Alternative Mechanical Modification for Robotic Control

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Abstract - *The project consists of the design, manufacture and assembly of a mechanism to aid mechanical movement, thank you to gears and potentiometers to control the movement of the robotic arm, as an alternative to the remote control system. The rotary-type potentiometers control 4 geared motors placed in the waist, shoulder, arm and wrist controls to give greater precision in movements. The precision potentiometer and gears control the gearmotor at the base of the arm to provide an additional 270° degrees of movement. Both the base of the potentiometers and gears were designed in the SolidWorks software, then they were sent in STL format to the CURA software, in which the parameters of the piece to be printed are defined, the material that was used to print each one of the pieces was ABS type filament (acrylonitrile butadiene styrene).*

Key words: **Key word 1 - Robotic Arm, Key word 2 - potentiometer, Key word 3 - 3D Printing, Key word 4 - Cura software.**

1. INTRODUCTION

The project accomplished out consisted in the design, manufacture and assembly of the bases of the potentiometers and gears as a mechanism to control the movements of the robotic arm, using potentiometers that provide degrees of freedom in each important point such as: Waist, shoulder, arm and wrist.

As it is known, the potentiometers or the "ollas", as they are common known in electronics, these are a variable resistance. The value of this resistance can be changed from zero to a defined limit, as these are used by many electronic devices to set the output level and can also be applied to perform an adjustment command or action, in other words, the potentiometer detects any irregularity and correct it.

Both bases where the potentiometers and gears have been placed, were manufactured thanks to 3D printing, also called additive manufacturing, it is a set of techniques that produce objects by adding layers of material that correspond to successive 3D model cross sections.

2. DEVLOPMENT

We used the following material, 3D printer and software to design and manufacture the bases where the potentiometers and the two gears of the base are located.

- SolidWorks
- Ultimaker Cura
- ABS type filament
- Anet A8 3D printer

2.1 WHAT IS SOLIDWORKS?

SolidWorks is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs primarily on Microsoft Windows that allows in an intuitive and fast way the creation of Solid Models in 3D, Assemblies and Drawings. It is based on parametric modeling, reducing the effort required to modify and create variants in the design, since the dimensions and relationships used to make operations are stored in the model.

For the design of the pieces, measurements were taken from the extremities of the arm where the bases will be placed so that they will made to measure.

Piece 1 (Fig. -1) will be placed on the base next to the robotic arm shoulder.

Fig -1: Piece 1

Likewise, part 2 (Fig. -2) will be the one that produces the twirl of the potentiometer in the same place.

Fig -2: Piece 2

Part 3 (Fig. -3) will be placed above the elbow´s gearmotor.

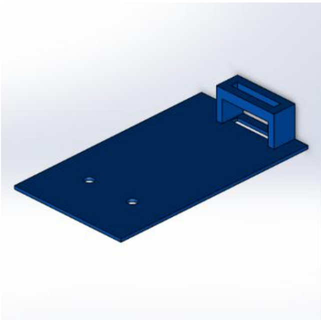

Fig -3: Piece 3

Piece 4 (Fig. -4) will be placed above the wrist´s gearmotor.

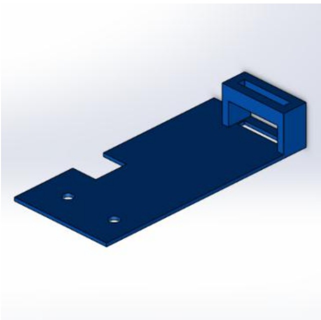

Fig -4: Piece 4

Piece 5 (Fig. -5) will be the one that produces the twirl of the potentiometer, and it will be placed in piece 4.

Fig -5: Piece 5

Piece 6 (Fig. -6) will be placed on one side of the robotic arm supported by the base and will be the one that will hold the potentiometer where the sprocket-wheel will be placed.

Fig -6: Piece 6

For the design of the gears, the SolidWorks "Toolbox" tool was used with the following properties:

Table -1: Gear Properties 1

Properties	
Module	2.75
Number of teeth	40
Face width	5
Cube type	Type A
Nominal shaft diameter	100

Fig -7: Gear 1

Table -2: Gear Properties 2

Properties	
Module	2.75
Number of teeth	10
Face width	5
Cube type	Type A
Nominal shaft diameter	5

Fig -8: Gear 2

2.2 STATIC ANALYSIS

For the static analysis, the gears were considered as solid, with the following properties provided by the same software according to the type of material used in this case is ABS:

Table -3: Volumetric properties (Fig. -8)

Volumetric properties (Fig. -8)	
Mass	0.00261229 kg
Volume	2.56106e-06 m^3
Density	1020 kg/m^3
Weight	0.0256004 N

Table -4: Volumetric properties (Fig. -7)

Volumetric properties (Fig. -7)	
Mass	0.00706032 kg
Volume	6.92189e-06 m^3
Density	1020 kg/m^3
Weight	0.0691912 N

2.3 PROPERTIES OF THE MATERIAL

An ABS type filament was used since it is ideal for the production of objects that must be subjected to mechanical forces, pieces with inserts. It has a good dimensional stability. This is because it is more flexible than PLA, ABS is ideal for mechanical designs or those with recessed parts or connected pins.

Table -5: Material Properties

Properties (ABS)	
Name	ABS
Model type	Linear elastic isotropic
Error criterion	Unknown
Traction limit	3e+07 N/m^2
Elastic Module	2e+09 N/m^2
Poisson Coefficient	0.394
Density	1020 kg/m^3
Shear module	3.189e+08 N/m^2

2.4 BURDEN AND FASTENINGS

The following two fastenings and one burden were used:

Table -6: Fastenings

Fastening name	Fastening details	
Fixed-1	Entities	1 face(s)
	Type	Fixed geometry
fixed hinge-1	Entities	1 face(s)
	Typo	Fixed hinge

Table -7: Burden

Burden name	Burden details	
Torsion-1	Reference	FACE< 1 >
	Type	Apply torque
	Value	6 N.m

A type of solid mesh was used with a total number of nodes of 83310 and a total number of elements of 48277.

Fig -9: Gear mesh 7 and 8

Table -8: Data about the mesh control

Name of the mesh control	Mesh Control Details	
Control-1	Entities	7 face(s)
	Units	mm
	Size	0.529365
	Coefficient	1.5

2.5 STUDY RESULTS

After running the study with the data mentioned above, the following results were obtained.

Table -9: Tensity Results (Chart -1)

Name	Type	Mín.	Máx.
Tensities1	VON: Tension de von Mises	7.110e-06 N/m^2 Nodo: 54482	2.008e+08 N/m^2 Nodo: 9427

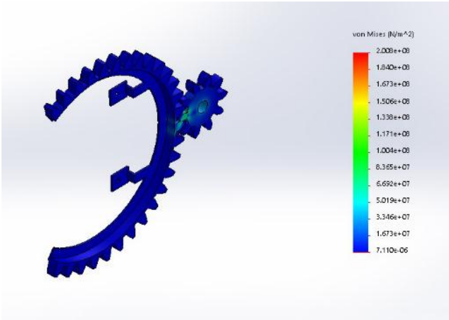

Chart -1: Tensity Results

Table -10: Displacements Results (Chart -2)

Name	Type	Mín.	Máx.
Displacements1	URES: Resulting Displacements	0.000e+00 mm Nodo: 14535	1.080e+00 mm Nodo: 12045

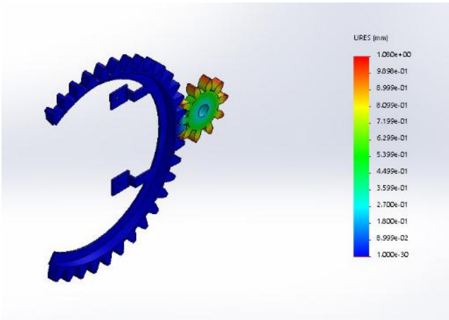

Chart -2: Displacements Results

Table -11: Deformation Results (Chart -3)

Name	Type	Mín.	Máx.
Unit deformatioms1	ESTRN: Equivalent unit deformations	2.784e-15 Element: 40245	8.377e-02 Element: 1925

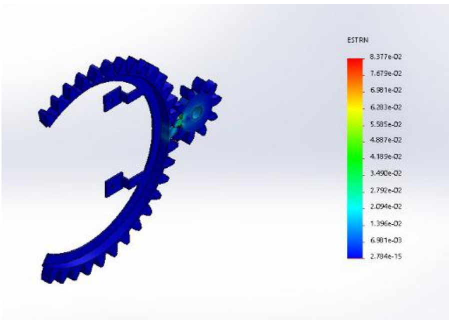

Chart -3: Deformation Results

After analyzing the results of the study, it was concluded that the design of the gears was carried out correctly and would withstand the strains and forces that will be applied with the movements of the gearmotor at the base of the robotic arm.

2.6 3D PRINTING

Once positive results were obtained in the analysis and design of the other parts of the mechanism, each one of the parts were saved in STL format to be able to give them the printing parameters in the Cura software.

2.7 WHAT IS CURA?

Cura is a 'Slicer' software to process the design files in 3D and do the 'slicing', that is, to generate each layer that will be manufactured by the 3D printer, so this way we obtain a GCode file that will be transmitted to our 3D printer.

It has advanced options for control of fill and speeds of movement, printing and retraction, as well as a mode for novice users.

The printing parameters that were used to print the mechanism parts are the following:

Table -12: Print parameters in Cura

Height cape	0.15 mm
Wall thickness	1 mm
Filler density	100%
Print temperature	215° C
Print platform	90° C
Print speed	40 mm/s
Refrigeration	Disabled
Support Density	25%
Border width	5 mm

2.8 3D PRINTER

The 3D printer that was used was the ANET A8, its characteristics are the following:

- Print volume: 220 x 220 x 240 mm
- Structure material: acrylic
- Print platform: aluminum
- Heads: 1
- Head diameter: 0.4 mm
- Layer thickness: 0.1–0.3 mm
- Offline printing via SD card
- LCD screen: Yes
- Print speed: Up to 100mm / s
- Diameter of the filament: 1.75 mm
- File format: G-Code, OBJ, STL
- X / Y axis accuracy: 0.012mm
- Z axis accuracy: 0.004mm
- Voltage: 12 V
- Software: Cura
- Certificates: EMC, FCC, LVD, RoHs

3. RESULTS

After designing in SolidWorks, the bases where the potentiometers and the base gears are located, a stress study was carried out on the gears to know if their design was adequate for correct operation. Thanks to that, each of the pieces could be manufactured using 3D printing, likewise each one of them was manufactured to suit the arm, it was easier to assemble them to it for a good fit and operation. In addition, it performs the movement function without any inconvenience, the potentiometers were activated and deactivated according to the movement that it must develop.

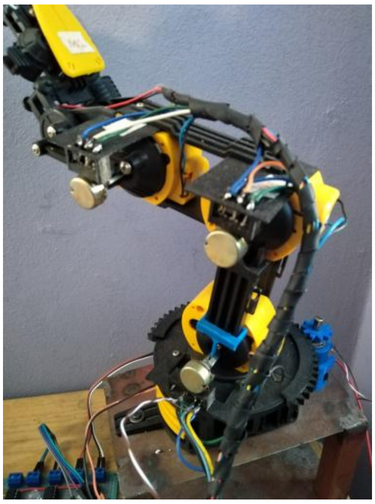

Fig -10: Mechanism assembly

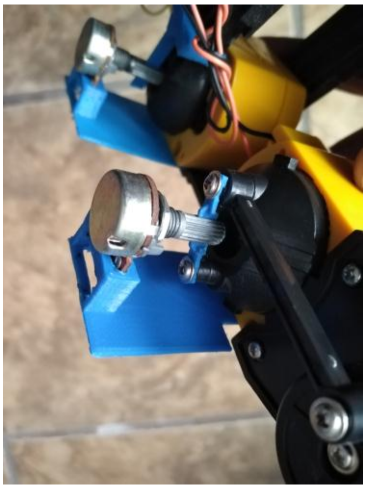

Fig -11: Elbow and wrist mechanism

4. CONCLUSION

With the research carried out on mechanical systems and with calculations, the gears and bases of the potentiometers were designed, which were drawn in the SolidWorks software to print them later based on filament, and mount them in the strategic places of the robotic arm, with the help of SolidWorks and stress analysis, we corroborate the function of the mechanical part (gears). With the help of these tools and research we can innovate the robotic arm.

With the design of this alternative system it was possible to manipulate and move the robotic arm specifically "table arms", which do not achive the degrees of freedom necessary for their movement in a way that facilitates its operation.

A mechanical modification, as simple as it may be, can help any system. The bases of the potentiometers are a good alternative, since they do not reduce mobility or function to the movements, they are positioned in the strategic parts of the arm. On the other hand, the ring gear located at the base of the arm, is a means of transmission of torque, compared to transmission by bands.

The mechanical alternatives serve to maximize times and these efforts, as well as efficient optimization, the correct operation with gears is achieved.

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BIOGRAPHIES

Jaime Sánchez Arroyo graduated as a T.S.U in Industrial Area Maintenance of the Technological University of Tlaxcala in 2019. During May-August period he worked in the company Servicio Especializado de Grúas Diaz Hermanos S.A de C.V. He is currently studying Industrial Maintenance Engineering at the Technological University of Tlaxcala.

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Jonny Carmona Reyes graduated from the Technological Institute of Apizaco in 2010 with a bachelor´s degree in Electronic Engineering, specialty in automation and instrumentation. He worked as an electronic engineer in MIF company, developing electronic projects for the steel industry from 2010 to 2015. Since to 2013, he has been working as a teacher in the Technological University of Tlaxcala in the industrial maintenance career.

Moisés Sánchez Moredia earned a Bachelor of Arts in Applied Modern Languages, specialized in English as a second language teaching by Universidad Autónoma de Tlaxcala. He holds a Master´s Degree in School Administration and Management by Universidad Internacional de la Rioja (UNIR). From 2016 to 2018, He was the coordinator of the English area in Universidad Tecnológica de Tlaxcala where he currently teaches English in Industrial Maintenance Engineering.