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ADVANCEMENT ON BIOMATERIAL IMPLANTS: A REVIEW

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Abstract –The property modification plays a key role in coordinating with the intricacy of the biological system. Appropriate customized surface alteration can increase the surface characteristics and properties of the implants. This review article is promised to discuss the advancements of biomaterial implants done on the basis of surface characteristics, biocompatibility and physical properties. Change in the input parameters of non conventional machining to study its effect on Ti 6Al 4V and using selective laser sintering to produce CrCoMo alloys at different orientation results in the output that increases material removal rate and strength of the implant respectively. There is an ample scope of growth in working on implants of various types and performing various kinds of machining on it to enhance the biological as well as physical properties.

Keywords – Biomaterials, Biocompatibility, Surface Characteristics, Electric Discharge Machining.

I. INTRODUCTION

Biomaterials are the materials used as a replacement of part of a human's body performing the same function as that of a body part. The biomaterial used for a specific application should sustain in a working condition for a longer period of time i.e. the material should be corrosion resistant, reliable, economical and safe in such an environment. These can be natural and synthetic, basically used to improve the quality of life of human beings. Biomaterials are used as hip joints, bones, dental implants, stents etc [1].

The different types of biomaterials are polymeric, metallic, bioceramics biocomposites. Polymeric biomaterials, various polymers that are used as biomaterials such as nylon, silicon, Rubber, polyester, polytetrafluoroethylene (PTFE), polyvinylchloride (PVC), polypropylene (PP) etc. The advantages that makes them fit for the use of biomaterials is that they are very easy to fabricate and Resilient(means they are able to withstand and recover from difficult situations or conditions). The polymeric biomaterials degrade and deforms, so they are needed to be changed after a particular period of time. In biomedical applications, the polyvinylchloride is used as blood vessels, polypropylene is used to make disposable syringes etc [2]. Metallic biomaterials**,** Metals that are used as biomaterials in biomedical applications are titanium and its alloys, 316 L stainless steel, Co-Cr alloys. The metallic biomaterials are strong enough to withstand various stresses induced while performing its functions and they are made ductile. They are used as joint replacement, bone plates and screw, dental root implants, pacer etc.Titanium alloys, the most attractive metallic materials for biomedical applications. In medicine, they are used for implant devices replacing failed hard tissue. Examples include artificial hip joints, artificial knee joints, bone plates, screws for fracture fixation, cardiac valve prostheses, pacemakers, and artificial hearts. 316L Stainless steel, is considered as one of the attractive metallic materials for biomedical applications due to its mechanical properties, biocompatibility and corrosion resistance. Co-Cr alloys**,** were originally proposed for surgical implants over 60 years ago. Improvements in investment casting technology and a better metallurgical understanding of the cast Co-Cr-Mo system provided the technical justification to consider this alloy type for a variety of biomedical applications [3].Co-Cr alloy has also been widely used in the manufacture of stent and other surgical implants as Co-Cr alloy demonstrates excellent biocompatibility with blood and soft tissues. Bioceramics**,** the class of ceramics that are used to replace the body parts to perform the same function is called bioceramics. There are various bioceramics that are commomly used such as Alumina, zirconia, carbon, bioglass ceramics, calcium phosphate ceramics etc. They are highly biocompatible (general term to measure how compatible the materials are with the living tissues or cells) and strong in compression. Biocomposites, the term biocomposites refers to the those composites employed to biomedical engineering applications. The constituents retain their identities in the composite. They do not dissolve completely into each other although [4]. Normally, the constituent components can be physically identified and exhibit an interface between one another. The biocomposites are basically anisotropic in nature which means the mechanical properties of the composites changes with change in the direction. Since we know the biocomposites are made of constituents which are not completely dissolved in each other so by altering the constituent phase of biocomposites one can obtain various biological as well as mechanical properties [5].

Biocompatibility, the condition of being compatible with living tissues and living cells when a biomaterial is exposed to the biological surroundings. It is also the ability of a material of not having the toxic effect of that particular material to the biological system. To check the biocompatibility of the biomaterial various testing techniques are present. Single biomedical device is made up of different biomaterials having their own biocompatibility value, but a researchers are interested in calculating the biocompatibility of a device itself as a whole [6].

II. LITERATURE SURVEY

Narayan et al.(2010) [7] has worked to study the effect of the zinc oxide coating on the nanoporous alumina membrane. He observed that the zinc oxide-coated nanoporous alumina membranes demonstrated antimicrobial activity against Escherichia coli and Staphylococcus aureus bacteria and he found this technique is having high potential to improve the surface characteristics of nanoporous alumina membrane.

Rivera et al. (2011) [8] has worked on the manufacturing of biomaterial using a technique of rapid prototyping. They used Selective Laser Sintering technique of additive manufacturing and studied the effect of different sintering orientation on the mechanical properties of CoCrMo alloys. After performing their experiments they found that when sintering is done in x-y orientation(when specimen longitudinal axis is in horizontal direction) using appropriateparameters the tensile and fatigue properties are higher as compared to sintering done in z orientation(when specimen longitudinal axis is in vertical direction) using same parameters.

Chemani and Chemani (2012) [9] has studied the requirements of cement used by dentist as per the app.lication. Basically zinc phosphate cement used by dentist is made up of zinc oxide alone or mixed with other oxides. He started working on modifying the composition of zinc phosphate cement by changing the amount of various oxides added to it and studied the physical and the mechanical properties. He then compared the properties with the ADA standard Zinc phosphate and found that the compressive strength and many other mechanical properties increases.

Parida et al.(2012) [10] has worked on classifying the biomaterials on the basis of their usage in biomedical applications. They told that biocompatibility, bioinert, surface reactivity are the important parameters that one should know while using any particular kind of biomaterial. Otherwise not having proper classification knowledge can lead to the negative effect on human's body.

Klocke et al.(2013)[11] has worked on influence of the Electro Discharge Machining on the Biocompatibility of the Biodegradable Magnesium alloys. Due to extraordinary biocompatibility of Magnesium alloys it gets degrades inside the human body at faster rate that result in the lost of the structural stability. He combines the Electro discharge machining with plasma electrolytic conversion to modify the surface by improving the surface properties like micro and macro-structures.

Cattalini et al.(2013) [12] has worked on the Nano-composite Biomaterial that releases calcium for bone tissue engineering scaffolds. He initially developed a biomaterial consisting of alginate matrix of calcium ion and bioactive glass nanoparticle. A film is formed on this biomaterial whose surface characterization was carried out by Scanning Electron Microscope and IR. The embedment of bioactive glass nanoparticle into alginate films results in the improved tensile strength and stability of films is quite good as they do not degrades after 60 days.

Faktorová. et al.(2015) [13] has worked on the dependence of the impedance on the crack depth with the help of microwave frequencies which is used as technique known as noninvasive for bones used as biocompatible materials. Reflection coefficient is the parameter used to quantify this assessment. The comparison of measured and calculated results is made in the form of common graph. The presence of defects in the materials used in bone replacement can be found.

Shreepad and Ravi (2015) [14] used additive manufacturing technique like RPT to manufacture biomaterials so as to get the excellent properties. He manufactured hydroxyapetite (Hap) ceramic and HAp zirconia composites with the help of Fused Deposition Modelling technique. Before the RPT technique came into existence the only way to manufacture these materials was with help of conventional machining. He used three nozzle systems in FDM to manufacture the material in which one nozzle is provided with heating arrangement and other two were used to provide transient Hap and solvent. After performing his manufacturing, he came out with the result that the mechanical properties and porosity were as per desired by the bone structure.

Martinez-Carranza et al. (2016) [15] has worked on treating the full thickness cartilage with the help of metallic resurfacing implant. This problem takes time to heal and sometimes these lesions produce and shows no symptoms and results into the disease of osteoarthritis. They studied the safety of the metallic implants that were used to treat the problem of lesions.

Todai et al.(2017) [16] has worked on developing a new type of biomaterial known as Novel TiNbTaZrMo high-entropy alloys (HEA). The design of HEA is on the basis of various parameters like mixing enthalpy, omega parameters, delta parameter and valence electron concentration theory. The newly developed biomaterial has BCC structure with different lattice constants. The results shows that the newly developed biomaterial has high strength and biocompatibility that it's pure form of titanium.

Chudacik et al. (2017) [17] has worked on the three dimensional numerical modeling of austenitic stainless steel used as biomaterial to study its physical properties. He created three models one is nonlinear inhomogeneity FEM model, linear inhomogeneity FEM model and third is the reference model. The models were subjected to the condition of stress corrosion cracks and fatigue. The non destructive technique like eddy current testing method was used to investigate the models. Investigation leads to the detection of cracks and numerical investigation was done to compare the detection ability.

Babík et al. (2017) [18] has worked on the identification of surface characteristics after miniature machining on titanium alloys used as dental implants. They found that surface characteristics have a great impact on the applications of dental implants. They determine different mechanical properties of various dental implant material and finds the material of particular grade with the best finest grain structure, surface roughness, mechanical strength.

Jahan et al. (2017) [19] has worked to compare the electro-discharge – machining done on biomaterials like Ni-Ti (Shape memory Alloy) and Ti-6Al-4V (Grade 5 titanium alloy). They analyzed the composition of surface, migration of material and micro hardness and compared them. After comparison they came out with result that Ni-Ti biomaterial has smoother surface than Ti-6Al-4V and surface micro hardness was increased in both materials to equal extent. Composition of biomaterial was also changed due to the migration of material from dielectric and tool electrode.

Wang et al. (2017) [20] has studied the corrosion behavior of biomaterial like titanium implant having different surface morphologies. They prepared four different surface morphologies like smooth surface, microstructure surface, micro/nanostructure surface and functionalized micro/nanostructure surface. Electrochemical workstation in Ringer's solution was used to evaluate the corrosion behavior of different surface morphologies of dental implant. After comparing the corrosion behaviour they found that corrosion resistence of micro/nanostructure surface is the best while that of microstructure surface is the worst.

Salahshoor et al.(2017) [21] has worked to improve the corrosion performance of Magnesium-Calcium Alloy used as biomaterial. They used the synergistic dry cutting-finish burnishing to improve the surface finish, high compressive hook shaped residual stress profile, extended strain hardening in subsurface and change of grain size.

Jenko et al.(2018) [22] studied the microstructure and surface chemistry of the new and used titanium and CoCrMo alloys used for knee and hip endoprostheses. The SEM, AES and EBSD (Phase analysis) technology were used to study the microstructure and surface chemistry. Basically EBSD is used to provide the phase of material. During the result they found that the thin oxide film is present on the titanium and CoCrMo alloys. The oxide film on CoCrMo alloys results in the increase of the biocompatibility and also prevents intergranular corrosion.

Bhui et al. (2018) [23] has worked on the effect of changing input parameters like current, pulse-on time, pulse-off time and voltage while doing EDM on titanium biomaterial of grade 5. They took material removal rate and surface roughness as an output parameter to investigate. While doing their experiments they found that the material removal rate increases with increase in the value of current and becomes maximum at 4 A. The same output parameter reduces with decrease in pulse-off duration. At a particular value of input parameters i.e. I=4 A; P-off= 120 μs; V=30 V, the development of pores and formation of carbides and silicades on the sample of titanium biomaterial of grade 5.

III. CONCLUSIONS

Surface reworking of the biomaterial implant is an ample concern with the wide range of study for enhancing the performance of biomaterial implant as well as the life in human's body. In profundity, a knowledgeable study on the surface characteristics tells us that surface modification process increases the biocompatibility, strength, corrosion resistance and provides finest grain structure. Besides that it has been concluded that when additive manufacturing is done in the different orientation the mechanical properties of the biomaterial implants altered. In one of the research papers it is investigated that more biocompatibility results in the less structural stability.

IV. FUTURE SCOPE

The researchers did work using EDM on biomaterials, in future they can use other type of non conventional machining process to continue the research. Zinc oxide coating was utilized to enhance the surface properties of implants. Further to proceed the experimentation, different biopowders can be used to examine the outcome on the surface. Alteration of abrasive jet machining parameters (mass flow rate, nozzle tip distance, gas pressure, velocity of abrasive particles and mixing ratio) on biomaterial implant can be estimated.

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