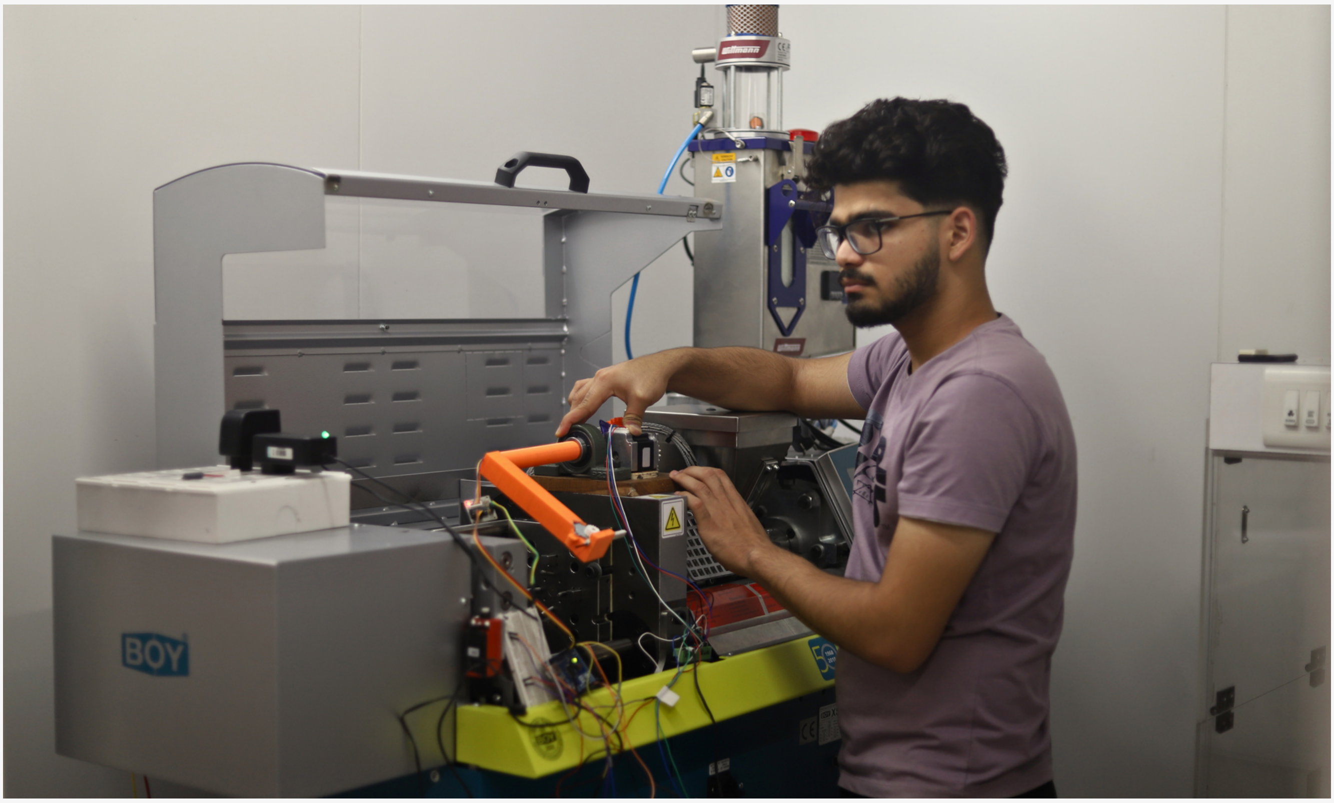
DEVELOPMENT OF A LOW-COST PICK AND PLACE ROBOT FOR MEDICAL MICROMANUFACTURING



GROUP 8

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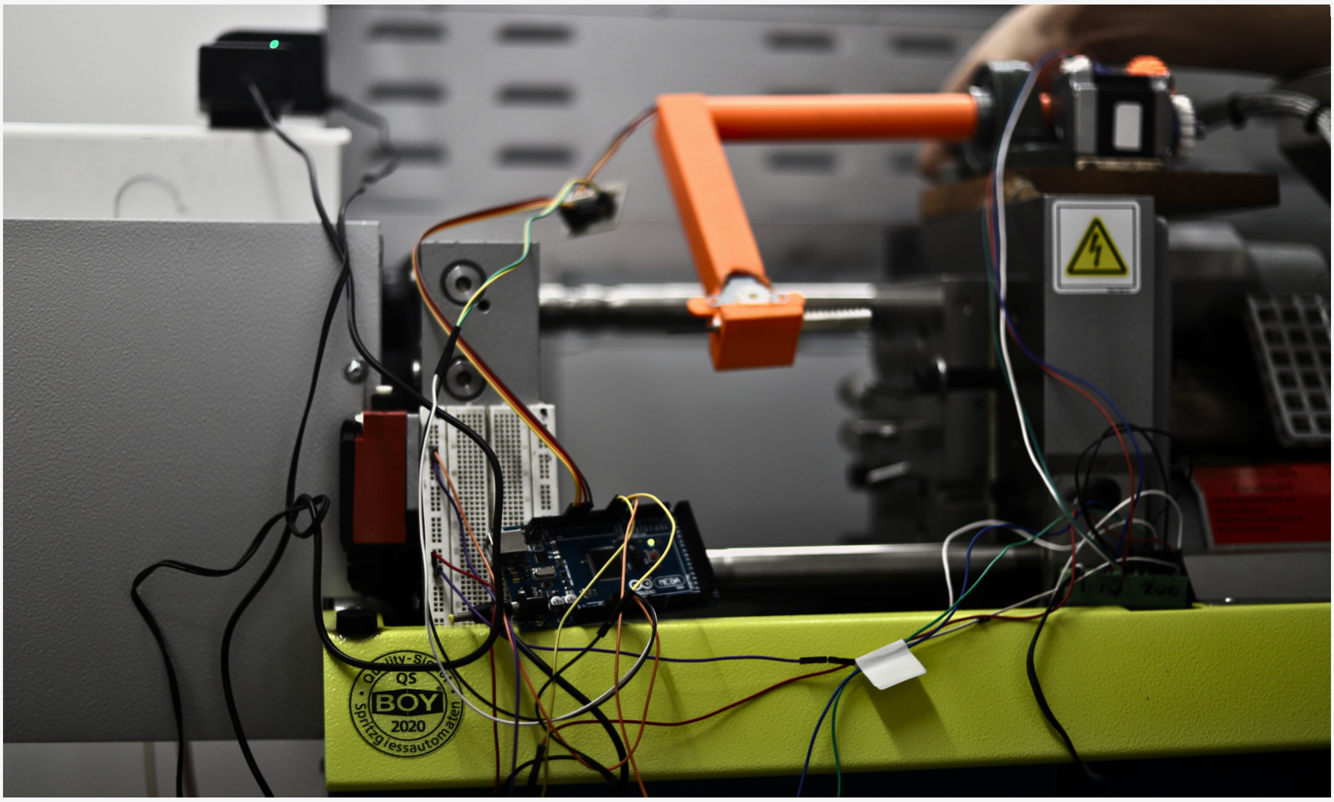
PROJECT DESCRIPTION

The development of a pick and place robot for injection molding in medical purposes involves the creation of an advanced robotic system capable of handling and placing micro medical components with precision and speed, ensuring consistent quality and reducing the risk of human error in the micro-manufacturing process.
This innovative technology requires a deep understanding of the specific needs of the medical industry, including regulatory requirements and safety standards, as well as advanced engineering skills to design and build a sophisticated mechanism capable of performing complex tasks. The pick and place robot must be able to operate with high accuracy and repeatability to ensure consistent quality and efficiency. Additionally, the robot must incorporate advanced safety features to prevent accidents and ensure the safety of both the operators and the products being manufactured.

OBJECTIVES

We have to design an automated mechanism for an injection molding machine to pick and drop manufactured products. The machine to be automated is used for micro manufacturing of medical products, specifically injection molding of heart stunts. Since, the part to be manufactured is very small so the mechanism should be very precise and accurate. We have to place the mechanism in an injection molding machine thus the mechanism should also be small.

OVERVIEW



DESIGNING PROCESS

Selection of Work Envelope

A cylindrical work envelope for robots is a specific type of workspace that allows a robot to move freely within a cylindrical area. by providing a three-dimensional workspace, a cylindrical work envelope allows the robot to access parts and components that might otherwise be difficult or impossible to reach. A cylindrical work envelope allows the robot to perform multiple tasks without requiring repositioning or manual intervention. This can help reduce cycle times and increase overall productivity. The cylindrical workspace is the best choice for our requirement.

Selection of Control System

A closed-loop system, also known as a feedback control system, is a system in which the output is continuously monitored and compared to the desired output or set point. But this might be complex in our case, for simplicity we can move to an open loop system.
An open-loop system, also known as a non-feedback control system, is a system in which the output is not continuously monitored or compared to a desired output or set point. Instead, the system relies on predetermined input values to achieve the desired output. Here our manufacturing can be seen as a cyclic process so we can use an open loop system. Also, the space restriction and low cost option will be an open loop system.

Selection of Drive Source

We have two options for drive source - servo motor and stepper motor. A servo motor is a type of electric motor that is used in a wide range of applications, including robotics, industrial automation, and CNC machines. The basic design of a servo motor includes a motor, a control circuit, and a feedback mechanism. Since we are using open loop system, so we will use stepper motor.
A stepper motor is a type of electric motor that is designed to move in precise, incremental steps. The basic design of a stepper motor includes a rotor, a stator, and a series of coils that are used to generate a magnetic field. In open loop system, we have to use that motor which is more precise. Thus, we will use stepper motor for this mechanism. We will use **NEMA23** and **28YBJ-48** motor in this mechanism.

Selection of Material

The slow turning speed of our mechanical arm and the lifting of a very lightweight stunt enabled us to use plastic in making of shafts and arm(PLA from 3d printing), although we used wood in the base, which carries the motor, the bracket, and the weight of the whole mechanism. Wood was taken into consideration because it is easy to cut and nail and bore into, After doing the calculations we concluded that plastic is more than enough to withstand the stresses and easy to 3d print.

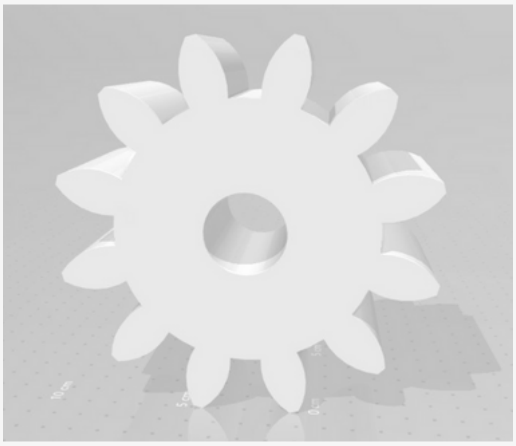
Selection of Location of Mount

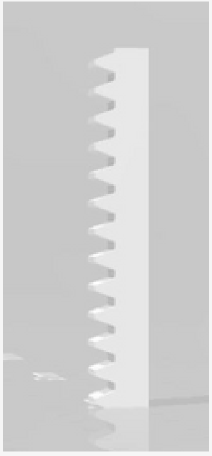
The location was decided after thorough inspection of the machine, we were given three choices based on the space utilization of the machine. One was below the mold, another tah on the side of the mold and last was on the top of the mold, So if we were going to mount our robot on the bottom of the mold, this will make our work envelope more complicated and we have to push the mechanism against the gravity quite often than the other available options, thus increasing the power requirement and chances of failure . The side mount location was rejected due to presence of a metal rod between the ejected part and the arm, also increasing the workload. The top of the mold was selected as the location of mount as this was the location where the work against the gravity is minimum and the work envelope is the simplest to work and implement.

CAD MODEL

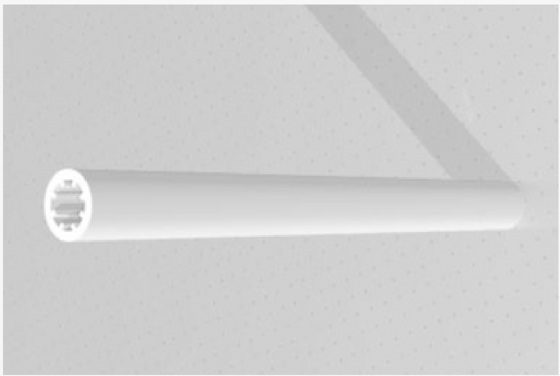
Rod for holding small motor and Rack and Pinion

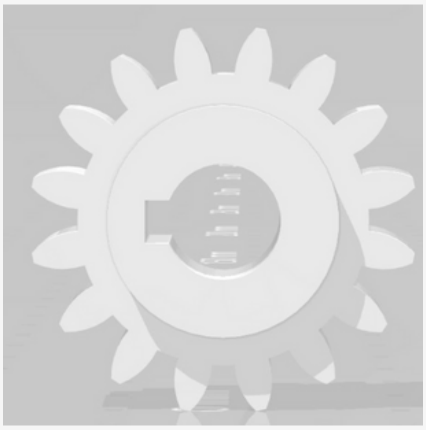
Rack and Pinion





Shaft and the gear





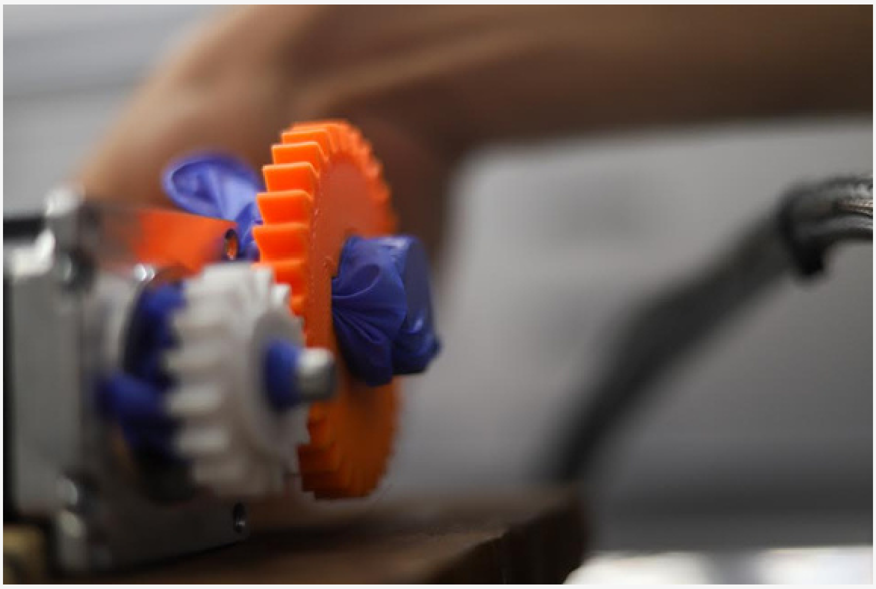
FEATURES OF DESIGN

Compact Design

When it comes to the design of low-cost pick and place robots for medical micromanufacturing, compactness is often a crucial factor. The smaller the robot, the easier it is to maneuver it in tight spaces, which is essential for handling small medical components with high precision. To achieve the compact design we used 3D printing technology to fabricate custom-designed parts, such as rods, gears and rack,

Spur Gear Transmission

When the smaller gear, known as the pinion, rotates, it meshes with the larger gear, known as the spur gear. As the teeth of the pinion engage with the teeth of the spur gear, they transmit motion and torque to the spur gear, causing it to rotate in the opposite direction. The gear ratio between the two gears is **1.54** and maximum angular velocity is 3 rad/sec

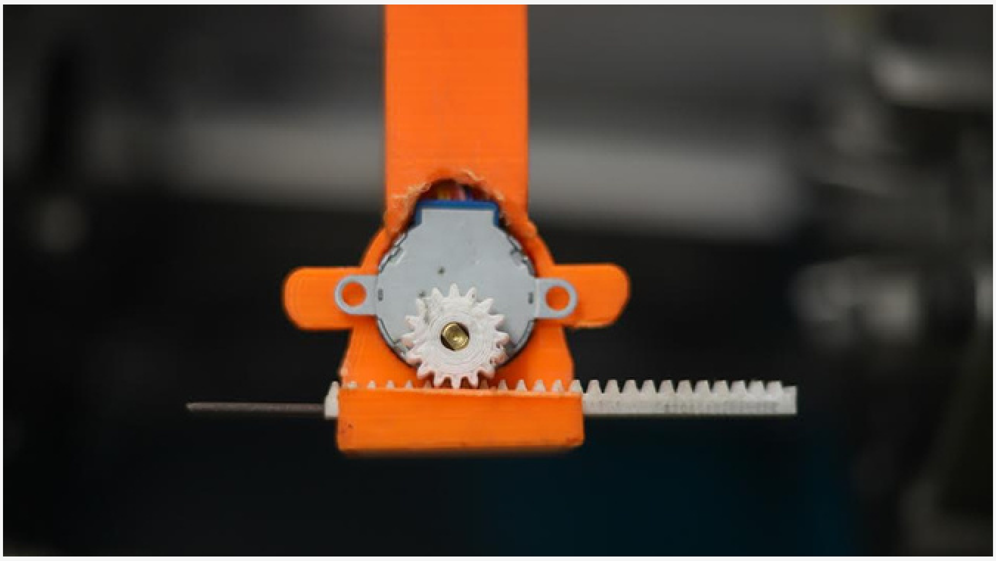


Adjustable Length

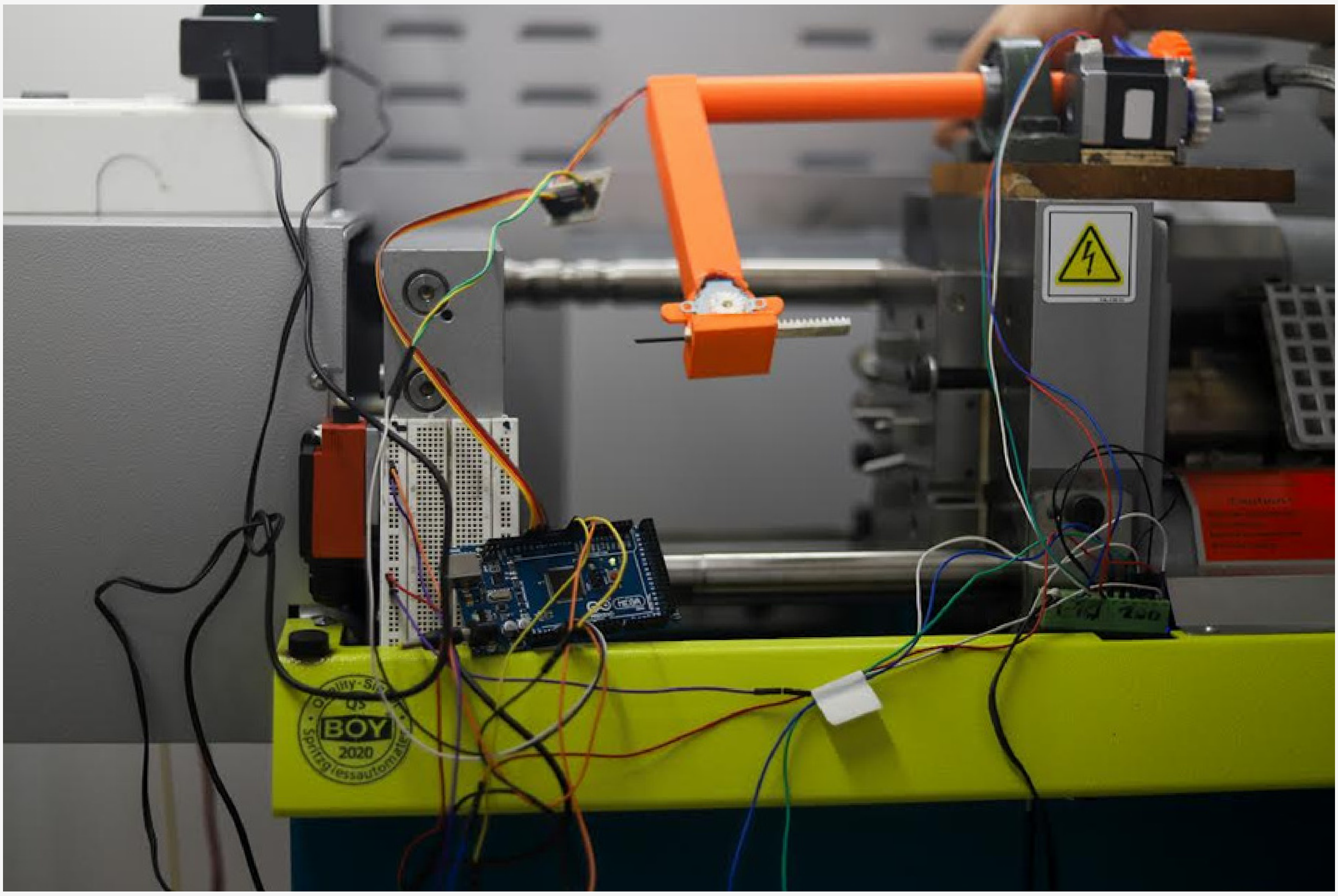
The gear on the shaft can be adjusted along its axis helping in the adapting of the mechanism according to the mold thickness,
This makes the whole mechanism a universal mechanism that can be used on all types of stunt making injection molding machines

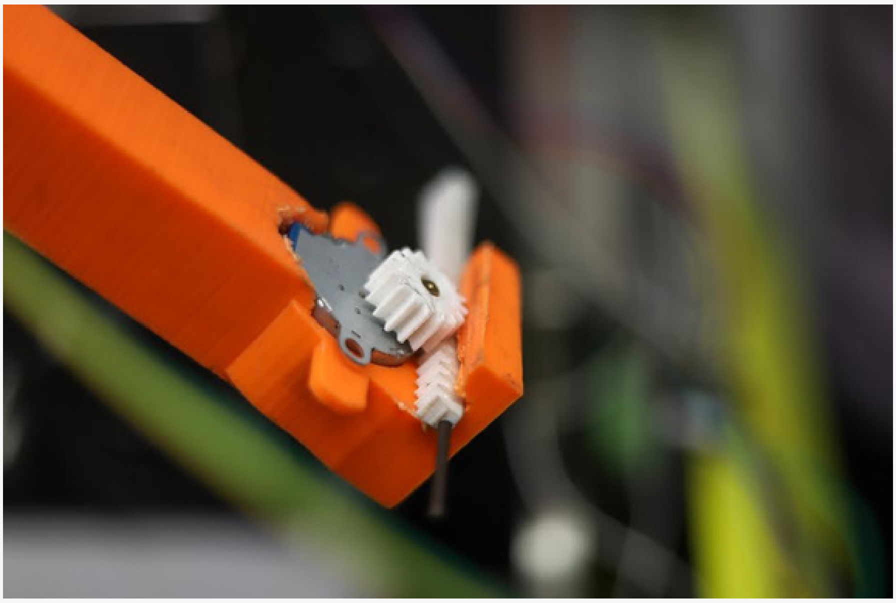
Rack and Pinion Mechanism

To pick the stunt from the mold we used the rack and pinion. At the end of the support beam, rack and pinion mechanism is used to engage or disengage the needle, which is used to pick the product.



IMAGES OF MODEL



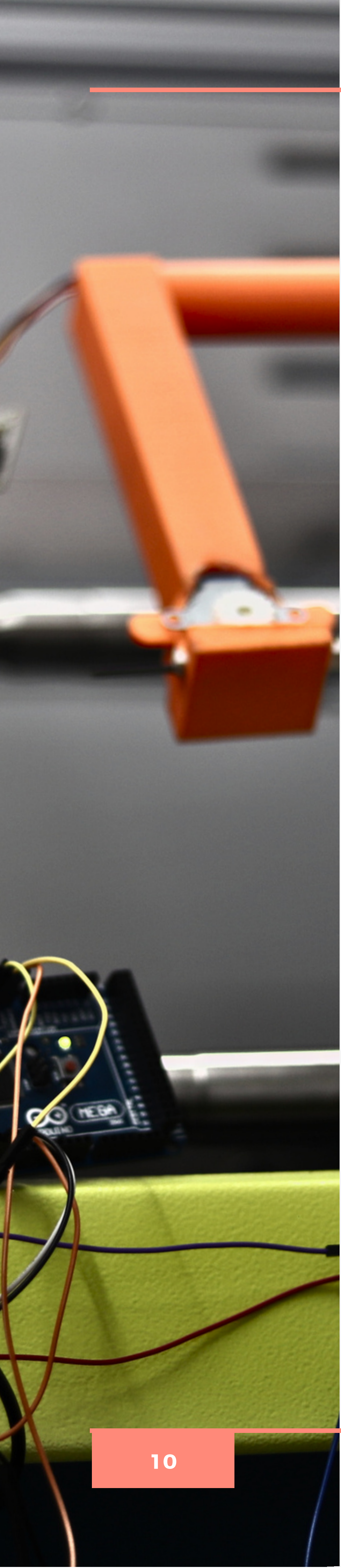


WORKING OF MODEL

The mechanism utilizes a limit switch to detect when a mold in an injection molding machine is open. This detection is necessary for the mechanism to perform its intended function, which involves a NEMA23 motor rotating a shaft by 90 degrees, and a small stepper motor driving a rack and pinion mechanism to move a pin into the center of the mold. Once the pin is in place, the rack retracts slightly and the NEMA motor returns the arm to its initial position at -90 degrees. The pinion then retraces its path and drops the object into a rectangular box. The mechanism is designed to repeat this process automatically, without any human intervention, until the limit switch detects that the mold is open again, thus forming a loop of picking and dropping.
In summary, this is a mechanism that relies on a combination of motors, gears, and limit switches to perform a specific task in an injection molding machine. The mechanism is designed to operate automatically, without the need for human intervention, by detecting when the mold is open and responding accordingly.

Video link :-

https://drive.google.com/drive/folders/11nUzLB9XBMSgNNMyIDiMYXMK5Q1p-TsY



EXISTING STUDIES

Several research studies have focused on developing low-cost pick and place robots for medical micromanufacturing. With high precision and accuracy, these robots are designed to handle delicate and small medical components, such as sensors, catheters, and needles.

- A review on existing systems for handling micro-parts was carried out recently by Antonio-José Sánchez-Salmerón and Rafael Lopez-Tarazon. The work was focused on the analysis of the main problems which limit the emergence of automated micro-handling systems. Some of the challenges associated with the handling of micro-parts were also examined.A key problem area limiting the emergence of automated micro-handling technology is lack of flexible and high-precision micro-handling machinery. Another problem is the lack of standardization due to which equipment makers spend an excessive amount of time and resources on custom automation solutions.
- Researchers at the National University of Singapore and University of California, Berkeley, aimed to develop a low-cost pick and place robot for medical micromanufacturing. The robot was designed to be compact, lightweight, and able to handle small parts with high precision. The researchers used a combination of off-the-shelf components and custom-designed parts to build the robot. They also developed a control system that enabled the robot to perform complex tasks with high accuracy.

RESULTS AND CONCLUSION

In conclusion, our project to create a robotic arm for automating the process of picking up stunts made from an injection molding machine and dropping them in a box has been a success. Our objective was to eliminate the need for human intervention in the production process, and we have achieved this goal.

The design and construction process involved developing a robotic arm that is capable of accurately and consistently picking up stunts from the injection molding machine and placing them in a box. We utilized a combination of motors, gears, and limit switches to automate the process, with a control system to coordinate the movements of the robotic arm.

The robotic arm has been tested and evaluated, and we are pleased with its performance and functionality. It is capable of picking up and dropping the stunts with precision and accuracy, and it can repeat the process continuously to produce a batch of stunts without any human intervention.

This project has significant implications for the manufacturing industry, as it demonstrates the potential of automation to streamline production processes and increase efficiency. Our project has shown that it is possible to automate a previously manual process, leading to cost savings, increased productivity, and improved product quality.

In the future, we could further improve the functionality of the robotic arm by incorporating machine learning algorithms to optimize its performance and make it more adaptable to different types of stunts. We could also explore the integration of sensors and cameras to enhance the robotic arm's ability to detect and handle different types of objects.

Overall, our project has been a success, demonstrating the potential of robotics and automation in the manufacturing industry. It has provided us with valuable experience in designing and building a functional robotic system, and we are excited to explore further developments in this field.

FUTURE SCOPE

The future scope of pick and place robots for injection molding of micro-manufactured medical parts is exciting and holds great potential for the medical manufacturing industry

- **Miniaturization:** The trend towards miniaturization in medical devices and components is likely to continue, driving the need for more precise and accurate pick and place robots capable of handling increasingly small and intricate parts. Future pick and place robots may need to be even smaller and more precise, with the ability to handle parts at the micrometer scale.

- **Integration with other technologies:** Pick and place robots for injection molding of micro-manufactured medical parts may become more integrated with other advanced technologies such as artificial intelligence (AI) and machine learning (ML) to improve accuracy and efficiency. AI and ML can enable the robot to learn from past experiences and improve its performance over time.

REFERENCES

https://www.researchgate.net/publication/223850590_Recent_development_in_micro-handling_systems_for_micro-manufacturing

https://www.researchgate.net/publication/267629954_Design_and_Manufacturing_of_a_Pick_place_robot_with_innovative_operation_and_controlling

https://www.electromate.com/automation-components/stepper-motors/nema-stepper-motors/

https://b2b.partcommunity.com/community/knowledge/en/detail/169/Rack%20and%20pinion
https://grabcad.com/library/a-simple-rack-and-pinion

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