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Design and Construction of Electromechanical Wrist Hand Orthosis with a Functional Interface

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Abstract
Electromechanical wrist hand orthosis[1] is used under different conditions. It can be used for stability purposes for a wide range of wrist movements. Do not bend the joints or prevent excessive propagation. The materials used include low-temperature[2] thermoplastic metal and thermoplastic sheets. To move the orthosis, a servomotor is used to move the wrist, which is controlled by the user interface. Instead of expensive fittings, a simple aluminum watch joint has been used to make it. To produce EWHO, first, the orthosis was designed by Inventor software. Depending on the wrist force, which is tolerable to the hand, this amount of force is analyzed on the sheets used in Abaqus software and Inverter software and analyzed for stress and ultimate stress. A Bluetooth board controls the movements of the wrist according to the user's command in the app depending on the type of user on the mobile or computer. The person or companion beside the person can help him or her to adjust the orthosis. Depending on one's disability, the orthosis can be adjusted to varying degrees and lead to one's recovery.The goal of this orthosis is to help patients with functional impairment in the wrist. Any type of functional disorder in his or her hand can result in the loss of individual independence and thus a threat to his or her social independence.

Keywords
EWHO Orthosis, Bluetooth Range, Inventor Software, Abaqus Software, Thermoplastics, Splint the Wrist

1. Introduction
Today, many of the orthosis patterns due to an overuse of materials to cover part of the forearm, wrist, and hand are heavy and very large [1]. Any type of affliction within the wrist can lead to dependency and the need to get things done [2, 3]. Following the discovery of X-rays and radiography, wrist malformations were observed [4, 5]. The wrist can be examined for damage to the ligaments or bone depending on the type of injury [6, 7]. Wrist orthosis is used to treat many problems such as wrist instability and wrist syndromes and nerve and muscle injuries, or limiting wrist movements [8]. The orthosis is intended to prevent deformity, protect the tissues, relieve pain, or seek out lesions [9]. There is need for a simple wrist orthosis that can be built correctly with minimal time and can be used for many years. Today, one of the most important requirements is that in addition to spending less, it depends on the patient's needs for an orthosis. Other factors can be cost-effective, lightweight, easy, and maintain the natural arch of the hand. Since orthosis is directly attached to the patient, the convenience of using it is one of these [10]. Grossman showed

[1]EWHO
[2]Thermoplastic

that the placement of the muscle in the inactive stretch leads to a change in its biomechanical, anatomical, and physiological characteristics [11]. In 1994, Hill's stated that total casting is more effective than conventional methods, such as passive motion range exercises, static stretching, and splinting [12]. According to the latest available data from 2016, the United States, about 282,000 people living with the SCI[3], and this number is estimated to nearly 17,000 new cases this year has to be increased [13]. Most of the cervical spinal cord injury in the C5-C7 section, which causes patients to lose upper and lower extremities, is associated with loss of ability to control specific body functions [14]. Patients with C5-C7, incomplete SCI, loss of prevention ability, but the wrist function is maintained almost entirely [15-18].

Thus, more rehabilitation techniques give the ability to understand and propagate the movement. This orthopedic phenomenon benefits from the maintenance of the wrist and is obtained by spreading the wrist to get the wrist for release [19-21]. However, these movements are opposed precisely in a way that peoples can understand and publish objects. Given that almost 90% of SCI cases are non-congenital, the target population was already bodied before SCI, so rehabilitation would be easier for patients if it could be handled in more intuitive ways [13, 22]. EWHO may help with the completion of the ADL[4], give rise to some degree of independence, but they can't independently mean, people with the SCI never feel the sense of independence[23].This right-handed and hand-operated athlete technology designed to help people with spinal cord injury, C6-C7 (SCI), independently activates the everyday life of ADLs [24].The decrease in the range of the wrist causes increased movements of the trunk and other joints of the upper limb[5] [shoulder, elbow, and forearm] [25]. Orthosis and splints are commonly used to improve the condition, range, movement quality, and hand performance. The therapists use upper extremity orthosis to increase the wrist and elbow range to improve the performance of hands with high muscle strength [26]. The wrist is very sensitive in structure, so care must be taken in the design and design of the ligaments and tendons in terms of the range of motion [27-29].

1.1 Methods of Investigation and Construction

In this project, it was tried to create electromechanical orthosis according to Gatto's et al. [25]. At first, electromechanical orthosis along with interfaces and other components are designed in Inventor software [30]. Then, the orthosis control box is designed and the interface between the orthosis parts and the motor required for handing movement is designed, Figures 1 and 2.

[3]spinal cord injury
[4]Activity of daily life
[5]shoulder, elbow, and forearm

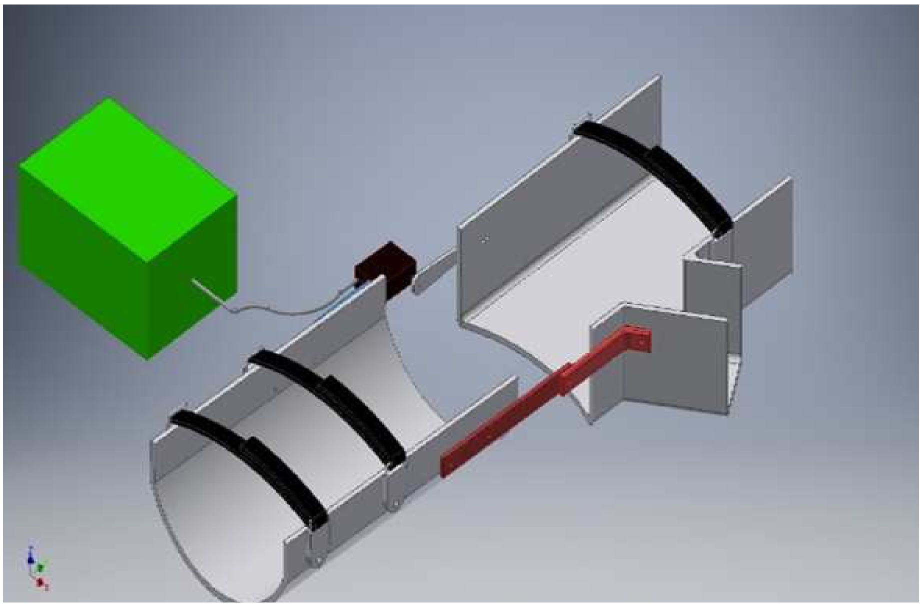

Figure1. Electromechanical wrist orthosis is designed in Inventor software

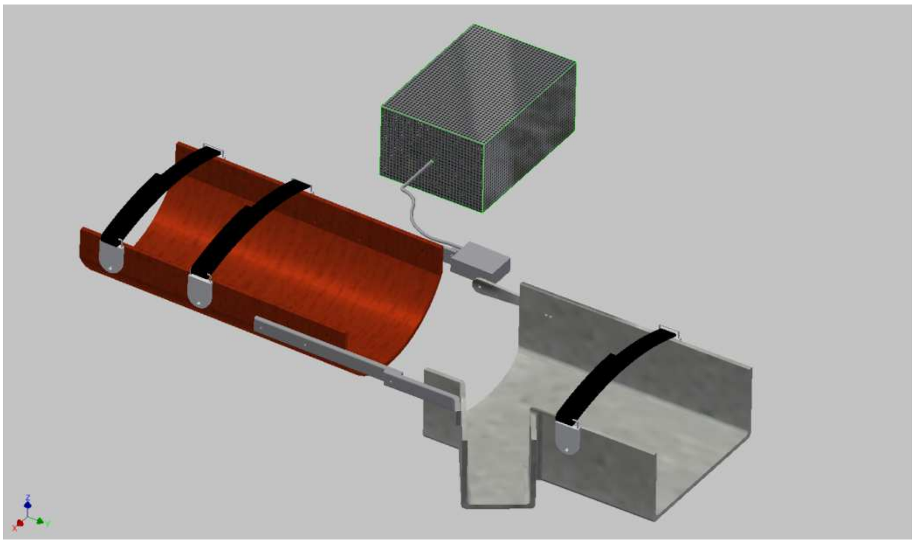

Figure2. The orthosis is prepared after the initial design

Part 1 is the Bluetooth board and the Arduino board, which are connected to a power supply by the Bluetooth board and provide the power needed to drive the motors. Part 2, provides the connection between the boards and the servo motor. Part 3 of the servo motor is used to provide the force necessary to move the wrist. Part 4 plates and joints are made of aluminum, which is used for the manufacture of orthotics joints.Part5, Thermoplastic sheets used in an orthosis, on which the hand rests, Figure 3.

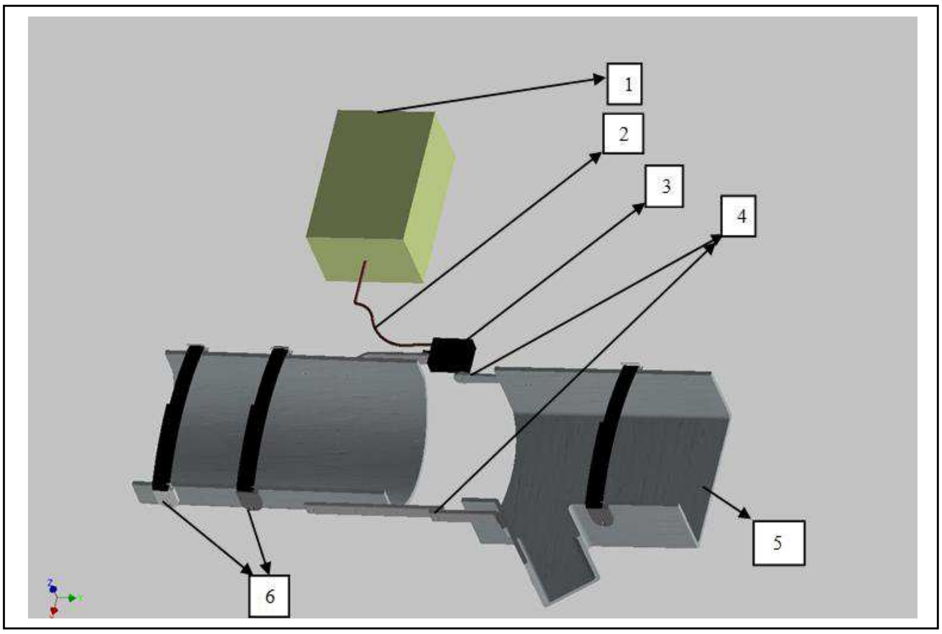

Figure3. The various parts of the orthosis, which are named

1.2 Build

Hand-held plates are needed first to make orthosis. These sheets, which are low-temperature sheets, are used in the manufacture of the orthosis [31-33].These additives include fillers, plastic solvents, lubricants, and colored materials. Gypsum and fiberglass gangs from this group are materials [31, 33-36]. High-temperature formable materials are used for spinal and lower extremity orthosis.

The basic point to be taken into account is that thermoplastic materials form at temperatures above 323 degrees Fahrenheit (ca. 162 °C).These materials become crystallized after cooling, and crystalline or glassy at low temperatures of 293 degrees Fahrenheit, and plays a very important role in the final strength of the orthosis. Unfortunately, an important issue to consider, in the manufacturing process is the warmth of the Positive Mold, because it does not cool quickly and becomes less crystalline and, consequently, the stiffness of the cut will be greater.

Rapid plastic cooling and thermal breakdown create internal fracture and internal shear stresses. Finally, it will cause fractures [34]. After selecting this sheet, it is necessary to contract the sheet into the furnace, then remove it and place it around the mold to give the sheet the desired shape. The layers and engine are intended to be placed on the same design pattern, Figure 4.

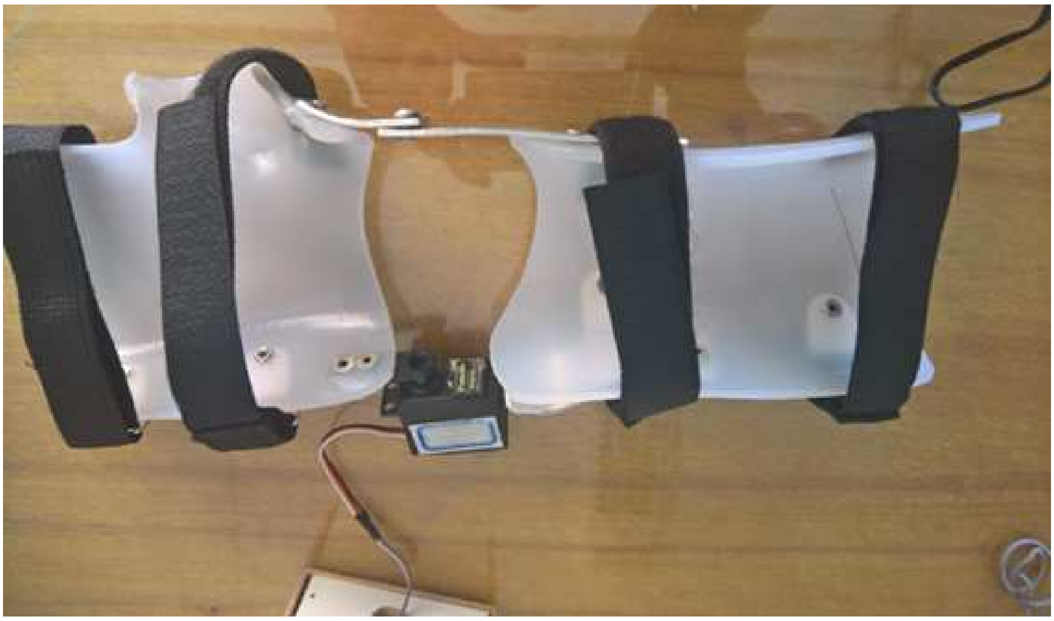

Figure4. Thermoplastic Sheets and Brackets and Engine

Finally, a box for Bluetooth and other boards like Arduino has been added. Arduino boards programming is done in Arduino software.

Now, electromechanical wrist hand orthosis is prepared. The Arduino board is used to control the engine and the movements of the orthosis. The Arduino software is used to provide the features needed to work with it. Arduino boards are used for processing, with many benefits to design and programming and the ability to add treatments. Arduino was created in the ARM for a cheap and easy behavior to use a full-fledged program. Arduino offers a simple software package (IDE), those which run on normal PCs, that allows it to run C^{++} programs [37, 39, 41].The Bluetooth module is used to connect to the computer. The module shown is the HC05 module for Bluetooth communication. The Bluetooth module is a standard HC-05 module with output. This module is very suitable for communication between the microcontroller and Bluetooth mobile and tablet as well as selection. This module can also be used to communicate between projects made with a microcontroller and Bluetooth-enabled laptops, allowing the individual to monitor it through a specialist or by the individual himself or herself following the application's custom settings [37-42].

After completing the steps, the following diagram shows how this orthosis is used comprehensively and it can be used for its capabilities, Figure4.

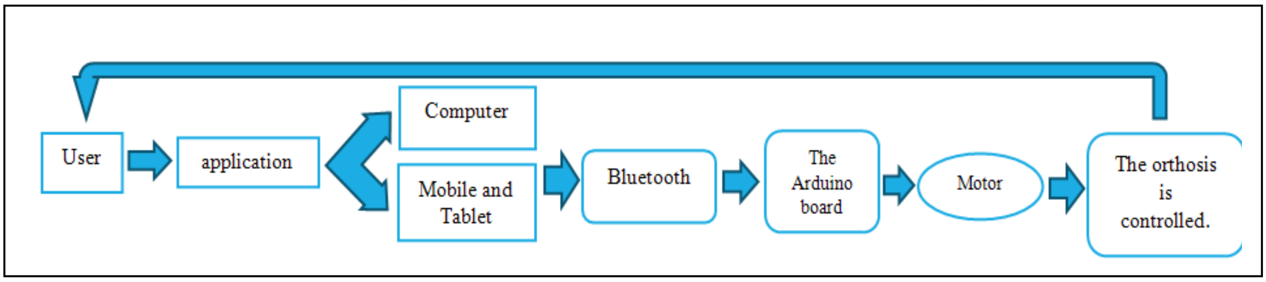

Figure3. The operation of the orthosis and how to control the orthosis are fully illustrated in the diagram below

According to the diagram, the application page has the opposite face, which can be saved to the times when the client is using it. The time of bending or opening is also stated, Figure 4.

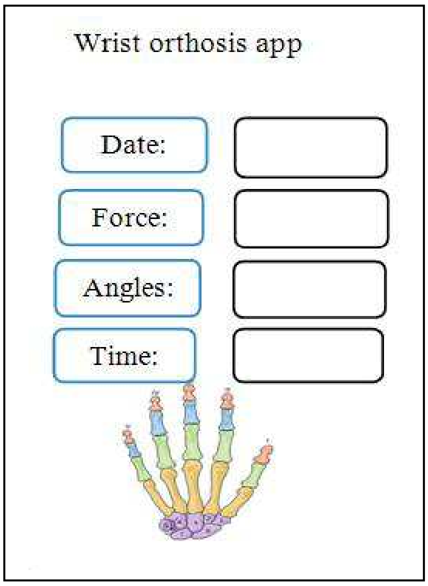

Figure4. Wrist electromechanical orthosis app in Mobile and Tablet or Computer

1.3 Checking Tension

In terms of design and manufacture, it is now time to take the orthosis test to better understand the use of force points on thermoplastic and aluminum sheets [49-51]. Due to the forces [43,44,47, 55] and degrees [52-54, 48, 43] of freedom [48, 40] that the wrist has, it is therefore important that the forces applied to the orthosis be increased so as not to cause problems for people of varying strength and type of disease and use for the assisted person. The orthosis does not damage the internal organs, such as the tendons [45, 46, 56, 63-66], when work with it [57].

Therefore, Abaqus software is used to obtain the palm and side aluminum sheets, which are used for the two-part orthosis connection. A force of 10 N, 30 N, 62.5 N [58-62] is used. Reducing computational costs in finite element analysis is one of the key pillars of the problem, and considering this is a sign of the analyst's high accuracy and deep vision, so it is enough to simulate it in Abaqus software to model On the other hand, according to the geometry shown in the Figure above, a separate analysis is required: an anchor, a cube and a force-load segment, Figure 5.

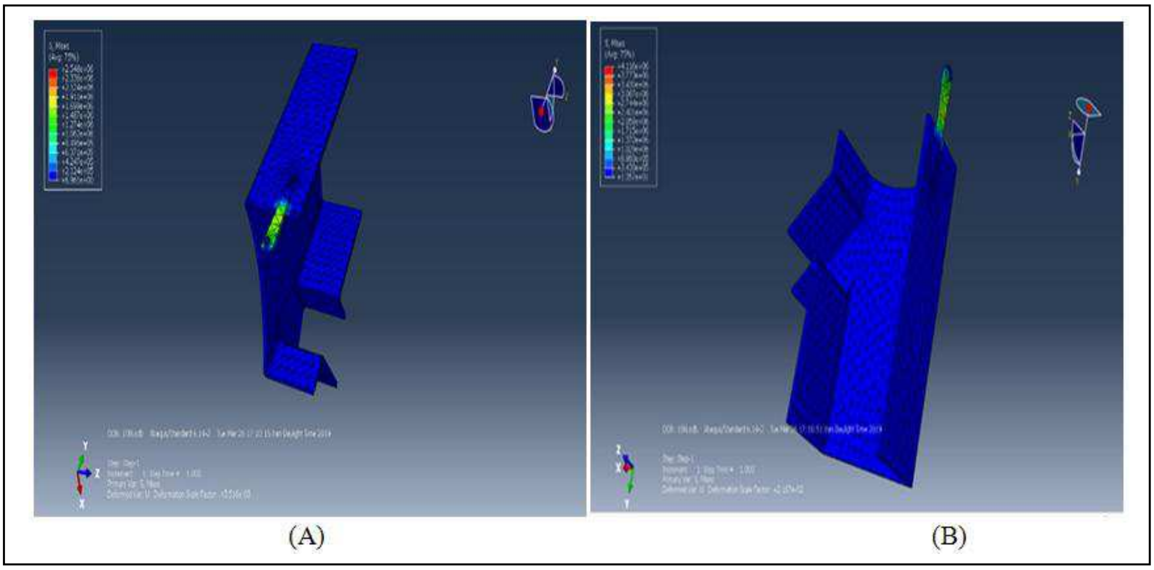

Figure5. A) Check the joints after applying a force of 10Newton, B) Check connections after applying a force of 62.5 Newton

Considering the amount of force required for the flexion and extension of the wrist at different points, it should be noted that at least 10 Newton and more forces, which is considered to be an average of 62.5 some more force, is applied to the lowest part of the orthosis. The result shows that the maximum fracture force of elemental fracture is less than that of the fragment does not deform such force, (Figure 6).

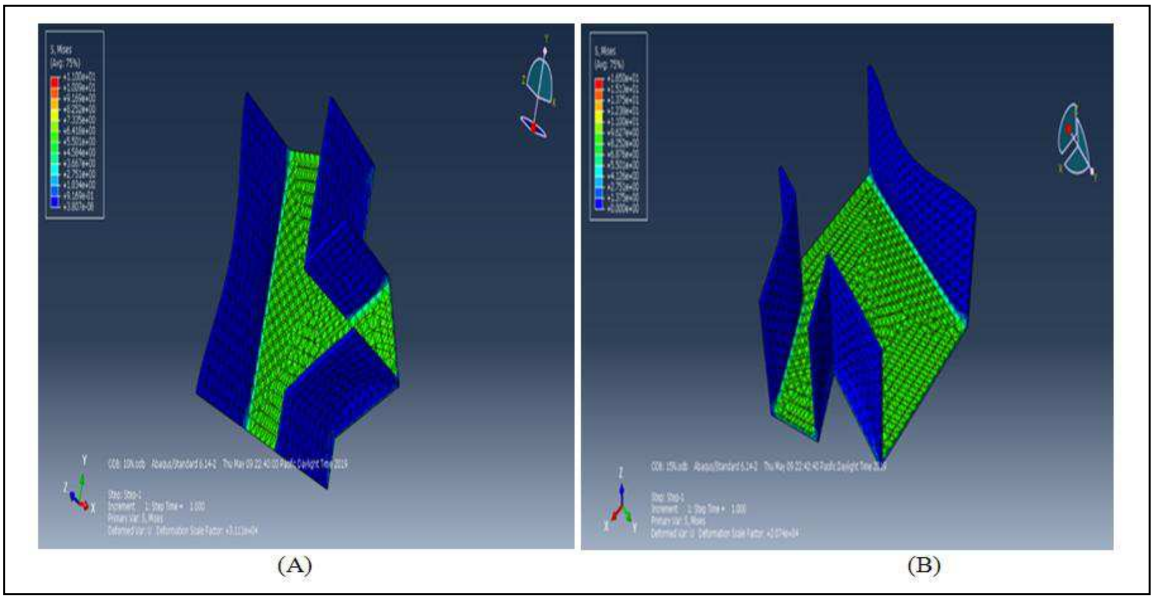

Figure6. A) The result is a 10N force on the bottom of the piece, B) The result of the force of 62.5N

Regarding orthosis and other data, graphs were also used to analyze the results of Abaqus software using time force to analyze the results. The above results were obtained using Von Mises criteria. According to the analysis obtained, from the Abacus software, the orthosis can be both fixed and used as a rehabilitation device and there is no deformation or fracture damage.

According to previous analysis in Abacus software, it is now time to check again the total force required with the inverter software orthosis material. In this analysis, a maximum force of 62.5 Newton is used, because if you answer it needs less force because it needs less force to perform the orthosis so it can accept it and be confident. For this purpose, after the design, the aluminum [66] properties are applied to the parts applied to the orthosis. The approximate mechanical properties are as follows, Table 1.

Table1. Mechanical Properties of Aluminum [66]

Property	**Value**	**Units**
Elastic Modulus	6.9e+010	N/m^2
Poisson’s Ratio	0.33	N/A
Shear Modulus	2.6e+010	N/m^2
Mass Density	2700	Kg/m^3
Yield Strength	55148500	N/m^2
Tensile Strength	124084000	N/m^2
Specific Heat	1300	J/(kg.k)

After the thermoplastic sheet aluminum shift that has already been explained concerning it's concurrently, turn to the analysis, which can be obtained as follows, Figure7.

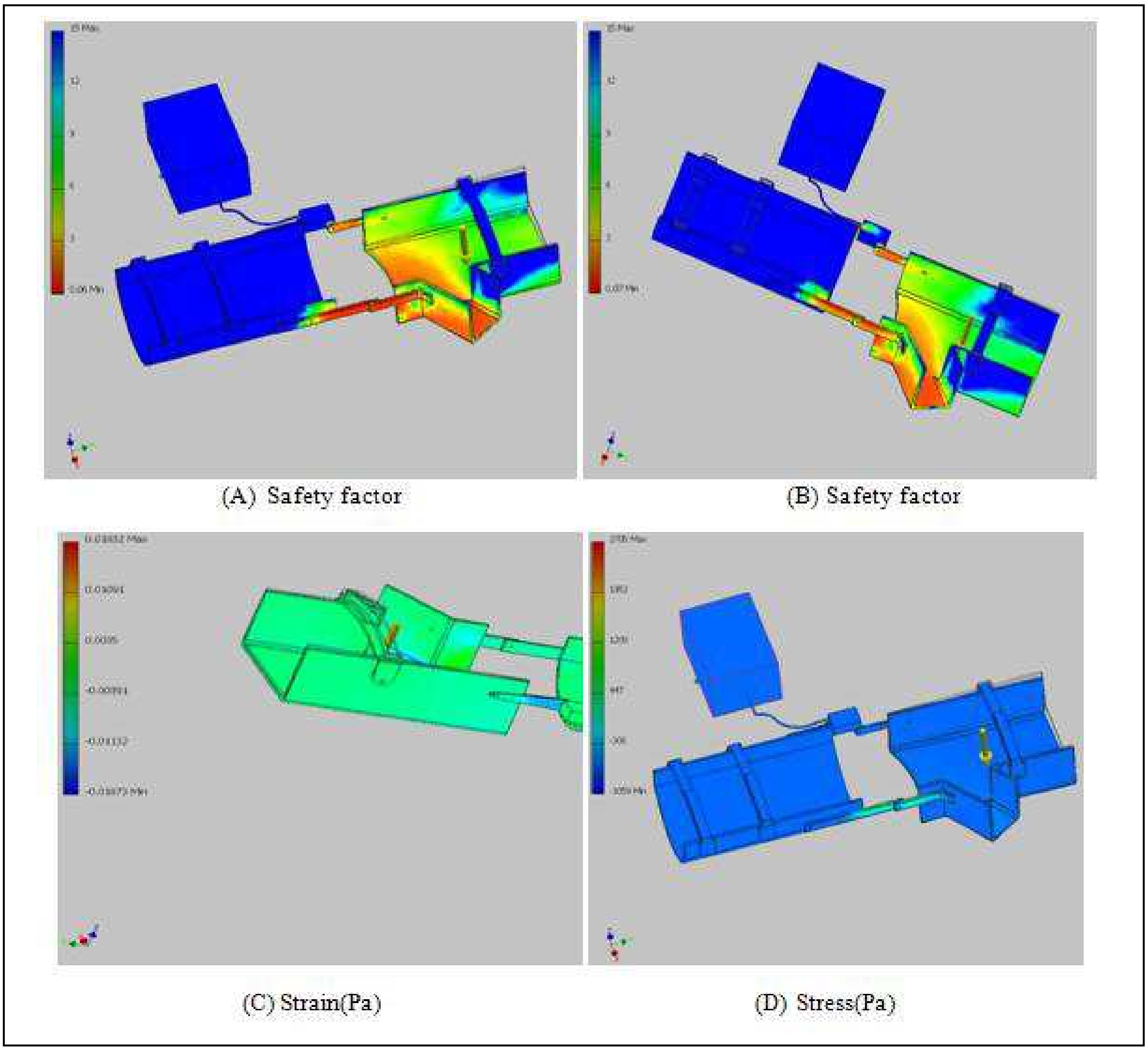

Figure**7.** Analysis of orthosis in inverter software

Finally, the strain diagrams obtained are shown below, as shown below. These graphs are obtained by analyzing the inside inverter software, which is at a specified time with the Pascal unit, Figure 8.

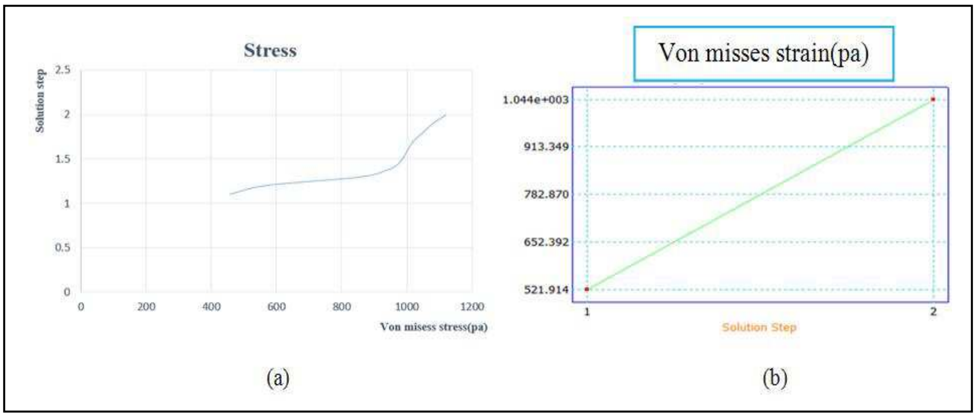

Figure8. Graphs obtained according to analysis inside Inventor software

2. Conclusion

This orthosis can be used in various centers for the wrist problem. Now, rehabilitation can improve the extensor muscle defect in a short time. As it is clear, this hand was difficult but now it can be treated with an orthosis. This orthosis can be used by different people and can be used both statically and dynamically according to its ability. Of course, the diagnosis and speed of treatment of peripheral nervous system injuries, depending on the level of injury, the severity of the injury, and the intermittent repair process for the construction of an orthosis, especially the electromechanical orthosis, must be taken into account with great care. It is used as a wrist stabilizer or a rehabilitation device. These or thoses are similar in structure to foot orthosis if other parts of the body have similar conditions and joints. The orthosis can be used with an interface and a rotary-propelled motor.

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