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DESIGN AND OPTIMIZATION OF A ROBOTIC ARM FOR SHEARING OPERATIONS USING ADVANCED MATERIAL ANALYSIS

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ABSTRACT:

This Project highlights the importance of digital prototyping over traditional prototyping in manufacturing engineering. In today's fast-paced industrial era, every company strives for speed and efficiency in manufacturing to meet client demands, with the agricultural sector being a notable exception. Robots now perform tasks more quickly, cost- effectively, and accurately than humans ever could. The moving parts of a robotic arm experience significant elastic deformations and stresses, often operating at velocities comparable to the tool itself. This project focuses on the shearing operation, with the primary challenge being the design and optimization of a lightweight robotic arm component that is both durable and reliable. Through extensive study, we have developed and analysed a jointed robotic arm where the base remains fixed, and the remaining joints can move vertically and horizontally. The design and analysis were conducted using three different materials: **Epoxy Carbon Woven**, **Steel Alloys**, and **AL-NI**. A force of 4000N was applied to the robotic arm to evaluate its structural and thermal performance. Ultimately, the study identifies the most suitable material among these three options for use in the robotic arm.

INTRODUCTION:

The essential purpose is to make a mechanical arm that consolidates solidness, accuracy, and strength proficiency. Shearing activities often include redundant, excessive-pressure errands that pressure essential mileage on mechanical components. To deal with those problems, this painting coordinates improved cloth research, which includes limited issue demonstrating (FEM), to understand substances and primary designs that amplify energy even as proscribing weight. Materials, for instance, excessive-energy compounds, composites, and lightweight polymers are assessed for his or her appropriateness in enduring monotonous burdens without compromising the arm's versatility or execution.

I LITERATURE REVIEW

1. Design and Execution of Pick and Spot Automated Arm [Ravi Kumar Mourya, Amit Shelke et. Al] Global Diary of Ongoing Exploration in Common and Mechanical Designing (IJRRCME) 2024. This challenge intends to plan and carry out a four-DOF pick and spot mechanical arm, which can be self-operable for undertakings, for example, greedy, lifting, setting, and turning in. The venture centers around a four-DOF defined arm with revolute joints for specific development among close by joints. Four servo engines are applied to carry out four levels of opportunity (four-DOF). Robot controllers are meant to execute required tendencies and their regulator configuration is similarly substantial. The AT uber 16 Advancement board is applied for servo engine hobby. The undertaking successfully completed the plan and creation of a four-DOF controller, using PC helped making plans gadgets like Creo 1.0 and AutoCAD. Hypothetical investigation of converse kinematics changed into directed to decide the stop effector's role and route, and FE Examination turned into done utilizing Ansys programming. The venture exhibits the importance of mechanical controllers in situating and arranging items for useful assignments.
2. Design Investigation of a Remote Controlled "Pick and Spot" Mechanical Vehicle [B.O. Omijeh And R. Uhumwamgho] Global Diary of Designing Innovative work 2023. This paper gives a plan exam of a Remote Controlled "Pick and Spot" Mechanical vehicle, zeroing in on protection safeguards inside the work surroundings and weather. The automobile has a five-degree mechanical arm with a base on top and 4 pressure wheels which can be especially managed to move it. The plan process carries gadget, programming, and execution. A model changed into labored to approve the plan determinations, and the consequences were exact. Robots are strongly recommended for organizations for protection and performance reasons. The plan of the robot makes it less complicated for human beings to cope with perilous articles in their contemporary condition and paintings surroundings, accomplishing perplexing and confounded obligations quicker and all of the greater exactly.

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III METHODOLOGY

DESIGN SPECIFICATIONS

DIMENSION	MEASUREMENT
Arm length	500-2000mm
Base diameter	300-600mm
Pay load capacity	1-500kg
Number of joints	04-Jul
Joint range	0-360
repeatability	0.02-0.1 mm
Maximum speed	1-10 m/s
End effector size	50-300 mm
Total weight	10-1000kg
Power consumption	100-5000 W

Types Of Materials or Material Data

3. 1 Epoxy Carbon Woven
3.2 Steel Alloys
3.3 Aluminium-Nickel:

IV INTRODUCTION TO CATIA V5R20

GETTING STARTED WITH CATIA V5R20:

Introduce CATIA V5R20 to your framework and afterward begin it by double tapping at the trade direction image of CATIA V5R20 at the paintings place of your PC. You can likewise choose Start > All Projects >CATIA > CATIA V5R20 from the taskbar to start the program plan packages and is basically for Car and Avionic commercial enterprise, where splendid surfacing or Class-A surfacing is utilized. The challenge of interpretability presented by CATIA V5 carries getting historical past records from the other computer aided design frameworks and, rather, between its very own object facts the board modules. The actual advantage t is that the connections live affiliated. Thus, any trade made to this out of doors facts receives counselled and the version can be refreshed hastily.

DESIGN OF COMPONENTS:

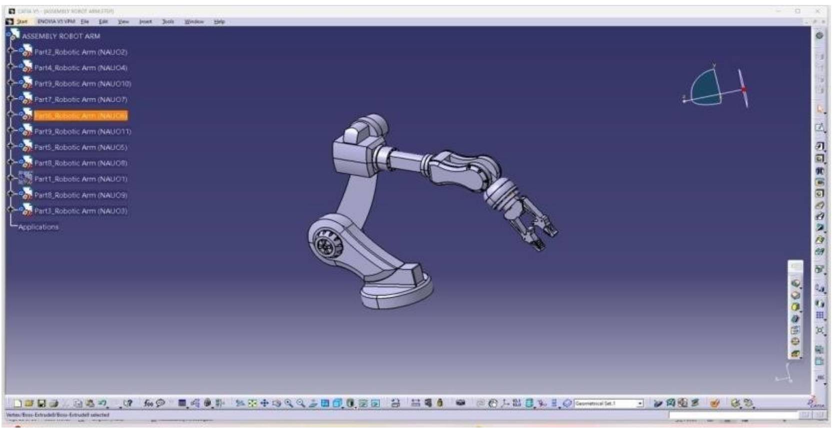

Fig 5.10: CATIA part of the finishing Robotic Arm.

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V INTRODUCTION TO ANSYS

STATIC ANALYSIS:

A static examination computes the influences of steady stacking situations on a construction, even as overlooking state of being inactive and damping influences, for instance, the ones added approximately via time differing hundreds. A static examination can, however, contain consistent dormancy masses (like gravity and rotational pace), and time-moving burdens that can be approximated as static equal burdens, (for example, the static comparable breeze and seismic loads in the main characterized in many production standards). Static examination makes a decision the removals, stresses, traces, and powers in designs or parts delivered approximately by using masses that don't set off crucial dormancy and damping influences. Consistent stacking and response situations are accepted; that is, the thousands and the design's response are expected to shift step by step concerning time. The forms of stacking that may be implemented in a static exam consist of: _ Remotely implemented powers and tensions

_ Consistent country inertial powers (like gravity or rotational velocity)

_ Forced (nonzero) relocations

_ Temperatures (for decent stress)

_ frills (for atomic enlarging)

A static examination may be both direct or nonlinear. A huge range of nonlinearities are accepted - large disfigurements, pliancy, creep, strain hardening, touch (hollow) additives, hyper versatile additives, etc. This examination offers an affordable concept whether or not the development or part will endure for the carried out most extreme powers. Assuming the strain values obtained in this exam crosses the passable worth, it will result in the frustration of the construction in the static condition itself. To live away from such a sadness, this research is essential.

MESHING THE GEOMETRY:

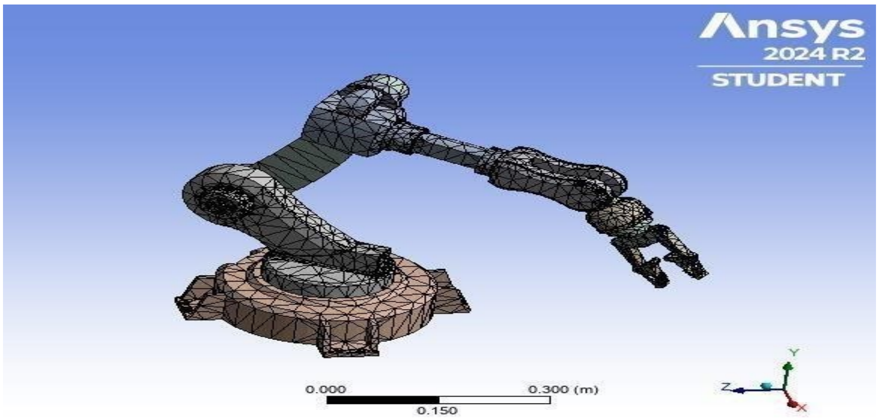

Fig 6.4: Mesh the geometry

Statistics	
Bodies	21
Active Bodies	21
Nodes	64104
Elements	35061
Mesh Metric	None

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STATIC STRUCTURAL ANALYSIS

EPOXY CARBON WOVEN:

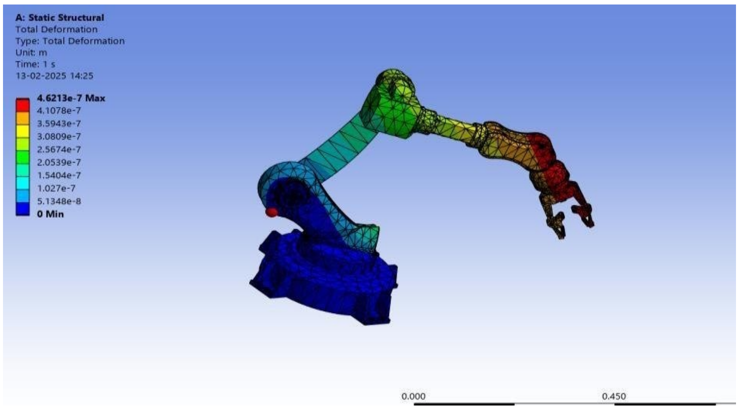

Fig 7.1: Total deformation(3.4173e+008m) applies the Arm

STEEL ALLOYS

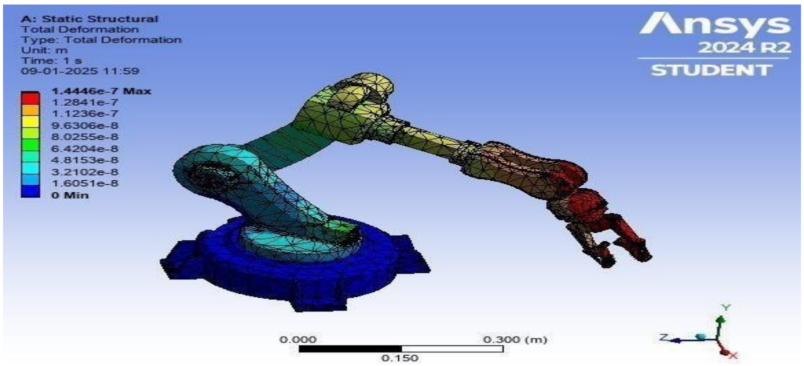

Fig 7.4: Total deformation applies the Arm

Definition			
Type	**Total Deformation**	**Equivalent Elastic Strain**	**Equivalent (von-Mises) Stress**
Results			
Minimum	0. m	1.3127e-019 m/m	1.2371e-008 Pa
Maximum	1.4446e-007 m	1.5008e-006 m/m	2.9938e+005 Pa
Average	8.6221e-008 m	2.0971e-008 m/m	3834.9 Pa

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Aluminium-Nickel

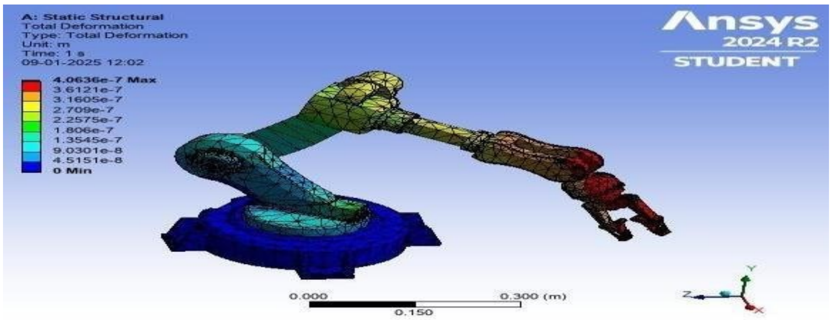

Fig 7.7: Total deformation applies the Arm

Definitio			
Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
Minimum	0. m	2.5319e-019 m/m	7.9421e-009 Pa
Maximum	4.0636e-007 m	4.153e-006 m/m	2.9403e+005 Pa
Average	2.4205e-007 m	5.914e-008 m/m	3844. Pa

MODEL ANALYSIS

Aluminium-Nickel

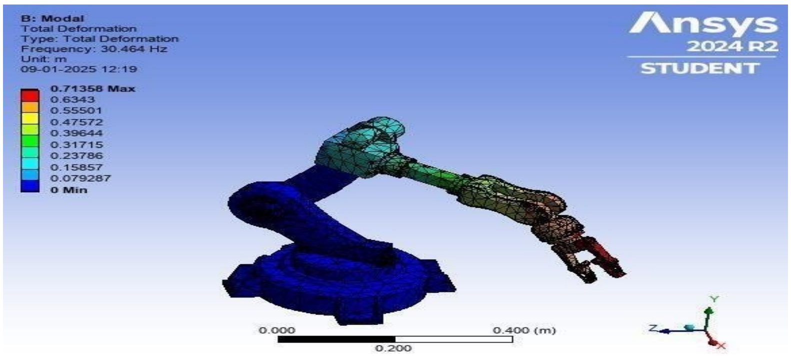

Fig 8.2: Model analysis of AL-NI Total deformation 1

EPOXY CARBON WOVEN

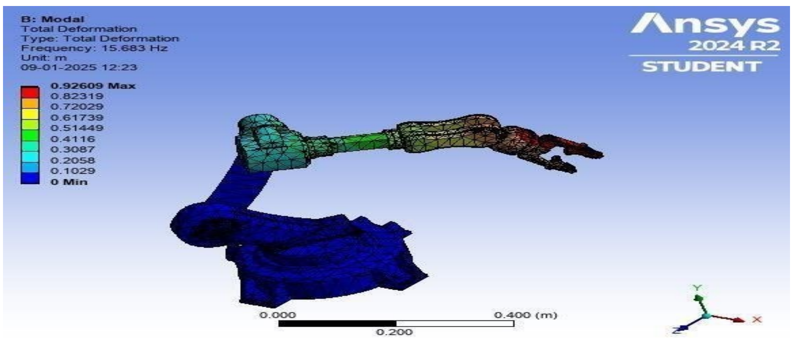

Fig 8.8: Model analysis of EPOXYCARBON WOVEN Total deformation 1

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STEEL ALLOYS

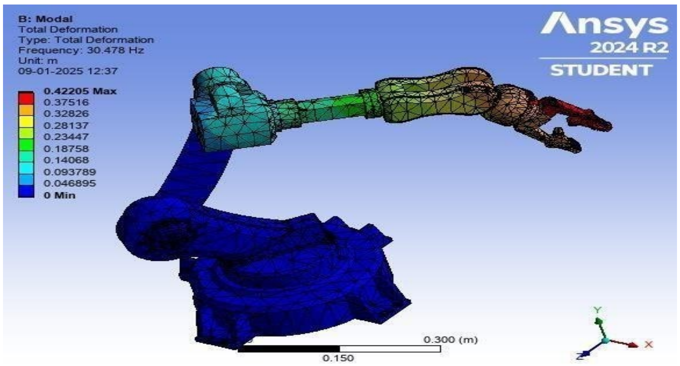
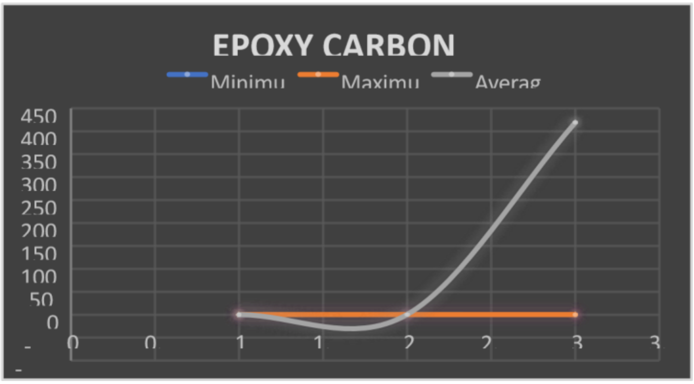


Fig 8.14: Model analysis of STEEL ALLOYS Total deformation 1

STATIC STRUCTURAL ANALYSIS

EPOXY CARBON WOVEN

Definition			
Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
Results			
Minimum	0. m	3.2663e-018 m/m	1.2644e-008 Pa
Maximum	3.4174e-006 m	4.3453e-005 m/m	2.8675e+005 Pa
Average	2.0402e-006 m	5.8953e-007 m/m	4192.8 Pa



Graph 8.1: EPOXY CARBON WOVEN

STEEL ALLOYS

Definition			
Type	**Total Deformation**	**Equivalent Elastic Strain**	**Equivalent (von-Mises) Stress**
Results			
Minimum	0. m	1.3127e-019 m/m	1.2371e-008 Pa
Maximum	1.4446e-007 m	1.5008e-006 m/m	2.9938e+005 Pa
Average	8.6221e-008 m	2.0971e-008 m/m	3834.9 Pa

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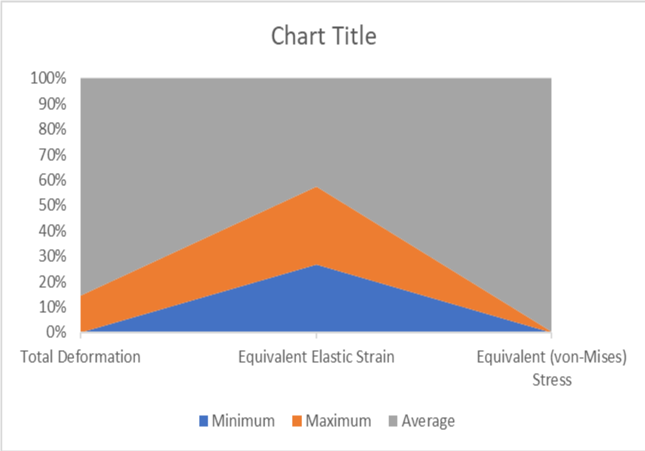
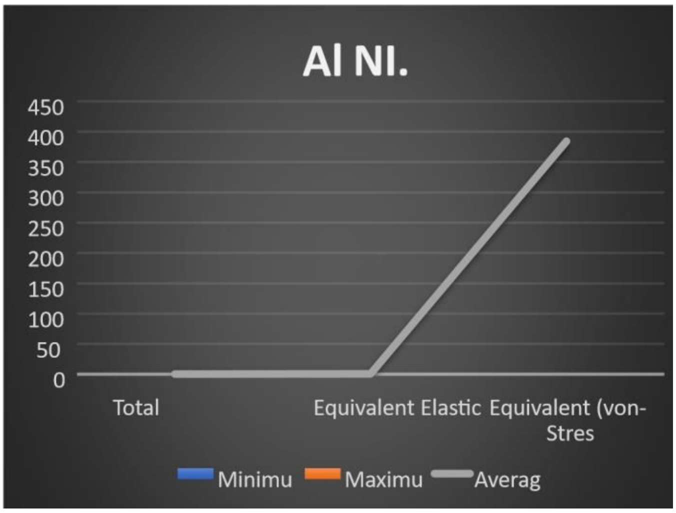


Graph 8.2: STEEL ALLOYS **AL-NI**

Definition			
Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
Results			
Minimum	0. m	2.5319e-019 m/m	7.9421e-009 Pa
Maximum	4.0636e-007 m	4.153e-006 m/m	2.9403e+005 Pa
Average	2.4205e-007 m	5.914e-008 m/m	3844. Pa



Graph 8.3: ALUMINUM NICKEL ALLOYS

RESULTS TABLE

Material	Total Deformation (m)	Equivalent Elastic Strain (m/m)	Equivalent (von-Mises) Stress (Pa)
Min		Max	Avg
Epoxy Carbon Woven	0.0	4.4174e-006	2.0402e-006
Steel Alloys	0.0	1.4446e-007	8.6221e-008
Aluminum Nickel	0.0	4.0636e-007	2.4205e-007

CONCLUSION

This project concludes that ***Epoxy Carbon Woven*** is the most effective material for the robotic arm designed for shearing operations. Compared to Steel Alloys and AL-NI, it offers a significantly better strength-to-weight ratio, which is crucial for enhancing speed, efficiency, and precision in robotic movement. Under a 4000N applied load, Epoxy Carbon Woven showed minimal elastic deformation and excellent thermal resistance, indicating high durability and stability under stress. Its lightweight nature reduces the load on actuators and joints, leading to lower energy consumption and extended component lifespan. These qualities make it highly suitable for applications requiring both mechanical strength and lightweight performance. Additionally, the reduced need for maintenance and improved operational reliability contribute to long-term cost savings. Overall, Epoxy Carbon Woven meets the key requirements for an optimized robotic arm, making it the ideal choice for advanced, high-performance manufacturing environments where efficiency and precision are critical.

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2. Design Analysis of a Remote Controlled “Pick and Place” Robotic Vehicle [**B.O. Omijeh And R. Uhumwamgho]** International Journal of Engineering Research and Development 2023. This paper presents a design analysis of a Remote Controlled "Pick and Place" Robotic vehicle, focusing on safety precautions in the workplace and environment. Raza K, Khan TA, Abbas N. Kinematic analysis and geometrical improvement of an industrial robotic arm. Journal of King Saud University-Engineering Sciences. 2018 Jul 1;30(3):218-23.

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