DEP Report Group – 8

Submitted by -

Atinderpal Singh - 2020MEB1274
Sehajpreet Singh - 2020MEB1314
Sujal Thakur - 2020MEB1319
Sumit Saini - 2020MEB1320
Tushar Sharma - 2020MEB1324
Pradeep Tripathi - 2020MEB1300

Topic -

Development of a low-cost pick and place robot for medical micromanufacturing

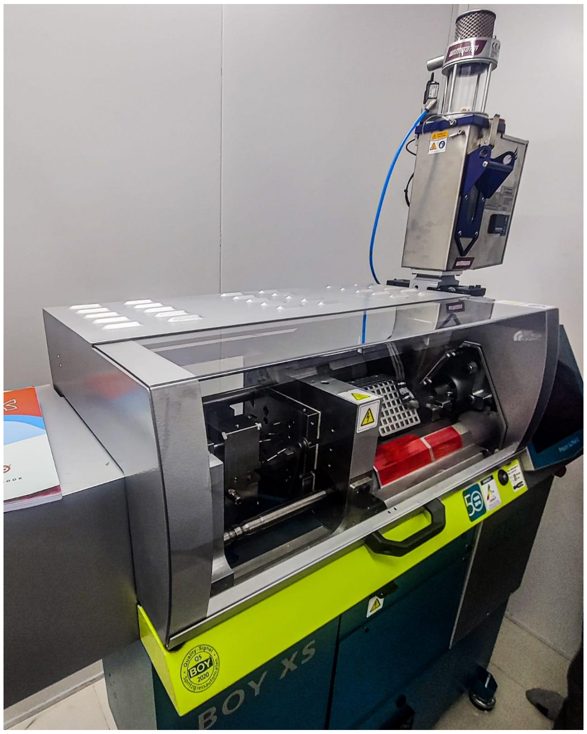
Aim –

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.

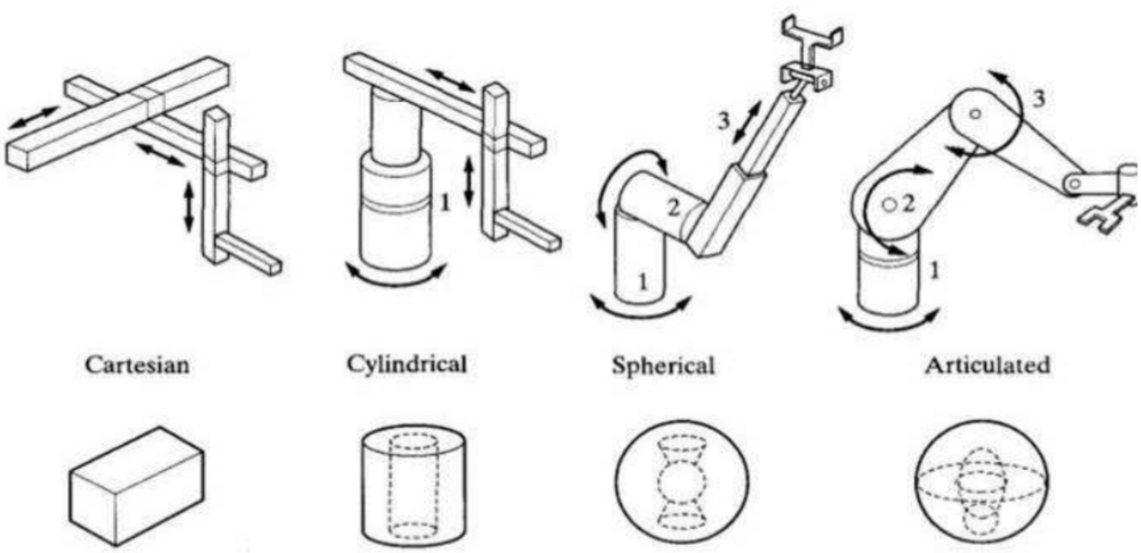
Problem Description –

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.



Designing Process –

- **Selection of work envelope shape –**

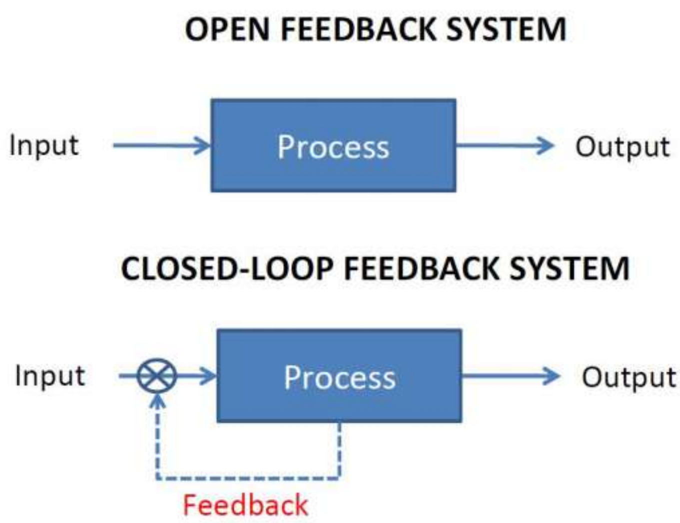


1. **Spherical Work Envelope** – A spherical work envelope for robots is a specific type of workspace that allows a robot to move freely in all directions within a sphere. This type of work envelope is particularly useful in applications where the robot needs to access workpieces or components from multiple angles, or where the workspace is limited. By providing a three-dimensional workspace, a spherical work envelope allows the robot to access parts and components that might otherwise be difficult or impossible to reach. But in our case we can further simplify the moment thus we can think of other work envelopes. We do not need to move the arm in all directions, so we can think of making it more simple and efficient.

2. **Rectangular Work Envelope** – A rectangular work envelope for robots is a specific type of workspace that allows a robot to move freely in a cuboidal space. By providing a three-dimensional workspace, a rectangular work envelope allows the robot to access parts and components within a defined area. By providing a three-dimensional workspace, a rectangular work envelope allows the robot to focus on a specific area, reducing the complexity of the task. This can help reduce cycle times and increase overall productivity. But still, it can be made more simple. By limiting the motion in two dimensions.

3. **Cylindrical 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 –**



1. **Closed Loop** – 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. The system then makes adjustments to the input in order to bring the output closer to the desired value. But this might be complex in our case, for simplicity we can move to an open loop system.

2. **Open Loop** – 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.

Microcontroller will be used according to the stepper motor.

- **Selection of Drive Source –**

- **Servo 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. The motor is typically a DC motor, although AC servo motors are also available. The control circuit is responsible for providing the motor with the correct amount of power and direction, while the feedback mechanism provides information about the motor's actual position, speed, and torque. Since we are using open loop system, so we will use stepper motor.

- **Stepper Motor** -A stepper motor is a type of electric motor that is designed to move in precise, incremental steps. It is widely used in a range of applications, including robotics, 3D printers, CNC machines, and industrial automation. 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. When an electrical current is applied to the coils, the rotor moves to align itself with the magnetic field. By controlling the electrical current applied to the coils, the motor can be made to move in precise steps. 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** motor in this mechanism.

· **Selection of Material –**

We were initially going to use plastics(PLA, ABS etc) because it was easier to print it in our labs with precession and it was cost effective, but after researching for some time we got to know that the upper mold of the injection molding machine which we have selected for the location of mounting of our mechanical arm, heats up to a certain temperature and the plastic we were using, might melt due to that and also the wear and tear of plastics is much more than some metals, due to which the calibration and synchronization of our arm will get disturbed quite frequently, thus defying the purpose of our robotic arm if we need more human help in maintaining.

So that's why we are going to use mixture of parts made by steel and aluminum based on availability and standard sizes of our components, also manufacturing processes of these materials can be accomplished in any manufacturing workshop thus the commoditization are easy

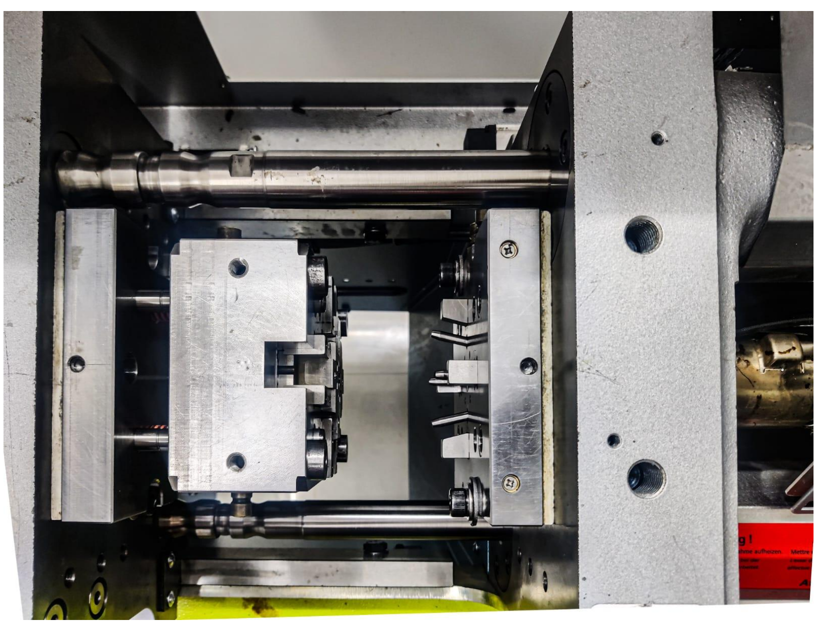
· **Selection of Process Layout –**

This injection molding machine is capable of producing heart struts of quite a few sizes. So we have decided to implement **batch production** techniques in our automation. So if we were to collect every single strut in a single test tube, then we have to open the glass chamber every time, this contradicts the whole use of the robotic arm. If we were to open the chamber every time, it’s better not to use any mechanism. So we decided that our cylindrical work space working arm will drop off the strut inside a plastic box for capacity of 10-15 struts and then we can replace that box with an empty box, for future we might be able to integrate a conveyor belt into the machine but due to space and time constraints, it is better to use this kind of batch production where we can produce a batch of 15 struts of same size in a single go and batches of different sizes in given time.

- **Selection of location of Mount –**

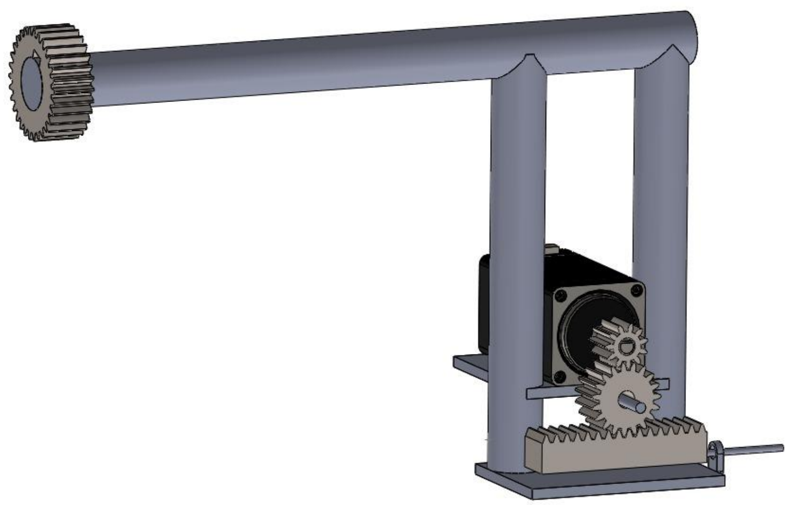
The location was decided after thorough inspection of the machine, we were given three choices based on the space utilization of the machine. One was below the mold, another tah on the side of the mold and last was on the top of the mold, So if we were going to mount our robot on the bottom of the mold, 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 upon, we would only have to use two stepper motor instead of 3 minimum in basic robotic arm if we mount this mechanical robotic arm on the top of the mold where the 2 grooves for mount is present as shown in the picture below(the two biggest hole on the right):

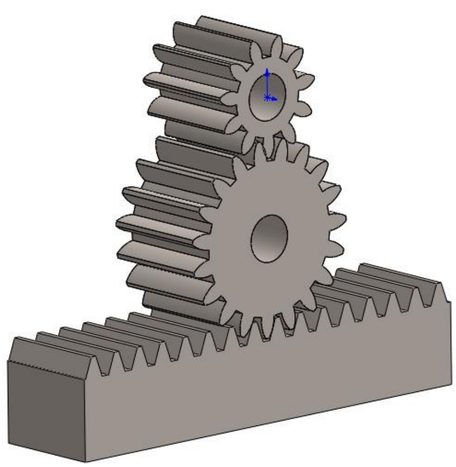


Features of Design –

- CAD Model –

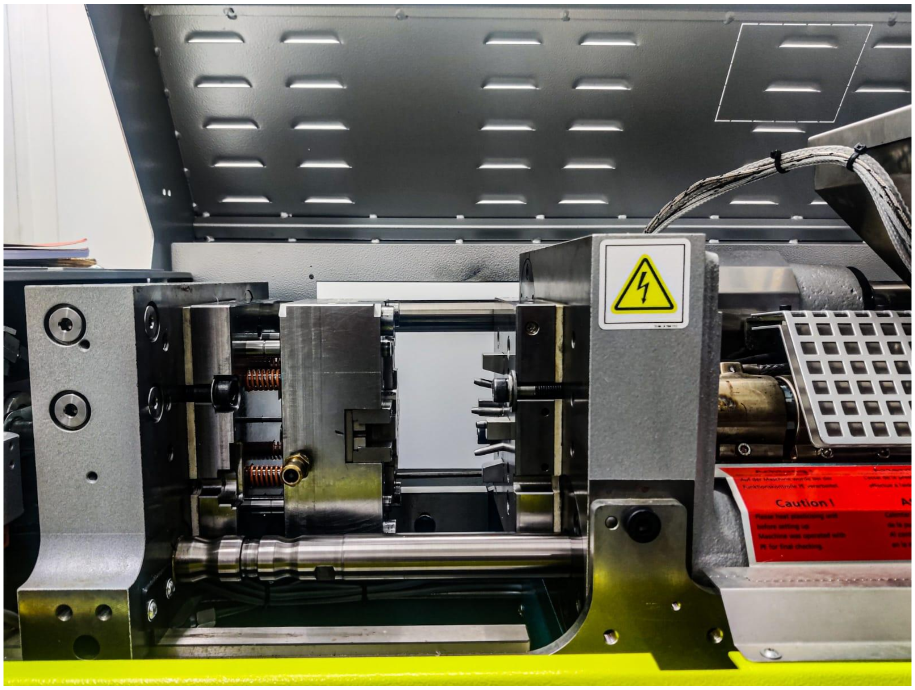


1. Compact design: The design is made so that it fits in the limited space with longitudinal length of 90 mm.
2. Rack and pinion mechanism: At the end of the support beam, rack and pinion mechanism is used to engage or disengage the needle, which is used to pick the product.



3. Spur gear transmission: Spur gears are coupled with the shaft of the stepper motor and the beam, to rotate the entire assembly.

4. No obstruction from the top: In most of the mechanisms the modification of top cover is necessary, but in this design, there is no need to open/ cut-open the top cover to accomplish the task.



Existing Studies –

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

- **Design and Implementation of Micro Mechatronic Systems- SMA Drive Polymer Microgripper** – by Yu-Heng Lai and R. J. Chang
- **Microclamping principles from the perspective of micrometrology** – by Stephan Jantzen, Martin Stein, Karin Kniel, Andreas Dietzel

Requirements –

An arduino board- https://robu.in/product/arduino-uno-r3/?gclid=EAIaIQobChMI_Y6G-ezG_QIVR5VLBR3jmwjoEAQYAiABEgJbgfD_BwE

A stepper motor(NEMA23)-
https://robocraze.com/products/23hs5628-nema23-stepper-motor?currency=INR&variant=40193193214105&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&https://robocraze.com/?utm_source=googleads&utm_medium=ppc&gclid=EAIaIQobChMIntzqke3G_QIVMZ1LBR3kHQN5EAQYAiABEgIO6vD_BwE

Stepper motor controller and driver-
https://robocraze.com/products/tb6600-stepper-motor-driver?currency=INR&variant=40193025835161&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&https://robocraze.com/?utm_source=googleads&utm_medium=ppc&gclid=EAIaIQobChMIr9Xa-u7G_QIVEAkrCh1lPAa9EAQYASABEgLF2vD_BwE

28BYJ-48 Stepper motor-
https://robocraze.com/products/stepper-motor28ybj-48-with-uln2003-driver-board?currency=INR&variant=40192743800985&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&https://robocraze.com/?utm_source=googleads&utm_medium=ppc&gclid=EAIaIQobChMIio2pzO3G_QIVI5VLBR1chwVdEAQYAyABEgJA5vD_BwE

Rack and pinion- Insourced, 3d printed

Steel and aluminum rods and sheets- Insourced from workshop

Pin- Insourced

MC38 magnetic reed switch-
https://robocraze.com/products/mc-38-wired-magnetic-house-security-alarm-sensor-for-door-and-windows?currency=INR&variant=40193815838873&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&https://robocraze.com/?utm_source=googleads&utm_medium=ppc&gclid=EAIaIQobChMIy5T69e3G_QIVGQ4rCh2uHQVnEAQYAiABEgIoPvD_BwE

Further Plan –

Manufacturing Process:- We will study different manufacturing processes so as to manufacture our rods, gears and base for the mounting, support and arm, and also manufacture these parts for our robot.

Controls:- As we have already mentioned that we will be using an open loop system, for this purpose we will use stepper motor and controller, we will write the arduino code and calibrate the code with our dimensions of the machine and process.

Test (By the First week of April):- To verify the calibrations and synchronicity of our machine also, to estimate the maintenance cycle time for this robot. We will also perform some failure tests on the parts, but it is not mandatory as the operation our robot will be performing is more precision based and not heavy loading based.

Conclusion –

The successful verification of the CAD model for the desired mechanism signifies a significant milestone in the project's progress. With careful consideration given to providing sufficient tolerances and accounting for all possible failure scenarios, the team can move forward with confidence towards fabrication. This stage will entail the actual realization of the envisioned design, and a high level of precision and attention to detail will be required to ensure the final product matches the expectations laid out in the CAD model.
The fabrication process will likely involve various stages, including material selection, sourcing of components, and assembly. The team will need to maintain close collaboration and clear communication channels to ensure that the process runs smoothly, and any challenges or unforeseen issues are addressed quickly and effectively. Throughout the fabrication process, regular checks and quality control measures will be necessary to maintain the desired tolerances and ensure that the final mechanism meets the required specification

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.

Reference –

https://www.electricalelibrary.com/en/2022/01/12/work-envelope-of-robots/

—-THANK YOU—