Jurnal Asiimetrik: Jurnal Ilmiah Rekayasa Dan Inovasi
Terakreditasi "**Peringkat 3"** berdasarkan SK Dirjendiktiristek, Nomor: 225/E/KPT/2022
Volume 6 Nomor 2 Tahun 2024, Juli 2024, Halaman 187-194
Website : http://journal.univpancasila.ac.id/index.php/asiimetrik/

p-ISSN 2655-1861
e-ISSN 2716-2923

Experimental and Numerical Testing of Jaw Gripper Design Using the Mass Reduction Method of Onyx-Carbon Fiber Material at PT. Matahari Megah

Pengujian Eksperimental dan Numerik Desain Jaw Gripper dengan Metode Pengurangan Massa Material Onyx Carbon Fiber di PT. Matahari Megah

Yudha Santoso[1]*, Agus Halim[1,2], Didi Widya Utama[1], Kevin Raynaldo[2]
[1]Mechanical Engineering, Universitas Tarumanagara, Jakarta, 11440, Indonesia
[2]PT. Matahari Megah, Jalan Raya Serang km 8,5 Kadu Jaya, Kec. Curug, Kabupaten Tangerang, Banten, 15810, Indonesia

Article information:

Received:
14/01/2024
Revised:
15/02/2024
Accepted:
27/02/2024

Abstract

A robot arm is a robot component in the motion subsystem of a robot system to determine the position and orient the object so that the robot can perform certain tasks, such as picking and placing an object. To use it as a pick and place, a gripper shaped like a human finger, commonly called a jaw gripper, is required, which is used to hold, tighten, hold, and release an object. The shape of the jaw gripper is designed and made according to the shape of the workpiece to be grasped, which was created by PT Matahari Megah using the 3D-printing method for its customer. The jaw gripper that has been designed still needs to be developed to produce a more optimal jaw gripper design, such as by reducing the use of excessive filament without reducing quality and minimizing costs incurred. Therefore, a more optimized jaw gripper test tool was made with a material reduction method using the generative design process in Inventor software, and physical testing was carried out on the ability to grip and deflection, compared to the testing process using a test system that had been designed with a dial gauge measuring instrument. The results of the comparison between the Inventor software results and the simulation results do not exceed 10%, with the difference at a pressure of 2 bars of 7% and the difference at a pressure of 4.6/5 bars of 1.87%.

Keywords: jaw gripper, optimal, testing system, deflection.

***SDGs*:**

Abstrak

Lengan robot adalah komponen robot pada subsistem gerak dari sebuah sistem robot untuk menentukan posisi dan mengorientasikan objek sehingga robot dapat melakukan tugas tertentu seperti mengambil dan menempatkan suatu objek. Untuk menggunakannya sebagai pick and place, diperlukan sebuah gripper yang berbentuk seperti jari manusia atau biasa disebut dengan Jaw gripper, yang digunakan untuk memegang, mengencangkan, menahan, dan melepaskan sebuah objek. Bentuk dari Jaw gripper didesain dan dibuat sesuai dengan bentuk benda kerja yang akan digenggam, yang dibuat oleh PT Matahari Megah dengan menggunakan metode 3D-printing untuk pelanggannya. Jaw gripper yang telah dirancang masih perlu dikembangkan untuk menghasilkan desain Jaw gripper yang lebih optimal seperti mengurangi penggunaan filamen yang berlebihan tanpa mengurangi kualitas dan meminimalisir biaya yang dikeluarkan. Oleh karena itu, dibuatlah alat uji Jaw gripper yang lebih optimal dengan metode pengurangan massa material menggunakan proses generative design pada software Inventor dan dilakukan pengujian fisik terhadap kemampuan mencengkeram dan defleksi serta dibandingkan dengan proses pengujian menggunakan sistem uji yang telah dirancang dengan alat ukur dial gauge. Hasil perbandingan antara hasil software Inventor dengan hasil simulasi tidak melebihi 10% dengan selisih pada tekanan 2 bar sebesar 7% dan selisih pada tekanan 4.6/5 bar sebesar 1.87%.

Kata Kunci: *jaw gripper*, optimal, sistem pengujian, defleksi.

*Correspondence Author
email : yudha.515200022@stu.untar.ac.id

1. INTRODUCTION

The development of technology is advancing over time, in the industrial world the production process almost uses an automation process to create a product quickly to overcome the increasing product needs and minimize the occurrence of errors. One of these technologies is robots (Pedersen *et al.*, 2016).

A robot is a mechanical device designed to facilitate human work in carrying out certain tasks such as carrying out heavy tasks or daily tasks and working tirelessly (Satria and Wati, 2019). Robots are now increasingly popular, not only in industry but also in education, health and many other fields (Jabbar and Yasdar, 2022). One of the commonly used robots is the robot arm.

A robot arm or what can be called a robot manipulator is a robot component of the motion subsystem of the robot system to determine the position, orient the object so that the robot can perform certain tasks as desired and can perform repetitive movements (Hassan and Baqar, 2015). Examples of using a robot arm include welding and to pick and place objects (Singh, Kumar and Vashisth, 2013). To use it as a pick and place object, a gripper is needed. Gripper is an end-effector of a robot arm (Rahmawan, Munadi and Prahasto, 2013). A gripper usually requires fingers or what is commonly called a Jaw gripper. Jaw gripper is a tool shaped like the fingers of a human hand that is used to hold, tighten, handle and release objects (Romano *et al.*, 2011). The importance of deflection testing on the jaw gripper is to determine the flexibility/strength of the jaw gripper when experiencing a load (Basori, Syafrizal and Suharwanto, 2015). This analysis is carried out to find out whether the jaw gripper with this mass reduction method can produce jaw gripper deflection strength on the existing jaw gripper.

The purpose of this research is to conduct physical testing of the Jaw gripper that has been optimized from its initial form by reducing the use of excessive filament in the initial design and comparing the deflection results that occur in the Jaw gripper with the simulation results. The shape of the Jaw gripper is designed and made to fit the shape of the workpiece to be gripped, the shape of the Jaw gripper is made by PT Matahari Megah using the 3D-printing manufacturing method for its customer at the OP 30 input station on the input and output gear shaft assembly automatic machine (see Figure 1). This machine is an automated system used to assemble gear pad shafts to produce an input shaft as part of a car gearbox.

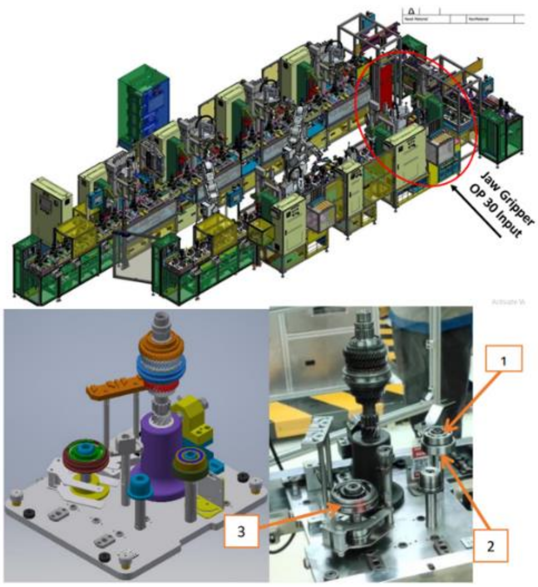


Figure 1. The OP 30 input station on the input and output gear shaft assembly automatic machine (Raynaldo *et al.*, 2020).

2. METHODOLOGY

The method used in conducting this research is to resimulate the optimal jaw gripper, print the generative optimization design mold of the optimized jaw gripper shape and test the deflection that occurs in the mold (Suhandar, Halim and Raynaldo, 2023). The jaw gripper has been optimized by the author before, Suhandar et al. (Suhandar, Halim and Raynaldo, 2023). Optimization of the jaw gripper is done by mass reduction and using the stress strength interpolation method of the existing jaw gripper with the optimized jaw gripper. The results of the stress strength simulation on the optimized jaw gripper are almost close to the results of the stress strength on the existing jaw gripper, so it can be concluded that the designed jaw gripper can be interpreted as having almost, the same capabilities as the existing jaw gripper at a cheaper manufacturing cost. Furthermore, a re-simulation is carried out on the optimal jaw gripper with different forces used, to compare the difference in deflection in each given force. Then the optimized jaw gripper is manufactured using the Markforged Mark Two 3D-printing method at PT Matahari Megah with Onyx-Carbon fiber material for deflection testing. This deflection test uses a dial gauge that has been designed and compares the test results with the simulation results.

This research uses a method by means of physical testing on the Jaw gripper that has been optimized. The system used in the physical testing of the Jaw gripper uses aluminum profiles as its basic component. This testing system is designed for the Jaw gripper testing site where the Jaw gripper is placed on this testing system with the help of the Schunk PGN - PLUS - 64 - 1 gripper with pneumatic assistance to make it easier to analyze the deflection that occurs when the Jaw gripper is used. The Jaw gripper testing system can be seen in Figure 2.

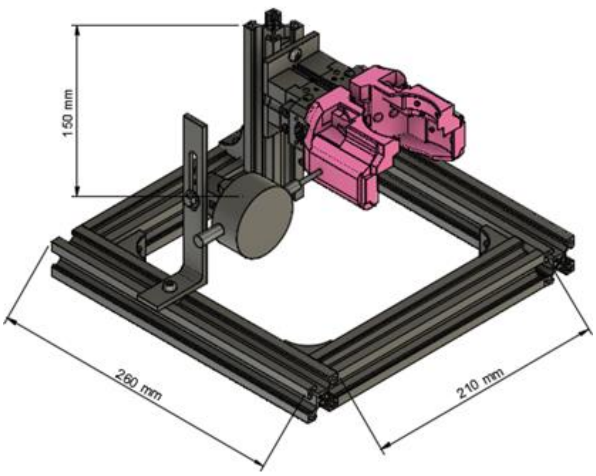


Figure 2. Deflection testing system of jaw gripper.

2.1. Operating Air Pressure Testing

The gripper analysis was carried out using the Schunk PGN-Plus-50-1-AS gripper (Schunk, 2023a) and for experimental testing using the Schunk PGN-Plus-64-1 gripper (Schunk, 2023b). Therefore, an analysis of the calculation of the test operating pressure was carried out to find out how much air pressure was needed at the time of testing the jaw gripper to grip the workpiece.

Experimental gripper operating pressure formula:

$$\begin{aligned}&\textit{Experimental Gripper}\ \mathrm{Max}\ \textit{Operating Pressure}\\&\times \textit{Experimental Gripper Closing Force}\\&= \textit{Simulated Gripper Max Operating Pressure}\\&\times \textit{Simulated Gripper Closing Force}\end{aligned} \quad (1)$$

Where, Experimental gripper closing force = 250 N; Simulated gripper max operating pressure = 6.5 bar; Simulated gripper closing force = 180 N.

3. RESULTS AND DISCUSSION

3.1. The Formula for Finding Experimental Operating Pressure

The maximum experimental operating pressure calculation results showed a pressure of 4.68 bar, which is equivalent to 180 N during simulation in Inventor software.

$$\textit{Experimental Gripper Max Operating Pressure} \times 250\ N = 6.5\ bar\ x\ 180\ N$$
$$\textit{Experimental Gripper Max Operating Pressure} = 4.68\ bar$$

This pressure was used as the maximum pressure used during the experimental deflection testing.

3.2. Design and Simulation of Jaw Gripper Using Generative Design Method

The design mass reduction is done with the generative design algorithm process in Inventor software. The results of this optimization process have been carried out and the results can be seen in Table 1.

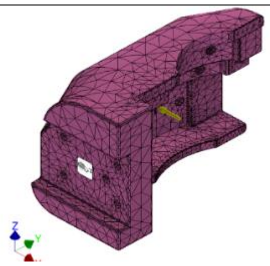
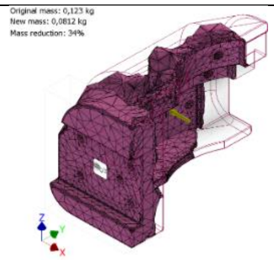
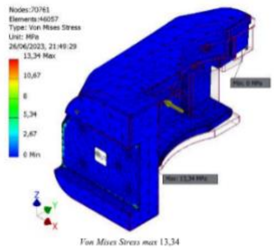
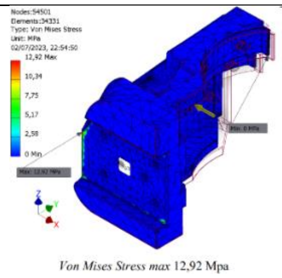
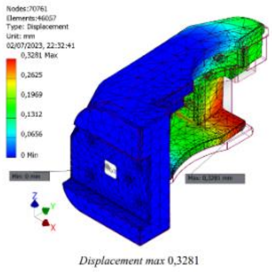
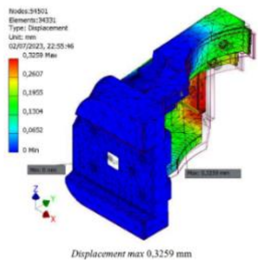
3.3. Deflection Simulation Results on The Optimized Jaw Gripper

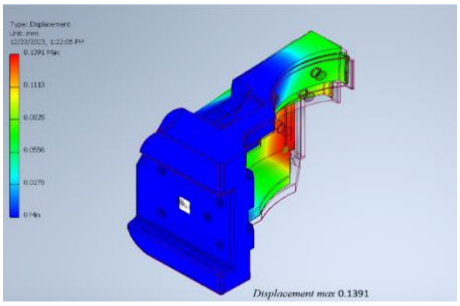
The results of the deflection simulations that have been carried out with various forces given in the simulation can be seen in Figure 3.

3.4. Optimized Jaw Gripper Manufacturing

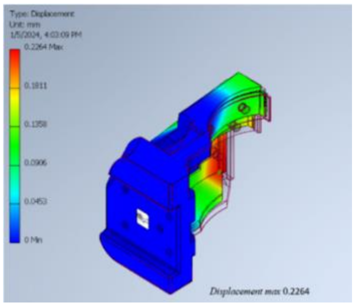
The manufacturing process uses Eiger.io software. Eiger.io is a website used to make settings for producing 3D printing mark two products (Markforged, 2024). The material used in making this Jaw gripper mold uses Onyx with Carbon Fiber reinforcement. The following is a picture of the settings used in making the Jaw gripper mold, shown in Figure 4.

Table 1. Comparison between existing jaw gripper (Hendito, Halim and Siahan, 2023; Suhandar, Halim and Raynaldo, 2023) and jaw gripper optimization results.

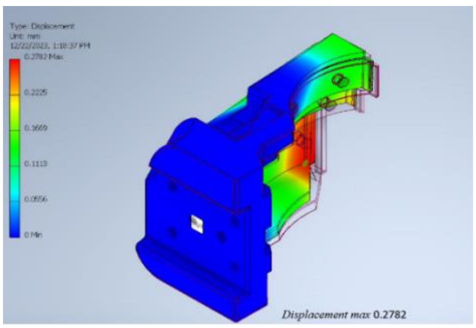
	Existing *Jaw gripper*	New Jaw Gripper with 34% Mass Reduction
Messing Mass		
Von mises stress		
Displacemnet		



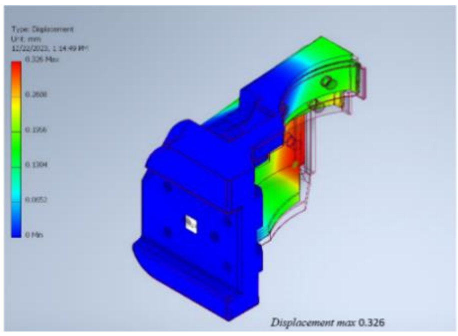
(a) Deflection with a force of 76.8 N (2 bar)



(b) Deflection with a force of 115. 2 N (3 bar)



(c) Deflection with a force of 153.6 N (4 bar)



(d) Deflection with a force of 180 N (4.6/5 bar)

Figure 3. Deflection simulation results on the optimized jaw gripper.

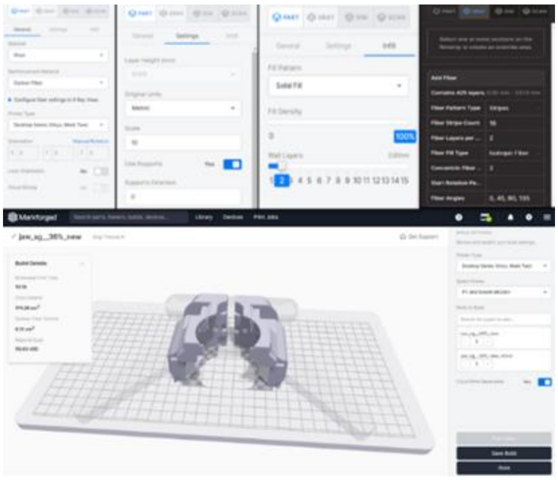


Figure 4. Jaw gripper settings on Eiger.io.

The following is an image of the printing process using Markforged mark two 3d printing at PT Matahari Megah in Figure 5. The following is a 3D printed image of a pair of jaw gripper using 3D printing, shown in Figure 6.

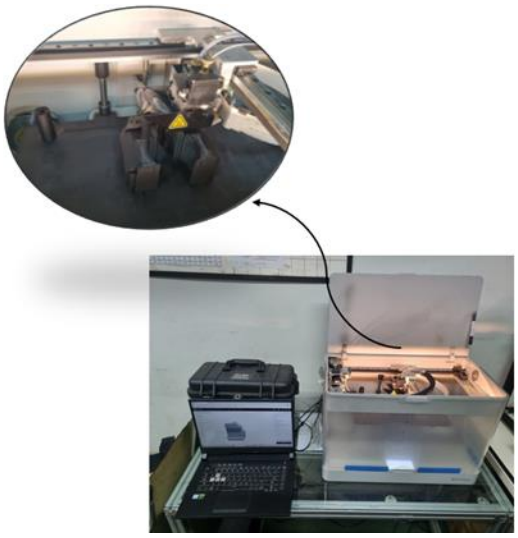


Figure 5. Jaw gripper printing process that has been optimized.

Figure 6. Printout of a pair of jaw grippers.

3.5. Jaw Gripper Deflection Test System Assembly

The jaw gripper deflection test system assembly uses aluminum profile components as the main component. This test system utilizes a dial gauge to determine the deformation of the Jaw gripper. This system is used as a place to put the Jaw gripper during testing so that when the Jaw gripper is tested there is no shift/displacement of the Jaw gripper or dial gauge. The following is a picture of the testing system for deflection testing on the Jaw gripper, shown in Figure 7.

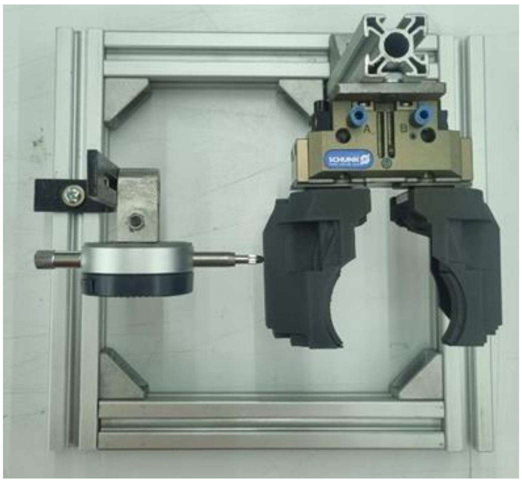


Figure 7. Jaw gripper deflection test system assembly.

3.6. Deflection Testing of Jaw Gripper

Deflection testing is carried out with a test system that has been assembled using pneumatic assistance by measuring the deflection that occurs at the point that experiences the largest deflection with the pressure difference used in the test. The following picture of the test points can be seen in Figure 8.

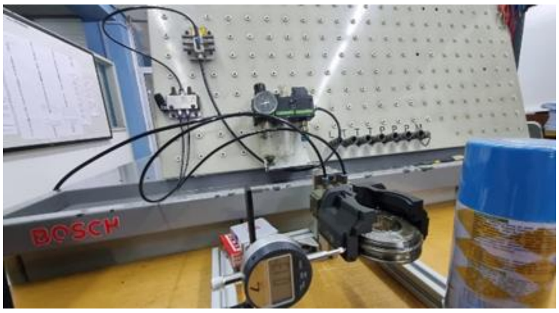


Figure 8. Deflection testing of jaw gripper.

3.7. Test Result

The following test results that have been carried out can be seen in Table 2 and the difference chart can be seen in Figure 9.

Table 2. Deflection test results

No	Pressure (bar)	Deflection Test result (mm)	Simulation Result (mm)	Difference in results (%)
1	2	0.13	0.1391	7 %
2	3	0.24	0.2264	5.6 %
3	4	0.29	0.2782	4.06%
4	4.6 / 5	0.32	0.326	1.87 %

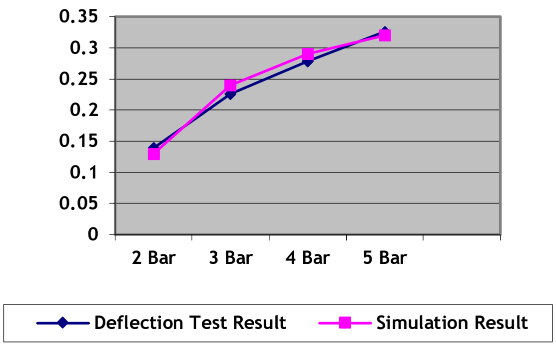


Figure 9. Experimental test result and simulation result chart

3.8. Description Testing Results

Deflection testing is the process of measuring or evaluating the deformation of a structure /object caused by a given load. This deflection test uses a dial gauge as a tool to detect the amount of deflection generated due to the jaw gripper gripping process against the workpiece, namely gear op 30 and uses the help of a compressor that is used to drain the fluid with the help of an air service unit tool used to regulate air pressure (Maskatim and Baidlowi, 2022).

The minimum air pressure used is 1 bar, which is the starting point/point 0 of the measurement. The pressure was then increased to 2 bar, 3 bar, 4 bar and 4.6/5 bar as the maximum pressure used. The location used to measure the deflection was divided into 1 point. The point used was the farthest point from the schunk gripper. The selection of this location/point was chosen because in the simulation process the furthest point experienced the greatest deflection.

The results of deflection testing at the farthest point and the largest pressure used, obtained the number listed on the dial gauge is 0.32 and the simulation results that have been carried out are 0.326. The percentage difference between the simulation results and the test results is 1.87% and is considered close to / experiencing deflection.

From the results of this test, it is found that the amount of pressure used in the test affects the amount of deflection that occurs. The greater the pressure applied, the greater the deflection produced in the jaw gripper. This test is also carried out by visual observation and each measurement produced will change with a difference that is not too much different. In this test, a valve is used as a regulator of fluid opening and closing. The time used in this gripping test is done in fractions of a second, which means the time needed is very fast in pressing the valve. Time also affects the deflection results obtained in this test.

4. CONCLUSION

Deflection testing is the process of measuring or evaluating the deformation of a structure/object caused by a given load. This test uses a dial gauge as a tool to measure the amount of deflection produced by gripping the workpiece. The deflection testing system is made to measure the deflection of the jaw gripper so that during the test the measuring instrument and jaw gripper do not experience movement. This testing system uses aluminum profiles as the main component so that other components can be supported and the results obtained can be accurate.

The jaw gripper used in this deflection test is a jaw gripper that has been redesigned using the mass reduction method performed in Inventor software. This design is made so that the jaw gripper is cheaper than before mass reduction and the quality is expected to be the same / close to the previous design. The quality of the design will be the same, when the test results produced are the same as the simulation results.

In this deflection test, varying results were obtained for deflection testing at the largest point with a pressure value of 1 bar, the deflection simulation result was 0.06955 mm, and the experimental result was 0 mm; at a pressure of 2 bar, the deflection simulation result was 0.1391 mm, and the experimental result was 0. 1391 mm and the experimental result is 0. 13 mm; at pressure 3 bar, the simulated deflection result is 0.2086 mm, and the experimental result is 0.24 mm; at pressure 4 bar, the simulated deflection result is 0.2782 mm and the experimental result is 0.29 mm; at pressure 4.6 bar/5 bar, the simulated deflection result is 0.326 mm and the experimental result is 0.32 mm.

ACKNOWLEDGMENTS

The authors would like to thank PT Matahari Megah and the pneumatics and hydraulics laboratory for helping to facilitate component tools and places for data collection.

REFERENCES

Basori, Syafrizal and Suharwanto (2015) 'Analisis Defleksi Batang Lentur Menggunakan Tumpuan Jepit dan Rolpada Material Aluminium 6063 Profil U dengan Beban Terdistribusi', *Jurnal Konversi Energi dan Manufaktur*, 2(1), pp. 50–58.

Hassan, M. and Baqar, M. (2015) 'Design and Implementation of a DTMF Based Pick and Place Robotic Arm', *Asian Journal of Engineering, Sciences & Technology*, 5(1), pp. 8-12.

Hendito, M., Halim, A. and Siahan, E. (2023) 'Physical Characterization of Onyx-Carbon Fiber Reinforced Material using Taguchi Method', *International Journal of Innovative Science and Research Technology (IJISRT)*, 8(6), pp. 3322–3326.

Jabbar, A.A. and Yasdar, Y. (2022) 'Sistem Kendali Gripper Adaptif Pada Robot Transporter', *Jurnal Mosfet*, 2(2), pp. 26-31.

Markforged (2024) *About Eiger*, *About Eiger*. Available at: https://support.markforged.com/portal/s/article/Eiger-Deployments (Accessed: 7 May 2024).

Maskatim and Baidlowi, M. (2022) 'Kendali Pneumatic Pada Gripper Robot', *Jurnal Elektrosista*, 10(1), pp. 61–74.

Pedersen, M.R. *et al.* (2016) 'Robot skills for manufacturing: From concept to industrial deployment', *Robotics and Computer-Integrated Manufacturing*, 37, pp. 282–291.

Rahmawan, A., Munadi, M. and Prahasto, T. (2013) 'Optimasi Gripper Dua Lengan dengan Menggunakan Metode Genetic Algorithm pada Simulator Arm Robot 5 DOF (Degree of Freedom)', *Jurnal Teknik Mesin*, 1(2), pp. 9–16.

Raynaldo, K. *et al.* (2020) 'Automation Systems In Automatic Assembling Gear Shaft Output As Car Gearbox Part At PT. Matahari Megah', in *IOP Conference Series: Materials Science and Engineering. 3rd Tarumanagara International Conference of the Applications of Technology and Engineering (TICATE)*, Jakarta, Indonesia: Universitas Tarumanagara, p. 012050.

Romano, J.M. *et al.* (2011) 'Human-Inspired Robotic Grasp Control With Tactile Sensing', *IEEE Transactions on Robotics*, 27(6), pp. 1067–1079.

Satria, D. and Wati, L. (2019) 'Prototype Robot Lengan Pemindah Barang Dengan Kendali Lengan Manusia Berbasis Arduino Uno', *Jurnal Ilmu Komputer dan Bisnis*, 10(1), pp. 2126–2134.

Schunk (2023a) *PGN 50-1*, *Gripping System*. Available at: https://schunk.com/in/en/gripping-systems/parallel-gripper/pgn/pgn-50-1/p/000000000000370099 (Accessed: 5 January 2024).

Schunk (2023b) *PGN 64-1*, *Gripping System*. Available at: https://schunk.com/in/en/gripping-systems/parallel-gripper/pgn/pgn-64-1/p/000000000000370100 (Accessed: 4 January 2024).

Singh, P., Kumar, A. and Vashisth, M. (2013) 'Design of a Robotic Arm with Gripper & End Effector for Spot Welding', *Universal Journal of Mechanical Engineering*, 1(3), pp. 92-97.

Suhandar, G.A., Halim, A. and Raynaldo, K. (2023) 'Optimasi Dan Analisis Desain Jaw Gripper Menggunakan Filamen Onyx Di PT. Matahari Megah', *Jurnal Serina Sains, Teknik dan Kedokteran*, 1(1), pp. 133–140.