PROJECT ON

Compliant Robotic Microgripper

PHASE I

Project report submitted for partial fulfillment of the requirement of the degree of Bachelor of Technology in Electrical & Electronics Engineering

Submitted by

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UNDER THE GUIDANCE OF

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Institute of Engineering & Management

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CERTIFICATE OF APPROVAL

This project report prepared by Kaustav Laskar, Andolan Majumdar, and Sourav Sardar entitled "Compliant Robotic Microgripper" is hereby approved and certified as satisfactory to warrant its acceptance as a prerequisite to the Degree of B.Tech in Electrical & Electronics Engineering for which it has been submitted.

It is understood that by approval, the undersigned does not necessarily endorse or approve any statement made, opinion expressed, or conclusion drawn there in approving the report only for the purpose it has been submitted.

Prof. Neeta Sahay
(Guide)

Examiner

Examiner

Head of the Department

ACKNOWLEDGEMENT

We express our profound gratitude and indebtedness to Prof. Neeta Sahay, of the Department of Electrical & Electronics Engineering of the Institute of Engineering & Management for introducing the present topic and for their inspiring guidance, constructive criticism, and valuable suggestion throughout the project work.

We wish to convey our sincere thanks to all faculty members who have patiently extended all sorts of help in accomplishing this undertaking.

Date: 26.11.22

ABSTRACT

Microgripper is an essential device in the micro-operation system. It can convert other types of energy into mechanical energy and produce clamp movement with the required chucking force, which enables it a broad application prospect in the domain of tiny components' processing and assembly, biomedicine and optics, etc. The performance of a microgripper is dependent on its power supply, type of drive, mechanism structure, etc.

In this project, we use 3D printing technology to develop a compliant gripper for micro-object manipulation. We studied different types of 3D printing materials. We also studied Pro-series software for mathematical and structural designing and simulation for redesigning. The resulting design of the gripper can be done by using ABS plastic.

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OBJECTIVE

Robots have existed for almost 100 years, and the improvement of mechanical movements has never stopped since then. Motion, precision, and control are continually improving and refined to optimize robotic handling. 3D printing is ideal for that robotic design.

- Integration and Innovation structure to save time and money on the assembly line.
- Structure and design in one line so the structure may be lighter.
- Gripper customization

LITERATURE REVIEW

Microgripper plays an important role in micromanipulation and micro-assembly tasks. Microgrippers with various actuation principles have been reported in the literature, such as electrostatic [1], electrothermal [2], and piezoelectric microgrippers [3]. In particular, the piezoelectric actuator [4], [5],is attractive owing to its merits of sub-nano-meter positioning resolution and rapid response speed.

In the article "**SOME ASPECTS OF MULTI-FINGERED GRIPPER**" the author discussed some aspects of multi-finger grippers. In addition, they have also discussed some limitations of this type of gripper. As this gripper is joint, so this type of Gripper could drop parts with loss in air pressure as this type of gripper is air pressure control. This type of gripper can only be for a singular purpose. In another paper **"Magnetic Gripper Using Magnetic Switchable Device"** where authors worked on magnetic grippers. The attraction gripper is fundamentally simple. There are two primary problems with this type of end effector. For a magnetic attraction gripper to work, the object it grasps must contain a ferromagnetic material such as iron or steel. The magnetic field produced by the end effector can permanently magnetize the objects it handles. In some cases, this is not a concern, but it can cause trouble in other instances.

Among the fundamental design parameters of a robotic arm, the ratio between the structure weight and the strength that can be held by it are especially relevant [2], and both of them are intrinsically related to the usual building materials, namely, aluminium and steel. Our aim was to improve these two key parameters by using ABS plastic in the design and construction of a robotic arm structure with six degrees of freedom. ABS plastic is a relatively light material and the most suitable one.

COMPLAINT STRUCTURE

Compliant mechanisms transfer motion, force, or energy through the deformation of their flexible components. It gains some or all of its motion from the relative flexibility of its members rather than from rigid-body joints alone. There are mainly three types of compliant mechanisms based on their distribution pattern namely:

- ❖ Lumped Compliant Mechanism.
- ❖ Distributed Compliant Mechanism.
- ❖ Hybrid Compliant Mechanism.

❖ **Design Method:**

Kinematics approach: Kinematics analysis can be used to design a compliant mechanism by creating a pseudo-rigid body model of the mechanism.

Structural optimization approach: In this method, computational methods are used for topology optimization of the structure. Expected loading and desired motion and force transmission are input and the system is optimized for weight, accuracy, and minimum stresses.

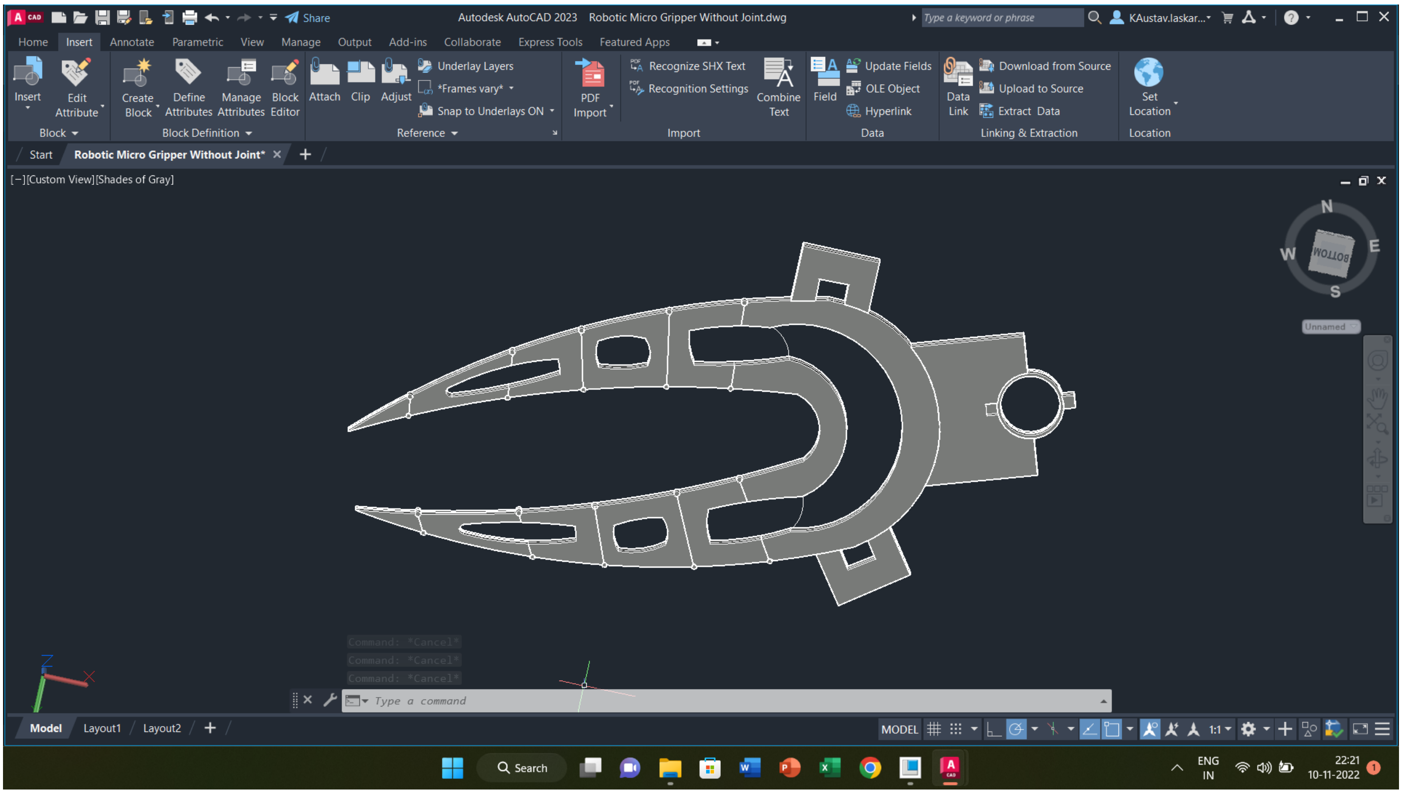
❖ **Advantages:**

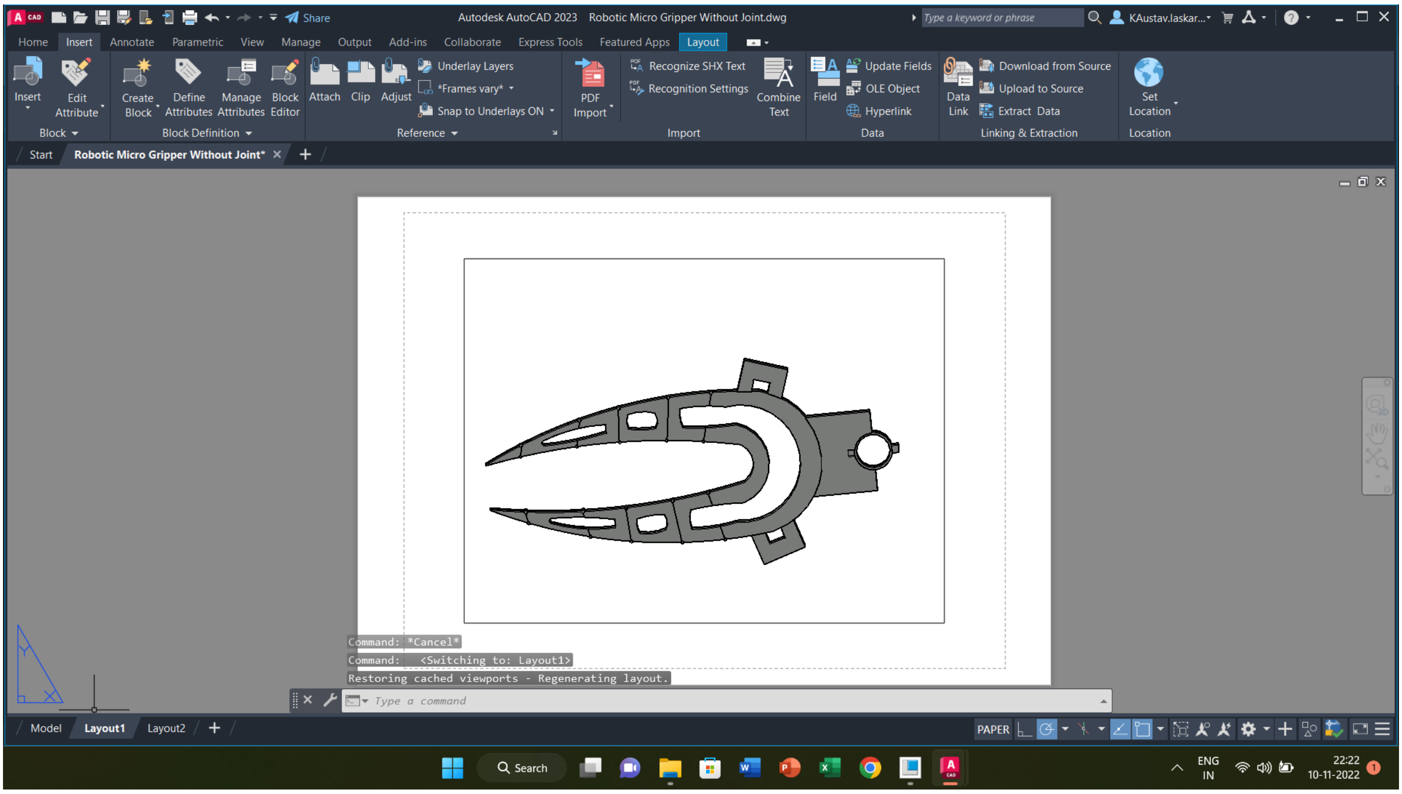
1. Low Cost
2. Better Efficiency

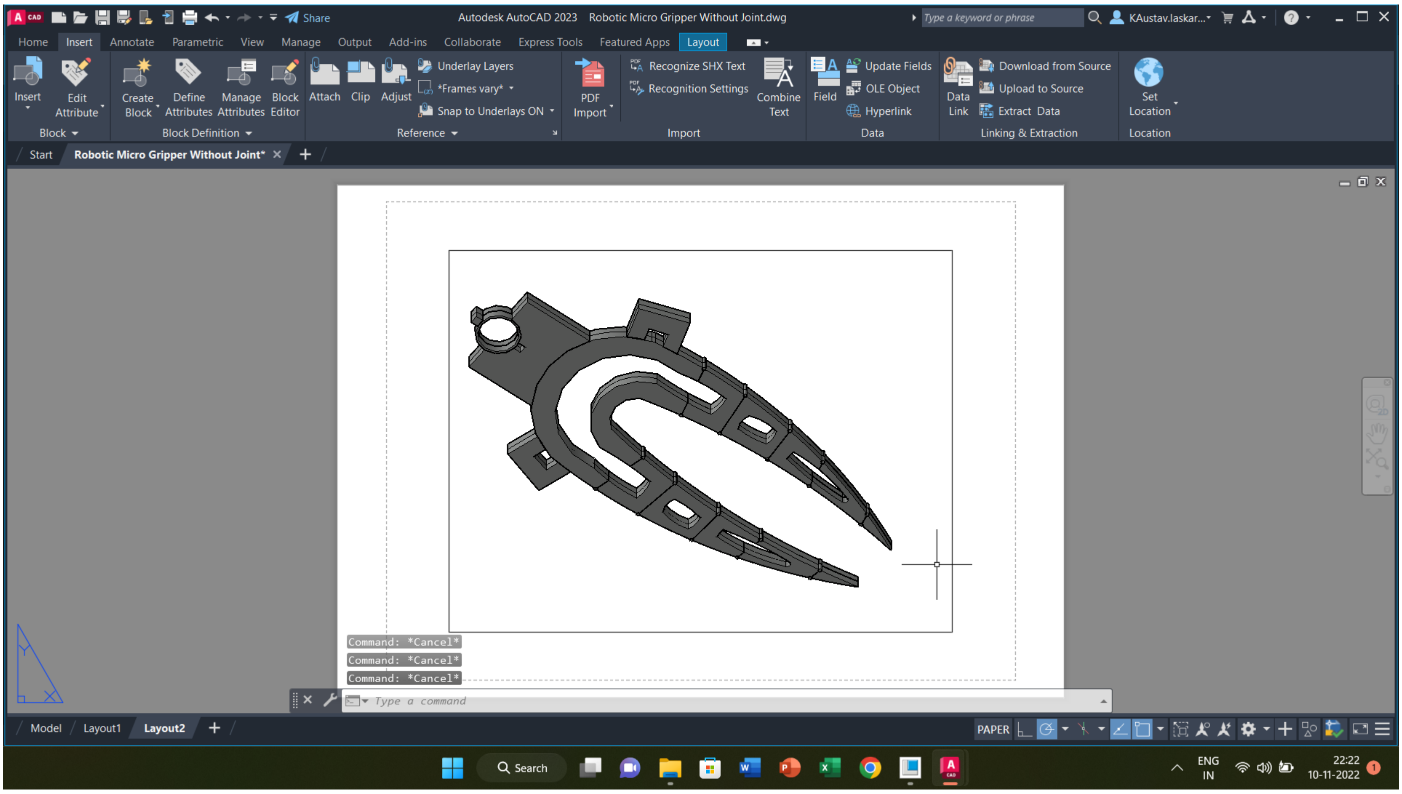
❖ **Disadvantage:**

1. No purely compliant mechanism can achieve continuous motion such as found in a normal joint. Also,
2. The forces applied by the mechanism are limited to the loads the structural elements can withstand without failure.
3. Due to the shape of flexure joints, they tend to be locations of stress concentration.

PROPOSED DESIGN






Autodesk AutoCAD 2023 Robotic Micro Gripper Without Joint.dwg
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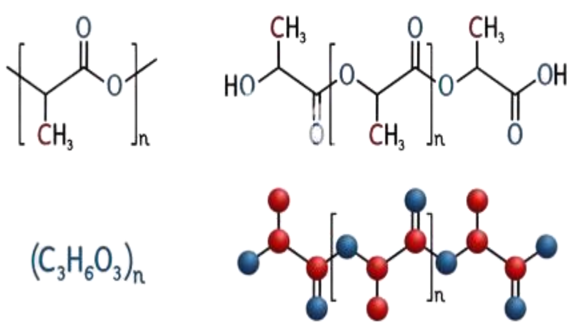
Model
Layout1
Layout2
PAPER

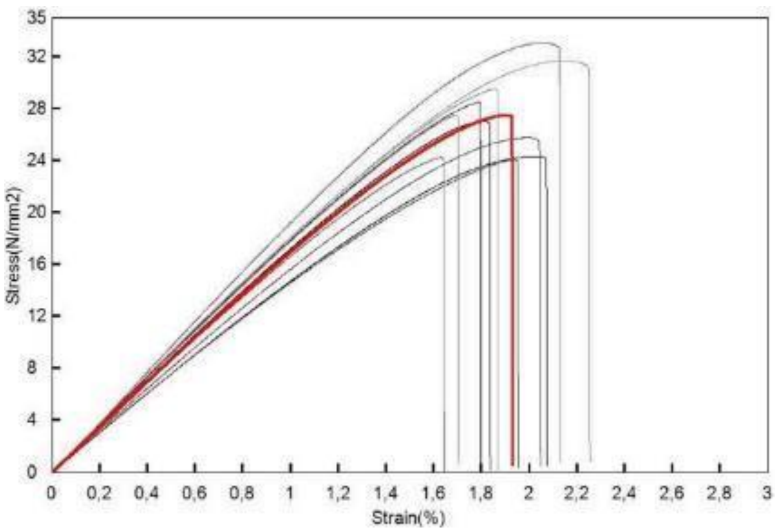
MATERIAL SELECTION

Low elastic moduli materials and smart structures that are inspired by nature empower soft robots to perform tasks by mechanically adapting their bodies to dynamic environments by undergoing extremely large deformations without any sign of material or structural failures due to their inherent softness. In this project, we have selected three materials primarily ABS, PLA, and Nylon.

- **Polylactic acid (PLA):** PLA is a user-friendly thermoplastic with higher strength and stiffness than both ABS and nylon. With a low melting temperature and minimal warping, PLA is one of the easiest materials to 3D print successfully. Unfortunately, its low melting point also causes it to lose virtually all stiffness and strength at temperatures above 50 degrees Celsius. In addition, PLA is brittle, leading to parts with poor durability and impact resistance.

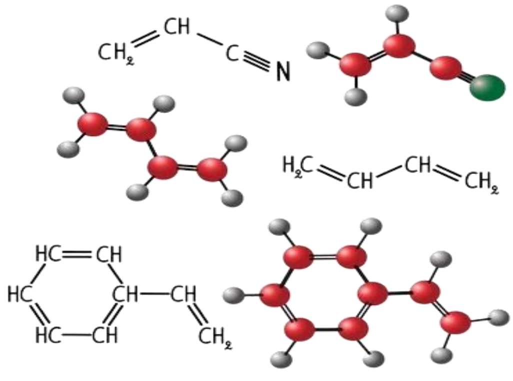


Although PLA is the strongest of these three plastics, its poor chemical and heat resistance force it into almost exclusively hobbyist applications.

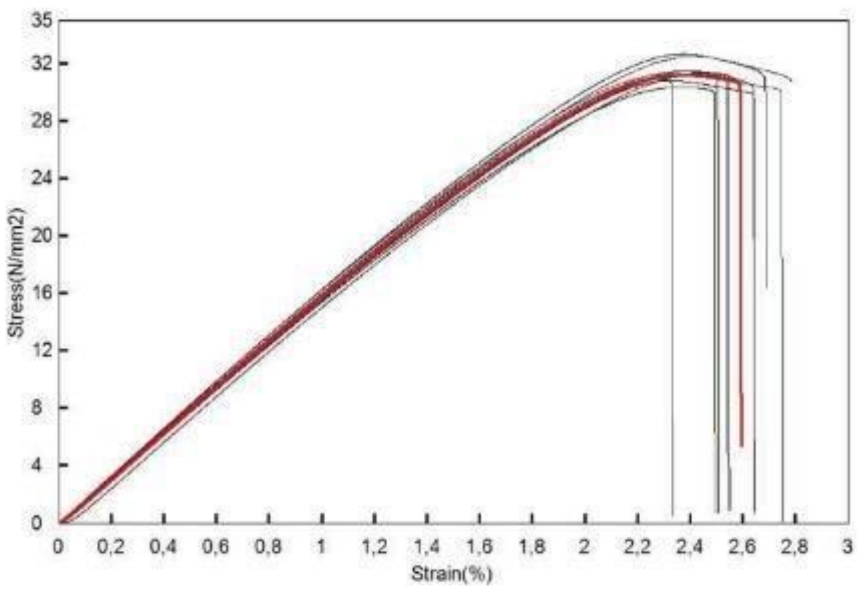


Strength-Stress Curve of PLA Material

❖ **<u>Acrylonitrile Butadiene Styrene (ABS)</u>:** ABS, while weaker and less rigid than PLA, is a tougher, lighter filament more suitable for some applications beyond pure hobbyist. ABS is a bit more durable, is about 25% lighter, and has four times the higher impact resistance. ABS does require more effort to print than PLA because it's more heat resistant and prone to warping. This calls for a heated bed and an extruder that is 40-50 degrees Celsius hotter. ABS, while by no means a heat-resistant plastic, has superior heat deflection temperature compared to PLA and nylon.

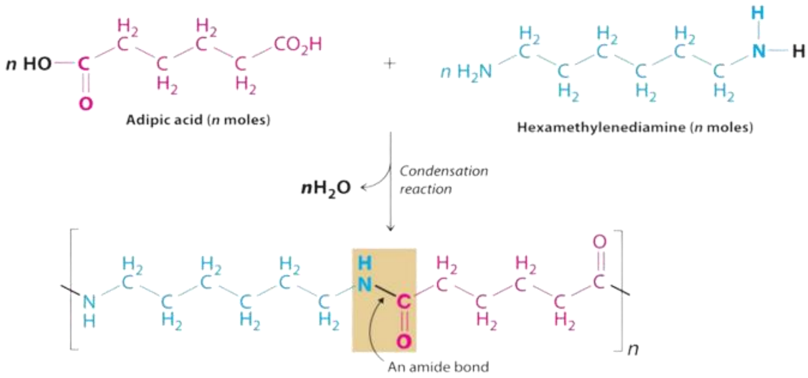


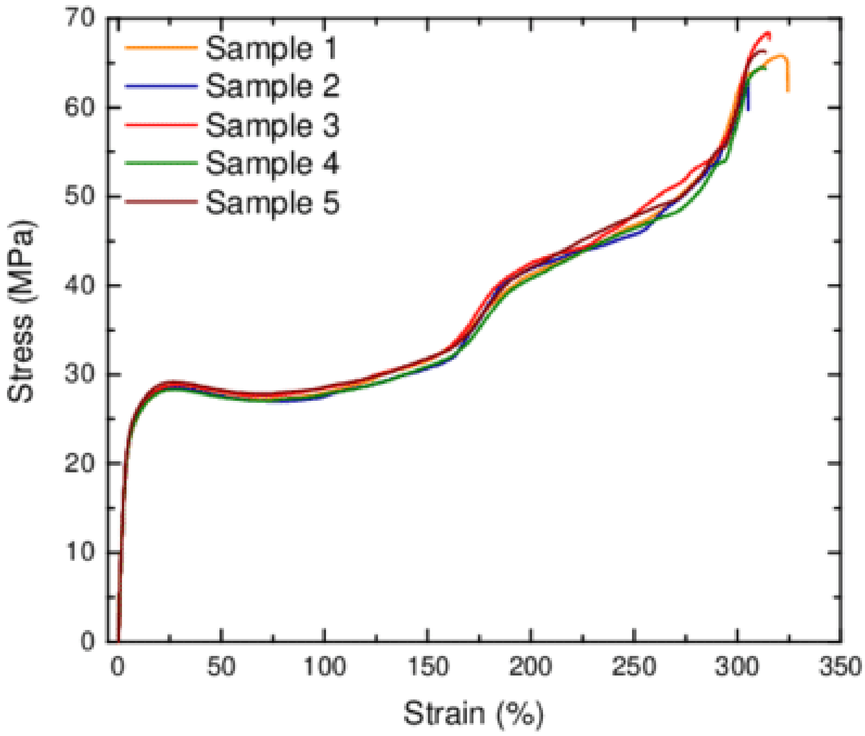
The improved durability over PLA lends ABS to some more practical applications, such as prototyping and low-stress end-use parts.



<u>Strength-Stress Curve of ABS Material</u>

❖ **<u>Nylon (With Onyx)</u>:** Filled nylon is a mixture of nylon with small particles of a stronger material such as fiberglass or carbon fiber. These mixtures preserve the favorable properties of nylon while adding considerable strength and stiffness. Markforged Onyx filament is an example of one of these mixtures, combining nylon with chopped carbon fiber in order to improve the key properties of the material. Onyx is 1.4 times stronger and stiffer than ABS and can be reinforced with any continuous fiber. The development of 3D-printed continuous fibers has enabled a new category of stronger 3D parts.





<u>Strength-Stress Curve of Nylon at Various Sample</u>

COMPERATIVE TABLE:

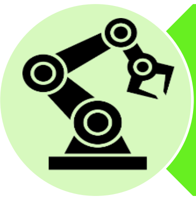
PROPERTIES	Acrylonitrile Butadiene Styrene	Nylon	Polylactic acid
Strength	●●○○○	●○○○○	●●●○○
Stiffness	●●○○○	●○○○○	●●●○○
Durability	●●○○○	●●●●○	●○○○○
Chemical Resistance	●○○○○	●●●●○	●○○○○
Printability	●●●○○	●●○○○	●●●●○
Heat Resistance	●●○○○	●○○○○	○○○○○

Properties	Acrylonitrile Butadiene Styrene	Nylon	Polylactic acid
Elongation	10-50%	60-110%	6%
Flexibility	1.6-2.4GPa	3.10GPa	4GPa
Hardness Shore	100	80	75
Stiffness	1.6-2.4GPa	1.27GPa	50-70MPa
Strength (Tensile)	29.8-43MPa	55-86MPa	50-70MPa
Young Modulus	1.79-3.2GPa	2.7GPa	3.5GPa

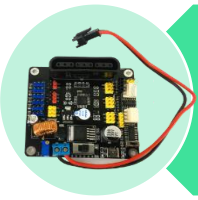
- ❖ From the above discussion, we have primarily selected ABS material for its less rigid, but also tough and lighter properties which make it a better plastic for prototyping applications.

FUTURE WORK

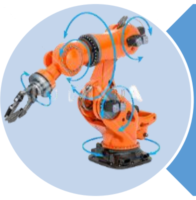
Simulation of this proposed design in software and observe its various parameter



Design modification according to our objective and simulation result



Implementation of motor drive, sensor, actuator, on it



Accommodate this gripper on a industrial manipulator

CONCLUSION

By the end of this phase I completion of this project we can clearly identify that 3D printed robotic gripper will be the most useful gripper in near future for its low cost and huge application. The compliant gripper are useful for its high accuracy grasping of small object with adaptive control of contact points along with the active surface of finger.

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