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An Effective Prototype Design and Development of Robotic Gripper

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Abstract: Technology makes many things easier, but it also makes things possible for people with disabilities. The goal of rehabilitation robotics is to provide robotic devices that can behave as functional extensions of the user while completing basic tasks. A rehabilitation robot's performance can be considerably improved by using a well-designed gripper as its end - effector. The gripper performs simple tasks such as picking up and moving objects, which aid with daily living activities. The present study starts with a comparison of methods for lifting and grasping to subsequently determine which approach is most appropriate for the pick and placement of the various components. A pre-study is prepared, along with a brief overview of the various transit networks. The most appropriate idea for future development and ultimate building is chosen after the pre-study concepts are created. In the robot cell simulation software ABB Robot Studio, the final design of the gripper tool is utilised to choose a suitable cell design. The gripper tool is made out of lightweight aluminium alloy and utilises electromagnet to pick up and remove the various staple components. ABB IRB 7600, with a handling capability of 150 kg and a 3.5m range, is used to construct the grab tool.

Keywords: ABB Robot Studio, Distanzring, robotic grippers,

I. INTRODUCTION

One of the most effective tools for improved, contemporary, and safer automation are industrial robots. Today's industrial sectors have extremely high requirements. Humans were initially intended to be supplemented or replaced with robots to do dreary, filthy, or hazardous tasks. Their uses include: automated manufacturing lines, detecting radiation zones, minimally evasive surgery, and study of the solar system in space. The modern industrial robotic arms outperform humans in a wide range of applications. Each one can lift 1,000 pounds [1], is reproducible to 10 micrometres [2], and can accelerate up to 15 g [3]. In addition, the cost of robotic grippers is falling, whereas the cost of manual labour is rising. As a result, industry and academia have developed increasingly complex robotic arms and grippers that can manage both form closure and force closure [1], two of the most important components of any robotic grasper. It is robotic grippers' job to interact with the environment and grasp things such as human hands for manipulation by humans [2]. As a result, [4] focuses on parallel manipulators gripper mechanisms. Grippers for use in surgery may be found in [5]. Only dual arm manipulation was discussed in [6]. Space robots were discussed in [7]. Robots used in manufacturing plants were examined in [8]. There was just a focus on the contact methods of micro components in [9]. Control methods for end effectors are described in [10].

This work, we hope, assists researchers and industry uncovers fresh grabbing mechanisms, their improvements, as well as the problems connected with these mechanisms. A discussion of the problems and potential directions in this subject concludes our discussion of our work in this area. This involves soft textiles, micro electro mechanical systems (MEMS) and synthetic sheets. Grippers are being developed utilising a variety of materials. The list includes piezoelectric crystals; shape memory alloys (SMAs), magneto rheological fluids (MR), and many others. The use of bio-inspired gripping mechanisms has also been explored in recent study, which uses nature to produce products that tackle challenges that are more industrial in nature.

This paper describes the design of a gripper to use in a robotic system. Metal parts are picked and placed by the robot. The components vary in shape and size. The robot's mission is to pick up various pieces from the laser cutter and carry them to various cells. A theoretical comparison of several picking and lifting techniques are made in order to select the optimal technique.

The major goal of this thesis is to recommend a suitable gripper for choosing and develop the gripper in the 3D-CAD programme Solid Works and use the designed gripper in the robot cell-simulation programme ABB Robot studio. The goal of utilising ABB Robot Studio is to understand how the gripper works in real life because the robot functions as they are programmed in the cell-simulated programme.

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II. CAD MODELLING

This paper provides a description of several concepts with various designs. An explanation of how the ideas are intended to operate, as well as their benefits and drawbacks, will be provided. Solid Works, 3D CAD software, was used to create the ideas. The electromagnets used in the ideas are manufactured by Svenska Magnet Fabriken. The tiny electromagnets have an outer diameter of 32 mm and can lift 250 N. The huge electromagnets have an outer diameter of 50 mm and can take up 700 N.

CONCEPT 1

Four electromagnets are used in Concept 1, as shown in figure 1. There are two big magnets and two little magnets. The electromagnets at the gripper's centre are the smaller ones, while the magnets at the far end are the bigger ones. The Flans portion will be picked up by the big magnets, while the Inner ring and Distanzring will be picked up by the tiny magnets. When the big magnets are turned on, the tiny magnets are turned off. When the smaller magnet selects, the bigger magnets are disabled. All four magnets will take up the remaining components, Hjulbana and Magnetplt. In the event of a power outage, the electromagnets will have a battery backup for further security.

Figure 1 CAD design of robotic gripper using concept 1

CONCEPT 2

Figure 2 describes concept 2. It uses eight electromagnets to make up the device. Six large magnets and two little magnets are included in the set. When it comes to electromagnet size, those placed in tool's centre are modest, while those located in its outermost wingtips are quite powerful. Unlike the small magnets, the Flans component will be attracted to the big magnets. The tiny magnets will also choose the Inner ring and Distanzring when the bigger magnets are off. To raise Hjulbana and Magnetplt, the centre magnets will use a combination of tiny and big magnets, while the electromagnets on both wings will be disabled. Batteries will safeguard the electromagnets if there is a power outage, adding an extra layer of protection.

Figure 2 CAD design of robotic gripper using concept 2

CONCEPT 3

Eight electromagnets are used in Concept 3. There are four big magnets and four tiny magnets in all, as shown in figure 3. The electromagnets at the centre of the idea are the smallest, while the electromagnets at the far end are the largest. The bigger magnets will attract the component Flans, while the smaller magnets will remain inactive. While the big magnets are deactivated, the tiny magnets will select Inner ring and Distanzring. The remaining components, Hjulbana and Magnetplt, will be scooped up by two tiny and two big magnets that are connected, and the electromagnets that do not make contact with the object while being raised will be deactivated. In the event of a power outage, the electromagnets will have a battery backup for further security.

Figure 3 CAD design of robotic gripper using concept 3

CONCEPT 4

Four electromagnets are used in Concept 4. The magnets in this idea work in the same way as the magnets in concept 1. The electromagnets in this idea do not need battery backup. The “fingers” as shown in figure 4, are what distinguishes this idea. When the robot is lowered, the fingers will rise to grasp the objects on the laser cutting table. When they are grasped and the robot raises the object slightly above the laser cutting table, the gripper's "fingers" will shut. In the event of a power outage, the fingers will capture the objects.

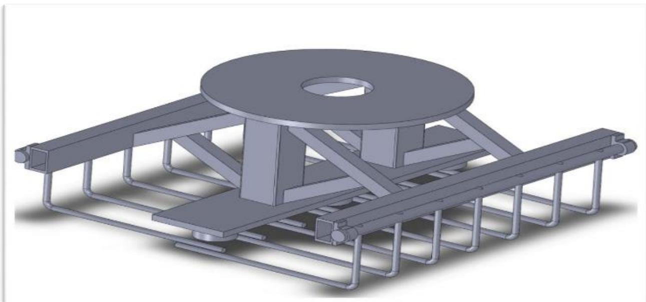

Figure 4 CAD design of robotic gripper using concept 4

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The product will be placed on an industrial robot. The product must be developed with the robot in mind. Because the industrial robot has not yet been chosen, none of the ideas satisfy the criteria. Later in this thesis, the industrial robot will be chosen, and the design of the gripper tool for installation on the chosen robot will be completed. None of the ideas will be discarded as a result of this criterion since the concept chosen later in this thesis will be developed with the industrial robot in mind.

A comparison among all the design concepts are described in table 1. It differentiates all the design on the basis of stability, design, weight, power failure criteria. The third concept earned the greatest score. In contrast, concept two is unstable while lifting things such as Distanzring, therefore concept three gets a higher grade. Simple and light, idea one is a winner, but some components, like Distanzring and Flans, come into contact with each other. Four-point contact is more stable than a two-point contact because these components are hefty and big. When handling large and heavy components, the third design generates four points of contact. Concept three is neither excessively complicated nor overly heavy. Consequently, concept three will be developed and built upon further in the next weeks.

Table 1 Comparison and rating among different design concepts.

Concept	Stability	Design	Weight	Power failure	Total points
Concept 1 	2 Too little contact between some parts	9 Simplest design	9 Lightest weight	10 Battery backup, secure all the way	**30**
Concept 2 	5 Stable for some parts, not stable for all the parts	8 Not complicated design	8 Heavier than concept1	10 Battery backup, secure all the way	**31**
Concept 3 	9 Stable for all the parts, 4point contacts for almost every part	8 Not complicated design	7 Heavierthanconcept2	10 Battery backup, secure all the way	**34**
Concept 4 	2 As concept1	1 Most complicated design	3 Heaviest one	4 Fingers for catching the parts in case of power failure, don't secure all the way	**10**

III. RESULTS AND DISCUSSION

The gripper tool's final assembly

For future development and construction, the third option can be selected, as previously indicated. This section describe in depth design concept and economic analysis. The gripper tool final assembly is shown in figure 5.

It's easy to use, as illustrated in Figure 5, because the gripper tool isn't overly complicated in design. Eight electromagnets are used in this gripper tool. A round part of the gripper tool's back connects to an industrial robot through electromagnets that are firmly fitted into square aluminium tubes. Aluminium tubes will be welded together, and round aluminium tubes will be connected to the square aluminium tubes when welding is complete. Screws will attach the gripper to the industrial robot. With the exception

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of the gripper-to-robot connection and a part known as magnethojare, all of the materials and components used in this final design are readily available.

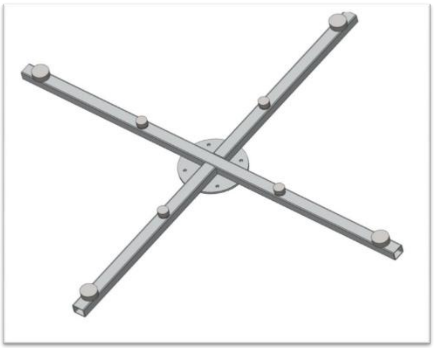

Figure 5 CAD design of assembled robotic gripper.

Gripping various types of components is possible with this gripper tool. Many components have four points of contact with the gripper, however only two points of contact exist between an Inner ring and the gripper. Distanzring can be selected using the four smallest electromagnets in the gripper tool's centre. Hjulbana and Mangetplt components are picked up by two tiny and two large electromagnets placed on an aluminium tube that is long and square in shape inside the gripper tool, two small electromagnets will grab the inner ring. There are several components involved in the gripper tool.

This gripper tool is comprised of 24 components. The components are shown in figure 6 and will be explained in detail in table 2.

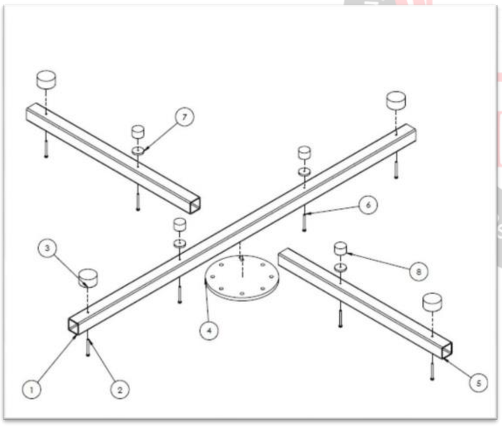

Figure 6 Various components of Gripper tool

Table 2 Designed details of various sub components of robotic gripper

Item No.	Part	Description	Quantity
1	Middle beam(mitten balk)	L=1300,40x40x3 mm	1
2	Hexagon Head Screw	ISO4017-M5x50	4
3	Big magnet (Stormagnet)	Holding force= 700N	4
4	Holder (Hallare)	Link between the robot and the gripper	1
5	Side beam (sidanbalk)	L=630, 40x40x3 mm	2
6	Hexagon Head Screw	ISO4017– M4x50	4
7	Magnet raiser (magnethojare)	D=32 mm, H=5 mm	4
8	Small Magnet (lighten magnet)	Holding force=250N	4

Due to aluminium's superior properties, it is utilised for this end structure. Aluminium is a lightweight and non-magnetic material, which is ideal for this design since the gripper tool's electromagnets might magnetise steel. The gripper tool's low weight is critical since industrial robots are intended to handle a maximum weight. Calculations of the gripper tool's strength were performed using solid mechanics. This calculation was performed to determine if the aluminium and dimensions of the gripper tool could withstand the forces to which they are subjected. The material is AW-EN 6063-T6 aluminium. Table 3 details the material's mechanical characteristics. [11]

Table 3 Mechanical characteristics of AW-EN 6063 T6 material

Ultimate tensile strength	241MPa
Tensile Yield Strength	**214MPa**

When lifting the heaviest component, the gripper tool's centre of torque will be the most important factor in lifting the component. Magnetplt has a maximum torque of 560 Nm, which is a lot of torque. The material has tensile yield strength of 214 MPa and a maximum stress of 136 MPa, suggesting that the shape of the gripper tool and the material being used are sufficient for choosing and placing the different notched components in their proper positions.

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The Finite Element Method, or FEM, was utilised in Solid Works, a 3D CAD application, to determine the strength. In this case, the aim was to establish where the gripper tool was under the most strain. In addition to the Magnetplt, which weighs 70 kg, a calculation was made for Flans, as it has an impact on the electromagnets at the far end. The result of the computation is displayed in Figure 7 on the next page the gripper tool's centre has the most stress, which can be seen in the figure and is represented by circles. Images of Magnetplt and Flans may be seen on each side of this page.

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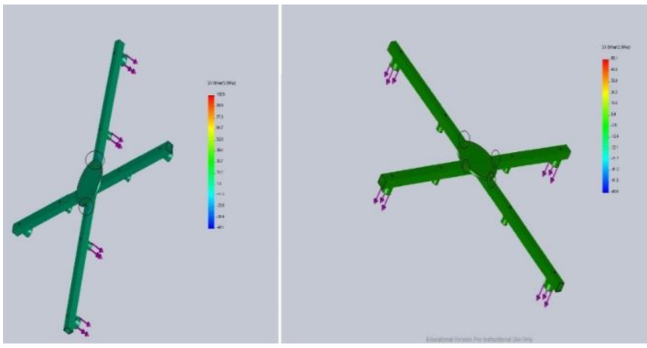

Figure 7 Contours of strength variation of gripper.

The displacement calculation was performed in the same 3D CAD software that was used in the prior instance. Figure 20 shows the outcome of the calculation. The impact is strongest near the end of the gripper tool while lifting Magnetplt, as seen in the picture to the left. When working with Magnetplt, the displacement is approximately 2 mm. The displacement while raising Flans is about 0.8 mm. This little shift has no bearing on the overall angle. A large angle will impact the electromagnets, but it will not be an issue in this instance.

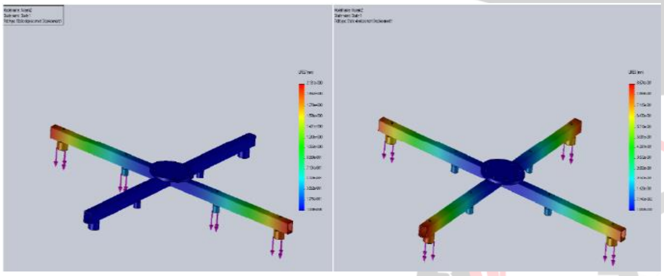

Figure 8 Contours of displacement variation of gripper.

Economic calculation

The total price for the gripper tool are about $10500, the economic calculation can be seen in table 4.

Table 4 Details of design cost of the present gripper

Part	Price	Quantity	Total
ENAW-6063T6	64.14 /m	3 m	192.5
SmallelectromagnetsEMAG32	573per unit	4units	2292
Large ElectromagnetsEMAG50	880per unit	4units	3520
Other material	-	-	500
Cost of work	-	-	4000
Total			10504.5

We tests a gripper tool we were working on, but also to learn more about robotized picking and placement for laser notched components. Description of the system, industrial robot and laser cutter in this paper. Obviously, this structured system does not resemble the planned system; constructing the full intended system takes time, and this thesis does not cover the entire system's growth. This is an important distinction to make. Details regarding the laser cutter and the industrial robot are provided below in this article. Table 5 shows the specifications for the ABB industrial robot.

Table 5 Design specification of industrial robot

Robot version	Reach	Handling capacity	Position repeatability
IRB7600	3.5m	150kg	0.08-0.09mm

Specification for the laser cutter from LVD (not exact measurement) can be seen in figure 9 and table 6.

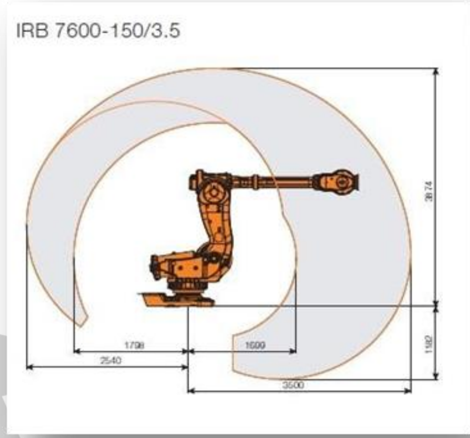

Figure 9 Geometrical Specification for the laser cutter from LVD

Table 6 Laser cutter specification

Length	Height	Wideness
13m	5 m	3 m

Figure 10 LVD laser cutter

A high-level summary of the hierarchical system ABB Robot Studio was used to create the system. Figure 11 depicts two industrial robots in this arrangement. The industrial robot with the gripper tool built is the one selecting and putting the various notched components. The other industrial robot is a large robot that is intended to feed uncut metal sheets into the laser cutter. However, in the thesis, this robot does not do any labour; instead, it only displays the position of the large industrial robot. The pallets indicate numerous stations for the various components. The yellow barriers are there to keep the

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system secure. The experiment began with the system's structure. The initial stage in structuring was to put the elements in the proper locations. There is a global coordinate-system in the Robot Studio. This coordinate system serves as the foundation for everything loaded into the application. This basic coordinate system may be used to coordinate the objects.

The next stage is to educate the robot and the gripper tool how to perform their jobs. This stage begins with the creation of work items and robot targets. The various notched pieces that lay on the laser cutter table are the work items in this system. After the work items have been specified, targets are generated. The targets are coordinate-systems at various locations across the system.

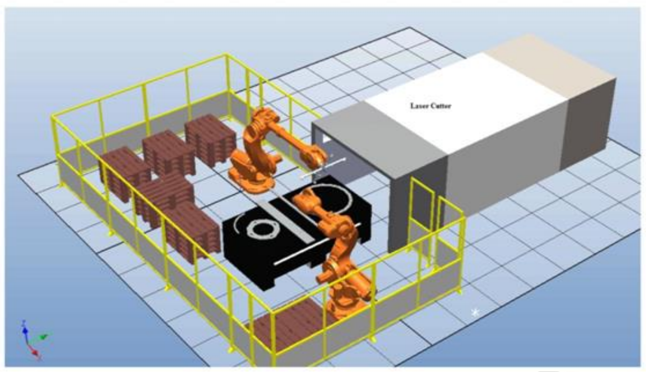

Figure 11 An overview of the structured system

In order to reach the numerous goals that have been set, the industrial robot is programmed.

Structured system summary: The system was developed at the ABB Robot Studio in New York. To illustrate this, consider Figure 11, which displays two industrial robots in this configuration. The notched components are selected and placed by the industrial robot with the gripper tool. Uncut metal sheets are fed into a laser cutter by a huge industrial robot. In the thesis, however, this robot does not do any tasks; in addition, the gripper tool must be taught on what it is supposed to do. As a preliminary step, the industrial robot was equipped with the gripper tool. When the industrial robot is configured to the right position for grabbing the different components, the gripper tool is activated. Signals for attaching and detaching the gripper tool have been created. As illustrated in figure 12, when the gripper tool is appropriately positioned, i.e. above the distanzring. Industrial robot delivers work item to destination station while gripper tool un-attaches work item, Distanzring. Figure 12 shows the entire delivery procedure for Distanzring.

Robot just shows the location of the big industrial robot. Numerous components may be found on the pallets. There are yellow barriers throughout the system to ensure that it is safe and secure for everyone. In the beginning, we looked at the system's structure to get a feel for it. When organising, the first step was to place the pieces in the right places. A global coordinate system is used in the Robot Studio, which allows you to move around the world. Everything loaded into the programme is built on this coordinate system. It is possible to coordinate the objects using this fundamental coordinate system. The next step is to train the robot and the gripper tool on how to do their duties correctly and efficiently. In this step, work items and robot targets are created. These are the work items in this system. After the task items have been selected, objectives are produced to help you achieve your goals. There are a number of coordinate-systems that are used as targets. It's up to the industrial robot's programmers to get it there.

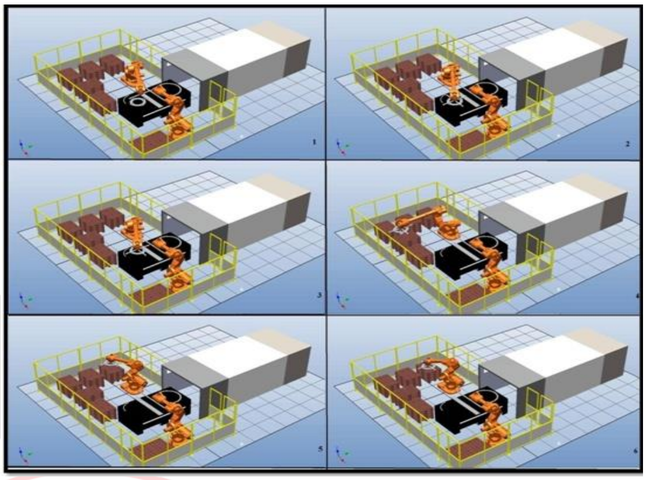

Figure 12 Transporting of Distanzring

IV CONCLUSION

To create an industrial robot gripper tool was a valuable learning experience. Starting out this degree project, the gripper tool didn't seem to be a problem at all. After reading the thesis, you'll see that there are a lot of variables to consider. ABB Robot Studio, a robot cell simulation programme, was used to build a gripper tool, produce assembly and detail drawings, and experiment with the gripper tool. Now that the thesis's aim has been achieved, the gripper tool may be tested on industrial robots.

1. It is observed that both the material and the design of the gripper tool were able to withstand the forces that were placed on it during testing. There was 214 MPa of material yield, and calculations showed that the material's maximum stress is only 136 MPa. However, if you try to conduct a similar calculation in Solid Works again, you will get different results, which may be caused by the differing mesh sizes in Solid Works. This tool's material and form can be changed if it needs to be more durable.
2. It is determined from the present study that there is a difference in the beginning position of components generated by the laser cutter compared to the ones utilised in the experiment. Also, the industrial robot must be able to determine the exact placement of the components,

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as well as which sections have been cut off, in order to be effective. There must be a limit on the length of the electromagnets so that they do not grab the sheet metal.

3. A few minutes of cooling time is required once the items are withdrawn from the laser cutter, as they will be surrounded by scrap metal sheets. In order to prevent the debris, the objects may need to be shacked before being lifted. Since the thesis's system does not mirror its planned one, it has been impossible to establish whether or not the items can be delivered within 30 minutes, which was a requirement.
4. Initially the gripper tool price was $50,000, however this study suggest the effective cost around $10,500; the product price is not exact since it was difficult to establish the price for welding and assembly procedures. An additional consideration was the size of the gripper tool, which was planned to be 2m by 2m, but was instead designed to be 1.3 m by 1.3 m.

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