



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Atul Singh Rajput

Roll Number : 196103009

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Name of Thesis Supervisor(s) : Dr. Manas Das and Dr. Sajan Kapil

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SHORT ABSTRACT

Additive Manufacturing (AM) or 3D printing provides the benefits of individualizing the implant per patient requirements. However, the poor surface quality of additively manufactured components is a major limitation as it increases its wear rate on their tribological interaction. Hybrid Electrochemical Assisted Magnetorheological (H-ECMR) utilizes the synergic action of mechanical abrasion and electrochemical reaction to enhance the surface quality of the parts without affecting their surface topography. The electrochemical reaction forms a uniform and thick oxide layer on the Ti-6Al-4V surface as layer thickness increases to 78 nm from its initial value of 8 nm, further improving its corrosion resistance. This work details the working principle of the H-ECMR finishing process with an analysis of the impact of process parameters on the reduction in surface roughness. The H-ECMR finishing process effectively applies to parts with initial surface roughness (R_a) in the sub-micron range. Hence, chemical etching or milling operation is used as an intermediated process after fabricating the Ti-6Al-4V biomedical implants by Laser Powder Bed Fusion (LPBF) or Selective Laser Melting (SLM) to reduce the surface roughness in the sub-micron range. The surface finishing operation is performed on the Ti-6Al-4V femoral head and bone plate to improve its surface quality and biocompatibility. Moreover, Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), and optical profilometer are used to examine the change in the surface quality before and after post-processing of the LPBF fabricated femoral head. The laser scanning study confirms that the femoral head's dimensional accuracy remains intact during the H-ECMR finishing process. The average surface roughness (R_a) value is reduced to 33.14 nm from its initial surface roughness value of 14.67 μm after the H-ECMR finishing to produce a mirror-like polished femoral head surface. The wear, corrosion, and wettability tests signify that the biocompatibility of the fabricated parts is enhanced after post-processing. The corrosion rate for the LPBF manufactured Ti-6Al-4V is 0.081 mm/year, further reduced to 0.0103 mm/year after the chemical etching as surface irregularities of LPBF fabricated surface are very high, creating the grooves for confined corrosion products. The wear rate value on the final polished surface is further reduced to 0.0046 mm/year as an electrochemical reaction during the H-ECMR finishing process, providing a uniform and thick passive oxide layer on the surface of Ti-6Al-4V. The wear rate corresponding to the LPBF fabricated, chemically etched, and polished surfaces are 18.86×10^{-5} , 6.36×10^{-5} , and 0.96×10^{-5} mm³/min, respectively.