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INVESTIGATION MODELS FOR VEHICLE DIRECTIONAL STABILITY- I part

МОДЕЛИ ЗА ИЗСЛЕДВАНЕ КУРСОВАТА УСТОЙЧИВОСТ НА ДВИЖЕНИЕ НА ЛЕК АВТОМОБИЛ – I ЧАСТ

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Abstract: The vehicle directional stability depends on various factors, such as tire construction, their lateral stiffness, the rapport H/L, the pressure and etc. The study presents a research of the influence of lateral stiffness of the suspension system and tire on vehicle stability. Three types of vehicle models were used by considering the degrees of freedom. The lateral tire-road forces are modeled using Pacejka's magic formula. The behavior of car stability has been simulated with MATLAB software. The results give the possibility to investigate the vehicle directional stability and the laterals dynamics process.

KEYWORDS: DIRECTIONAL STABILITY, MECHANICAL-MATHEMATICAL MODEL, LATERAL ELASTICITY

1. Introduction

The vehicle directional stability is important part of active vehicle safety. Stability of a vehicle concerns itself with the tendency of a vehicle to return to its original direction in relation to the oncoming medium (water, air, road surface, etc.) when disturbed (rotated) away from that original direction. The vehicle stability is influenced by many external factors (road roughness, lateral aerodynamics, tire construction) [1, 2]. Examination of the vehicle stability needs all this factors to be evaluated.

The goal of this work is the research of influence of some geometric and elastic parameters on vehicle directional stability.

2. Vehicle models

The situations are described by three different mechanical-mathematical models. The models are based on a simplified 4-wheel representation of a vehicle and separation of sprung and unsprung mass. The weight of the vehicle is supported by the sprung.

During the research we make the following considerations:

- The vehicle and its models are symmetrical to the axe O_x ;
- The dynamical process (displacement around to the axes O_y) isn't examined;
- The tire displacement is examined only around to the axe O_y ;
- Lateral tire force is modeled with Magic Formula [3];
- The differentials equations are linear.

2.1. Mechanical-mathematical model, examined the zone of directional stability

The model examined the vehicle stability with reporting the tire lateral elasticity was proposed in [4]. It's a plane model with 2-DOF. The 2 motions considered here are: lateral displacement around the axis O_y and rotation in the axis O_z .

Scheme of the model is shown to Figure 1. The point 1, 2, 3 and 4 are the projection of the wheels.

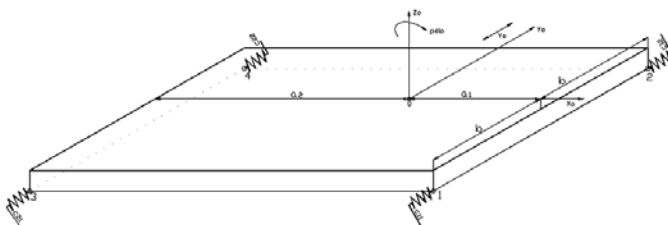


Fig. 1 Mechanical-mathematical model, examined the zone of directional stability

The equations of motion are as follows:

$$[M] \begin{Bmatrix} \ddot{y}_s \\ \ddot{\psi}_s \end{Bmatrix} + [C] \begin{Bmatrix} y_s \\ \psi_s \end{Bmatrix} = 0,$$

Where $[M]$ is the matrix of inertia which is symmetric to the main diagonal and has dimension 2×2 :

$$[M] = \begin{Bmatrix} m_s & 0 \\ 0 & J_s \end{Bmatrix}$$

Where $[C]$ is the matrix of elasticity which is symmetric to the main diagonal and has dimension 2×2 :

$$[C] = \begin{Bmatrix} 2(C_f + C_r) & 0 \\ 0 & 2(C_f a_1^2 + C_r a_2^2) \end{Bmatrix}$$

2.2. Mechanical-mathematical model "tire – suspension" examines the vehicle stability

In work [5] the vehicle directional stability was examined by mechanical-mathematical model with reporting the tire lateral elasticity and vehicle suspension elasticity. The scheme of the model is shown to Figure 2

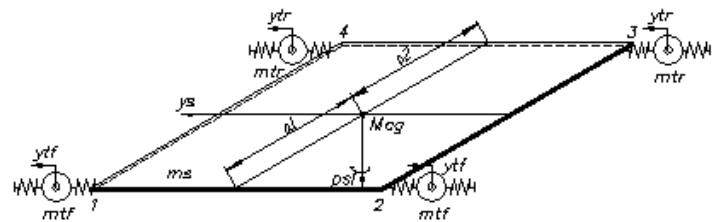


Fig. 2 Model "tire – suspension"

The system "tire – suspension" can be described as two tied subsystems. The one is the tire and the rim and the other is the suspension. Scheme of the tire model is shown to Figure 3.

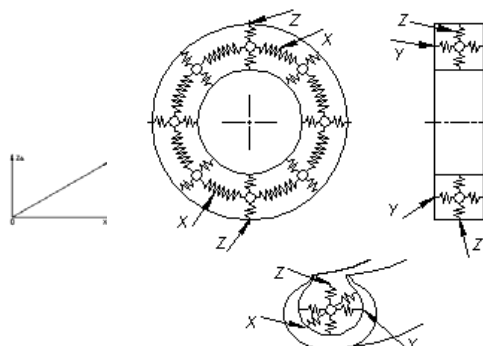


Fig. 3 Model of pneumatic tire

The model in figure 2 has a total of 6 DOF: translation in y and rotation ψ of the spring mass, translation in y of the unspring mass.

The equations of motion are as follows:

$$[M] \cdot \begin{Bmatrix} \ddot{y}_s \\ \ddot{\psi}_s \\ \ddot{y}_{u1} \\ \ddot{y}_{u2} \\ \ddot{y}_{u3} \\ \ddot{y}_{u4} \end{Bmatrix} + [C] \cdot \begin{Bmatrix} y_s \\ \psi_s \\ y_{u1} \\ y_{u2} \\ y_{u3} \\ y_{u4} \end{Bmatrix} = 0$$

Where [M] is the matrix of inertia which is symmetric to the main diagonal and has dimension 6x6:

$$[M] = \begin{bmatrix} m_s & 0 & 0 & 0 & 0 & 0 \\ 0 & J_z & 0 & 0 & 0 & 0 \\ 0 & 0 & m_u & 0 & 0 & 0 \\ 0 & 0 & 0 & m_u & 0 & 0 \\ 0 & 0 & 0 & 0 & m_u & 0 \\ 0 & 0 & 0 & 0 & 0 & m_u \end{bmatrix}$$

[C] is the matrix of elasticity which is symmetric to the main diagonal and has dimension 6x6:

$$[C] = \begin{bmatrix} 2(C_f + C_r) & 0 & -C_f & -C_f & -C_r & -C_r \\ 0 & 2(C_f a_1^2 + C r a_2^2) & a_1 C_f & -a_1 C_f & -a_2 C_r & a_2 C_r \\ -C_f & a_1 C_f & (K_f + C_f)_u & 0 & 0 & 0 \\ -C_f & -a_1 C_f & 0 & (K_r + C_r)_u & 0 & 0 \\ -C_r & -a_2 C_r & -C_r & 0 & (K_r + C_r)_u & 0 \\ -C_r & a_2 C_r & 0 & 0 & 0 & (K_r + C_r)_u \end{bmatrix}$$

2.3. Mechanical-mathematical model “tread – tire – suspension” examines the vehicle stability

The tread is that portion of the tire that comes in contact with the road. A model reported the tread lateral stiffness is investigated by Kunchev and Georgieva in [5]. The behavior of the vehicle is described using mechanical-mathematical model. Scheme of the model is shown to Figure 4.

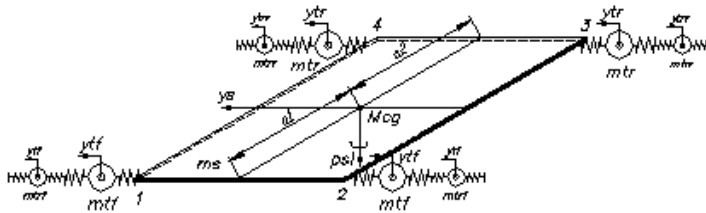


Fig. 5 Model “tread – tire – suspension”

The model has a total of 10 DOF: translation in y and rotation ψ of the spring mass, translation in y of the unsprung mass – translation in y of the tire and translation in y of the tread.

For the differential equations describing the system are valid:

$$[M] \cdot \begin{Bmatrix} \ddot{y}_s \\ \ddot{\psi}_s \\ \ddot{y}_{u1} \\ \ddot{y}_{u2} \\ \ddot{y}_{u3} \\ \ddot{y}_{u4} \\ \ddot{y}_{tr1} \\ \ddot{y}_{tr2} \\ \ddot{y}_{tr3} \\ \ddot{y}_{tr4} \end{Bmatrix} + [C] \cdot \begin{Bmatrix} y_s \\ \psi_s \\ y_{u1} \\ y_{u2} \\ y_{u3} \\ y_{u4} \\ y_{tr1} \\ y_{tr2} \\ y_{tr3} \\ y_{tr4} \end{Bmatrix} = 0$$

Where [M] is the matrix of inertia which is symmetric to the main diagonal and has dimension 10x10:

$$[M] = \begin{bmatrix} m_s & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & J_z & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & m_u & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & m_u & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & m_u & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & m_u & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & m_{tr} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{tr} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{tr} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & m_{tr} \end{bmatrix}$$

[C] is the matrix of elasticity which is symmetric to the main diagonal and has dimension 10x10:

$$[C] = \begin{bmatrix} 2(C_f + C_r) & 0 & -C_f & -C_f & -C_r & -C_r & 0 & 0 & 0 & 0 \\ 0 & 2(C_f a_1^2 + C r a_2^2) & a_1 C_f & -a_1 C_f & -a_2 C_r & a_2 C_r & 0 & 0 & 0 & 0 \\ -C_f & a_1 C_f & (C_f + K_f)_u & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -C_f & -a_1 C_f & 0 & (C_r + K_r)_u & 0 & 0 & 0 & 0 & 0 & 0 \\ -C_r & -a_2 C_r & 0 & 0 & (C_r + K_r)_u & 0 & 0 & 0 & 0 & 0 \\ -C_r & a_2 C_r & 0 & 0 & 0 & (C_r + K_r)_u & 0 & 0 & 0 & 0 \\ 0 & 0 & -K_f & 0 & 0 & 0 & (K_f + K_r)_u & 0 & 0 & 0 \\ 0 & 0 & 0 & -K_f & 0 & 0 & 0 & (K_f + K_r)_u & 0 & 0 \\ 0 & 0 & 0 & 0 & -K_r & 0 & 0 & 0 & (K_r + K_r)_u & 0 \\ 0 & 0 & 0 & 0 & 0 & -K_r & 0 & 0 & 0 & (K_r + K_r)_u \end{bmatrix}$$

3. Computer simulation

All vehicles models permit by variable of the input information

Nº	Parameter	Symbol	Value
1.	vehicle mass	m_s	1500, kg
2.	tire mass	m_u	35, kg
3.	tread mass	m_{tr}	2, kg
4.	yaw inertia of vehicle Oz	J_z	2500, kgm ²
5.	distance between CG and front axle	a_1	(1,15÷1,25)*, m
6.	distance between CG and rear axle	a_2	(1,25÷1,35)*, m
7.	front suspension lateral stiffness	C_f	(400000÷800000)*, N/m
8.	rear suspension lateral stiffness	C_r	(600000÷1000000)*, N/m
9.	front tire lateral stiffness	K_f	(50÷90)*, N/m
10.	rear tire lateral stiffness	K_r	(70÷110)*, N/m
11.	tread lateral stiffness	K_{tr}	500000, N/m
12.	front tire slip angle	α_f	(0÷3)*, degree
13.	rear tire slip angle	α_r	(0÷3)*, degree

to explore the influence of some construction parameters into the directional stability.

We used MATLAB software to calculate the Runge-Kutta method for the differential equations. It simulates the behavior of car with different position of center of gravity, with different wheel vertical load and variable lateral characteristic of suspension and tire.

Vehicle characteristics and numerical parameters were taken directly from the literature – table 1.

Table 1 Vehicle characteristics and numerical parameters
*in the simulation we combine the different value of those parameters

4. Results

Simulation results of *the first model* - displacements around the axes O_y and the angular displacement around the axes O_z when the center of gravity changes the position and for different value of tires lateral elasticity are given in table 2.

Table 2 Simulation results of the first model

c_y , kN/m		Distance from CG to front axel a_1 , m				
Front/rear wheel		1	1,2	1,25	1,3	1,5
50/50	Displacement around O_y , m	0,008714	0,008624	0,008658	0,008632	0,008694
	Angular displacement around O_z , grad	0,3924	0,3116	0,008931	0,2995	0,3895
60/60	Displacement around O_y , m	0,00796	0,007885	0,007903	0,007869	0,007943
	Angular displacement around O_z , grad	0,3586	0,2845	0,008154	0,2734	0,3556
70/70	Displacement around O_y , m	0,007391	0,007312	0,007311	0,007286	0,007354
	Angular displacement around O_z , grad	0,3321	0,2634	0,007553	0,2531	0,3288
80/80	Displacement around O_y , m	0,006928	0,006847	0,006843	0,006841	0,006898
	Angular displacement around O_z , grad	0,3105	0,2463	0,007066	0,2363	0,3076
90/90	Displacement around O_y , m	0,006534	0,006458	0,006454	0,006452	0,006487
	Angular displacement around O_z , grad	0,2921	0,2323	0,006661	0,2232	0,2902
50/60	Displacement around O_y , m	0,00831	0,008249	0,008232	0,008243	0,008256
	Angular displacement around O_z , grad	0,37	0,3661	0,3519	0,3111	0,3537
60/70	Displacement around O_y , m	0,007809	0,007592	0,007594	0,007583	0,007582
	Angular displacement around O_z , grad	0,3459	0,3331	0,3181	0,2553	0,3329
70/80	Displacement around O_y , m	0,007264	0,007076	0,007071	0,007067	0,00706
	Angular displacement around O_z , grad	0,3221	0,3101	0,2896	0,202	0,3084
80/90	Displacement around O_y , m	0,006807	0,006661	0,006646	0,006642	0,006637
	Angular displacement around O_z , grad	0,3009	0,2881	0,2655	0,1515	0,2936
90/100	Displacement around O_y , m	0,006364	0,006292	0,006287	0,006284	0,006312
	Angular displacement around O_z , grad	0,2859	0,27	0,2443	0,1057	0,2784
60/50	Displacement around O_y , m	0,008287	0,008219	0,008218	0,008231	0,008253
	Angular displacement around O_z , grad	0,3611	0,3021	0,3479	0,3599	0,3657
70/60	Displacement around O_y , m	0,007619	0,007577	0,007578	0,007573	0,007756
	Angular displacement around O_z , grad	0,3365	0,2442	0,3127	0,3307	0,345
80/70	Displacement around O_y , m	0,00708	0,007063	0,007061	0,00706	0,007225
	Angular displacement around O_z , grad	0,3154	0,19	0,2832	0,3052	0,322
90/80	Displacement around O_y , m	0,006658	0,006639	0,006637	0,006637	0,006774
	Angular displacement around O_z , grad	0,2976	0,1393	0,2576	0,2851	0,3008
100/90	Displacement around O_y , m	0,006332	0,006282	0,00628	0,00628	0,006332
	Angular displacement around O_z , grad	0,2815	0,09346	0,2376	0,2675	0,2844

The analysis of results shows that the system is unstable when the center of gravity changes his position.

Simulations results of *the second model* shown in fig. 6...8 demonstrate the displacement of tire center of gravity around the axis O_y as function of wheel slip angle.

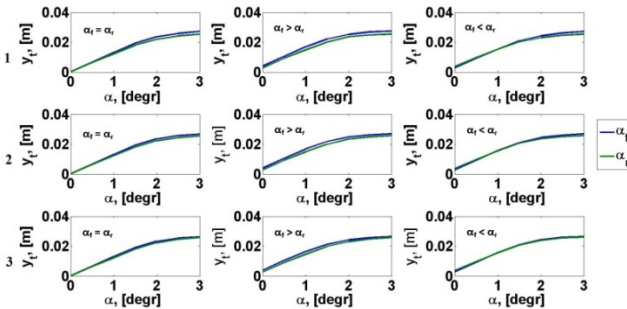


Fig. 6 Tire displacements around the axis O_y as function of slip angle estimate for:

$C_f = 400$ kN/m, $C_r = 600$ kN/m, $K_f = 70$ kN/m, $K_r = 100$ kN/m,
1 – $a_1 = 1.15$ m, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15$ m, $a_2 = 1.35$;

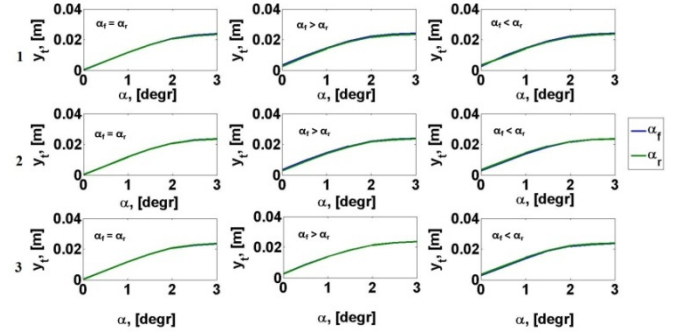


Fig. 7 Tire displacements around the axis O_y as function of slip angle estimate for:

$C_f = 400$ kN/m, $C_r = 600$ kN/m, $K_f = 90$ kN/m, $K_r = 90$ kN/m,
1 – $a_1 = 1.15$ m, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15$ m, $a_2 = 1.35$;

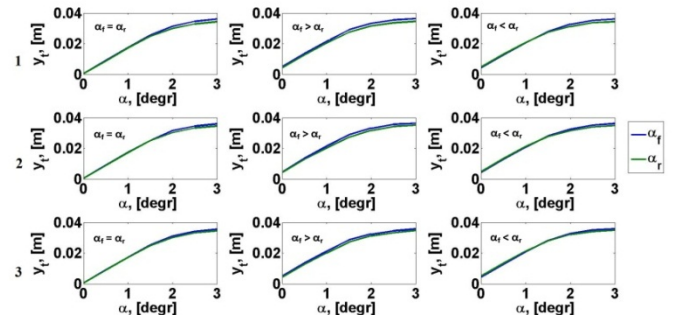


Fig. 8 Tire displacements around the axle O_y as function of slip angle estimate for:

$C_f = 400 \text{ kN/m}$, $C_r = 600 \text{ kN/m}$, $K_f = 50 \text{ kN/m}$, $K_r = 70 \text{ kN/m}$
 1 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$;

Simulations results of *the third model* shown in fig. 9...11 demonstrate the displacement of tire center of gravity around the axle O_y as function of wheel slip angle.

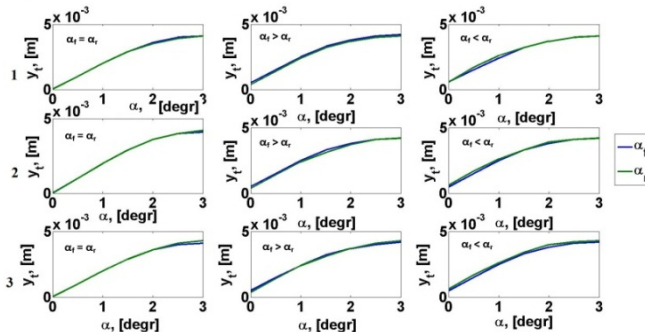


Fig. 9 Tire displacements around the axle O_y as function of slip angle estimate for:

$C_f = 400 \text{ kN/m}$, $C_r = 600 \text{ kN/m}$, $K_f = 70 \text{ kN/m}$, $K_r = 100 \text{ kN/m}$, $K_{tr} = 500 \text{ kN/m}$

1 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$;

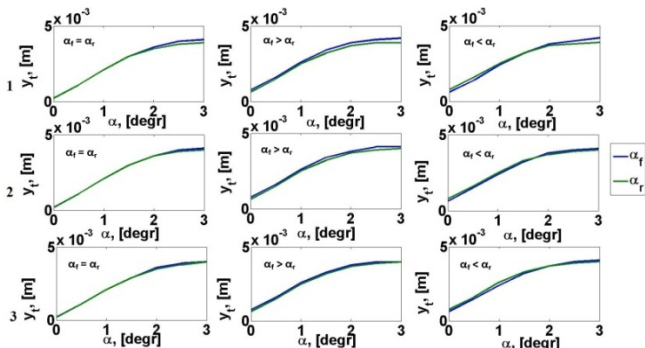


Fig. 10 Tire displacements around the axle O_y as function of slip angle estimate for:

$C_f = 400 \text{ kN/m}$, $C_r = 600 \text{ kN/m}$, $K_f = 90 \text{ kN/m}$, $K_r = 90 \text{ kN/m}$, $K_{tr} = 500 \text{ kN/m}$

1 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$;

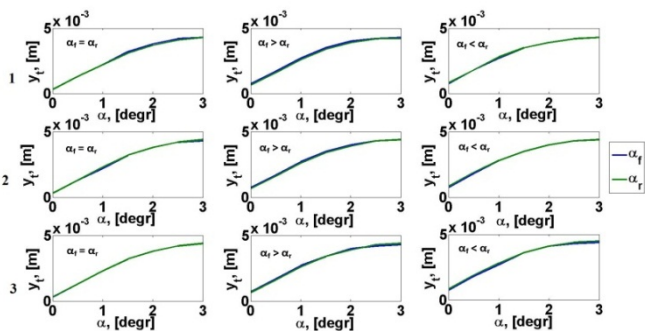


Fig. 11 Tire displacements around the axle O_y as function of slip angle estimate for:

$C_f = 400 \text{ kN/m}$, $C_r = 600 \text{ kN/m}$, $K_f = 50 \text{ kN/m}$, $K_r = 70 \text{ kN/m}$, $K_{tr} = 500 \text{ kN/m}$

1 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$; 2 – $a_1 = a_2 = 1.25$; 3 – $a_1 = 1.15 \text{ m}$, $a_2 = 1.35$;

The models include the influence of position of vehicle centre of gravity, the vertical load, the lateral stiffness of suspension, tire lateral stiffness and this of tire tread. The models give a possibility to see the influence of changing position of some geometric and elastic parameters on vehicle directional stability.

5. Conclusion

In this paper was investigated the vehicle directional stability. Three numerical models were developed to show the influence of elasticity of tire and suspension on vehicle stability. Simulation has been done at different value of lateral stiffness of tire and vehicle suspension, different position of center of gravity of vehicle and different value of wheel slip angle.

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Nomenclature:

m_s & m_u – sprung mass & unsprung mass, kg
 m_{tr} – tread mass, kg
 I_z – yaw inertia of vehicle, kgm^2
 a_1 – distance between CG and front axle, m
 a_2 – distance between CG rear axle, m
 C_f – front suspension lateral stiffness, N/m
 C_r – rear suspension lateral stiffness, N/m
 K_f – front tire lateral stiffness, N/m
 K_r – rear tire lateral stiffness, N/m
 K_{tr} – tread lateral stiffness, N/m
 α_f – front tire slip angle, degree
 α_r – rear tire slip angle, degree
 ψ – yaw rate, degree
 F_{yn} – lateral force in each tire, N
 $\ddot{y}_s$ & $\ddot{y}_u$ – lateral acceleration at sprung mass & unsprung mass, m/s^2
 $\ddot{y}_{tr}$ – lateral acceleration at tread, m/s^2
 $\ddot{\psi}_s$ – yaw angular acceleration at sprung, rad/s^2

INVESTIGATION MODELS FOR VEHICLE DIRECTIONAL STABILITY- II part

МОДЕЛИ ЗА ИЗСЛЕДВАНЕ КУРСОВАТА УСТОЙЧИВОСТ НА ДВИЖЕНИЕ НА ЛЕК АВТОМОБИЛ – II ЧАСТ

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Abstract: The paper presents a plane mathematical model of two degrees of freedom for vehicle directional stability. This model includes the lateral and yaw motions of the vehicle body. As a result, the model can be used for the analysis of the tire lateral stiffness and tire slip angle on vehicle directional stability. The behavior of vehicle stability has been simulated with MATLAB software. The results give the possibility to investigate the vehicle directional stability and the laterals dynamics process.

KEYWORDS: DIRECTIONAL STABILITY, MECHANICAL-MATHEMATICAL MODEL, LATERAL ELASTICITY, TIRE SLIP ANGLE

1. Introduction

The vehicle directional stability is important part of active vehicle safety. The generated forces between the tire and the ground surface play a primordial role in the vehicle stability during its movement. Then, it is essential to know these efforts in order to predict the vehicle trajectory. In fact, during a motion, the slip angles are produced and the tires generate the lateral efforts that make turn the vehicle in the wished direction by the driver. A specified modeling of these last parameters leads then to a better evaluation of possible trajectory and as a result to a better stability control [1, 2]. So, the slip angles and the efforts in the contact zone tire/road are the essential variables to diagnose the vehicle behavior and to control the risk of accidents connected with danger maneuvers

The goal of this work is the research of influence of tire lateral elasticity and tire slip angle on vehicles directional stability.

2. Vehicle models

Modeling the vehicle behavior in all is a complex subject and requires good knowledge of the components involved and their physics. That's way in this modeling has to take into account the tire elasticity in the contact area tire/road (see figure 1). This will give the possibility of better predict the vehicle trajectories.

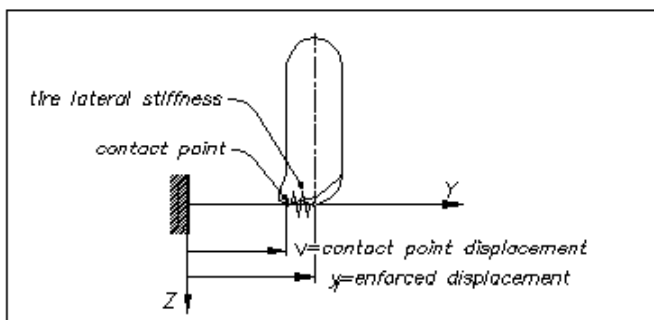


Fig. 1 Contact zone tire/road

The first step in the study of the vehicle directional stability is to create a mathematical model that have to represent the physical system with good approximation. During the research we make the following considerations:

- The vehicle and its model are symmetrical to the axis O_x ;
- The dynamical process (displacement around the axis O_z) isn't exanimated;
- The laterals forces are due to wind force;
- The tire lateral force varies linearly with the slip angle;
- The tire angles (τ) are small ($\cos \tau = 1$ et $\sin \tau = \tau$).

2.1. Plane model examining tire lateral elasticity and wheel slip angle

The model examinating the vehicle stability with reporting the wheel slip angel is known in the literature as Rocards model [3, 4].

The authors in [4] develop the Rocards model as taking account the lateral elasticity of the tire (see figure 1). The used model in the research is called "plane model examining tire lateral elasticity and wheel slip angle".

The different parameters of the model are schematized on figure 2. The vehicle motion is defined by its translation around the axis O_y and its rotation about the axis O_z . The vehicle is considered as a rigid body (sprung mass) related to the wheels. The point 1, 2, 3 and 4 to the figure 2 are the projection of the wheels.

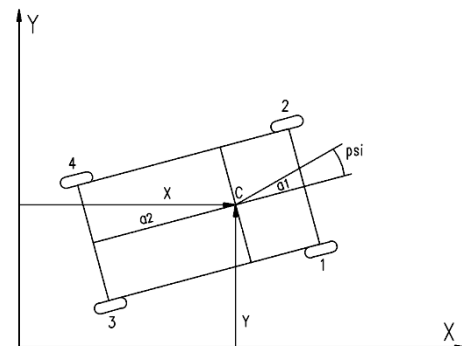


Fig. 2 Plane mode examining tire lateral elasticity and wheel slip angle

From figure 3 the slip angles $\delta_1, \delta_2, \delta_3, \delta_4$ can be determinate by coordinate y, so we have:

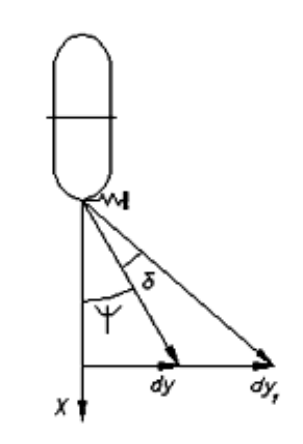


Fig. 3 Wheel slip angle δ

$$tg(\psi) = \frac{dy}{dx} \rightarrow \psi = \frac{dy}{dx} \rightarrow dy = \psi \cdot dx$$

$$tg(\psi + \delta) = \frac{dy_1}{dx} \rightarrow \delta = \frac{dy_1}{dx} - \psi \rightarrow \delta = \frac{dy_1 - dy}{dx} = \frac{dy_1 - \psi \cdot dx}{v \cdot dt}$$

If the vehicle moved with a pure rolling motion (the slip angle for the wheels were all zero) then the displacements of the point of contact of the wheels with the ground would be the same as the displacement of the center of gravity C in any interval δt : $dx=dx_1=dx_2=dx_3=dx_4=V \cdot dt$, where V is the speed of the vehicle in direction O_x .

The equations of motion are:

$$m\ddot{y} + k_1(\delta_1 + \delta_2) + k_2(\delta_3 + \delta_4) + 2(c_1 + c_2)y + 2(c_1a - bc_2)\psi = F_y$$

$$J_{Oz}\ddot{\psi} + k_1a_1(\delta_1 + \delta_2) - k_2a_2(\delta_3 + \delta_4) + 2(c_1a^2 + c_2b^2)\psi + 2(c_1a - bc_2)y = M_\psi$$

Substituting for $\delta_1, \delta_2, \delta_3, \delta_4$ we obtain:

$$m\ddot{y} + \frac{2}{v}(k_1 + k_2)\dot{y} + \frac{2}{v}(k_1a_1 - k_2a_2)\dot{\psi} - 2(k_1 + k_2)\psi + 2(c_1 + c_2)y + 2(c_1a - bc_2)\psi = F_y$$

$$J_{Oz}\ddot{\psi} + \frac{2}{v}(k_1a_1^2 + k_2a_2^2)\dot{\psi} - 2(k_1a_1 - k_2a_2)\psi + \frac{2}{v}(k_1a_1 - k_2a_2)\dot{y} + 2(c_1a^2 + c_2b^2)\psi + 2(c_1a - bc_2)y = M_\psi$$

Taking F_y, M_ψ to be zero, $I=m \cdot \rho^2$ and after substituting these relationships to the equations of motion. To solve the equations assume $y=Ae^{pt}$ and $\psi=Be^{pt}$ and substituting these value to the motions equation. To have a solution the equations system is necessary the matrix from the coefficient in front of the A and B to be equal to zero. So, we have:

$$\begin{vmatrix} p^2 + 2\frac{(k_1 + k_2)}{mv}p & 2\frac{(k_1a_1 - k_2a_2)}{mv}p - 2\frac{(k_1 + k_2)}{mv} \\ 2\frac{(k_1a_1 - k_2a_2)}{mv}p & p^2 + 2\frac{(k_1a_1^2 + k_2a_2^2)}{m\rho^2v}p - \frac{(k_1a_1 - k_2a_2)}{m\rho^2} \end{vmatrix} = 0$$

After matrix development is obtained:

$$p^4 + \frac{2}{mv} \left[k_1 \left(1 + \frac{a_1^2}{\rho^2} \right) + k_2 \left(1 + \frac{a_2^2}{\rho^2} \right) \right] p^3 + \left[\frac{4 \left[(k_1 + k_2)(k_1a_1^2 + k_2a_2^2) - (k_1a_1 - k_2a_2)^2 \right]}{m^2\rho^2v^2} - \frac{2(k_1a_1 - k_2a_2)}{m\rho^2} \right] p^2 = 0$$

This may be divides by p^2 :

$$p^2 + \frac{2}{mv} \left[k_1 \left(1 + \frac{a_1^2}{\rho^2} \right) + k_2 \left(1 + \frac{a_2^2}{\rho^2} \right) \right] p + \left[-\frac{2(k_1a_1 - k_2a_2)}{m\rho^2} + \frac{4k_1k_2(a_1 + a_2)^2}{m^2\rho^2v^2} \right] = 0$$

The analysis of stability is made with the criteria of Raus-Kurvtz by creating a square matrix from the characteristic equation $A(s) = a_0s^n + a_1s^{n-1} + \dots + a_{n-1}s + a_n = 0$.

For being systems stability is necessary $a_0 > 0$ and $\Delta_1, \Delta_2, \dots, \Delta_n$ to be always positive. Where $\Delta_1, \Delta_2, \dots, \Delta_n$ are:

$$\Delta_1 = \|a_1\|, \Delta_2 = \begin{vmatrix} a_1 & a_3 \\ a_0 & a_2 \end{vmatrix}, \Delta_3 = \begin{vmatrix} a_1 & a_3 & a_5 \\ a_0 & a_2 & a_4 \\ 0 & a_1 & a_3 \end{vmatrix}, \dots, \Delta_n = \|\Gamma\|$$

In our case $a_0 > 0$, so to have a cars stability motion is necessary the moment of intertie of front wheels to be smaller than that of rear wheels.

For the vehicles speed is obtained:

$$v^2 \geq \frac{\frac{4k_1k_2(a_1 + a_2)^2}{m^2\rho^2}}{\frac{2(k_1a_1 - k_2a_2)}{m\rho^2}} = \frac{2k_1k_2(a_1 + a_2)^2}{m[k_1a_1 - k_2a_2]}$$

3. Computer simulation

The vehicle model permits by variable of the input information to explore the influence of some construction and tire parameters into the directional stability.

We used MATLAB software to calculate the Runge-Kutta method for the differential equations. It simulates the behavior of car with different position of center of gravity and variable lateral characteristic of tire.

Vehicle characteristics and numerical parameters were taken directly from the literature table 1.

Table 1 Vehicle characteristics and numerical parameters

m	Vehicle mass	1 500	kg
a	Distance from CG to front axel	1	m
b	Distance from CG to rear axel	1,5	m
I_{z0}	Moment of inertia to axe Oz	2 500	Kgm ²
c_y	Lateral stiffness of each tire to axe Oy	57 000	N/m

4. Results

Simulations results of the model are shown in fig. 4...11 demonstrate the displacements are around the axes O_y and the angular displacement around the axes O_z as function of coordinate of center of gravity, the steering force characteristics for the front k_f and rear tires k_r and vehicles speed.

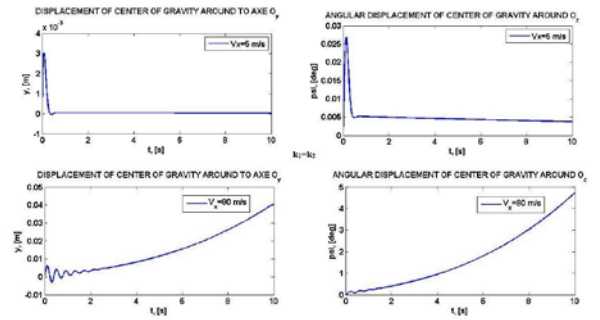


Fig. 4 Displacements are around the axes O_y and the Angular displacement around the axes O_z
Distance from CG to front axel $a_1 = 1.2$, $V_{cr} = 0$ km / h

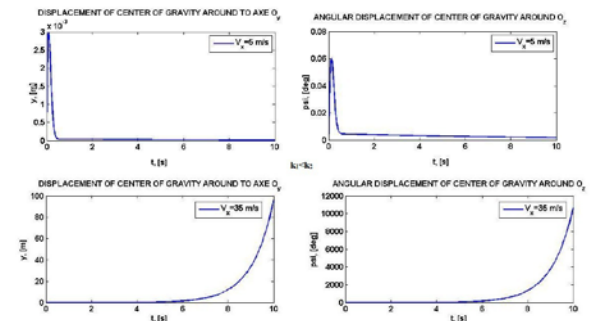


Fig. 5 Displacements are around the axes O_y and the Angular displacement around the axes O_z
Distance from CG to front axel $a_1 = 1.2$, $V_{cr} = 0$ km / h

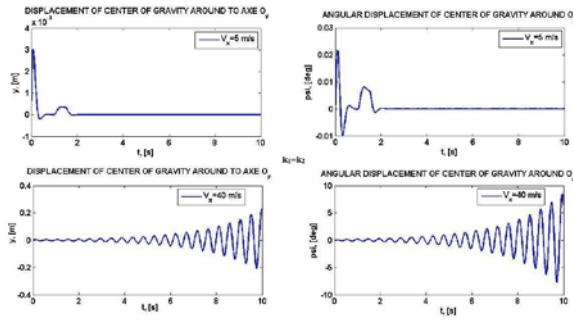


Fig. 6 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.2$, $V_{cr} = 0$ km / h, with disturbing force

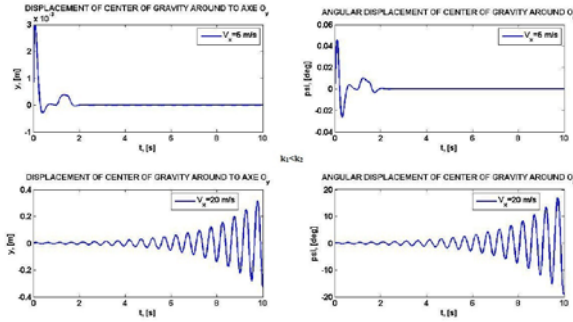


Fig. 7 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.2$, $V_{cr} = 0$ km / h, with disturbing force

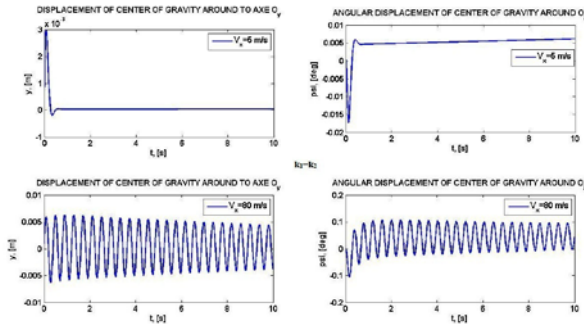


Fig. 8 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.3$, $V_{cr} = 294$ km/h

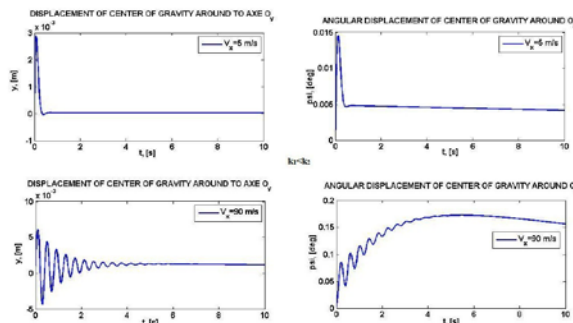


Fig. 9 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.3$, $V_{cr} = 294$ km / h

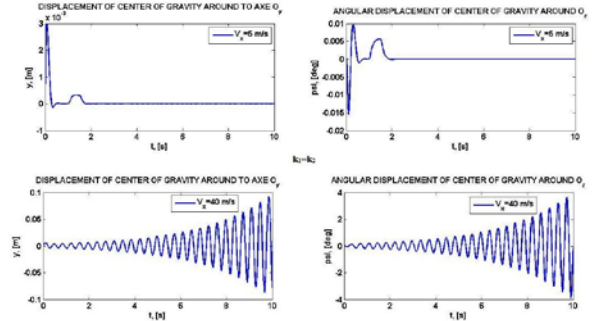


Fig. 10 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.3$, $V_{cr} = 294$ km / h, with disturbing force

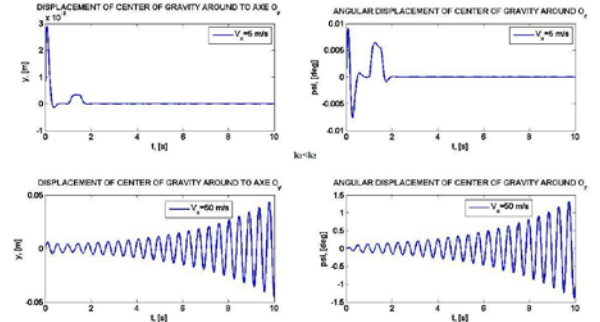


Fig. 11 Displacements are around the axes Oy and the Angular displacement around the axes Oz
Distance from CG to front axel $a_1 = 1.3$, $V_{cr} = 294$ km/h, with disturbing force

5. Conclusion

In this paper was investigated the vehicle directional stability. The numerical model was developed to show the influence of elasticity of tire and wheel slip angle on vehicle stability. Simulation has been done at different value of tire cornering stiffness and different position of center of gravity of vehicle.

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Nomenclature:

- m_s – sprung mass kg
- I_z – yaw inertia of vehicle, kgm²
- a_1 – distance between CG and front axle, m
- a_2 – distance between CG rear axle, m
- C_f – front suspension lateral stiffness, N/m
- C_r – rear suspension lateral stiffness, N/m
- K_f – front tire cornering stiffness, N/grad
- K_r – rear tire cornering stiffness, N/grad
- F_y – lateral force, N
- δ – tire slip angle, degree
- ψ – yaw rate, degree
- $\ddot{y}_{su}$ – lateral acceleration at sprung mass, m/s²
- $\ddot{\psi}_s$ – yaw angular acceleration at sprung, rad/s

MINIMUM WAGE AND REMUNERATION FORMING SYSTEMS

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Abstract: *The trends in the evolution of labor productivity and wages of employees and workers are important aspects for growth management. The salary depends on many factors, some of which can cause significant changes during the current period of remuneration. The report examined the minimum wage and how it affects in general the employees' remuneration*

Keywords: MINIMUM WAGE, REMUNERATION, EMPLOYEES

1. Introduction

The increase in labor productivity and remuneration of employees and workers is of key importance for the effective management of the organization. Leading factors in determining the salary are the level and dynamics of labor productivity and the minimum wage in the country.

2. Theoretical aspects of remuneration

Staff remuneration is one of the main activities in human resource management and the successful development of the organization depends on its efficiency. In the process of development of the remuneration policy the management staff of the organization should take into account many factors that affect it. Depending on the place of their origin, these factors can be divided into two main groups - internal and external factors (Tab. 1). External factors occur outside the organization, but affect the remuneration of its staff, while the internal ones appear in the organization itself.

Table 1. Grouping of factors influencing remuneration

External factors	Internal factors
Means of subsistence Labor market Legislation in the country	Performed work -quantitative -quality Trade unions Labor productivity Type of organization

- Means of subsistence reflect the amount of money needed to maintain the standard of living in certain economic and social conditions in the country;

- The state of the labor market and the interrelation between supply and demand of labor are the main factors that determine the level and dynamics of wages. When there is a shortage of labor force employers tend to offer higher wages. When labor supply is higher than demand employers offer lower wages and employees who have been long time in the labor market are ready to work for lower wages.

- Legislation in the country affects both the terms of standard of living and the creation of economic and social conditions for economic growth. The impact of state institutions on wages occurs through the tax and social security policy. The high amount of mandatory contributions to social security and health insurance limits the growth of real wages.

- Work nature is a determining factor in the wage formation. The amount of labor at certain quality is the process of expending physical and neuro-psyche energy in the production of a particular type of product or service. Accordingly, the salary will be higher for larger quantity of work and vice versa. According to L.Byars and L.Rue the development of remuneration system in the organization depends largely on the analysis of the labor, which includes [2]:

- Description and analysis of the main activities carried out at the workplace;

- Frequency of performance of the working tasks (daily,

monthly tasks are described consistently);

- Final results of the working process.

- The availability of professional units in the organization and their influence on employers in collective wage bargaining affect the level and dynamics of remuneration.

- The level and dynamics of labor productivity is crucial in determining wages. The increase of labor productivity leads to rise of the wages.

- The type of organization, its size, scope of activity, structure and strategy are the main factors in the process of determining the remuneration of staff. Financial stability of the employer creates opportunities for the payment of high salaries. Understanding the factors that affect wages gives an opportunity to the management staff of the organization to govern them. Each employee's remuneration should ensure his/her standard of living and should be in compliance with the required for the position physical and intellectual skills, qualifications and etc. Therefore, wages and other remuneration components should be properly defined.

The design and implementation of the remuneration system in the organization should be based on the following basic principles:

- Competitiveness - to take into account market levels of remuneration (salaries in other organizations);

- Fairness - if funds for premiums are provided, they should be deserved and fairly distributed;

- Clear and understandable for the employees system of remuneration;

- To motivate staff to high performance and quality work.

Complete and accurate characterization and classification of remuneration systems is a difficult task because in many organizations the remuneration system is considered as a confidential information. The most commonly used systems of wages are:

1. Payment according to the duration of the work - the amount of remuneration is determined by multiplying the number of working days/hours and the daily/hourly basic wage for the job or the position.

2. Payment according to the output - the wage depends on the amount of production and freight rate per unit.

3. Percentage pay - the revenue achieved by the worker/ employee/ group for the organization serves as an indicator for the assessment of the work and the remuneration is calculated as a percent of it.

4. Mixed payment - formed by elements of the salary for time and output.

5. Payment in accordance to the efficiency of operations - the remuneration of employees depends not only on achieving or maintaining standards in the specific workplace, but also on achieving the performance indicators adopted in the organization.

Additional payments to the main salary are widely applied in practice, which in shape resemble the salary, but are perceived as non-traditional forms. They are regulated by the relevant collective agreement and are intended to supplement the salary. In some cases they are social payments that are made on the initiative of the employer or trade union and are included in the provisions of the

collective working agreement. The amount of remuneration in the organization depends as well as on overtime and night work, on duty work, etc.

Recently, the complex technical processes play increasing role on the working process. Man is a direct consumer of technology thus it is essential to identify his/her needs. Changing requirements for the qualifications and skills of employees and workers, labour mobility, stress and many other factors are related to new technologies [1].

The model used by our country for determination of wages is outdated because it is based on a single payment and additional benefits. This approach is thought by both employers and employees to be inadequate. Therefore, this model should be changed.

In organizations whose main aim is the increase of profits it is difficult to maintain a high salary. As long as the profit and the marginal product of labor increase the wages will go up. Hiring an additional worker means that the revenue from the final output will decrease. The company will hire extra staff, provided that the salary is reduced.

3. Approaches for determining the minimum wage and labor productivity

The minimum wage is the lowest hourly, daily or monthly remuneration that employers may legally pay to their employees. In the Republic of Bulgaria, the minimum monthly salary is regulated by the Labour Code, while its amount is determined by the Council of Ministers. It is updated regularly with a decree of the Council of Ministers.

The level of the minimum wage depends on many factors:

- The needs of employees and their families;
- The level of the average wage in the country;
- The means of subsistence and the changes that occur to them;

• Social benefits;

• Standard of living of social groups with incomes higher than the minimum wage;

• Economic factors such as the level of labor productivity, the need to reach and maintain a certain level of employment in the country or a region.

Two approaches are applied to determine the minimum wage:

Global approach - the amount of the minimum wage is determined by the following formula:

$$MW_1 = MW_0 \cdot K_i, \quad (1)$$

where:

MW_1 - minimum wage for the future period;

MW_0 - minimum wage for the current period;

K_i - coefficient of inflation

Analytical approach, which involves the following steps:

• Preliminary Stage:

- Determining a subsistence minimum, social minimum, existence minimum and threshold of poverty. The subsistence minimum includes the existence minimum and the social minimum.

- Consideration the priorities of the social policy of the country;

- Consideration the availability of economic resources;

- Consideration of the role of social security systems as additional sources of income;

- Consideration of the nature of the anti-inflationary policy in the country;

$$MW_1 = S_p + S_c - SP_f \quad (2)$$

where:

S_p - money amount of the monthly social minimum of a parent

S_c - money amount of the monthly social minimum of a child

SP_f - social benefits for a household

The German parliament only in 2014 has begun to discuss a bill setting the minimum gross hourly wage in Germany. It is

expected that the proposal for the minimum wage will come into force next year. The minimum hourly wage will be applied in two years.

The main difference between the Bulgarian and German model of minimum wage is that in Germany the minimum wage will not be applied to all employed. For example, it will not be applied to the employees under 18 years, to those returning to work after long-term unemployed in the first 6 months of their reintegration into the labor market and etc.

Table 2. Minimum wages in the EU for the period 2013 - 2014

Countries	2013 (euro)	2014 (euro)
Luxemburg	1874	1921
United Kingdom	1264	1293
Belgium	1502	1502
France	1430	1430
Slovenia	784	784
Romania	157	191
Bulgaria	158	174

Table 2 presents the minimum wages in some EU Member States for the period 2013-2014. The highest minimum wage is in Luxembourg, while the lowest in the whole European Union - in Bulgaria. Only Romania in 2013 had a lower minimum wage than in our country, but in 2014 it was changed and Bulgaria keeps the last place. Graf. 1 shows the levels and dynamics of the minimum wage in some EU Member States for the period 2013 - 2014.

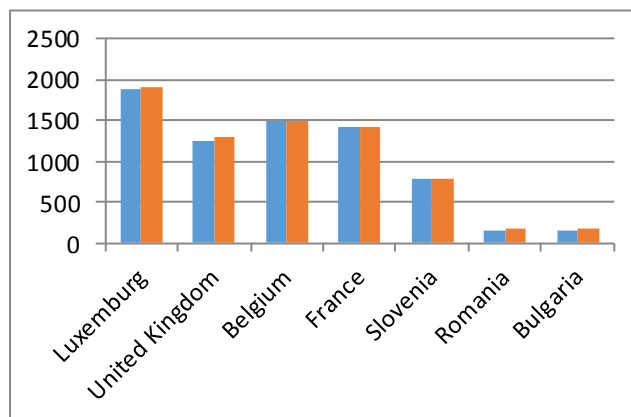


Figure 1. Wages in the EU

Fig. 1 shows that for the period 2013 - 2014 the minimum wage in most EU Member States remains constant, indicating a lower unemployment in those countries. The lowest minimum wage in Bulgaria can be explained by the lowest level of labor productivity in the country (Tab. 3).

Table 3. Labor productivity per person employed 2013

Group	Labor productivity per person employed (euro)	Countries
1.	43.4 - 71.6	Bulgaria, Romania, Hungary
2.	71.9 - 82.6	Poland, Portugal
3.	82.6 - 107.10	Germany, Slovakia, United Kingdom, Greece
4.	107.10 - 114.5	Austria, Spain
5.	114.5 - 163.9	Belgium, France, Luxembourg

According to Eurostat data [9], EU Member States can be grouped into five groups according to labor productivity. For 2013, the lowest labor productivity per person employed is 43.4 euro in Bulgaria, and the highest 163.9 euro in Luxembourg, i.e. labor productivity in Bulgaria is 4 times lower than that of more

developed countries in the EU. At the same time the minimum wage in Bulgaria is lower than 10 times (Tab. 1). Important in determining the minimum wage is the level of labor productivity. Table. 2 presents labor productivity per person employed and the minimum wage for Bulgaria, as well as the minimum social security threshold for the Chemistry industry. The main purpose of the application of the minimum social security threshold by economic activities is the attempt to terminate the unfavorable trend of formal social security paid on minimum wage and unofficially payment of a higher salary. Combating the shadow economy by the application of social security threshold is particularly necessary in a situation of a crisis and limited public resources.

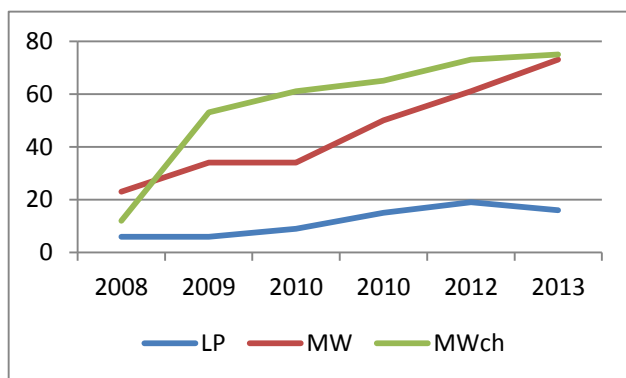
In the negotiation of the minimum social security threshold in Bulgaria the following factors have been taken into account:

- The minimum wage in the country (lev);
- The rate of growth of the minimum wage (%);
- The inflation rate in the country (%).

Table3. Labor productivity and Minimum wage
2003 г. – 2013 г.

Year	Labor productivity per person employed (euro)	Minimum wage (euro)	
		Bulgaria	Chemistry industry
2003	34.7	56	104
2004	34.7	61	105
2005	35.8	77	106
2006	36.4	82	115
2007	37.4	92	126
2008	39.7	113	154
2009	39.7	123	193
2010	40.8	123	203
2011	42.9	138	208
2012	44.5	148	218
2013	43.4	159	220

Fig. 2 shows that the rate of growth of labor productivity for the period 2007 - 2013 was an average 11.83 % (based on data for 2007). For the same period, the minimum wage increased on average by 45.83% and the minimum social security threshold for the chemical industry with 56.50%.



Graph 2: Labor productivity, minimum wage and minimum social security threshold for the chemical industry for the period 2008-2013

Despite the high growth rate of the minimum social security threshold for the chemical industry in Bulgaria compared to labor productivity, only 20% of the country's needs of chemicals and products are provided by domestic production. Around 50 000 people are employed in the chemical industry sector (8% of the employed in the industry as a whole), they produce 22% of the industrial production and provide 25% of total Bulgarian exports. The number of employed in the chemical industry for the period 2008 - 2012, however, decreased by 21%, which led to decrease of the volume of production.

Minimum wage reflects the minimum social standard that is a result of legal and political norms aimed at ensuring a decent life and respecting the social rights of citizens. Minimum social standards in each country have to comply with those requirements. They must guarantee the equal access of all citizens to goods and resources. Unlike in the majority of EU Member States the minimum wage in our country cannot perform these functions. The effect of the minimum wage in Bulgaria will occur when it reflects the minimum social standards and becomes a real measure of labor. But it requires an increase of the minimum wage not in percent but in times.

In the model of "effective wage" in the classical theory it is assumed that it is possible in a short term period for the wage growth to outpace productivity growth. The social welfare systems in the country also play in this model as an alternative minimum income. This model could be applied in countries where social assistance is not as developed. The formation of the minimum wage that is higher than the rate of productivity growth would lead to an increase in wages of low-skilled workers. Application of new technologies, however, reduces the need for low-skilled workers and increases the share of high- skilled employed.

3. Results and discussion

Raising the minimum wage in Bulgaria is essential for the welfare and purchasing power of the employed and their families. However, when this increase is a direct function of the existence or social minimum or is a result of administrative measures, the following adverse trends occur:

- Increase of the employers' expenses for wages and social and health insurance, lay-off of staff and increase of the level of unemployment in the country;
- Inability to create new jobs;
- Conditions for concealment of income and increase of the share of shadow economy;
- Lower economic growth and risk of bankruptcy of small and medium enterprises;
- Reduction of investment in the economy, due to worsened economic conditions (low wage costs, insurance, etc.).

4. Conclusion

Therefore, in determining the minimum wage, it should be taken into account the impact of the real current economic factors and the level of labor productivity in both the industry and the country. It should also be considered the positive and negative consequences of increasing the minimum wage not only on individual groups of workers and employers, but also on society as a whole. Solving problems in negotiating the minimum wage should be done through negotiations between representatives of government, employers and trade unions.

Acknowledgment

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TRANSFORMATION OF FLEXIBLE ART IMAGE USING SOFTWARE APPLICATION

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Abstract: The report examines the 5-way method as a process with clearly defined intellectual relations – idea, point object, sketch, digital image and implementation. In the first experiment the idea is to create a design product based on photography. In the second experiment the idea is suggesting certain feelings and thoughts through artwork. This initial stage is the accomplished design product transformed into an artwork by traditional painting techniques, collage and assemblage.

Keywords: art, design product, software, digital image, photography, sketch, artwork, traditional painting techniques

1. Introduction

Define the term flexible art image.

The flexible art image is part of the terminology of the visual arts.

The term visual art is any art form as graphics, painting, sculpture, photography, video, film and architecture. Within this concept including all the traditional techniques in drawing, industrial design, graphic design, fashion design, interior design and decorative art.

Art in its general terms is visualizing the ideas of the author followed by knowledge and skills related to the aesthetic rules of representation.

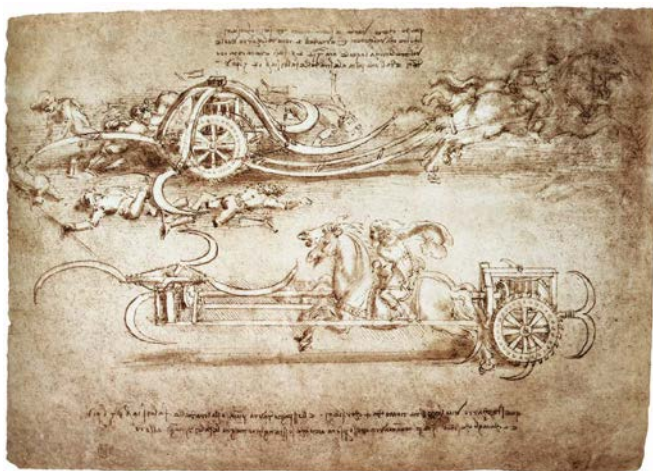
Each artwork in the flexible arts is representing its idea, expressed by the corresponding language. By its means of expression creates a specific image that is artistically recreated.

That is why the concept of flexible art image represents:

- Express language of the arts;
- The idea of the author;
- Visually transmitted image of a particular theme;
- In individual works or series, we track specific storyline.

One of the biggest names in the art world, but also in architecture and design from a modern viewpoint is Leonardo Da Vinci. His sketches are then one-of-a-kind, showing in detail each part and its function. We can trace the origin of certain ideas.

The following sketch is a model of a chariot in which the creative implementation of artistic interpretation is on drawing level only. (Fig.1) But accompanying notes help the identification of the



painting with the modern version of the design-sketch.

Fig. 1 Model of Scythed chariot (Royal Library in Turin0.1485y. 20sm/28sm

Another representative of the Renaissance in Italy is Michelangelo Buonarroti - one of the biggest names in the history of the visual arts.

His knowledge and skills in the field of painting and sculpture are studied and analyzed in many schools today. Very typical for him is the appearance of the plastic volume and shape both in the sculpture and in the painting. Every detail has been previously studied and presented as an idea in a particular drawing, which is then implemented in a particular work.

The Sistine Chapel painted ceiling in Rome is a peculiar example of "breaking" the architectural plane of the ceiling with the help of perspective and picturesque flexible art image.(Fig. 2) The storyline is presented through scenes and portrait images of various prophets.



Fig. 2 The painted ceiling of the Sistine Chapel in Rome

In sculpture authors work with volume that develops in space. The air is additional element to establish the composition of the sculpture group. The idea of motherhood recreated in Pieta by Michelangelo (Basilica 'Saint Peter', Rome) is an example of a visual representation of the volume in space. (Fig. 3)

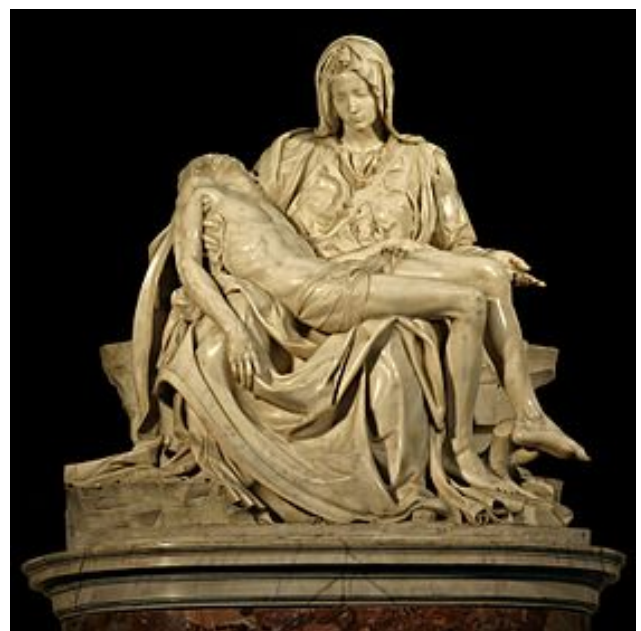


Fig. 3 "Pieta", 1498-1499, the Basilica 'Saint Peter', Rome

The above authors are primarily active in the field of fine arts, but their appearances as designers and architects is part of the history of art. Their knowledge in the fields of science and arts ranks them next to the biggest names in the field and in the design from present-day perspective.

Their experience gives us foundation for the possibilities of science and art to be presented as a synergistic model of knowledge. That is exactly why new technologies allow one plastic art image to be transformed and presented as a graphic equivalent of an idea.

With the advancement of new technologies and after digitization of data, more computer graphics are created.

The term computer graphics in its general sense means any image created with the help of hardware and software that is not sound or text. Manipulation of images (photography) with the help of software, creation and finishing details of images.

The role of photography is to preserve the digital idea of the photographer. The photograph (photo) itself can serve as a way of documenting, with the intention to keep visual materials. It can also serve as sealing of certain moments and emotions that subsequently be used to create flexible art image, performance or design product.

The flexible art image in the photography can be achieved with achromatic (black, white and grey) or chroma colors. Themes ranging from landscapes to portraits. Its types are:

- Black-white photography;
- Portraite photography;
- Landscape photography;
- Macro photography;
- Micro photography.

The flexible art image is used in the learning process. It can be achieved by the expressive language of painting, graphics, sculpture and photography. Its final execution in the design process must be done with the help of a software. That is why it requires a certain method through which its transformation is not simply a mechanical transfer, but a process where the flexible art image is expressing more of its own characteristics after a necessary image processing.

2. Introduction in the 5-way method

The necessity of knowing how to create an image with various drawing and painting techniques gives the foundation for a method to use these skills while creating the computer graphic image.

Utilization and application of this knowledge is the first step in the creation of an aesthetically pleasing artwork - design product.

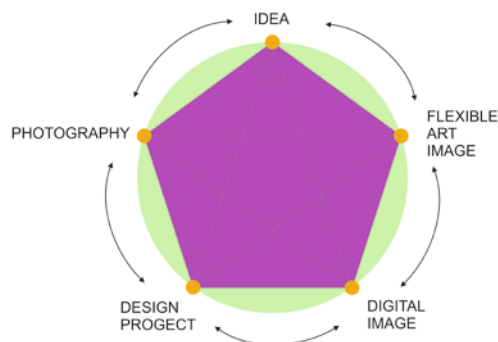
The 5-way method is introduced, with the help of which the relationship between art, design and digital synthesis and manipulation of the visual content is showed.

The birth of an idea, transforming it into a specific theme, the creation of the story is a mental process. Mental links - idea - object - sketch - digital image - implementation are part of the creative act. (Table 1) For the implementation it is necessary to create a specific sketch, with the help of which a digital image becomes reality.

The created prototype can be implemented in a particular material.

The method is based on a specific scheme combining the following divisions: an idea, object, sketch, digital image and implementation.

Table 1. Two ways, mental links (idea – object – sketch – digital image - implementation).



At the start of a project related to a particular implementation, various directly or indirectly ideas related to a specific theme are analyzed. Collecting ideas can be effected by different means of techniques and technologies. This leads to a synthesis and development of a particular object.

Next step in the analysis of ideas is the creation of sketches that illustrate important moments in the final implementation. Sketches could be made using conventional painting techniques, such as use of pencil and paper or description.

Defining the term **analytical sketch** (expressing the idea of creating an object with the help of words (speech, writing))

Analytical sketch is the expression of an idea by means of speech. A series of precise moments, colors, shapes, specifying the final product is built.

Sketching can be a mix of illustration and analytical sketch describing important moments concerning the object (as in the sketch of Leonardo Da Vinci). In the analytical sketch, the role of the teacher is leading. He uses the words to help the student to analyze and objectify in details his idea until its final clarification. The notes or amendments that the student adds or removes in the drawing are specific to the current verbal analysis of the idea. That's exactly when the analytical sketch becomes the basis for its further development and implementation using a software product.

3. First and second experiments

In 2014 an experiment was conducted with students of 2-nd course classes in History of Art and Design, majoring in Engineering Design at the Technical University - Sofia, which aims to implement this method to quickly absorb, analyze and improve the options for the implementation of a design product.

The theme was Ancient Egypt.

The requirement is a cardboard or watercolor paper in the following paper size formats: A4, 35/25 or 35/50. The techniques to use are tempera and / or watercolor. An implementation is chosen i.e. a patterned fabric or a curtain, with a limit of up to 5 colors. The main task is to select a single element associated with Egyptian Art (figure, shape, ornament, capital, architectural object, etc.) and to make different version with different styles. The variants of the stylizations can be penciled with the help of a black pencil or fine-tipped pen in the form of graphics. A mandatory condition is to create a frieze composition with tempera if the implementation is a curtain.(Fig. 4 and Fig. 5)



Fig. 4 Patterned fabric and a curtain, student work



Fig. 5 Implementation of a curtain, student work

The theme for the second experiment was Ancient Greece.

The requirement is a cardboard or watercolor paper in the following paper size formats: A4, 35/25 or 35/50. The techniques to use are tempera and / or watercolor. Students are given the opportunity to select compositions suitable for accessories and jewelry. On the selected paper format and with the selected technique, the author should draw a set of at least three accessories or jewelry items. Ornaments or use of specific works of art from the period of Ancient Greece are applied in the final works. It is mandatory to properly scale each object considering the size of the other objects.

After drawing the sketches with the traditional techniques, a design project of two pages of a catalog must be created with the help of the following image editing tools: Adobe Photoshop, Corel's CorelDraw, Adobe Illustrator or Adobe InDesign (the student is allowed to use one or more of these tools to complete the task). Symbols, text, illustrations, etc. necessary for the design of the catalog could be used as well.(Fig. 6 and Fig. 7)

The traditionally made final works can be photographed, scanned or created within the selected software.

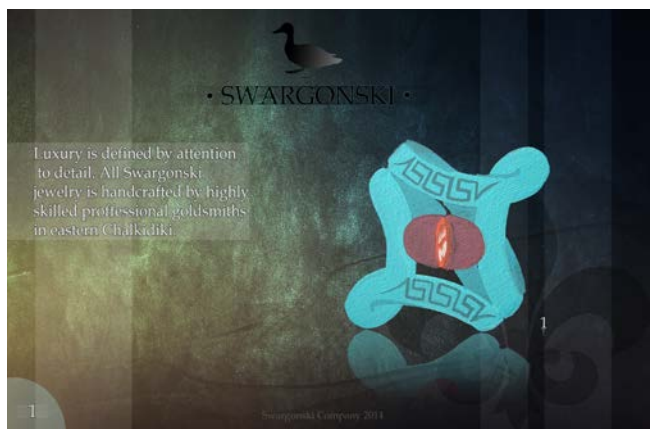


Fig. 6 Jewelry, final project, first page, student work

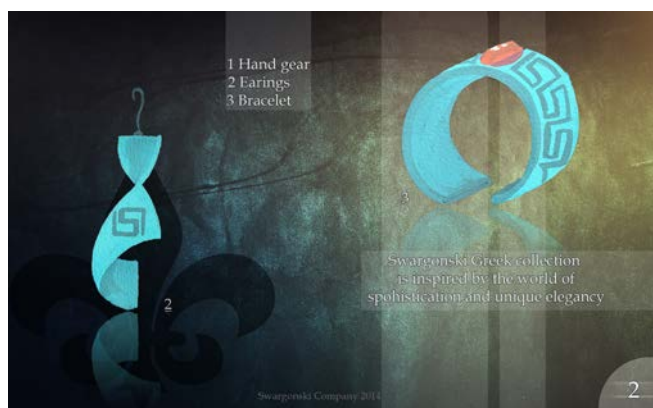


Fig. 7 Jewelry, final project, second page, student work

4. Creating a design product using readymade graphics

The method could be implemented in other sequence. The initial step is to use previously taken portrait photography.(Fig. 8) The implementation is as follows:

After taking the portrait photography, the digital image is then edited with the tools provided by the software. The new digital image is consequently manipulated in Adobe Photoshop to a moment, when the idea does not differ from the original flexible art image, making it ideal for a design project.(Fig. 9)

With the help of the digital image and the tools available in the software, a vector image is then created, allowing lossless image manipulation.

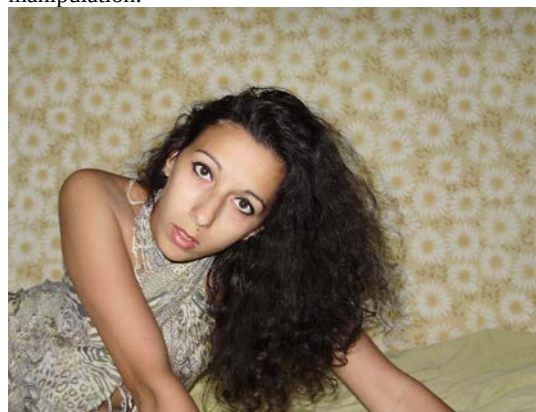


Fig. 8 Self taken photography



Fig. 9 After manipulation in Adobe Photoshop

The implementation is then formatted to the final print size, required for printing the design project - business card.(Fig. 10)

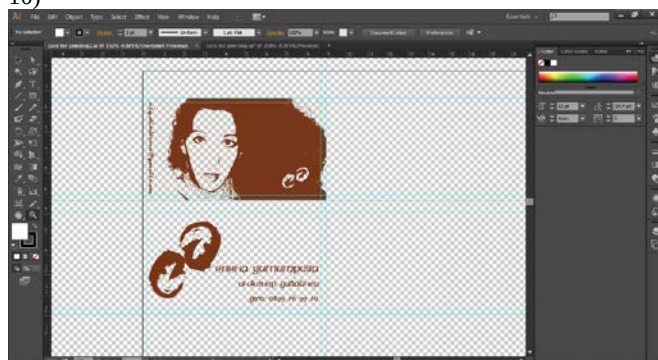


Fig. 10 Preparing the business card for printing, Adobe Illustrator

5. Conclusion

This method is preferred when working with students, because each stage is part of the above mentioned circuit.

The 5-way method is not limited to the curriculum of specialized schools, but can also be used in companies which deal with advertising.

The essence of the method is to create a digital image, that can therefore be used in the graphic, interior, industrial, fashion and automotive design. Developing a special system to analyze the studies made, by using a composed conceptual scheme.

The method allows making both design products and the flexible art images.

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DETERMINATION OF HEAT TRANSFER COEFFICIENT BY INVERSE HEAT TRANSFER ANALYSIS WITH THERMOGRAPHIC EXPERIMENT

Определение коэффициента теплоотдачи решением обратной задачи из термического эксперимента

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Abstract: The objective of this paper is to determine temperature dependent heat transfer coefficient for the characterization of building porous materials in the range 20 – 60 °C, using the approach based on the solution of the inverse heat transfer problem and the results of measuring boundary conditions. The Levenberg – Marquardt iteration algorithm in software MATHEMATICA is applied to solve nonlinear system of algebraic equations resulting from the sensitivity matrix. The surface temperature distribution is measured using the infrared camera.

KEY WORDS: HEAT TRANSPORT COEFFICIENT, INVERSE PROBLEM, THERMOGRAPHY, BUILDING MATERIAL

1. Introduction

The heat transfer coefficient - quantity controlling heat transfer process is given by Newton's law of cooling of porous materials exposed to normal climatic conditions and can be determined using standard laboratory techniques. However, current research in determining the construction materials thermophysical properties indicates the unsuitable nature of standard measuring methods, Shin et al [1].

In order to determine the thermal characteristics of structural, thermal-protective and thermal-insulating materials as a function of temperature, the inverse heat transfer problem should be solved. New methodology combines accurate measurements of thermal quantities, which can be experimentally observed in real conditions and accurate data processing, based on the solution of inverse heat transfer problem. Performed inverse analysis involves the optimization procedures with the classical least squares calculations of the objective functions (differences of calculated from the perfect solution of the direct problem and measured temperatures).

In the present paper, the method for estimating heat transfer coefficient is carried out for building porous material. For such material the goal is to estimate the characteristic as temperature function by using results of measuring boundary conditions and surface temperature of body under consideration. The proposed procedure of determining heat transfer coefficient consists of heating a cylindrical geometry sample by a surface heating element and measuring (after reaching a steady-state) temperatures along side of the specimen using an infra-red camera. Temperature measurements are then processed through the inverse thermal modelling software, which identifies unknown heat transfer coefficient occurring in the model. It has to be stressed, that an infra-red camera used in the experiment allows to utilize a large amount of temperature measurement. This generally makes the approach fairly stable and accurate.

2. Preconditions and means for resolving the problem

2.1 Experimental setup

The sample is a part of vertical object made of the two same coaxial cylinders with surface heater in between them. In this paper only the

results measured on the upper cylinder are processed. The sample is mounted vertically and heated from the bottom base by surface heater with constant electrical power. The sample is embedded in chamber with constant temperature. The experimental setup ensures axis-symmetric cooling conditions of 2D steady-state heat transport in the specimen. The surface temperature distribution of the specimen is measured by infrared camera, see Fig.1.

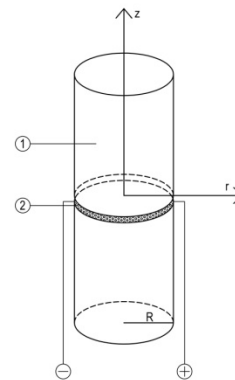


Fig. 1 Setup of experiment 1 – heater, 2 – sample

2.2 Mathematical model of 2D steady state heat transfer

The governing equation for above axis-symmetric steady-state thermal conditions, for material which thermal conductivity $\lambda(T)$ is temperature dependent, can be written as

$$\text{div}[\lambda(T)\nabla T] = 0 \quad (1)$$

Where $T(r, z)$ is temperature field of the sample, r and z are the radius and the height of the specimen, respectively.

Heat transfer along the surfaces of the specimen is defined by boundary conditions, which are expressed as follows

$$-\lambda(T)\frac{\partial T}{\partial z} = q \quad r \leq R \quad \text{and} \quad z = 0 \quad (2)$$

$$-\lambda(T)\frac{\partial T}{\partial r} = h_v(T)(T - T_e) \quad r = R \quad \text{and} \quad 0 \leq z \leq H \quad (3)$$

$$-\lambda(T)\frac{\partial T}{\partial r} = h_H(T)(T - T_e) \quad r \leq R \quad \text{and} \quad z = H \quad (4)$$

Where T_e is the ambient temperature, q is the heating flux, $h_v(T)(T - T_e)$ and $h_H(T)(T - T_e)$ represents the heat exchanged with the ambient air, $h_v(T)$, $h_H(T)$ are the heat transfer coefficients dependent on temperature, which controls cooling process alongside and top surfaces, respectively. Considering temperature range of interest in building applications is $(20 - 60)^\circ \text{C}$.

2.3 Inverse determination of heat transfer coefficient

The objective is to determine the heat transfer coefficients with the assumption that everything in the direct heat transfer problem (1) – (4) is known except for one and some temperatures T_i^m , where $i = 1, 2, \dots, N_m$, which are measured at well defined locations alongside surface. The results of surface temperature measurements are assigned as necessary additional information to solve the inverse problem. In the inverse problem (1) – (4) it is necessary first of all to indicate the temperature range $[T_{\min}, T_{\max}]$ of the unknown function (heat transfer coefficient), which is general for experiment, and for which the inverse problem analysis has a unique solution. In the solution of the formulated direct problem, we employ a centric-difference scheme. As already mentioned, it is assumed that heat transfer coefficient varies with temperature. Hence the whole temperature range is divided into certain number of sub-ranges within which particular properties are modeled as piecewise linear. This practically means that one has to identify small number of parameters which represent heat transfer coefficient values at selected temperatures.

We want to find such a heat transfer coefficient $\mathbf{h} = (h_1, h_2, \dots, h_{N_h})$, that the objective function [2]

$$S(\mathbf{h}) = \sum_{i=1}^{N_m} \frac{1}{\delta_T^2} (T_i^m - T_i^c(\mathbf{h}))^2 + \sum_{j=1}^{N_h} \frac{1}{\delta_{h_j}^2} (h_j - h_j^0)^2 \quad (5)$$

reaches the minimum among all admissible vectors $\mathbf{h}$, where $(h_1, h_2, \dots, h_{N_h})$ stand for the heat transfer coefficient values at selected temperatures (respectively locations alongside and top surfaces) T_j with $j = 1, 2, \dots, N_n$; $T_i^c(\mathbf{h})$ are calculated temperatures (at the positions where temperatures T_i^m are measured) with estimates for the unknown quantities $\mathbf{h}$. The standard deviation δ_T is error associated with the temperature measurement. In processing the results of real experiments there are always errors, depending on a number of reasons. First of all, the errors in the experimentally measured data are both, random and systematic by nature. Random errors in input data are stipulated by a spread of thermal and electrical characteristics in measuring devices, by inaccuracy of their calibration, etc., as a rule, these errors show a large enough value. Systematic errors in the input data are usually connected with inaccuracy in determining the

coordinates of positions of T_i^m , with displacement of the specimen during filming survey etc. The second group of errors – the errors of finite-difference approximation of differential operator in initial problem and round-of errors in computer. Besides, there are errors because of uncertainties in the a-priori assigned characteristics of mathematical model (1) – (4), which are determined either through calculations or from a solution of the corresponding inverse problem. The deviation δ_{h_j} is an interval within each of the parameters h_j is allowed to vary around a priori (i.e., guessed) parameter h_j^0 . The function $S(\mathbf{h})$ becomes the standard least-squares method when the δ_j are set to infinity, and h_j will be fixed to the value h_j^0 . The values h_j in each interval, $[T_j, T_{j+1}]$ are linearly interpolated. The minimizing procedure, in which components of the vector $\mathbf{h}$ are updated, is based on the concept of sensitivity coefficient [3]. In order to minimize $S(\mathbf{h})$, one writes

$$\frac{\partial S}{\partial h_j} = \sum_{i=1}^{N_m} \frac{-2}{\delta_T^2} (T_i^m - T_i^c(\mathbf{h})) \cdot Z_{ij} + \frac{2}{\delta_{h_j}^2} (h_j - h_j^0) \quad (6)$$

where Z_{ij} is the sensitivity coefficient.

$$Z_{ij} = \frac{\partial T_i^c(\mathbf{h})}{\partial h_j} = \frac{T_i^c(h_1, \dots, h_j, \dots, h_{N_h}) - T_i^c(h_1, \dots, h_j, \dots, h_{N_h})}{\delta h_j} \quad (7)$$

where δh_j is an a priori variation of the parameter h_j . In the iterative procedure, the calculated temperatures $T_i^c(\mathbf{h}^{k+1})$ at iteration $(k+1)$ is linearized as follows

$$T_i^c(\mathbf{h}^{k+1}) = T_i^c(\mathbf{h}^k) + \sum_{r=1}^{N_h} Z_{ir} \cdot \Delta h_r \quad (8)$$

It is quite easy to verify, that substituting (7) into (8) the system of linear equations is obtained as follows

$$\sum_{r=1}^{N_h} \left(\sum_{i=1}^{N_m} \frac{Z_{ij}}{\delta_T^2} + \frac{\delta_{jr}}{\delta_{h_j}^2} \right) \cdot \Delta h_r = \sum_{i=1}^{N_m} \frac{1}{\delta_T^2} (T_i^m - T_i^c(\mathbf{h}^k)) \cdot Z_{ij} - \frac{1}{\delta_{h_j}^2} (h_j^k - h_j^0) \quad (9)$$

where δ_{jr} is the Kroneker symbol. The increments of the parameters are found at each iterations as the solution of the system (9).

The identification procedure of the quantities $h_1, h_2, \dots, h_{N_h}$ is as follows. The components of vector $\mathbf{h}$ are initiated to some values $\mathbf{h}^0$ and the temperatures $T_{ij}^c(\mathbf{h}^0)$ are calculated from the direct problem. (In this work the centric - difference approximation is utilized). Each of the parameters h_j^0 is varied by δh_j , temperatures are calculated again and sensitivity coefficients are deduced (each time the vector $\mathbf{h}$ is updated) using (7). $N_m \times N_m$ system equations (9) are solved to obtain the increments, Δh_j and h_j values are updated: $h_j^{k+1} = h_j^k + \Delta h_j$, the calculation proceeds with the next

iteration. The procedure is finished, if the maximum relative variation of the parameters $\left| \frac{\Delta h_j}{h_j} \right|$ is smaller than the desired tolerance. This presented modified the least-squares technique is implemented as the main program calling the direct CDM heat flow code [2]. The effectiveness of the used iteration process is measured by the residual

$$RMS = \sqrt{\frac{1}{N_m} \sum_{i=1}^{N_m} (T_i^m - T_i^c(\mathbf{h}))^2} \quad (10)$$

3. Results

In this work, the temperature dependent heat transfer coefficient was determined from experimental set-up with steady-state thermal conditions, as mentioned in the section 2. The sandstone sample has radius $0,025\text{ m}$, height $0,08\text{ m}$, temperature dependent thermal conductivity is $(0,82+0,015.T)\text{ W.m}^{-1}.\text{K}^{-1}$ for temperature interval $20 - 60\text{ }^\circ\text{C}$, the heat flux supplied by heater is 348 W.m^{-2} , the temperature in the chamber is $20\text{ }^\circ\text{C}$. The surface temperature distribution was carried out by NEC TH7102MX infrared camera. Such images guarantee that measurement errors generally do not exceed $0,2\text{ K}$. An infrared picture of the specimen surface is shown in Fig.2.

Figure 3 demonstrates results obtained for heat transfer coefficient alongside the specimen as temperature dependence.

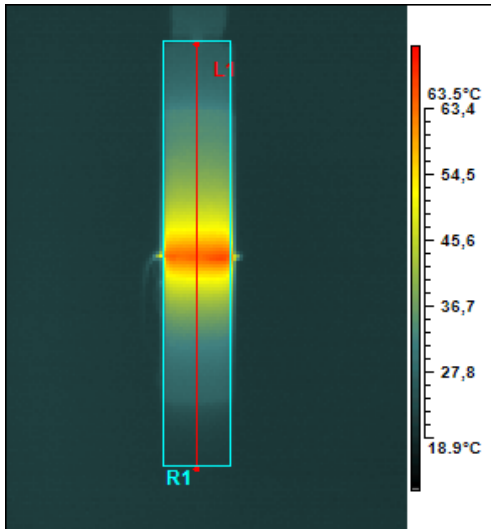


Fig. 2 Thermography of surface temperature field

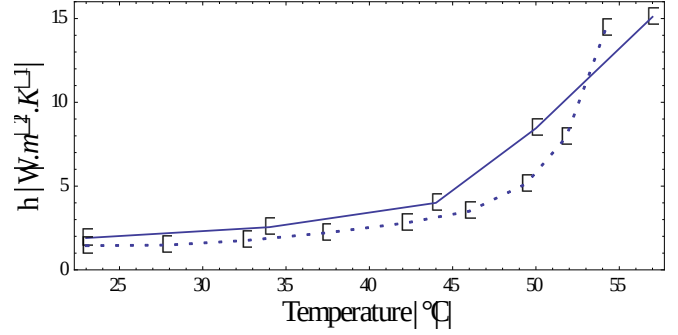


Fig. 3. Temperature dependence of heat transfer coefficient from sample sides for different number of subintervals

4. Conclusions

In this paper the procedure of the determining of heat transfer coefficient of concrete materials, based on steady-state temperature measurements using an infrared camera is proposed. Collected temperature measurements are processed through the inverse thermal modeling software which utilizes an appropriate model of heat transfer phenomena and identifies heat transfer coefficient as temperature function. This work presents the inverse analysis which is a primary step of designing an experiment to measure selected thermal properties materials.

Acknowledgment

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WEB-BASED SYSTEM FOR MAILPIECE DIAGNOSTICS INTENDED TO USPS

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Abstract: Everyday millions of letters are redirected from old to new addresses of their recipients. It happens because people are changing their homes or job, so the companies changing their location. In order to avoid sending the letters to old and then to the new addresses, which spends lots of recourses, a new generation of Postal Automated Redirection System /PARS/ is applied in USPS. The PARS consists of more than 50 processing sorting centers /P&DC/ equipped with special optical character recognition SW which automatically redirects the letters to the new addresses. This paper presents the design and development of WEB-based Performance Diagnostic System /PDS/ intended to operative control, monitoring and diagnostics of PARS HW and SW components, as well diagnostics and analysis of sorted letters. The PDS can be used for on-line remote control of PARS and the quality and performance of the sorting process.

Keywords: AUTOMATION SOFTWARE, WEB BASED UI, REDIRECTION SYSTEMS

1. Introduction

Nowadays because of mobility many people are changing their location or jobs. The delivery of letters or parcels to their new addresses becomes of great importance and saves time and money to the postal services.

In USA more than 40 millions letters are redirected each day. During the process of sorting the letters (mailpieces) are delivered to one of the nearest Processing Distribution Centers (P&DC), forming Postal Automated Redirection Systems (PARS) of the United States Postal Services (USPS). The letters are sorted automatically and then delivered to the recipients. In case of change of addresses PARS is responsible to redirect letters to their new addressees or to return them to the senders.

Current paper describes the design of WEB-based Performance Diagnostics System (PDS) intended to collect status, monitoring and diagnostics information about PARS systems, as well to collect data regarding the redirected letters and related to them Change Of Address (COA) forms.

1.1 Process of letters sorting and redirection

- Letters are delivered to the nearest P&DC;
- The surface of each letter is scanned and the image is sent to the optical character recognition (OCR) system which finds the address data;
- Using the address a request to the national database of addresses (Address Directory) is sent and as result the sorting information is provided;
- On the base of this information the letter is directed to the special box (shoot) of the sorting machine. The box collects the letters to specific street or area of the town/village;
- From this box the letters are delivered by the carrier (postman) to the recipients.

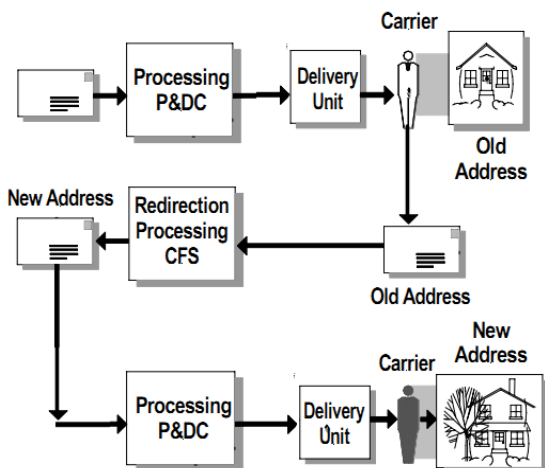


Fig 1 Delivery of letter to the new address without PARS

In case the recipient changes its address (fig 1) the postman manually delivers the letter to old address and then after finding out that the addressee is not available there he delivers the letter to the redirection unit where new address is provided by the COA Form Service (CFS) and the letter is redirected to the new or the same P&DC. Then the same sorting procedure is applied again. In order to find new address in CFS site the recipient who changed its address must provide to USPS services the COA form with its old and new address (Fig. 2).

Fig. 2 Change Of Address (COA) forms

In order to improve letters sorting in PARS system first the address found by OCR is checked both in current address directory and in CFS directory (Fig 3). If new address is reported by CFS it is printed in P&DC and stamped to the letter. Then the letter is automatically directed to the new address.

It can be seen that new approach saves lots of efforts, energy and time.

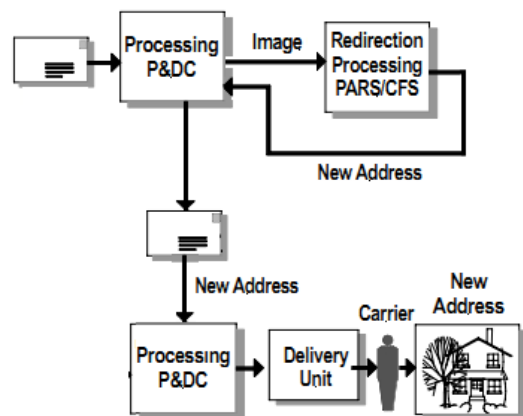


Fig 3 Delivery of letter to the new address with PARS

In case the customer did not provide its new address the mail is returned to the sender.

1.2. Providing the COA information

The customer who changes its address must provide new address by:

- sending a mail to USPS;
- filling manually the COA form (at post office);
- filling the same form to the WEB site of USPS.

In paragraphs above the automatic recognitions of the addresses in P&DC sites was discussed. In some cases of handwritten address the OCR algorithm could not find the whole address of the letter. In this case to solve the problem the image of the letter is sent to Remote Encoding Center (REC) where the address is resolved by human help. There on video-terminal the address is completed by the operator. As soon the address is completed it is returned from REC to P&DC and the letter is sorted.

1.3. The main HW and SW systems involved to letters processing

The main hardware system are sorting machines equipped with cameras ad barcode readers. Next are transportation subsystems. The sorting machine has specific software for on-line OCR of the sender and the receiver addresses and post stamps types and their price.

The main OCR related subsystems are:

- RIC - redirection image controller – subsystem managing images from the cameras by the following components:
 - o IH/ - image handler which is converting the images from the cameras to the image file formats used by the readers
 - o IC - image controller, controller managing the IH
 - o SC system controller
 - o CDB - data bases for statistical and other data
- AFR – address forwarding reader – subsystem for OCR address recognition (AFR-I) and for post stamps recognition (AFR- II)
- CFR – change of address (COA) forms reader – subsystem responsible for COA forms with new addresses (forms filled by the people changed their addresses or by the postman)

Each sorting machine is capable to process up to 50000 letters per hour. In order to do that it uses lots of IHs, ICs, AFRs, CFRs running in parallel on tens of PCs.

All mentioned above subsystems and components are forming the Image Management System (IMS) of the P&DC or of the REC. The diagnostics, monitoring and control of the SW subsystems of the sorting machines of each P&DC or REC is provided via internet on the base of the current PDS. The PDS is running as a specialised server on a Tomcat Apache WEB server installed on each P&DC or REC.

2. PDS systems' requirements

The following functional requirements derive from the general P&NC, REC and PDS system requirements [1,2,4] and can be summarized as:

- Authentication of logging of up to 60 users.
- Monitoring permanently of the IMS hardware and software components and providing real-time maintenance diagnostics for the verification of the operational status of the whole IMS.
- Providing the possibility to start/stop the IMS and each of its subsystems and components.
- Monitoring of the connections between current P&DC and other P&DC (named REC, NTSC , etc)
- Providing IMS statistics (for mails site performance, AFR , CFR, Benchmark, etc.)
- Monitoring the Network status
- IMS diagnostics including network diagnostics and performance
- Computer diagnostics (HDD info and system logs)
- Software diagnostics (shared memory and processes view)

- Providing capability to install, update backup and restore the system software or firmware
- Letters (mailpiece) diagnostics
- COA forms diagnostics
- VDT diagnostics (related to manually coded COA forms using video terminals).
- Address Directory diagnostics.
- Number of saved (processed) letters/COA forms is up to 300000 per day and must be collected for one month period.

3. Architecture of the System

As a result of the analysis of the requirements and taking into account similar solutions in postal automation systems [1,2,3] the architecture (Fig. 4) of the WEB-based PDS server was developed. The server is executed within the Apache Tomcat Server container. It is a servlet container [4] that is used in the official Reference Implementation [5] for the Java Servlet and Java Server Pages technologies, as well Ajax and Struts Technologies.

The components forming the the systems are:

- PDS Web UI including UI Framework – base of the IMS Diagnostics UI, Statistics UI, RTE UI, OS/HW and HDD Diagnostics UI and Backup/Restore UI
- PDS Server including:
 - o IMS Monitoring and Diagnostics component
 - o Statistics component
 - o OS/HW and HDD Diagnostics component
 - o Backup/Restore component
 - o RTE server processing real-time events
 - o Message layer component
 - o Mailpieces and COA forms Diagnostics component
 - o Directory Diagnostics component

They are described in the next sub-sections.

The PDS communicates to the external IMS subsystems via messages sent/received over TCP/IP sockets. On each external system (PC) the PDS client DLL or PDS service is running. They are providing API from the specific system and PDS.

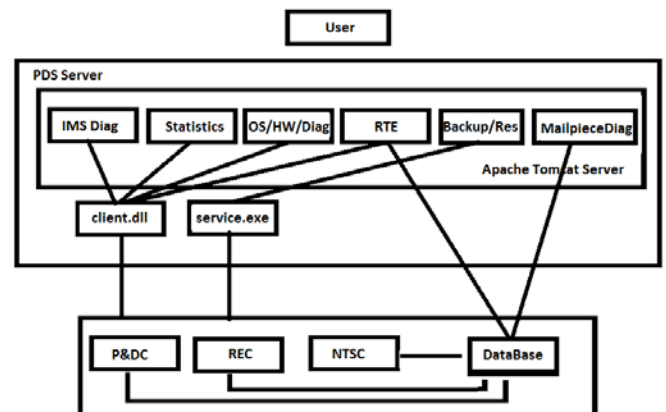


Fig. 4 PDS Architecture

Users are connected over secure HTTP to the PDS server using Internet Explorer browser.

3.1. WEB UI component

This component is responsible for preparing all jsp (java server pages) provided to the user. It deals also with the actions that can be triggered by the user (clicking different buttons in Browser). It provides servlets manipulations and tables' decorations. It takes info about the status, statistics, diagnostics and other data from other PDS components which are provided to the user. The component is sending periodically auto refresh messages in order to keep the status data presented on the user browser up to date.

3.2. IMS monitoring and diagnostics component

This component ensures the monitoring, diagnostics and control of entire IMS and all its SW and HW systems and components. The component has to provide:

- Reporting Logical Status Change of SW subsystems and components;
- Reporting of Physical Status Change of IMS Computers;
- Monitoring of the IMS Status and reporting Overload of certain Subsystem;
- Monitoring the Storages Status and Computer Storage Status
- Monitoring the Network Status
- Controlling IMS System (Start, stop restarts shutdown of IMS)
- Monitoring the Connections
- Monitoring SW Processes
- Reporting SW Component Versions
- View or Download of Log and Configuration Files

3.3. Run Time Event Server

The Run Time Event (RTE) Server deals with the special messages (info, warning errors, fatal errors) produced by the all SW components of the IMS. The RTE messages are stored permanently on the data base server and are available on request to the PDS. In some case information about this message has to be sent by mail to the IMS operators, technicians or managers. These activities are done by the RTE server component. It is responsible also for:

- Presenting of All RTEs
- Presenting of RTE Detailed info for one selected RTE
- Adding or Modifying RTE Filter
- Update of RTE Note Field
- Create/ Delete RTE Mailing List
- Add/ Delete Member to Mailing List
- Add /Remove Filter to Mailing List
- Add Filter to UI Notification 12
- Remove Filter from UI Notification
- Export RTE List
- Delete RTE older than
- Delete RTE mails older than 25 days.

The flow of action when some option is activated in RTE menu includes query to the RTE component which send the query to the data base and when the result is available it parses it and presents it to WEB UI screen

Other PDS components as HW/OS/HDD diagnostics and Backup and Restore component are using the same flow of actions when communicating to the corresponding IMS subsystems. The difference is that HW/OS/HDD diagnostics component is using Windows API for getting OS, BIOS and hard disk data, instead of the client API (see Fig. 4).

Backup and Restore component is using COOL command scripts which are activated by the PDS service (service.exe on Fig 4). Only the names of the scripts are different then those used to start/stop computers, etc.

3.4. Mailpieces and COA forms diagnostics

This component is responsible to send queries to the database to extract data regarding processed by the P&DC or REC mails or COA forms. Each query can be with variable number of fields describing lots of letter/COA form attributes as ZIP code , type of mail (firs class, military, foreign, etc.), city, state, names of sender/recipient, etc. As a result series of letters ' or COA forms images are presented for diagnostics or analysis to the user.

4.PDS WEB UI structure and views

The following figure (Fig 5) gives the structure of the menu items of the PDS WEB UI, as well some of the UI pages representing most of the features of the PDS. The menu items are grouped into five general groups (IMS Monitoring IMS Diagnostics, Run Time Events, Backup and Restore and Administration).

Next page (Fig. 6) represents combined IMS system status view. With green bar graphs are presented the IMS subsystems that are in Ready state, with yellow the Not Ready subsystems and with red those in Malfunction state. Below the bar graphs tin the table the current number of those subsystems (IH, RIC, AFR, etc.) is given. In the upper part the tabs of all available IMS statistics ate given. By selecting tabs the needed statistics can be seen. By the use of the buttons the entire IMS can be Restarted or Shutdown.

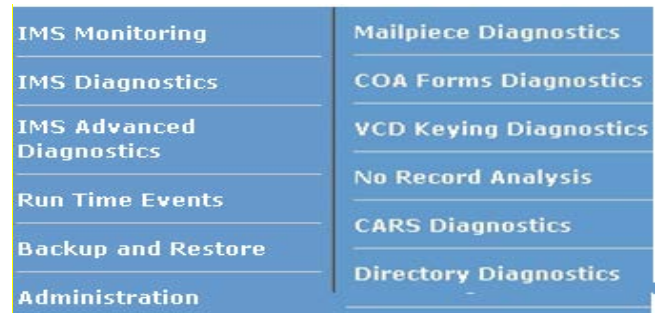


Fig.5 PDS WEB UI Menu Items

Below the bar graphs tin the table the current number of those subsystems (IH, RIC, AFR, etc.) is given. In the upper part the tabs of all available IMS statistics ate given. By selecting tabs the needed statistics can be seen. By the use of the buttons the entire IMS can be Restarted or Shutdown.

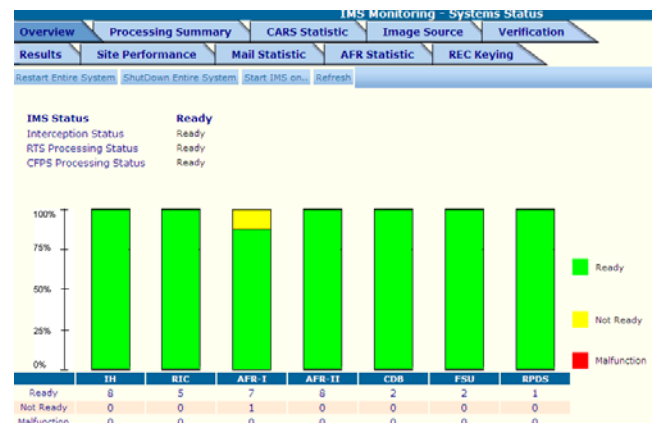


Fig. 6Monitoring the IMS System Status

The Status of the all IMS computers is given on Fig. 7. From this web page the user is able to access the status of SW subsystems/components (Fig. 8) running on the selected computer.

IMS Monitoring - Computer Status				
Start Stop Restart Shutdown Reboot Refresh				
Select all	IP Address	Hostname	Subsystems	Status
☐	10.10.16.186	SCLACAMRIC0	→	● Ready
☐	10.10.16.187	SCLACAMRIC1	→	● Ready
☐	10.10.16.188	SCLACAMRIC2	→	● Ready
☐	10.10.16.189	SCLACAMRIC3	→	● Ready
☐	10.10.16.190	SCLACAMRIC4	→	● Ready

Fig. 7 Computers Status Page

IMS Monitoring - Subsystem Status						
Refresh						
IP Address	Hostname	Subsystem	Component	Status	Overload	
10.10.16.186	SCLACAMRIC0	RIC 01	FSU 01	● Ready		
10.10.16.186	SCLACAMRIC0	RIC 01	CDB 01	● Ready		
10.10.16.187	SCLACAMRIC1	RIC 02	FSU 02	● Ready		
10.10.16.187	SCLACAMRIC1	RIC 02	CDB 02	● Ready		
10.10.16.188	SCLACAMRIC2	RIC 03	IC 01	▲ Warning	■	→
10.10.16.189	SCLACAMRIC3	RIC 04	IC 02 (master)	● Ready		
10.10.16.189	SCLACAMRIC3	RIC 04	SC 01	● Ready		

Fig. 8 Subsystems Status Page

On the page below (Fig. 9) the diagnostics page – Hard disk info can be seen, available via Diagnostics/Hardware/HDD.

Local Performance Diagnostic System		UNITED STATES POSTAL SERVICE®
IMS Diagnostic - Harddisc		
Back		
HDD Info	SCLACAMRICO	
Drive C:	Physica (System)	
File System	NTFS	
Volume serial No	2001-FFDD	
Total Size	80 GB	
Partition size	38.4 GB	
Free Size	29.5 GB	
% Free	67%	
Driver Description	SAMSUNG SP0411N	
Driver Date	2001-07-01	
Driver Version	5.1.2535.0	
Drive D:	Logical	
File System	NTFS	
Volume serial No	FA01-FABC	
Partition Size	38.4	
Free Size	29.3 GB	
% Free	60%	
Driver Description	SAMSUNG SP0411N1	
Driver Date	2001-07-01	
Driver Version	5.1.2535.0	

Fig. 9 Hardware- Hard Disk Info Page

Next two pages (Fig. 10 and 11) present the Mailpiece diagnostics screen of WEB UI and search criteria related to different letter's attributes, as well the one of the results of the search. The attributes of the letters or the COA forms are too many and their explanation exceeds the volume of current paper. For example when the OCR algorithm tries to find the recipient address or the sender address different approaches (using barcode, ZIP codes (3, 5, 11 digits) including city, state codes, recipient name abbreviations) are applied. So the diagnostics of mailpieces can include variations of these or others attributes, as well the attributes that are related to the ID of sorting machine, time of sorting, type of the mail (first class, ordinary, military mail, etc).

Fig. 10 Mailpiece Diagnostic search screen

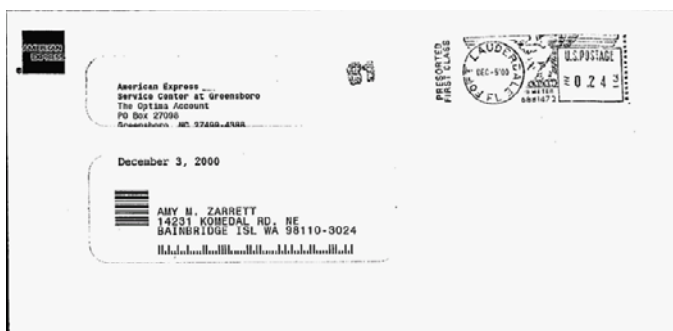


Fig. 11 One of the found results (mailpiece) matching the search criteria

Similar to the figures 10 and 11 above are the search screens for analyzing COA forms. The differences in them are related to the structure and the information of the COA form, given on Fig. 2.

Search criteria related to VCD keying diagnostics include how many steps (keys pressed) are used by the operator in REC site to complete letter's or COA forms' address.

5. Conclusion

Presented in the paper WEB based PDS system was developed on request by Siemens PA [7] and was intended to USPS. The author of the paper was a project manager of one of the significant part of the system and was involved in PDS requirements analysis, SW architecture development, coding and testing of SW components.

Implemented PDS system provides abilities for on-line remote control, monitoring and diagnostics of IMS systems working in all P&DC and REC sorting centers of USPS. PDS ensures detailed information and statistics to users of different levels – operators, technicians or managers that can be used for taking operative and strategic decisions, in the field of postal automation.

Abilities for mailpiece and COA diagnostics can be used for further software improvement of the OCR readers (AFR and CFR)

Developed PDS Web Based architecture was already modified and applied successfully in the area of Automatic Number Plate Recognition (ANPR) systems [1,2]. In this case it was used for a remote control and tuning of the parameters of a new generation ANPR cameras used for traffic control, tolling or parking access, etc.

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SIMULATION ON SINGLE CYLINDER DIESEL ENGINE AND EFFECT OF COMPRESSION RATIO AND EGR ON ENGINE PERFORMANCE AND EMISSION

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Abstract: In this research, the one dimensional (1D) CFD modelling of four-stroke direct injection diesel engine is developed by AVL Boost software. The performance of a diesel engine increases with increase in compression ratio. Variable compression technologies in IC engines are used to increase fuel efficiency under variable loads. Exhaust gas recirculation is a common way to control in-cylinder NOx production and is used in most modern high speed direct injection diesel engines. However the effect of EGR on performance, combustion and emissions production at different compression ratios are difficult to depict. In the present work an attempt was made to study the effects of exhaust gas recirculation on performance, combustion and emissions of a variable compression Diesel Engine. The test was conducted at different compression ratios with different loads and for different EGR rates.

Keywords: SIMULATION, DIESEL ENGINE, MODEL, AVL BOOST, PERFORMANCE, SINGLE CYLINDER, EGR, VCR

1. Introduction

Diesel engines are characterized by low fuel consumption and very low CO emissions. However, the NOx emissions from diesel engines still remain high. Hence, in order to meet the environmental regulations, it is highly desirable to reduce the amount of NOx in the exhaust gas. The Diesel engines by small power have a wide range of application for the mechanization of the most activities in industry and agriculture. Owing to their low fuel consumption, they have become increasingly attractive for smaller lorries and passenger cars also. But higher NOx emissions from diesel engine remain a major problem in the pollution aspect. In order to reduce emission levels, some external engine features can be applied, such as EGR or after-treatment systems. EGR systems have been used to reduce emissions of nitrogen oxides (NOx) from diesel engines.

Cylinder charge dilution with exhaust gas can be classified into internal EGR and external EGR. With external EGR, exhaust gas is taken from the exhaust port and supplied into the inlet port. Internal EGR is achieved by increasing NVO (negative valve overlap) during exhaust stroke, which requires an improved cam that can rapidly switch cam profiles to achieve any variable valve timing, otherwise it's impossible to independently and effectively control EGR ratio. This greatly limits the application of internal EGR. As a result, external EGR has become widely used on today's automobile engines. External EGR has a relatively low cost. It only needs to use dedicated EGR control valve, which can control EGR rate effectively under all work conditions of engine [1–4].

When EGR is applied, engine intake consists of fresh air and recycled exhaust gas. EGR (%) usually represents the percentage of the recirculated exhaust gas. The percentage of exhaust gas recirculation is defined as the percentage of recirculated exhaust in total intake mixture [5]. Where m_i is the mass of total intake mixture and m_{EGR} is the mass of the EGR.

$$E(\%) = \frac{m_{EGR}}{m_i} \cdot 100 \quad (1)$$

The principal source of NO formation is the oxidation of the nitrogen present in atmospheric air. The nitric oxide formation chain reactions are initiated by atomic oxygen, which forms from the dissociation of oxygen molecules at the high temperatures reached during the combustion process.

Shahadat.et.al [6] studied the combined effect of EGR and inlet air preheating on engine performance in diesel engine. They found that at medium load conditions, oxides of nitrogen (NOx), carbon monoxide (CO), engine noise, and brake specific fuel consumption decreased when inlet air preheating and EGR were applied together as compared to those during normal operations of the engine.

Arjun Krishnan et.al [7] studied the Prediction of NOx reduction with EGR using the flame temperature correlation technique. They developed a procedure to calculate the reduction in NOx levels due to EGR, given only engine base-data. This approach utilised the flame temperature correlation technique to obtain NOx predictions with sufficient accuracy – 6.5% at part loads.

Avinash kumar.et.al [8] studied the effect of EGR on exhaust gas temperature and exhaust opacity in compression ignition engines. They found that that the exhaust gas temperatures reduce drastically by employing EGR. Thermal efficiency and brake specific fuel consumption are not affected significantly by EGR. However particulate matter emission in the exhaust increases, as evident from smoke opacity observations.

AVL Boost is based on 1D gas dynamics which account for fluid flows and heat transfer. Each component in an AVL Boost model is discretized or separated in many smaller components. These components have very small volumes and the fluid's scalar properties in these volumes are assumed to be constant. The scalar properties of a fluid include pressure, temperature, density and internal energy. Each volume also have vector properties that can be transferred across it's boundaries. This properties include mass flux and fluid velocity.

2. Data Needed for Building an Engine Model

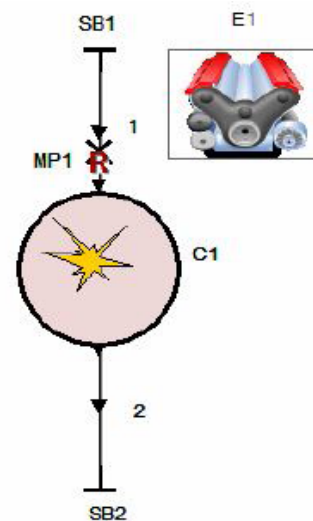


Fig. 1 Model of Single Cylinder Diesel Engine: SB-system boundaries, MP-measuring points, C-cylinder.

AVL Boost is a software tool that consists in a pre-processing program, used for initial data entry and technical characteristics of the engine to be designed as model. After forming the engine assembly with annexes systems, mathematical equations and algorithms of the model with the graphical user interface (GUI) will analyze and calculate the processes that are required during simulation [9, 10]. The model for the engine designed in AVL BOOST application is shown in figure 1.

A list of information that is needed to create a model in AVL BOOST is included in library. The main features of the diesel engine that have been used as initial data to define the cylinder parameters are presented in table 1. Cylinder (C1) of the model in AVL Boost is connected with element Engine (E1), and it defines the type of engine used, operating speeds on it, moments of inertia and break mean effective pressure (BMEP). Combustion method is Mixing Controlled Combustion model that predicts the rate of heat released (ROHR) and NOx emissions on the quantity of fuel in the cylinder and the turbulent kinetic energy introduced by the injection of fuel [8].

Table 1: Specification of the engine.

Engine Parameters	Value	Unit
Bore	76	[mm]
Stroke	65	[mm]
Displacement	295	[cc]
Power	4	[kw]
Speed	3000	[rpm]
Compression ratio	17:1	-
Valve lift	8,5	[mm]
Piston pin offset	10	[mm]

The pre-processing step of AVL Boost enable the user to model a 1-Dimensional engine test bench setup using the predefined elements provided in the software toolbox. The various elements are joined by the desired connectors to establish the complete engine model using pipelines

3. Result and Discussion

After definition of the engine parameters has been run a series of simulations, and then plot the results in Impress Chart were was analyzed.

The running simulation result is all of the engine performance data with the constant engine speed (rpm) by varying the compression ratios. This model was running at speed 2000 rpm.

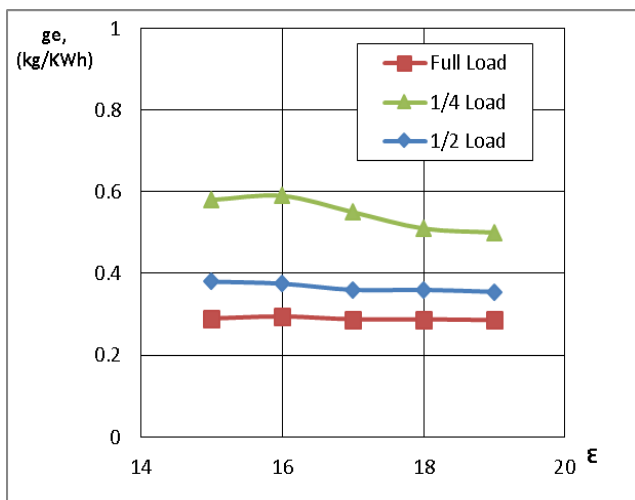


Fig. 2 Influence of Compression ratio on Specific fuel consumption at different loads

In Fig. 2 the specific fuel consumption at various loads and compression ratios are presented. With increase in compression ratio the specific fuel consumption decreases irrespective of the load except at compression ratio 16 due to less ignition delay and more combustion duration.

Figure 3 shows the effect NOx at different loads and compression ratios. With increase in load the NOx value also increased due to more heat release and caused for dissociation of gases.

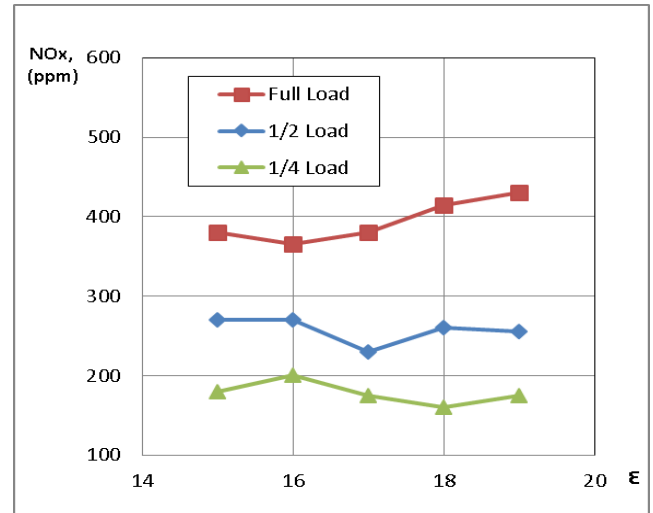


Fig. 3 Influence of Compression ratio on NOx emission at different loads

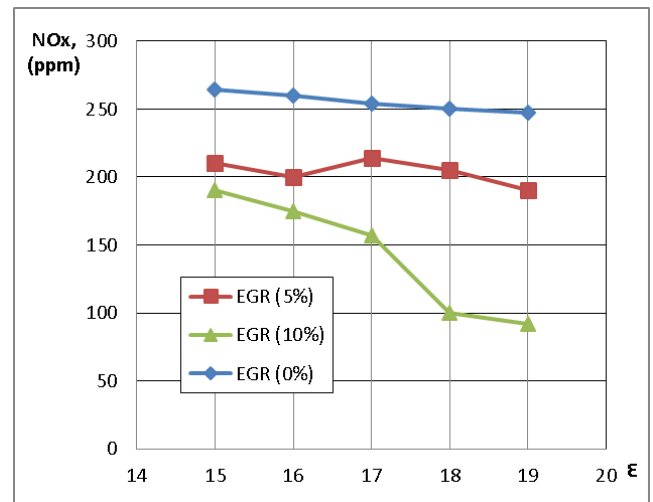


Fig. 4 Influence of EGR on NOx emission at different compression ratio

Figure 4 shows the effect of exhaust gas recirculation (EGR) on NOx emissions. The model simulation result shows that with increase in percentage of EGR the NOx emissions are decreased. These are mainly due to the lower combustion chamber temperatures caused by EGR and because the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture.

3. Conclusion

This paper present the results of the engine cycle simulation of a single cylinder, direct injection diesel engine with different compression ratios, percentages of EGR and loads to estimate

performance, combustion and emission characteristics of the engine. using AVL Boost software. It was found that with increase in compression ratio the specific fuel consumption decreases. The results obtained indicated that with increase in % EGR the NO_x emissions was gradually decreases at different compression ratios due to less flame temperatures and low oxygen content in the combustion chamber. The high degree of recirculation is suitable for higher compression ratio because at compression ratio 19 and 10% EGR the percentage reduction of NO_x was 36%.

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STUDY OF SEVERE PLASTIC DEFORMATION BY MULTI-DIRECTIONAL SHEARING

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Abstract: In order to impose an extremely large strain on the bulk metal without changing the shape, many SPD processes have been developed. This paper presents the numerical study of severe plastic deformation by multi-directional shearing in order to determine the materials behaviour in the case of complex solicitations conditions and estimate the magnitude of the final strains obtained. Two hardening laws are considered for describing the material behaviour: Swift and Ludwick law. The comparison of the numerical results with experimental values for higher levels of strain shows that the Ludwick model presents a better agreement with experimental data. The presented paper gives a method and a numerical tool to study the severe plastic deformation of the materials and to predict the level of the obtained plastic strain.

Keywords: SEVERE PLASTIC DEFORMATION, SHEARING, ULTRA-FINE GRAINED STRUCTURE

1. Introduction

The processes of severe plastic deformation (SPD) are defined as metal forming processes in which a very large plastic strain is imposed on a bulk process in order to make an ultra-fine grained metal [1-3]. The ultra-fine grained metal obtained after the SPD processes is used to produce lightweight parts by using high strength metal for the safety and reliability of micro-parts and for environmental harmony.

In the conventional metal forming processes such as rolling, forging and extrusion, the imposed plastic strain is generally less than about 2.0. When multi-pass rolling, drawing and extrusion are carried out up to a plastic strain of greater than 2.0, the thickness and the diameter become very thin and are not suitable to be used for structural parts. In order to impose an extremely large strain on the bulk metal without changing the shape, many SPD processes have been developed.

The metals processed by SPD exhibit high strength, ductility and fatigue characteristics. Among many interesting properties of UFG metals is their ability to flow easier and at lower temperatures when forged into complex shapes.

Thanks to their various qualities, such as price or physical and mechanical properties, metallic materials, and more especially steels, appears in many branches of industry, like: automobile and aircraft industries, medical implants, defense industry, etc. This supply, whose first utilizations go back to more than 3000 years, takes advantage of an important research and development work, which regularly results in new steel families, or new forming processes. These evolutions concern as much steel producers as steel users.

Among the industrial applications of SPD techniques, bolts in the automobile and aircraft industries are manufactured with titanium alloys using ECAP process shown in figure 1.



Fig. 1 Bolts used in the automobile and aircraft industries–SPD Ti alloy [4].

Recently, in a Japanese National Project, sheets of low carbon steel of 2 mm thickness with ultra-fine grains were manufactured by the TMCP process. In the case of use of these sheets the deep drawing ratio was 1.9 and the parts were used in sheet metal forming as shown in figure 2 [5].



Fig. 2 UFG C-Mn steel sheet forming for automotive industry [5].

Ultra-fine grain sized titanium (UFG Ti) obtained by severe plastic deformation presents a bright potential for biomedical applications because it provides the strength of titanium alloys without toxic alloying elements, such as Al and V that, by dissolving away from the implant, may be harmful to human health.



Fig. 3 UFG titanium dental implants [6].

The advantages of UFG metals utilization for light armor fabrication are: reduction of fuel consumption, higher speed, better maneuverability, longer operation range, air-transport of vehicles to remote location.



Fig. 4 Light armor (armor plates and armor penetrators) for military vehicles [7].

Shear tests simulations were the objects of a lot of studies these last years.

In 2003, numerical simulations of the direct shear test were led in Aston University from Birmingham, by Thorton and Ling [8].

The performance was realized under constant normal stress conditions. It resulted in the presentation of a comparison between the average shear to normal stress ratio on the shear band and force data at the boundaries. The principal direction of stress and strain rate turned out to be coaxial under steady state conditions.

Still in 2003, International Conference on Computational Plasticity [9] was the scene of a performance about numerical shear tests for different elasto-plastic laws, through the simulation of a cyclic simple shear test. A high strength steel sheet was modeled, and used three different constitutive plastic laws derived from Teodosiu's model. The goal of the study was to provide a numerical idea of stress-strain path in the center of an experimental test sample.

More recently, in 2008, Härtl and Ooi [10] led a study bringing into play experiments and simulations of direct shear tests, which focused especially on porosity contact friction and bulk friction. It describes a work about the Jenike shear tester, using both experiments and discrete elements simulations. A lot of tests, both on spherical glass beads and paired glass beads, were performed to estimate influence of a particle shape, stress level and packing density on the bulk friction at limiting shear. Three dimensional elements simulations were created, to verify the predictive capability of finite element method, by comparison to experimental observations.

2. Objectives

In the conventional metal forming processes such as rolling, forging and extrusion, the imposed plastic strain is generally less than about 2.0. When multi-pass rolling, drawing and extrusion are carried out up to a plastic strain of greater than 2.0, the thickness and the diameter become very thin and are not suitable to be used for structural parts. In order to impose an extremely large strain on the bulk metal without changing the shape, many SPD processes have been developed.

The objectives of this paper are:

- Simulation of a complex shear state in a blank sheet
- Study of materials behaviour in the case of complex solicitations conditions, as close as possible to the ones encountered during the forming process

3. The method

Different hypothesis have been made, so as to lead to the final geometry. First of all, working on a metal blank intended a model where a dimension was negligible, compared to the two others. Thereby, the hypothesis of a plane stress state was selected. Furthermore, for a reason of simplification, and a fortiori of limitation of calculation time, using a bi-dimensional model was decided. Thus, horizontal and vertical directions correspond respectively to the X and Y axis.

The final selected shape turns out to be a square, with a side length of 30mm. In each direction, a 2mm wide band located in the middle of the length is reserved for the pure shear solicitation. Considering a maximal magnitude for translation of 0,8mm, trigonometric relations lead by tangent to a value of angular deformation γ of approximately 20° , which is a standard regularly encountered in deep-drawing. The dimensions of the square, and especially the quotation on 30mm, were defined in order to be predominant on the length of 2mm, and so as to limit the boundary effect. It also gives a ratio of 15, greater than 10, the minimal value for a pure shear state. These considerations lead to the creation of a useful zone in the middle of the square.

Two models were made in order to fulfill previously presented objectives:

- The Monotone Composed (MC) model : a numerical simulation of a monotone shear, followed by a second one leant of 90° from the initial direction, making up a kind of cyclic shear, more complex than the unidirectional cyclic shear
- The Cyclic Composed (CC) model : a numerical simulation of a cyclic shear, followed by a second one leant of 90° from the initial direction

The numerical simulation is performed using MARC Mentat finite element code.

The first monotone composed model was configured (figure 5) with two consecutive mechanical loadcases of 10 seconds (steps of 0,2 seconds) and the only setup of position.

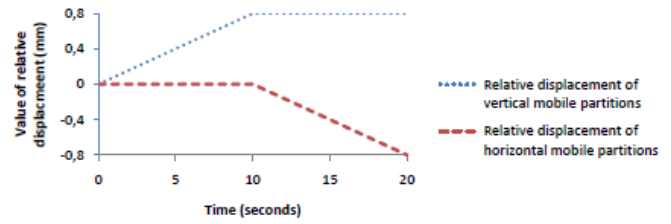


Fig. 5 Monotone composed model kinematics.

The effects of the imposed two loadcases are: first step-vertical displacement of 0,8mm with constant velocity (figure 6.b); second step-horizontal displacement of 0,8mm with constant velocity (figure 6.c).

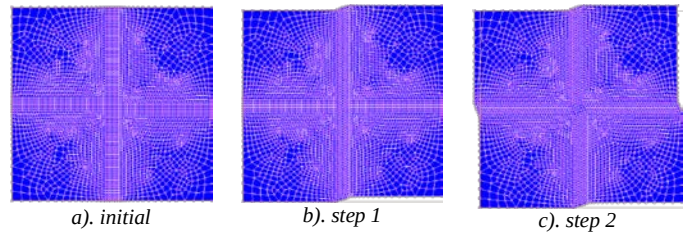


Fig. 6. Mesh evolution in MC model

The second cyclic composed model has still a configuration based on mechanical considerations. Because of the higher complexity of the shear solicitation, the duration of each loadcase reaches now 40 seconds, with still constant steps of 0,2 seconds.

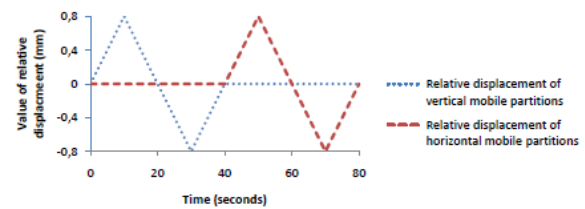


Fig. 7 Cyclic composed model kinematics.

Like in the previous model, the first loadcase corresponds to the vertical shear solicitation: there is firstly a translation of 0,8mm in the direction of axis; then, the displacement continues in the other sense, in order to reach another variation of 0,8mm in the opposite sense; finally, after a last reversal of move, the model comes back to its initial position. The second loadcase is the transposition of the previous one in the horizontal direction.

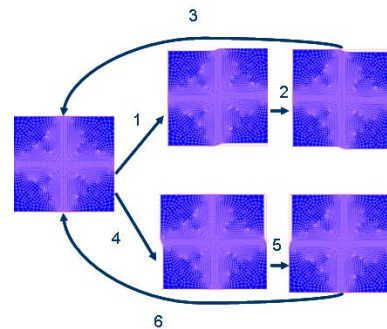


Fig. 8 Mesh evolution in CC model- 6 steps.

The first simulations were realized with a rough regular mesh. It was then refined, in order to identify zones where the level of stress was the most important. It turned out to show unsurprisingly a predominance of the intensity of the stress state in the 5 partitions making up the bands, reserved for the shear solicitation. Thus, mesh

density in the 4 remaining low stressed parts was reduced in a progressive way, so as to limit calculation time, without favoring a propagation direction.

The mesh of the two models is lightly different. This distinctness originates in the mode of loading. In the CC model, the first loadcase ends in a position close to the initial one, whereas the second loadcase of the MC model starts with a deformed model. Taking into account this displacement leads to this difference between MC and CC model, whose meshes are respectively composed of 3303 and 3187 nodes.

The Finite element type 3 was selected. This family, composed of elements for plane stress solicitations, with four nodes (ideal toward the geometry) and with a full integration calculation (for a better accuracy in the results), turned out to be the best choice for this simulation.

In this study, the aluminium alloy AA5182 is concerned and this material is tested considering two hardening laws: Swift and Ludwick law.

Globally, materials are supposed to have an isotropic behaviour. They are defined by their stiffness properties, through Young's modulus and Poisson's ratio. The parameters intended to specify their elasto-plastic behaviour are also filled in. Every useful magnitude is either dragged from another study, or from experiments realized for the occasion, and is specified in the tables 1 and 2.

The mathematical expression of Swift law is:

$$\sigma = A(\epsilon_0 + \bar{\epsilon}^p)^n \quad (1)$$

where: B , ϵ_0 and n are specific parameters of the material, respectively the material consistency, elastic yield strain and hardening parameter; σ and $\bar{\epsilon}^p$ represent the equivalent stress and plastic strain.

Table 1: Swift law material parameters

Material		AA5182
Isotropic Properties	Young's Modulus [MPa]	72000
	Poisson Ratio	0,32
Elasto-Plastic Properties	Parameter ϵ_0	0,00716
	Parameter A	493,1
	Parameter n	0,242

The mathematical expression of Ludwick law is:

$$\sigma = \sigma_0 + K\bar{\epsilon}^n \quad (2)$$

where: σ_0 , K and n represent specific parameters of the material, respectively the elastic yield stress, material consistency and hardening parameter; σ and $\bar{\epsilon}$ represent the equivalent stress and strain.

Table 2: Ludwick law material parameters

Material		AA5182
Isotropic Properties	Young's Modulus [MPa]	72000
	Poisson Ratio	0,32
Elasto-Plastic Properties	Parameter σ_0 [MPa]	149
	Parameter K	334,11
	Parameter n	0,374

4. Results and discussions

In order to estimate the truthfulness of results from the simulations, a comparison with experimental data was realized. Curves representing the behaviour of the material under a specific solicitation were plotted, through the relation between the stress component σ_{12} and the plastic strain component ϵ_{12}^p . The goal was to determine which one was the closest to reality. Unfortunately, experimental data were obtained from a unidirectional shear test. That is the reason why the comparison can only be done for the first part of the curves.

Results from numerical simulations of the monotone composed model come from a point in the middle zone of the blank, to wit the

node 3183. The curves (figure 9) can show as expected the change of direction during the process. Globally, the material with the Swift law has a curve, whose shape is closer to the experimental data than the Ludwick law. But this observation is especially valid for quite low values of strain. Indeed, results for higher levels of strain show that the Ludwick model presents a better agreement with experimental data.

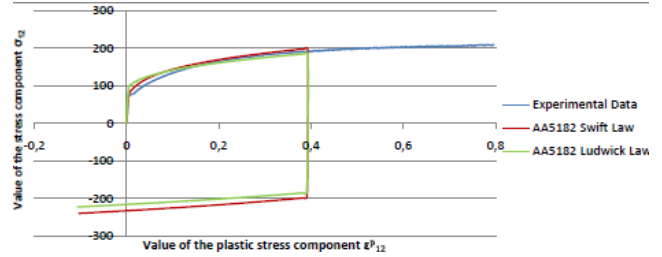


Fig. 9 Experimental and numerical $\sigma_{12} - \epsilon_{12}^p$ curves.

The same analysis was made for the cyclic simulation, in the zone similar to the previous case, to wit the node 3104. A continuous line and a dotted line enable to differentiate the two loadcases. For each loadcase, it is also possible to identify the beginning of the solicitation, the first change of sense, and the second change leading to the initial shape (value of strain null).

The shape of the curves (figure 10) shows the non recognition of the kinematic hardening effect, potentially leading to an overestimation of the level of stress. As the impact of this consequence is lower with a Ludwick model, involving a better accuracy of the results, this hardening law was given priority for the rest of the study.

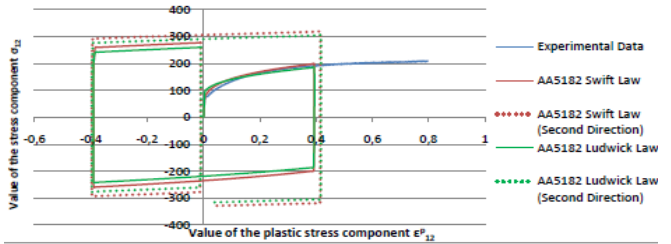


Fig. 10 Experimental and numerical $\sigma_{12} - \epsilon_{12}^p$ curves.

Among the diverse kinds of results which can be obtained from the simulations, it is possible to get an estimation of the final level of strain in the observed zone. More accurately, they can be used, so as to detect the apparition of a mechanical phenomenon, the Severe Plastic Deformation (SPD).

Studies over the last decade improved a lot the knowledge about this effect, but works remain to be led, so as to better understand and control it. Globally, SPD engenders the formation of a very fine crystalline structure in metals and alloys, by the creation of micrometer and sub micrometer sized subgrains, in the material. The main hypothesis is that short and long range intersecting shear bands produced by plastic deformation have a predominant role for the grain subdivision and the recrystallization process. It results in an observation of the enhancement of mechanical properties, by an increase of hardness, yield stress, and even physical properties. Experiments realized on aluminium alloys [11] showed a microstructure refinement at room temperature from an effective strain introduced of 1,16.

Results presented in this part concern the aluminium alloy 5182. The representation of the final total equivalent plastic strain shows the highest levels in the middle of the model. The figure 9 gives a cumulate value for the plastic strain component ϵ_{12}^p of 0,9.

The same analysis was made in the case of the cyclic composed simulation, whose configured solicitation was more complex. The following graph turned out to show a similar place for highest levels of final total equivalent plastic strain to the previous case.

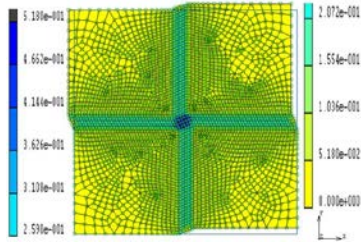


Fig. 11 Distribution of the plastic strain component ϵ_{12}^P in monotone composed model of multi-directional shearing

The figure 10 gives there a cumulate value for the plastic strain component ϵ_{12}^P of 3,2.

5. Conclusions

The magnitude of the final strains obtained reached values higher than the considered criterion 1,16. Consequently, the different solicitations applied on the metal blanks can potentially engender the apparition of the severe plastic deformation. It result the following conclusions:

- Detection of Severe Plastic Deformation:

- Normal Criterion regarding the cumulated plastic strain: 1-1,2 (found from scientific literature)
- Values of cumulated plastic strain are:
 - first case of loading (MC): 1
 - second case of loading (CC):3,7

- It is then possible to conclude that this kind of shear deformation make a potential apparition of this effect.

As noticed previously, the importance of the kinematic hardening phenomenon turned out to be strategic for the quality of final results. Its configuration in a material could improve consequently the truthfulness of data resulting from simulations. As well, the utilization of Swift law, whose fidelity to experimental values seemed to be higher than Ludwick law, could also amplify this effect.

Nevertheless, some other parameters could make the transposition from experiments to numerical simulations more difficult. It is underlined by the study of the severe plastic deformation detection, whose presence impacts on material properties during the simulation. The absence of the notion of crystallographic structure, and a fortiori of structure evolutions, constitutes a limit for this software, and the accuracy of the results it gives. The control and the modelling of such an effect can constitute an interesting stake for a new study.

Withal, as the working of the numerical modeling seemed to be promising yet, it could be fast customized, so as to lead to a more complex kind of deep-drawing. Thereby, modifications on punch shape or on blank holder, by adding draw beads, can be considered.

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STUDY OF THE LATERAL DEVIATION OF ELECTRIC BICYCLE AS FUNCTION OF THE TOTAL MASS AND THE BATTERY POSITION

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Abstract: The paper examines the dynamic behavior of an electric bicycle depending on the total mass of the bicycle, the cyclist and the battery on the one hand and on the other - on the place of the battery. The experiment demonstrates that in its movement at a constant speed the electric bicycle behaves as inverted pendulum.

Keywords: electric bicycle, lateral deviation, planned experiment, weight, battery position

1. Introduction

With more than $100 \cdot 10^6$ bicycles produced every year for the period of 2005-2014, and constantly increasing share of the electric bikes – 33% of all produced bikes for 2014, electric bicycles are taking a huge part of the market. In other words, these not that modern vehicles (the first patent is from 1898 by O. Bolton [9]), that have been neglected in the past because of their high weight and short range are currently seeing their renaissance. It started in 1990 by using lighter and more powerful batteries and drastically increased by the introduction of improved Lithium-Ion batteries in 2002.

The electric bicycles are ecological vehicles and with guaranteed speed limit of 25 km/h are fitting in the category of traditional bicycles which allows them to be used on velo-paths and in parks. They are also free of tax compared to other motor vehicles. They require minimal parking space and at the same time allow the rider to reach long ranges with less muscle power, especially while climbing steep hills. Regardless of their still high price (1500÷8000 €) electric bicycles are constantly increasing their market share. In addition some Bulgarian manufacturers as DRAG [6], CROSS [5] and ZECOTEK [7] are introducing their own electric models with satisfactory sales.

Some of the biggest automotive brands as Mercedes, BMW, Smart, Opel and Audi are also introducing their own electric bikes as in the case of Smart we are seeing a second generation of their model. In addition there are other brands that have focused only in the production of electric bicycles like Gocycle [8]. In all models serious attention has been paid to the design of the vehicle as a major factor that affects the sales of the product. In addition some of the ads are presenting the bicycle as integral part of a car of the same brand. In these cases the topic about the correct placement of the battery and the impact of the total weight of the bicycle are often neglected. A serious omission compared to the huge number of theoretical studies on the dynamics of standard bicycles [13] etc. In the scientific fields there is a long dispute about the justification of the stability of these quite popular vehicles which are the objects of different studies [12] and design [10]. The main dispute is whether the inverted pendulum effect or the gyroscopic one is determinative for the stability of the vehicle in motion. As a result it becomes clear that in motion with constant and relatively high speed the weight should be placed as high as possible analogously to the “construction” of some high-speed animals as horses, deer and antelopes. At the same time it is well known that during starting and stopping or low speed movement it is better if the mass center is located lower. In other words it is required to find an optimal compromise solution of this task.

In two previous articles by the author of the current one was made a multifactor comparison of the constructions of electric bicycles produced by leading manufacturers and it was also empirically proved that the position of the mass center of the bicycle is a function of the battery position.

The purpose of the current article is to present the result of an experiment with existing electric bicycle with the lateral deviation as a parameter and the total sum of the bicycle, battery and rider as one input factor and the height of the battery position as another.

2. Essentials of the study

To achieve the aim of the study we held a complete factor experiment [1], [2] of type “FPE3²”, with matrix presented in table 1 with input factors and parameters:

- X_1 и X_2 – the code values of the first – total weight of the rider + electric bicycle + battery G , (kg) and second input factor – the height of battery position - H cm placed on the frame on the axis defined by the head tube and the pedals;
- Y_{1E} , Y_{2E} and Y_{3E} are the values for the lateral deviation measured during the experiment – vibration displacement during crossing an obstacle with constant height $h = 4$ cm, with movement speed of 15 km/h, and total mass, respectively $G_1 = 125$ kg, $G_2 = 100$ kg and $G_3 = 75$ kg, and height of the battery position respectively $H_1 = 70$ cm, $H_2 = 65$ cm and $H_3 = 60$ cm.

The experiment was held on a horizontal alley with flat surface. The height of the battery position was controlled by meter and for zero base was used the surface of the terrain. The battery was fastened in the required position with plastic brackets.

The riders selected for this experiment, including the author of this article, were with linearly increasing weight in order to achieve the corresponding linear raise of the input factor – total mass of the rider, the electric bicycle and the battery. The total weight of the bicycle and the battery varies of 25 to 50% of the weight of the rider. The riders maintained a constant speed measured by a controller of the Shimano brand mounted on the handlebar. During the experiment the movement was accomplished by using only muscle power and not electric assistance in order to achieve better safety for the participants in the experiment and to allow them to concentrate more fully on their side task – manual control of the vibration meter and the movement speed. The experiments were conducted multiple times in order to avoid random mistakes related to the maintenance of constant speed, the required time for activating the vibration meter, the need of proper balance during the bicycle movement etc.

On the asphalt terrain an artificial obstacle was mounted – hard wooden block with length of 1 meter and calibrated square cross-section. In order to reduce the hit of the impact as an alternative a PVC pipes with proper diameter were used. The results from the experiment showed that there is no significant difference between values of the lateral movement as a function of the obstacle cross-section. The wooden blocks were properly mounted to the terrain with steel nails.

The parameter (lateral vibrational displacement) examined as a characteristic of the dynamic behavior of the electric bicycle was controlled and recorded with portable vibration meter IL-V 12000. The vibration meter was mounted on the handlebar with securing strap close to the right hand of the rider in order to give maximum convenience of use to the rider – using the thumbnail for turning it on and off and resetting the value during movement.

The portable vibration meter is realized with piezo sensor, amplifier, linearizing block and LCD display. It has its autonomous power source thanks to two batteries by 1.5V each (SR44). The dimensions of the vibration meter are

commensurate to a pen and its weight is 44 grams which means that it could not affect the values of the studied parameter.

On fig.1 is presented the electric bicycle used for this experiment which is produced by Drag LTD – Sofia.

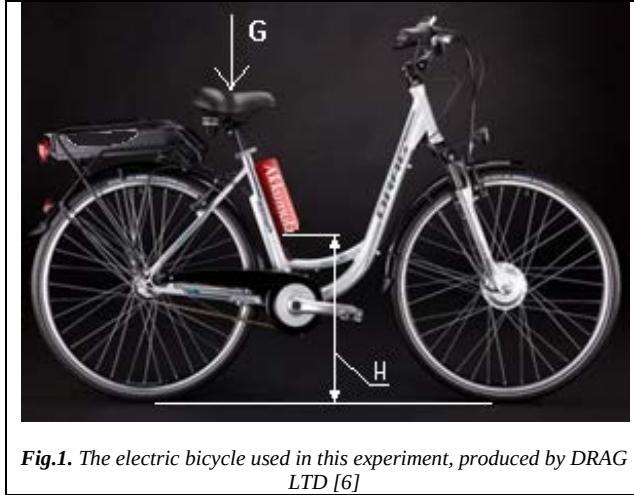


Fig.1. The electric bicycle used in this experiment, produced by DRAG LTD [6]

The aim is to develop a mathematical-stochastic model of second order of the following type:

$$Y = b_0 + b_1 \cdot X_1 + b_2 \cdot X_2 + b_{12} \cdot X_1 \cdot X_2 + b_{11} \cdot X_1^2 + b_{22} \cdot X_2^2,$$

where the unknown parameters are calculated based on the following formulas [2]:

$$b_0 = \frac{5}{9} \sum_{j=1}^9 x_{0j} \cdot \bar{y}_j - \frac{1}{3} \sum_{i=1}^2 \sum_{j=1}^9 x_{ij}^2 \cdot \bar{y}_j$$

$$b_i = \frac{1}{6} \cdot \sum_{j=1}^9 x_j \cdot \bar{y}_j \quad b_{ik} = \frac{1}{4} \cdot \sum_{i=1}^2 \sum_{j=1}^9 x_{ij} \cdot x_{kj} \cdot \bar{y}_j$$

$$b_{ii} = \frac{1}{2} \cdot \sum_{i=1}^2 \sum_{j=1}^9 x_{ij}^2 \cdot \bar{y}_j - \frac{1}{3} \sum_{j=1}^9 \bar{y}_j$$

Table 1

j \ i	X ₁	X ₂	Y _{jE}	Y _{cp.} = $\frac{1}{3} \sum_j Y_j$	Y _M
	G _j , kg	H _j , cm			
1	+1 125	+1 70	16,2; 7,4; 10,8	11,47	10,15
2	0 100	+1 70	10,0; 11,7; 14,6	12,10	13,87
3	-1 75	+1 70	22,9; 21,3; 18,9	21,03	23,09
4	+1 125	0 65	12,9; 17,0; 19,5	16,47	14,51
5	0 100	0 65	11,1; 10,7; 13,3	11,70	17,36

6	-1 75	0 65	24,7; 23,9; 26,4	25,00	25,73
7	+1 125	-1 60	8,2; 5,6; 13,7	9,17	9,94
8	0 100	-1 60	24,8; 17,8; 28,8	23,8	21,94
9	-1 75	-1 60	13,1; 12,7; 20,1	15,30	19,45

With algorithmic code and the assistance of software tool - MATLAB [11], the parameters of the model are calculated, their impact is verified and is made a check of the model adequacy. The model in a coded form is the following:

$$Y = 17,3633 - 4,0367 \cdot X_1 - 0,6117 \cdot X_2 - 0,8587 \cdot X_1 \cdot X_2 + 0,5400 \cdot X_1^2 - 2,2450 \cdot X_2^2.$$

Based on the parameter values of this model and signs of coefficients we can make the following conclusions:

- the value of free coefficient $b_0 = 17,3633$ is higher compared to the rest of the parameters which means that there are additional factors that have not been taken into attention with this model;
- the signs of the liner factors (b_1 and b_2) and in front of the pseudo-linear one ($b_{1,2}$) are negative which leads to the conclusion that with the increase of the input values we are seeing reduce of the value of the parameter – the lateral deviation;
- the coefficient $|b_1| = 4,0367$ is bigger than $|b_2| = 0,6117$, which means that the total weight (G) of the electric bicycle, rider and the battery are with higher importance compared to the second parameter (H) – the height of the battery position;
- the coefficient $b_{12} = 0,8587$, that shows the combined effect of two input factors has value commensurate of the value of the second coefficient b_2 and higher by absolute value;
- the signs of the square coefficients (b_{11} и b_{22}) are alternative which means that with the increase of the value of the first factor the value of the lateral deviation increases and vice versa with the increase of the second factor the value of the deviation lowers.

In the programming code with separate module was checked the importance of each coefficient and the adequacy of the model as in both cases we have used the criterion of Ronald Fisher (1857-1936) [1].

In the check of the coefficient importance are calculated the parametric values of the model excluding the minimal by absolute value coefficient ($b_1^2 = 0,54$). The calculated value

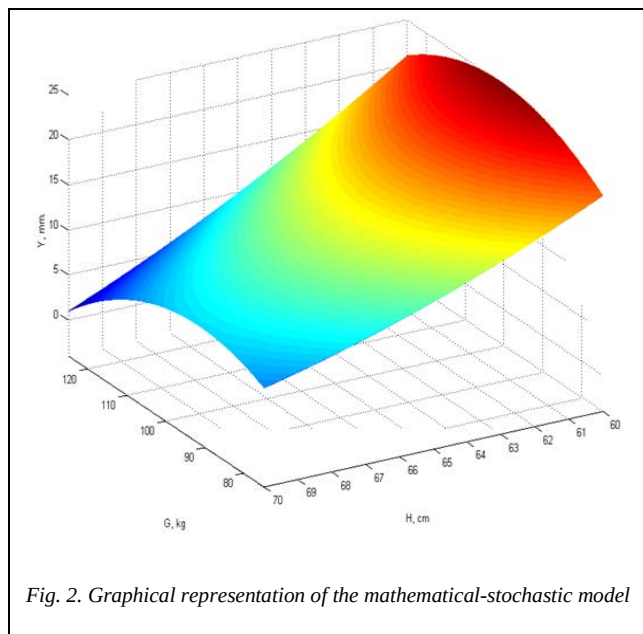
$$F = 0,56 < F_{\alpha=0,05; K1=1; K2=8} = 5,32$$

shows that all of the coefficients in the model are significant for the proper calculation of the value.

Comparing the average value of the empirical results (Y_{Ei}) reported during the experiment and the average value of the parametric model values (Y_{Mi}) is another proof of the adequacy of the model, because the calculated value of the Fisher's criteria is lower than the one from the table.

$$F = 0,87 < F_{\alpha=0,05; K1=1; K2=8} = 5,32$$

The same program code was used to create the graphical representation of the model, shown on figure 2.



The minimal values of Y (minimal lateral vibration deviation of the electric bicycle) is calculated with the following combination of the factor values $G=G_{\max}$ (total weight of 125 kg for the electric bicycle, the rider and the battery) and $H=H_{\max}$ (the maximal height of the battery position during the experiments of 70 cm).

As a result it becomes clear that the higher position of the battery ($H_{\max} = 70$ cm) measured according to the terra, combined with movement with constant speed (in this case 15 km/h), leads to lower values of the lateral vibration deviation which proves the analogy with the inverted pendulum system.

3. Conclusion

The result of this study proves the thesis that the higher placement of the battery is recommended for better stability and dynamic behavior while cycling with higher speed. It is assumed that the cyclists who ride with higher speed are more experienced in general and will be able to easily overcome the processes of starting and stopping where the lower speed and the higher mass center are precondition for lower stability. At the same time for customers who are expected to ride the bikes with lower speed, for example elders and children, it is recommended the battery to be placed lower and provide an extra stability while starting and stopping the movement.

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IMPLEMENTATION OF AN AUTOMATED DOCUMENTED IN TEACHING TECHNICAL DOCUMENTATION

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Abstract: *This report examined the means of automated design and analysis of technical documentation in CAD environment. Based on the analysis is to develop a methodology for course work in the discipline technical documentation using CAD systems for students of all engineering disciplines. The introduction of CAD products CAD early in training will enhance student motivation for their use - further in the education process in diploma projects.*

Keywords: ANALYSIS, AUTOMATED, CAD PRODUCT DESIGN, TRAINING

1. INTRODUCTION

The mounting requirements for the design, manufacture of parts and assemblies, and free use of their forced use of new tools. One of these tools in order to automate the process of design and design documentation of technical products are CAD / CAM systems.

Increasingly their widespread requirement to put higher education institutions to be covered in the training of students in the classes provided for the execution of assignments in this course Technical Documentation.

Aided design is carried out with different systems in complexity, scope and application areas. Modern CAD systems are designed for the design of components, assemblies, devices, development of new and modernization of existing technical documentation. CAD systems have options for creating 2D and 3D geometric model of the project [1].

The most widely used in the learning process graphic system AutoCAD, due to their advantages in terms of projection drawing and the requirements of the standards for the development of design documentation [2]. CAD high-end systems are increasingly used in production and in the training of planners and designers [3]. This is Tuck as they provide very good opportunities for design, modeling, documentation and manufac of parts and assemblies in CAD / CAM environment. All this gives grounds to say that the question of the implementation of automated design training students in the discipline Technical Documentation is particularly striking.

This work relied on an approach to training students in design automation in the CAD environment through the implementation of a volume of the tasks in the course " Technical Documentation " (TD).

The main tasks are:

- Analyzing the technical documentation and graphic CAD systems;
- Justification appropriate CAD / CAM systems for training of students of mechanical specialties;
- Development of methods for the use of CAD systems in the performance of assignments;

To perform the tasks used programming systems automated design AutoCAD and Solid Works.

2. Analysis of technical documentation in CAD environment

With the help of CAD systems automation design is done in an easy and simple way, leading to maximum gain .

By CAD products to automate the design process reduces the time to build sites which in turn allows engineers to direct his attention to innovate. Through the rapid development of digital prototypes can detect any errors before they are sent for production. Thanks to creative approaches that accelerate and facilitate the production process, AutoCAD is the most widely used of this class CAD systems to create a drawing [4].

The program's functionality helps to conceptualize and visualize projects developed to accelerate the implementation of the tasks. Through embodied in it means of parameterization of the drawings are decreases timing verification and editing projects. The associative interface makes working with the program attractive, easy to learn and use, and helps to increase the overall productivity in the design.

Technical drawings play an important role in all areas of engineering i.e. engineering design is based on drawings. The accuracy of implementation is supported by means of the graphic based CAD systems. To make the 3D image using two-dimensional drawing requires specific knowledge, skills and technical idea, ensuring sufficient precision to enable the product to be designed and put into production. These are subject specific knowledge of engineering drawing and technical documentation.

Most - widely used graphical and training systems engineering students are:

- Low grade - AutoCAD;
- Midrange – Solid Works, Solid Edge and Inventor;
- From - class - Pro Engineer, CATIA;

Possibilities for constructing documentation that give us CAD systems:

- By modeling engineering components, which allows for the geometric description of the object by concepts such as opening, rib and more. To this end, student learning is on the system Solid Works.
- In the process of designing the main burden falls on the creative process rather than the creation of drawings;
- Design starts directly with dimensional modeling of parts and the device as a whole;
- Drawings generated nearly completely automatically by the system as can be created as options as needed, and complying with the relevant standards of a country;
- Changes in structure or design of such devices is not necessary to always start from the beginning, since the models can be changed;
- Possibility to exchange data with other systems using standardized graphics file standards;

3. Development of methodologies for the discipline technical documentation using CAD systems

In the course work in the discipline technical documentation necessary Freshmen to acquire basic knowledge and skills to work with graphic systems AutoCAD and Solid Works. Acquired basic knowledge will be useful for the design of coursework in the subjects taught in the upper courses of mechanical engineering.

The system is oriented to Solid Works parametric modelling and assembly of complex products with a large number of details. It includes tools for: the creation of sketches, modelling and documentation of parts and assemblies, creating presentations and the availability of additional applications. Learning the basics of graphical system would benefit students at - in its further their course and diploma projects.

Advantages of the system Solid Works are:

- A quick and easy performance of the geometric shape of the projected object;
- Developing spatial reasoning through three-dimensional modelling of parts;
- Visualization of the interaction between the constituent parts and the operation of the assembled ones place, a dynamic model;

Based on studies on the use of CAD systems in order to satisfy market needs in the education of students in exercises coursework in the discipline to be included:

1. Depicting a third image, given two appropriate sections and sizing in a programming environment AutoCAD (Fig. 1) ;
2. Displaying 3D image of the detail of item 1 (Fig. 2).
3. Drafts of average - intricate detail of the kind using software Solid Works (Fig. 3) ;
4. Implement drawing of assembled ones place product Solid Works (Fig. 4 , Figure 5 and Figure 6) ;

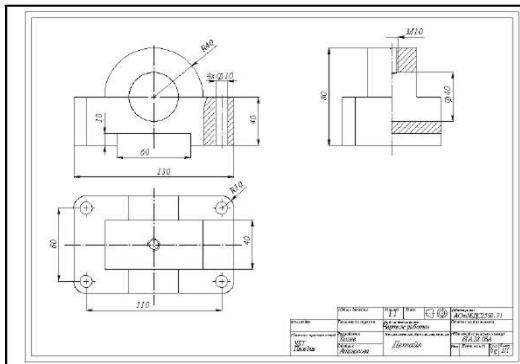


Fig. 1 Depicting a third projection, given two

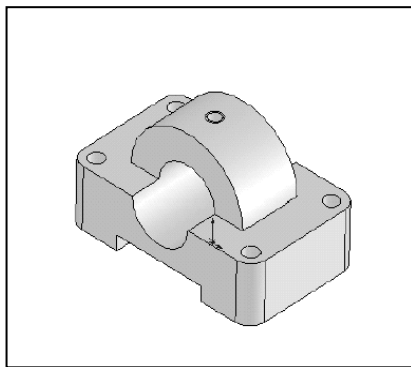


Fig. 2 3D image detail

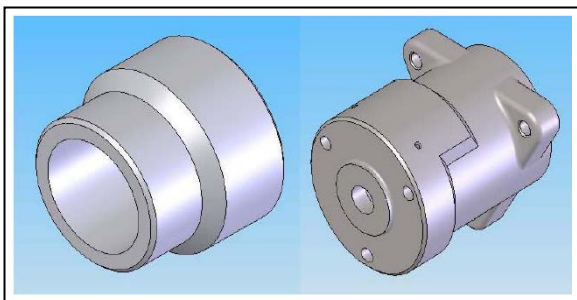


Fig. 3 Geometric model of simple and medium - the intricate details of nature

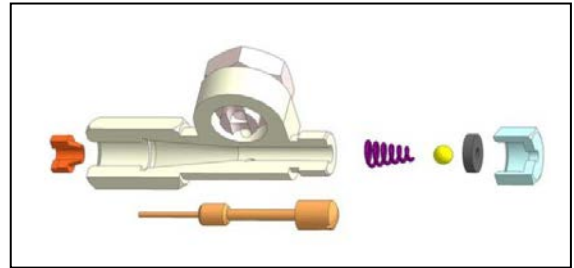


Fig. 4 Components of the assembled ones place

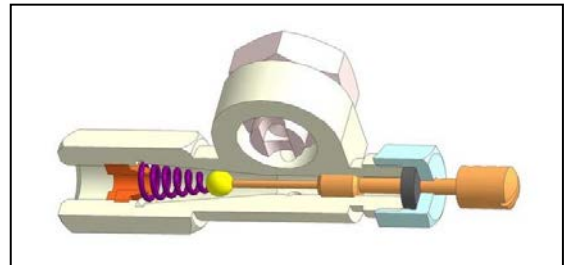


Fig. 5 A longitudinal section of an assembled ones place

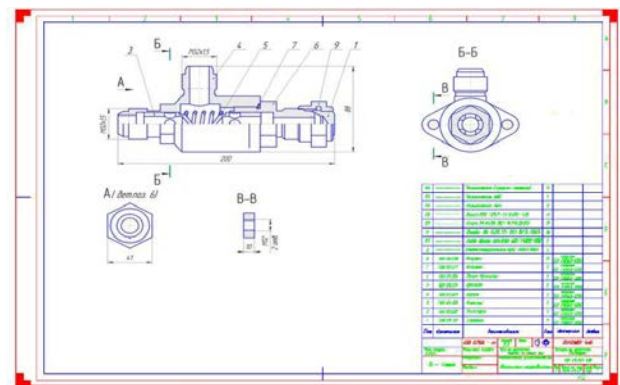


Fig. 6 Drawing of the product "Valve"

Fig. 5 is a section view of an assembled ones place of the product "Valve" on a given secant plane through graphics system Solid Works. Cut gives a good idea of the mutual arrangement of the individual elements of the piece and its assembly. The base is necessary to develop a design drawing of the assembled ones place that facilitate the development of spatial reasoning of students shown in Figure 6.

Opportunity to develop the imagination of students in a drawing detailing the general appearance is of great importance in the preparation of the course, since courses in design - above courses need to be able to read and analyze drawing different designs mechanical products.

4. CONCLUSION

Everything said above - we can conclude that:

1. Needed - a good cross-curricular link between general and specific subjects taught in mechanical engineering courses at universities to introduction of CAD systems in the learning process.
2. Through the introduction of CAD products CAD early in training will enhance student motivation for their use - further in the education process in diploma projects .
3. Utilizing graphical systems design is undoubtedly an advantage for future professionals in their independent or joint professional work.

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PERFORMANCE MANAGEMENT MODEL FOR HIGH-TECH ENTERPRISES

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Abstract: *In the contemporary knowledge-based economy human factor is one of the core competitive advantages of high-tech enterprises. Crucial to the development and commercialisation of innovations is the development of competencies of the human resources. Substantial part of the high-tech enterprises are challenged to define precisely what are the most important competencies they need to evaluate and to reward, as well as to foster and develop further in their personnel in order to improve their performance. The aim of the paper is to suggest and analyze the role of an appraisal and performance management model. The model is aimed at helping managers evaluate effectiveness and efficiency of the personnel performance. Further, it can be used as a tool that will aid the decision making process concerning appraisal and reward, training and development, and last but not least the career growth.*

Keywords: PERFORMANCE MANAGEMENT, HIGH-TECH ENTERPRISES, INNOVATION, PERFORMANCE MANAGEMENT MODEL

1. Introduction

The transition towards knowledge based economy, as well as the European Union (EU) strategic priorities 2020 [2] challenge anew the management of modern high-tech enterprises. Creation and dissemination of new knowledge and innovations have become crucial factors to the competitiveness. The role of the human factor as a leading source and determining asset in the innovations creation and development process sets new requirements in front of the measurement of effectiveness and efficiency of research intensive labour. Due to its specific competencies the research and development (R&D) personnel plays a significant role to the business outcomes and has a substantial impact on the sustainable competitive advantage. The performance management of research intensive labour becomes an important topic in the contemporary management science that needs further development.

During the last 10 years performance management has imposed as an approach contributing to organisational effectiveness and sustainable competitive advantage, focusing on appraisal, development and retention of one of the most valuable resources in the company [1,10,11,12].

The aim of the present paper is to develop an appraisal and performance management model that will aid performance management of innovation intensive labour. This model can be used as a tool that will facilitate the decision making processes regarding appraisal and reward, training and development, and last but not least the career growth of core staff in high-tech enterprises.

2. Innovation management in high-tech enterprises

There are two approaches to define the high-tech enterprises. The first one is based on the share of research, engineering and technical personnel occupied in the industry compared to overall number in all industries. The second one is based on the expenses for R&D in comparison to the total profit as a measure of the research intensity.

Enterprises in which the personnel involved actively in research intensive labour exceeds three times the average for the country or those in which the share of R&D expenses per capita involved in research compared to the overall personnel are above the average on a national level are defined as high-tech [5].

High-tech enterprises are essential to the development of a knowledge based economy. The further development and improvement of performance management systems in high-tech enterprises fosters the productivity and the efficiency of labour thus contributing to the sustainable competitiveness.

High-tech enterprises are tightly linked to the technological innovations leading to new or improved products or services. Further, they have a significant economic impact, due to the R&D investments and above the average sales growth.

3. Performance management of the R&D personnel

Performance management is crucial to the competitiveness of high-tech enterprises. Shortage and lack of highly qualified personnel is one of the major factors constraining the innovation activity of the enterprise.

When the performance management issues are considered it is important to point out that there are various categories of personnel in business organisations, namely: key workers, supporting workers, specialists, managers etc. [11]. The personnel in high-tech enterprises engaged in research are sub-divided into researchers, technical and supporting staff [3,8,9,13]. This classification is important from the performance management point of view since the various types of personnel participate and contribute in a different way in the value creation process in the enterprise.

Competences are an important indicator for the personnel appraisal and performance management. Competencies are defined as measurable or observed knowledge, skills, abilities and behaviors, critical to the successful job performance [3,7,10,14]. Competencies are needed to ensure the effective and efficient performance of the employees and achievement of the best results for the enterprise. The personnel engaged in research belong to the group of the specialists.

The core competencies of the employees engaged in research are grouped in three areas: scientific competencies and research skills, ability to manage projects and teams and interpersonal skills. Research competencies are related to the specific scientific knowledge, the ability to acquire it, analyze and adapt to a new context or problem. The skills to manage projects and teams are essential for researchers who manage research projects or applied scientific projects [4].

The specific competencies of the personnel, engaged in the generation, creation, development and dissemination of innovations, in high-tech enterprises requires specific approach towards the performance management that will facilitate the productivity increase and improve the work efficiency. In the human management literature [15] the debated on methods and metrics and their impact on performance management of the research intensive

personnel is still ongoing. However, this managerial activity is crucial to the innovation activity of the enterprise and needs further research.

4 Performance management model

When assessing the work performance of personnel occupied in research authors suggest taking into consideration the following factors: results achieved, the collaboration during the assessment period and what competences are acquired during the job performance. The performance results evaluated are the effectiveness of employee's performance compared to the job description and duties, and the achievement of the assigned goals. Authors suggest a three level appraisal scale to be applied – low, medium and high (fig. 1). Provided a more accurate or in depth appraisal is needed to be made the scale can be five, seven or even more levels, however it should be acknowledged that this additionally complicates the evaluation process and the interpretation of the results.

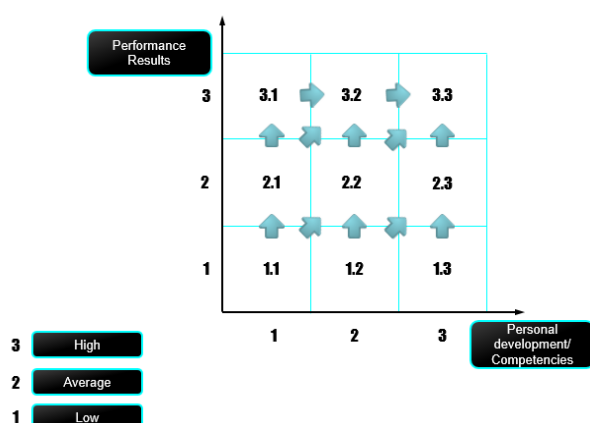


Fig. 1. Performance Management Model

This model has nine positions depending on how the employee has been assessed by his/her supervisor. In addition a comparison between the evaluation of the supervisor or a team leader, self-assessment and assessment by a third party can be made. The variations between different evaluations can be analyzed as it is in a 360 degree appraisal.

The proposed model builds on the Black Mouton leadership grid [2] impacting directly on the results, motivation and satisfaction of employees with their performance. The similarity between the two models is the drive to find a solution that will aid the improvement of the performance results, but while the Black Mouton leadership grid [2] is focused on the managerial staff of the company, the suggested new model is directed towards the assessment of the performance of the employees occupied in research activities. Changes in the behavior and the performance of employees that are beneficial to the enterprise are indicated by arrows that show the direction in which the performance of the employees should be changed in order to develop further their potential and the company growth.

The positions in the performance management model are as follows:

Position 1.1 indicates poor performance and a low level of skills, which may be considered as an indicator of a low potential for further development of the employee. In this case the employee is considered to be a potential cost to the company, and in case some measures to improve his performance and expertise are not taken it would be better to make him/her leave the company. His/her options for further development are in the direction of positions 1.2, 2.1, 2.2. Moving to position 1.2 is beneficial to the employee because it leads to further development of his/her competencies and

qualifications as a result of training, mentoring, etc., however his/her work results are still poor or unsatisfactory, and the training expenses are not justified. By moving to position 2.1 the employee improves his/her performance results. This effect can be achieved as a result of increase of motivation, good leadership or efficient team work, but this does not lead to development of new skills or competencies. The best move is towards position 2.2. This means that the employee has improved his/her and thus company performance, while improving and developing his/her skills. In a personal level this situation puts the employee in a more favourable position on the labour market.

Position 1.2 is characterized by low performance and average level of skills and potential for personal development of the employee. Moving towards positions 2.2 and 2.3 is beneficial to the employee making possible his further career growth and further personal development in the future. The suggested managerial decision is to offer additional training to the employee that will contribute to the increase of his/her productivity and the quality of work. Typically these are trainings improving the way of work and facilitating the achievement of the specific job requirements.

Position 1.3 reveals people with special qualities and potential for further development, but low performance results. The task of the manager is to find out the core reasons for these poor results and seek solutions to the problems. These employees are "question marks", because they possess all qualities and skills needed to do the job, but their performance results are unsatisfactory. The task of the manager is to find out the cases for this and to take certain actions so that such employees move to position 2.3. Often it is needed to retain these employees even if this requires some additional efforts of their supervisors or managers.

Position 2.1 represents employees with skills to cope with the work at a satisfactory level which do not possess the required competencies. These employees need additional training to acquire the knowledge and the skills needed to improve their performance results, as well as cooperation and team work. Provided such workers keep their performance level is a sign that the training is not enough and the employee needs also some additional motivation.

Position 2.2 is common case in most companies and the personnel working in them – typically these are employees with average competencies and potential for development whose performance is about the average. Usually in this case fall newly employed with average or high qualification, but without any practical experience, as well as employees who have no ambition for development and are happy with their performance reward. The last category of employees may look for security without willingness for further development or career growth. In this case they can be motivated to increase their productivity and the quality of their work using monetary instruments to increase their performance reward to a certain level and following a clearly specified bonus system. Most of the employees in this situation are stuck in their career development or close to retirement and do not see sense for further career development.

Position 2.3 requires excellent leadership skills of the management and the line managers in the enterprise. Employees following in this position perform below the level of their knowledge and skills and perform to the level so they do not fall in a lower appraisal group. In such cases a mentoring is a possible solution in order to motivate them. There are many cases when employees having the required competencies do not perform to their best not because of insufficient payment, but due to some other reason. There are other important incentives and motivators, such as providing the opportunity to improve competency, acquire new skills, receive recognition for a well done job, involvement in the decision-making. In order to be able to retain such employees and benefit from their competencies a mentoring approach is required. The

possible solutions in such cases are career development, more personal responsibility and other tools for talent development.

Position 3.1 describes cases of high performance but low competence. In this case fall people without qualifications needed, but highly motivated and committed, willing to prove themselves. People in this position should be rewarded for their efforts and achieved results, as well as they should be encouraged to develop further. Even the fact that they are top performers is beneficial for the company, and it is not necessary to plan their career development. Keeping this level of competence – performance balance is good enough for the company, however provided there is increase of their competencies is an additional bonus to the company.

Position 3.2 represents average performance and not average competencies. Employees in this position represent potential managers and leaders in the organisation. In order to develop further these employees it is needed to develop special training programme that will aid their career growth within the company.

Position 3.3 represents employees with the highest competencies who provide the best performance in the company. Such employees are ready to proceed to the next level of their career development. These are the employees with the highest potential to be next generation leaders and managers on a strategic level. In some cases if retained in the same position over a longer period of time there is a risk they become demotivated and the level of their performance might decline. Another risk is they might find another option for their career development and the company might lose them. If we make an analogy with the Black Mouton leadership grid [9] - these managers are leaders focused on task achievement and motivation of personnel, balancing the objectives of the enterprise and the satisfaction of the employees.

The performance management model can be based on a variety of criteria and can apprise quantitatively the potential of the employees and the expected value to the company in future.

The nine possible positions can get the relevant measurement using a points system (we suggest a 100 points system as most easy to understand).

An indicative distribution of the points is presented on fig. 2. The possible managerial decisions for the various positions are outlined on the right side.



Fig. 2. Rating scale

For example, if the employee receives between 0-40 points he/she must leave the organisation or be warned that this will follow provided he/she does not improve his/her performance during the next reporting period or trial period.

Between 40-50 points means some additional training is needed, in order to improve productivity and performance results.

Between 55-70 points outlines a satisfactory performance, which should be improved through motivation by appropriate bonus scheme in accordance with the abilities of the company and the personnel capacity.

Between 70-85 points means the material motivation is not enough, but some additional training and qualification would be required in order to ensure better performance and facilitate the career growth.

Between 85-100 points requires consideration of opportunities for career growth and further development, which can be both hierarchical and horizontal.

The lowest point levels correspond to the need for additional training in order to acquire new knowledge and skills in order to handle the task, followed by appraisal of the performance and material motivation for better performance and quality of work.

The highest point levels show it is needed to provide opportunities for further development, as well as work towards the retention of the best performance and the most developed competencies in order to be used by the management of the enterprise to contribute to the value creation.

4. Conclusions

The performance management model links the leadership style and the appraisal, reward and development methods in the company. The model is based on performance results, which can be quantitative or qualitative. For the research personnel in the high-tech enterprises it is quite difficult to determine the work results and the achievements. On the other hand the model is based on the acquired and developed in the process of work competencies and gives information about the potential for development of the employees. The model is meant to aid the effective and efficient human resources management of research intensive labour in high-tech enterprises. However, further analysis and development of the assessment procedure are needed in order to link the performance results and competencies and the decision making process regarding the opportunities for career development, increase of the rewards and training.

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