The 3rd International Conference on "Computational Mechanics and Virtual Engineering"

COMEC 2009

29 – 30 OCTOBER 2009, Brasov, Romania

RESEARCH ON THE KINEMATICS OF A PREHENSION MECHANISM BASED ON THE SNAKE BIOMECHANISM

Liliana Luca[1], **Iulian Popescu**[2]
[1]University Constantin Brancusi , Targu Jiu, ROMANIA, lylyanaluca@yahoo.com
[2]University of Craiova , Craiova, ROMANIA, rodicaipopescu@yahoo.com

Abstract: *We study the kinematics of a prehensile mechanism based on the study of the snake masticatory apparatus. Laws of motion are established for the two conducting elements and there are determinated the positions of the mechanism, checking the opening area and the packing domain. We are looking for more advantageous solutions by changing some dimensions of the mechanism.*
Keywords: *snake biomechanism, prehensile mechanism kinematics*

1. INTRODUCTION

Based on the study of the movements of the snake masticatory apparatus, was developed a kinematic scheme of the equivalent prehensile mechanism, given in figure 1. For the calculations below it was considered the drawing in figure 1 as being at 1:1 scale, the quotes having the data values which are shown in figure.

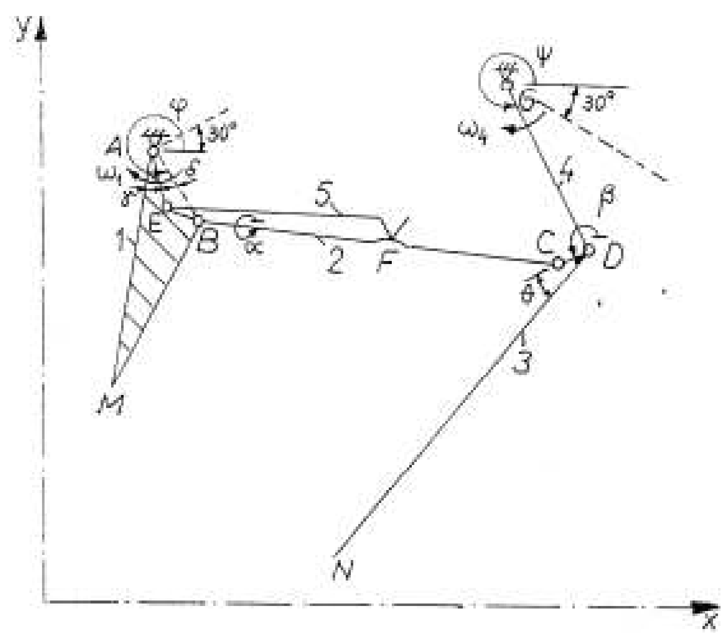

Figure 1: Kinematics scheme

2. THE MECHANISM STRUCTURE

The mechanism from figure 1 is plane. It has 5 elements, 6 couplings of the fifth grade (A, E, B, C, D, G) and a superior coupling of IV th grade in F (the contact between 2 and 5, in F, is assured permanently by an arch and the 2 element is shaped).
Follows: M = 3 • 5.2 • 6.1 = 2

They are considered the leading elements 1 and 4.
The mechanism is composed of:
- leading elements 1 and 4-with rotation movement;
- BCD dyad of RRR type;
- EFF dyad of RRR type of fig. 2 (the upper coupling element of F was replaced with FF 'and couplings F, F `)

Real elements are curved rods, but for calculations were simplified as in figure 1.

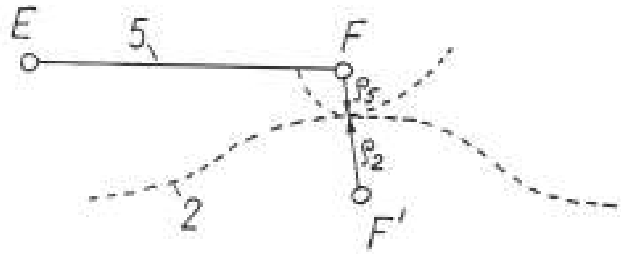

Figure 2: EFF' dyad of RRR type

3. KINEMATIC STUDIES

We aimed to see if the equivalent mechanism ensures –as positions- similar movements to the biomechanism.

We started in the field of motion of each leading element, from fig. 1. It was taken as time to open -2 seconds.

To establish the laws of motion of the leading elements, we left from the areas division (angles) in each 50 intervals, considering the angular speeds constant.

With an adjusted program of "linear regression", were calculated the values for angles, at different values of time "t", the results being presented in table 1.

Table 1: The values of Fi and Psi angles

t	Fi	Psi	t	Fi	Psi	t	Fi	Psi
0	30	-30	.65	2.700005	-39.75	1.299999	-24.59997	-49.49999
.025	28.95	-30.375	.6749999	1.650005	-40.125	1.324999	-25.64997	-49.87499
.05	27.9	-30.75	.6999999	.6000061	-40.5	1.349999	-26.69997	-50.24999
075	26.85	-31.125	.7249999	-.4499932	-40.875	1.374999	-27.74997	-50.62499
.1	25.8	-31.5	.7499998	-1.499992	-41.25	1.399999	-28.79997	-50.99999
.125	24.75	-31.875	.7749998	-2.549992	-41.625	1.424999	-29.84997	-51.37499
.15	23.7	-32.25	.7999998	-3.599991	-42	1.449999	-30.89997	-51.74999
.175	22.65	-32.625	.8249998	-4.64999	-42.375	1.474999	-31.94997	-52.12499
.2	21.6	-33	.8499998	-5.69999	-42.75	1.499999	-32.99997	-52.49999
.225	20.55	-33.375	.8749997	-6.749989	-43.125	1.524999	-34.04997	52.87499
.25	19.5	-33.75	.8999997	-7.799988	-43.5	- 1.549999	-35.09996	-53.24999
.275	18.45	-34.125	.9249996	-8.849983	-43.87499	1.574999	-36.14996	-53.62498
.3000001	17.4	-34.5	.9499996	-9.899986	-44.24999	1.599999	-37.19996	-53.99999
.3250001	16.35	-34.875	.9749996	-10.94998	-44.62499	1.624999	-38.24996	-54.37499
.3500001	15.3	-35.25	.9999996	-11.99998	-44.99999	1.649999	-39.29996	-54.74999

.3750001	14.25	-35.625	1.025	-13.04998	-45.37499	1.674999	-40.34996	-55.12499
.4000001	13.2	-36	1.05	-14.09998	-45.74999	1.699999	-41.39996	-55.49999
.4250001	12.15	-36.375	1.075	-15.14998	-46.12499	1.724999	-42.44996	-55.87499
.4500001	11.1	-36.75	1.1	-16.19998	-46.49999	1.749999	-43.49996	-56.24999
.4750001	10.05	-37.125	1.125	-17.24998	-46.87499	1.774999	-44.54996	-56.62499
.5000001	8.999998	-37.5	1.15	-18.29998	-47.24999	1.799999	-45.59996	-56.99999
.5250001	7.949999	-37.875	1.175	-19.34998	-47.62499	1.824999	-46.64995	-57.37499
.55	6.9	-38.25	1.2	-20.39998	-47.99999	1.849999	-47.69995	-57.74999
.575	5.850001	-38.625	1.224999	-21.44998	-48.37499	1.874999	-48.74995	-58.12498
.6	4.800001	-39	1.249999	-22.49997	-48.74999	1.899999	-49.79995	-58.49998
.625	3.750002	-39.375	1.274999	-23.54997	-49.12499	1.924999	-50.84994	-58.87498
1.949999	-51.89995	-59.24998	1.974999	-52.94995	-59.62498	1.999999	-53.99995	-59.99998

The obtained laws of motion are given in figure 3. They are linear laws.
Based on fig. 1 are written the relations for positions:

$$x_B=x_A+AB\cos\varphi \quad (1)$$
$$y_B=y_A+AB\sin\varphi \quad (2)$$
$$x_E=x_A+AE\cos(\varphi-\delta) \quad (3)$$
$$y_E=y_A+AE\sin(\varphi-\delta) \quad (4)$$
$$x_M=x_A+AM\cos(\varphi-\delta-\gamma) \quad (5)$$
$$y_M=y_A+AM\sin(\varphi-\delta-\gamma) \quad (6)$$
$$x_C=x_B+BC\cos\alpha=x_D+CD\cos\beta \quad (7)$$
$$y_C=y_B+BC\sin\alpha=y_D+CD\sin\beta \quad (8)$$
$$x_D=x_G+GD\cos\Psi \quad (9)$$
$$y_D=y_G+GD\sin\Psi \quad (10)$$
$$x_N=x_D+DN\cos(\beta+\theta) \quad (11)$$
$$y_N=y_D+DN\sin(\beta+\theta) \quad (12)$$
$$(x_E-x_F)^2+(y_E-y_F)^2=EF^2 \quad (13)$$
$$tg\alpha=(y_F-y_B)\,/\,(x_F-x_B) \quad (14)$$

For the F area only F position interested, writing two relations (a distance and an angle).

Carrying on, was made a program for analysis of mechanism positions. With this program, was originally obtained an intermediate position of the mechanism (fig. 4), chosen in order to more clearly see the position of F. After that, we drew more positions of the mechanism (fig. 5).

It is noted that the mechanism is similar to the biological one, achieving a large opening, but not too close "packed".

It was found that small variations of sizes given in fig. 1, affect a lot the working area of the mechanism.

To find other variations (especially because we left from some dimensions offered by biologists, with more errors), it has been changed only GD cotation (in fig. 5 it was taken GD = 38). Thus, GD = 30 resulted in 6 drawing, which shows a better "packing" but also a bigger opening. For GD = 35 were obtained:

-limit positions of the mechanism and some intermediary ones(fig. 7);

-several successive positions (fig. 8) from which you can see distinct trajectory of F;

In fig. 8a, 8b, 8c are given the coordinates variation of interest points on the mechanism; it is found that these variations are nonlinear.

It is noted that the value of GD = 35 is the most convenient, because it provides values close to the biomechanism.

From fig.8 is also observed that the movement of element 3 is made with big variable speeds, from one area to another (the spaces between the entries are unequal, although time periods are equal).

Observing some overlapping-returns in fig. 8, was represented separately the trajectory of N in fig. 9 for GD=35. At the same time, was represented the trajectory of F. For GD = 38, were obtained the trajectories for N and F points in fig. 10.

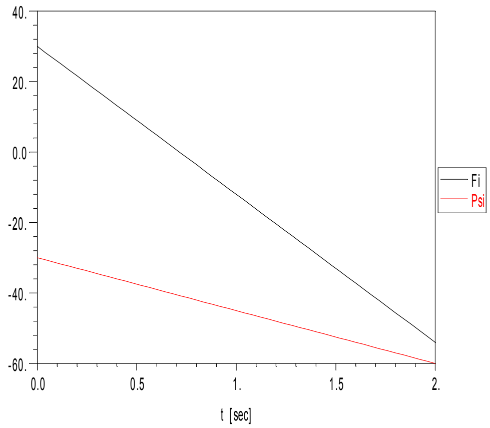

Figure 3: Laws of motion

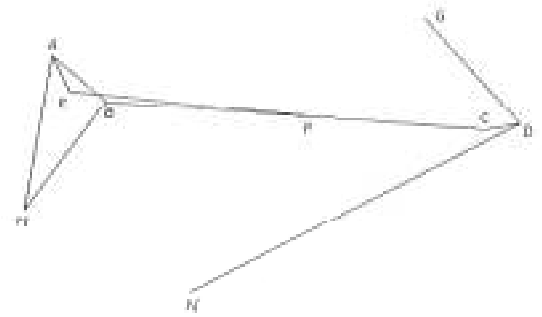

Figure 4: The mechanism in an intermediate position

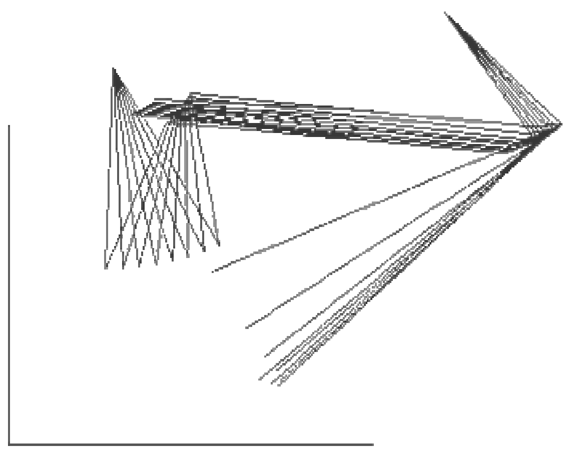

Figure 5: The mechanism positions (GD=35)

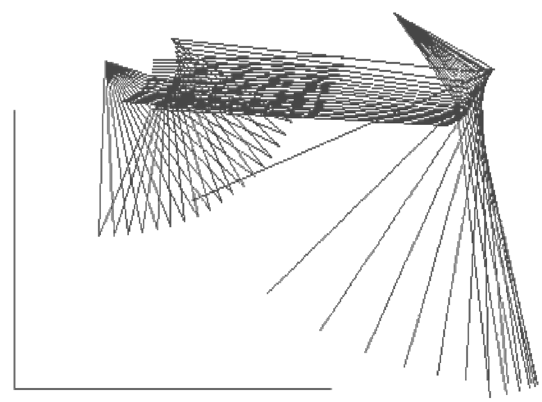

Figure 6: The mechanism positions (GD=30)

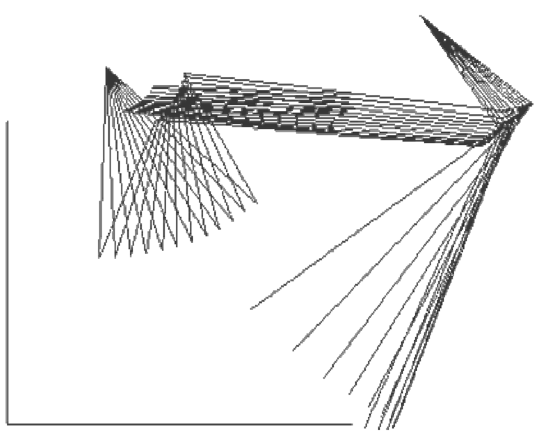

Figure 7: The mechanism positions (GD=35)

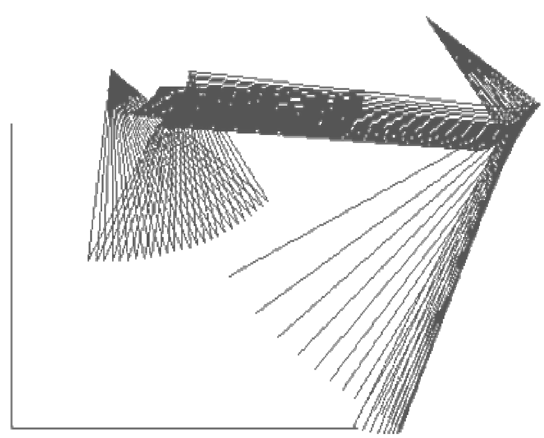

Figure 8: The mechanism positions (GD=35). F trajectory

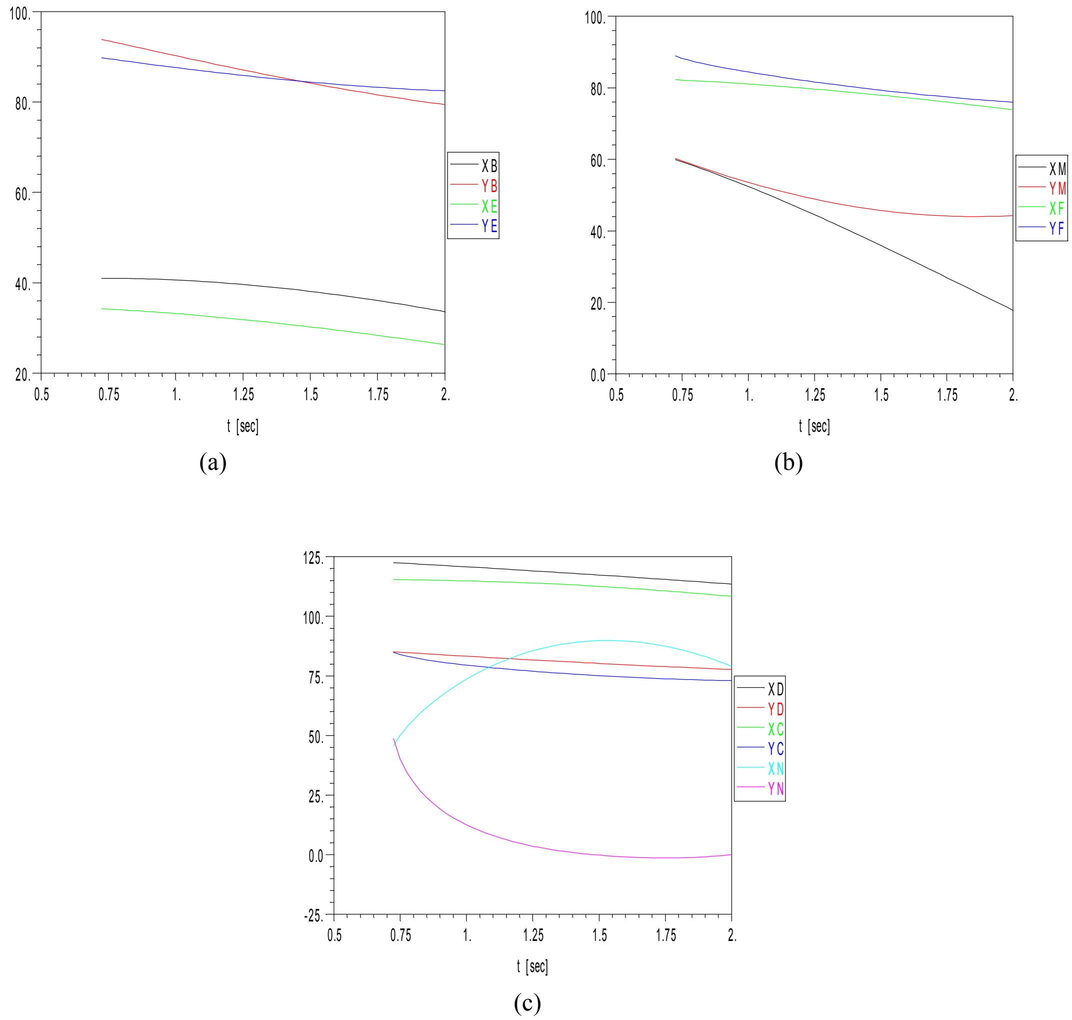

Figure 8 a,b,c: The coordinates variation of interest points on the mechanism

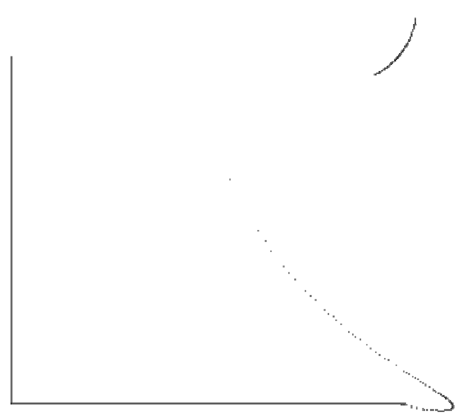

Figure 9: The trajectory of N for GD=35

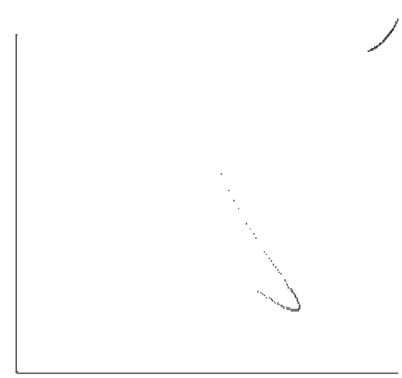

Figure 10: Trajectories for N and F(GD=38)

There have been tried also another solutions to find an opening and a more convenient packaging, adjusting simultaneously more quotations. Results are shown in:

- figure 11: GD=35, BC=80;
- figure 12: GD=25, BC=75;
- figure 13: GD=35, BC=75, y_G=95;
- figure 14: GD=38, BC=75, y_G=102.

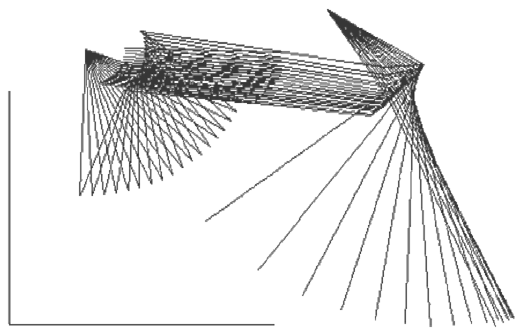

Figure 11: The mechanism positions (GD=35, BC=80)

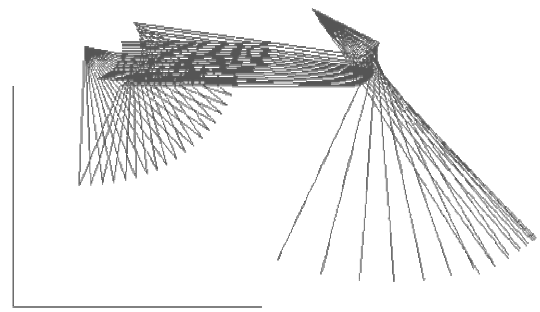

Figure 12: The mechanism positions (GD=35, BC=75)

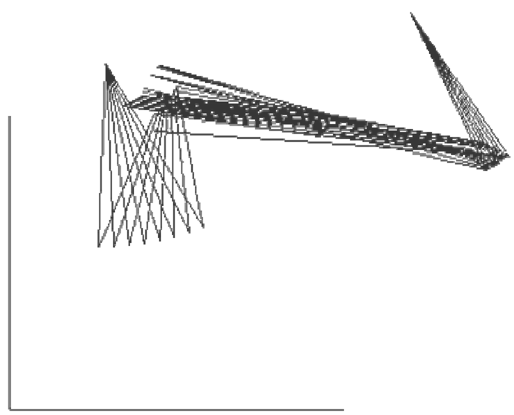

Figure 13: The mechanism positions (GD=35, BC=75, y_G=95)

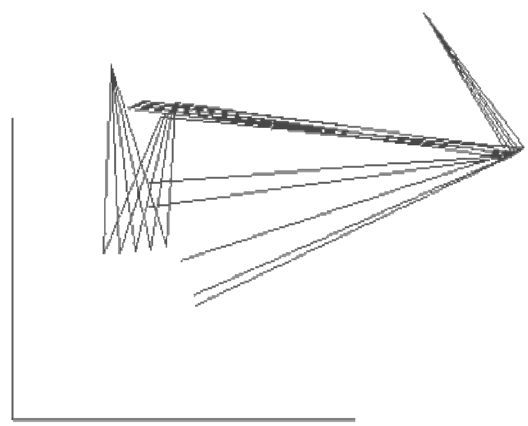

Figure 14: The mechanism positions (GD=38, BC=75, y_G=102)

4. CONCLUSIONS

□ The equivalent mechanism havs two leading elements.
□ The resulted successive positions of the mechanism ensure the proper functioning of the prehensive mechanism.
□ With the change of some dimensions of the mechanism, we can obtain more advantageous solutions regarding the opening race and the packing degree.

REFERENCES

[1] Luca L. : Teza de doctorat. Contributii la sinteza unor mecanisme de prehensiune pe baza biomecanismelor. Univ din Craiova,2000

[2] Popescu I. Luca L. : Biomecanismede prehensiune. Ed Scrisul romanesc, Craiova, 2000