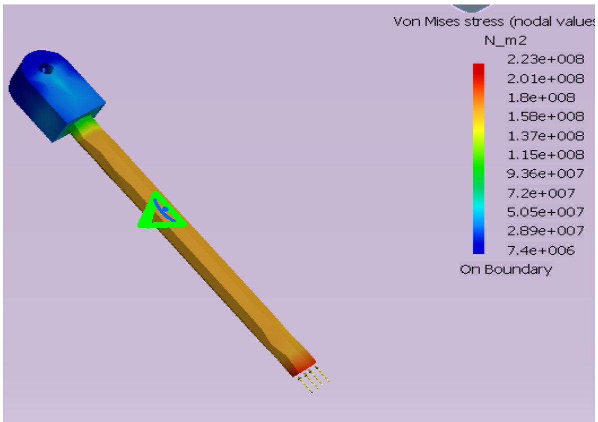

Fig. 3.5: Stresses induced in the Piston Shaft

3.6. Stresses Induced in the Joint Top:
5.09e7N/m2 Von mises Stresses induced in Foot Top.

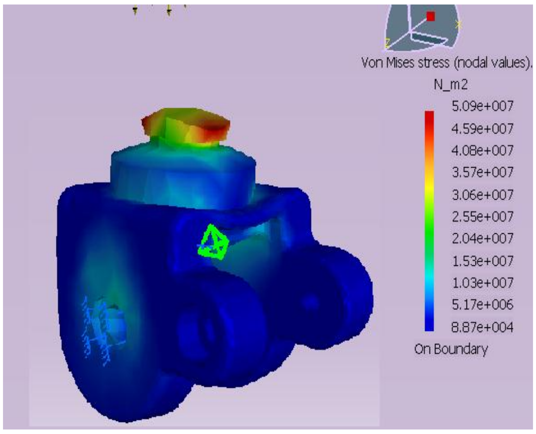

Fig. 3.6: Stresses induced in the Joint Top

3.7. Boundary Conditions:

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

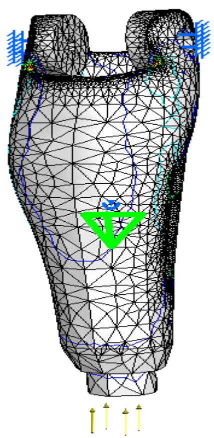

Fig. 3.7: The constrained Lower App

3.8. Stresses Induced in the Lower App:

4.96e7 N/m2 Von mises Stresses induced in Lower App.

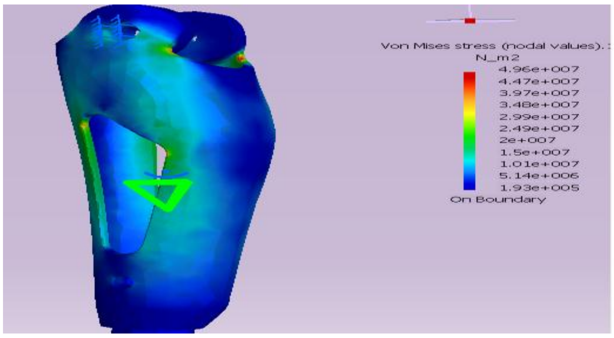

Fig. 3.8: Stresses induced in the Lower App

3.9. The Cylinder up of Aluminum:

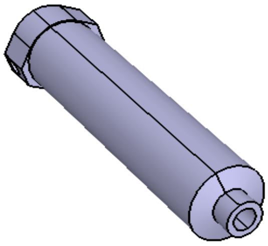

Fig. 3.9: Modelling View Cylinder

3.10. Boundary Conditions:

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

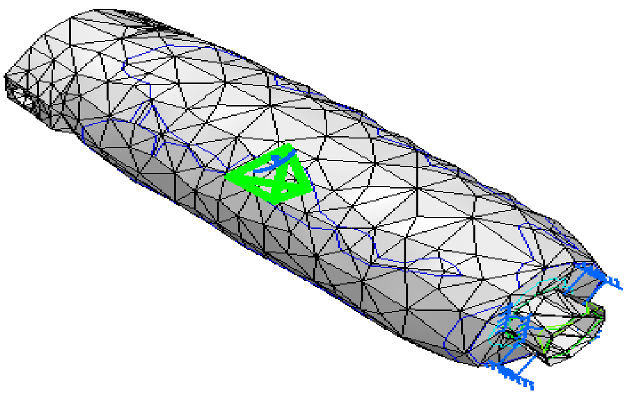

Fig 3.10: The constrained Cylinder

3.11. Stresses Induced in the Cylinder:

1.49e7 N/m2 Von mises Stresses induced in Cylinder.

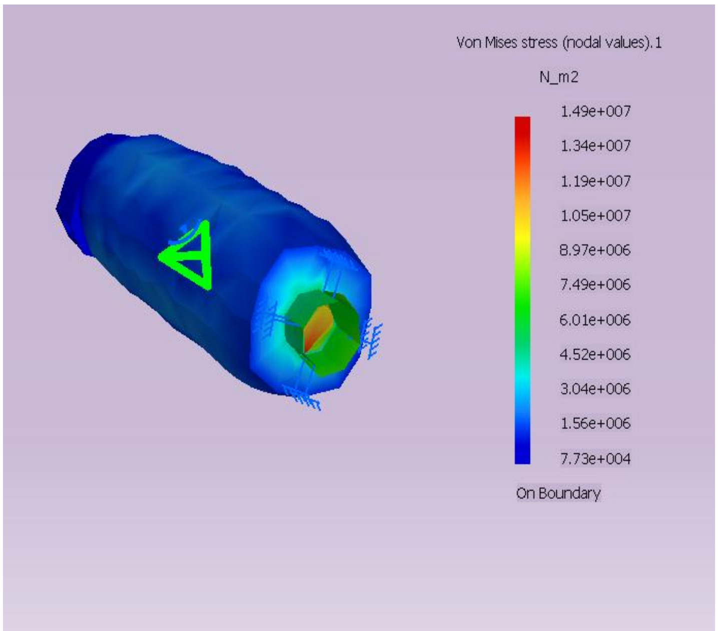

Fig. 3.11: Stresses induced in the Cylinder

D. Results Obtained:

The Result obtained from the Optimization analysis.

The Result obtained from the analysis after optimization.

1. The Maximum 9.01e7 N/m2 Von mises Stresses induced in the Foot tube. The Maximum 90 N/mm2 Von mises Stresses induced in the Foot tube is bellow Yield stress 125 N /mm2 FOS = 1.3. The factor of safety is 1.3 as the Foot tube is safe.
2. The Maximum 4.59e7 N/mm2 Von mises Stresses induced in the Foot stem. The Maximum 45 N/mm2 Von mises Stresses induced in the Foot stem is bellow Yield stress 125 N /mm2 FOS = 2.7.
3. The Maximum 7.77e7 N/mm2 Von mises Stresses induced in the connector. The Maximum 77 N/mm2 Von mises Stresses induced in the connector is bellow Yield stress 125 N /mm2 FOS = 1.6.
4. The Maximum 2.59e8 N/mm2 Von mises Stresses induced in the Cylinder. The Maximum 259 N/mm2 Von mises Stresses induced in the Cylinder is bellow Yield stress 500 N /mm2 FOS = 1.9.
5. The Maximum 2.23e8 N/mm2 Von mises Stresses induced in the Piston shaft. The Maximum 223 N/mm2 Von mises Stresses induced in the Piston shaft is bellow Yield stress 500 N /mm2 FOS = 2.2.
6. The Maximum 5.09e7 N/mm2 Von mises Stresses induced in the Joint top. The Maximum 50 N/mm2 Von mises Stressesinduced in the Joint top is bellow Yield stress 125 N /mm2 FOS = 2.5. The factor of safety after optimization is between 1.3 to 2.7. As the leg is safe. Cost of manufacture can be brought down by 30 to 40% as the leg weight also low. It will make more comfortable to the patients.

IV. CONCLUSIONS

Though the solution obtained by FEM is discrete node points, it can be extended to all location of the body.
FEM can be employed as a powerful design analysis and validation tool to detect any flaws in the system and critical points even before the actual installation of the system.
FEM can be employed for non-engineering applications.

Artificial limb 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 artificial limb is safe and the cost of manufacture can be brought down. We are able to get finish product.

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