MEASUREMENT OF DECELERATION ON THE ACCELERATOR PEDAL CONNECTION

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1. EXPERIMENTAL RESEARCHES

1.1. Experimental measurements of acceleration pedal joint points displacement conducted on a domestic vehicle

In a laboratory of "Zastava Automobili" plant, before it evanesced as the result of the economy transition, a certain number of researches have been performed in order to reach one goal - car safety improvement. Those researches have been conducted in order to reach and to fulfill certain criteria which are obliged in high developed countries, above all to fulfill ECE regulation in order to secure driver's and passenger's safety which will be in accordance with demands of a market.

One of conducted researches is recording of joint point displacement among the acceleration pedal and a car body, figure 1. and details 1.a) and 1.b).

Figure 1: *Figure of examined part*

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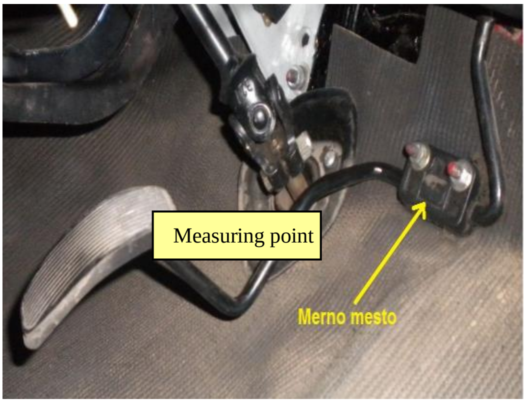

Figure 1a): Measuring point "A"

Figure 1.b): Detail

Recorded diagram, here enclosed, is taken from a manufacturer's data base, figure 2.

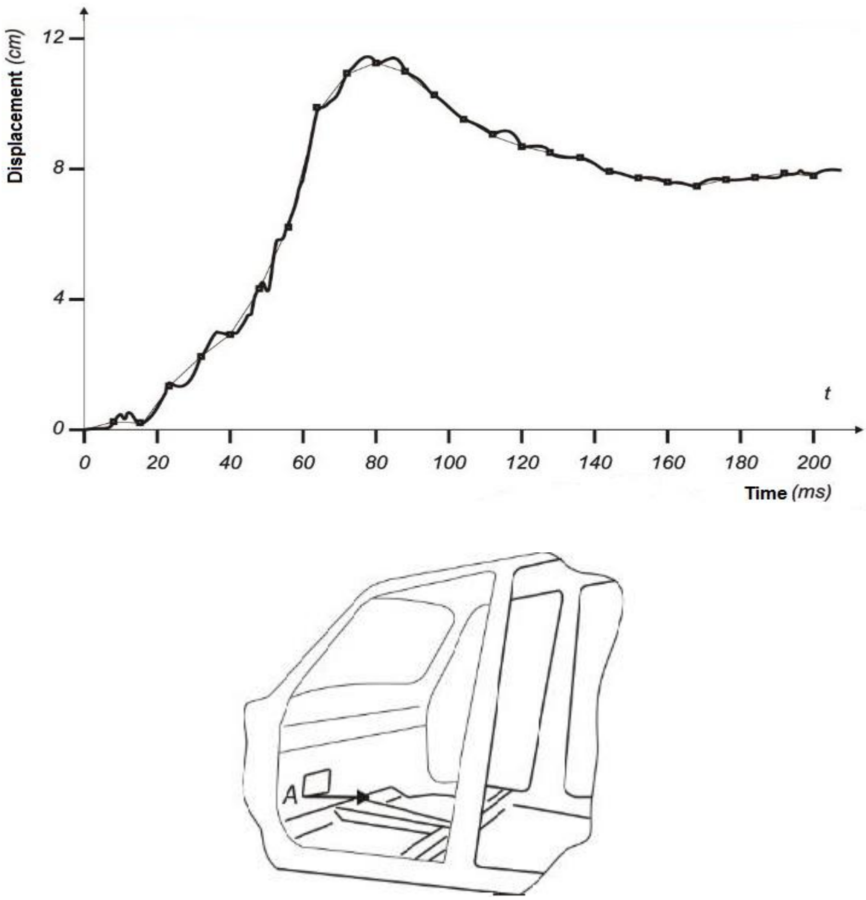

***Figure 2:** Recorded diagram and a scheme of the location where the emitter was placed*

In a diagram a displacement of car body partition wall, in the area of its connection with the acceleration pedal, is shown depending on time.

By means of numerical differentiation, are obtained speed and acceleration values in "A" point, as shown in table 1.

Table 1: *Displacement, speed and acceleration values in "A" point (Figure 2.)*

No.	Time t (ms)	Displacement x (mm)	Speed (m/s)	Acceleration (g)
1.	0	0.0	0.32	-4.9
2.	8	2.5	-0.07	19.9
3.	16	2.0	1.52	-6.0
4.	24	14.1	1.04	-2.3
5.	32	22.4	0.86	10.7
6.	40	29.3	1.72	9.1
7.	48	43.0	2.45	24.0
8.	56	62.5	4.36	-36.4
9.	64	97.4	1.45	-12.6
10.	72	109.1	0.45	-10.1
11.	80	112.6	-0.37	-7.1
12.	88	109.7	-0.93	1.3
13.	96	102.2	-0.83	2.1
14.	104	95.6	-0.66	3.1
15.	112	90.3	-0.42	2.0
16.	120	87.0	-0.26	0.6
17.	128	84.9	-0.21	-3.5
18.	136	83.2	-0.49	2.9
19.	144	79.4	-0.25	0.7
20.	152	77.3	-0.19	0.8
21.	160	75.8	-0.13	5.0

In this case, beginning of plastic deformation will occur approximately after 16 ms, during that time deformation of car body is 2 mm. Deformation is being progressively increased up to its maximum value, 112.6 mm in this case for the period of 80 ms. After the highest value is reached, partition wall deformation is being decreased due to elastic features of the material approximately to 75 mm, after that a permanent plastic deformation occurs (approximately 80 mm).

By differentiation of recorded displacement values the speed and acceleration values of the joint point among the acceleration pedal lever and a car body are obtained. Acceleration diagram is shown in figure 3.

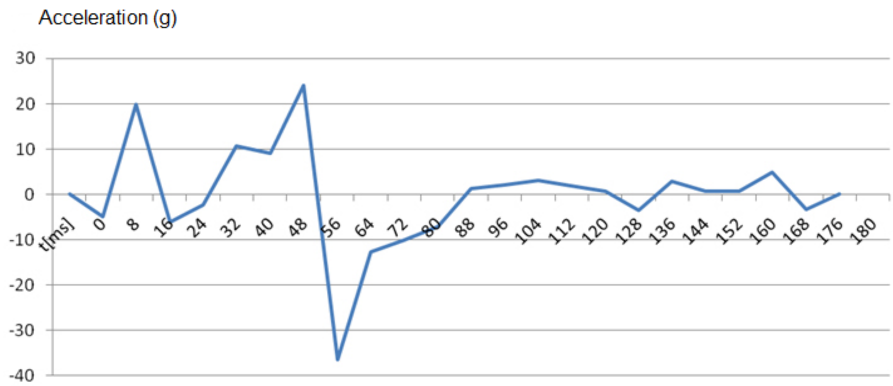

Figure 3: *Acceleration diagram (g) depending on time (t)*

Based on a diagram (figure 3.) it might be concluded that in the area of maximal displacements, acceleration modify its sign. From the aspect of driver's safety the most suitable case is when the acceleration values have the same sign. The "maximum" on a displacement curve, in figure 2. is characteristic for so called "snapp-through" problems, because the examined section of a car body is convex, observed along the force direction. Based on a thin shell theory it's familiar that for smaller displacements a curve has to be reduced and the thickness of the metal sheets has to be increased.

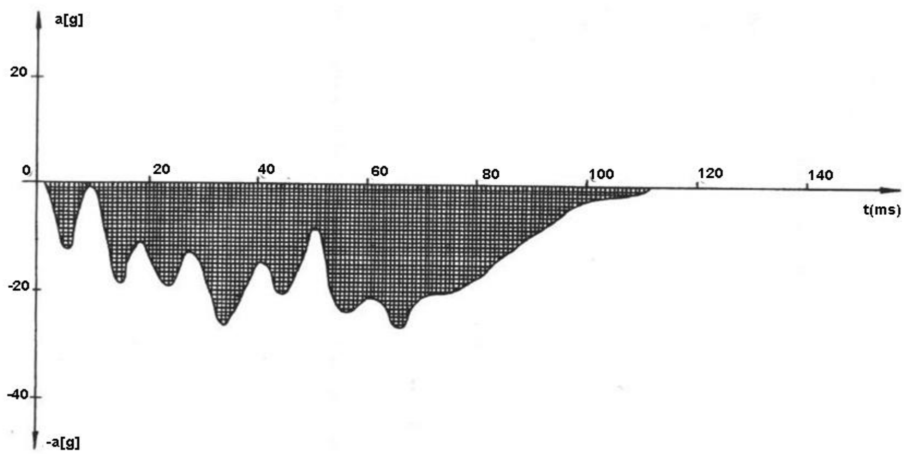

Figure 4: *Diagram of deceleration alteration for the frontal impact at the speed v=13,42 [m/s], measuring point is in passenger compartment based on ECE 33*

A diagram shown in figure 4. presents vehicle's deceleration in a function of time, which is obtained by direct crash to a fix barrier. Deceleration value "U" is about 30 g, such a value might be considered as a satisfactory result from the aspect of driver's safety within a cabin compartment. Boundary deceleration values, which will guarantee drivers safety and preserve him from the injuries, are various for different parts of driver's body and these values are depending on acceleration effect during the time. Observing the available data, for medium class passenger cars, measured acceleration mostly do not exceed 40 g. Also, it should be notified that acceleration values should have the same sign, all the time during the impact interval.

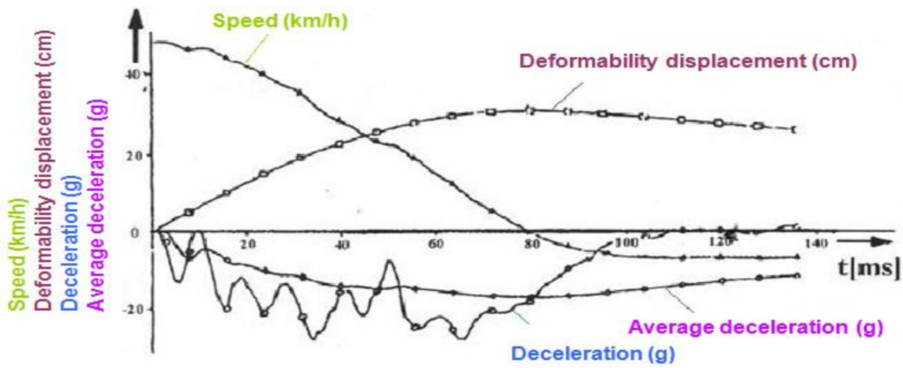

Figure 5: *Speed, deceleration and deformability displacement alterations of the same passenger car during direct impact to a fix barrier*

Based on a car deceleration diagram (figure 5.) it's possible to calculate impulse of the impact force per mass unit, same as the value of the impact coefficient [k]. Based on deformability displacement curve it's possible to calculate maximum deformation value same as the permanent deformation value.

1.2 Measurements of some other manufacturers

Examination results are depending great deal on material features same as on vehicle's weight, i.e. on weight/mass distribution along the vehicle. On the following examples will be shown the effect of a vehicle's weight to acceleration (g) which is being transmitted to a driver. Values presented in figures 6, 7, 8 and 9 are obtained by the measuring conducted inside the passenger compartment (cabin) according to ECE 33 regulation.

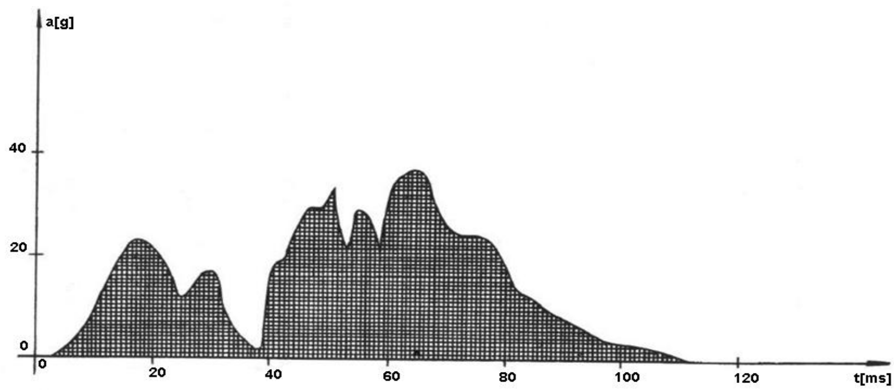

Figure 6: *Deceleration diagram of a light passenger car, [1]*

The effect of a vehicle's mass on to maximal deceleration is shown in figures 6. and 7. while the effect of the weight/mass distribution i.e. the power-train position is shown in figures 8. and 9.

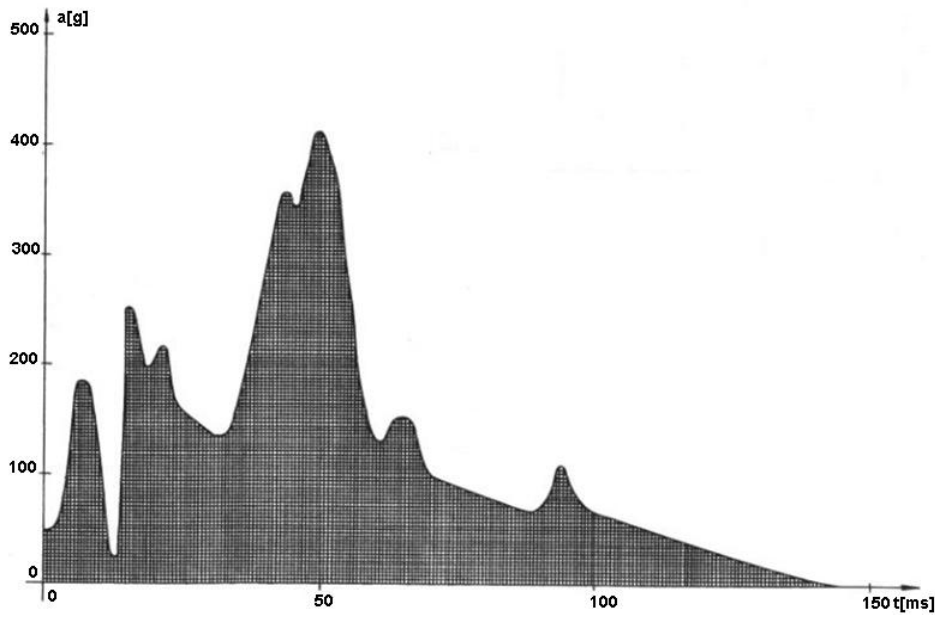

Figure 7: *Deceleration diagram of a heavy passenger car, [1]*

Examples of mass distribution effects to deformation and acceleration (g) values:

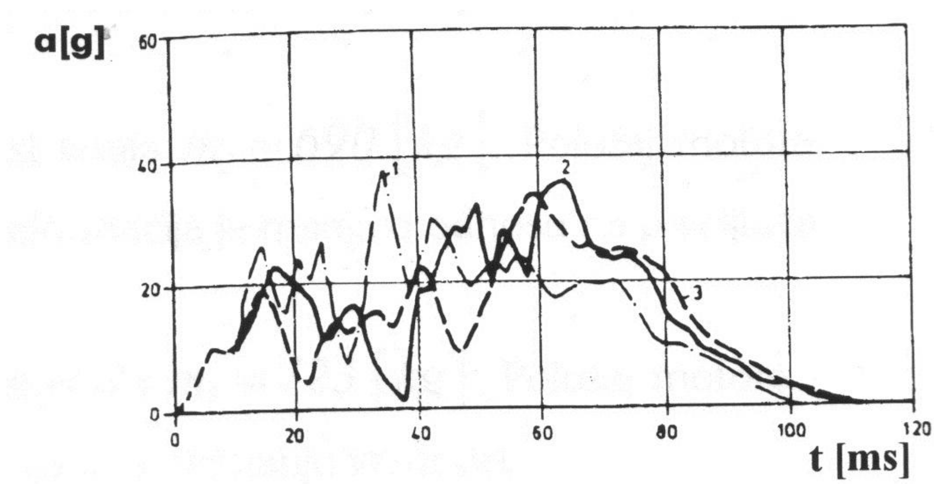

Figure 8: *Deformation characteristic for the vehicles m≤800kg, V=50km/h at the frontal impact, [2]*

Curve 1 - characteristic of a vehicle 640kg weight with the front engine

Curve 2 - characteristic of a vehicle 690kg weight with the rear engine

Curve 3 - characteristic of a vehicle 723kg weight with the rear engine

Curve 1 – If in a "acceleration-time" and "force-road" diagram the values of maximum deformation are observed it is obvious that in this case deformation is the highest.

Curve 2 – maximum deformation diagram in this case is lower than in a first case.

Curve 3 – maximum deformation in this case is the lowest.

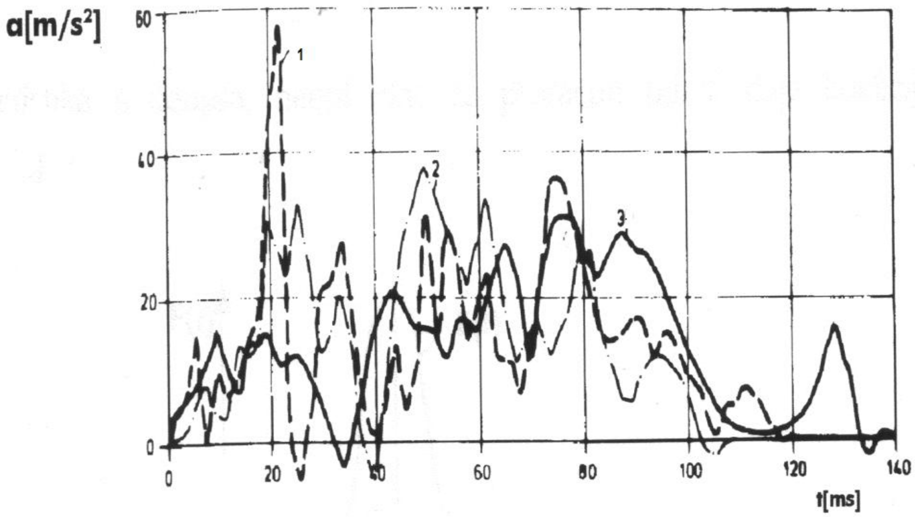

Figure 9: *Deformation characteristic for the vehicles m≤1300kg, V=50km/h at the frontal impact, [2]*

Curve 1 – Vehicle 1250kg weight, with the front engine

Curve 2 – Vehicle 1215kg, weight, with the front engine

Curve 3 – Vehicle 1252kg, weight, with the rear engine

Curve 1 – the value of maximal deformation in this case is the highest.

Curve 2 – for the same position of the engine (front) with vehicle's weight reduction and maximal deformation values are also decreased.

Curve 3 – Vehicle with the highest weight, with the rear engine, the value of maximal deformation is the lowest.

2. ACCELERATION ANALYSIS IN ACCELERATION PEDAL JOINT POINTS DEPENDING ON DIFFERENT STIFFNESS OF THE JOINTS

By deformation displacing variation x, the features of different joints were simulated and numerically compared accelerations.

2.1 The case of stiffener joint than the initial one

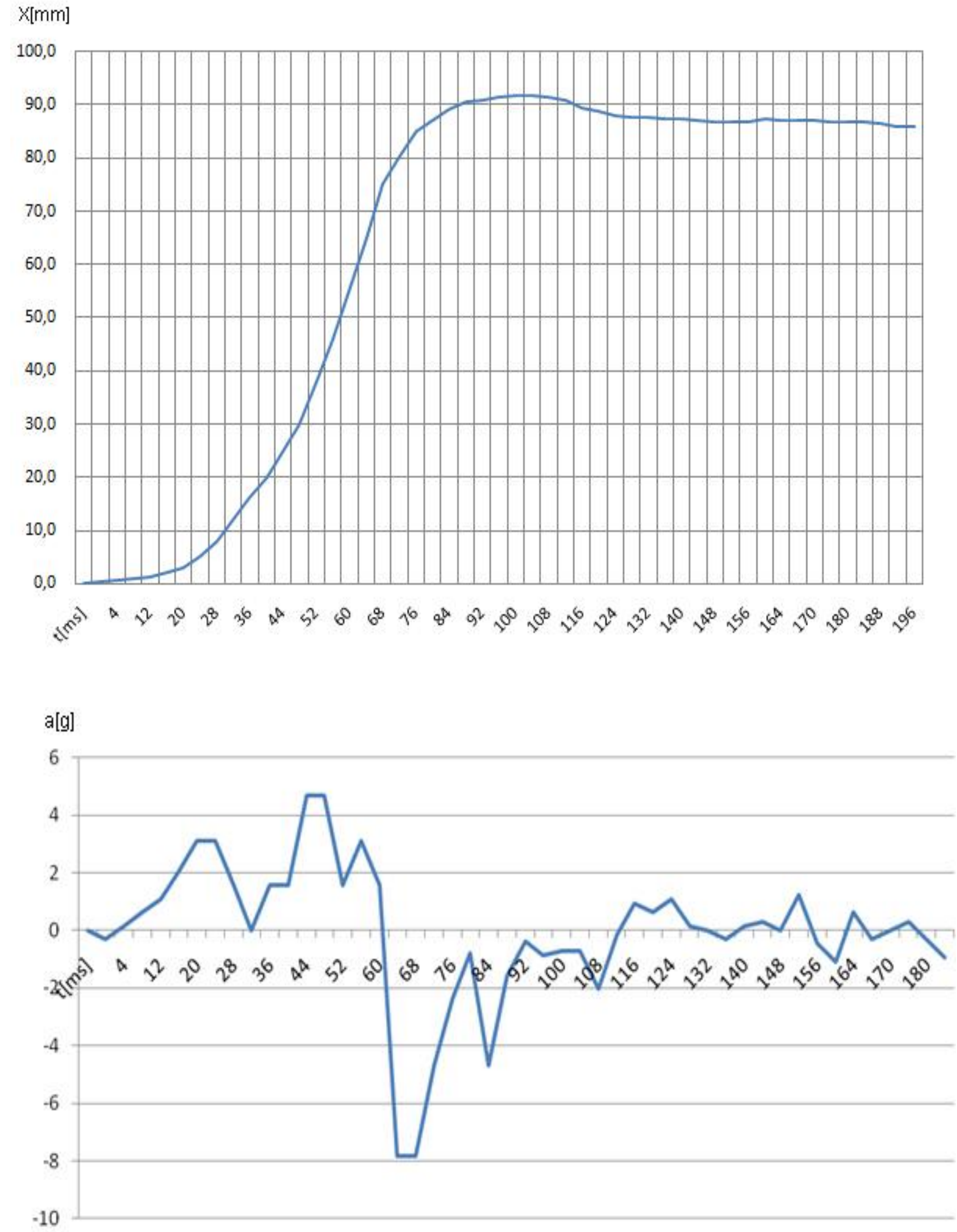

Figure 10: *Displacement and acceleration (g) dependency on time*

2.2 The case of initially stiff characteristic with big relaxation

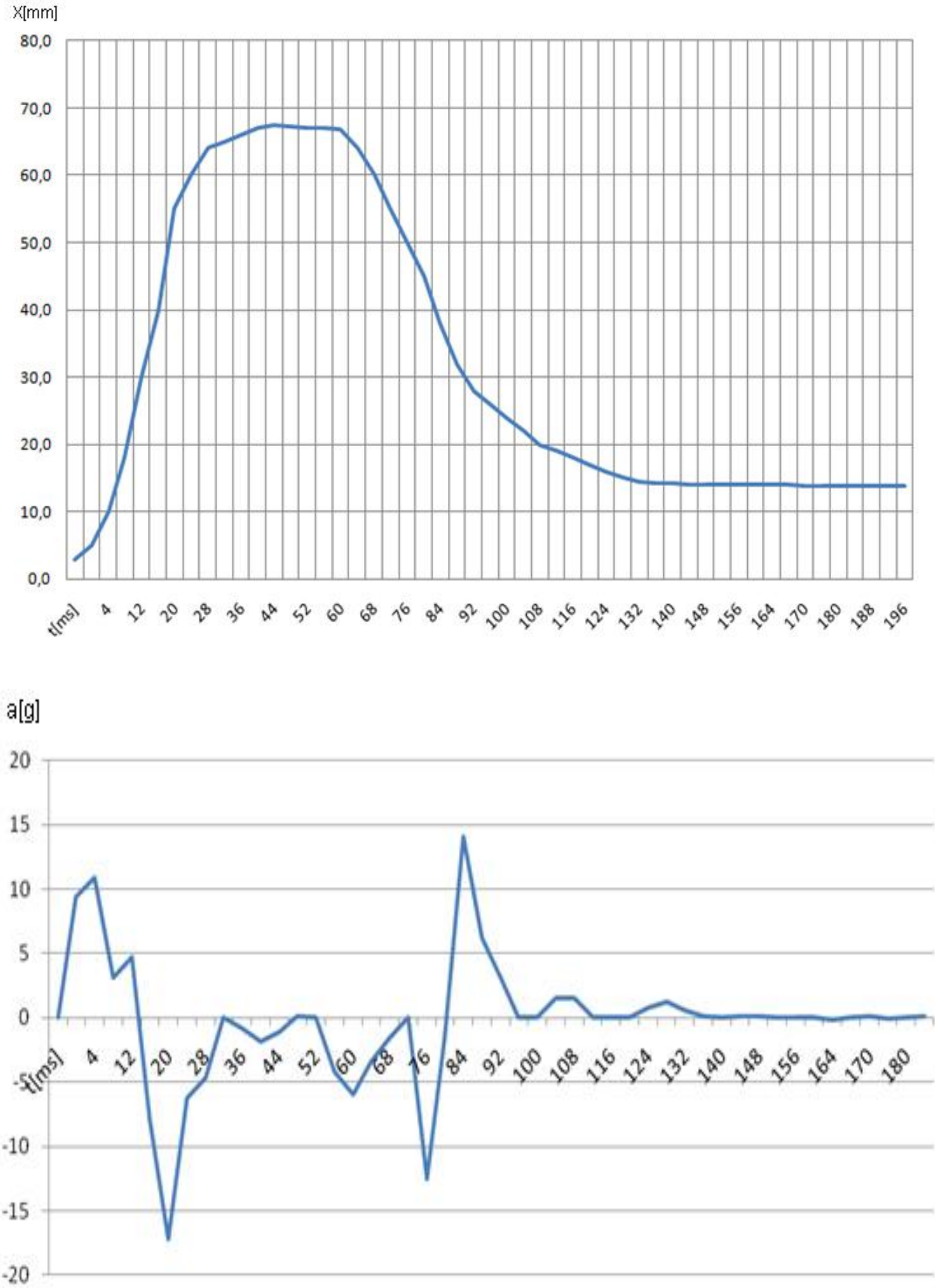

Figure 11: *Acceleration (g) dependency on elastic material deformations*

2.3 The case of congealed characteristics

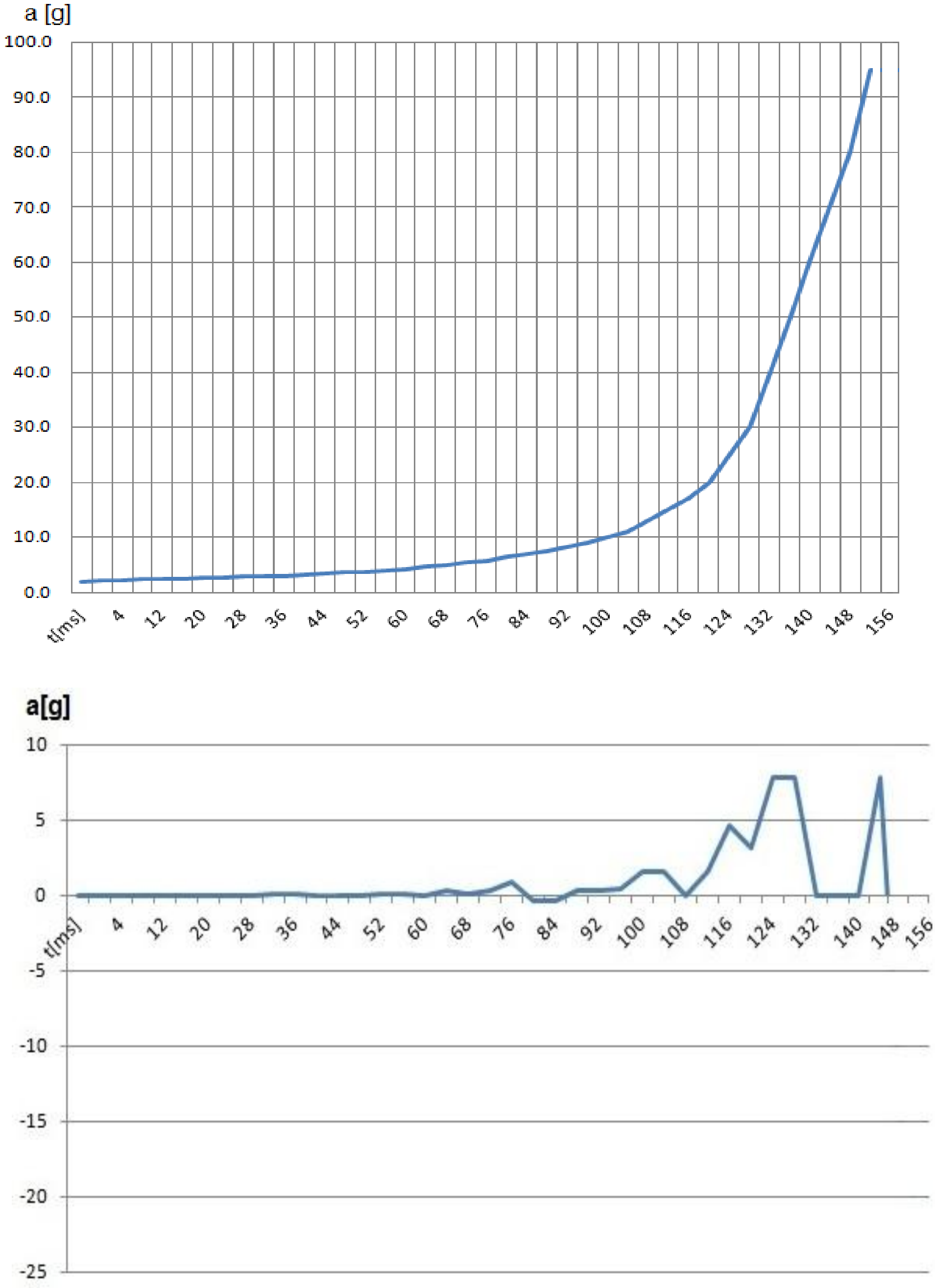

Figure 12: *Acceleration (g) dependency on fragile material deformation*

It's quite obvious that the latter characteristic is the most convenient both from the aspect of acceleration level and from the aspect of the moment, when the maximum is reached. Postponed period required for reaching the maximum value gives the possibility for safety system action.

CONCLUSION

Based on this paper it can be concluded that accelerations created during the deformation of the partition wall in the connection point with the acceleration pedal has to be reduced to its lowest intensity, and their maximum to be postponed to the up most moment. Impact interval should be the shortest it's possible. In this way the impact force F_U is also reduced in order to avoid driver's leg injuries during the crash.

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