Maestría en Ingeniería en Automatización de Procesos Industriales

Structural design and modeling of the movement control of a vertical greenhouse prototype

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1. Introduction

In México, the cultivation of greenhouse vegetables is growing rapidly compared to open field crops. According to the federal government (SAGARPA) and the Mexican Association of Protected Horticulture (AMHPAC), annual growth is around 1200(one thousand two hundred) hectares per year. [1]

The types of greenhouses most used are: 1. House or shade mesh, 2. Macrotúnel or high tunnel, 3.Microtúnel, also called low tunnel or mini greenhouse. [2]

This work presents the mechanical and control system for angular speed, torque, inertia, mass, engine power, in addition to performing the analysis of the mechanism that will move the prototype. [3]

2. Objectives

2. 2.1. General purpose

- Design the structure and motion control model of a vertical greenhouse prototype.

2.2. Specific Objectives

- Design the structure of the vertical greenhouse.
- Model the vertical greenhouse movement control system.

3.Methodology

3.1 Structural design of vertical greenhouse

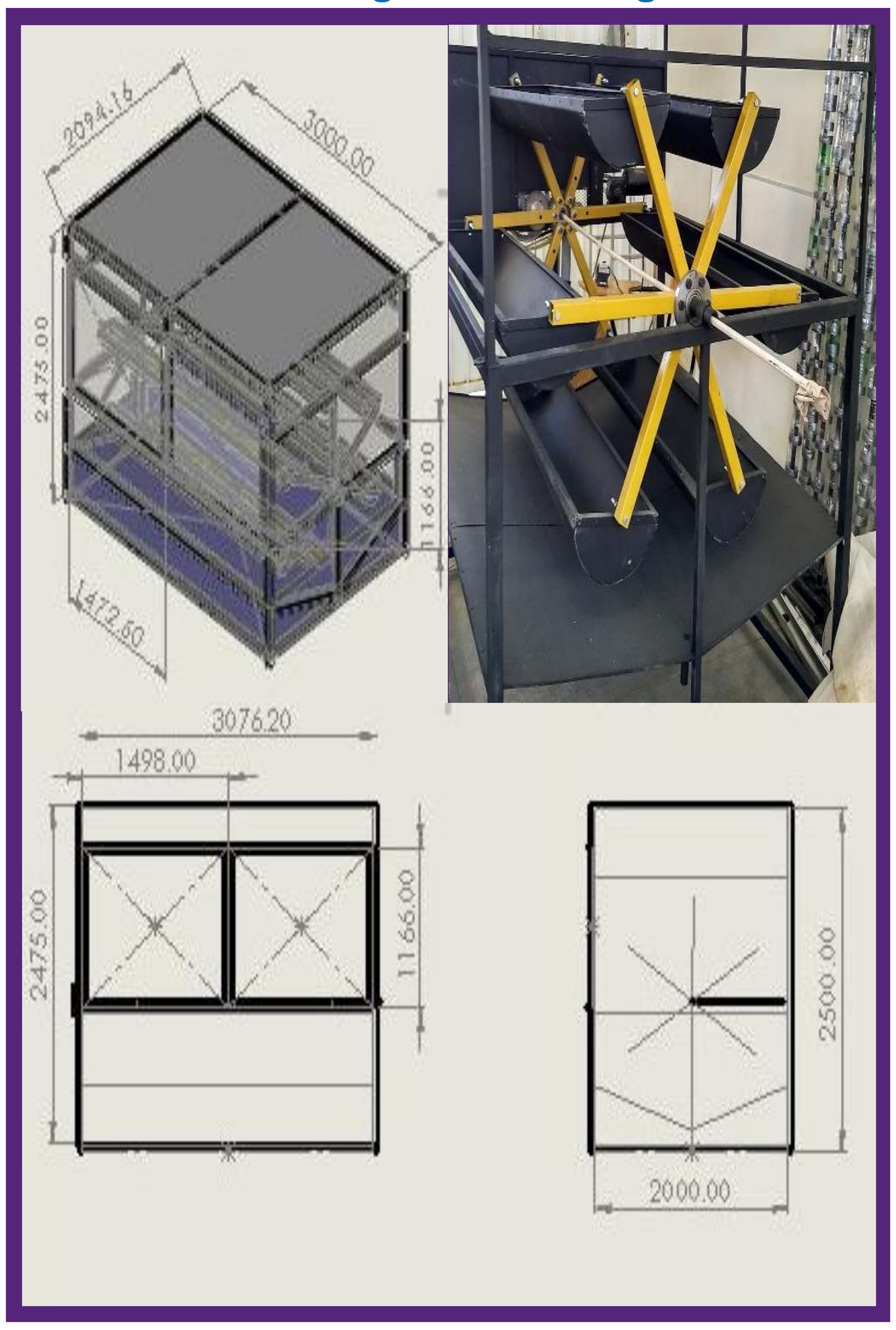

Figure 1. Structural design of vertical greenhouse

3.2 Characterization of Motor and Pulleys

The mechanical system of movement is mainly constituted by:

1. Gear Motor
2. Ribbed pulleys
3. Gears

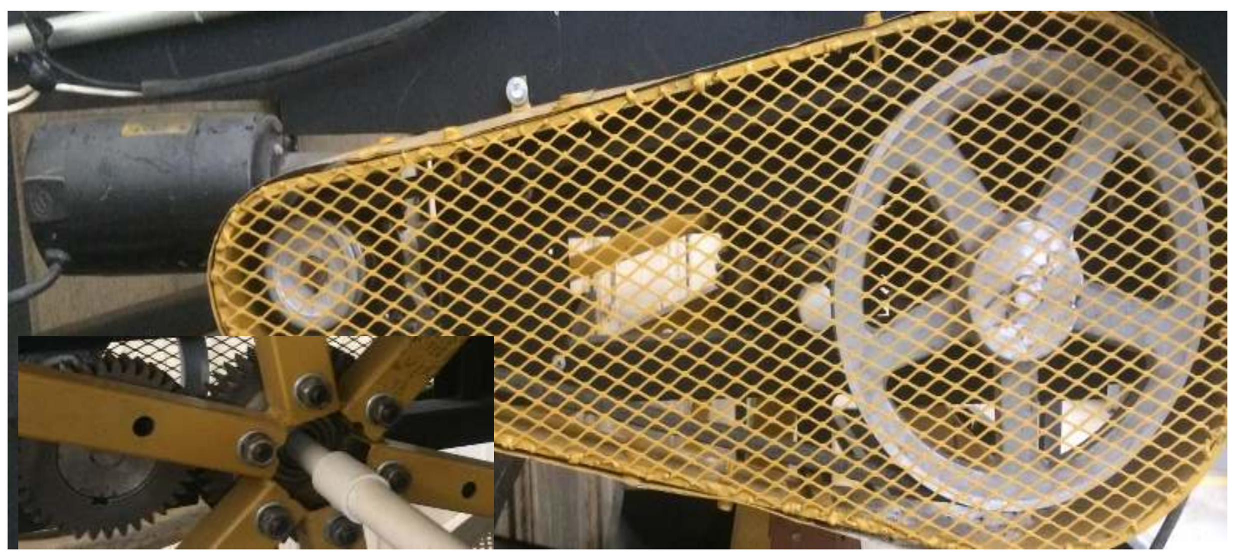

Figure 2. Motor, pulleys and gears of the vertical greenhouse

Motor of Permanent Magnets of a HP= 1/4 y 68 RPM	Characteristics of Small pulley	Characteristics of the Big Pole
Drive pulley speed Vr	W1= Speed of the small Pulley	W2= Speed of the Big Pulley
Vr= d2 / d1= 254mm/ 63.5mm = 4 rpm o 25.13 rad/min	w1= 68 RPM o 427.26 rad/min ; d1=63.5mm	$w2 = \frac{(d1)(w1)}{d2}$ w2= (2.05)(68) / (9.55) =14.60 rmp o 91.73 rad/min ; d2= 254 mm
Belt Speed Vb $Vb = \frac{dp1}{2} w1$	The contact angles with the band or strap	The contact angles with the band or strap
dp1=step diameter 1 fpm=driving torque	$\theta 1 = 180° - 2\ \sin^{-1}(\frac{d2-d1}{2C})$	$\theta 2 = 180° + 2\ \sin^{-1}(\frac{d2-d1}{2C})$
Vb=437.93 in/min= 36.49 fpm	θ1 = 157.36 degrees	θ2 = 202.64 degrees

Figure 3. Characteristics of motor and pulleys of the mechanism

	Shaft diameter	Internal diameter of the gear	Primitive diameter or pitch circle	Module (m)	Circular step	Number of Teeth	External diameter
Engrane 1	20 mm	64 mm	124 mm	3.2	10mm	38	127mm
Engrane 2	20 mm	86 mm	147 mm	3.2	10mm	46	150 mm
	Tooth thickness	Inside diameter	Tooth foot	Height of the tooth	Diametral step pd	Circular step	Distance between Centers C
Engrane 1	6mm	110mm	6mm	9mm	0.3mm	10 mm	138.5mm
Engrane 2	6mm	133mm	6mm	9mm	0.3mm	10 mm	138.5mm

Figure 4. Characteristics of mechanism gears

3.3 Modeling and Implementation of the vertical greenhouse control system

Variables of the diagram:

Va = 76.56
ra =5.6
TL = 0.4
Laa = 0.0012
Ta = Laa / ra
Kv = 8.86
J = 0.0000975
Bm = 2.99

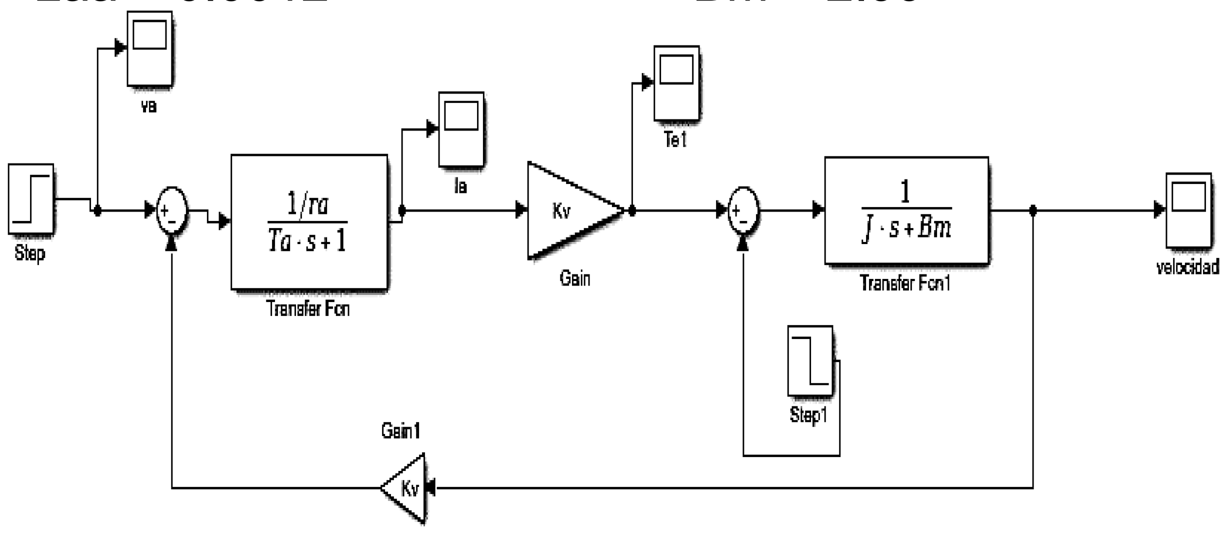

Figure 5. Variables obtained, electrical diagram and block diagram in Matlab [3]

4. Results

The results that are presented in the following graphs show the data obtained in the methodology

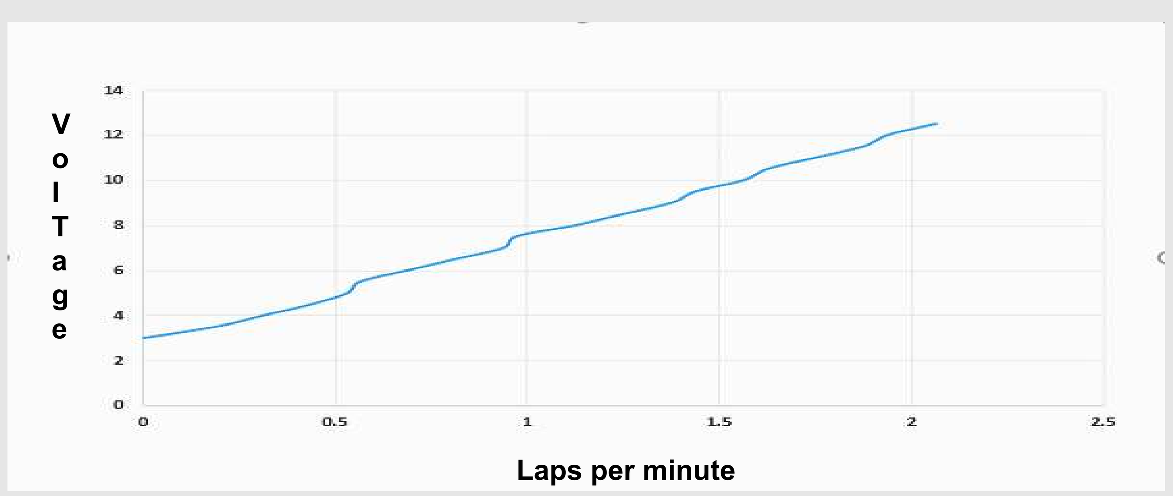

Figure 6. Voltage vs Laps per minute.

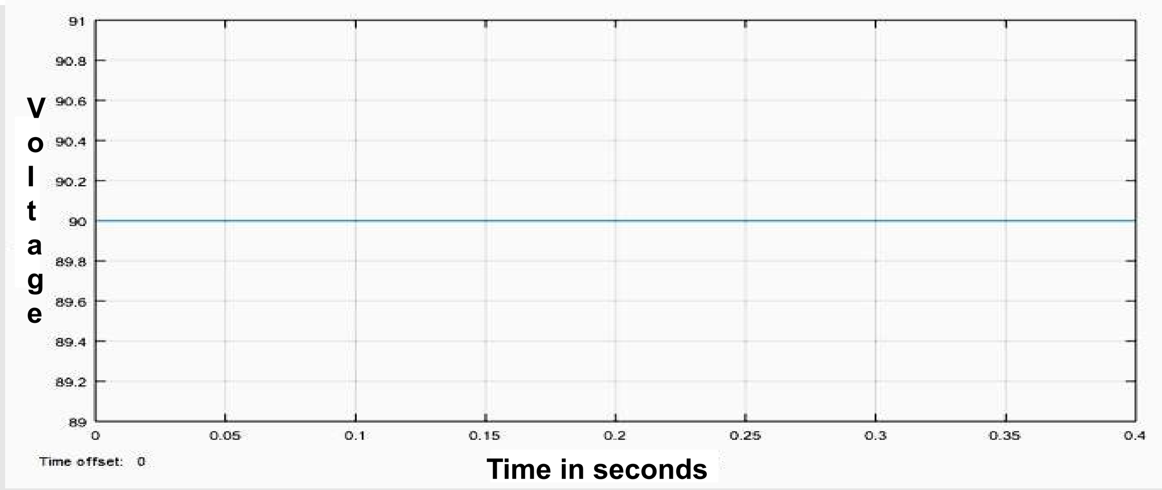

Figure 7. Graph of Nominal Voltage Va terminals of the armature

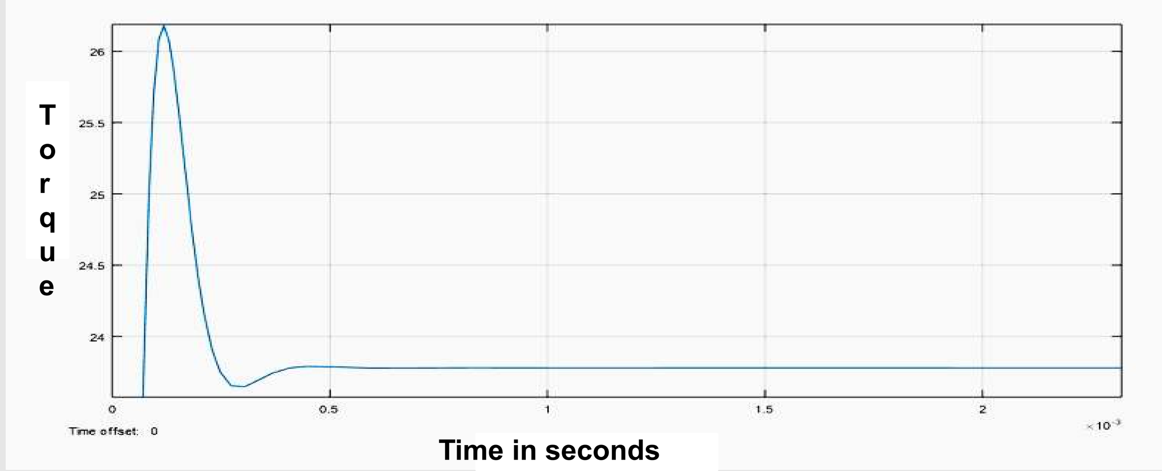

Figure 8. Graph of Te Torque by friction.

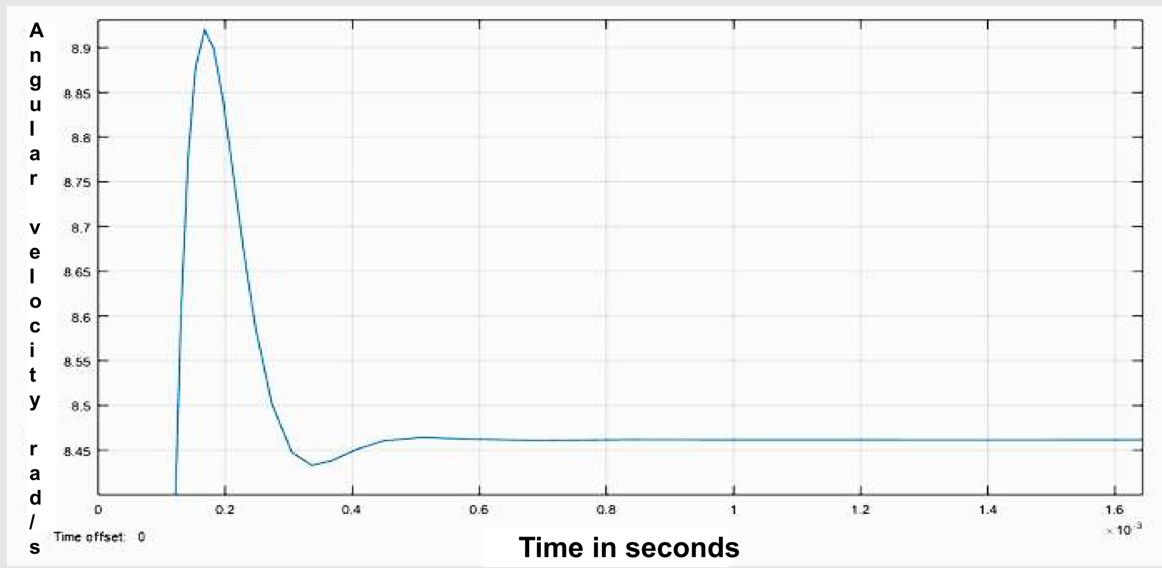

Figure 9. KV Graph angular velocity.

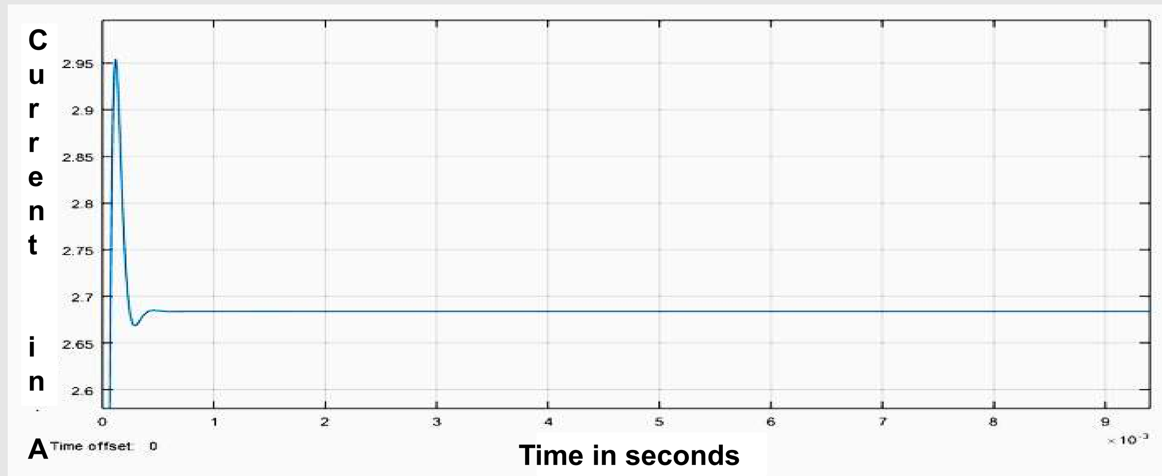

Figure 10. Graph of the nominal current of the armor

5. Conclusions

From the proposed work, the structural design of the greenhouse was achieved, as well as the movement control model, from the use of a cd gear motor, grooved pulleys with V-band and gears of 38 and 46 teeth.

Once the prototype was designed, each of the components forming the mechanism was characterized in the same way a mathematical model was established for the operation of the direct-current motor reducer from Matlab-Simulink.

The prototype is already physically developed and is working according to what is established in the model. In the future it is intended to implement the temperature and humidity sensors of the substrate in order to have an effective irrigation control and a control model of closed loop that with a small margin of error in the parameters, verifies that the mathematically characterized is correct.

Acknowledgements

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References

[1] K. den Herder. (08/04/2016)., "Las hortalizas mexicanas de invernadero aumentan 1.200 hectáreas al año." url: http://www.freshplaza.es/article/96745/Las-hortalizas-mexicanas-deinvernadero-aumentan (2017).

[2] S. . de enero de 2017)., "Tipos de estructura para la agricultura protegida." url: http://www.gob.mx/sagarpa/articulos/tipos-de-estructurapara-la-agricultura-protegida (2017)..

[3] F. O. G. Manzanilla, ""diseño de un prototipo de planta generadora de energía eléctrica por medio de un canal parabólico y energía solar," (2017).

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