MIKRON

Team

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Directed by Dr. Derek Reamon

EASY-20

A high-speed, electrically-actuated gripper for your modern automation needs

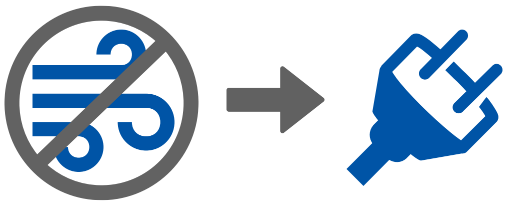
DESIGN CENTER COLORADO

Mechanical Engineering
UNIVERSITY OF COLORADO BOULDER

Contents

MOTIVATION

Mikron designs and builds custom machines for customers to automate production and assembly lines. Many of these machines require the use of grippers—which are predominantly pneumatically actuated—to locate, pick up, and manipulate parts of an assembly or mechanism. Some applications, such as those in smaller facilities or clean rooms, make the use or implementation of a compressed air system inconvenient or impossible. Meanwhile, electricity and electrical systems are abundant in all industrial buildings, making electrically-actuated grippers an attractive solution where the application of pneumatic systems is infeasible. Electric grippers currently available on the market are limited and their performance does not live up to their pneumatic counterparts, which limits the functionality of machines in applications where pneumatic grippers are not ideal.



Our objective is to design an electrically-actuated gripper that achieves performance specifications that are competitive with the pneumatic Schunk MPG 25. With an electric gripper to replace the pneumatic grippers commonly used on Mikron's custom machines, they will be able to operate in a wider range of facilities and applications.

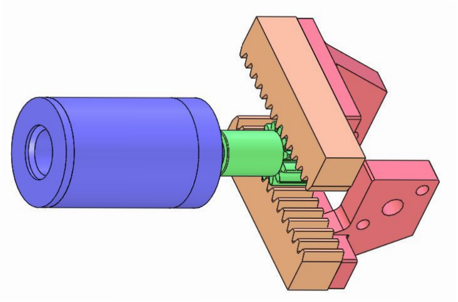
The Schunk MPG 25 is a pneumatic gripper commonly used on Mikron's automation solutions due to its specifications for speed, force, and repeatability. It uses compressed air to drive the jaws at the bottom to open and close. The use of compressed air allows the gripper to be compact and grip with relatively high forces.

https://schunk.com/us_en/gripping-systems/product/2414-0340010-mpg-25/

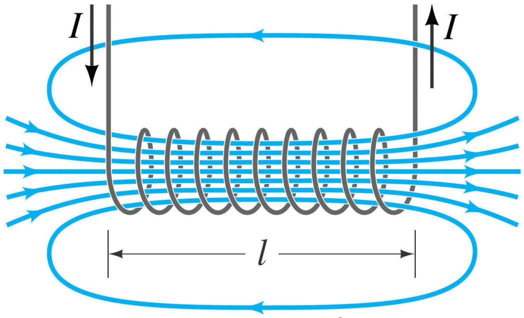
CONCEPTS

After many brainstorm sessions, the team came up with numerous design concepts for gripping ranging from adaptations of current market designs to entirely novel ideas. The following were some of the top contending ideas that were ultimately ruled out by our final design choice.

Rack and Pinion: While this design would have met every requirement, this is a commonly used solution with little to no room for innovation. In addition, the complexity of machining the gears needed at the sizes desired would have been a costly process.

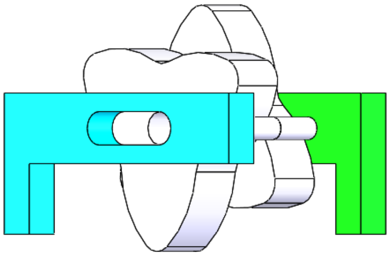


Solenoid: This concept was an exciting pursuit for us; however, it became apparent that this would not be sufficient in meeting the requirements. The solenoid would likely be able to actuate in time but not with enough force. Additionally, a solenoid that could meet the performance requirements would be too large and costly to produce.



https://socratic.org/questions/if-current-passes-through-a-solenoid-will-two-consecutive-loops-move-towards-or-

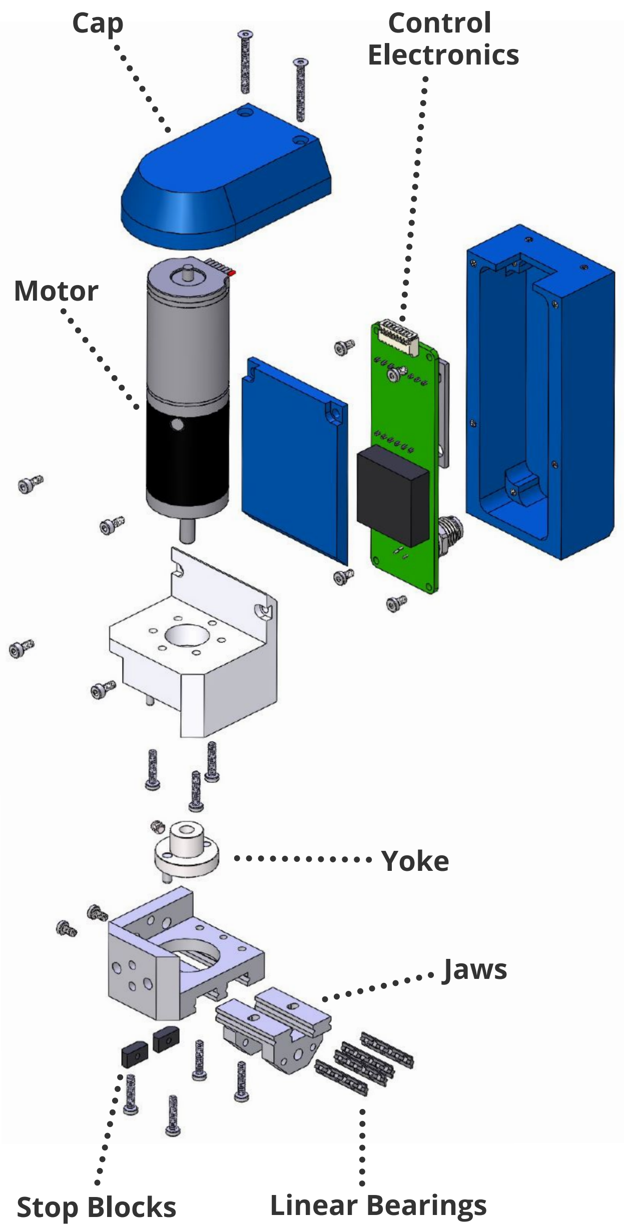
"Fidget Spinner": This functions as a cam following system. While this design is original, it is a complicated process to calculate and determine force outputs as well as to fabricate. Its complex geometry also causes losses that are not inherent in other designs.



SOLUTION

The EASY-20 (Electrically Actuated Scotch Yoke) utilizes a scotch yoke mechanism to create its gripping motion. The circular yoke is fixed to the motor shaft. Two pins, which are pressed into the yoke, actuate the jaws by traveling in slots to convert their circular motion into linear motion. The adjacent figure illustrates all of the components that go into making the EASY-20 gripper. Throughout the design process, the team focused a great deal on reducing the number of critical components to reduce tolerance stacking and simplify the assembly process for project scalability.

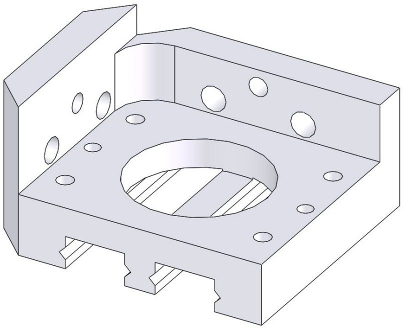
Design Feature	Benefit
Precision mounting holes	Exact locational knowledge of gripping center
Multiple mounting faces	Allows for greater user configuration
Titanium Nitride coated jaws	Reduces part wear and increases gripper lifespan
Replaceable Delrin stop blocks	Reduces wear on expensive jaws Customizable stroke lengths
Exposed motor	Allows motor to self-cool during operation
Optional cap	Further protects PCB enclosure
3D printed components	Reduces manuf. cost and production time



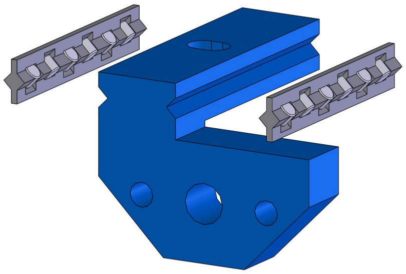
SOLUTION

How does it work mechanically?
Despite this EASY-20's relative simplicity to assemble, the components that make it up must be fairly complex to minimize the number of moving parts and increase the precision of the gripper. Special care was taken into designing each components to be both functional and machinable.

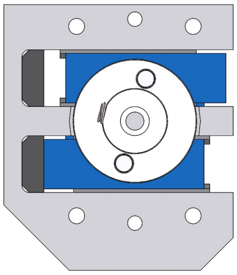
Sectional: This component makes up the "business end" of the gripper. To minimize tolerance stackup, both the mounting features and jaw locating features are designed into this part. V-grooves are machined in to serve as linear bearing rails. This saves a large amount of space that would otherwise be occupied by additional hardware.



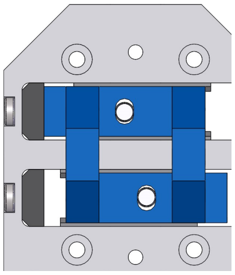
Jaws: The jaws are the parts that actuate linearly to create gripping motion. They also have V-grooves machined in to save space. They are further equipped with precision mounting features for finger extensions. A slot is machined into the top of the jaws to allow the yoke pins to push them along their tracks.



Yoke: The yoke is designed to mount to the flat side of the motor shaft. There is a precision step machined into the center bore to tightly locate it axially. This prevents the yoke from rubbing against other components while minimizing clearance space. The figures to the right show the stacked assembly of the dynamic parts of the gripper.



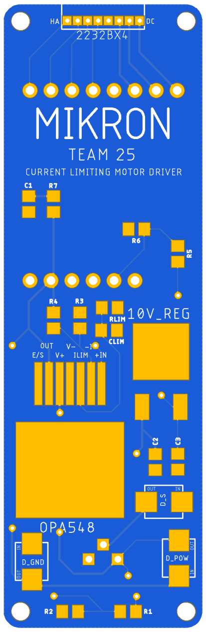
Top View



Bottom View

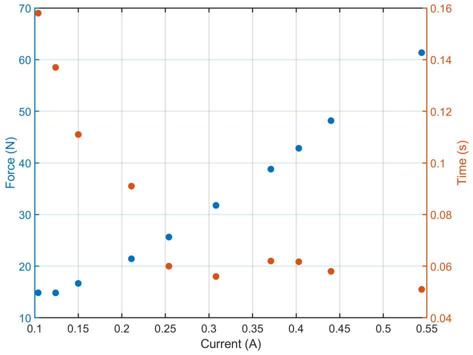
SOLUTION

How does it work electronically?
The EASY-20 is superior to its pneumatic counterparts in part because of its customized output. In the case of the EASY-20, this output is achieved through the use of a current limiting operational amplifier. This way, the output voltage and the maximum output current can be set through various resistor networks. This variable power source circuitry is also completely analog to increase speed.



PCB: All current limiting is done internally with no need for user input. However, more customization is possible with the use of a potentiometer as opposed to discrete resistors. An external power supply is connected with an M8, 3-pin connector (12V, GND, and DIR). The DIR pin determines the direction of clamping. A picoblade connector is utilized to communicate between the motor and the PCB.

Motor: The EASY-20 utilizes the Faulhaber 2232 BX4 DC Brushless Motor. This motor was selected for its robustness and speed when compared to brushed motors and stepper motors, respectively. It is operated in conjunction with a driver, designed to control speed. Yet, the torque can be controlled by limiting the current input to the power supply of the motor.



Scalability: The EASY-20 is designed to grip at 40N but the design is scalable to smaller and larger clamping forces. As can be seen in the figure to the left, the EASY-20 is capable of gripping at anywhere between 25N and 60N in less than 70ms. This can be done by simply changing the resistance utilized to limit the output current.

OPERATION

Flow of Operations

Power Input

The M8, 3-pin connection provides the input voltage, current, and desired direction required to power the EASY-20 for both inwards and outwards gripping.

↓

Control Circuit

The input power gets sent through the electrical control circuit to output a specific voltage and current to the motor which is calculated from the desired gripping strength.

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Motor Output

Based on the input power from the circuit, the motor outputs a specific torque that determines the closing speed and gripping strength.

↓

Mechanical Translation

The scotch yoke mechanism translates rotation from the motor into similar, high-precision linear motion of two parallel jaws.

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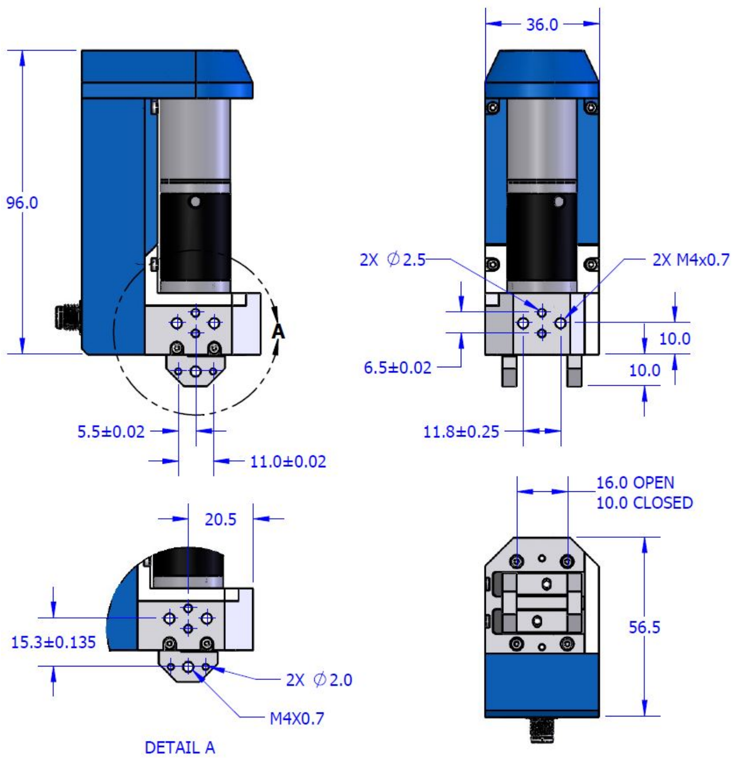
Gripping Strength

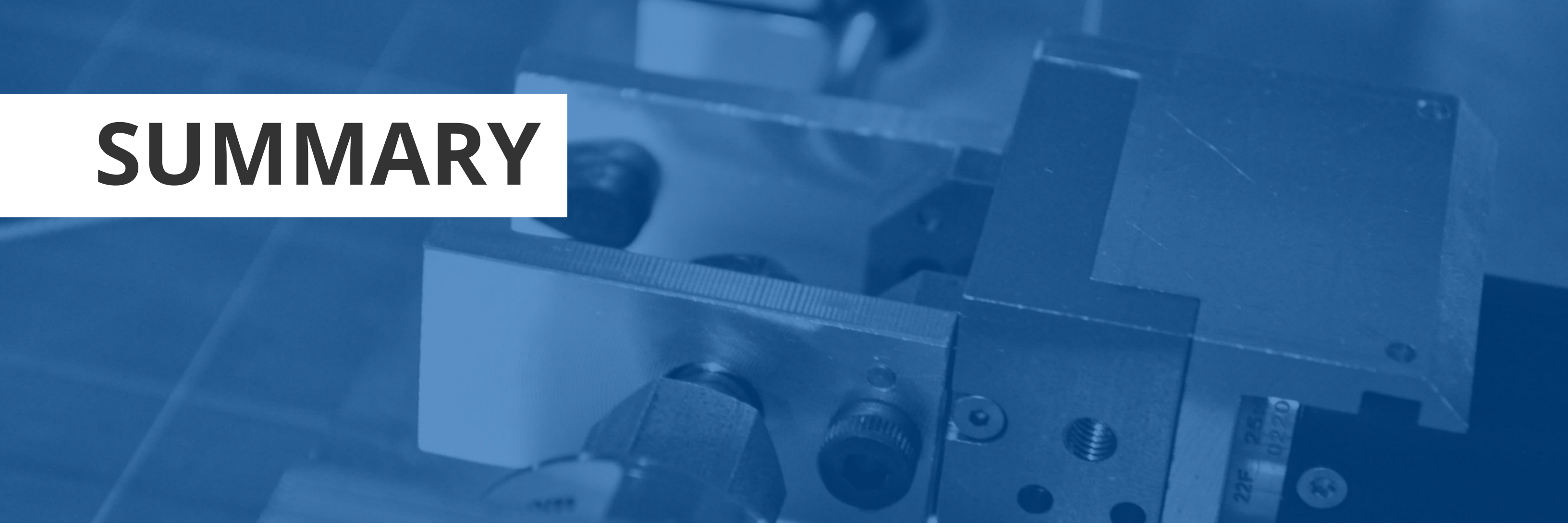
The grip strength slightly fluctuates throughout the stroke, however the two jaws always have balanced gripping strength on the object.

SPECIFICATIONS

The EASY-20 was designed to outperform the best electric grippers and live up to the industry standard for pneumatic grippers. It surpasses the force and speed of electric grippers while keeping the same accuracy of the electric and pneumatic grippers. The figure to the right shows the gripper's scale and precision as well as the call-outs for mounting features. Below is a table listing out the EASY-20's specs as well as specs of comparable grippers.



Specifications	EASY-20	SCHUNK EPG 25-N-N-B	SCHUNK MPG 25
Grip Force (N)	40	20-40	28-31
Closing Time (ms)	60	90	20
Stroke (mm)	3±0.013	3±0.020	3±0.020
Required Inputs	12V, 0.5A	24V, 1A	0.67cm^3 of fluid per stroke
Gripper Mass (kg)	0.3	0.11	0.06
Clean Room Compatible	Yes	Yes	Clean Room Filter Required
Size (mm)	36 x 56.5 x 96	26.5 x 18 x 72.7	26 x 18 x 26



SUMMARY

After a long and busy two semesters Team25 is proud to present the product they have created. From the testing completed thus far, the electrically actuated gripper has been able to meet or surpass the performance requirements set by Mikron for gripping force, closing and opening speed, and stroke repeatability. The EASY-20 also meets Mikron's desire for scalability as its gripping force can be adjusted between 25 and 60 Newtons while keeping the closing/opening speed within its requirement. Though initial tests indicate that the gripper should last a long time in operation, further extensive cycle testing will be required to verify the gripper's lifetime.

An area where the gripper could be improved upon is in its size. Currently, the EASY-20 is larger than the closest comparable Schunk gripper; however, the team believes that with more time to revise the design of the gripper shell, the size could be reduced to dimensions competitive with the Schunk EPG 25-N-N-B. The gripper also has two pinch points located where the jaws hit the stop blocks. To fix this issue the team would have liked to design hard stops into the yoke, away from the user’s fingers to prevent injury.

Looking forward, the team expects that this design can be implemented in many manufacturing lines in the future. Given more testing and a few fixes to the current version, the EASY-20 electric gripper can *easily grasp* a spot among the others grippers used in high-speed manufacturing applications.

MEET THE TEAM

Joaquin Castillo is a graduating senior in Mechanical Engineering. He served as the teams Systems Engineer where he focused mainly on component and subsystem interfaces. He also helped with design work and test planning. His main interests within his major are in design and robotics. He is interested in working in the aerospace industry as well as on humanitarian and environmental projects. This summer he will be working at SpaceX in California as a build engineer where he will be applying skilled learned through his Senior Design experience. He will also be continuing his education in the Mechanical Engineering master's program at Stanford University in Autumn 2020 with a focus in mechatronics.

Nathan Clair is a graduating senior in Mechanical Engineering. He served as the team's Manufacturing Engineer, where he focused his efforts on manufacturability of design for all parts. He also assisted in design work and creating drawings to convey design intent. He is interested in product design and manufacturing and enjoys applications of mechanics and dynamics in projects and everyday life. Nathan is interested in the manufacturing and cycling industries, where his academic and personal passions can meld together. In August 2020, he will start work at Hirsh Precision Products as a Product and Process Engineer, where he is excited about growing his experience in manufacturing and DFM.

Jamie Frankel is a graduating senior who is also pursuing her master's in Mechanical Engineering focusing on product design and entrepreneurship. She was the CAD Engineer for the team and helped design the gripper as well as created the models in both SolidWorks and Inventor. Jamie applied her experience with GD&T to create drawings for mass manufacturing. This position allowed her to delve further into her passions for CAD and thorough design as well as manufacturing. She will continue at Ball Aerospace as an Associate Thermal Engineer designing multi-layer insulation blankets for spacecraft focusing on cryogenic applications.

Jackson Hootman is a graduating senior in Mechanical Engineering. He served as the team's Test Engineer, in which he developed project goals and specifications, designed testing procedures, and conducted thorough analysis of the EASY-20's performance. This role complimented his interests in mechatronics and data analysis. Jackson also served as the lead Electrical Engineer on the team, conducting electrical analysis and designing the PCB. He is interested in a career in product design and/or entrepreneurship. In Fall of 2020, Jackson will be returning to CU Boulder to pursue a master's degree in Mechanical Engineering but is still seeking part-time employment.

MEET THE TEAM

Alexander Savage is a graduating senior in Mechanical Engineering. He served as the Financial Manager and focused on the financial aspects of the project as a whole, but also on the electro-mechanical systems integration and thermal properties of the electrical system. His main interests within his major are analytics, thermal design, and system integration. He is currently looking for a job that makes a positive impact on the world and a place where he feels like he is helping to make a positive change in the industry he works in.

Nate Wang is senior in Mechanical Engineering and will be graduating in the Winter of 2020. Nate worked as the Logistics Manager on the team and also helped with designing and manufacturing. As part of the Naval Reserve Officers Training Corps program at CU Boulder, Nate will commission into the United States Navy upon graduation. With intentions of making a career out of Military Service, Nate hopes to utilize his engineering degree after the military in defense contracting.

Joseph Wilson is a graduating senior in Mechanical Engineering with a minor in Energy Engineering. He is also pursuing a master's in Mechanical Engineering and is the student lead for his thesis project conducting a CFD analysis of a Negative Pressure Isolation Ward for COVID-19 patients. His role on the team was Project Manager, responsible for scheduling and coordinating all subsets of the project. He is interested in pursuing a career in the development of renewable energy systems, ideally utilizing his knowledge of CFD.

Team 25 would also like to acknowledge and thank the following people for their incredible help

Dr. Derek Reamon - Dr. Julie Steinbrenner - Dr. Daria Kotys-Schwartz - Gabe Rodriguez - Danny Straub - Sean Sundberg - Greg Potts - Chase Logsdon - Shirley Chessman - Victoria Lanaghan - Mo Woods - Trevor Roberts - Vincent Maeder - Vincent Mettraux - Trent Noonan - Brock Derby - Austin Nicholson - Collin Rudnitski - Jeramie Chlumski - Steve Knabe - Molly the dog - and Ace the dog