Abstract--- Bone is a "composite" material. Consists of an inorganic material and organic material. Inorganic molecules band together in an orderly sequence to form fibrils molecular structure. Hip joint prosthesis, Modification, transplantation and Replacement is the solution for most of the problems in medical field for hip joint Anthroplasty. Hip joint is a complex joint in the human body. Under excess loadings or impacts, bone fractured, and there are many types of bone fractures depending on crack size orientations, morphology and location. The mean load on hip joint is up to 3 times of body weight. Peak load during jumping can be as high as 10 times of the body weight as reported by many scientist and scholars. These loads are repetitive and fluctuating depending on the activities such as standing, sitting, jogging, stair casing, climbing etc. Based on the geometry, design, and material of the prosthesis, Young’s modulus of the material is a critical design variable, because it largely determines how load is transferred through the stem. Therefore, durability of Hip joint is of critical importance. Due to these factors, an attempt is made to develop bio polymer matrix composites using high density polyethylene as the matrix material and TiO$_2$ particles and Al$_2$O$_3$ particles as the reinforcement material with varying percentage using rule of mixture of composites viz, 5%, 10%, 15% and 20% using twin extruder injection molding machine. All the samples are subjected to tensile strength test, Hardness test, corrosion, wear, Flexural strength test and Fractography test using SEM.

Keywords--- Hip Joint, Bio Polymer Matrix Composite, Fabrication & Testing

I. INTRODUCTION

BiOMATERIALS are natural or synthetic materials, used to replace part of a living system or to function in physiological body condition. This group of materials includes metals, ceramics, polymers and composites materials. Because metals are having higher stiffness to prevent stress protection, polymers tend to be flexible and weak to meet the mechanical demands for prosthetic materials.

Composites materials are having the advantageous of high specific modulus and strength-to-weight ratio. Composites can also have superior toughness to prevent crack propagation. Total hip replacement is a surgical procedure in which the diseased parts of the joint are replaced and removed with new artificial material, which is known as prosthesis. Stiffness of metals and alloys used for prosthesis are 5 to 20 times higher than the stiffness of the bone which leads to stress shielding and finally the fracture. S.Mazurkiewicz et al [1] in their research examined the methods of evaluation of mechanical properties of polymer matrix composites. Specimens were prepared by injection molding machine using polyamide as matrix material with 10, 20, 30, 40 and 50% glass fiber, and polyacetal matrix with 15, 25 and 35% glass fiber and 10, 15, 25% of mineral filler and polypropylene with the same contents of mineral filler. They conclude that there is a relationship between the value of dissipation energy and mechanical properties of examined composites. And it is recommended to verify the methodology of marking Young’s module and other mechanical properties of thermoplastic composites. Mirigul Altan et al[2] The research carried by them high lights the mechanical and morphological studies on polymer matrix composites by considering high density polyethylene and polypropylene as the matrix material and surface modified nano sized TiO$_2$ particles as the reinforcement. They conclude that TiO$_2$ powder behaves like nucleating agent for crystallization. Impact
strength of fabricated composite material decreases with increase in the percentage of reinforcement due to rigid structure of TiO$_2$ particles and tensile strength and young’s modulus of composite were increase with increase in the percentage of reinforcement. Kazuya Okubo et al [3] in their research work they investigate the development of composites for ecological purposes using bamboo fibers. They conclude from experimental results that bamboo fibers (bundles) had a sufficient specific strength, which is equivalent to that of conventional glass fibers. The tensile strength of the bamboo fiber bundle is as high as that of jute fiber. W. Pompe et al[4] In The research work carried by them developed an artificial biomaterial for knee joint replacement by building a graded structure consisting of ultra-high molecular weight polyethylene. The ingrowths behavior of titanium implants into hard tissue can be improved by depositing a graded biopolymer coating of fibronectin. Functionally graded macro porous hydroxypatite ceramics were studied in order to improve osteo conduction in bone implants. The research has thus far focused on hard tissue replacement. M HALL et al [5] in their research work they analyzed the effect of friction on explanted hip prosthesis by considering Charnley prosthesis design of hip prosthesis. They stated that friction has a minimal role to play in the loosening of the acetabular component in spite of the higher friction values of explanted prostheses. Charnley total hip replacement was designed principally to minimize the shear stresses at the cement bone interface through the action of a small femoral head and thick acetabular socket. C. M. MANJUNATHA et al [6] in the research work carried out by author studied the tension fatigue behavior of glass fiber reinforced composite with rubber particle. A thermosetting epoxy polymer was modified by incorporating 9wt% of CTBN rubber micro particles. The addition of rubber particles increased the epoxy fatigue life by a factor of about three to four times. They conclude that the experimental S-N data obtained was fit to Basquin’s law.

II. EXPERIMENTAL DETAILS

The composites specimens were fabricated using Twin screw Extruder and Injection molding machine of 75 Tonnage capacities. High density polyethylene is used as matrix material and TiO$_2$ and Al$_2$O$_3$ particle size of R104 grade were used as reinforcement. Matrix and reinforcement were blended and fed into hopper. The material is then plasticized. The molds are then passed to water bath for cooling and operating temperature of machine maintained was 175, 180, 185 and 180 ºC and injection pressure of 65 Mpa. Composite specimens were fabricated using rule of mixture of composite Viz 5 wt%, 10 wt %, 15 wt % and 20 wt % Al$_2$O$_3$ particles of varying reinforcement and 10 wt %, TiO2 as per ASTM standards.

Tensile Test: The Tensile test and Flexural bending strength test were carried out in the Hydro servo controlled Universal Testing Machine (UTM). Tensile test specimens were fabricated as per ASTM standard D3039. Load and strain ranges should be selected so that the test will fit the range. The maximum values to be recorded should be as close to the top of the selected scale as convenient without running the risk of going past full scale. The dimensions needed to calculate the cross sectional area of the reduced section should be measured and recorded. These measurements should be repeated for every specimen. Hardness of the specimens was evaluated using Shore D Hardness tester as per standards. Fractography of the fractured surface of specimens was studied using SEM. Also the specimens were subjected to corrosion study test using salt spray test rig for 24 Hr by maintaining Ph value of 7 ad 5% NaCl (AR Grade) Solution in distilled water as per ASTM B117-2007. The fabricated specimens are having high corrosion resistance and are not subjected to corrosion.

III. RESULTS & DISCUSSION

Fig-1 and Fig-2 below shows the Stress Vs strain diagram and variation in Tensile strength of composite specimens with varying percentage of reinforcement respectively. The Tensile strength of composite material increases with increasing % filler contents (5%, 10%, 15%, and 20%) of the composite specimens, which in turn increases the load carrying capacity of the composite material. The maximum peak tensile strength achieved is 16.667 Mpa and young’s Modulus of 1800 Mpa for 20 wt % of polyethylene / TiO$_2$-Al$_2$O$_3$ composite specimen.
Figure 1: Stress Vs Strain Diagram for HDPE/10wt% TiO2 -20wt% Al2O3

Figure 2: Variation of Tensile Strength for HDPE/TiO2-Al2O3 Composite

Fig-3 below shows the variation in Flexural Strength of composite specimens with varying percentage of reinforcement. The Flexural Strength of composite material increases with increasing % filler contents (5%, 10%, 15%, and 20%) of the composite specimens.
Figure 3: Variation of Flexural Bending Strength for HDPE/TiO₂-Al₂O₃ Composite

Fig. 4 below shows the variation in hardness of composite specimens with varying percentage of reinforcement. The Hardness of composite material increases with increasing % filler contents (5%, 10%, 15%, and 20%) of the composite specimens.

Figure 4: Variation of Hardness for HDPE/TiO₂-Al₂O₃ Composite
Figure 5: Fractured Surface of HDPE/TiO$_2$-Al$_2$O$_3$ Composite

Fig-7 shows fractured surface of HDPE/10 wt% TiO$_2$-15 wt% Al$_2$O$_3$ Composite and of HDPE/10 wt% TiO$_2$-20 wt% Al$_2$O$_3$ Composite respectively. Fractured surface indicates homogeneous mixing of HDPE with TiO$_2$ and Al$_2$O$_3$ particles also no casting defects are observed, which in turn enhances the mechanical properties of above fabricated composite specimens.

IV. CONCLUSION

Composite materials have found wide use in orthopedic applications, particularly in bone fixation plates, hip joint replacement, bone cement, and bone grafts. The investigations of all possible factors which may affect the lifetime, together with response of human body, bone parts, tissues, and muscles, changing itself with increasing age, cannot be performed by normal procedures, but needs more sophisticated approach. Bio polymer matrix composite specimens were fabricated using injection molding machine with varying percentage of reinforcement. Hardness of composite specimens was increased with varying percentage of reinforcement. Maximum tensile strength achieved is 16.63MPa. Tensile strength of composite was increased with varying percentage of reinforcement.

REFERENCES


