Adjustable testbench system to stretch optical fiber

Plataforma de pruebas ajustable para estrechar fibra óptica

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Abstract

Actually, the use of optical fiber has been extended to several applications, not only its use for telecommunications; nowadays, optical fiber is used for sensor construction and instrumentation. For that reason, modifications and deformations in optical fiber sections are required and in order to observe how light transition is performed through to the fiber. The construction of this platform has the main objective to accomplish stretching test with different tensions on the fiber, different exposition terms to the electric arc and finally the gap between electrical electrodes to modify the affectations on the fiber, that are applied on the fiber. The different parts this system is conformed with, are presented in this work and the main features of each stage.

Instrumentation, Optical fiber stretching, tensions, Tensions, deformations

Resumen

En la actualidad, el uno de fibra óptica se ha extendido a diversas aplicaciones ya no solo en el campo de las telecomunicaciones, ahora se emplea en la construcción de sensores e instrumentación, para lo cual se requiere hacer modificaciones o deformaciones en secciones de la fibra óptica y observar como se ve alterada la transmisión de luz dentro de la fibra. La construcción de esta plataforma tiene como objetivo realizar pruebas de estrechamiento con diferentes tensiones sobre la fibra, diferentes periodos de tiempo de exposición al arco eléctrico y finalmente la separación entre electrodos para modificar las afectaciones que se pueden infringir sobre la fibra. El trabajo describe las diferentes partes que conforman el sistema y las principales características de cada etapa.

Instrumentación, Estrechamiento de Fibra óptica, Tensiones, Deformaciones

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Introduction

Devices of stretching optical fiber filament have been used as sensors, using the optical property of the evanescent field during signal transitions. Therefore, the optical fiber interaction with several material such as alcohol, silicon oxide and even construction material, is improved and amplified by this property. In some cases alcohol for example, in medical areas for instance optical fiber is used to sense human body fluids; silicon oxide used to improve the effects of Raman spreading, also in force and temperature measurements; with construction material, the concrete deformation cab be measured by deformation of the optical fiber filament as well. This research has as mail purpose to design, build and test a stretching machine for micro-optical glass fibers employing an electric arc, with the idea of softening glass optical fibers and applying different tensions on the fiber filaments.

At the biggening of the XXI century, many investigations on stretched glass optical fiber (SGOF) took place, using the property of evanescent field for optical signals SGOF. During the last eight years, the same effect has been observed on micro and nano fibers, in this case µSGOF and nSGOF, which have shown better results, obtaining low lost by attenuation and using the no-lineal effects of the evanescent field. The sensors based on µSGOF have also shown better results on alcohols, they are manufactured by butane gas flame as mention by Shan 2013. µSGOF are also an option for remote detection such as humidity, refractive index detection, steam detection, biomedicines, chemical analysis, environmental engineering and car industry, Razak 2017. Since The µSGOF have proved to have optical power leak guided, they are used in sensors for surface plasmon resonance on glass optical fibers, as described in Jafari 2017. For some sensors, a thin metal film is applied and to polish the narrow part of the cone of the optical fiber, it needs to be submerged in hydrofluoric acid, which can lead to 40 µm diameters, as explained by Yu 2014. Many other applications are presented by the author Lim 2012 and Lee 2019, for example: no-linear optical effects amplified, including Brillouin dispersion, Raman amplification and the generation of super continuous. Also, as mentioned by Garcia-Fernandez 2011, it is the µSGOF interferometer with its construction and tests.

Then, µSGOF are used to achieve a diabatic transmission of approximately 99% for the fundamental mode, presented by Lützler2012 and Ward 2014. Researches for a µSGOF knob resonator and Mach-Zehnder interferometer to measure temperatures and refractive indices by Gomes 2017. Finally, different laser sources are employed for to stretch optical fibers, as mentioned by Sumetsky 2010 and Gai 2012.

Therefore this prototipe, as the proposed one by Figueroa 2022, can prompt to start medical applicacion. In addition to what Garcia 2022 where a surface detector usind ultraviolet light for a robot, optical fiber light may result in an alterantive such a Time-of-Flight sensor, which are designed to sense the time light takes to go and come. Similarly to the pruposed system control, Sanchez 2022, used a fast development board what ends to be good and cheap alternative.

Stretching platform

In particular, this proposed work has the target of developing a system, that allows infringing deformations on the glass optical fiber by tension or/and different exposures to electric arcs. On one hand, the fiber can suffer several levels of tension, which is produced by a fixed clamp and a mobile one, the mobile clamp is located on a platform that is motor-shaft connected with a ball screw to displace and produce tension. On the other hand, the electric arc, it is produced in different triggering pulses, it can be a time on and a time off or several times on and off in a specific term, as it can be observed in figure 1.

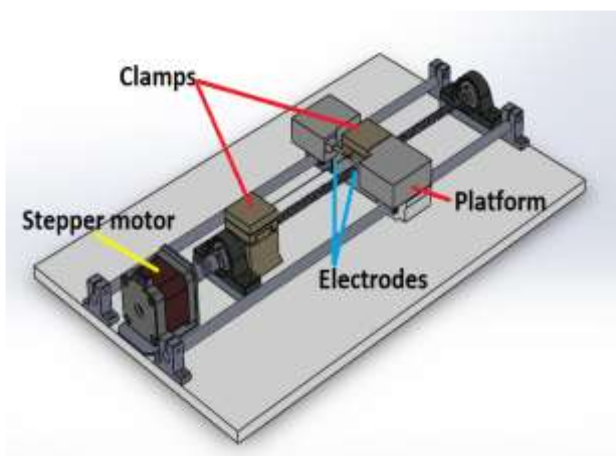

Figure 1 Basic concept of the platform

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Here the system has to sense the tension applied on the optical fiber, which is achieved by a strain gauge installed under the fixed clamp and its measurement is converted in newtons per meter, once the cell is characterized and linearized using measurement patterns previously. For electric arcs, there are two functions that can be modified independently, the gap between both electrodes and the triggering pulses.

Electric arc

Indeed Electric arc is generated by the flybacks converters series-connected; both consume energy from the same power source. Using a optocoupler circuit to isolate from the timer board and avoid damage to it. The circuit to generate the pulsing voltage for flyback converters is presented in figure 2a and both converters' series-connected in figure 2b, respectively.

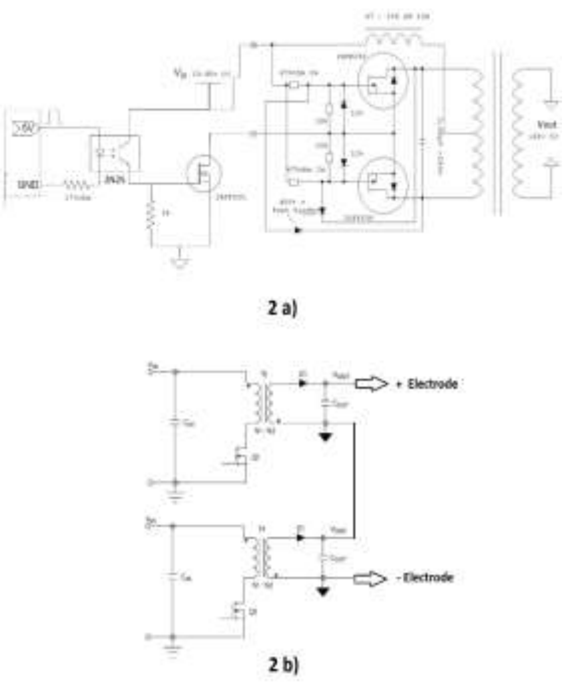

Figure 2 Schematic diagram, a) circuit to drive each fly-back converter, b) Tow converts series-connected

Then the driver circuit is supplied by 30 dc Volts, then the driver commutates at a frequency of 10 kHz, its output generates a 140 dc Volts (pulsating), after that this output is the input for each fly-back converter parallel-connected to the driver circuit; finally, the converters have an output of 10 kVdc, which generates a 20 kVdc approximately, so with this amount of voltage an electric arc is created, their terminals can be close to each other from 3 mm to 10 mm.

Movement of electrodes

Eventually, The mechanism for separating the electrodes can be observed and the rest of the system are in figure 3. They are placed on two stepper-motor mechanisms. Both motors are driven by a L293 driver circuit, that is connected and controlled by the main board (ATmega 2560).

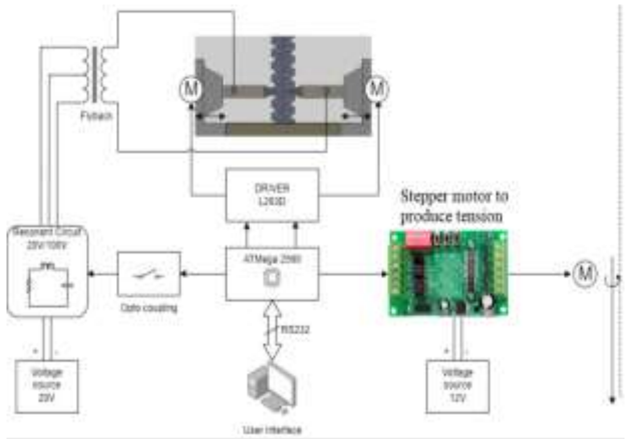

Figure 3 General block Diagram with the system stages

Tension measurement

Secondly, the stepper motor, seen in figure 1, is connected to a stepper motor Tb6560 driver as observed in figure 2. As previously mention, the tension is measured by a strain gauge connected to the ATmega board as well. Its values are sent to the microcontroller on the development board and control the tension is then applied. This connection is presented in figure 4.

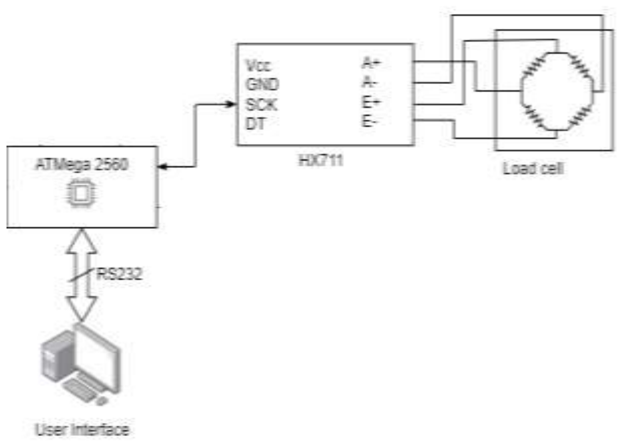

Figure 4 Strain gauge connection

Importantly, the strain gauge must be connected by means of a circuit to condition and amplify the electrical signal, so the microcontroles ADC can read that signal.

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System interface

Summarizing, there is a human-machine interface HMI or display, where several parameters have to be settled, for example: electrode gap, time and pulses for the electric arc. The HMI is presented in figure 5. It is communicated with the ATmega board by USB, so the complete system is controlled by the computer. Certanly, this is one of the system advantages, it can be connected to almost any Windows-compatible computer, due to the platform modularity, the system can eventually be updated to sense other variables or add more stages to the equipment. Since the system is open access user can modify it as much as necessary. It is necessaty to mention that the HMI was designed in Microsoft Visual Studio

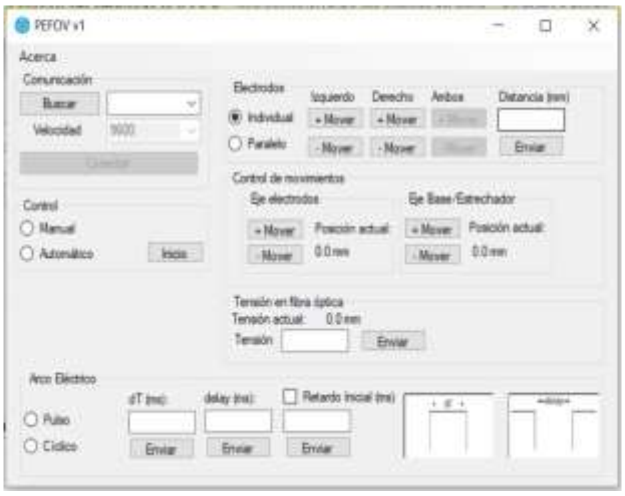

Figure 5 HMI on the computer

Equipment operation

Afterword, when the fiber is placed in position and system is connected (USB-port), application must be initialized. Then the port speed has to be settled. After that user has to set tension and time for pulses. Operation is described in figure 6. It is important to follow the sequence so the communication can be stablished.

Finally, the optical fiber filamente has to be placed in position and secured to keep in its place during tests. Later, the electrodes should be alighned so the electric arc affects the surface of the filament. The arc is strong enough to burn so its important to start with a low level arc. Furthermore, time is a key aspect, it must be short terms or pulsing discharges.

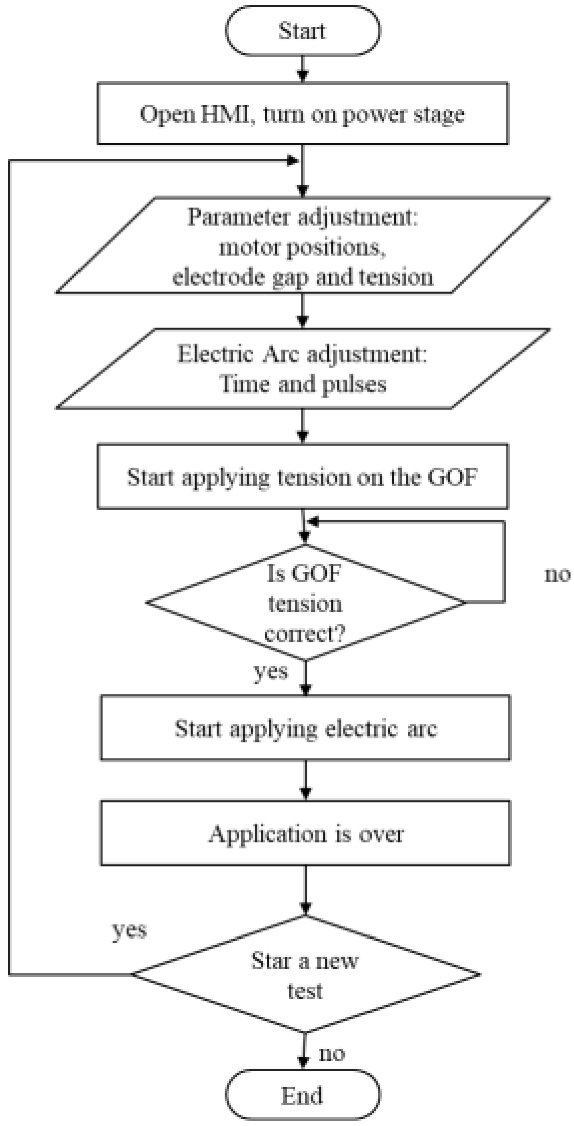

Figure 6 Stage of the stretching process

Indeed a performance of the system cab be seen on figure 7, where the fiber is settled under tention and exposed to the electric arc, in order to get stretched and therefore affectation on its structure. Also in picture 8, a close up to the electric arc exposure took places. Where the optical fiber filament is under the effects of temperature.

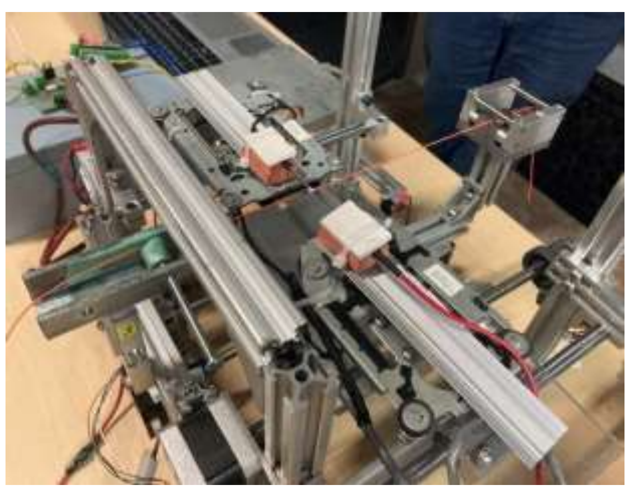

Figure 7 Stretching platform in operation

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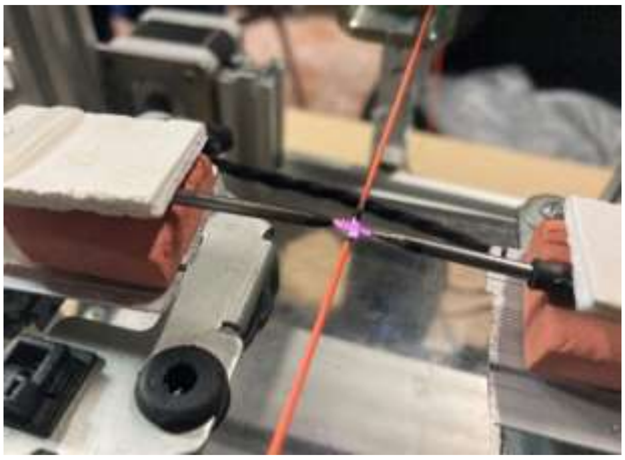

Figure 8 Close up to the electric arc

Results

Several tests took place on the system stretching, the GOF was espoused to a tension of 0.9 newtons, and the GOF had an elongation of 0.5 mm with pulsing intervals of 2 seconds on and 3 seconds off for 15 seconds, the platform has proved its effectiveness, modularity and functioning. The GOF got stretched and parameters can be adjusted as needed by user. In figure 9, the complete platform can be observed.

Figure 9 Complete stretching system

Conclusions

A robust system was built to produce electric arcs strong enough to heat up GOF at the point to stretch them. An electric circuit was developed with a software and a HMI to control periods for the electric arc and the tension applied to the optical fiber. The system is modular and open architecture to be able to incorporate more stages and add other parameters for more integrated tests. With this prototype, it is expected to start new researches on medical, construction and environmental sensors.

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