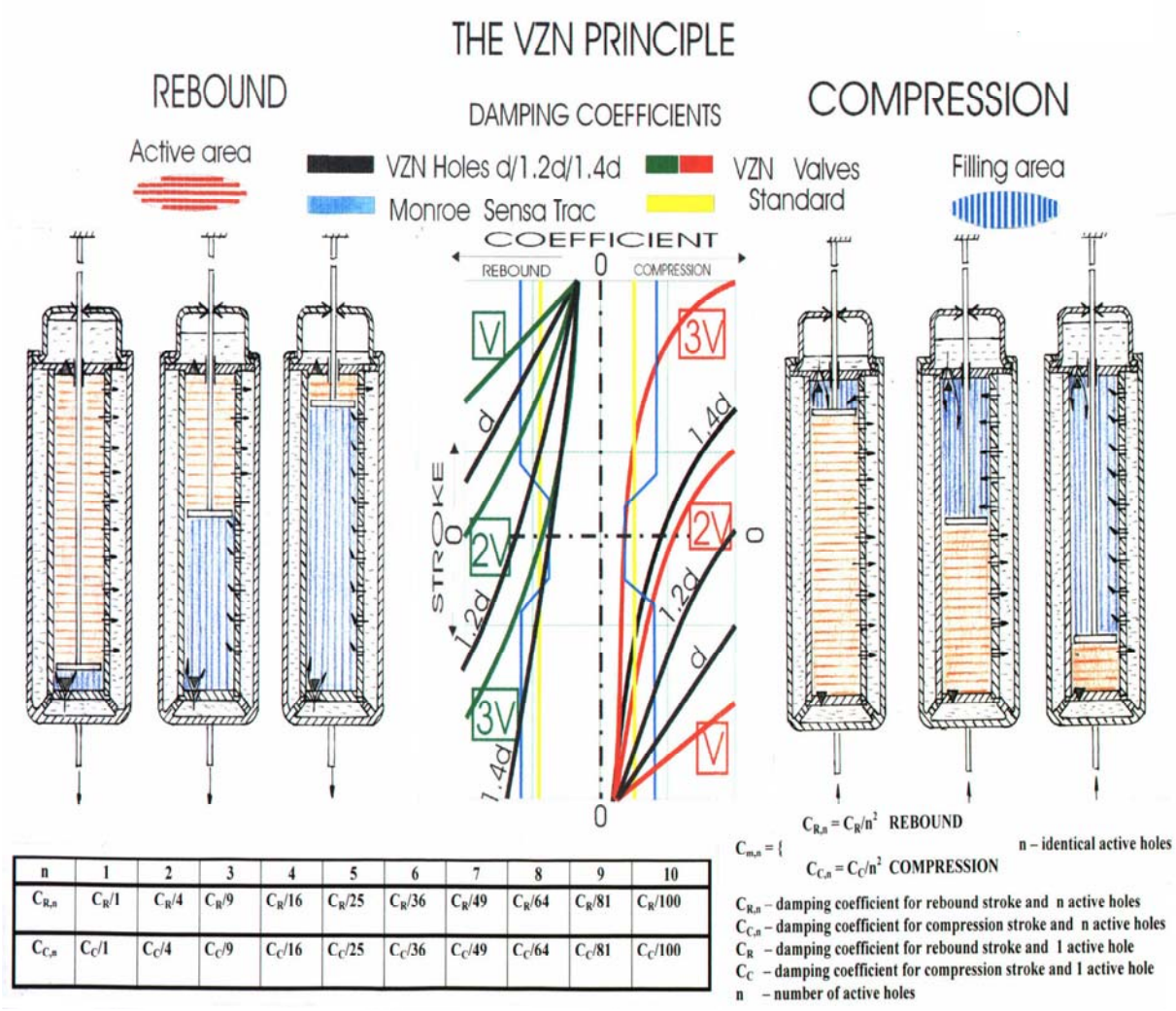
ON **"VZN"** SHOCK ABSOBER CONCEPT PERFORMANCES

The **"VZN"** shock absorber concept is a new Romanian concept granted with European Patent EP 1190184, and Romanian Patent 118546 giving high performances at low costs. The VZN acronym is abbreviation for VARIABLE ZETA NECESSARY for well navigation, in all road and load conditions, where ZETA represents the relative damping, which is stepwise changed automatically, according to the piston position.

The energy dissipation system of the self-adjustable shock absorber "VZN" consists of an inner cylinder having sideways damping valves, placed optimally between to the ends. The inner cylinder is closed at ends with inner head and valve body, either containing or no filling valves. The piston slidably mounted within the inner cylinder, without filling and damping valves.



n	1	2	3	4	5	6	7	8	9	10
$C_{R,n}$	$C_R/1$	$C_R/4$	$C_R/9$	$C_R/16$	$C_R/25$	$C_R/36$	$C_R/49$	$C_R/64$	$C_R/81$	$C_R/100$
$C_{C,n}$	$C_C/1$	$C_C/4$	$C_C/9$	$C_C/16$	$C_C/25$	$C_C/36$	$C_C/49$	$C_C/64$	$C_C/81$	$C_C/100$

$C_{R,n} = C_R/n^2$ REBOUND

$C_{m,n} = \{$ n – identical active holes

$C_{C,n} = C_C/n^2$ COMPRESSION

$C_{R,n}$ – damping coefficient for rebound stroke and n active holes
$C_{C,n}$ – damping coefficient for compression stroke and n active holes
C_R – damping coefficient for rebound stroke and 1 active hole
C_C – damping coefficient for compression stroke and 1 active hole
n – number of active holes

Figure 1 –The "VZN" principle

Due to this structure the shock absorber assures on both rebound respectively compression strokes small damping coefficients at the beginnings of strokes due to the fact that the liquid is discharged through a high number of damping valves, medium damping coefficients at the medium position due to the fact that the liquid is discharged through a

medium number of damping valves, while when the piston approaches by strokes ends the damping coefficients increase due to the reduction of the active damping valves numbers.

Fig. 1 presents the VZN principle of the self-adjustable shock absorber, relative to the standard and Monroe Sensa Trac variants. It shows the damping coefficient evolution for compression and rebound stroke. At the standard solution, they are constant along the stroke. At the Monroe Sensa Trac solution the damping coefficients have decreased values on rebound and compression in the medium position, in order to confer high comfort at the little unevenness. At the VZN concept, for identical damping valves, or metering holes the damping coefficients decrease with the square number of active valves or metering holes. “d” represents the metering hole diameter, and “V” the piston speed.

The theoretical analyses show the progressive damping coefficients at roll and pitch (because it decrease with the square of the number of active metering holes) give by VZN shock absorber, confers:

1. An anti-unbalance torque, progressive with the roll/pitch angle, so giving roll/pitch stability at unbalancing
2. An anti-redressing torque, regressive with the roll/pitch angle, so favoring roll/pitch stability at redressing

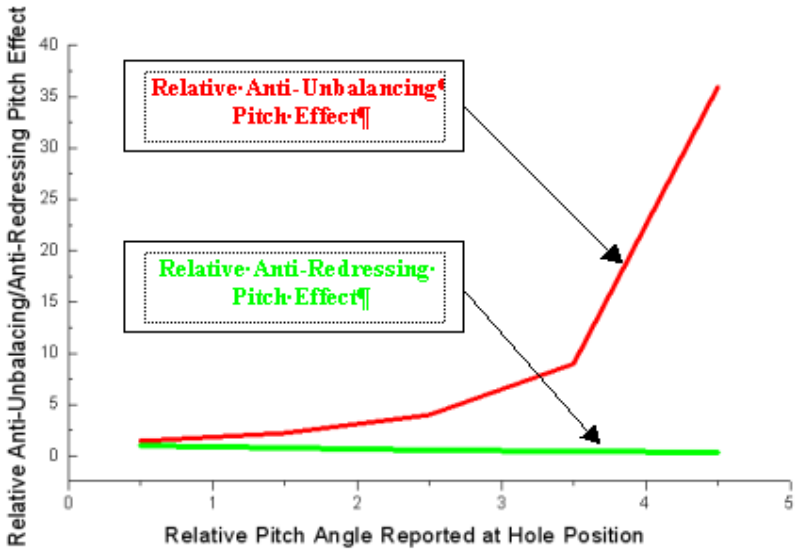


Fig. 2 The VZN shock absorber anti-pitch behavior, relative to the standard one

The simulation made on a theoretically optimized VZN shock absorber model, on hard road conditions, confirm the next advantages relative to standard one:

- Touches very rarely and softly the stop bumpers, at unevenness roads
- Reduce car body highest vertical accelerations values 5 times
- Reduce the car body root mean squares values 49%
- Reduce highest forces in stop bumpers values 23 times
- Reduce the root mean squares forces in stop bumpers values 14 times
- Are efficient even 50% efficiency
- Give the SKYHOOK behavior

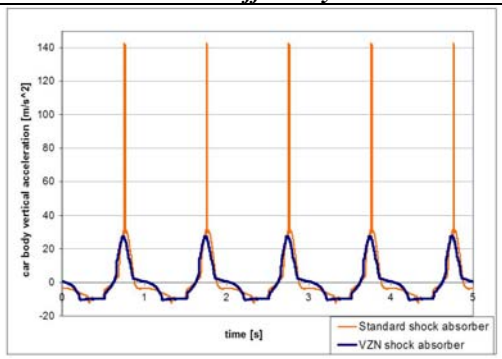
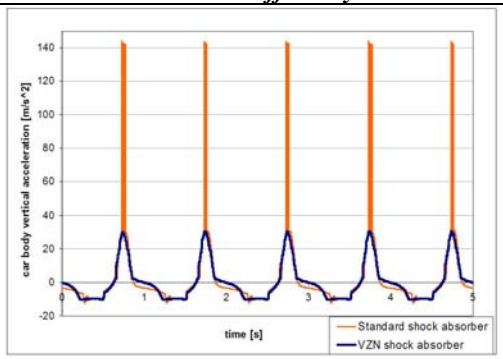
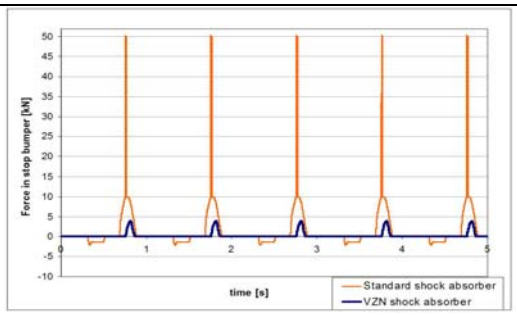
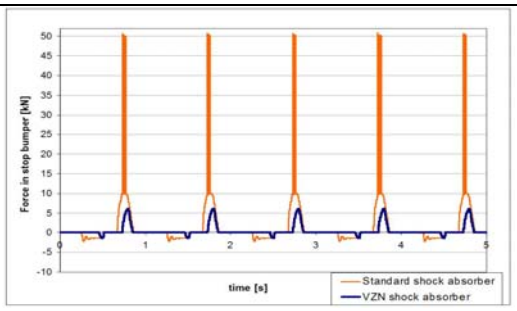
	100% efficiency	*50% VZN efficiency*
Body vertical accelerations [m/s²]	 $\ddot{x}_{1,\mathrm{RMS,VZN}} = 10.62$ / $\ddot{x}_{1,\mathrm{RMS,standard}} = 12.78$ m/s²	 $\ddot{x}_{1,\mathrm{RMS,VZN}} = 11.11$ / $\ddot{x}_{1,\mathrm{RMS,standard}} = 14.72$ m/s²
Forces in stop bumpers [kN]	 $\mathrm{RMS_{VZN}} = 0.86$ / $\mathrm{RMS_{standard}} = 3.88$ [kN]	 $\mathrm{RMS_{VZN}} = 1.49$ / $\mathrm{RMS_{standard}} = 4.65$ [kN]

Fig. 3. Car body behaviors for road profile with amplitude 0.2m at frequency 1Hz

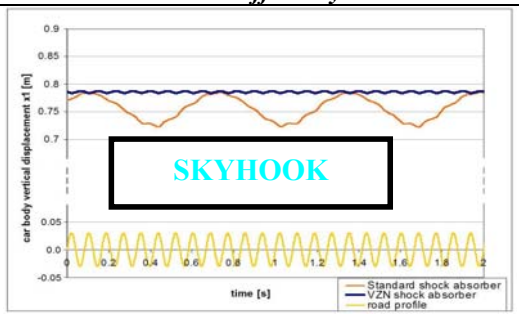
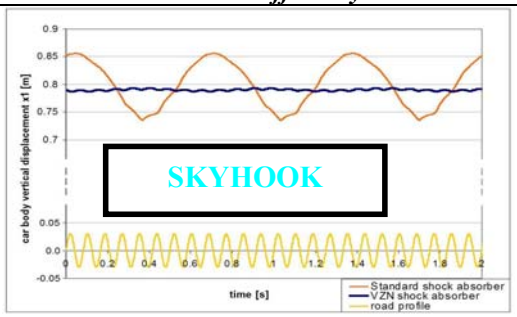
	100% efficiency	*50% VZN efficiency*
Body vertical displacements [m]	 $\bar{x}_{1,\mathrm{VZN}} = 0.786$ / $\bar{x}_{1,\mathrm{standard}} = 0.756$ [m] $\sigma_{x_1,\mathrm{VZN}} = 0.001$ / $\sigma_{x_1,\mathrm{standard}} = 0.020$ [m]	 $\bar{x}_{1,\mathrm{VZN}} = 0.790$ / $\bar{x}_{1,\mathrm{standard}} = 0.803$ [m] $\sigma_{x_1,\mathrm{VZN}} = 0.0016$ / $\sigma_{x_1,\mathrm{standard}} = 0.04$ [m]

Fig. 4. Car body behaviors for road profile with amplitude 0.03m at frequency 12Hz

The paper will present, design solution, a brief of these results and new results on road and test benches, showing the automotive self-adjustable shock absorber VZN, confers high performances, nearly semi-active suspensions, at low costs, nearly standard shock absorbers, being a great future opportunity**.**