Concentration of Zirconia on Mechanical Characteristics of Peek Composite Composed With Carbon Fiber

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Abstract: Hybrid nanocomposites are widely used in various sectors, such as automotive, aerospace, and construction. It contains a polymer matrix filled with two or more filler materials such as zirconia nanoparticles and carbon fiber the primary element enhancing excellent mechanical properties for that reason choose Polyether ether ketone (PEEK) sheets in this review of present work hybrid nanocomposite-based on the PEEK sheets along with zirconia nanoparticles varies range such as 0,1,3 & 5wt% and 20wt% of carbon fiber by using Hand layup associated with hot compression mold. to enhance the behavior of mechanical strength the testing and evaluation of such as XRD, Tensile, flexural, impact strength, and fracture toughness presently four layers are formed by using the hand layup method. The first layer is PEEK/0wt% Zirconia /carbon fiber/zirconia/PEEK similarly the second layer is PPEK/1wt% Zirconia /carbon fiber/zirconia/PEEK. The third and fourth layers only vary with zirconia composition such as 3wt% and 5wt% by recorded maximum value of tensile strength and fracture toughness is 198 MPa and 1.9 MPa0.5 similarly flexural strength and impact strength was found 195 MPa and 15.1 J/mm2.

# Introduction

The study of erosion behaviors of thermoset and thermoplastic resin and their hybrid material composites Erosion is a major issue create several problem like failure, collapse, the degradation of surfaces, severe accidents various composition of thermoplastic polymers using silica as the erodent, PEK, PA6, PA66, and UHMWPE If increased to 20% or 30% GF, the rate of erosion decreases and also using metallic coating to overcome draw back of erosion [1-3]. The addition of 0.5% GNPs to Cu–ZrO nano composite influenced cu particles prepared by powder metallurgy technique. If increasing graphene nanoplatelets (GNP) reduce wear and increase mechanical strength [4-8].  Contribution of graphene nanoplatelets (GNP) and zirconia ceramic nanoparticles (ZrO) fabricated using a hot pressingmachine hybrid nano composite reinforcing GNP (0.5 wt%) and zirconia (4 wt%) if increasing 2-20wt% of zirconia gradually improve fracture toughness [5-9] composing alumina (Al2O3) and silicon carbide (SiC) nanoparticles using ultrasonication and magnetic stirring hybrid carbon fiber-reinforced polymer nanocomposites by hand lay-up and compression molding. Al2O3 loading at 1.75wt% flexural strength modulus improved by 31.76% and 37.08%, maximum impact strength was improved by 30.45%.[10-12].Reinforced basalt fiber/epoxy composite adding Zirconium oxide (ZrO2) and graphene oxide (GO) such as ZrO2 is varies on (1, 2, and 3 wt.%), similarly GO is (0.1, 0.3, and 0.5 wt.%), if the composition of 2wt% ZrO2 with 0.1wt5 GO present exhibit better result of impact strength, shear strength [6].graphene oxide (GO), carbon nano tubes (MWCNT), zirconium oxide (ZrcO2) by hydrolysis method develop only weak interfacial bonds during anchoring of metal oxide due to its poor solubility[13-16]. alumina-zirconia based nano composites reinforced with namely zirconia (ZrO), graphene (GN) and carbon nanotubes (CNTs) Al2O3-based nano composites reinforced with 10wt% ZrO, 0.5wt% GN and 2wt% CNTs were prepared and sintered at a temperature of 1600°C additions of GN and CNTs to achieve wear resistance, upto 93% wear rate reduction [17-21]. The ceramic nano composite hydroxyapatite(HA)–zirconia (ZrO)–carbon nanotube (CNTs) various range of CNT (1, 5, and 10 wt%) sintering at 11500c via Hot isostatic pressing (HIP) and cold isostatic pressing HA–ZrO–CNT-1% and HA–ZrO–CNT-5% increased by36.8% and 66.67%, of micro hardness respectively and also to achieve better strength and quality [22-23]. Fabricated ZrO particles dispersed epoxy nano composites by using ultrasonic mixing for improving the toughness and reduce fracture initiation to estimate SEM, Mechanical strength [10]. Manufactured AA2024 alloy and 1 wt% ZrO/AA2024 composite, the(0.2 wt% GNPs + 1 wt% ZrO)/AA2024 composite enhance the highest tensile strength of382 MPa and elongation of 16 % [24-25]. Hybrid Cu–ZrO/GNPs nano composites fabricated using powder metallurgy technique. If adding GNP with increased compressive strength recored by 504.6 Mpa at 0.5% [26-27]. Zirconia used as thermal protection layer for the carbon fiber reinforced polymer (CFRP). Exhibit better bonding at the interface bonding between the composite skin and CFRP.coated composite can be withstand temperature upto 2500c [28-32]. Zirconium and carbon-carbon composite using this combination to improve compressive strength by 48% Adding 10% zirconium with carbon excellent thermal insulation and mechanical strength [33-35]. Contributing Zro2 and Go of epoxy composite gradually increase zirconium also improve mechanical strength upto 28% [36]. There are three different types of nano sized fillers such as (zirconium dioxide, silicon dioxide, and boron nitride) carbon fiber-reinforced polymer matrix influenced by polymer composite materials compressive strength to increase 30-70% similarly hardness 38-55% [37-39]. zirconium oxide (ZrO2) reinforced filler concentration with loading 1-3 wt% if adding 3wt% of PA12 47% increase strength .similarly 10wt% for Polylactic Acid (PLA) 20.2 % increase strength for 3D printing application using thermoplastic material improved mechanical strength [40]. Carbon nano tubes (MWCNT), zirconium oxide (Zrco2), cobalt oxide (Co3o4) is to develop polymer composite reduce catalyst electro chemical reduction to study structural aspect and XRD pattern to exhibit specific capacity 258.9 c/g at high current density 1 A/g [41]. Carbon fiber reinforced epoxy composite 0.5 SWCNT to achieve tensile strength 681Mpa and elastic modulus 62Gpa, PVA, 3wt% graphene tensile strength recorded 65 mpa and youngs modulus 2.1 Gpa polymers is in soluable cannot using solution of mixung or melt mixing mainldraw back is polymerization [42]. Mos2 and Zro2 with0.8 wt% filler can improve the mechanical properties and corrosion resistance of the coatings 0.8wt% coated to improve mechanical strength maintain high temperature 1080c at 6hr by using hydro thermal method [43]. Reinforced polymer composite contain Zro2,Sio2,Cus,Zno,Cuo and Tio2 into polymer material different wt fraction of nano particles using various techniques adhesive reinforcement which helps to bind the filler material prevent the composite from damage to its surroundings 20wt% increase in the tensile and flexural strength without organic filler 0-1.25wt% Pbo 6.48 & 45.31 luffer fiber epoxy composite 25.48 and 42.44 Mpa of flexural strength. Exhibit Impact strength 7.09 and 7.5% of filler 0-1.25wt pbo [44]. If adding PEEK only tensile strength is recoreded by 106.9±4.7MPa and elongation is 25.6±7.2MPa increase Sio2& Cufe2O2 nano particles tensile strength maintained at the PEEK 108.4±0.4MPa and 114.4±1.6MPa corresponding elongation is 19.8±0.4 and 14.7±3.2 [45]. Manufacture PEEK composite reinforcement of 66wt% of carbon fibers with preperg layer via compression loading increasing carbon fiber to improve mechanical and wear properties at different temperature exhibits tensile and flexural strength of the both exceeding 1000 Mpa at room temperature 810±10MPa and 512±12MPa at 2000c similarly composite sample varies tensile and flexural strength is 458±22MPa and 290±18Mpa at 3000c [46-48]

The present study developed carbon fiber with Zirconia nano particles to overcome the drawback of poor surface quality, mechanical strength and interracial bonding between matrices. To enrich PEEK composite by addition of 20wt% carbon fiber with zirconia nano particles varies 0, 1, 3, and 5wt%  via hand layup with hot compression molding setup.

# Materials and Methods

Polyether ether ketone (PEEK) sheets with poly ceramic hybrid nano composite consists of mechanical strength [49-52] PEEK is chosen for this study and is widely used in thermoplastic applications. carbon fiber is light weight material exception of strength to weight ratio and corrosion resistance that’s reason for choose carbon fiber similarly zirconia nano particles excellent tensile strength and fracture toughness. zirconia used for high thermal stabilty application for that reason for choosing zirconia nano particles (50nm) are taken as filler material for this study adding the 20wt% carbon fiber with PEEK composite Zirconia nano particles marginally improved impact and mechanical strength reason are selected as 0,1,3 and 5wt% as filler material.

The polyether ether ketone matrix adds 20wt% of carbon fiber compose and various ranges such as 0,1,3 and 5wt% zirconia nanoparticles filler via hand layup with hot compression molding. it consists of the control unit, upper mold, lower mold, and Die, carbon fiber is mixed with 20 wt% of the chopped form (2-5mm) of PEEK matrix and Zirconia nanoparticles in various ranges of 0,1,3 & 5wt% blended 120 rpm stirrer speed prepare four type of layer for this composition PEEK/0wt% Zirconia/Carbon fiber/Zirconia/PEEK remaining three layer varies 1wt%,3wt% and 5wt% of zirconia by using a hand layup method with hot compression molding With the aid of a control unit to monitor temperature difference from 25 to 230⁰C preheated at 110⁰C make composite sample 30X30X0.20cm PEEK mat for behavior study. Load applied between upper mold to lower mold of the hot compression molding machine.

# Results and Discussion

Fig 1 shows that the tensile strength of the composite and composite sample estimated by ASTM D3039 testing margin highlights a 4% error the composite sample 1 consists of PEEK/Carbon fiber 80:20 ratio weight percentage with no added filler note down tensile strength is 175 MPa generally carbon fiber lightweight material high strength weight ratio so that to achieve a highest tensile strength of the composite the corresponding composite sample 2 is with 1wt% of zirconia nanoparticles to obtained slight variation of tensile strength is 184 MPa. Similarly composite sample 3 contains PEEK,20wt% of carbon fiber remaining 3wt% of zirconia nanoparticles value of tensile strength recorded by 191 MPa, while the final composite sample 4 consists PEEK,20wt% of carbon fiber remaining 5wt% of zirconia nanoparticles gradually improved by 198 MPa.

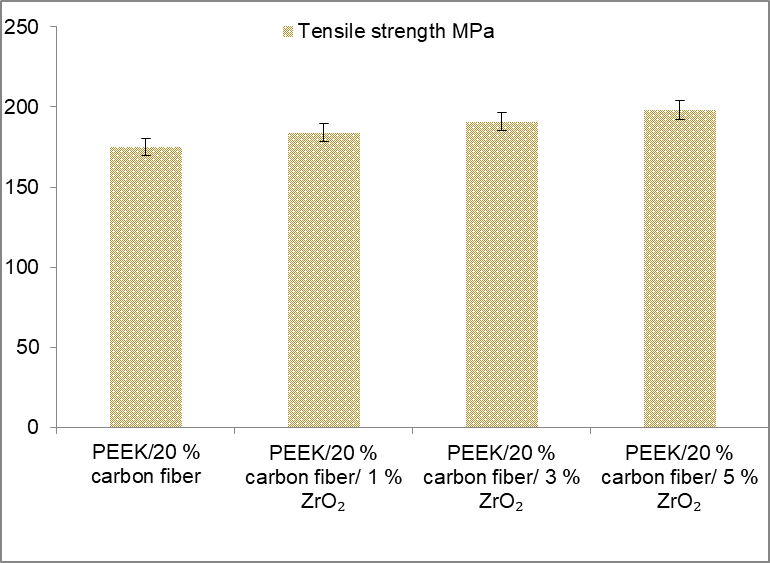
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Fig. 1 Tensile strength of composites

  The PEEK composite sample prepares four sets of samples. The composite sample 1 adding with the composition of 80wt% of  PEEK remaining 20wt% of carbon fiber with no added filler fracture toughness reading noted that 1.4 MPa0.5 as shown in Fig 2. Corresponding the composite sample 2 by adding 1wt% of zirconia nanoparticles with 20wt% of carbon fiber and PEEK the fracture toughness of composite observed 1.5 MPa0.5The increasing value  3wt% of zirconia nanoparticles remaining 20wt% of carbon fiber and PEEK noted fracture toughness is 1.7 MPa0.5and 5wt% of zirconia nano particles and 20wt% of carbon fiber and PEEK noted fracture toughness is 1.9 MPa0.5. The reinforcing GNP (0.5 wt%) and zirconia (4 wt%) the hybrid nanocomposite exhibit 35.7 % better fracture toughness than sample 1.

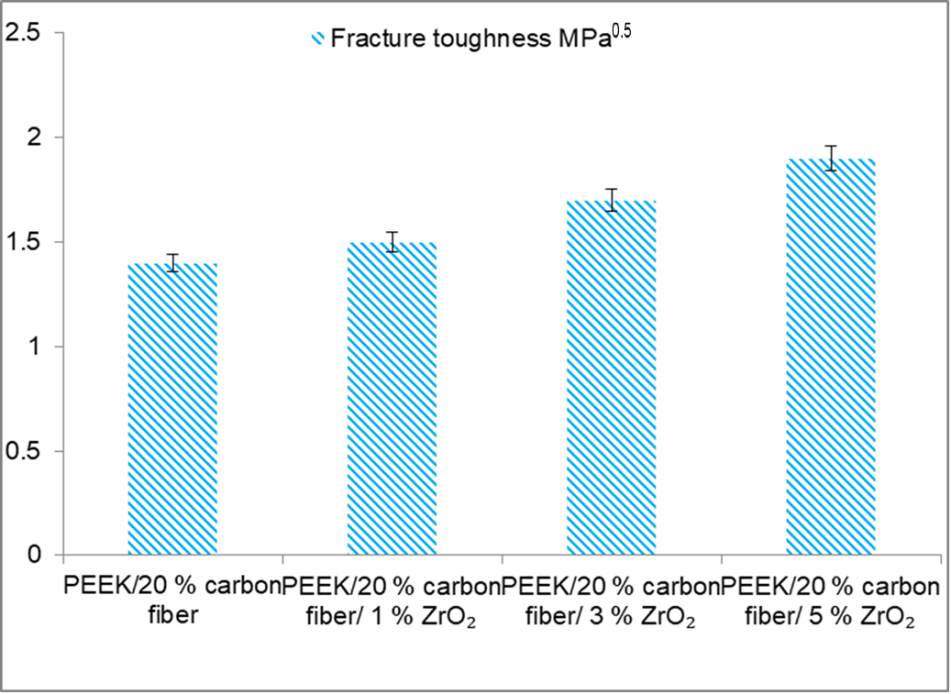


Fig. 2 Fracture toughness of composites

Figure 3 shows that the flexural strength of a composite sample of the PEEK matrix. Adding 20wt% of carbon fiber with 80 wt% PEEK no added nano particles of varied weight percentages. The PEEK composite sample of flexural strength 1 is noted by 195 MPa. The addition of 20wt% of carbon fiber with 80wt% PEEK and 1wt% of zirconia nanoparticles of composite sample 2 is obtained in flexural strength of 210 MPa. The flexural strength of composite sample 3 is 230MPa due to adding filler 3wt% of Alumina nanoparticles with 20wt% of carbon fiber and PEEK. The  composite sample 4 is noted at 256 MPa adding 5wt% of Zirconia nanoparticles 20wt% of carbon fiber and PEEK the Prepared (PEEK) matrix composite reinforced with carbon own higher flexural strength of 256 MPa and 31.2 % better than the sample 1.

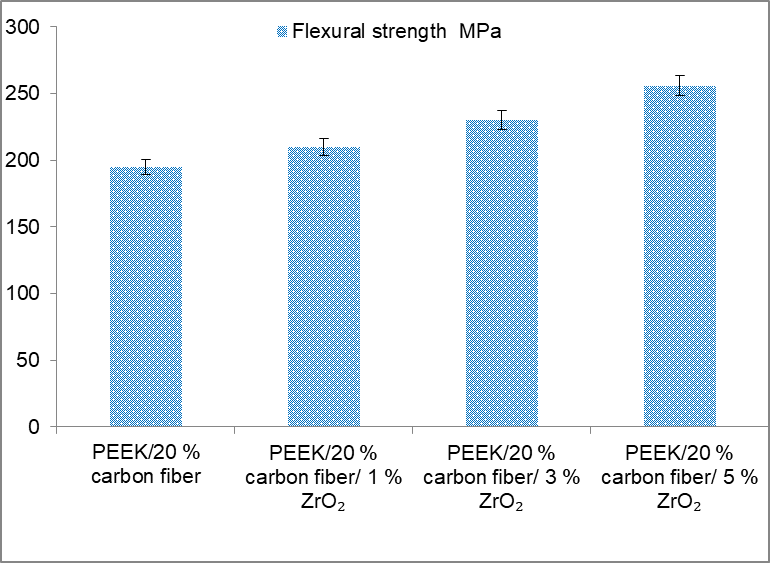


Fig.3Flexural strength of composites

Compose 20wt% of carbon fiber with no adding zirconia nanoparticles of varied weight percentages. As shown in Fig 4. The PEEK composite sample of impact strength 1 is observed by 9.6J/mm2prepare Compose  20wt% of carbon fiber with 1wt% zirconia nanofiller The composite sample 2 is obtained in impact strength 11.2J/mm2. Since the impact strength of composite sample 3 is 13.4J/mm2 by adding filler 3wt% of Zirconia nanoparticles with 20wt% of carbon fiber. An effective pinning action and strong interfacial strength influenced to better impact toughness. The composite sample 4 is noted at 15.1J/mm2.composing 5wt% of Zirconia nano particles and 20wt% of carbon fiber the composite sample B4 is increased by 57.3% in flexural strength as compared to composite sample 1 without filler

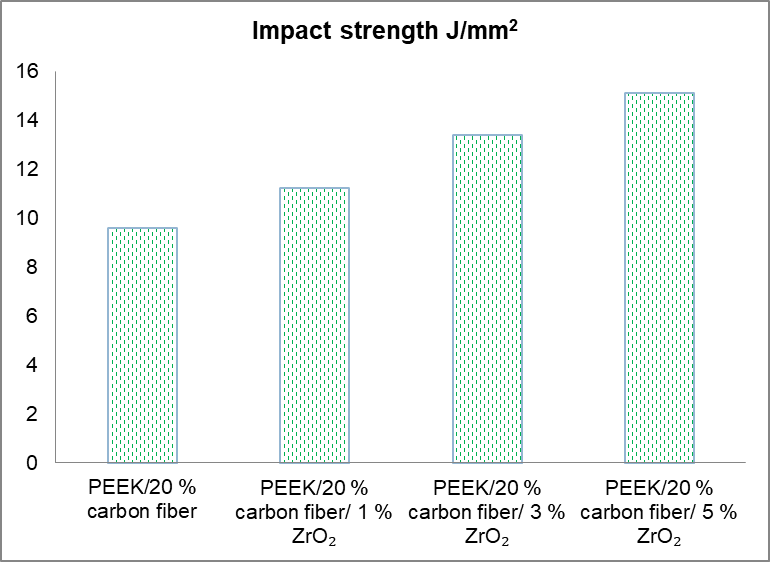


Fig.4 Impact strength of composites

# Conclusion

Poly-ceramic hybrid composites such as carbon fiber and zirconia nanofiller by using hand layup with hot compression molding setup. Testing and analysis of tensile strength, fracture toughness, flexural strength, Impact strength, (mechanical behavior) of composites were studied via ASTM standard and results are summarized below. The composition sample 4 prepared 20wt% carbon fiber with 5 wt% zirconium found superior to others. The tensile, fracture toughness, flexural and impact toughness of PEEK with 20 % carbon/5 wt% zirconium found 13%, 35.7%, 31.2% and 57.3% higher than the PEEK/20% carbon fiber composites.

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