Evolution of the term polymer engineering essay

Engineering

Metals as we know have various applications in our daily life but has some disadvantages in it the main problem with the metals is it problem of rusting. Crores of rupees are lost due to rusting of the metals every year . Another problem which is frequently encountered in the automobile industry is the high weight of metals. The metallic body car is strong enough but has less fuel efficiency due to its high weight. These are examples of some of the basic problems with the metals. So if we are able to find some alternatives to metals with the same strength of with less weight we can solve these problems and contribute a lot to his developing world. As polymers are the one of the fastest growing industries researches have shown that if we work with some of the nano properties of polymers these problems could be solved. So this is the main reason for picking up this challenging project on mechanical strength of polymers.

Evolution of the term POLYMER

Metals have been known to the human civilization from as long as 6000 BC. With the passage of time and advent of science and technology, these metals have been put under the scrutiny by various researchers for large number of decades. The greatest hindrance that the researchers have come across is that these metals have a limited source and that they cannot be reproduced synthetically. This has been the main reason for the researchers to look for alternatives to metals that can replace them in such a way that implementation of these substances in the field of applied sciences can be a productive and efficient investment in the field of technology.

What is a POLYMER?

The term polymer attributes to a molecule having a structure composed of multiple repeating units, which leads to the origination of a characteristic of high relative molecular mass and varying properties. The variation in the properties could inculcate changes in physical, chemical, mechanical, electrical, magnetic properties and so on. Here we focus basically on the different " MECHANICAL" related properties of polymers and try to find if we can actually replace metals by polymers.

MECHANICAL PROPERTIES AND THEIR BASIC DEFINITION:

Some of the mechanical properties that we introspect into are as follows:

Modulus of Elasticity

An elastic modulus, or modulus of elasticity, is the calculative description of an object or any substance's tendency to be deformed elastically when a force is applied to it. In terms of stress and strain relationship that we discuss later, the elastic modulus of an object is defined as the slope of its stress–strain curve in the elastic deformation region.

Stress & Strain

We define Stress or Mechanical Stress as a physical quantity that expresses the internal forces that neighbouring particles of a continuous material exert on each otherOn the basis of the above definition for stress, we can define Strain as the displacement and deformation that occurs due to the internal forces exerted by the neighbouring particles on one another.

Brittleness & Ductility

Brittleness of a material can be defined as the deformation that a material suffers when subjected to some significant stress. We can in the field of material sciences define Ductility as a solid material's ability to deform under tensile stress. It can be further characterised as a material's ability to be drawn into wires.

Creep Rate

We can define Creep rate as the tendency of a solid material to move slowly or deform permanently under the influence of various stresses. This property is temperature dependent and directly proportional to the increase in the temperature.

Hardness

Hardness can be suitably defined as the measure of how resistant any solid matter is to the different kinds of permanent shape change when a force is applied onto it. Hardness is dependent on ductility, stiffness, strain, viscosity, etc.

Fatigue

Fatigue can be defined as the progressive and localized structural damage that occurs when a material is subjected to a cyclic type of loading.

Fracture

Fracture as the word is very common to us refers to the separation of an object or material into two, or more, pieces under the action of stress.

TENSILE STRENGTH

The tensile strength can be defined as the maximum tensile stress that any object can take before breaking. There are mainly three types of tensile strength namely: 1. Yield strength2. Ultimate strength3. Breaking strength

COMPRESSIVE STRENGTH

Compressive strength is the capacity of the material or the structure to withstand axially directed pushing force.

DATA COMPARING THE YOUNG'S MODULUS BETWEEN POLYMERS AND METALS:

Material Modulus of elasticity

(GPA)

PE-LD 0. 0004PE-HD 0. 0005PP 0. 0084PVC-U 0. 0028PS 0. 0091ABS 0. 0070PC 0. 0084POM 0. 0080PA6 0. 0085PA66 0. 0075PMMA 0. 0084PET 0. 0083PBT 0. 0080PSU 0. 0094CA 0. 0085CAB 0. 0082Phenol-Formaldehyde-Resins 0. 0054Urea-Formaldehyde-Resins 0. 0065Melamine-Formaldehyde-Resins 0. 0052

The Young's modulus for the metals are listed below:

BRASS 96-120BRONZE 100- 125COPPER 117STEEL 200WROUGHT IRON 190-210TUNGSTEN 450-660DIAMOND 1220By comparing the above data of a mechanical property such as young's modulus between polymers and composites we observed that simple polymers are not enough to replace the metals when it comes to the strength part. So there is a definite need to modify the polymers in order to achieve the required strength.

COMPOSITES A STEP AHEAD:

With the development of polymer science and technology and the urge to improve upon the strength of the properties of polymers scientists have been working on composites for many years. The composites can be defined as the materials created when two or more distinct and identifiable components are combined. The properties of the combined material formed is different from their parent property. The formation of composites can be of many types they can be metal-metal, metal-polymer, ceramic polymer, polymer-polymer. The combination of polymer-polymer is classified as under: CopolymersPolymer blendsPolymer alloyPolymer compositesPolymer composites due to their lightweight, chemical and corrosion resistance as well as heterogeneous composition provide unlimited possibilities of deriving any characteristic material behavior. This unique flexibility in design tailoring and other characteristics, such as ease of manufacturing, high effectiveness have attracted the attention of engineers and material scientist and technologists. THEY HAVE BECOME MATERIALS OF 21ST CENTURY TO MEET THE REQIREMENTS OF SPACE, MISSILE, MARINE AND MEDICAL AID TECHNOLOGIES.

FIBER REINFORCED POLYMER COMPOSITES:

During the last few years, natural fibres have received much more attention than ever before from the research community all over the world. These natural fibres offer a number of advantages over traditional synthetic fibres. In the present communication, a study on the synthesis and mechanical properties of new series of green composites involving hibiscus sabdariffa fibre as a reinforcing material in urea–formaldehyde (UF) resin based polymer matrix has been reported.(** CHEMICAL STRUCTURES WILL BE SHOWN IN THE HARD COPY DUE TO THE CONSTRAIN OF DOING MANUAL WORK IN THIS WORKSPACE.)

MECHANICAL TESTING AND ITS RESULTS:

TENSILE STRENGTH:

It has been observed that composites with particle reinforcement showed more tensile strength which was followed by short fibre and long fibre reinforced composites. Particle reinforced polymer composite could bear a load of 332. 8 newton at an extension of 2. 2 mm. Short fibre reinforced polymer composite could bear a load of 307. 6 newton at an extension of 2. 23 mm.

COMPRESSIVE STRENGTH:

Compressive strength of urea-formaldehyde resin has been found to increase when reinforced with fibre. It has been found that with particle reinforcement compressive strength increases to a much more extent than short and long fibre reinforcement. Various test methods were adapted for mechanical characterization of natural fibre reinforced polymer composites. In case of MECHANICAL behaviour particle reinforcement of the urea-formaldehyde resin has been found to be more effective as compared to the short fibre reinforcement. These results suggest that hibiscus sabdariffa fibre has immense scope in the fabrication of natural fibre reinforced polymer composites.

THERMOSETTING COMPOSITES:

Several important classes of thermosetting resins are used as composites matrices. They include unsaturated polyesters, vinyl esters, phenolics, furan resins, polyamides and bismaleimides. The thermosetting polymers combine with reinforcement at their intermediate stages either as liquid, resin solutions or powders . Chemical reactions when induced will cause a permanent structuring of the resins through the stages of flow and gelation to final completion of the cross linked molecular structure. Thermosetting matrix materials result in composites that have higher specific tensile strength and stiffness properties than metal matrix composites. They are also more advanced in fabrication technology and are lower in raw material cost and fabrication cost. Many variations are possible even with the selection of some class of resin because of the different reaction mechanism exist. Two main type of reaction can be distinguished mainlyCondensation reactionsAddition reactions

Different types of thermosetting resins are:

Unsaturated polyester resinsVinyl ester resinsEpoxy resinPhenolic resinPolyimidesBismaleimidesFuran resinsSilicone resinsNow the different types of thermosetting resins used according to their different applications as in this project we are mainly interested for the mechanical strength comparable with metals so we have decided to look at the following:

EPOXY RESIN

This family of oxiranes containing polymers can be made from wide range of starting materials and provide a broad spectrum of properties and gives great versatility in choice of processing and controllable high performance characteristics . Their good adhesion characteristics with glass, aramide carbon and inorganic fibers have resulted a successful matrix for fiber composites. They have good balance of physical, mechanical and electrical properties and have a lower degree of cure shrinkage than UPE and VE resins. Other features for composites applications are relatively good hot /wet strength, chemical resistance, dimensional stability, ease of and low material costs. Over the past two decades their heat stability and resistance have been improved. Curing of epoxy resin: Epoxy resins are classical matrix resins for composite . They can be cured by six different curing agent types namely by: AminesAnhydridesCarboxylic acidsPhenolic compoundsLewis acid catalystsBasic catalyst such as tertiary aminesThe epoxy groups are capable of reacting with a wide variety of functioning groups such as COOH, OH, NH2 anhydride etc. In structural composites anhydrides and amines are widely used as curing agents. The curing agents are used according to their applications for example Anhydrides provide good electrical insulating properties, thermal resistance and environmental stability. The only disadvantage of epoxy resins is its instability at very high temperatures.

POLYIMIDES:

Epoxy resins are inadequate for high temperature applications. However polyimides and bismaleimides are the good candidates for high temperatures applications as matrix materials. Some polyimides can be used at a temperature of about 300 to 360 degree celsius . They find high applications as high performance materials especially in aerospace and electronics. Polyimides as matrix in conjugation with carbon fiber are used in missile technology and space transportation systems where temperatures upto 260 degrees is experienced. THE AEROMATIC HETEROCYCLIC STRUCTURE OF THE POLYMER BACK BONE IMPARTS HIGH TEMPRETURE STABILTY(** CHEMICAL STRUCTURES WILL BE SHOWN IN THE HARD COPY DUE TO THE CONSTRAIN OF DOING MANUAL WORK IN THIS WORKSPACE.)

- By varying the heterogeneous chains different types of polyimides are available. The final properties of polyimides can be tailored by the choice of R and R'. These structures are thermally stable and thermo oxidatively stable. There glass transition temperature is high. These polyimides are classified into following categories: Condensation polymersAddition polymersPolymerization of mesomeric reactants polyimides

WHY THERMOSETTING RESINS…..??

The composite industry is currently dominated by thermosetting resins because of their historical availability, relative ease of processing, lower cost of capital requirement, low material cost and large database available for resins. Thermosetting resins such as epoxides are available in the form of oligomeric and monomeric low viscosity liquid forms that have excellent properties for proper penetration of fiber bundles and proper wetting of fiber surface by resin. The epoxy prepegs improve the quality and reproducibility. Prepegs can be used to yield high quality composite parts with low scrappage.

THERMOPLASTIC RESINS:

The main use of thermoplastic as matrix material originates with a view to provide low cost manufacturing. Factors contributing to these are: Long prepeg stabilityFast processing cycleEase of quality controlAbility to reprocess in order to remove imperfectionsHigh damage toleranceThe physical entanglements between chains impart strength to a thermoplastic . The effect of entanglements become significant when the chains exceeds a critical molecular mass with an increase in molecular mass, the polymers will exhibit an improved performance with at the cost of increased viscosity and therefore difficulty in processing. The properties of thermoplastic resins are influenced by the degree of crystallinity, crystalline morphology and orientation which are in turn governed by the processing conditions. Most advanced thermoplastics are processed by compression, transfer and injection moulding. The chemical structures of some thermoplastic polymers are shown below:(** CHEMICAL STRUCTURES WILL BE SHOWN IN THE HARD COPY DUE TO THE CONSTRAIN OF DOING MANUAL WORK IN THIS WORKSPACE.)These polymers are heavily aromatic in nature. These polymers chains, which do not possess bulky side groups, tend to exhibit some crystallinity because of their better structural symmetry. DIFFERENT TYPES OF THERMOPLASTIC RESINS ARE: Polyarylene ethersThermoplastic polyamidesPhenylene sulphidePolybenzimidazoleAeromatic liquid crystalline polymers(LCP)Now since we are interested in mechanical strength of polymers the resins which can fulfill our demands are POLYBENZIMIDAZOLE and AEROMATIC LIQUID CRYSTALLINE POLYMERS.

POLYBENZIMIDAZOLE

PBI resins have superior thermal and physical properties. It may be produced by reacting aromatic diamines with aromatic diacids to form relatively low molecular mass prepolymers . Polymers prepared from 3, 3’ diaminobenzidine and diphenyl isophthalate have shown good stability. The production of PBI demands the utilization of high temperatures and an inert atmosphere. THE Tg OF PBI CAN APPROACH UPTO 420 CELCIUS. Due to this property they are potentially useful in high temperature laminate and adhesive formulations. PBI provides COMPOSITES with good mechanical properties to about 250 degree celsius and offer good stability after aging.

AEROMATIC LIQUID CRYSTALLINE POLYMERS:

They are characterized by a train of para-oriented ring structures to give a stiff chain with a high molecular length to width ratio. LCP's have superior tensile properties along the axis of orientation and yet are easy to process. Melt viscosity can be low and relatively insensitive to temperatures and shear rates. Liquid crystalline morphology may not be possible in a densely packed reinforcement work. The LCP's have major property advantage over other groups of polymers, provided the polymers could be oriented to provide maximum properties in the desired directions. The factors governing the choice of matrix resins can be many and for each composite system key features must be assured and balanced before final selection is made. Thermoplastics have not reached the level of sophistication and problem still exist with poor resin on uniformity on the fiber, poor fiber wetting and excess void formation. However they offer advantage of cost, quality control and toughness and damage tolerance. Manufacturing cost of thermoplastics is rather high. But can be reduced in view of the fact that most epoxy prepegs are discarded after two weeks on the shelf. In contrast the thermoplastics prepegs are high molecular mass and unlimited shelf life. No refrigeration is required and the material is not hygroscopic. Moreover they are also environmentally safer.

DESIGN OF HIGH TEMPERATURE MATRIX RESIN

One of the main disadvantages of the polymers composites regarding its mechanical strength is its failure at high temperature . So it is of sole interest for the scientists working on the polymer composite to work and design polymers which could sustain its mechanical properties even at very high temperatures. Demand of low density high specific modulli polymers based composite for high temperature application is increasing for MILITARY AIRCRAFTS for higher speed and higher performance. For polymers to endure higher temperature for a long period, the polymer must have a high GLASS TRANSITION or MELTING TEMPARETURE and good thermal stability, in addition to the other properties needed for specific application. Common high temperature polymers being considered for composite matrix use include polybenzimidazole, polyetherimides, and polymide sulphones. The structures of some of them are given below:(** CHEMICAL STRUCTURES WILL BE SHOWN IN THE HARD COPY DUE TO THE CONSTRAIN OF DOING MANUAL WORK IN THIS WORKSPACE.)As it is clear from the structures of the given polymers that the presence of aromatic groups in the main chain contributes to the high Tg value and also contributes to the high tensile and shear properties.

FACTORS INFLUENCING HEAT RESISTANCES:

Important factors to consider include those that will influence Tg and those that will influence the thermal stability. Tg or Tm can be raised by incorporating polar side groups by increasing the opportunities of hydrogen bonding, by actual cross linking of chains and by incorporating the bulky cyclic groups in the main chain. The use temperature can also be raised by stereospecifc polymerization to increase regularity in the chain. Chemical factors which influence heat resistance includes primary bond strength, secondary bond strength, resonance stabilization, mechanism of bond cleavage, rigid inter chain structure, cross linking and branching.

FABRICATION OF POLYMERS BASED COMPOSITES:

The method applied for the fabrication of polymer composites has effects on the mechanical properties of composites. The increasing demands for the improved quality of the products have led to the evolution of variety of fabrication techniques for example use of water jet, laser beam etc. We are going to focus on the techniques which could help in the production of the polymer composites with improved mechanical properties. THERMOSETTING POLYMERS: The fabrication methods for the development of thermoset polymer composites are mainly based on the two principals: They require an energy source to convert the material into a formable state and subsequently to cure the polymer matrix. They require the use of pressure to shape and consolidate the composite. RESIN INJECTION MOULDING METHOD: Resin injection moulding is one of the most widely used composite manufacturing methods; it is categorized as a closed moulding medium volume production. In this process a viscous resin is injected under pressure into a mold cavity that is gel coated and contained reinforcements . The reinforcements and core material are placed in the mold and the mold is hot, closed and clamped and transfers heat to the moving viscous resin. The reinforcements are performed in a separate process and can be quickly positioned in the mold. The other methods used for fabrication of thermosetting composites are: Wet lay upPrepeg methodVacuum bagMandrel wrappingCompression mouldingPultrusionFibre windingAdhesive bondingThe role played by fibre volume fraction, fibre alignment and production quantities in the development of various fabrication techniques is important in composite industry and it needs to be considered. The fibre volume fraction decides the product functioning either for a structural application or non structural application like chemical resistance or electric insulation. THE FIBER ALINGNMENT DECIDES THE STRENGTH AND STIFFNESS PROPERTYOF THR TERMINATORS DUE TO THE ABILITY OF ORIENTATION PF FIBERS IN THE DESIRED DIRECTIONS. THERMOPLASTIC COMPOSITES: The main methods for the fabrication of thermoplastic composites: FLUIDIZED IMPREGNATE TECHNOLOGYWET POWDER TECHNOLOGYDRY POWDER TECHNOLOGYCOMMINGLED YARN TECHNOLOGYThe process mentioned above produces thermoplastic composites but the production of thermoplastic matrix composites have several disadvantages associated with it: The processing temperature is higher than those required for epoxy based composites. The present cost to thermoplastic materials and performs for advanced composites is higher than that of conventional thermosetting resins. The manufacture of thermoplastic prepeg or other type of perform is much difficult.

CURRENT RESEARCHES:

The importance of polymers and its composites in industry can be seen through the current researches held on this topic. The researchers are trying to find the ways of improving the mechanical strength of the polymer composites by studying their various properties at different conditions. Major recent research and ongoing researches on polymer composites are: POLYMER MODIFIED CONCRETETECHNIQUES FOR COMPOSITESPOLYMER MATRIX COMPOSITES FOR EXTREME ENVIRONMENTBIO BASED POLYMER AND COMPOSITESSURFACE MODIFICATION OF WOOD POLYMER COMPOSITES

CONCLUSION:

The primary aim of our project was to study upon the mechanical behaviour of polymer materials and to find a substitute for metals in terms of strength (if possible) . On going through the properties and the data we could possibly fetch, we reached a conclusion that simple polymer materials are too weak if we talk in terms of mechanical strength . Here we landed upon an all new term spelled as " polymer composites". In this we encountered various types of polymer composites such as UREA-FORMALDEHYDE RESIN, EPOXY RESIN etc. The basic idea that we could make out on going through all the minute details was that if these composites are fabricated in a proper manner, they can be helpful in matching with the strength of the metals. Moreover these materials are eco friendly in nature which can help in the keeping the environment pollution free thus making our society an ideal habitat. All the conclusions that we jumped on from time to time during the course of this project were completely our owns’ effort and we expect the reader to read it as an idea and not as an affirmative.