Development Process

First Prototype

A rack and pinion are a type of linear actuator that is made up with a circular gear which is known as pinion and engaging with a linear gear which is generally known as rack, which operates to translate rotational motion into linear motion.

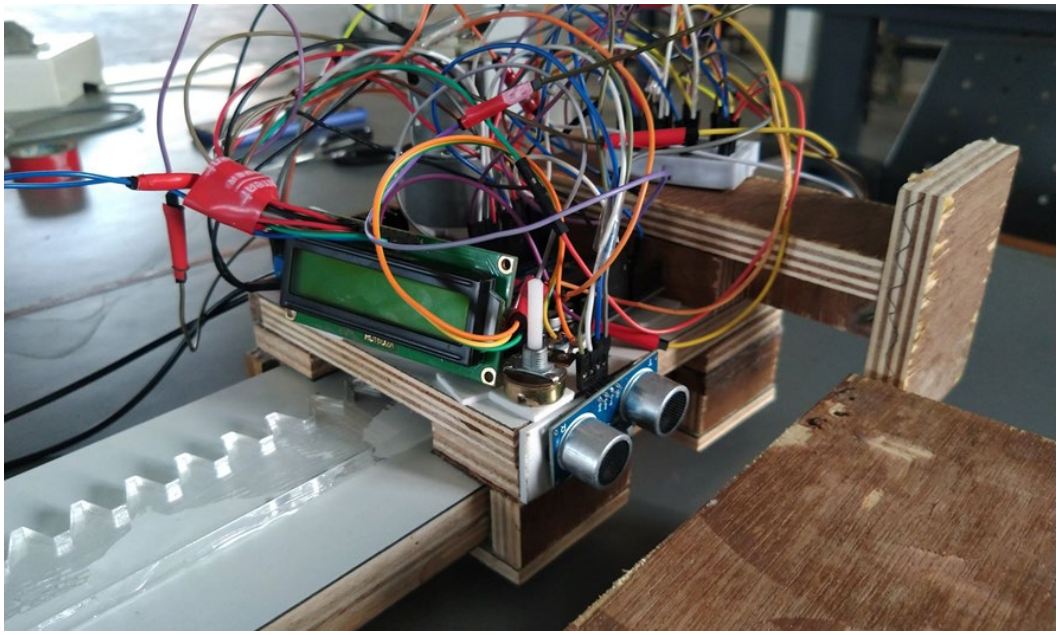


Figure. First Prototype Set-up

As shown in this picture, this is the first trial model of rack and pinion mechanism in which the Linear guideway was made from plywood with top and bottom surface covered with sun-mica to reduce the friction so the sliding platform can side on it hazel free, the rack was made from acrylic sheet through laser cutting. Not only the rack but also, mold cart and platform were made out of plywood and the mold-cart wheel and pinion was 3D printed using PLA material.

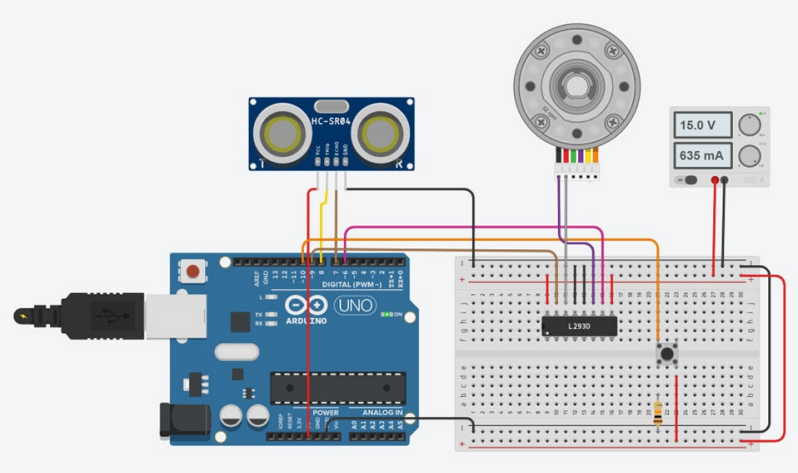


Figure. Circuit Diagram

Circuit diagram consist of sensor, motor & motor driver, and Arduino UNO. A single distance sensor is used to detect a mold cart when it gets aligned with the platform. Then, pinion motor will rotate and push that mold cart at its defined location.

The main advantages to choose this mechanism are it is easy to implement due to its low set-up requirement; after installation if some technical problem arises or the mechanism stops working, the foundry process will not come to halt as the process can be still done manually. Moreover, manpower can be reduced, and production can be increased.

While building and testing the prototype, challenges faced are,

- Excessive vibrations due to larger play between platform slider and rack. (Manufacturing Error)
- Control operation of the mechanism was not accurate due to backlash of the pinion and major lags during computation.
- Less Hardware accuracy.

Second Prototype

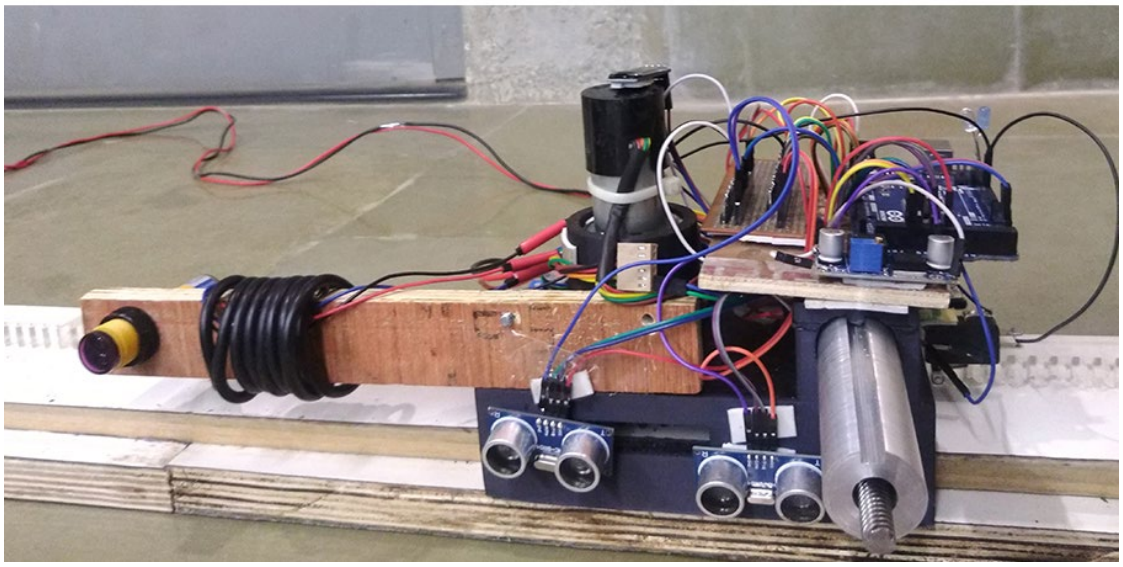


Figure. Second Prototype Set-up

A second Prototype is scaled down version of the real scale model which is supposed to be installed at the RBD Engineers Pvt. Ltd. which is $^{1}/_{Fifth}$ of the actual size. In this model, few things were modified such as platform shape, actuators, and sensors. For that, Platform and pinion were made from a 3D printer due to complex shape and the length of the rack & linear guideway extended to around 2 meters for better flexibility and understanding. Sliding platform design was modified to as inverse trapezoidal shape to reduce the play between the platform and linear guideway and to have better gripping; leadscrew operated pushing rod was introduced to push the mold carts which is mounted on the platform and it works as an actuator and limit switches were used to constraint the movement of the sliding platform on the rack guideway.

In the previous prototype, control of the sliding platform was based on the time duration and calculated distance based on the time which was not accurate as it did not include the backlash experienced by the pinion, computational time, and lags. While in this prototype, controlling of the platform works totally on the feedback of the sensors.

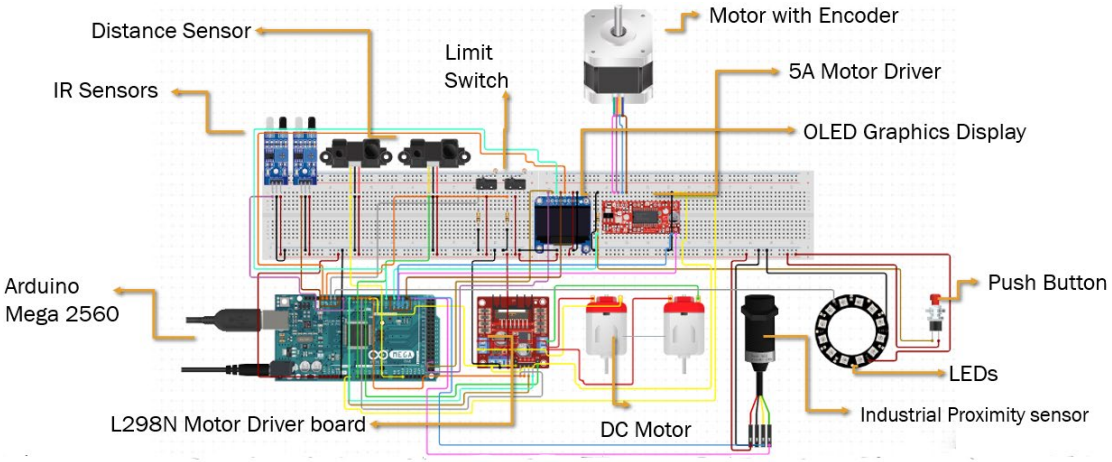


Figure. Circuit diagram

Circuit diagram consist of sensor, motor & motor driver, and Arduino UNO. Two distance sensors are used to detect a mold cart when it gets aligned with the platform. Industrial proximity sensor is mounted on the probe to sense ahead the already placed mold cart. And IR sensors are used to avoid collision when it is working.

Challenges faced in second prototype are:

- Wobbling of the lead screw due to designing error.
- Manufacturing error in mounting the motor due to that meshing of pinion and rack is not proper which sometimes results in slipping of pinion.

Modifications needed are:

- Support for the shaft need to be increased so that wobbling of the leadscrew rod will be minimized.
- The platform is to be made as accurate as possible based on the feedback of errors made in this model; so, mounting of the motor is done properly.
- Another leadscrew actuator will be made and added for the unloading mechanism.

Components Details

Distance Sensor

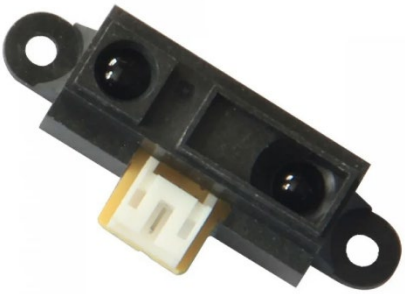


Figure. Distance sensor

The sensor uses a beam of infrared light to reflect off an object to measure its distance.Since it uses beam triangulation to calculate distance, it is able to provide consistent and reliable readings which are less sensitive to temperature variation or the object's reflectivity. The sensor outputs an analog voltage corresponding to the distance of the object and can easily read by an Arduino board.

IR sensor

An Infrared (IR) sensor is an electronic device that emits the lights to detect and measure presence of the object.

Figure. IR sensor

Two IR sensors are used to detect an obstacle which comes in the way of the sliding platform while performing its task. Both the IR sensors are placed at each end of the platform to avoid collision.

DC Geared Motor with Encoder & 5A motor driver

Figure. DC Geared Motor with Encoder

The DC Geared motor with Encoder 300 RPM is a robust encoder based DC servo system which drives the encoder feedback to achieve maximum rated torque at lower speeds along with perfect positioning.

Limit Switch

Limit switch is an electromechanical device that is operated by a physical force which is applied to it by an object.

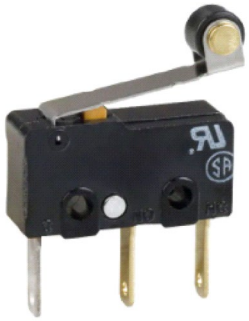


Figure. Limit switch

In the rack and pinion mechanism, Limit switches are placed on the platform so when the cart passes over the small blocks (placed on the guideway) which constrains the movement of the sliding platform on the guideway.

Arduino Mega 2560

Figure. Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 with 54 digital input/output pins, 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

DC Motor and L298N Motor Driver board

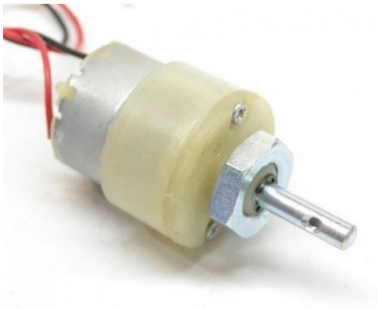


Figure. DC Geared Motor

DC geared motors- 12 V are generally a simple DC motor with a gearbox attached to it. 12V DC geared motors widely used for robotics applications. Very easy to use and compatible with an Arduino board. L298N H-bridge module with onboard voltage regulator motor driver can be used which has a voltage of between 5 and 35V DC.

Push Button

The Push button is used for the manual command which is supposed to be given by the field worker when the unloading of the mold carts needs to be started.

Figure. Push Button

IR Proximity Sensor

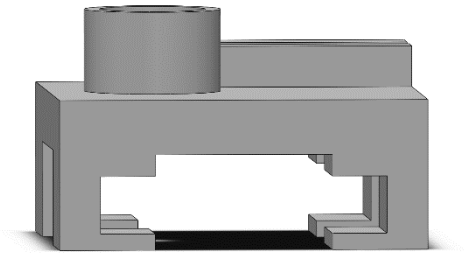
The sensor takes a continuous reading of any obstacle and settles it at output in TTL form within 2ms and provides an easy interface of 3-wire with power, ground and the output voltage. The sensor works on 5V input. Its Detecting range is 3cm to 80cm and also has an inbuilt potentiometer to set range of the module manually.

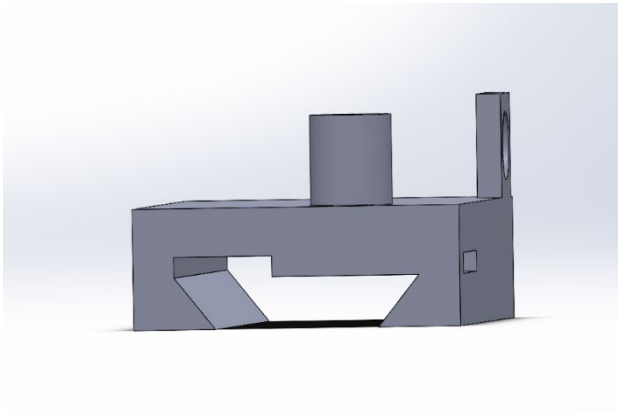
Figure. IR Proximity sensor

Comparison between 1st and 2nd Prototype

Hardware

- The slot in the Platform and Linear guideway's shape was of rectangular bar ; while in 2nd Prototype, they are of the Inverse trapezoidal shape.





- The module of the rack and pinion has been reduced in the 2nd prototype in order to lower the backlash error.

Controlling

- The control of the sliding platform was based on the time duration and calculated distance based on the time, which was not accurate as it does not include the backlash experienced by the pinion, computational time and lags.
- Removing all those dependencies and errors, the 2nd prototype works totally based on the feedback of sensors. Also, few safety features such as collision detection have been added.