A SOLUTION FOR CRASH AND HIGH GROUND UNEVENNESS EFFECT REDUCING

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Abstract

On landing operation, a brutal contact with the deck or ground, or high ground unevenness can damage the plane or chopper and hurt the pilot, the crew or the passengers. The paper presents the advantages confer by suspensions using VZN dampers, in this situation. The Romanian self adjustable damper (shock-absorber) concept-VZN-granted with European Patent EU 1190184 and Romanian Patent 118546 assures damping coefficients increasingly by stroke from lower value up to the very high values, giving thus possibility to dissipate a huge energy at all speed regimes high, medium or low. With a convenient damping valve placement and dimension, the VZN concept confers possibilities to assure constant deceleration forces, at the human body limit resistance, this solution dissipating the maximal energy quantity. The paper evaluates by simulation, the behaviour at vertical crash of aerial vehicles equipped with suspension using VZN and standard dampers. The results given by VZN concept is 200% better than the standard dampers, this new solution giving high possibilities to reduces the risk at landing, a better passengers and body protection, without increased costs. The VZN principle, and damping coefficients, comparative with standard and monroe sensa trac, the kinematic model, speed - time and acceleration evolution for VZN and standard dampers, detail for acceleration - time evolution at VZN and standard dampers acceleration - time evolution for VZN and standard dampers are presented in the paper.

Keywords: *progressive damping, VZN, simulation, crash, passenger protection, body protection*

1. Introduction

The proposed self-adjustable shock absorber is called VZN, this acronym being abbreviation For Variable Zeta Necessary, for well displacement in all road and load conditions, where zeta represents the relative damping, which is adjusted automatically, stepwise, according to the piston position. The VZN shock absorber consists of an inner cylinder having sideways valves or metering holes, inside a slidably piston moving. For VZN principle understanding, Fig. 1 presents from left to right three situations, with the piston in start, middle and ending position, on compression stroke. The number of active metering holes decreases, so the fluid flows out with increased resistance, generating increasing damping coefficients with the stroke. The situation is similar on rebound stroke.

Thus, for VZN the damping force is adjusted stepwise, as function of the instantaneous piston position, i.e., both on rebound and compression the damping coefficients have: low values at the beginning of the strokes (the hydraulic fluid flows out through all the metering holes); moderate values at the middle of the strokes, for a good tradeoff between comfort and wheel adherence (the hydraulic fluid flows out through half of the metering holes); high values in the working area between middle and end strokes, for better adherence and good axle movement brake (the fluid flows out through quarter of the metering holes); and very high values at the end of the strokes, for better body and axles protection (the fluid flows out through only one or two metering holes).

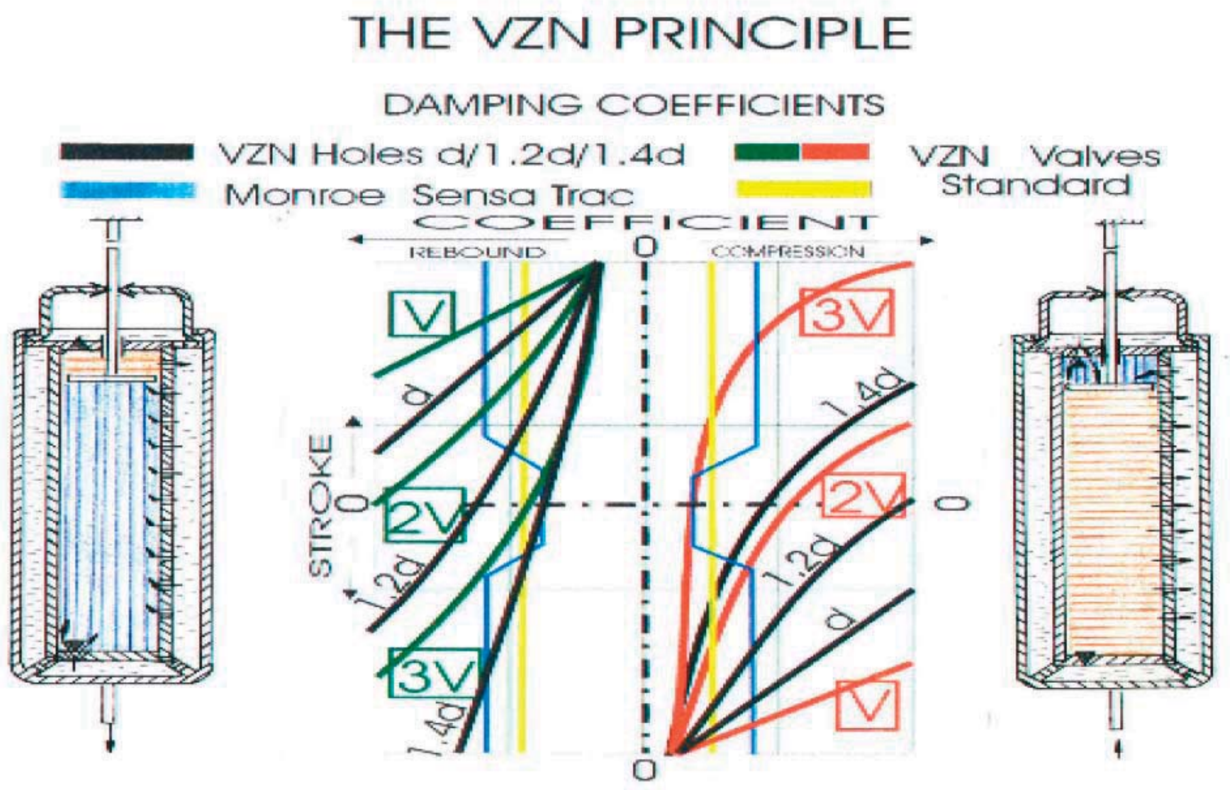

Fig. 1. The VZN principle, and damping coefficients, comparative with standard and Monroe Sensa Trac

For aerial vehicles design of VZN shock absorber was optimized in order to assure a constant damping force at the upright human body limit resistance.

In what concerns the quality/price ratio, the passive dynamic VZN shock absorber realizes an improved and better adapted damping than a standard suspension, for more or less the same price and technological simplicity.

2. On crash at free fall down

We have considered a body free fall down some meters and decelerated by the suspension at the sledge/wheel contact with ground. The work hypotheses were:

- the damping stroke may be 0.5 m,
- the „d" vertical human limit deceleration is 9 g, where „g" is gravitational acceleration,
- the energy dissipated in damper is equal with the cinematically energy,
- the spring force is neglected being low 100 times than the damping force,

- the VZN dampers give constant deceleration,
- the standard dampers give inconstant deceleration.

The kinematical model is presented in Fig. 2, where from left to right are:

- the initial moment when chopper at the „H" height start free fall down,
- the moment of contact between chopper sledge/wheel and ground when started decelerated movement,
- the final moment when the damper had dissipated energy on the „h" distance.

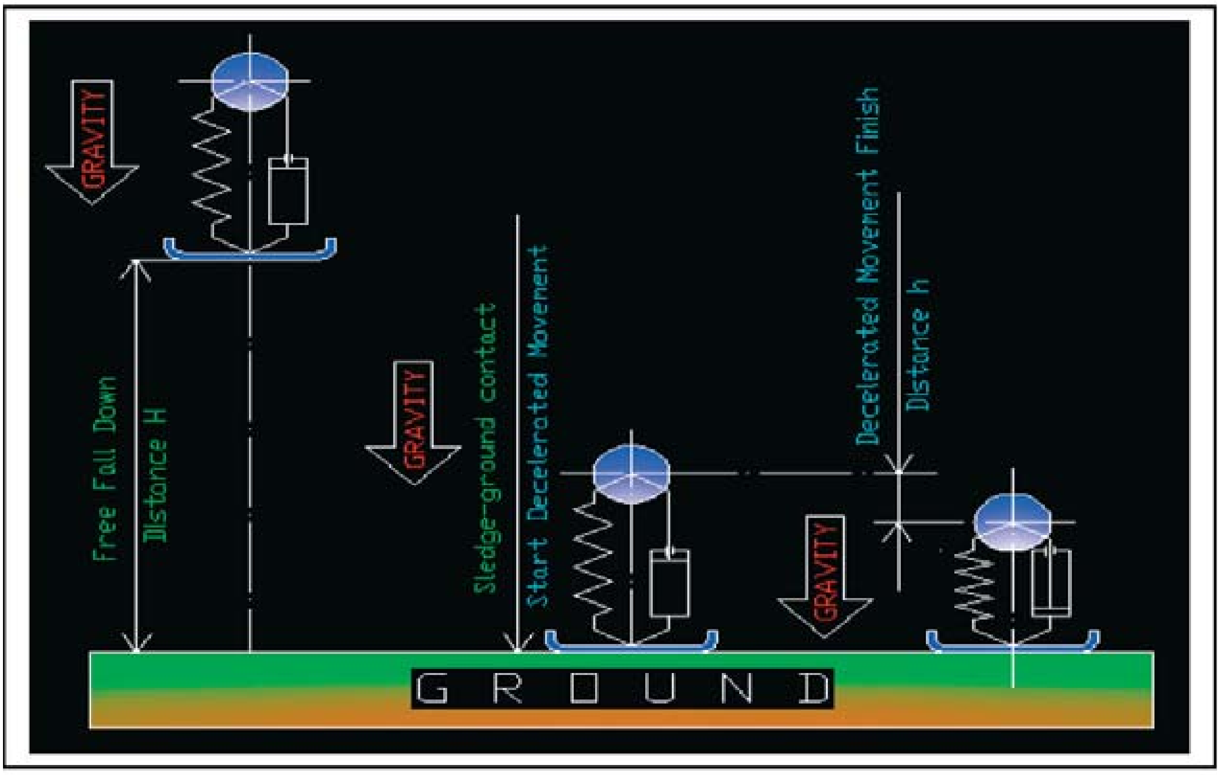

Fig. 2. The kinematic model

We consider the situation characteristic both free falls down and landing on unevenness tarmac. The potential energy has in the moment of sledge/wheel - ground contact is

$$E_{pH}=mgH. \tag{1}$$

This energy „E_{pH}" is dissipated by the dampers. In order to protect the human body the best way to decelerate is a constant deceleration at the safety value, e.g. „9 g" So the maximum energy dissipated by the dampers is at constant deceleration:

$$E_{dh} = F_{dh}\cdot h = (m\cdot d)\ h = [m\cdot(9g)]\ h = 9mgh. \tag{2}$$

From equality of both energy given by equation (1) and (2) result the height „H" from which the chopper can fall free, without passengers' damages.

$$H_{d=9g,h}=9h. \tag{3}$$

Using a suspension with constant deceleration damping force on all stroke, starting from the speed „V_{gH}“ up to the movement finish, the maximum speed value in the impact moment has expression (4), the value corresponding at h = 0.5 (we consider practically)being presented at (5):

$$V_{d=9g} = \sqrt{2gH} = \sqrt{2g(9h)} = 13.288\sqrt{h}\,, \tag{4}$$

$$V_{gH}=9.39[m/s] = 33.82[km/h]. \tag{5}$$

Generally, in case of constant deceleration "d" the height "H_{dh}" of free fall and the speed „V_d” are:

$$H_{dh}=(d/g)h, \tag{6}$$

$$V_{dh} = \sqrt{2gH} = \sqrt{2g(d/g)h} = 1.418\sqrt{dh}\,. \tag{7}$$

Tab. 1. Some values for free fall height and contact chopper sledge-ground speed, damped on strokes 0.25 m and 0.50 m with constant decelerations g, 3 g,6 g, 9 g

$d[m/s^2]$	g		3g		6g		9g	
$h[m]$	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
$H_{dh}[m]$	0.25	0.50	0.75	1.50	1.50	3.00	2.25	4.50
$V_{dh}[m/s]$	2.208	3.122	3.824	5.408	5.408	7.649	6.624	9.368
$V_{dh}[km/h]$	7.949	11.239	13.766	19.469	19.469	27.536	23.846	33.725

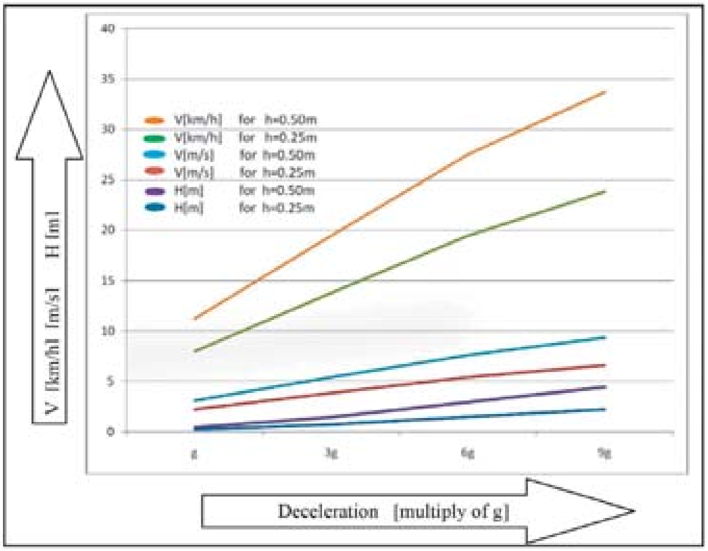

Fig. 3. Values for free fall height and contact chopper sledge-ground speed, at damping on strokes 0.25 m and 0.50 m with constant decelerations g, 3 g, 6 g, 9 g

3. Simulation at free fall down, using VZN and Standard damping

The VZN shock absorbers assures the previous desiderate e.g. constant damping force at all stroke, starting from the speed "V_{gH} "up to the movement finish with a convenient metering holes or damping valves dimension and placement, without electronics or other components.

Using model presented in *Fig.2*, simulations with constant deceleration, realized with VZN dampers and with inconstant deceleration, realized by standard dampers, for a chopper free falling, were realized.

The simulation was realized with ADAMS software, View module, for next conditions:

- Chopper mass m = 2000 [kg],
- Free fall height H = 4 [m],
- Maximum deceleration d = 9 g = 88.29 [m/s^2],
- At VZN damping is realized with constant deceleration d = 9 g = 88.29 [m/s^2].

At standard damper, damping is realized with variable deceleration, the damping force being given by relation:

$$F_{St} = c_{St} \cdot V^2 = 2250 \cdot V^2, \tag{8}$$

$$c_{St} = (F_{dMax} / V_{g\,H}^2) = [(m \cdot d_{Max}) / V_{g\,H}^2] = [(2000 \cdot 88.29) / 8.858^2] = 2250 \; [\mathrm{N} \, \frac{s^2}{m^2}]. \tag{9}$$

The speed and acceleration evolution for both kinds of dampers are presented in the Fig. 4 - 6. In red colour is presented the VZN diagrams and in blue the diagrams for standard dampers.
The results demonstrate the great advantages confer by the dampers giving constant deceleration, for vehicles and human body protection. This solution specific for VZN dampers better than solution with standard dampers where the deceleration of 18000 [m/s^2] is 200% increased than 9 g deceleration, e.g. the human body limit.

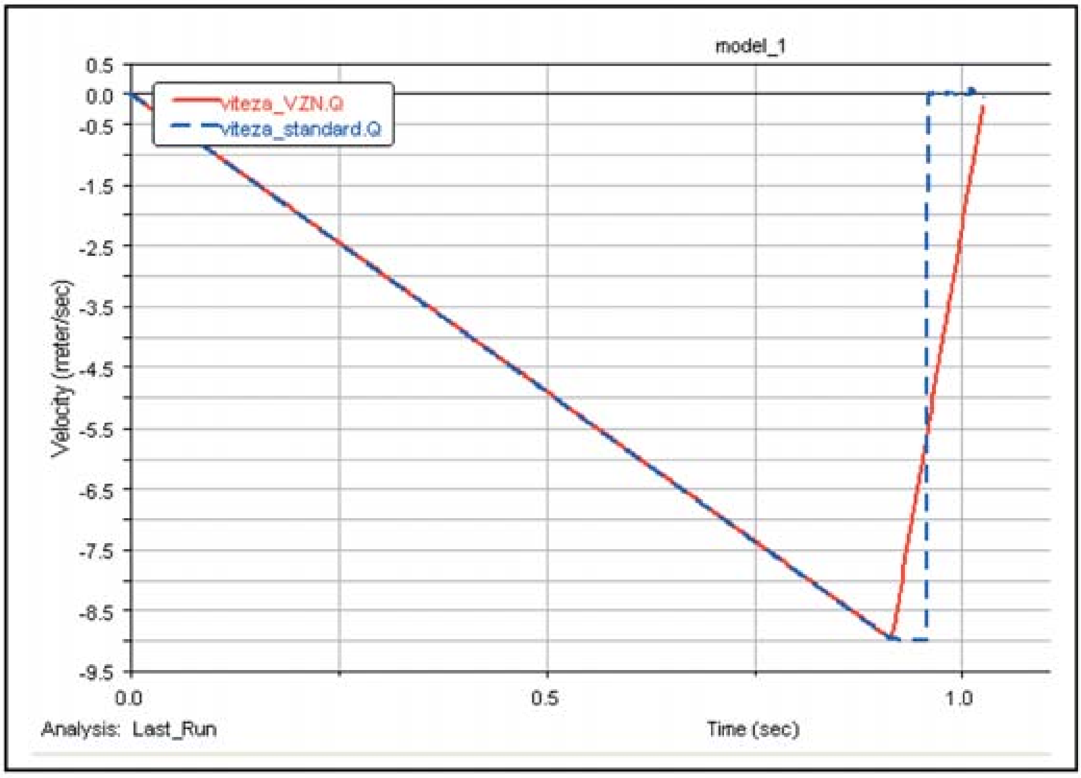

Fig. 4. Speed - Time evolution for VZN and Standard dampers

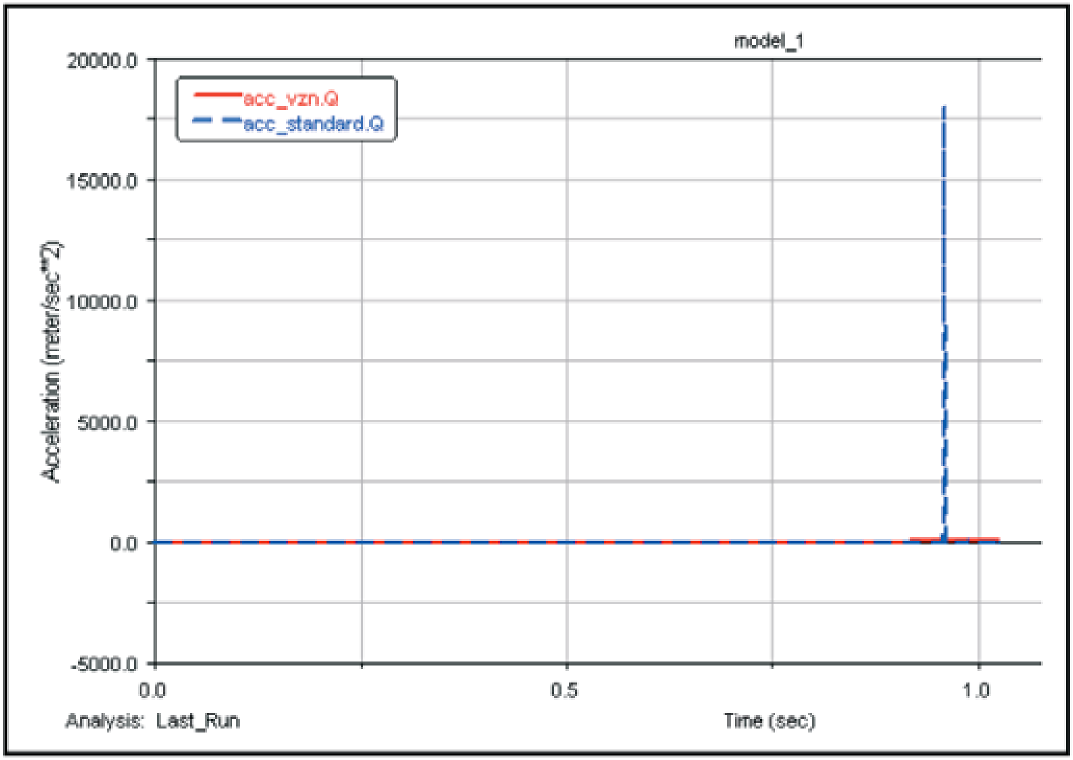

Fig. 5. Acceleration - Time evolution for VZN and Standard dampers

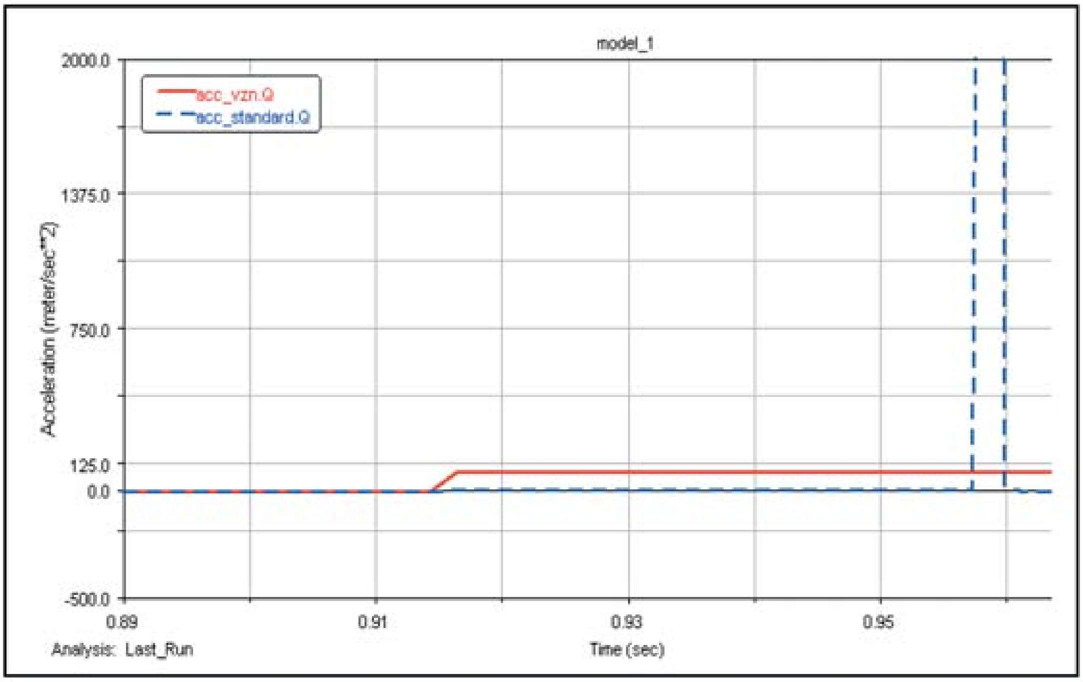

Fig. 6. Detail for Acceleration - Time evolution at VZN and Standard dampers Acceleration - Time evolution for VZN and Standard dampers

4. Conclusions

The paper presents another application of the VZN damper (shock absorber) concept, e.g. reducing the crash effect at free fall down. Due to its capacity to realize constant damping force despite the speed evolution, without electronics or other mechanism, the VZN damper tuned to realize the maximum deceleration supported by human body (9 g), assures maximum energy dissipation for a piston stroke. At this simulation the standard damper realize in the first moment this deceleration, but after speed decreasing the deceleration is more reduced because the damping force means damping coefficient (constant) multiplying with square speed. So at standard damper the energy is less dissipated and thus at the damper's stroke speed is significant generating a brutal collision. The diagrams show the chopper with standard damper produces deceleration of 18000 [m/s^2], the VZN dampers giving a constant deceleration of 9 g (88.29 [m/s^2]), that means the VZN is better 200% comparative to standard one.

The same, at VZN dampers capacity to realize constant damping force despite the speed evolution, gives possibilities to be used in bumpers, to reduce crash effect at car's collision.

This performance adds to the next, demonstrated in previous papers:

- The VZN does not hit the stop bumpers, in opposition with the standard shock absorber the piston hits regularly the stop bumpers, giving hard collision forces,
- Decreased car body vertical accelerations,
- Skyhook behaviour,
- Increased adherence,
- Increased axles, body and passengers protection,
- Reduces pitch and roll.

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