PERIODONTAL DISEASE APPARATUS USED FOR MEASURING AND COMPUTERIZED MONITORING USING A SLIDING BEARING WITH A HELICAL CONVOLUTE ELEMENT

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Ghidajele de alunecare sunt subansambluri mecanice foarte bine definite atât sb aspect teoretic cât şi ca realizări constructive, principalele mărimi de interes fiind jocurile / preciziile din ghidaj şi forțele de frecare. În general ele controlează însă mişcări pur liniare. Un caz special de ghidare apare atunci când elementul mobil / ghidat este flexibil şi se deplasează pe un traseu sinuos. O asemenea situație s-a identificat la un instrument medical utilizat pentru măsurarea adâncimii de desprindere a gingiei față de dinte, pe seama căreia se decide stadiul unei afecțiuni parodontale. Acest instrument trebuie să aibă un palpator – o tijă cilindrică flexibilă cu diametrul de 0,5 m, care să se deplaseze pe un spațiu de 20 mm cu o forță rguros constantă de 0,2 N. Condiția de forță constantă impune o forță de frecare constantă a cărei cunoaştere, bayată în special pe o cercetare experimentală, face obiectul prezentei lucrări, în care sunt redate şi analizate rezultatele obținute.

Sliding bearings are very well defined both from theoretical as well as constructive point of view mechanical assemblies, the main features being the gap between the bearing's elements, its precision and the frictional forces. In general, they control the purely linear movements. A special case occurs when the mobile / guided item is flexible and moves on a winding path. Such a situation was identified at a medical instrument used for measuring the gum's detachment from the tooth depth, which can tell the periodontal disease's evolution status. This tool should have a stylus - a flexible cylindrical rod 0.5 mm in diameter, which move over a distance of 20 mm with a constant force of 0.2 N. The medical rigorous condition requires a constant friction force whose knowledge, based mainly on experimental research, represents the present work's goal, the results being presented and analyzed.

Keywords: Sliding bearing, Computer monitoring, Periodontal disease, Controlled friction

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1. Introduction

Following the tests carried out on a PhD thesis it was realized the need for a lower friction force. The problem consists in guiding a 0.5 mm wire diameter of on a path that contains two curves with very small radius. The first two straight lines are forming an obtuse angle and the last two a right angle. The end of the wire is not to be guided. It will always remain outside the curvature zone. Distal end's position is determined with a magnetic sensor and a magnetic strip (their position will be determined from tests) (Fig. 1).

Fig. 1. Stylus, bearing, magnetic sensor and magnetic strip

The need for a lower and constant friction force is obvious. The idea of using a "helical" bearing emerged in this context. The bearing consists of a coil spring inserted into a rigid tube and fixed to its walls. The tube has the desired shape and the arc will take this shape.

Because no experimental research was found in this direction, it was decided to study the coil springs and hence the "helical" bearing's step importance over the friction force between the guided wire and the bearing. This bearing type is described in U.S. Patent no. 4462644. However, this patent describes another use for it [1].

2. The experimental method

To complete the research two IMADA force sensors were used (ZP-ZP-5N and 500N) [2] and a test stand produced by the same company (HV-500N) [3], mounted as shown in Fig. 2. Three coil springs with the following technical characteristics were made from the same blank (0.3 mm thick wire) (Fig. 3):

- the first coil spring:
  - step: 1.5 mm;
  - outer diameter: 4.1 mm;
- the second coil spring:
  - step: 0.5 mm;
  - outer diameter: 4.5 mm;
- the third coil spring:

- step: the turns are touching;
- outer diameter: 4.5 mm;

In each case the measuring length on which the experiments were made was approximately 40 mm.

The necessary tubes for the experiments were constructed based on the following assumptions:

a) the testing is done on longer than needed measuring length and because experimental stand's dimensions a 40 mm was achieved;
b) the study will be done on a straight direction for a better experimental repeatability; a complex construction will induce construction errors, and many errors will appear, that could hardly be controlled;
c) the same material will be use to always have the same friction coefficient;

Fig. 2. IMADA force gauge and stand during an experiment

d) as many repetitions as possible will be done to get an average closer to reality.

Given these assumptions the springs were built having a height of 50 mm.

Fig. 3. The three coil springs and the rod used in experiments

The tubes were made from thin sheets of paper and glue. To ensure a rigid fixation between the springs and the tubes and that they have a proper inner diameter, they were built around the springs. The spring was surrounded by a paper sheet and then a thick layer of glue was applied. The same operation was repeated several times. Afterwards several tape layers were applied and they were allowed to dry for 24 hours. The resulting rigid tubes have an inside diameter equal to the springs outer diameter, and those are rigidly fixed to the walls (Fig. 4).

A rod with a smaller diameter than the spring's inner diameter was attached at the force gauge so that they can come into contact with the bearing on a single line. The rod's end that touches it is tapered to reduce the problems that might arise from clinging to the coils (Fig. 3).

Fig. 4. An example of a rigid tube and spring used during experimentation

All three bearings were placed at the same point in a fixed mounting system (Fig 4). The force gauge and the rod were mounted eccentrically to the bearing's symmetry axis so that a contact between them will appear.

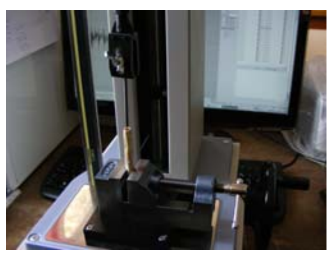

Fig. 5. The rod, one of the tubes and the test stand during the experiment

The measuring length was chosen so that the rod will not rise above the bearing's upper end and at the lower end the force will not exceed the maximum force gauge's permitted value. Thus it resulted a 40 mm distance.

After the experiments were started it was noticed that the force values are very small, so the gauge with the upper permitted force value of 500 N was no longer used. Thus all measurements were made with the 5 N force gauge.

For each bearing were performed 20 experiments for stroke (the rod advances from top to bottom and then the data acquisition stops and the system is repositioned for a new experiment).

The data acquisition was done with a PC and the ZP Recorder software [4] offered, also, by IMADA, via a USB connection. This program provides the results as a graph representing the force over time evolution (Fig. 6).

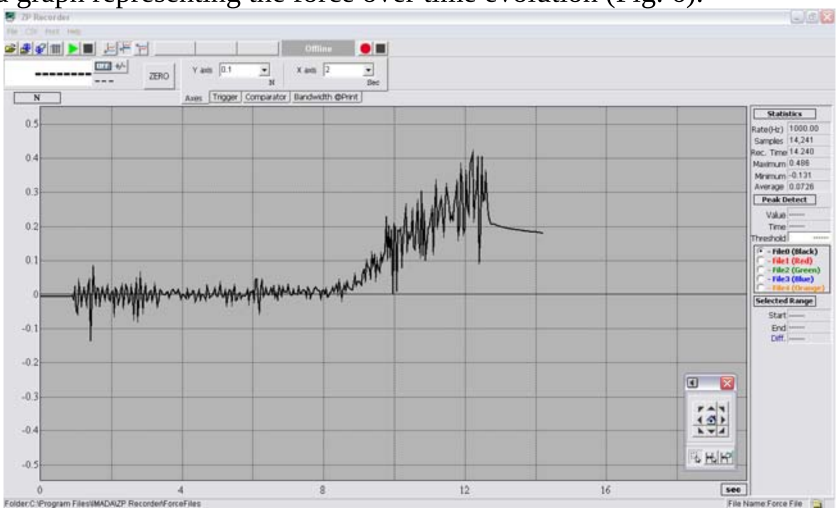

Fig. 6. A ZP Recorder screen capture after an experiment made for this paper

The gauge's movement is done manually with the test stand's mechanisms and its position is observed. A constant speed was tried to be kept and the results show the fact that the time for each experiment are equal or very close.

3. Data processing

Data were exported in the ".CSV" and ".PDF" file format to be processed using spreadsheet programs and at the same time, to be easily visualized (Fig. 7, Fig. 8, Fig. 9).

In all graphics two areas with different characteristics can be seen. An area in which the force varies roughly around the same values and an area in which the value ranges vary following an ascending curve. The second zone corresponds to the rod touching the bearing's lower end, where the rod is forced to deviate from the vertical direction. Because this situation will not be found in the original problem, the data from the first area will be processed.

To collect the necessary data each record is seen and the time period from which they are retrieved is visually determined. The numeric data are picked from the ".CSV" files. These values are averaged, the peak is determined and the percentage of how higher it is from the average is calculated with the following formula:

$$v = \left| 100 - \frac{mean}{\max} \cdot 100 \right| \tag{1}$$

In formula (1) v represents how higher it is from the average (%), $mean$ is the arithmetic mean of the selected values (N) and $\max$ is the maximum of these (N). After the processing the results are tabulated and the average, the peak and the percentage of how higher it is from the average are determined.

4. Conclusions

The results are presented in tables for a better differences illustration (Table 1, Table 2 and Table 3). It is noted that the best results were obtained when the 0.5 mm step "helical" bearing was tested. With these results it appears that the best results are obtained with such guides.

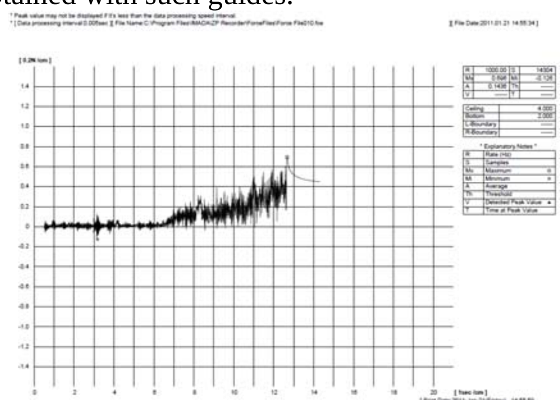

Fig. 7. Diagram representing an experiment for the first coil spring

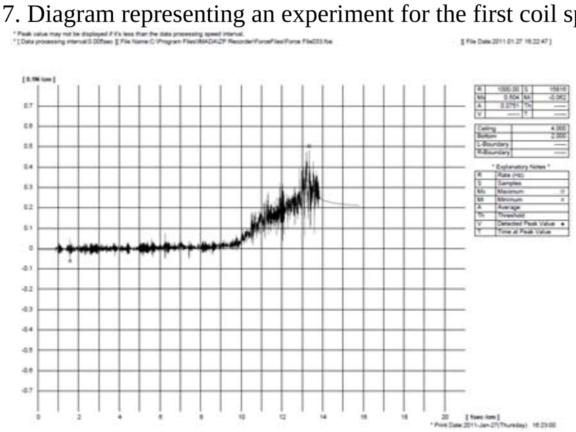

Fig. 8. Diagram representing an experiment for the second coil spring

Future improvements

Although differences are quite large the study should be repeated with a larger experiments number and experiments for the return path, from the bearing's bottom end to the top after which the data acquisition stops and the system is repositioned for a new determination, should be made. It also would be useful to use a motor driven test stand to ensure a rigorously constant speed.

Another direction the study should be conducted would be to carry it for a guide with one or two curves because the literature suggests that friction would be lower in the second case.

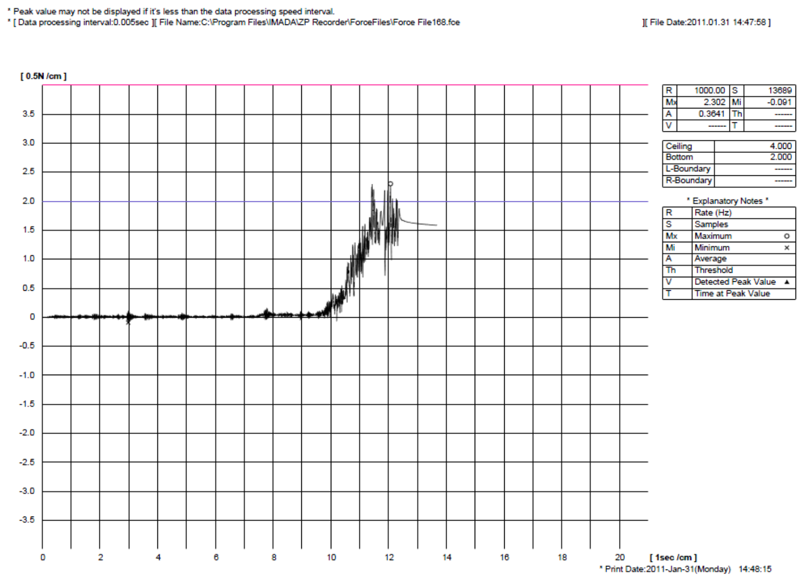

Fig. 9. Diagram representing an experiment for the third coil spring

Table 1

Experimental results for the first coil spring

the first coil spring					
experiment no.	total time	processing time	mean	maximum	percentage variation
1	15,614	3,000	0,019	0,085	342,332
2	16,229	3,000	0,014	0,091	558,927
3	12,979	4,000	0,021	0,126	498,653
4	15,689	5,000	0,021	0,095	358,729
5	15,124	4,000	0,021	0,092	328,615
6	13,707	3,000	0,026	0,106	313,127
7	16,465	5,000	0,019	0,114	495,537
8	14,304	5,000	0,020	0,132	553,970
9	17,615	6,000	0,018	0,116	562,649
10	13,627	6,000	0,017	0,100	479,139
11	13,819	6,000	0,025	0,162	538,906
12	14,250	6,000	0,018	0,129	605,509
13	12,856	6,000	0,017	0,099	486,117
14	13,790	6,000	0,017	0,094	443,955
15	12,483	5,000	0,020	0,094	371,656
16	14,653	6,000	0,020	0,121	509,106
17	11,868	6,000	0,022	0,165	655,610
18	13,308	6,000	0,020	0,100	397,517
19	16,591	7,000	0,017	0,091	443,701
20	13,625	7,000	0,022	0,119	431,243
mean	14,430	5,250	0,020	0,112	468,750
maximum	17,615	7,000	0,026	0,165	655,610
percentage variation	22,074	33,333	30,017	47,916	39,863

Table 2

Experimental results for the second coil spring

the second coil spring					
experiment no.	total time	processing time	mean	maximum	percentage variation
1	16,655	7,000	0,013	0,081	502,794
2	17,127	5,000	0,010	0,078	645,441
3	16,548	6,000	0,011	0,069	518,261
4	16,622	7,000	0,009	0,057	521,224
5	16,935	7,000	0,010	0,051	421,366
6	16,300	7,000	0,011	0,077	605,516
7	17,539	8,000	0,012	0,084	629,776
8	18,244	9,000	0,011	0,063	477,511
9	16,154	8,000	0,012	0,070	503,006
10	17,978	9,000	0,010	0,059	466,279
11	16,971	8,000	0,010	0,058	452,908
12	16,553	8,000	0,011	0,069	539,525
13	16,321	7,000	0,010	0,097	890,113
14	16,591	6,000	0,011	0,057	441,611
15	15,476	7,000	0,014	0,071	401,165
16	16,453	6,000	0,011	0,104	884,880
17	16,673	7,000	0,012	0,089	647,020
18	15,353	7,000	0,013	0,080	513,376
19	14,597	6,000	0,012	0,097	684,441
20	14,331	6,000	0,016	0,106	574,672
mean	16,471	7,050	0,011	0,076	566,044
maximum	18,244	9,000	0,016	0,106	890,113
percentage variation	10,764	27,660	37,373	39,750	57,252

Table 3

Experimental results for the third coil spring

the third coil spring					
experiment no.	total time	processing time	mean	maximum	percentage variation
1	14,490	5,000	0,032	0,157	390,211
2	14,781	6,000	0,031	0,088	187,881
3	13,674	6,000	0,028	0,182	552,345
4	13,237	5,000	0,023	0,200	785,661
5	16,019	7,000	0,019	0,174	805,650
6	12,971	6,000	0,018	0,138	666,823
7	14,213	5,000	0,016	0,102	539,242
8	13,371	9,000	0,020	0,126	530,168
9	13,689	9,000	0,021	0,192	822,717
10	12,873	9,000	0,020	0,129	551,270
11	15,550	8,000	0,015	0,081	449,889
12	13,942	7,000	0,016	0,094	491,966
13	12,289	6,000	0,019	0,117	506,359
14	12,988	6,000	0,018	0,086	371,733
15	13,106	6,000	0,018	0,116	528,335
16	11,976	7,000	0,018	0,112	518,014
17	12,733	6,000	0,016	0,106	560,937
18	11,781	6,000	0,021	0,154	619,817
19	13,174	6,000	0,020	0,132	558,124
20	12,319	6,000	0,019	0,112	478,971
mean	13,459	6,550	0,020	0,130	545,806
maximum	16,019	9,000	0,032	0,200	822,717
percentage variation	19,022	37,405	56,839	53,965	50,734

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R E F E R E N C E S

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