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IMPLEMENTING INDUSTRIAL ROBOTICS ARMS FOR MATERIAL HOLDING PROCESS IN INDUSTRIES

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ABSTRACT

Because of its high accuracy work and simplicity of carrying out heavy operations, the Articulated Robotic Arm was gaining a lot of traction in the industry. The modeling and study of an adaptable robotic arm that can be used for material management activities are the subject of this research. SOLIDWORKS® software was used to design and simulate the articulated robotic arm with an object handling effector. In the early stages of modeling, an examination such as research of the finite element approach would be extremely beneficial. The analysis' findings will reveal the design's strengths and weaknesses. The numerical simulation analysis was performed on the prototype of a robotic arm using the ANSYS® software workstation to investigate alternative components and loading situations. The findings of the investigation are examined to select the appropriate material and to ensure that the articulated robotic arm was feasible.

Keywords: Finite Element, Material Handling Gripper, ANSYS® Robotic Arm, SOLIDWORKS®.

1. INTRODUCTION

Robotics is an enthralling branch of science concerned with the design, modelling, analysis, and implementation of robots. Robots are employed in a wide range of industries and production processes. Robots are employed in manufacturing operations like the welding process, spray coating, chopping, machining, assembly, cutting, place and pick, stacking, product checking, and experimenting in today's industries [1]. Many technological disciplines of today's production and industry choose lightweight architecture. However, the majority of studies are limited to the automobile and aerospace industries [2]. The substitution of a widely used material with a substance that can perform the same functions while being lighter is a common strategy. Various studies have been conducted to evaluate the efficiency or performance of robots using various parameters and approaches. Pupaza et al [3] used the information from these investigations to reduce the amount of material used by making geometrical adjustments to the robotic arm's second plane and conducting a strength-based study. The robot arm got lighter as a result of this analysis, and there was no distortion for the same kind of load. New materials and arm topologies were investigated in additional investigations by Chong et al.[4] and Rueda [5] by evaluating the stress and shear deformations created on the robotic arm. These studies yielded the appropriate motor and weight quantity. Industrial robots are remote control systems that include connectors, joints, motors, detectors, a processor, and a hardware or software emulator. The robot base is attached to one end of the arm, while the other is equipped with a 'tool,' which can be a hand, a grip, or any other end effector that resembles a human hand [6]. A robot was an electromechanical machine that is guided by many computers and electronic software. The robot was attached to a PC, which is configured to drive the motors on the robot movements, allowing it to do various tasks [7]. The arm was the part of the robot that directs the final grabber arm to complete the tasks it has been given.This placement may not be possible if the arm architecture is too large or small [8]. The purpose of using a robotic arm is to reduce human mistakes and effort. On the tips of the robotic arm, mechanical grippers are utilized to select and position objects or perform materials management activities [9].

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Grippers are used for a variety of functions, including the unloading and loading of workpieces like metal sheets, pallets, food products, and so on [18-26]. In the industry, unloading and loading of heavy items are done physically; to execute these types of tiresome activities constantly, we need to use a robotic arm [10]. The purpose of this project is to build a six-jointed articulated robotic arm with a single mechanical grip movement and to select a suitable material that can handle a large weight. The SOLIDWORKS® program will be used to design the entire robotic arm [27-38]. The main job is to use the ANSYS® software workbench to do numerical simulation on selected materials to optimize the robotic arm. It will aid in selecting the critical assembly portions as well as the right materials for robotic arms utilised in industry [39-49]. Moreover, the findings of this research support the strategy and growth of the robotic arm [50-55].

2. METHODOLOGY

a. To begin, the needs for the robotic arm are gathered and developed in the form of a drawing, which is expressed in a very 2D sketch.
b. The complicated created 3D solid view will then be generated in SOLIDWORKS® employing instructions and limiting conditions.
c. Open the model in the ANSYS® program workstation and import it.
d. The input parameters will be decided by determining the right materials for this type of industrial application after the data has been imported.
e. Now we'll make a mesh and apply boundary conditions to it.
f. The mechanical assessment of the robotic arm would be carried out under various load scenarios to get distortion and stress patterns that will be used to investigate the design.

2.1. Kinematic analysis

RoboAnalyzer 3D Model-based robotics program is used to determine the basic design parameters of a specified kind of robot, which determines the location and rotations of its End-effector, speeds of various articulation, and length of the required link by resolving the analysis of the nonlinear equations. RoboAnalyzer collects Serial robot's DH data. As an input, the manipulator uses their revolute articulation. It then generates a 3D model of the robots for each of the DH values. The 3D tracking window provides zoom, pan, and tilt capabilities that can be used. The dynamic CAD prototype is developed by observing the 3D model from multiple perspectives.

2.2. CAD modeling

According to the conclusions of the inverse dynamical analysis of the 3D Model, a dynamic CAD modelling is created on the Solid Works application, which can replace the time-consuming process of architectural remodelling. The structure knows how to parametrically generate a model with one of the tools in a way that the model's shape cannot be changed by changing the constraints. As a result, a CAD model can be employed in the design. The effective architecture of the robot could be done by changing the model restrictions in each iteration. In technological design challenges, parametric modeling has become a competent and vital tool.

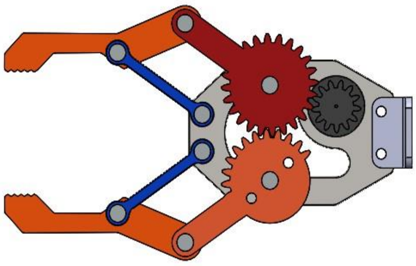

Fig. 1. Base Model of older version

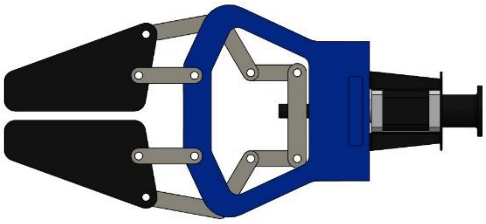

Fig. 2. The base model of the newer version

Figure 1 and 2 shows the base model sample of an industrial robot with the older version and new version of it.

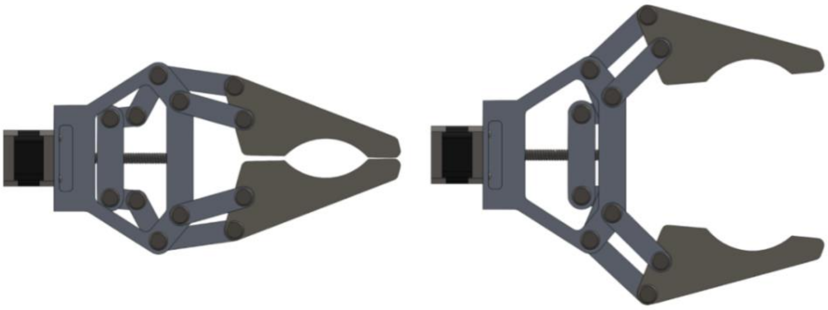

Fig. 3. Top view of the rack and pinon Mechanism

Figure 3 shows The material holding region of the industrial robots' top view. In this part where the robot can carry the weight and distribute it to the other region without any manual effort.

Fig. 4. Connector 2 Model **Fig. 5.** Gripper Model

Figure 4 shows the robot with 2 point connector which can carry more number of objects whereas figure 5 shows the gripper model because the gripper plays an important role while carrying a material if the gripper model of the robot fails to carry material from the destination properly.

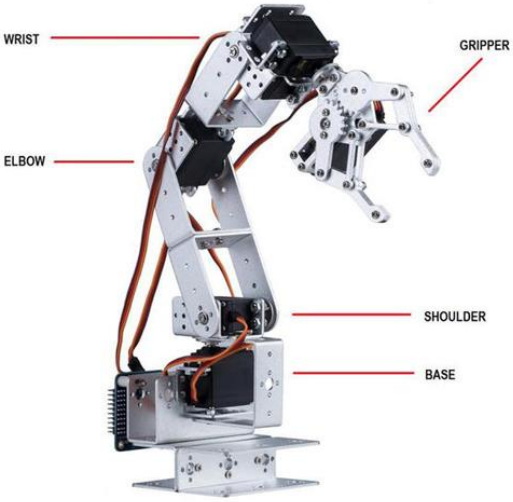

Fig. 6. Arm Assembly

Figure 6 gives a detailed description of the Robot Arm assembly. The robot's arm is made up of the wrist, elbow, gripper, shoulder, and the base.

All of the components of the robotic arm are created separately in SOLIDWORKS® and then combined using conditions and restrictions. SOLIDWORKS® was chosen because it has recently been utilized by several studies and has been shown to assist cut robot development and design time, enhance designer efficiency, and increases the performance and quality of robot modeling. Figures 1–5 depict the various components of the robotic arm. Figure 6 depicts the assembling of these various elements into a fully articulated robotic arm.

2.2. Structural Analysis

The findings of the FE analysis define the pressure condition of a structure under a certain load. The input data for FE study includes the arm shape with the FE analysis, model parameters, and loading criteria. The loading factors are determined by the direction and position of each weight input to the element. To solve different linkages under pressure due to loading situations, the finite element approach was used. The material qualities and component behaviour are considered to be linearly flexible [12].

The usage of FEA is a fantastic method. Simulation has the advantage of taking less time, costing less money, and being easier to compare to the experiment technique.

The robotic arm's SOLIDWORKS® assembly is changed to STEP or IGS file format before being imported into the program. The structural analysis toolbox in ANSYS® software is used to estimate component pressures and distortion.

2.3. Meshing

The practise of splitting a model into a number of parts such that when a load is applied to it, the weight is distributed uniformly was known as meshing.Typically, it is discretization. A finite number of items must be discretized from the continuum.

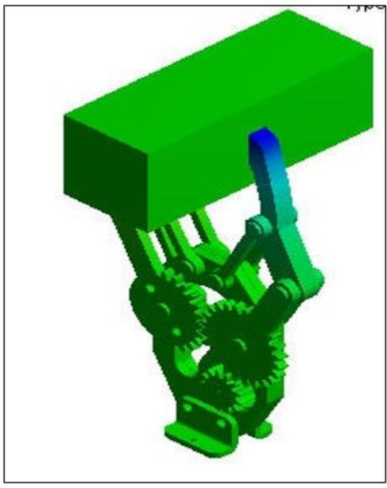

Fig. 7. Combination of Robotic Arms

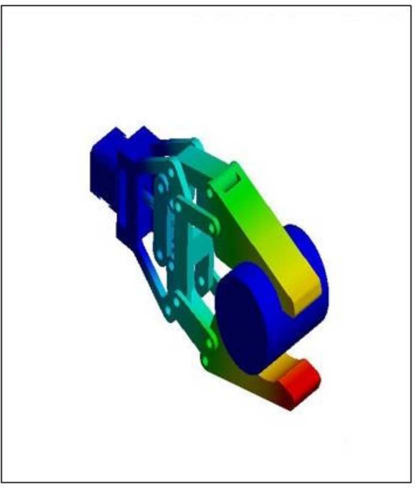

Fig. 8. Gripper symbiosis

With a change in the number of components and component size, the structure of the FEA findings can be significantly altered. Triangular pieces are used to fine-tune the robotic arm's meshing. The entire number of elements is 46193, while the total number of nodes is 76424. The meshing was depicted in Fig. 7 and 8.

2.4. Properties

Because of their high strength and ability to withstand huge forces, steel plate and Aluminum Composite 356 have been chosen as the robotic arm materials. The features of both materials are shown in tables 1 and 2 below.

Tab. 1: Structural Steel Properties

Properties	Tensile Yield Strength	Tensile Ultimate Strength	Compressive Yield Strength	Density
Values	$2.5\times10^8 Pa$	$4.6\times10^8 Pa$	$2.5\times10^8 Pa$	$7850 Kg/m^3$

Table 1 shows the structural analysis of the steel with certain important properties like tensile yield strength, tensile ultimate strength, Compressive yield strength, and density.

Tab. 2: Aluminum Alloy 356 Properties

Properties	Tensile Yield Strength	Tensile Ultimate Strength	Shear Strength	Density

Values	$2.05\times10^8 Pa$	$2.5\times10^8 Pa$	$2.05\times10^8 Pa$	$2680 Kg/m^3$

Likewise table 1, table 2 shows the properties for Aluminum alloy of 356 value. The properties of aluminum 356 alloys includes tensile yield strength, tensile ultimate strength, Compressive yield strength, and density.

3. RESULTS AND DISCUSSION

3.1 Investigation of kinematics

Kinematics is a term that refers to how things move. Manipulator is a major issue in the automated control of robot manipulators. People talked about the theoretical foundation in this section. Among. Kinematics of an instructional robotics arm using the KUKA KR5. Here we offer the Joint, which is a six-rotation revolution robot. Offset (b): The length of the baseline perpendicular to the connections on the joint axis. The connection's length (a) was determined by. The length between the perpendicular axis of the two objects is measured. The torsion angle is the angle formed between the orthogonal. (a). Predictions in a plane perpendicular to the conventional standard along the pivot axis. Joint: Perpendicular projections are those that are not parallel to the standard. The pivot axes plane is perpendicular to it. Each DE factor, referred to as the joint factor, is changeable for each type of connection, while the three remaining variables are referred to as connection and constant variables.

3.2 Analysis of Force

The analysis is carried out using two various materials, Structural Steel and Aluminum Alloy 356, to apply varying forces to the robotic arm's end effector or gripper. Total distortion and total identical results Stresses of 300N, 400N, 500N, and 600N are applied to 4 different loading circumstances. The structure will collapse if the ultimate tensile value exceeds the shear stress. Fig. 9-12 show the Structural Steel robotic arm's deformation and stress fluctuation. Fig. 13-20 depicts the deformation and stress fluctuation on the robotic arm made of Aluminum Composite 356.

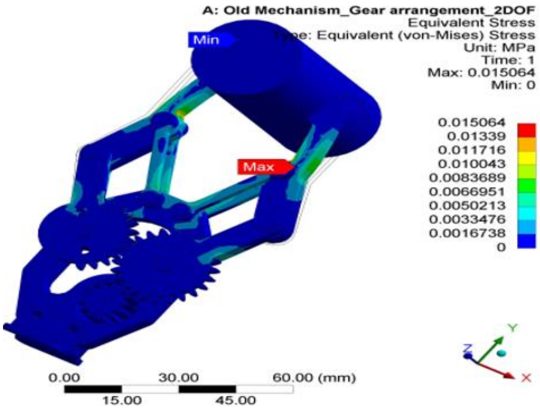

Fig. 9. Deformation in the 300N range with stress analysis at 300 N

Figure 9 shows the robot arm with a weight of 300 N through which the stress analysis of the robot with this weight must be analyzed.

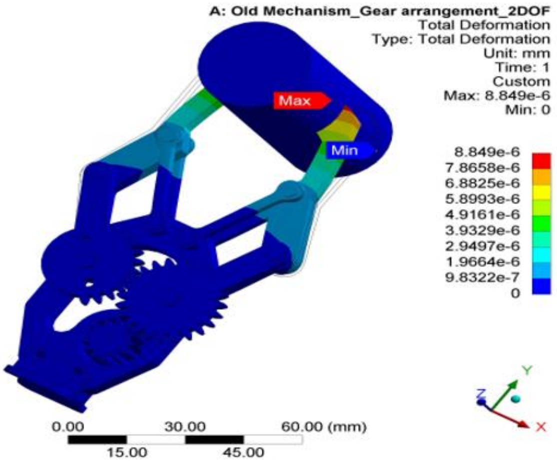

Fig. 10. Deformation in the 400N range with stress analysis at 400 N

The above figure 10 describes the weight carrying capacity of the robot at 400N where the stress estimation of the robot with 400 N is also analyzed.

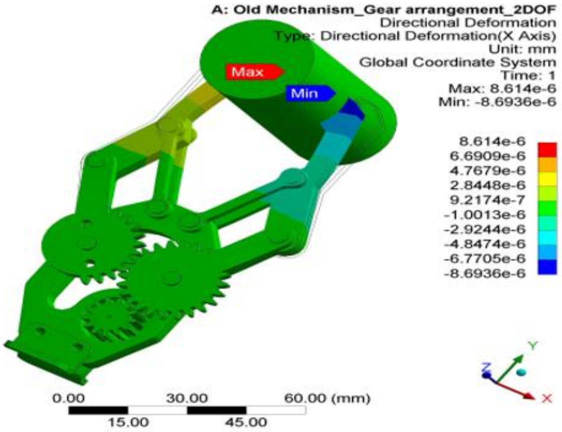

Fig. 11. Deformation in the 500N range with stress analysis of 500 N

Figure 11 shows the robot arm with a weight of 500 N through which the stress analysis of the robot with this weight must be analyzed.

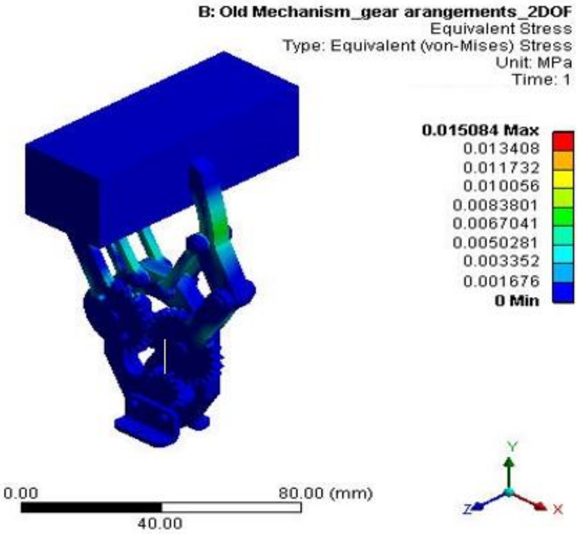

Fig. 12. Deformation in the 600N range with stress analysis of 600 N

As shown in figure 12 the robot is carrying more weight when the weight of the material get increased its load-carrying capacity also increases and more stress may arise in the region.

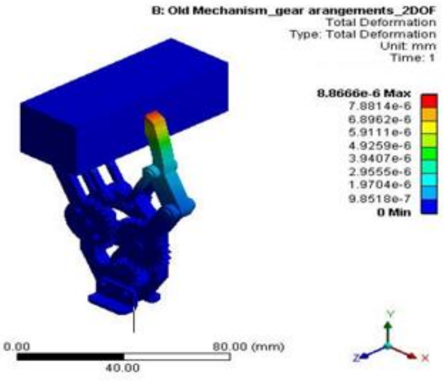

Fig. 13. Deformation in the 300N range

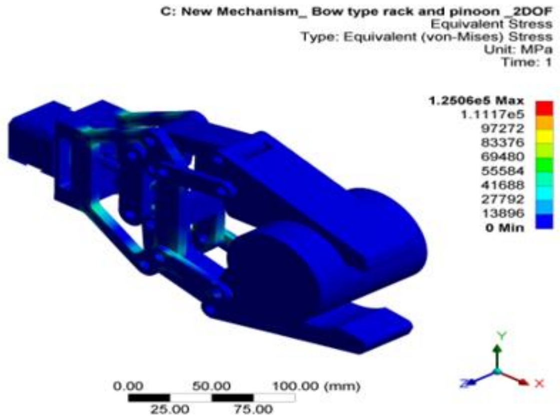

Fig. 14. Stress Analysis at 300*N*

Figure 13 and 14 shows the robot which a square shaped weight as a sample for testing its stress with the same range of 300N. when the weight of the material increases the stress in the arm may increase.

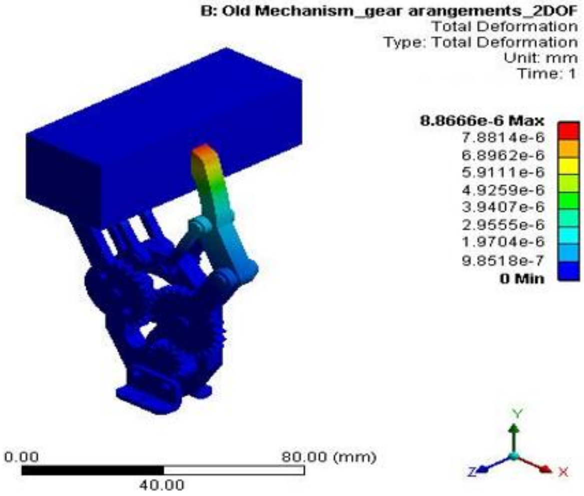

Fig. 15. Deformation in the 400N range

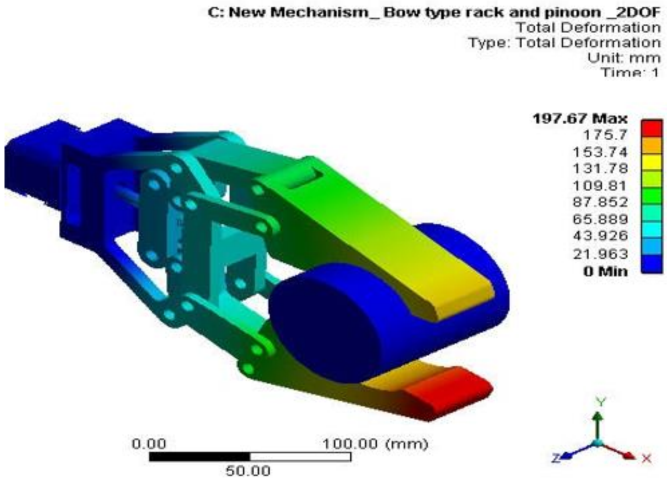

Figure 16. Stress Analysis at 400*N*

Figure 15 and 16 shows the old mechanism and the new mechanism of load carriage by a robot. The stress evaluation may vary based on the mechanism.

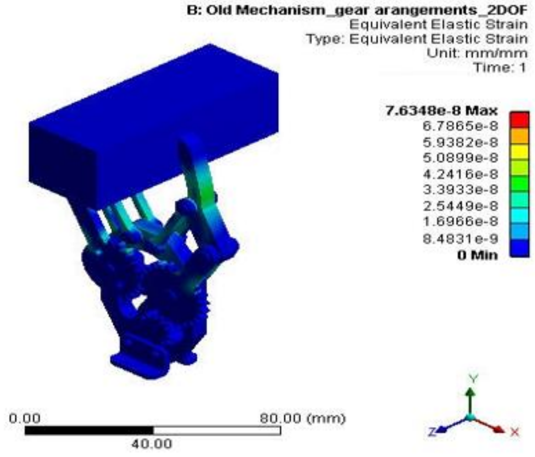

Fig. 17. Deformation in the 500N range

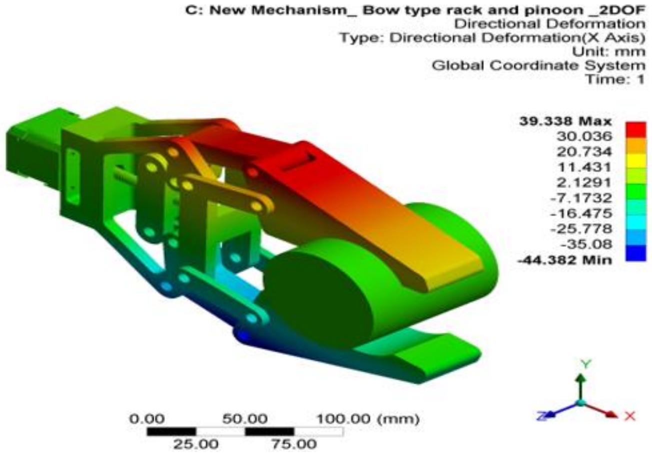

Fig. 18. Stress Analysis at 500*N*

Figures 17 and 18 show the load-carrying capacity of a robot with 500 N using the old and the new mechanism where the stress analysis for this process is analyzed to know the capacity of the robot for carrying weight.

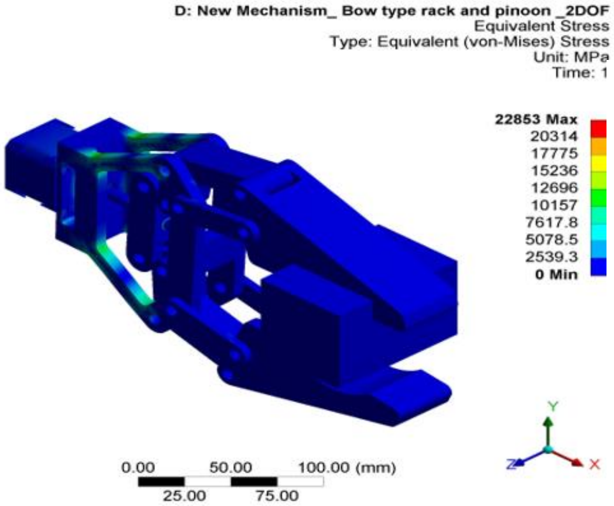

Fig. 19. Deformation in the 600N range

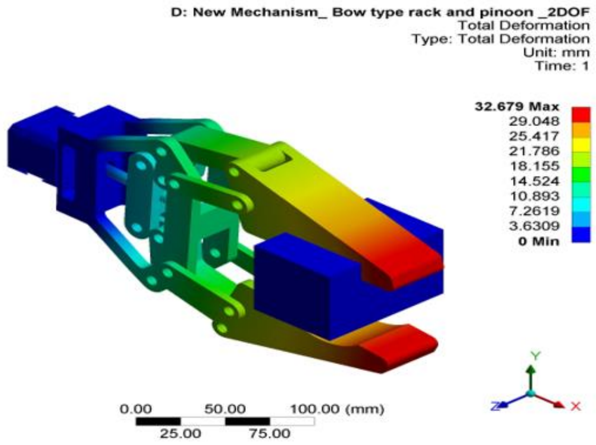

Fig. 20. Stress Analysis at 600*N*

Figures 19 and 20 show the robot with maximum weight carriage when the weight of the load increases in such case the stress in the arm region of the robot may increase.

Tab. 3. Results of Structural Steel Analysis

Sr. No.	**N)**	**Max Equivalent Stress (MPa)**	**Max Deformatio (mm)**
1	350	90.9089	0.13578
2.	450	145.98	0.78589
3.	580	156.98	0.98753
4	650	165.98	0.86456

Tab. 4. Analysis Results for Aluminum Alloy 356

Sr. No.	**Force (N)**	**Max Equivalent Stress (MPa)**	**Deformation (mm)**
1.	400	89.097	0876542
2.	380	143.87	2.9867
3.	490	178.87	2.0968
4.	540	167.98	3.08689

Tables 3 and 4 show that all strain distribution statistics for both components are within authorised limits, i.e., they are less than the maximum shear stress. However, for the same weight, the SSA outperforms the Aluminum Alloy Arm. In the case of the Aluminum Alloy Arm, the distortion is slightly larger. As a result, a structural steel robotic arm is the most reliable option. Furthermore, both results suggest that the structural integrity of both flexible robotic arms satisfied the operational needs and that they are suitable for further research.

4. CONCLUSION

Today's generation requires a versatile and low-cost robotic hand that mimics the human hand. An articulated robotic arm was built using SOLIDWORKS®, a 3D CAD application, and then exported to ANSYS® for material analysis. This robotic arm could be utilized in a variety of sectors for operations like picking and placing, assembling, and so on. The structural analysis was shown to be correct. The arm appears to be meeting design specifications and capable of carrying a variety of payloads. This is appropriate for hazardous areas in companies and will aid in production. The simulation will be possible in the future in the chosen workspace.

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