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FEA Analysis of Robotic Arm Components

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Abstract: Industrial robotic arms are one of the most prevalent forms of robots that are used in a variety of industries today, including manufacturing, automotive, and agricultural. Robotic arms, which are also known as articulated robotic arms, are quick, dependable, and accurate, and they can be programmed to do an unlimited number of jobs in a wide range of settings. The purpose of this study is to evaluate the structural feasibility of using lattice structures as a means of improving the manipulator arm's strength to weight ratio. The methods of finite element analysis are used throughout the process of investigating the structural viability of a robotic arm. An ANSYS simulation run is used as the basis for the finite element analysis of the robotic arm. The outcomes of the study have shown that even with the addition of lattice structures, the shear stress and equivalent stress are well below the safe range. A weight reduction of about 20.1% was accomplished because to the utilization of the lattice architecture. Because of its lower mass, the robotic arm has a lower need for the torque that the servo motor must have in order to move it.

Key Words*:* Robots, design, ANSYS, weight reduction , servo motor.

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1. INTRODUCTION

Industrial robotic arms are one of the most prevalent forms of robots that are used in a variety of industries today, including manufacturing, automotive, and agricultural. Robotic arms, which are also known as articulated robotic arms, are quick, dependable, and accurate, and they can be programmed to do an unlimited number of jobs in a wide range of settings. In factories, they are used to automate the execution of repetitive tasks like applying paint to equipment or parts; in warehouses, they are used to pick, select, or sort goods from distribution conveyors to fulfill consumer orders; and in agricultural settings, they are used to pick ripe fruits and place them onto storage trays. In addition, as robotic technologies advance and industrial settings become more networked, the capabilities of robotic arms continue to improve, making it possible for new use cases and commercial operating models to be implemented.

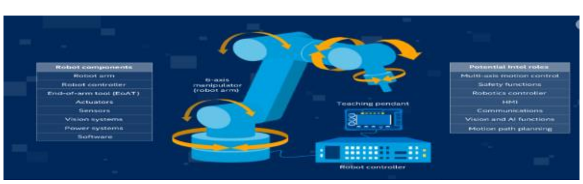

Figure 1: Robotic arm motion [6]

In the past, a robotic arm needed to be taught to do tightly specified tasks, such as picking up a single kind of item from a given spot and orienting itself in a particular way. The robots were not able to distinguish one kind of item from another, detect the placement of an object to within a certain tolerance (area rather than precise position), or alter their grip depending on the orientation of the object.

2. LITERATURE REVIEW

The improvement of human-machine communication between the Leap Motion controller and the 6-DOF Jaco robot arm is documented in the aforementioned piece of published research [1]. The algorithm was designed to provide a more accurate mapping between the hand motions of the user and the control provided by the Leap Motion device. The technology ought to make it possible for a more natural connection between humans and computers, as well as for the robot arm to be fooled. There has been discussion over the use of this interactive human robot in the context of ambient assisted living, which includes the incorporation of several different operating circumstances.

It has been suggested that accelerometers be used in order to develop a robotic arm that can mimic the natural movements of a human arm and operate the robotic arm. The ATmega32 and AT mega 640 platform, in addition to the personal computer processing signal, were used in the development of this arm's upgraded version. In conclusion, it is reasonable to anticipate that this arm model will solve an issue such as putting or picking up potentially hazardous things or non-harmful objects that were previously located distant from the user.

The building and development of a microcontroller (AT mega) robot arm is documented in the aforementioned body of literature [3]. The robotic arm has a touch-sensitive surface and may be instructed to move in a linear fashion in accordance with the purpose. The movement of the user's arm is tracked by the system, and the robot arm is programmed to replicate the touch input that was given. The number of potentiometers that are implanted in the glove may be determined by touch. The position of the servo motors that drive various components of the arm may be controlled by the movement of the potentiometer.

In the research that was published [4], he presented a novel and much better natural interface for the purpose of remote control of the robot arm. Nertial moving trackers are used in the construction of the interface. There are two distinct kinds of moving tracks in use. The Xsens Xbus Kit tracker is the first, followed by the Razer Hydra Controller as the second kind of tracker. Within a three-dimensional setting, the design of the robot arm is figured out with the help of the Hydra controller. The processing of acceleration data in order to measure the exact position of a robotic arm in a sufficient way for the user's movement is one of the most challenging challenges that this article successfully solves in a manner that is both complete and clear. The values and findings of the physical interface test are decided based on the outcomes of the algorithms' parameters.

An accelerometer-based control system for an industrial robot was presented in the aforementioned piece of literature [5]. These accelerometers are worn on the arms of humans in order to record and analyze their activity (gestures and posture). The arm motions and posture were identified with the use of an Artificial Neural Network (ANN) that had been trained using the back transmission technique. The user initiates a touch or a halt at about the same time as the robot starts to move, which is about simultaneously (low response time). The findings indicate that the technology offers control of industrial robots in a manner that is simple to understand. Sensitivity to touch and degree of experience gained (92%).

3. OBJECTIVES

The purpose of this study is to evaluate the structural feasibility of using lattice structures as a means of improving the manipulator arm's strength to weight ratio. The methods of finite element analysis are used throughout the process of investigating the structural viability of a robotic arm. The ANSYS simulation program is used to carry out the finite element analysis on the robotic arm.

4. METHODOLOGY

The steps of CAD designing, meshing, boundary condition, and solution are all included in the process of analysis. The CAD design of the arm manipulator is produced in 3D modelling design software, and it is then loaded into ANSYS design modeller for further analysis. The design of the robotic arm that was imported is seen in figure 2.

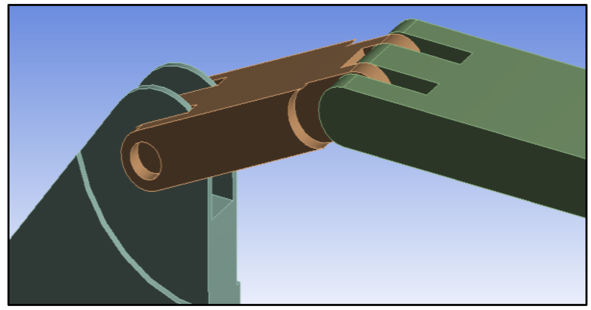

Figure 2: Robotic arm CAD design

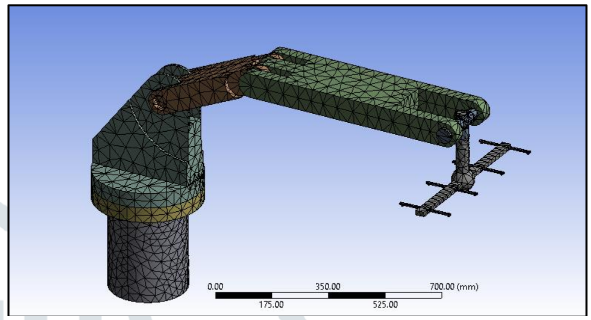

Figure 3: Robotic arm meshed model

The model of robotic arm is discretized with normal inflation rate of 1.3 and growth rate set to 1.2. The meshing is done with fine sizing. The model has complexity in shape without topological consistency and therefore the model is meshed using tetrahedral element type.

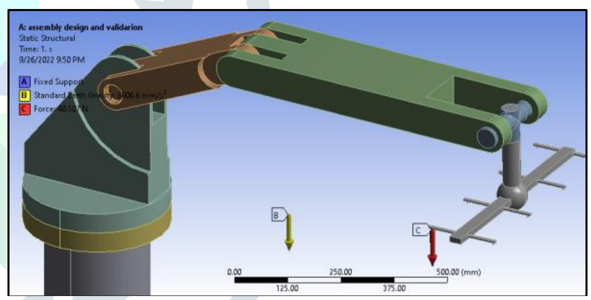

Figure 4: Applied boundary conditions on robotic arm

The structural loads and boundary conditions are applied on robotic arm manipulator assembly as shown in figure 4 above. The structure is applied with fixed support at the base and downward force is applied on the manipulator end surface. After applying boundary conditions, the simulation is run.

5. RESULTS AND DISCUSSION

The FEA simulation is conducted to determine deformation, equivalent stress and shear stress of robotic arm assembly. The maximum deformation is obtained at the end of the manipulator wherein the deformation value us more than .418mm which is observed at the end region and reduces towards the base of the robotic arm.

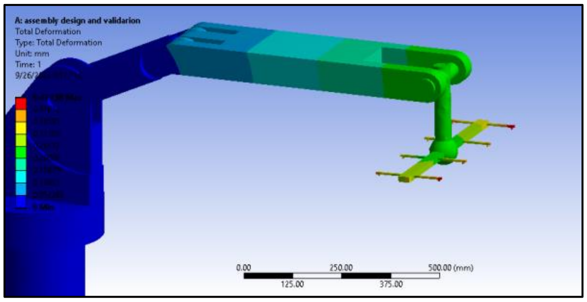

Figure 5: Total deformation on robotic arm assembly

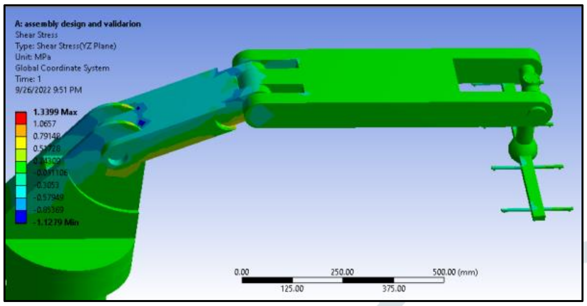

Figure 6: Shear stress on robotic arm assembly

The shear stress distribution plot is obtained from the FEA analysis as shown in figure 6 above. The shear stress observed to maximum at the corner regions of the manipulator arm wherein the magnitude of shear stress is more than 1.06MPa.

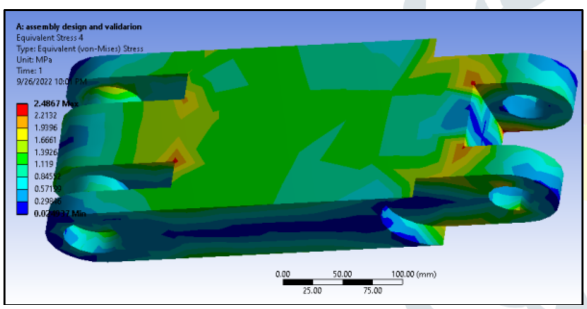

Figure 7: Equivalent stress on robotic arm assembly

The equivalent stress distribution plot is obtained for manipulator arm as shown in figure 7 above. The maximum equivalent stress is observed at the corners of the structure as shown in red coloured region. The equivalent stress at this region is more than 2.2MPa.

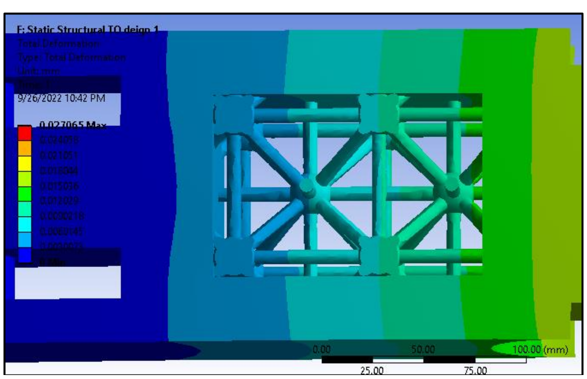

Figure 8: Total deformation on beam lattice design

The maximum deformation plot is obtained from the FEA analysis of beam lattice design of robotic arm assembly. The maximum deformation value obtained is more than .021mm.

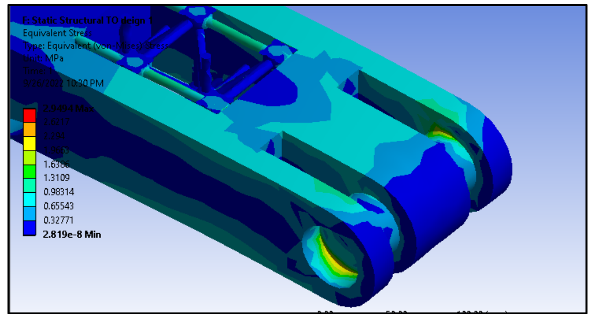

Figure 9: Equivalent stress plot on beam lattice design

The equivalent stress distribution plot is obtained for beam lattice design of robotic arm manipulator as shown in figure 9 above. The equivalent stress distribution is non uniform across the lattice and at the solid zones of arm. The equivalent stress value at various regions is more than 1.638MPa.

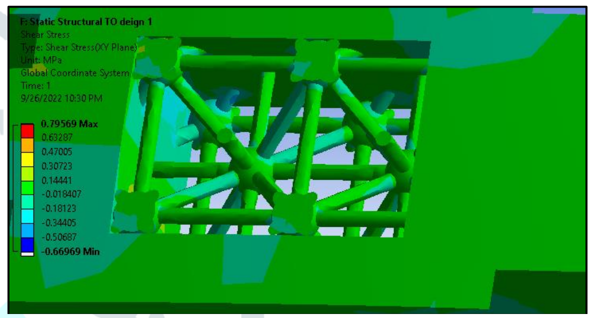

Figure 10: Shear stress plot on beam lattice design

The shear stress distribution plot is generated for arm manipulator encompassed with beam lattice design. The shear stress value is obtained to be maximum at the corner regions as shown in yellow coloured region. The maximum shear stress magnitude is more than .63MPa. The shear stress at most of the regions is almost uniform wherein the magnitude is .307MPa.

6. CONCLUSION

In order to identify areas of the robotic arm assembly that are subject to high stresses and deformation, a FEA analysis is performed on the assembly. The use of lattice designs for the arm helped to contribute to a considerable reduction in the weight of the arm. The outcomes of the study have shown that even with the addition of lattice structures, the shear stress and equivalent stress are well below the safe range. A weight reduction of about 20.1% was accomplished because to the utilization of the lattice architecture. Because of its lower mass, the robotic arm has a lower need for the torque that the servo motor must have in order to move it. In order to identify areas of the robotic arm assembly that are subject to high stresses and deformation, a FEA analysis is performed on the assembly. The use of lattice designs for the arm helped to contribute to a considerable reduction in the weight of the arm. The outcomes of the study have shown that even with the addition of lattice structures, the shear stress and equivalent stress are well below the safe range. A weight reduction of about 20.1% was accomplished because to the utilization of the lattice architecture. Because of its lower mass, the robotic arm has a lower need for the torque that the servo motor must have in order to move it.

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