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THE CONCEPTION OF A NEW ACTION SYSTEM OF THE WINDSHIELD WIPERS MECHANISMS AND THE RECIPROCAL VALIDATIONS OF THE PHYSICAL AND THE VIRTUAL RESULTS

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Abstract: The paper presents the conception of a new action system of the windshield wipers mechanisms by substitute the rotate movement (electrical motor) with the linear displacement (hydraulically motor). After this we concept the virtual model and made the specific test for the reciprocal validation of the physical and the virtual results.

1. INTRODUCTION:

In the paper are presented experimental testes who to compared with theoretical testes and its can to reciprocal validations of the physical and the virtual (ADAMS model).

For obtained these comparisons must follow the next stages:

- ✓ to realization the test sample;
- ✓ to realization the virtual model;
- ✓ to realization the numerical and experimental simulations;
- ✓ to compare the theoretical and experimental results.

The experimental simulations represent the dynamic comportment in the functional conditions.

2. TO REALIZATION THE TEST SAMPLE AND THE VIRTUAL MODEL

The experimental test for the dynamic comportment, in functions condition was realized a test sample to the windshield wiper mechanism from *DACIA LOGAN* car. The rotation movement from electric motor (fig. 1) was replacing with the linear movement from a hydraulic motor.

The figure 2 present the replacement of the spherical joint (*B*) with a translations joint who introduce the movement in the wiper mechanism and the rotation joint (*A*) is replacement with a spherical joint.

Use *the numerical value* from real geometrical parameters:
X_A = 0 [*mm*]; Y_A = 0 [*mm*]; Z_A = 0 [*mm*]; X_E = 115 [*mm*]; Y_E = 120 [*mm*]; Z_E = 10 [*mm*]; X_G = -430 [*mm*]; Y_G = 130 [*mm*]; Z_G = 20 [*mm*]; l_{AC} = 750 ÷ 1150 [*mm*]; l_{CD} = 20 [*mm*]; l_{CE} = 65 [*mm*]; l_{DF} = 570 [*mm*]; l_{FG} = 60 [*mm*], and with the *ADAMS* soft, we realized the virtual model of the windshield wiper mechanism (fig. 3).

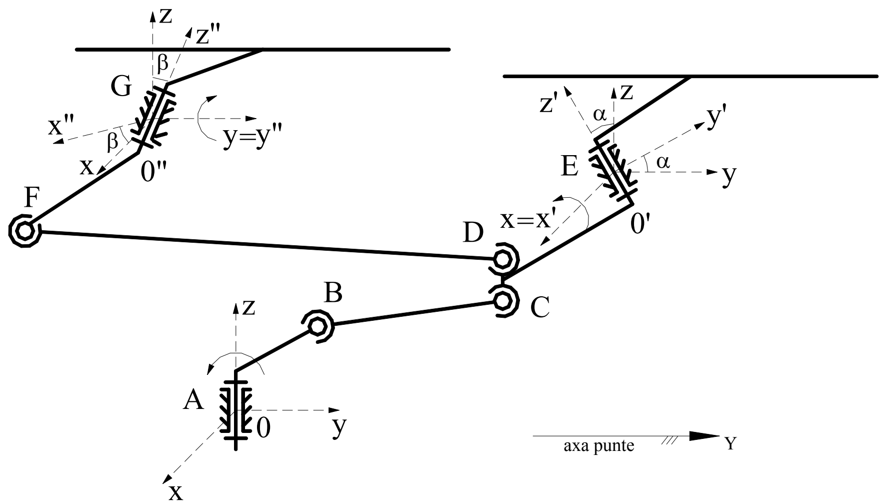

Fig. 1. The structural scheme of the wiper mechanism from DACIA LOGAN car.

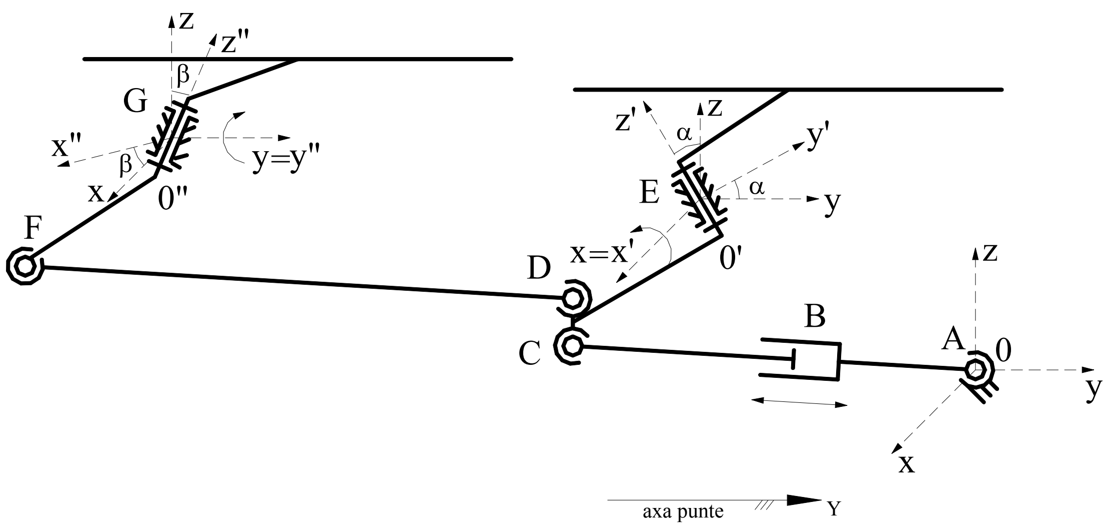

Fig. 2. The structural scheme for experimental tests.

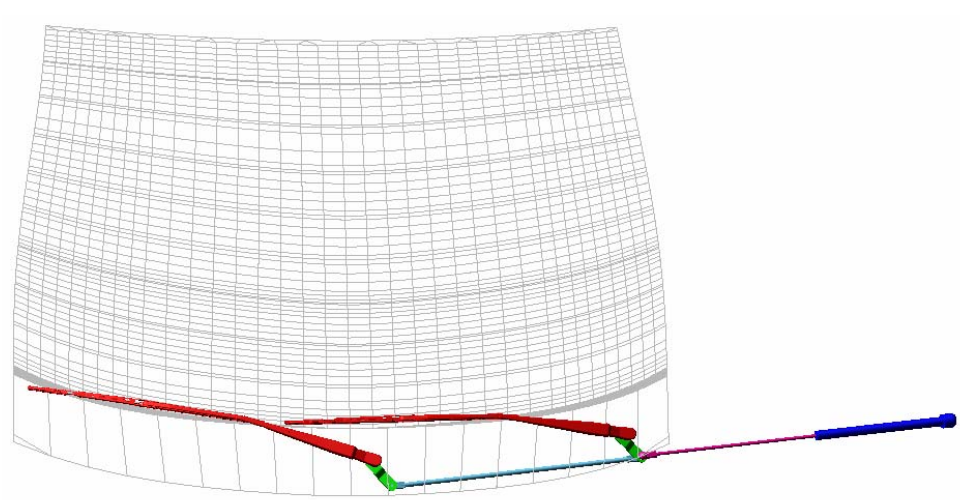

Fig. 3. The virtual model of the wiper mechanism for experimental tests.

3. THE FORCES LOADED OF THE WINDSHIELD WIPER MECHANISM

With a design and calculate program, the theoretical tests are effectuated on the windshield wiper mechanism *DACIA LOGAN* car, but and windshield wiper mechanism with hydraulic action too, because we want to theoretical determinate the frictions torque between windshield and blade.

Methodic:

- to loading the virtual wiper mechanism (considered like a plan mechanism) with forces and torques (fig. 4);
- to correlate the forces between the wiper arms, with a *k* coefficient;
- to transfer the equivalent resistance to an single arm (fig. 5);
- to make the balance of the equivalent arm.

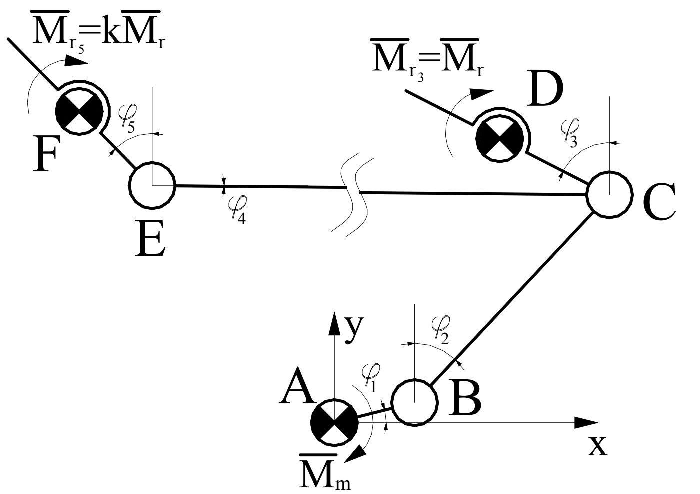

Fig. 4. The load scheme of the wiper mechanism.

According to figure 5, in the *F* joint we have the relation *(1),* and transfer the forces from the *5* element to the *3* element obtain the relation *(2).*

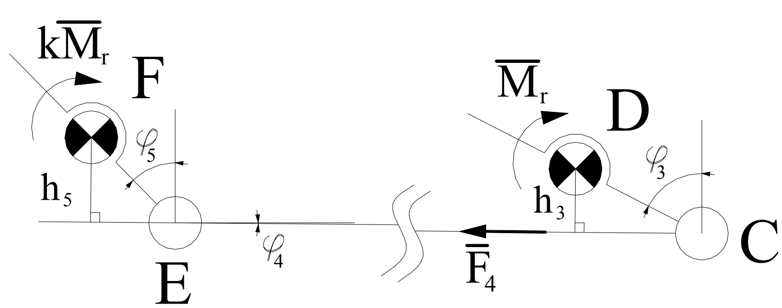

Fig. 5. The quadrangle contour equilibrium.

$$F_4 = \frac{kM_r}{h_5} = \frac{kM_r}{l_5 \cos(\varphi_4 + \varphi_5)} \tag{1}$$

$$M_{r_3}^{st} = F_4 h_3 = \frac{kM_r}{l_5 \cos(\varphi_4 + \varphi_5)} \cdot l_3 \cos(\varphi_3 + \varphi_4) \tag{2}$$

If we analyzed the *ABCE* quadrangle contour equilibrium, loaded with M_m and $M_r + M_{r_3}^{st}$ torques, according to figure 6 in the *B* joint we have relation *(3).*

From the *3* element equilibrium (fig. 7) obtain the relation *(4)* and from equal between the relations *(2)* and *(4)* resultant the value of the resistant torque M_r for a measure or impose motor torque M_m.

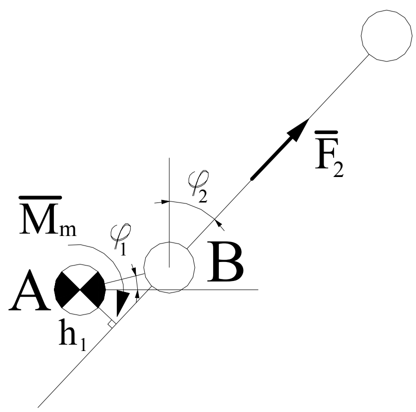

Fig. 6. The forces from the B joint.

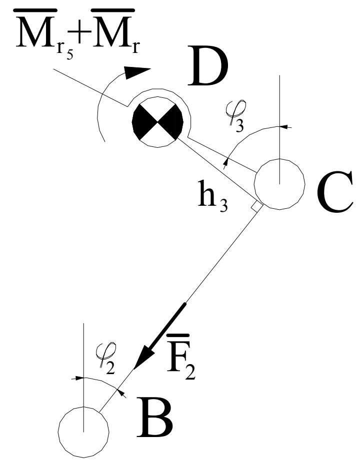

Fig. 7. The 3 element equilibrium.

$$F_2 = \frac{M_m}{h_1} = \frac{M_m}{l_1 \cos(\varphi_1 - \varphi_2)} \tag{3}$$

$$M_r + M_{r_5} = F_2 h_2 = \frac{M_m}{l_1 \cos(\varphi_1 - \varphi_2)} \cdot l_3 \sin(\varphi_2 + \varphi_3) \tag{4}$$

$$M_{r_5}\left(1 + \frac{k l_3 \cos(\varphi_3 + \varphi_4)}{l_5 \cos(\varphi_4 + \varphi_5)}\right) = M_m \frac{\sin(\varphi_2 + \varphi_3)}{\cos(\varphi_1 - \varphi_2)} \cdot \frac{l_3}{l_1} \tag{5}$$

$$\Rightarrow M_r = M_m \cdot \frac{l_3}{l_1} \cdot \frac{\sin(\varphi_2 + \varphi_3)}{\cos(\varphi_1 - \varphi_2)} \cdot \frac{1}{1 + \frac{k l_3 \cos(\varphi_3 + \varphi_4)}{l_5 \cos(\varphi_4 + \varphi_5)}} \tag{6}$$

Use the numerical values of the geometrical parameters $l_1 = l_{AB}$ = 45 [*mm*], $l_2 = l_{BC}$ =155 [*mm*], $l_3 = l_{CD}$ =65 [*mm*], $l_4 = l_{CE}$ =575 [*mm*], $l_5 = l_{EF}$ =60 [*mm*], the coefficient *k* = 1 and the measurement of impose motor torque M_m = 200 [N], we can calculate the value of the resistant torque M_r for different positions of the wiper mechanism, in function of the angles values:

- for the start position φ_1 = 14 [grd], φ_2 = 43 [grd], φ_3 = 63 [grd], φ_4 = 0,05 [grd], φ_5 = 41,5 [grd] and result M_r = -713,049 [N];
- for a intermediary position, when φ_1 = 55,5 [grd], φ_2 = 34 [grd], φ_3 = 19,5 [grd], φ_4 = 2 [grd], φ_5 = 3 [grd] result M_r = -12,8397 [N];
- for the maxim position φ_1 = 103 [grd], φ_2 = 26,5 [grd], φ_3 = 27 [grd], φ_4 = 4 [grd], φ_5 = 54,5 [grd] and result M_r = 35,55266 [N];

Analogous it calculated for the wiper mechanism with driven by hydraulic motor too (fig. 8).

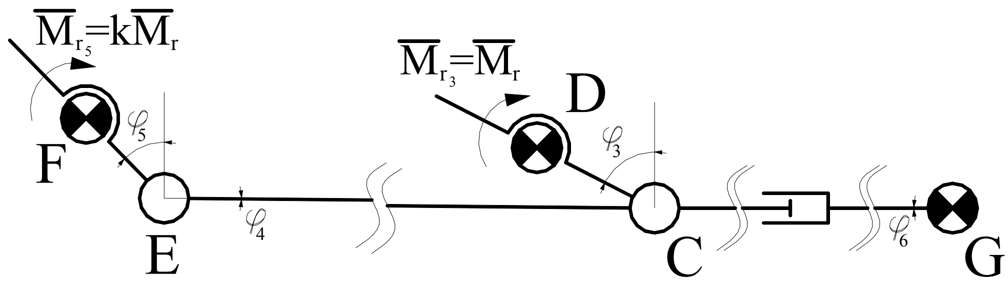

Fig. 8. The load scheme of the wiper mechanism with driven by hydraulic motor.

In the *E* joint we have relation *(7)*, in the *C* joint, by transfer from the *5* element, we have relation *(8)* and from the *3* element equilibrium (fig. 9) obtain the relation *(9)*.

$$F_4 = \frac{kM_r}{h_5} = \frac{kM_r}{l_5 \cos(\varphi_4 + \varphi_5)} \tag{7}$$

$$F_4 h_3 = \frac{kM_r}{l_5 \cos(\varphi_4 + \varphi_5)} \cdot l_3 \cos(\varphi_4 + \varphi_3) = M_{r_3}^{st} \tag{8}$$

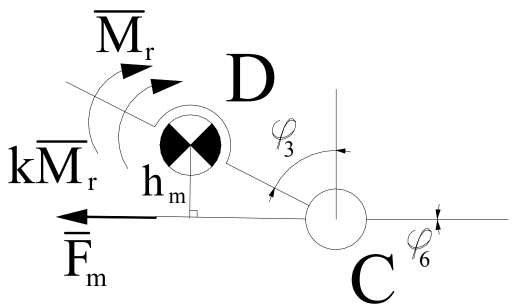

Fig. 9. The 3 element equilibrium.

$$M_m = F_m h_m = F_m \cdot l_3 \cos(\varphi_3 + \varphi_6) \tag{9}$$

From equal between the relations *(8)* and *(9)* resultant the value of the resistant torque M_r .

$$M_r \left(1 + \frac{kl_3 \cos(\varphi_3 + \varphi_4)}{l_5 \cos(\varphi_4 + \varphi_5)} \right) = F_m \cdot l_3 \cos(\varphi_3 + \varphi_6) \tag{10}$$

$$\Rightarrow M_r = \frac{F_m \cdot l_3 \cos(\varphi_3 + \varphi_6)}{1 + \dfrac{kl_3 \cos(\varphi_3 + \varphi_4)}{l_5 \cos(\varphi_4 + \varphi_5)}} \tag{11}$$

Use the numerical values of the geometrical parameters l_3 = 65 [*mm*], l_4 = 575 [*mm*], l_5 = 60 [*mm*], the coefficient *k* = 1 and the measurement of impose motor force F_m =200[N], we can calculate the value of the resistant torque M_r for different positions of the wiper mechanism, in function of the angles values:

- for the start position φ_3 = 63 [grd], φ_4 = 0,05 [grd], φ_5 = 41,5 [grd], φ_6 = 0 [grd], $l_6 = l_{CG}$ = 1620 [*mm*] and result M_r = -32544,6 [N];
- for a intermediary position, when φ_3 = 19,5 [grd], φ_4 = 2 [grd], φ_5 = 3 [grd], φ_6 = 1,1 [grd], $l_6 = l_{CG}$ = 1657,5 [*mm*] result M_r = -9838,68[N];
- for the maxim position φ_3 = 27 [grd], φ_4 = 4 [grd], φ_5 = 54,5 [grd], φ_6 = 0,9 [grd], $l_6 = l_{CG}$ = 1710,5 [*mm*] and result M_r = -15902,6 [N];

The next step is to draw the graphics for the force $F_m(t)$ and the torque $M_r(t)$, respective the force $F_m(\varphi_6)$ and the torque $M_r(\varphi_6)$.

4. TO COMPARE THE THEORETICAL AND EXPERIMENTAL RESULTS

After the experimental tests we obtain the results for dynamic comportment of the windshield wiper mechanism. The following graphics represent the action force, in the theoretic and the experimental test, for the dry or wash windshield, for one or many drive.

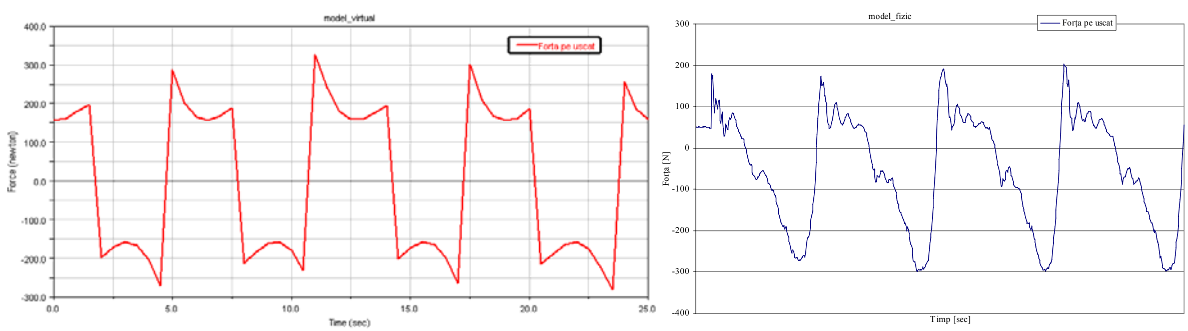

Fig. 10. The compare of the action force graphic for many drive with dry windshield.

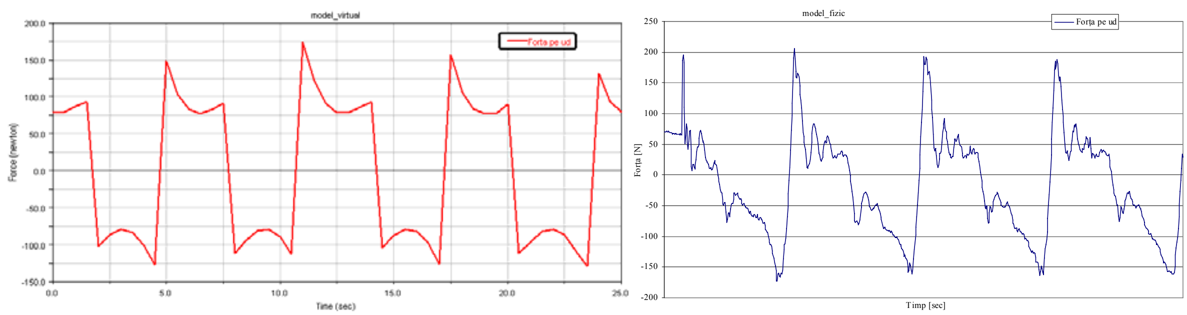

Fig. 11. The compare of the action force graphic for many drive with wash windshield.

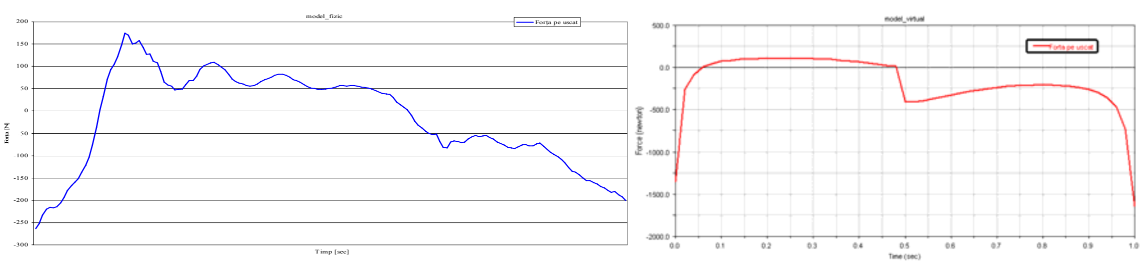

Fig. 12. The compare of the action force graphic for one drive with dry windshield.

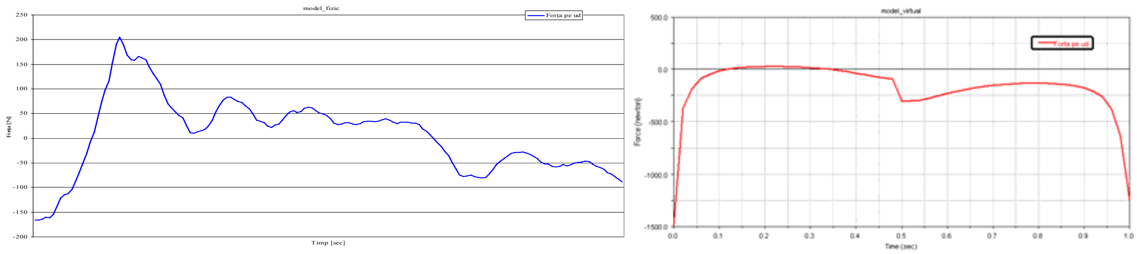

Fig. 13. The compare of the action force graphic for one drive with wash windshield.

For to validation of the obtain results, respective the virtual model, in the table 1 is present the value for the variations of the action force from the hydraulic cylinder. These values are obtained from function to the physical model and the simulation of the virtual model. The figure 14 and the figure 15 represent superimpose of the graphics that are before studied.

Table 1.

Dry windshield		*Wash windshield*	
Physical model	***Virtual model***	***Physical model***	***Virtual model***
-263,864	-135,234	-165,675	-149,13
-251,965	-26,2385	-164,257	-37,5455
-233,939	-9,07807	-136,794	-8,79821
-151,175	8,353244	-68,6957	0,234376
2,479171	9,206635	-30,8367	1,241486
147,6667	9,793366	188,6745	2,372211
37,09135	4,855071	32,37717	-2,1326
2,444319	1,415879	27,89183	-5,21941
-45,2167	-41,4851	-9,29306	-30,3618
-82,4259	-40,9755	-74,2007	-17,7686
-69,9251	-39,6132	-76,7956	-16,4505
-66,6312	-37,6395	-75,8405	-15,3813
-68,6265	-35,3391	-74,3034	-14,5407
-78,2002	-24,0798	-48,8038	-13,8386
-78,3133	-26,3555	-48,3982	-14,6266
-73,3063	-29,9887	-51,6453	-17,8586
-71,8478	-36,114	-58,5912	-26,2074
-127,291	-47,5652	-69,2173	-37,7668
-164,08	-73,3486	-76,8268	-63,1999
-200,417	-164,111	-87,5334	-124,541

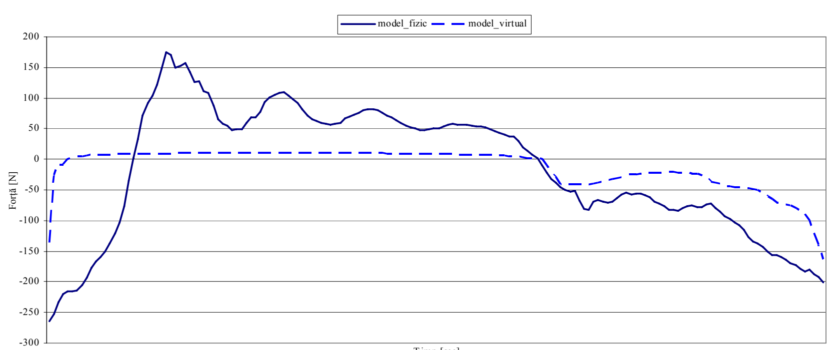

Fig. 14. Superimpose the theoretic and the experimental graphics with dry windshield.

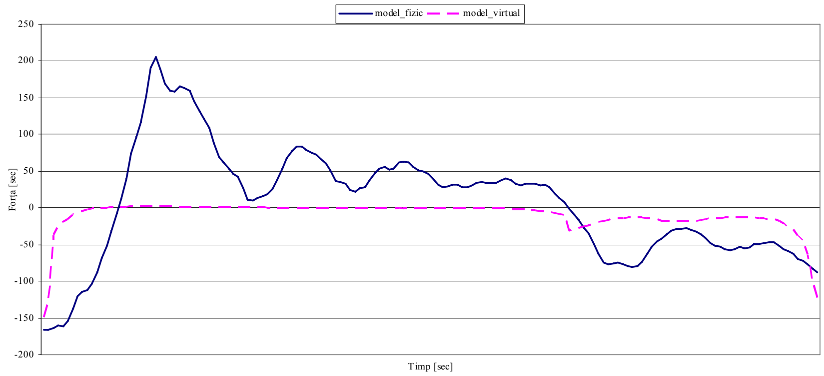

Fig. 15. Superimpose the theoretic and the experimental graphics with wash windshield.

5. CONCLUSION

From comparative analysis we can do the following conclusions:

- the dynamic variations of the action force from the hydraulic cylinder determinate to experimental test is qualitative similar with the same force determinate to theoretic test;
- the values obtain for the action force determinate to experimental test are close to the same values determinate to theoretic test, but the first is different by the trepidations;

Is a good correspondence between the theoretical and the experimental tests, so the virtual model and the experimental stamp are reciprocal successfully validation.

6. REFERENCES

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