INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Now-a-days freeform surfaces are frequently used in different industries due to its usefullness. Finishing of freeform surface is a challenging and a complex task. In medical industry, surface of femoral component of a knee joint implant is fabricated freeform shape to increase the resemblence between actual human knee movement and the artificial one. Magntic field assisted finishing (MFAF) process is used to counteract the problems faced during finishing of femoral knee implant and to provide required uniform surface roughness and charaterstics. A novel MFAF polishing tool is designed and developed. As the polishing tool is newly developed, hence its capability to finish Ti alloy for biomedical application is explored in the present study. Also, the competency of the developed tool to finish freeform surface is investigated. This process uses magnetorheological (MR) polishing fluid whose rheological behaviour is controllable by external magnetic field. Two type of MR fluid is synthesized to generate required surface for biomedical application on Ti alloy. The obtained surface roughness after finishing with MR fluid of Type – I is 10 nm and with MR fluid of Type – II is 70 nm. From wettability study, it is found that the surface finished with MR fluid of Type – I is hydrophilic in nature while with MR fluid of Type – II is hydrophobic. The surface characteristics obtained from MR fluid of Type – I is better suited for semi-permanent type of implants or implants which partake in relative motion like femoral part of knee joint and hip joint. From experimental studies, it is found that in MFAF process parallel toolpath performs better than spiral toolpath while finishing Ti alloy at the nanometer level. 3D surface roughness parameter (*Sa* (arithmetic mean of absolute height), *Spk* (reduced peak height), *Sk* (core roughness depth) and *Svk* (reduced valley depth)) values of the finished surface provide an understanding of the surface characteristics. The optimum values of *Sa*, *Spk*, *Sk* (core roughness depth) and *Svk* are observed with 901 rpm of the tool, 0.60 mm working gap and 4.30 hrs. of finishing time. MFAF process provides

nanometer level surface finish along with necessary surface topography for better wear properties to achieve better performance and longer femoral knee implant life. From experimental investigation, it is concluded that at high working gap, the finishing capability of abrasive particles reduces due to insufficient magnetic field in the finishing zone. Furthermore, after 6 hrs. of finishing time, the surface roughness of the workpiece increases again due to the ploughing effect by the abrasive particles on the already finished workpiece surface. The analysis of finishing forces involved in the present MFAF process is carried out for better understanding and precise control of the process. Simulation study of MFAF process concerning finishing forces is carried out in two FEA based software. Validation experiments are conducted to substantiate the simulation study. A material removal model for a single abrasive particle is also simulated. A statistical DOE analysis is also conducted to evaluate the significance of each process parameter. After analysis of experimental results, it shows that F_n acting on the abrasive particles increases with increased CIP concentration. Although, the increase in abrasive concentration in the MR fluid, working gap and tool rpm results in a reduction in F_n. F_{tan} increases continuously with the increase in tool rpm, CIP concentration, abrasive concentration and decreases with working gap. MFAF tool has the ability to finish freeform surface of femoral knee implant almost uniformly along the surface curvature with necessary requirement of surface properties with minimum surface roughness (*Sa*) of 23.21 nm. Tribological study is carried out to analyse the performance of the MFAF polished surface compared to manually hand polished (HP) surface on ultra-high molecular weight polyethylene (UHMWPE) material of ASTMF648 standard used in tibial bearing surface. The volume loss analysis proves that the femoral knee implant polished using MFAF process will have fewer problems related to wear debris. The wear analysis shows that the wear of UHMWPE bearing surface will be less with MFAF polished femoral component. The wear of UHMWPE bearing surface will be less with MFAF polished femoral component as presumed from surface roughness analysis. The wear test analysis demonstrates that MFAF polished femoral surface will provide higher performance with a long implant life than hand polished surface.