

DESIGN AND CONSTRUCTION OF A WORKBENCH FOR TESTS IN A DENTAL WRENCH WITH DIGITAL DISPLAY

Abstract. *Wrenches have been used in dental surgeries to measure the torque applied to bolts. An excess or lack of torque in the screw fixation can cause gaps or deformations that resulted in the loss of the implant. The conventional wrenches used in dentistry do not have displays to indicate the applied torque. The main objective of this work is to development this dental wrench. In this paper will be present the design and fabrication of a workbench to test the sensor that will be applied to high-precision digital Torque Wrench to be use in dentistry. The aim is to ensure the accurate determination of the intensity of torque applied to the bolt.*

Keywords*: dental wrench, strain-gage, senso*

1. INTRODUCTION

Engineering tools has been used to help doctors and dentists to restoring function lost, illness or trauma. It has been noticed that many advance in dentistry and medical area is happening because of the interaction of these areas with others area. This interdisciplinarity has become needed to promote the advances in biomaterials area applied in human health (KASEMO, B 2002).

Anthropological findings in Europe and Central America indicate that the use of prosthetic devices started a long, long time ago. The human has been used equivalent material like human and animal tooth to recover body functions (CESCHIN, J.R. 1984).

In 1952 Swedish researchers developed new dental implant concept, the osseointegrate implant. Its efficiency has been proved since then due uncountable dental implants that is working for long time (BRANEMARK P.I *et al* 1969). These same authors developed the first titanium dental implant screwed in the bones without interaction with soft tissue (BRANEMARK P.I *et al* 1969).

The search for elastoplastic materials to replace human parts as prosthetic devices has been one of the goals of the material researchers this century (CORREIA, S.M.B, 1999). In the last few years osseointegrated implants has been used as a dental prosthesis root. During the osseointegrated implant operation it is necessary to fasten a prosthetic root to the bone where will be fix the prosthesis. The stability of the prosthesis is manly depended of the stability of the screw fixation and the osseointegration. The screw fixation is direct related with the implant class and shape, the resistance of the bone and the applied torque to screw during surgery (MISCH, C.E, 2006; HAACK J. *et al,* 1995). The correct torque applied to the screw is essential to the integrity of the prosthesis/implant interface. Implant producers presents the torque necessary to maximize the implant efficiency, but the relaxation of the screw is one of the most common causes of fail in dental implants (BINON P, 1994; NAERT I., 1992; JEMT T.,1991) due a wrong torque applied during fasten.

When the screw relax from the bone all the dentist work needs to be repeated. Some dentist has sensibility to identify the correct force applied to fasten the screw to maximize the implant quality. This quality is normally based on the dentist know how and not because of the tools that he uses (MISCH, C.E., 2000; MCGLUMPHY *et al,* 1998).

The main goal of this work is to develop a wrench with digital display for measurement of the correct torque applied during surgery of dental implants with low cost. In this paper will be present the development of a workbench to measure the torque applied to the sensor fixed in a beam similar to the one in dentists tools.

2. METHODOLOGY

2.1 Workbench

The workbench is divided in 3 (three) sections:t bench, measure system and torque system.

The Torsion system was first designed in CAD environment, and was tested many possibilities. In the Figure 1 is present the model of of the system.

The Torsion bench was mounted with a steel board (1), two roller bearings (2). In the first were fixed two bearings 6001 ZZ/C3FBJ (6) and an axis (4) free to roll.

In this axis the metal cilinder (9) used as a test object was fixed with a pin (8), and the bodies was fixed with a pin in the system, including the cover (5).

The torsion benchwas build with steel AISI 1045, and the test piece with aluminum with 8,0±0,2 mm of diameter and 90,0±0,2 mm length, with 2 (two) holes in the borders.

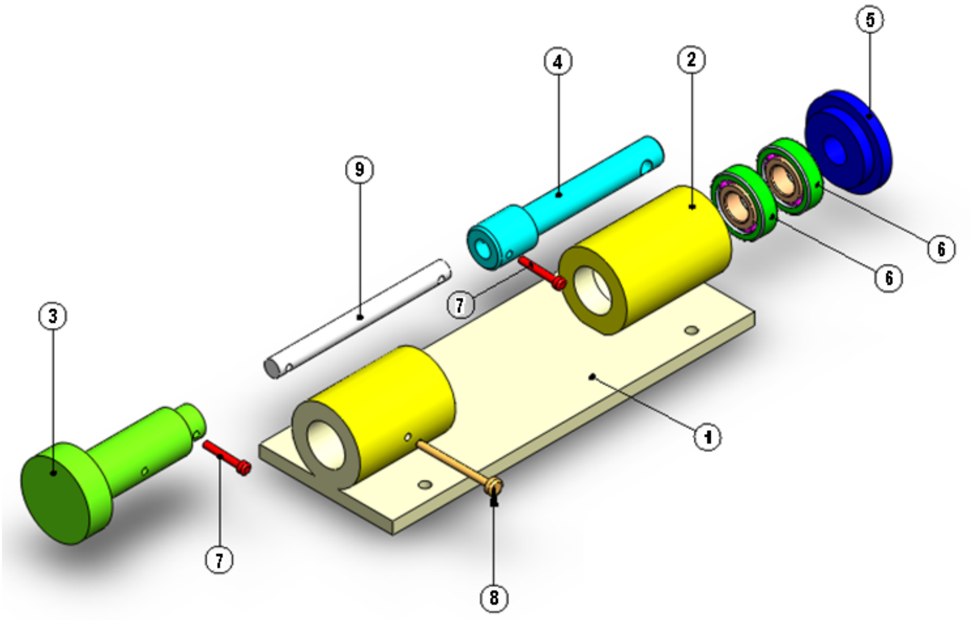
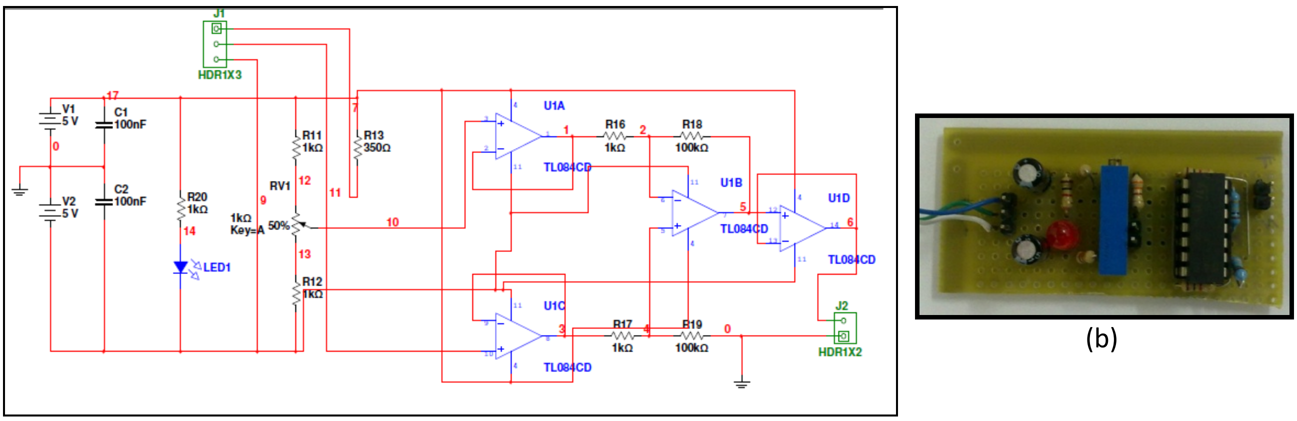


FIGURE 01: Exploded view

The measure system is mounted with a dc power supply of ± 5 Volts, a strain-gage in Wheatstone ¼ bridge and a trimpot, a sign led and an amplifier and filtering board (Figure 2) and a digital multimeter with resolution of 0,01V.



(a)

FIGURE 02 – (a) schematics of the circuit board. (b) – circuit board

The strain-gage was fixed to the test piece to measure the deformation. Before fix the stran-gage rhe piece was cleaned and sanded with sandpaper 220, than 360 and 400. The roughness of the surface helps in the fixing of the strain-gage. After that it was used swab with isopropyl alcohol and others components to prepare the surface. It was used super Bonder ® Loctite, to fix the stran-gage in the test piece as follow:

1 – It is clean a piece of glass with isopropyl alcohol;
2 - The sensor It is place at the glass with the filaments to up;
3 – It is use an adhesive tape over the sensor;
4 –Glue is added over the test piece and the sensor was moved to over the glue using the adhesive tape. There is no contact with the sensor and human hand.
5 – A socket T-50 is fixing to the test piece with the sensor.

The sensor was tested after the fixing process.

The torque system is a lever and a bulkhead, like the one used in pan balance, fixed in the torsion system. The lever have 6,0±0,3 mm do diameter and 122,6±0,1 mm length. The bulkhead was fixed in the lever with 100±0,5mm of distance from the center of torsion.

The procedure to fix the torque system in the torsion bench and to build the workbench it describe as follow:

1 – The torsion bench was fixed in a rigid table;
2 – The test piece was attached to the bench using pins;
3 –The lever and the bulkhead was attached in the torsion bench
4 – The wires it was connected and the circuit is turned on;

2.2 The tests

Mass Standards of 100±0,1g, 200±0,1g, 300±0,1g, 400±0,1g and 500±0,1g from LEYBOLD, called as M1, M2, M3, M4 and M5, were used to apply and static torque in the workbench. M5 was added to the in the bulkhead for 3 minutes to verify the sensor response, and the fixation process. The mass of the lever and the bulkhead were measured using DENVER INSTRUMENT scale with 0,01g precision.

The sensor response was measured using the LEYBOLD mass standards attached to the bulkhead to generate torque. Each mass was used alone and the sensor response was measure during 1 minute. For each mass was made 3 tests on each direction.

The torque (N.m) applied to the system was calculated using the equation (1), which each component represents the force of its mass in a distance from the rotation point (FIGURE 03).

$$M_t = F_m d_m + F_b d_b + F_l d_l \quad (1)$$

F_m – Force of mass standard;
d_m – Distance from the mass standard centroid and rotation point;
F_b – Force of the bulkhead;
d_b – Distance from bulkhead and the rotation point;
F_l – Force of the lever
d_l – Distance from the lever centroid and the rotation point.

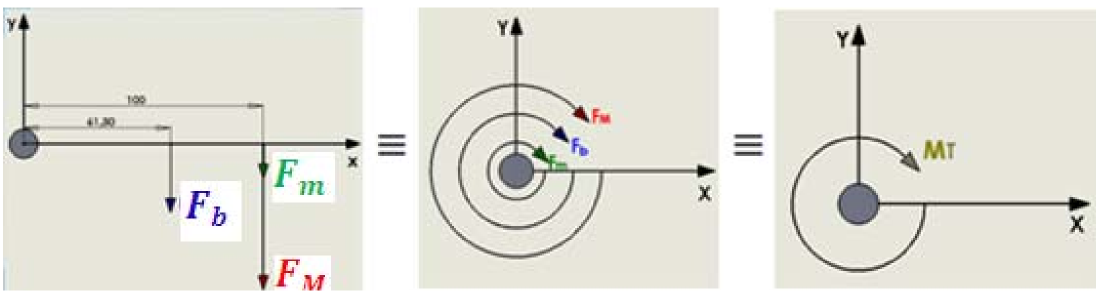


FIGURE 03 – Forces and Torques applied to the system

3. RESULTS AND DISCUSSION

The tests were named as T1, T2, T3, T4 and T5 according to the mass used to generate the torque (Table 01). It was realized testes in both directions, clockwise and a counter-clockwise to analyze the sensor response.

The lever mass is 26,3±0,3g The distance between lever centroid to rotation point is 6,13±0,5cm, consequently $T_L = F_L*d_L$ = 1,75±0,2N.cm. The bulkhead mass is 6,0±0,3g and the distance to rotation point is 10,0±0,5cm consequently $T_b = F_b*d_b$ = 0,62±0,1N.cm. The gravity (g) was considered as 9,81 m/s^2.

Table 1. Experimental results for flexural properties of CFRC-4HS and CFRC-TWILL composites.
Span/depth ratio = 35:1. Average results of 7 specimens.

	T1		T2		T3		T4		T5	
mass (g)	M1 $10,0 \times 10^{1} \pm 0,1$		M2 $20,0 \times 10^{1} \pm 0,1$		M3 $30,0 \times 10^{1} \pm 0,1$		M4 $40,0 \times 10^{1} \pm 0,1$		M5 $50,0 \times 10^{1} \pm 0,1$	
Distance - d_m (cm)	10,0 ± 0,005		10,0 ± 0,005		10,0 ± 0,005		10,0 ± 0,005		10,0 ± 0,005	
Force - F_m (N)	$9,81 \times 10^{-1} \pm 0,001$		1,96 ± 0,002		2,94 ± 0,002		3,92 ± 0,003		4,90 ± 0,003	
Torque – T_m (N.cm)	10,3 ± 0,5		20,6 ± 1,0		30,9 ± 1,5		41,2 ± 2,0		51,5 ± 2,5	
Torque – T_L (N.cm)	1,57 ± 0,15		1,57 ± 0,15		1,57 ± 0,15		1,57 ± 0,15		1,57 ± 0,15	
Torque – T_b (N.cm)	$6,18 \times 10^{-1} \pm 0,06$		$6,18 \times 10^{-1} \pm 0,06$		$6,18 \times 10^{-1} \pm 0,06$		$6,18 \times 10^{-1} \pm 0,06$		$6,18 \times 10^{-1} \pm 0,06$	
Total torque (N.cm)	12,5 ± 0,07		22,8 ± 0,08		33,1 ± 0,09		43,4 ± 0,10		53,7 ± 0,11	
Tension measured (Volts ± 0,005)	clockwise	Counter - clockwise	clockwise	Counter - clockwise	clockwise	Counter - clockwise	clockwise	Counter - clockwise	clockwise	Counter - clockwise
	0,01	-0,01	0,02	-0,02	0,03	-0,03	0,04	-0,03	0,05	-0,05

Using table 01, it was built the Figure 04, which represents the Voltage in sensor x applied torque.

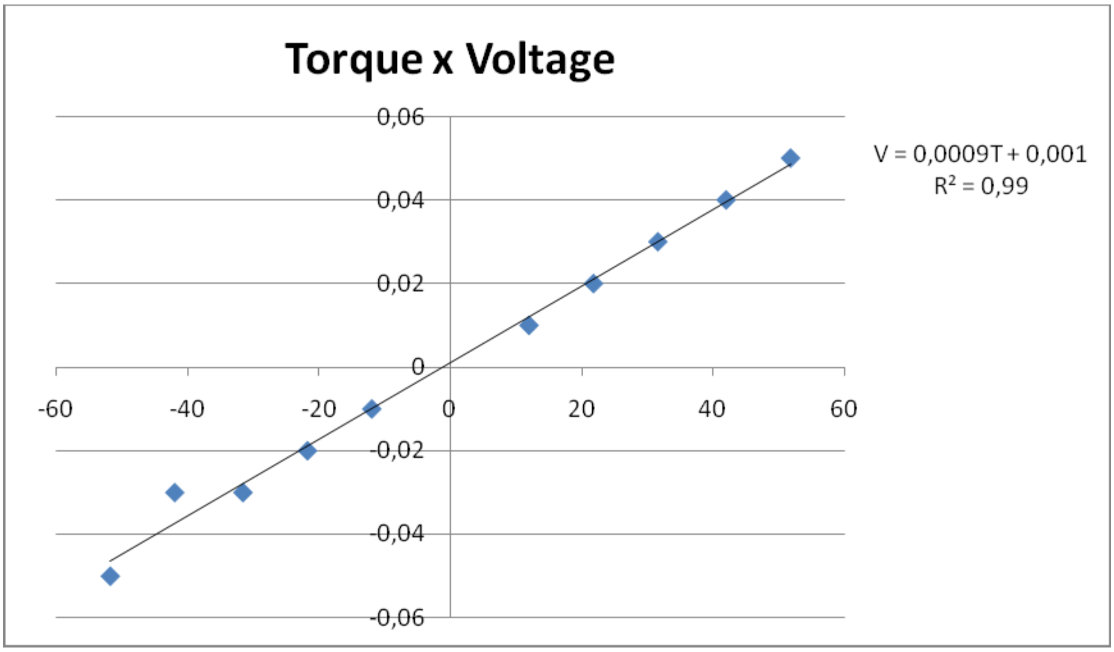


Figure 04 - Torque x Voltage

The line (y) in figure XX represents the relation between the torque and the Voltage. The equation with R^2 almost equal 1 (one) represents that the relations is completely linear. This means that the use of one strain-gage is enough to correlate the deformation with the applied torque.

With Table 01 is possible to notice that the main errors in the system are related with the voltage, with a percentage error of 50% in test T1. For the point of the test T4 counter-clockwise was expected a value -0,04V, but it was found -0,03V. This value can be explained due to resolution of the system. It is necessary a more accuracy system to get a better curve for the signal and maybe the use of two strain-gages as counterproof. The main objective now is to develop a better filter, amplifier and capture system for better resolution to be able to adapt this system into a dentistry tools.

4. CONCLUSIONS

With the results and the knowledge acquired during the development and test of the workbench it is possible to notice that this methodology is stable and capable to be use in the development of dental wrench with digital display.

It is necessary a better resolution for the signal analysis.

It is possible to determinate the torque and the signal response using standard mass.

It is necessary more tests for the development of the dental wrench with digital display, but the same methodology and workbench can be used. It is necessary change the distance of the bulkhead to change the torque in the system.

In the workbench it is use only one lever with the bulkhead. This system results in a torque and a reaction in the rotation axis, but the two roller bearings were use to eliminate the deformation causes the direct force.

5. ACKNOWLEDGEMENTS

This optional section must be placed before the list of references.

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7. RESPONSIBILITY NOTICE

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