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Design and Analysis of Artificial Leg Mechanism for Above Knee Amputees

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Abstract — *The purpose of this paper is to represent the research and analysis of prosthesis, some of performance test experiments are done by using 3 different materials. In order to provide an ideal experimental platform for the performance test of prosthesis. Artificial leg is an important part for the people who are disabled and handicapped, and its main function is to provide the disabled people with healthy normal function, which provides flexibility in their daily activities. Artificial legs are designed to meet required values for tensile strength, density, corrosion resistance, shear strength, flexibility, durability, and cost- efficiency. The above consideration depends on the properties of the materials used for the foot's design. . In this paper, aluminum, titanium, Stainless steel materials and their values of the prosthetic foot have been used. The objective of the artificial leg mechanism is to allow standing and walking, providing a stable base of support and conserving as much energy as possible by using suitable material among aluminum, titanium & stainless steel which allows us to make the prosthesis as light as possible, and its resistance to the corrosion will wipe out rusting problems.*
Keywords *— Artificial leg, Titanium, Aluminum, Stainless steel, Modeling, CREO, ANSYS Work bench.*

I. INTRODUCTION:

Artificial leg is one of the important components for the disabled and handicapped people's where they uses these artificial legs as the replacement of their leg. These artificial legs are made up of the different materials where each metal is used for the each part so, that which can bring comfort and flexibility for the people who are using them for their daily activities. As pylon is made up of carbon and body of the leg is made up of aluminum and stainless steel and titanium as well. Each material has it's own unique values in them. There are many reasons for people using these artificial leg such as some might met with an accident and for other's it could be the birth reasons. Making the proper alignment between the leg and limb is more important than the fixing the artificial leg for the person. There are lot more parts which could complete make the artificial leg before a person use it. Such as Hinge joint, hydraulic, pneumatic and mechanical mechanism devices which could add an advantage for the people to make their move very easily and do their activities. That's the reason why we are using the three different materials to test their strength, stress, strain, equivalent stresses and resistivity to corrosion and nature of their material while alignment to the limb and hinge joint. And the other main reason would be the life existence of the material cause that could play an major role in the usage of the artificial leg mechanism. And also our research is done for the above knee amputees where the above knee amputees is different from below knee amputees as such above knee amputees concentrates more on the presence of more proximal disease or failed wound healing from a below knee amputees. We are using the CREO software for the design of the artificial leg for above knee amputees. And analysis part is done by the ANSYS software where we get the all the values of these three different materials which could be better for the body of the artificial leg for above knee amputees. By observing all the values obtained from the analysis we will be using that material as the body of the artificial leg. And also we use the hinge joint as the connection between the limb and leg and also pneumatic device for the leg, because it helps the people to move fast with the small force given to the leg in any particular direction. And the metal we use for the leg will give more flexible and comfort for the people to walk and do their daily activities.

II. LITERATURE REVIEW:

[1] Chin T, Sawamura is a professor who has reviewed on Physical fitness of lower limb amputees. His objective is to research on the cardiorespiratory of the physical fitness of amputees and handicapped subjects of the same ages and to demonstrate progress of the person's fitness of their leg amputees. He has selected 31 people for his experiment purpose and later he has sent them for some of the tolerance tests where they were under some noticed of their strength's . He has conducted this experiment by using the cycle ergometer driven by the intact leg. He has noticed the values after the experiment has increased than before values of his experiment has done. The values before the examination are 18, 12, 63 and after the experiment the values we obtained are much higher than this values. By these experiment he has stated that fitness of the amputees is

clearly less than the dis-abled people and their amputees can be recover by a poorly condition after the tolerance examination. These are the things reviewed by the professor chin T, Sawmura.

[3] Nolan L has reviewed on Carbon fiber prostheses and running in amputees. His main focus was on the improvement of the increasing the performance of the artificial leg and also to concentrate on the functional background of the artificial leg also. He wanted to give the mechanical advantage for the artificial leg by adding the devices which can make the artificial leg behaves as the normal functioning leg as others. And this review is based on the carbon prosthesis and effects on the running activities of the amputees.

[1] Enoka RM has reviewed on below-knee amputee running gait. He analyzed in his review that the temporal and length characteristics of their running strides and also the angular displacement patterns of their intact and prosthetic limbs. He has tested six individuals who are running with their locomotors with different places looks similar to the non-amputees people or normal people. As there is one of the prosthesis which is not tendency to run as normal amputees and they thought that could be fixed by the prosthesis leg modifications and can be able to make run as normal prosthesis does. And also with the training of the prosthesis leg to be work as usual to the normal gait. Conclusion of these experiment is to make the lower amputees can also run with the suggested directions.

[1] Henk EJ has reviewed on the skin problems in the lower limb amputees. The main reason of this experiment is to run on the skin problems of the lower limb amputees and also to know the reasons for it. The problem between the limb and leg and their alignment. As he has done lot of his research on this reason but he couldn't find the reasons for it.

III. METHODOLOGY

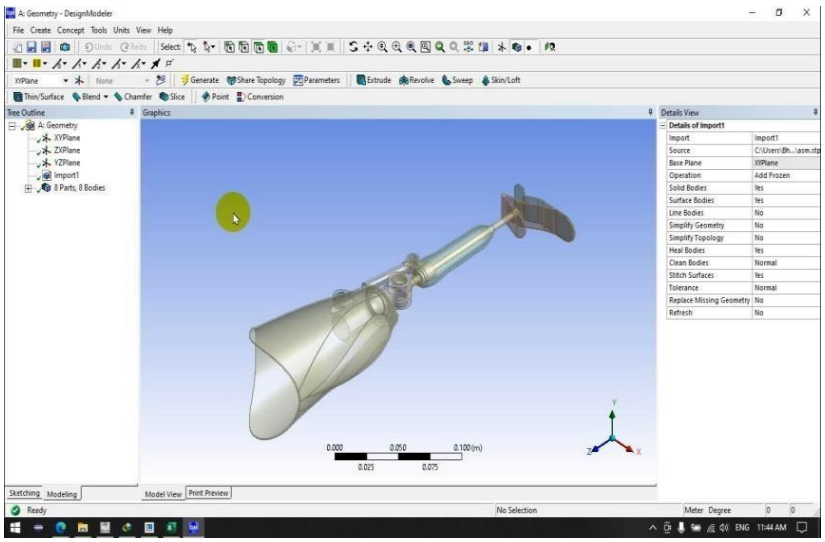

Fig: 2.1 Design of Artificial Leg for Above Knee Amputees Using Creo Software.

In these part we are going to find the values of the each material (Titanium, stainless steel and aluminum) under different loads starting from 50 -120kgs. The analyzing the values and considering the deformation and factor of safety as majors we choose the metal which is confortable for better usage for above knee amputees.

By finding all the values of the metals we try to find it's drawbacks as well if they are made better we could try making that material much better than before. We get the deformation point for every material as well where stainless deforms at 93kgs, Titanium deforms at 104kgs, and Aluminum deforms at 103kgs. Where the factor of safety becomes 1 after these deformation points crossing for these metals.

Applications of Loads: Structural Analysis

Condition 1: force of movement, fixed peddles – deformation, strain & stress during the load applied

S.NO	Load – N	Deformation - mm	Stress - Mpa	Strain - mm
1.	490.5	1.1069	86.446	0.0012511
2.	539.55	122.96	95.452	0.0013814
3.	686.7	1.5688	122.96	0.0017795

Table 2.1 Values of Aluminum Material

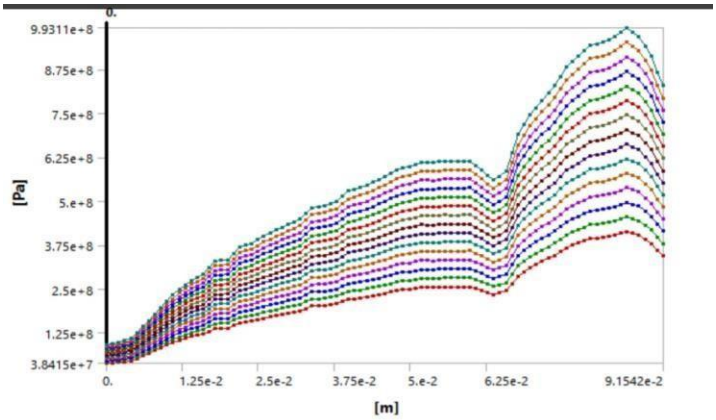

Fig 2.2 : Stress Vs Strain - Aluminum Material.

Condition 2: force of movement, fixed peddles – deformation, strain & stress during the loadapplied.

S.NO	Load – N	Deformation - mm	Stress - Mpa	Strain - mm
1.	490.5	1.1069	86.446	0.0012511
2.	539.55	1.1069	86.446	0.0012511
3.	588.6	1.1069	86.446	0.0012511

Table: 2.2 Values of Titanium Material

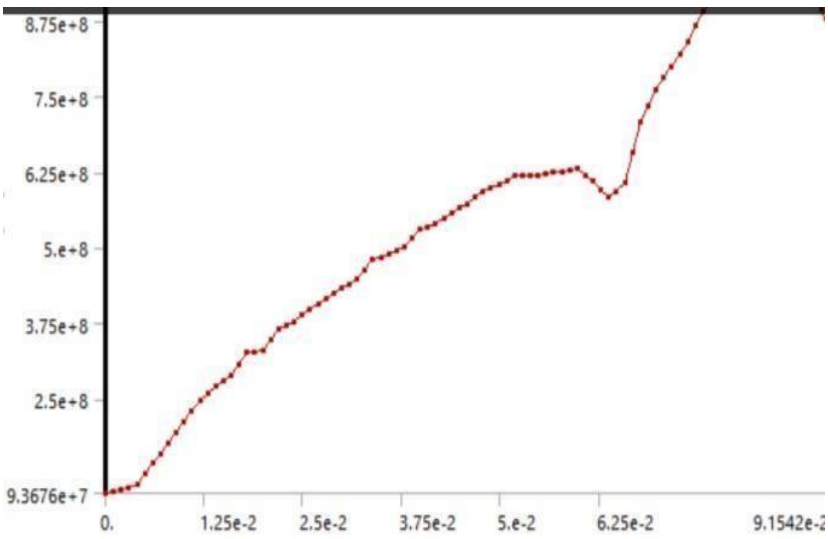

Fig: 2.3 Deformation Point of load on Titanium Material.

IV. RESULT AND DISCUSSION:

This part mostly concludes the material which we wanted to use for artificial leg mechanism for above knee amputees by the values which we got through the analysis part. Where Titanium has the most prior advantage than other two metals in terms of resistivity, high density, load withstand capabilities and many other factors as well. The major drawback we see in this is the price is way much higher than other metals as well.

And the aluminum has almost similar values to the titanium, but titanium metal has higher life existence. So any way titanium has better quality for making artificial leg for above knee amputees for confortable usage

Each property of the materials varies from the others. The deformation of the Titanium material occurs at 104kgs, for Aluminum it occurs at 103kgs and Stainless Steel turns at 93kgs Where the Factor of Safety becomes greater than 1 atthese deformation points of these materials.

Titanium

Mechanical Properties: Titanium has excellent ductility and tensile strength. It's minimum yield strength is between 240 and 241Mpa in commercially pure grade 1. Ti-10v-2Fe-2AI has the highest yield strength of all titanium's alloy at126Mpa.

Aluminum Properties

Mechanical Properties: Aluminum is a metal-like element with both metal and no-metallic properties, situated in the boron and carbon family. Though aluminum is one of Earth's most abundant elements, it must be sourced from bauxite ore and undergo a production process before becoming commercially pure, viable aluminum.

Stainless Steel Properties: They have magnetic properties, too, offers good ductility, tensile- property stability, and resistance to corrosion, thermal fatigue, and stress-corrosion cracking.

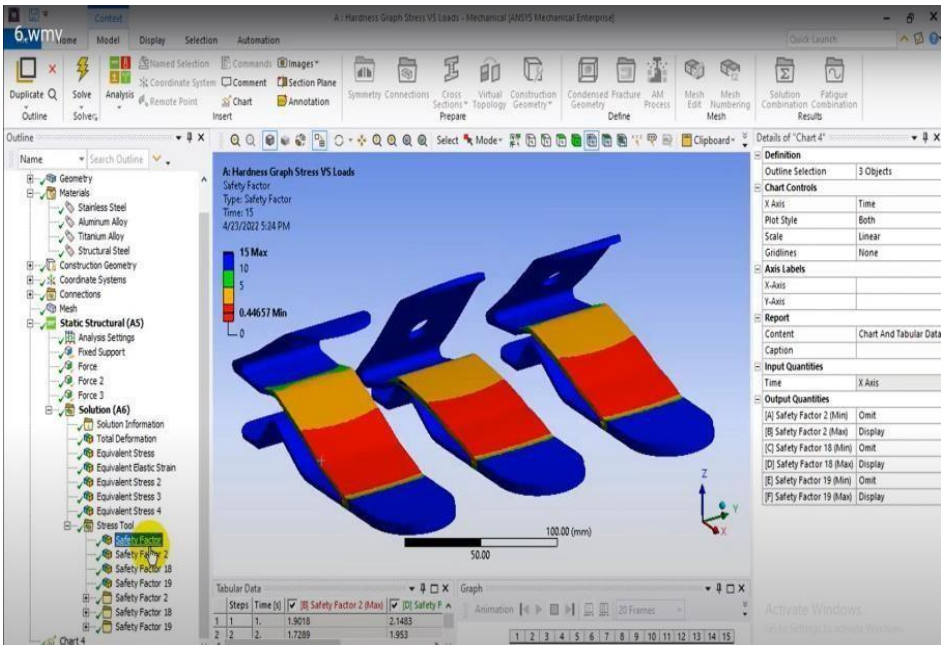

Fig 3.1: Stress of 3 different materials.

V. CONCLUSIONS

By observing all the analysis values of the different materials (Titanium, Aluminum and Stainless Steel) we can conclude that Titanium has a priority advantage than other metals. In terms of Tensile strength, Yield's strength , young's modulus, Hardness, Load with stand Capabilities, Resistivity, and also metal density. There are more such factors which say's titanium is the best and safe material used for artificial leg mechanism for above knee amputees. Another reason why we choose the titanium is because of it's life existence. Metallic alloy such as titanium continue to be one of the most important components used in orthopedic implant devices due to favorable properties of high strength, rigidity fracture toughness and their reliable mechanical performance as replacement for hard tissues. Prime example of titanium implants used in orthopedics would include prosthesis hip and knee replacements for various types of arthritis affecting these joints, spiral fusion instruments for stabilizing degenerate and unstable vertebral segments, and fracture fixation devices of various types such as plates, screws and intramedullary rods. This reduces the risk of pain or irritation associated with dramatic temperature changes.

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