Abstract

Big terrorist attacks in Iraq and led to the rise of the amputation number, It is found that Iraq now forefronts the world countries in amputations number. However, typically 80% of the lower limb amputations are trans-tibial.

In this work, Fifteen laminated composite materials used for manufacturing trans-tibial prosthetic sockets by using vacuum molding technique. The matrix materials of these composites are of three types: Epoxy, poly methyl methacrylate (PMMA), and a Blend of (50 wt. %Epoxy and 50 wt. % PMMA. Each one of these matrices was reinforced with five groups of woven fibers and particles. The first group consists of perlon layers, the second consists of fiber glass layers, the third group consists of carbon fiber layers, the fourth group consists of hybrid (carbon and glass) fiber layers, and the fifth group consists of hybrid (carbon and glass) layers with micro & nano Silica particles.

The tensile properties (Young's modulus, tensile strength and elongation at break), max. shear stress, fracture toughness and fatigue properties (S-N curve, strain energy-N and fatigue limit) were measured experimentally.

The theoretical part of this work deals with calculations of the fatigue ratio, theoretical factor of safety and failure index in addition to the calculations of Poisson's ratio and density.

The finite element technique (ANSYS-11) is used to analyze and evaluate fatigue characteristics by observing the contours distribution of fatigue life, safety factor, equivalent Von Mises stress, total deformation and maximum shear stress. This was done by constructing fifteen models for the socket which were treated as three-dimensional structure composite material.

The results show that changing the type of reinforcement and matrix has a great influence on the measured properties and as follows:

The (strength / density) ratio, Young's modulus (E) and ultimate tensile strength of (Blend with Glass reinforcement are the highest. Adding SiO_2 particles to Epoxy matrix composite increases the tensile modulus and tensile strength of Hybrid

(Glass+Carbon) reinforcement significantly by (1.5) and (1.7), respectively when compared with composites without SiO_2 particles.

The highest maximum shear stress is obtained in Blend with (Glass, Hybrid (Glass+Carbon), Carbon reinforcement composites with 59.42, 46.79 and 30.05 MPa, respectively.

The maximum fracture toughness is obtained in (Epoxy with Carbon reinforcement) composite with 9.83 $MPa.m^{1/2}$.

(Blend with Glass reinforcement) composite have the highest fatigue and strain energy limit with (62) MPa and (96.66) $Joul/mm^3$, respectively.

(Blend with Glass reinforcement), (Blend with Glass + Carbon reinforcement), (Epoxy + Carbon reinforcement) and (PMMA with Glass + Carbon reinforcement) composites have the highest safety factor of (9.3, 8.5, 6.9 and 6.7), respectively when compared with other laminated composites.

Reinforcement with perlon gave the lowest values in all measured properties in the three matrices used in this study.

(Blend with Glass reinforcement), (Blend with Glass + Carbon reinforcement), (Epoxy + Carbon reinforcement) and (PMMA with Glass + Carbon reinforcement) composites gave optimum experimental, numerical and theoretical results which make them the best candidate to improve the fatigue characteristics of trans-tibial prosthetic socket.