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PERFORMANCE EVALUATION OF COMPOSITE STRUCTURES FOR ROBOT APPLICATION – AN OVER VIEW

[1]VIJAYAGIRI SRIPAL, [2]SAI KUMAR AMDA
[1]Assistant professor, Mechanical engineering, St Martin's Engineering College
Secunderabad-500100, Telangana state, India.
[2]Assistant professor, Mechanical engineering, JB institute of engineering and technology, Hyderabad, Telangana state, India
[1]v.sripal1@gmail.com, [2]108saikumar@gmail.com

Abstract:

Robot applications are becoming needy in the present scenario of human life in both developing and developed countries in various zones such as space applications, industries and home needs etc. The durability of materials in robotic construction in the present era also a major criterion in shape based robotic development. Even though some researches on base materials with lightweight materials like alumina, fiber etc., there is a lack of economized base high strength composite materials. This paper focuses a review on the robotic application-based material developments in the past two decades, advantages drawbacks and methods. The objective of this study based on material properties with respect to robot manipulator performance criteria, by which optimum results could be obtained based on experimental and analytical evidence carried out by the past researchers and the need of future work.

Keywords: *Robot applications, Material composites, Mechanical properties.*

1.0 Introduction:

Economic based robot technology will be much needed in the future era of civilization, as a part of technology revolution, robotic structures with reliability and performance has to investigate. **Dai Gil Lee et al. [1]** in their study about composite materials with fiber reinforcement having superior qualities than traditional materials in strength and modulus weight ratios.**Jinyi Lee et al. [2]** in their research on fast dynamic biped robot, the foot structure designed with composite epoxy materials concluded that the composite material having higher specific fatigue limit and material damping when compared with traditional materials like aluminum. Composite materials can be tailored to meet the specific requirements of each design.Serial lightweight robot mechanisms developed with natural fibre and evaluated its characteristics as per ASTM standards by **Gourav Pandey et al. [3].** To reduce self-weight vibrations Brintrup equation and Halpin–Tai equations used in rule of mixtures for composite mixtures, the evaluation of properties perpendicular or transverse to the fibre direction to get optimum result. Fabricating natural fibers as an alternative reinforcement for fiber reinforced polymer (FRP) composites, even though CFRP and GFRP materials have good characteristics eco-friendly, bio degradable materials with high specific strength materials needed asassessed by **Ku.H.et al. [4].**Image capturing, and autonomous control systems needed for component placement robots with high strength and light weight like rover vehicles. As a part of these studies, **H. Das et al. [5]**hasstated that specific developments include a tool to reduce robot design iteration cycles and optimize on design solutions, use of advanced materials and structures. **K.S.Meenalochani[6]** investigate about the natural fibers concluded that the availability of natural fibers are more but the composites made from natural fiber was almost redundant due to high performance of CFRP and GFRP composites.

Gordaninejadt et al.[7]concluded that the differentiation between linearity and non–linearity geometrical structures gives different structural flexibility and it is important in composite material fabrication respect to robotic manipulators.**Gordaninejadt et al. [8]** hasdeveloped phenomena on reducing the positional inaccuracies of a flexible, revolute, prismatic robotic manipulator. Dynamic deflections reduced by developing composite materials as structure development including dynamic model.

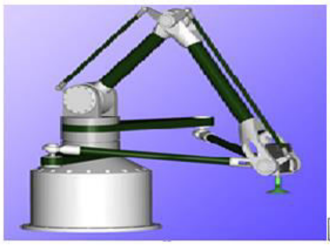

Fig.1 - Axis pick and place robot

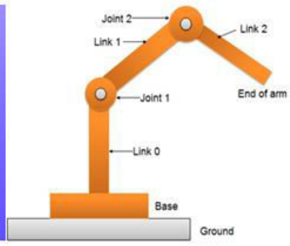

Fig.2 Schematic diagram of a Manipulator

2.0 Characterization and processing of Composites

Ke-Chang Hung et al. [9] in their research about the lignocellulosic fibres as a part of wood plastic composites,after milling and sieving, the LFs of different lignocellulosic materials showed different morphologies. Among all the LFs used in this study, the highest activation energy of thermal decomposition at the 10% of conversion rate was observed for Chinese fir. Cellulose content of the fibers is important to define mechanical properties of biodegradable materials; acetylation treatment is a good option since the test samples reported the highest flexural strength, Plantain fiber can be used in several industries due to its high potential observed in its mechanical resistance, high porosity, and flexural strength according to **Yuliana Cadavid Mora et al.[10]**. The chemical characteristics of a calcium aluminate-phenol resin composite with very high flexural strength are discussed. The flexural strength of the composite was found to be 120 to 220 MPa, which is greatly dependent on the fabrication method. Experimental data of calcium aluminate-phenol resin composite with differential scanning calorimetry, electron probe microanalysis, conduction calorimetry, and X-ray diffraction analysis. Based

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on findings by **Dinilprem Pushpalal et al. [11]** propose a cross-linking mechanism assumed to occur in processing and during curing.

Pop, P. A et al. [12] some manufacturing processes of composites, as laminating, filament winding, pultrusion, resin transfer molding, and them large applications in aeronautics, automotive, maritime, etc. **Mukund Narayan Pandey[13]**insisted that care has to be taken at the mechanical design and machining accuracy to increase the safety with robotic arms, suitable control policies have to adopt for fabrication of industrial robots. **Bendali Nadir Ouali Mohammed[14]**in their study purpose is to obtain smooth trajectories with minimum time using spline cubic functions under a various kinematic and/or dynamic constraints, taking into account a full dynamic model of robot manipulator and with a large number of via points. **Rahul Reddy et al. [15]** has worked on the filament winding process that can be exceedingly robotized and repeatable, with generally low material expenses. Fiber winding yields parts with remarkable circumferential or "band" quality. The most noteworthy volume single utilization of fiber winding is golf club shafts.

3.0 Robot Manipulators design and optimization:

Duc Hoang Nguyenet al. [16]has stated that when the responses are obtained in real mode of findings the optimal trajectories including SFLA will be having different robot manipulators which can be decided under different circumstantial characteristics**S. Abrate[17]**has reported thatwhen dynamic rigid body is an efficient tool for estimating the effect of inertial joints and torques and having a better control system with robot manipulators. **S. Datta & R. Ray [18]**studied on first indigenous autonomous mobile robot, the developed effort for AMR, which can carry out tasks in manufacturing. The manipulator studied for heavy loads with composite materials.**H.-C. Möhring[19]**discussed about the design and application of composite materials with some structures components, technical potentials, and challenges. **Heather Wyattet al. [20]** studied on environmental impacts and life cycle management, the arms are made with three different materials, the arm application developed for LCD panel handling. **Dai GU Lee, Kwang Seop Jeong, [21]** has implemented pile tests in sand fora four-axis robotic manipulator; a random of tests has been conducted with different sand samples for load test.**Adrian Martinet al. [22]**has carried out different types of tests by evaluating the basic functionality which can simulate the platform of some physical and mattering conditions that can be very realistic to find the best structure of the manipulator which can be valued in normal and aggressive conditions. **C. K. Sung and s. S. Shyl[23]** hasreported that by enhancing with the hardware controller which is existing in the industry in construction of robot manipulators, the joints are to be

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followed a condition in torque development which faces the variation of forces in the end effector. **S S Raoet al. [24]** has proven thatwhen the static load capacity and dynamic criteria are generalized with inertia and dynamic manageability, the responses can be carried out in different design stages. **Bhupender et al. [25]** has carried out work bydesign optimization and synthesis of the robotic arm is considered in this pattern. Due to the deflections, stresses and strains, the load will be out sorting the method for finite element analysis. **André Gallant et al. [26]** reported thatdue to some payload conditions, the robotic manipulators could be considered because of their workspace.The simulated and experimental results can show that payload capacity which can be increased and compared to nominal values.**Pradeep Upadhyaya[27]**studied on hybrid natural fibre reinforcement with poly propylene as a composite, poor resistance in absorption of water was the drawback of natural fibre in life cycle analysis.**Atef A. Ataet al. [28]**has presented that an optimal trajectory selection approaches such as kinematics and dynamics techniques with various constraints are presented and explained.**Ilbeom Choi, Dai Gil Lee[29]** has conducted the research and found that the natural frequencies of the arm were 650 Hz for steel and 1340Hz for composite, as well as damping ratio of steel was 0.007 and 0.001 for carbon fiber epoxy composite. **Darrin Willis et al. [30]** has investigated **d**ifferent manipulator layouts and an ideal design was selected for a robotic arm that has a 5 [m] reach, 50 [kg] payload, and is intended to operate on large objects with complex curvature.**Bendali Nadiret al. [31]** hasstated thatdue to some trajectories with minimum time and cubic functions the kinematic and dynamic constraints are taken into consideration in modeling the robot manipulator which are having a large number of dynamic conditions.**Aleksandar, Shurbevski [32]** has reported that with some combinational factors and gradient optimization techniques developed the multi-sphere purposefully workable robotic arm with two- and three-dimensional packages. **Mohd. Nayab Zafar J. C. Mohantab [33]** researches on the autonomous mobile robot in static and dynamic environments with collision free motion by obstacle detective control systems in order to safety. **Seyed Mohammad Reza Farituset al. [34]** in his research implementing control signals to monitor robot velocity and torque obtained at linkages, a standard form of optimal design used to solve the problem. **Amol, A. Khalate [35**] hasfound that when the stability of the proposed controller is having asymptotic stability due to their design procedure and is straight forward based on their fuzzy rules and control strategies. **Christopher C. Ihueze [36]** concluded that in practice multiple axial stresses be consider with every possible combination of critical stresses, but it is difficult tests in biaxial and tri axial state.**Oussama Khatib[37]** in his study stated that mobile manipulation capabilities are key to many new applications of robotics in space, underwater, construction, and service environments.**Bhupender Rahul [38]** concluded that novel optimization methods needed to check the robotic arm applications with synthesis techniques to reduce the mass. **Yogita U. Medhaneet al. [39]**Composites are most promising materials for components of current and future engineering structures, with a significant demand at present in aircraft and aerospace industries. Modal analysis is the study of the natural characteristics of structures.**Maren Bennewitzet al. [40]** has reported the optimizing priority and development schemes can enhance the decoupled planning techniques in robot manipulator design. The existing approaches apply a single priority scheme which makes them overly prone to failure in cases where valid solutions exist.**Mohd. Nayab Zafaret al. [41]** said thatwhen a robot has the special ability in determining the research which is focusing on the path planning and different control strategy the advantages and disadvantages will be highlighted.

Vertutt et al. [42] haspresented an approach to analyze Manipulator key parameters such as position, orientation, force, acceleration and stiffness. **B. S. Thompson, D. Zuccaro et al. [43]** investigated on dynamic deflections in links with composite materials of graphite epoxy material, yield conservative analysis with more specific details needed to check the transient behavior of robotic arm. **S. Ramachandran, B. Srinivasulu et al. [44]** has stated that the maximum deflection of links fabricated using steel is approximately 3.4 times greater than that of 0° graphite epoxy laminate. **K. Krishnamurthy et al. [45]** in their study explain about the induced vibration and concluded that materials with epoxy resins given good results when compared with the conventional materials like steel and aluminium for low weight and heavy weight.**Yavuz et al. [46]** in their research concluded about flexibility of composite material manipulators with light weight causes for vibration in dynamic loading conditions. **L. Malgaca et al. [47]** have studied the flexibility of links and joints affects the dynamic behavior of manipulators. Vibration tests of the composite manipulator are realized for the stationary and non-stationary cases. **Young Goo Kim et al. [48]** carried outresearch on the composite third robot arm with composite yoke, the composite cylindrical tubular structure and the aluminum flange. **Tsuneo Yoshikawa et al. [49]** enhanceda unified description of the two major approaches to force control has been presented and several research topics related to force control have been surveyed. **D. Abraham et al. [50]** surveyed about composite laminates with different fiber fractions, by consolidating lower pressure to find out mechanical and thermal properties variation in light weight robots. **Torgny Brogardh et al. [51]** optimized robot performance with fatigue load, thermal performance

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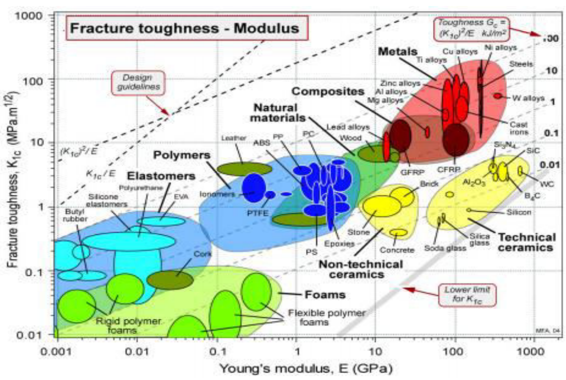
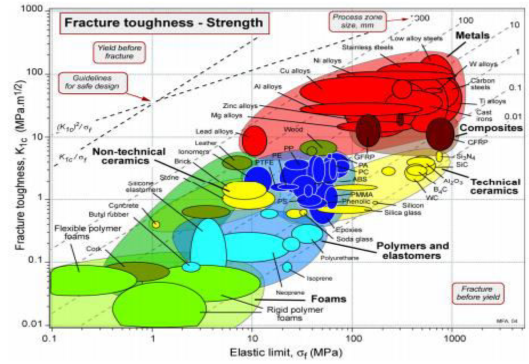
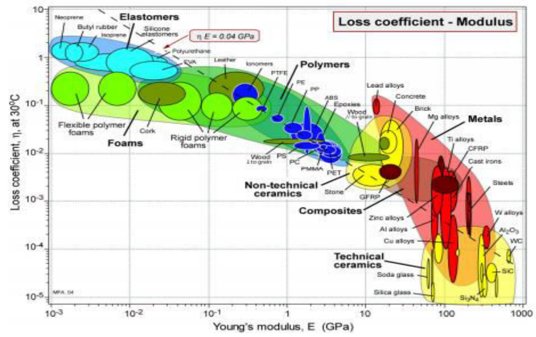
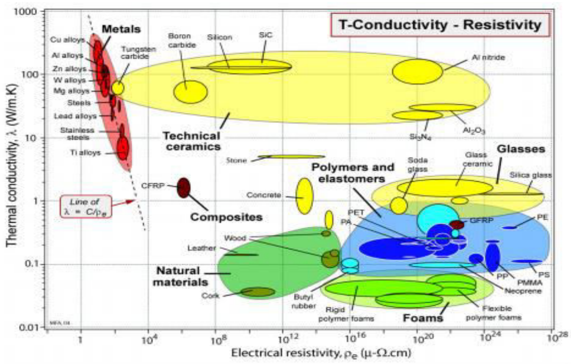
introduced in light weight robots with adaptive techniques. **R. Chandra et al. [52]** researched for different applications with optimization techniques for FRP composites, design considered for damping of manipulator arm and concluded that further researches needed to get good results in composites. **Chol et al. [53]** in his studies about elasto dynamic deflections by changing the maneuvers, a light weight arm was retrofitted and programmed for high stiffness manipulators. **Carlos G. DaVila [54]** has enhanced the **f**racture mechanic models of matrix cracks are used to develop a criterion for matrix failure in tension and to calculate the associated in situ strengths. **Konstantinov et al. [55]** has developed a structure which is structure is decomposed in typical units, which represent the elements of a modular design and assembly system for robots and manipulators. Following Ashby charts describes different material properties and process attributes for necessary design of hybrid composites.









Charts reference: MIKE ASH, engineering department, university of Cambridge, U.K

4.0 Use of composites in robotic Manipulators:

Jagannatha et al. [56] have designed and implemented robotic arms with four degrees of freedom with a lightweight matrix material in production-based industries by using aluminum matrix materials. **Clementchristydeepak et al. [57]**The matrix stiffness values almost equal to steel and more works done on carbon fibre epoxy composites gives five times

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more specific modulus values where staking angle below 15^0. **Gururaja, Hari Rao [58]** worked on smart hybrid composites, given some details about the availability, outline of some of the trends, obvious and speculative, with emphasis on various applications.**C. K. Sung et al. [59]** studied on advantages of fiber reinforced composites having high strength for four bar mechanism operating with high speeds, as a part of it found that power consumption reduced with composites due to its flexible response. **Sung, B. S et al. [60]** has reported that composite specimens having much higher values in damping and an advantage of mechanism implementation like four- bar, slider crank, responses of graphite epoxy laminates given good results. **Jan Swevers, Chris Ganseman[61]** investigating on advanced robotic controller with computed torque and velocity controller, the performance directly depends on the model accuracy and material specified for the structure. **Syafiqah Nur Azrie Safri [62]** focused their research on hybrid composite reinforcement of both natural and synthetic fiber to improve the structural characteristics, impact resistance as well as penetration behavior. **Dany Arnoldo, Hernandez[63]** has done micro-graph analysis after the tensile test shows that cracks propagation starts in manufacturing defects, which lead the carbon fiber to be pulled out instead of breaking. Mechanical and micro- graph tests has been made to understand cracks propagation, manufacturing defects on CFRP without breaking. **Daniela Rus and Michael[64]** study in the robotic application area some persistent challenges in developing soft robotics as they pertain to design fabrication and computational controlling systems.

5.0 Conclusion:

Composites materials deserve many superior characteristics than conventional metals like Steel and Aluminum. It's also reported that composites are very much viable for Robot structures to obtain optimum performance results like Excellent strength-to-weight and stiffness-to-weight ratios and lower deformation of composites than steel and Aluminum; Torque reduction thereby low power consumption. There is a need to analyze the use of Hybrid Composites (fabricated out of Natural and Synthetic fibers) for the application of Robot Structures to achieve optimum cost. **Xiaodong Zhou and Shusheng Bi [65]**the design challenges for compliant legged robots are analysed. This review will provide useful guidance for robotic designers in creating new designs by inheriting the virtues of those successful robots according to the specific tasks.**C. F. Earl J. Rooney[66]** the robot manipulator itself imposes restrictions on the tasks which can be performed. The arrangements of the links and joint axes will affect the ability to manipulate in complex workspace environments.

Based on past research reviews, it shows that for most of the composites being used in the area of robotics because it shows excellent mechanical and thermal properties. Most of the future era robotics is becoming a need in industrial applications at a cause of automation. Such requirements tend to the research objectives to concentrate on low-cost composites for different applications. Along these researches on the composite materials are needy along with the processing methods. In the functioning of the robot application, the thermal properties and its electrical properties are a bit difficult to get identified and focused. An influencing factor that is self-weight of the robot also acts on the efficiency of the robot the design of robot with good strength and less weight with low cost becoming a task. Most of the researches focused on the composites on either CFRP or GFRP or metallic fibers and polymers, hybridization of composites with strengthening methods not yet updated in a proper practical way researches need with relevant optimization on hybrid composite structures.

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