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STUDY CONCERNING DYNAMIC KINEMATICS OF AN OSCILLATORY SLIDER MECHANISM

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Abstract. The oscillatory slider mechanism is frequently used in machine construction. An illustrative instance is mechanism of shaping - machine that contains in his structural scheme an oscillatory slider mechanism. This paper undertakes a study upon kinematical characteristics thinking mass and acting forces of mechanism. The study demonstrates a very important influence of mass and forces upon kinematical characteristics of mechanism. Are obtained in this way dynamic kinematical characteristics (dynamic velocities and accelerations) that to have to consider in design calculation of mechanism.

1. NOTATIONS

Bellow in the paper, the following notations are used: l_1 - crank length, l_{3m} - maxim length of slider, l_4 - basis length, φ_1,φ_2 - (Fig. 1), I_{11} - moment of inertia of balanced crank, I_{12} - moment of inertia of unbalanced crank, m_{12} - mass of unbalanced crank, m_2 - mass of slider block, I_{22} - moment of inertia of slider block, m_{32} - mass of slider unbalanced, I_{31} - moment of inertia of slider balanced, I_{32} - moment of inertia of slider unbalanced, v_{M21}, v_{M31} - kinematical velocity of mass center M_2 and M_3, respectively, v_{M2ri}, v_{M3ri} - dynamic velocity of mass center M_2 and M_3, respectively, a_{M20}, a_{M30} - kinematical acceleration of mass center M_2 and M_3, respectively, a_{M2ri}, a_{M3ri} - dynamic acceleration of mass center M_2 and M_3, respectively. M_{red1} - equivalent moment of mechanism reduced at element (1), $I_i(\varphi_1)$ - equivalent moment of inertia of mechanism reduced at element (1), I_{i0} - equivalent moment of inertia of mechanism reduced at element (1), for $\varphi_1 = 0$, ω_1, ω_{31} - kinematical angular velocity of crank and of slider respectively, ω_{1ri}, ω_{3ri} - dynamic angular velocity of crank and of slider, respectively, ε_1,, ε_{30} - kinematical angular acceleration of crank and of slider, respectively,ε_{1ri}, ε_{3ri} - dynamic angular acceleration of crank and of slider, respectively, M_1, M_3 - acting moment of crank and of slider, respectively.

2. INTRODUCTION

Oscillatory slider mechanism is frequently used in structure of machine construction. An illustrative instance is mechanism of shaping - machine that contains in his structural scheme an oscillatory slider mechanism. This paper undertakes a study upon kinematical characteristics thinking mass and acting forces mixing and shaking systems. Frequently, slider (3) describes an oscillating movement or a movement of rod. In last case sliding block (2) describes an oscillating movement. An oscillatory slider mechanism (Fig. 1) was considered [4], ... ,[7], [9], [10], [14], [16], [17], [21]. Slider (3) works as fulfillment element. Technological researches [4], [7], [17] prove that vibrations of the technological systems exercise a very great influence upon the mechanical manufacture precision.

In design calculation of kinematical parameters, the characteristics of the mass as well as of the force of the mechanism are neglected, usually [1], [8], [11], [15], [18]. [20], [22], [24]. Also, the crank angular velocity ω_1 is considered to be constant and consequently angular acceleration of crank ε_1 is considered to be null ($\varepsilon_1 = 0$).

For a computer simulation were considered 8 cases: 1 - crank balanced, $m_2 = 0$, slider balanced; 2 - crank balanced, $m_2 \neq 0$, slider balanced; 3 - crank balanced, $m_2 = 0$, slider unbalanced; 4 - crank balanced, $m_2 \neq 0$, slider unbalanced; 5 - crank unbalanced, $m_2 = 0$, slider balanced; 6 - crank unbalanced, $m_2 \neq 0$, slider balanced; 7 - crank unbalanced, $m_2 = 0$, slider unbalanced; 8 - crank unbalanced, $m_2 \neq 0$, slider unbalanced.

Treated mechanism is represented in (Fig. 1) [9].

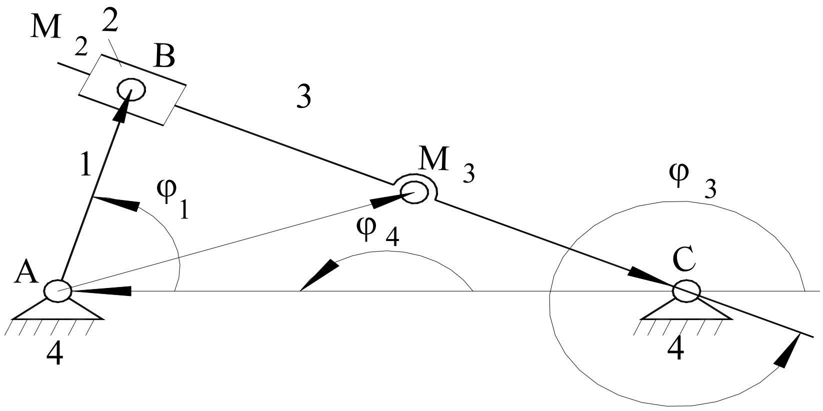

Fig. 1 - Oscillatory slider mechanism
1 - crank, 2 - sliding block; 3 - slider, 4 - frame

3. CALCULUS RELATIONS

For leading element, crank (1), to see [12].
For slider block (2),

$$v_{M21} = l_1 \cdot \omega_1$$
$$v_{M2ri} = l_1 \cdot \omega_{1ri} \tag{1}$$
$$a_{M20} = l_1 \cdot \omega_1^2$$
$$a_{M2ri} = l_1 \cdot \sqrt{\omega_{1ri}^4 + \varepsilon_{1ri}^2} \tag{2}$$

For slider (3),

$$\omega_{31} = \omega_1 \cdot \varphi_{31}$$
$$\omega_{3ri} = \omega_{1ri} \cdot \varphi_{31} \tag{3}$$
$$\varepsilon_{30} = \omega_1^2 \cdot \varphi_{311}$$
$$\varepsilon_{3ri} = \omega_{1ri}^2 \cdot \varphi_{311} + \varepsilon_{1ri} \cdot \varphi_{31} \tag{4}$$
$$v_{M31} = \frac{l_m}{2} \cdot \omega_{31}$$
$$v_{M3ri} = \frac{l_m}{2} \cdot \omega_{3ri} \tag{5}$$
$$a_{M30} = \frac{l_m}{2} \cdot \sqrt{\omega_{31}^4 + \varepsilon_{30}^2}$$
$$a_{M3ri} = \frac{l_m}{2} \cdot \sqrt{\omega_{3ri}^4 + \varepsilon_{3ri}^2} \tag{6}$$

In relations (1) , ... , (6):

$$\varphi_{31} = \frac{l_1 \cdot (l_1 - l_4 \cdot \cos\varphi_1)}{l_1^2 + l_4^2 - 2 \cdot l_1 \cdot l_4 \cdot \cos\varphi_1}$$
$$\varphi_{311} = \frac{l_1 \cdot l_4 \cdot (l_4^2 - l_1^2) \cdot \sin\varphi_1}{(l_1^2 + l_4^2 - 2 \cdot l_1 \cdot l_4 \cdot \cos\varphi_1)^2} \qquad (7)$$

4. OBTAINED RESULTS AND COMMENTARY

A calculus program for following values of work parameters was run: $\varphi = 0,10 \cdot \frac{\pi}{180}..2 \cdot \pi$; ω_1 = 100 s^{-1}, l_1 = 0. 2 m , l_{3max} = 0.725 m , l_4 = 0. 5 m , I_{11} = 0.46 Nsm^2, m_{12} = 2.75 kg, I_{12} = 0.057 Nsm^2, m_2 = 0.5 kg, I_{22} = 0.000186 Nsm^2, I_{31} = 1.4 Nsm^2, m_{32} = 4 kg, I_{32} = 0.175 Nsm^2, m_2 = 0.5 kg, I_{22} = 0.000186 M_1 = 3.5 Nm, M_3 = - 2.3 Nm, i = 1, .. , 8.

In Figs. 1, ... , 14 are represented results obtained through a computer simulation.

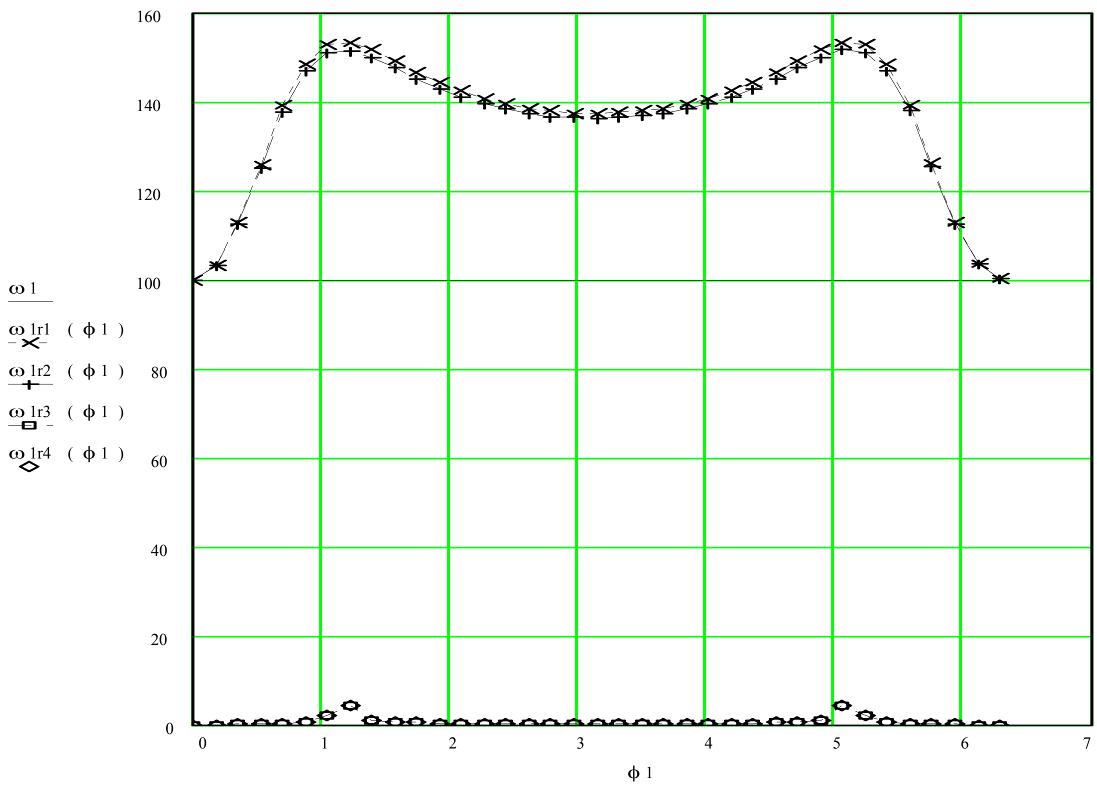

Fig. 2. *ω_1, ω_{1r1}, ω_{1r2}, ω_{1r3}, ω_{1r4}* ***depending on*** *φ_1*

Velocities ω_{1r1}, ... , ω_{1r8} reach much bigger values in comparison with kinematical angular velocity ω_1 and they are strong variable (Figs. 2, 3). The biggest values 288.31 s^{-1}, are reached by ω_{1r5} in comparison with ω_1 = 100 s^{-1}. For mass center M_2 of slider block 2 the biggest values 57.662 ms^{-1} is reached by dynamic velocity v_{M2r5} in comparison with velocity v_{M21} = 20 ms^{-1} (Figs. 6, 7). For slider 3 dynamic velocity ω_{1r5} reaches the biggest value of 53.9664 s^{-1} in comparison with 28 s^{-1} reached by ω_{31} (Fig. 9). For mass center M_3 of slider 3, the biggest value 19562.8 ms^{-1} is reached by dynamic velocity v_{M3r5} in comparison with reached value 10000 ms^{-1} of kinematical velocity v_{M31} (Fig. 11). Relative dynamic velocity v_{B23} reaches the maxim value 57.4589 $ms^{-}1$ through v_{B23r5} in comparison with 20 $ms^{-}1$ reached by kinematical relative velocity v_{B231} (Fig. 13).

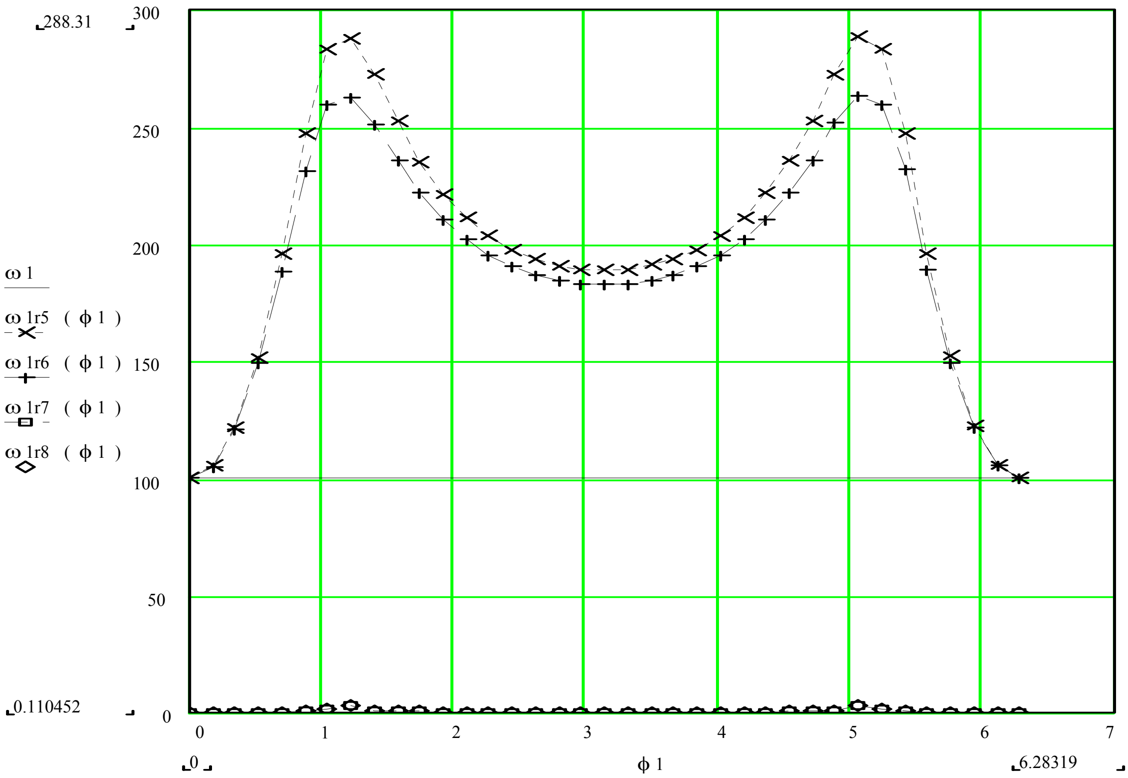

***Fig. 3.** ω_1, ω_{1r5}, ω_{1r6}, ω_{1r7}, ω_{1r8} **depending on** φ_1*

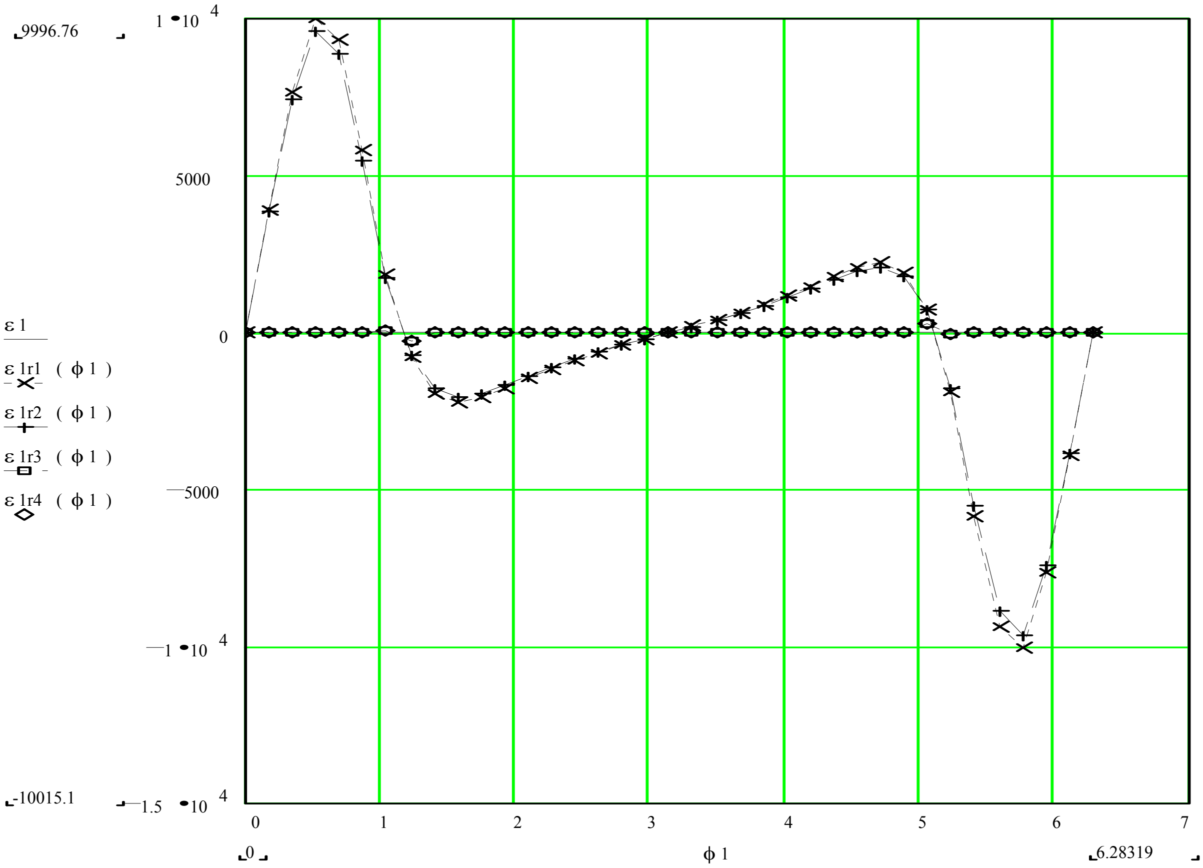

***Fig. 4.** ε_1, ε_{1r1}, ε_{1r2}, ε_{1r3} ε_{1r4} **depending on** φ_1*

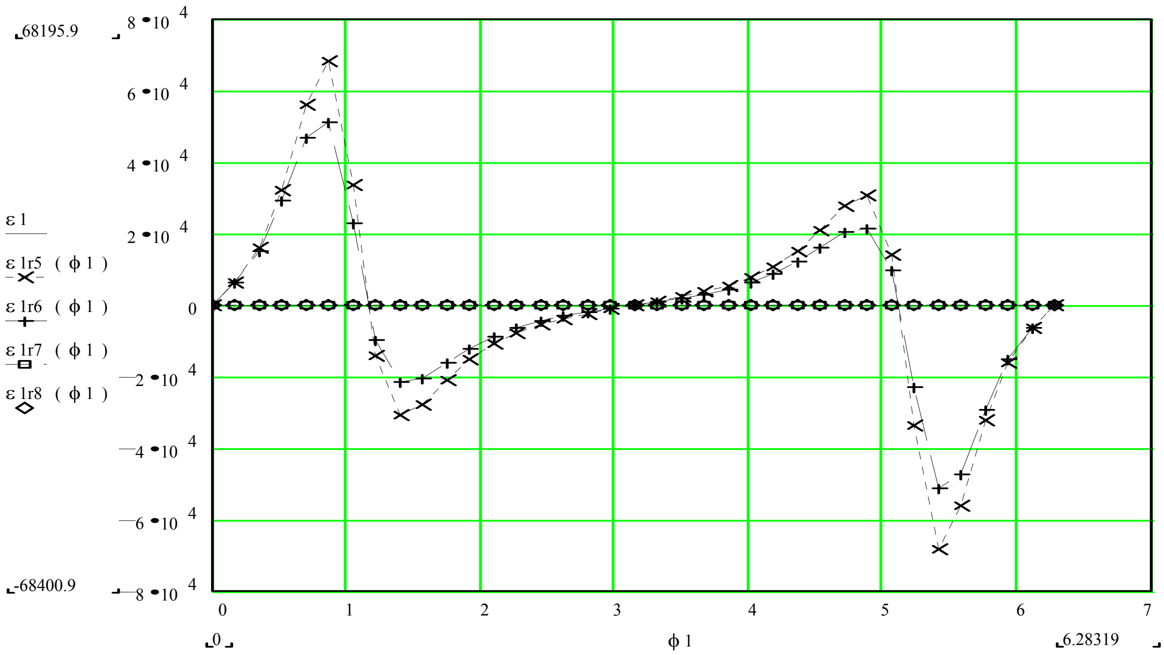

Fig. 5. ***ε_1, ε_{1r5}, ε_{1r6}, ε_{1r7}, ε_{1r8} depending on φ_1***

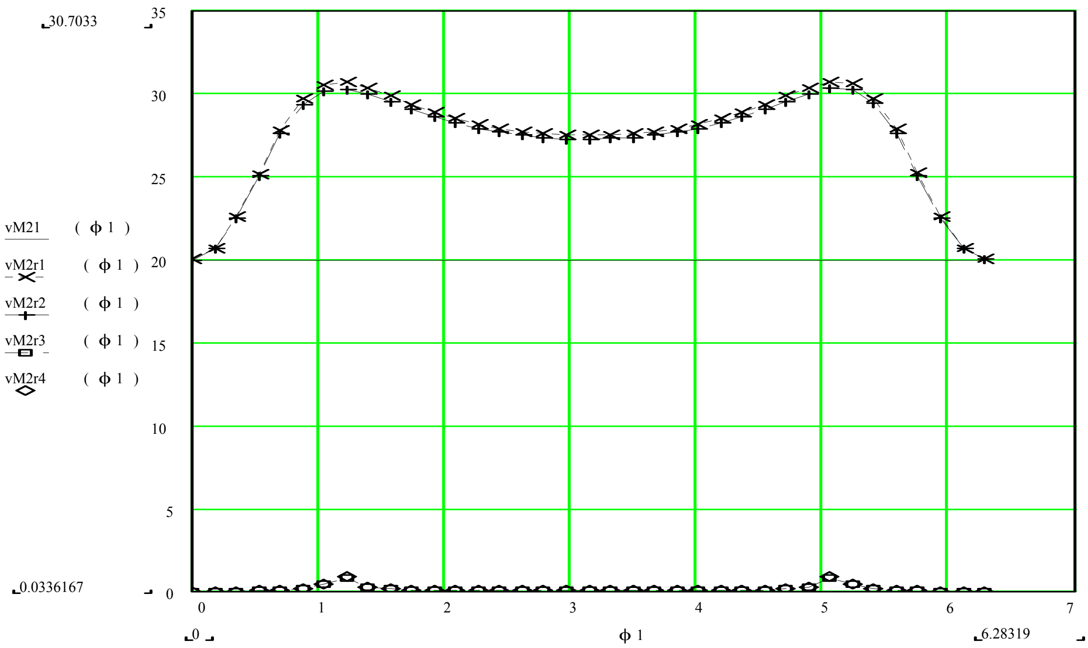

Fig. 6. ***v_{M21}, v_{M2r1}, v_{M2r2}, v_{M2r3}, v_{M2r4} depending on φ_1***

Dynamic angular accelerations ε_{1r1}, ε_{1r2} reach values of -10051.1 and 9996.76 s^{-2} (Fig. 4) but ε_{1r5}, ε_{1r6} reach values of -68400.9 and 68195.9, $\pm$ 51000, respectively (Fig.5) in comparison with kinematical acceleration $\varepsilon_1 = 0$. For mass center M_2 of slider block dynamic acceleration a_{M2r5} reaches values of 2000 and 18353.1 ms^{-2} in comparison with kinematical acceleration $a_{M20} = 2000\ ms^{-2}$ (Fig. 8). For slider 3, dynamic angular acceleration ε_{3r5} reaches values of -38724.4 and 8580.7 s^{-2} and the cinematic acceleration ε_{30} reaches values of $\pm 7000 s^{-2}$. The acceleration a_{M3r5} of mass center M_3 of slider 3 reaches values between $1\text{x}10^6$ and $1{,}4\text{x}10^7$ ms^{-2} in comparison with kinematical acceleration a_{M30} that reaches values between $0{,}1\text{x}10^6$ and $2{,}8\text{x}10^6$ (Fig. 12). Relative acceleration a_{M23r1} reaches values between $-1{,}18.\text{x}10^{17}$ and 4501,61 ms^{-2} in comparison with kinematical acceleration a_{M230} (Fig. 14).

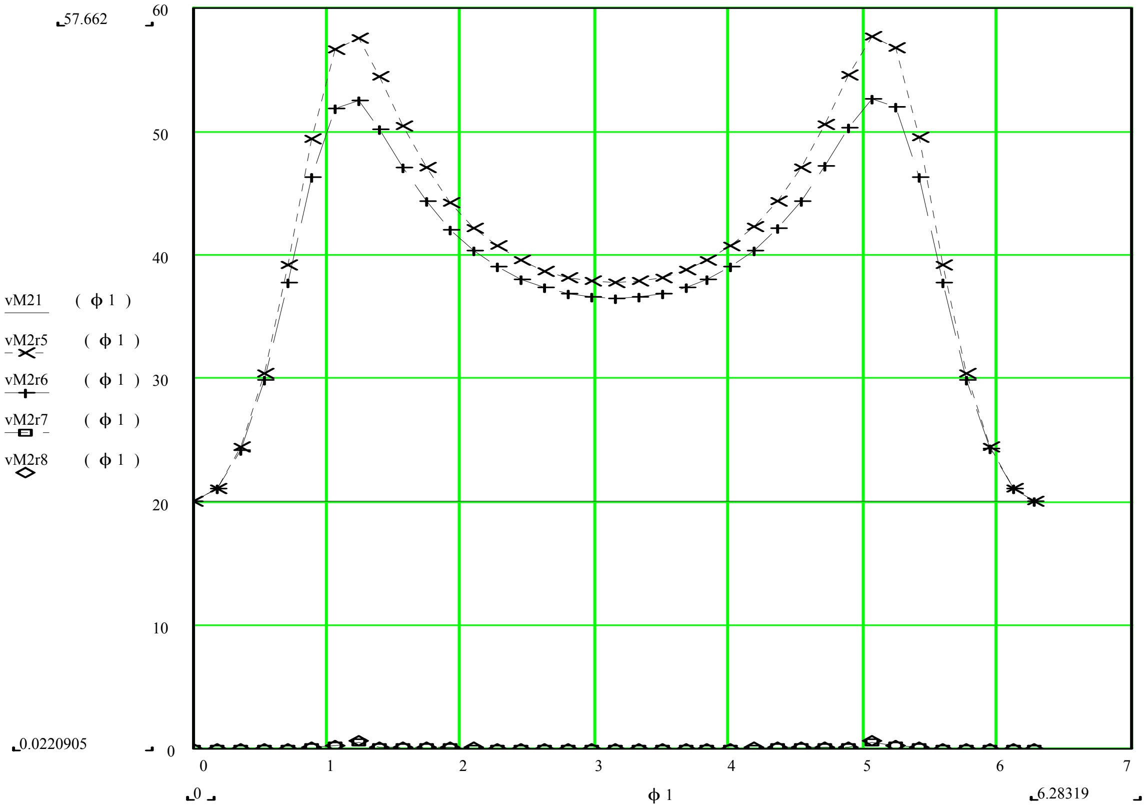

Fig. 7. v_{M21}, v_{M2r5}, v_{M2r6}, v_{M2r7}, v_{M2r8} **depending on** φ_1

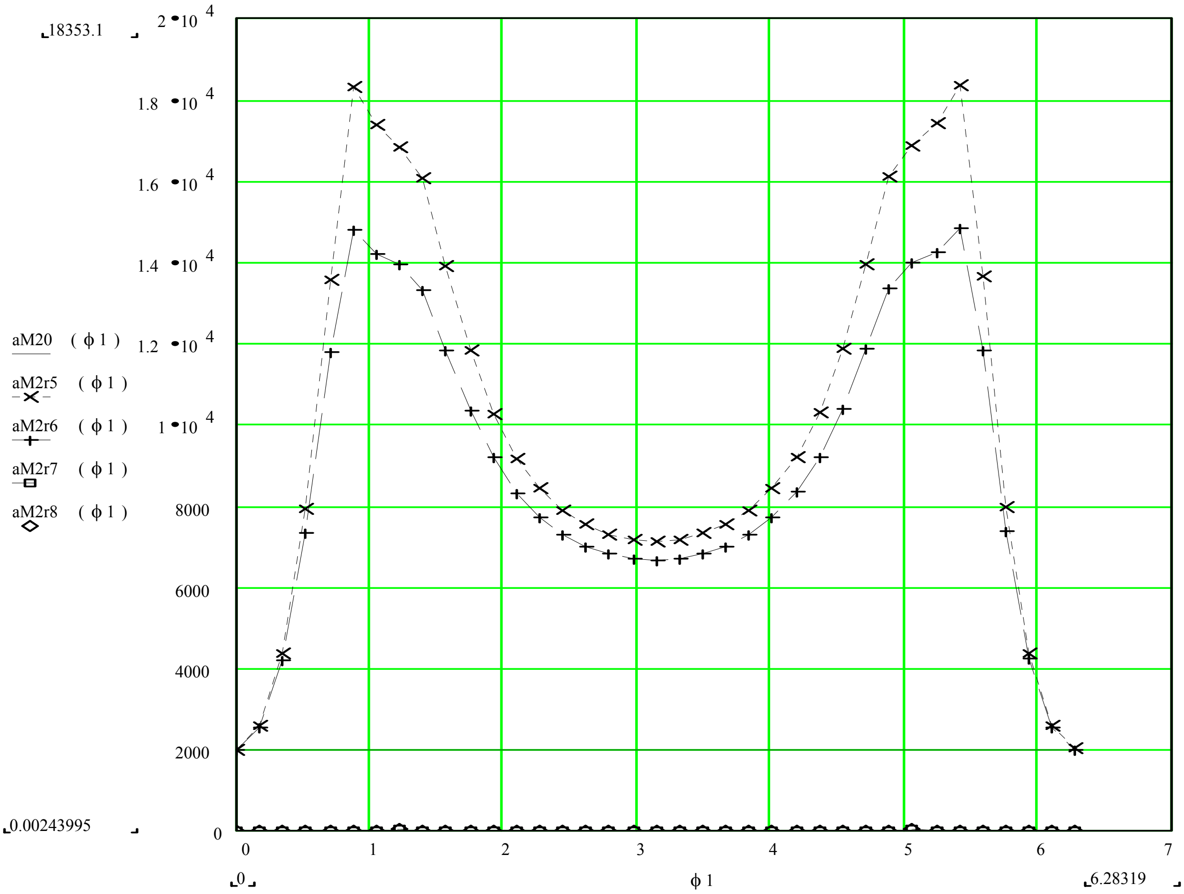

Fig. 8. a_{M20}, a_{M2r5}, a_{M2r6}, a_{M2r7}, a_{M2r8} **depending on** φ_1

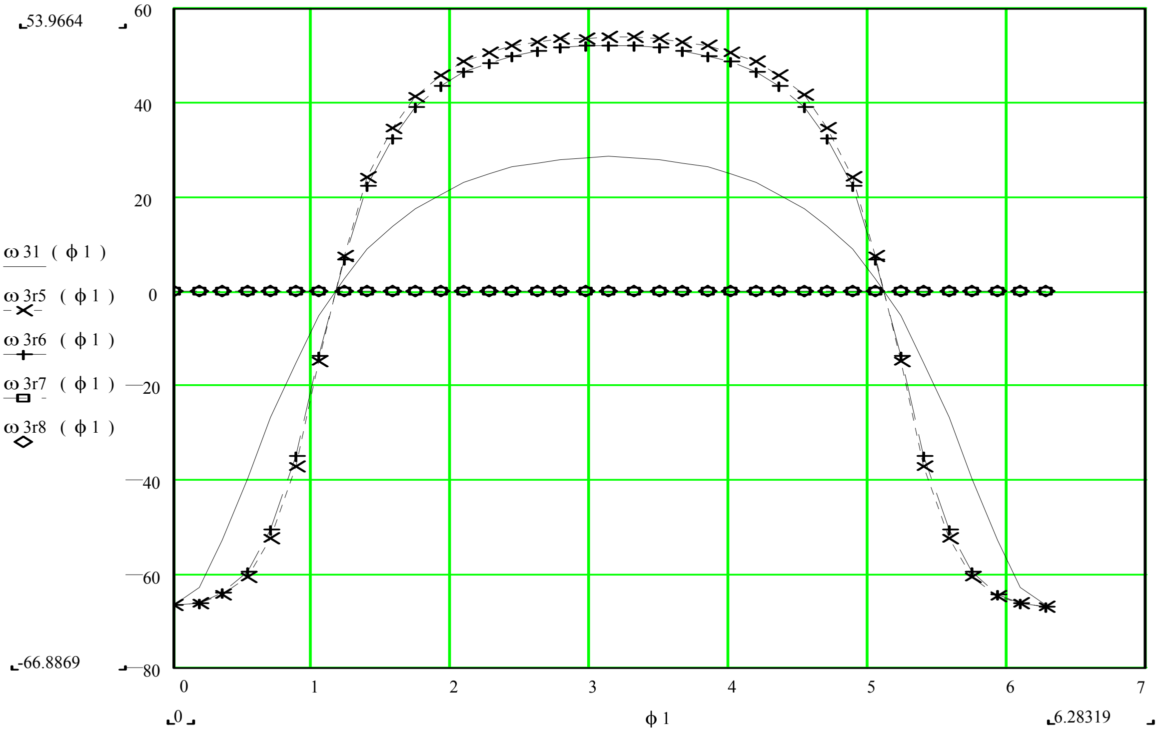

Fig. 9. ω_{31}, ω_{3r5}, ω_{3r6}, ω_{3r7}, ω_{3r8} ***depending on*** φ_1

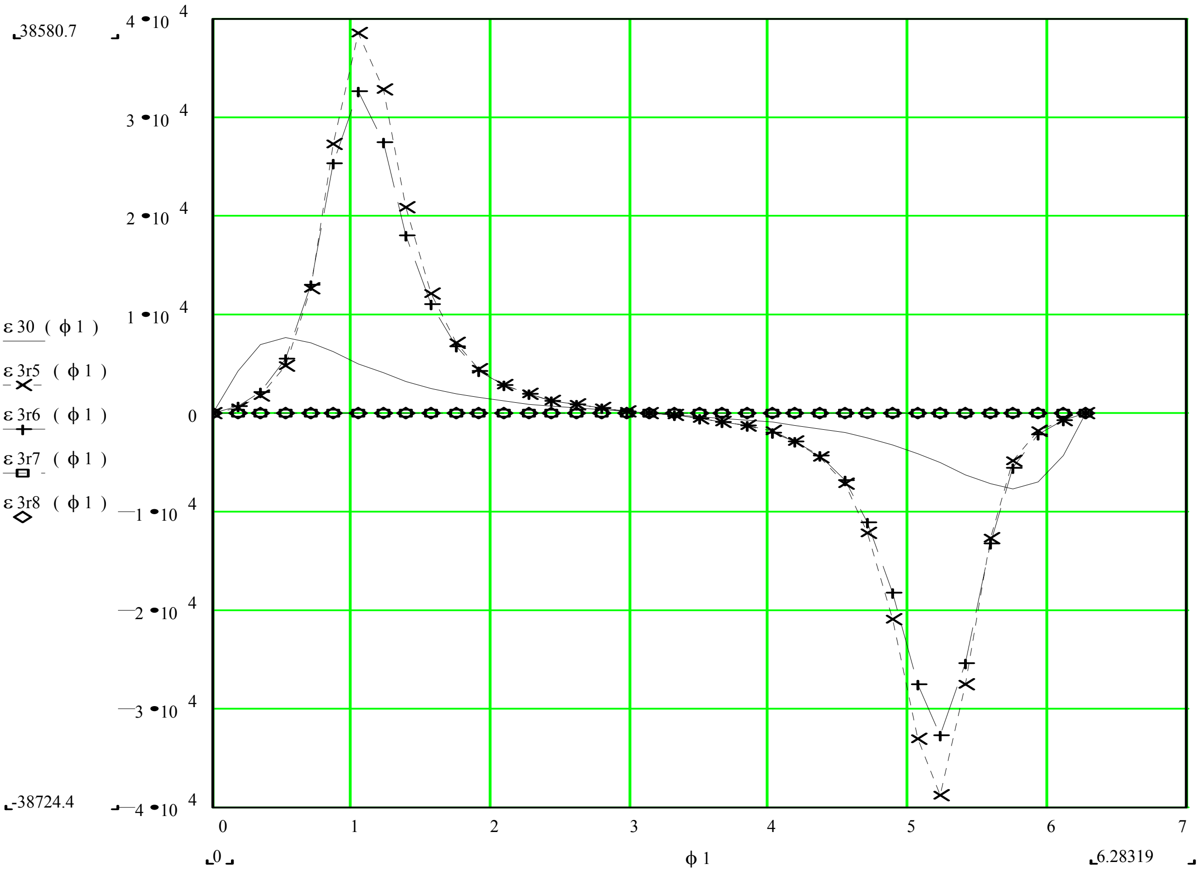

Fig. 10. ε_{30}, ε_{3r5}, ε_{3r6}, ε_{3r7}, ε_{3r8}, ***depending on*** φ_1

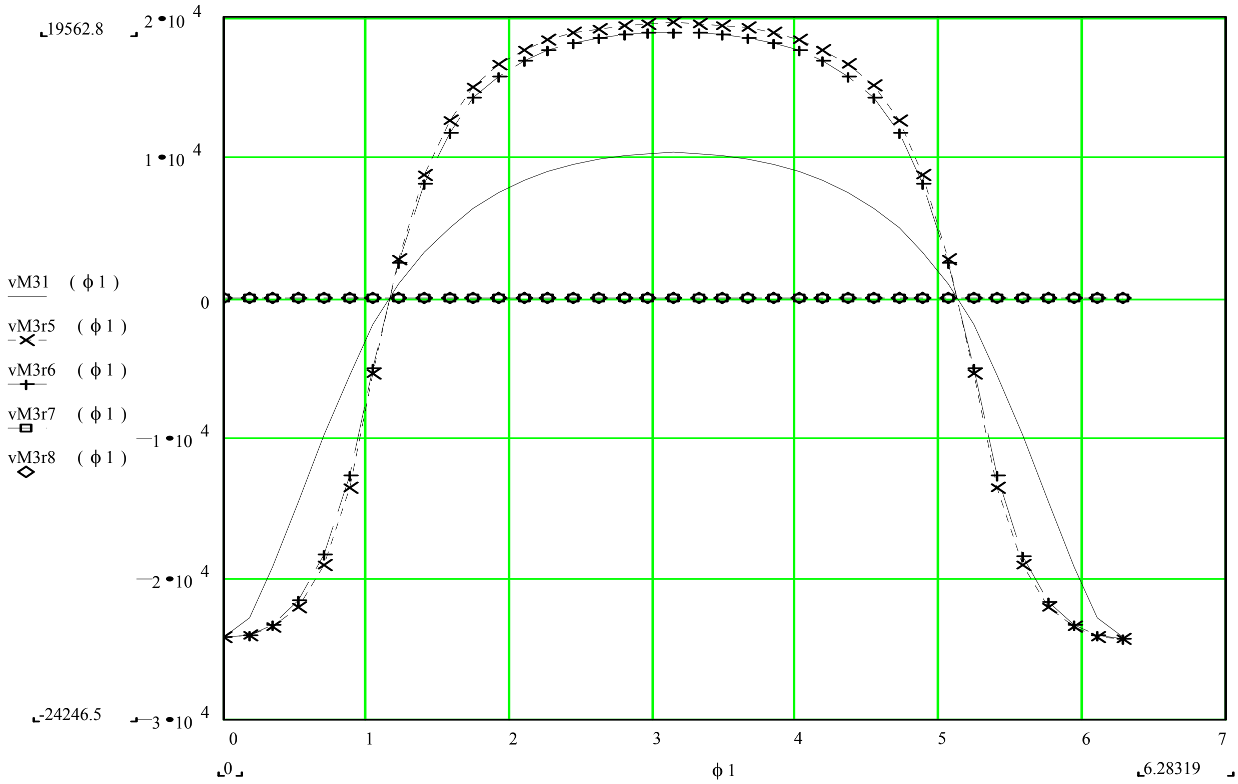

Fig. 11. v_{M31}, v_{M3r5}, v_{M3r6}, v_{M3r7}, v_{M3r8}, *depending on* φ_1

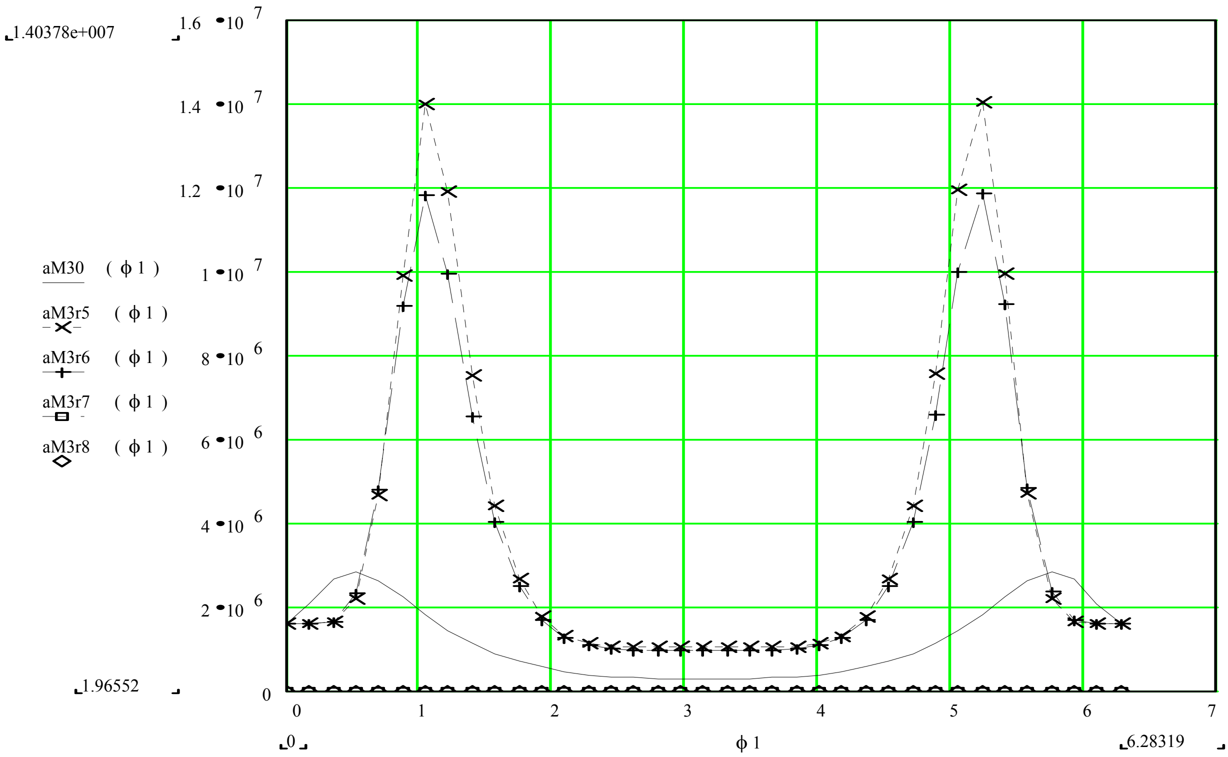

Fig. 12. a_{M30}, a_{M3r5}, a_{M3r6}, a_{M3r7}, a_{M3r8}, *depending on* φ_1

To take into account that velocities as well as accelerations corresponding of 3rd, 4th and 7th, 8th cases have insignificant values.

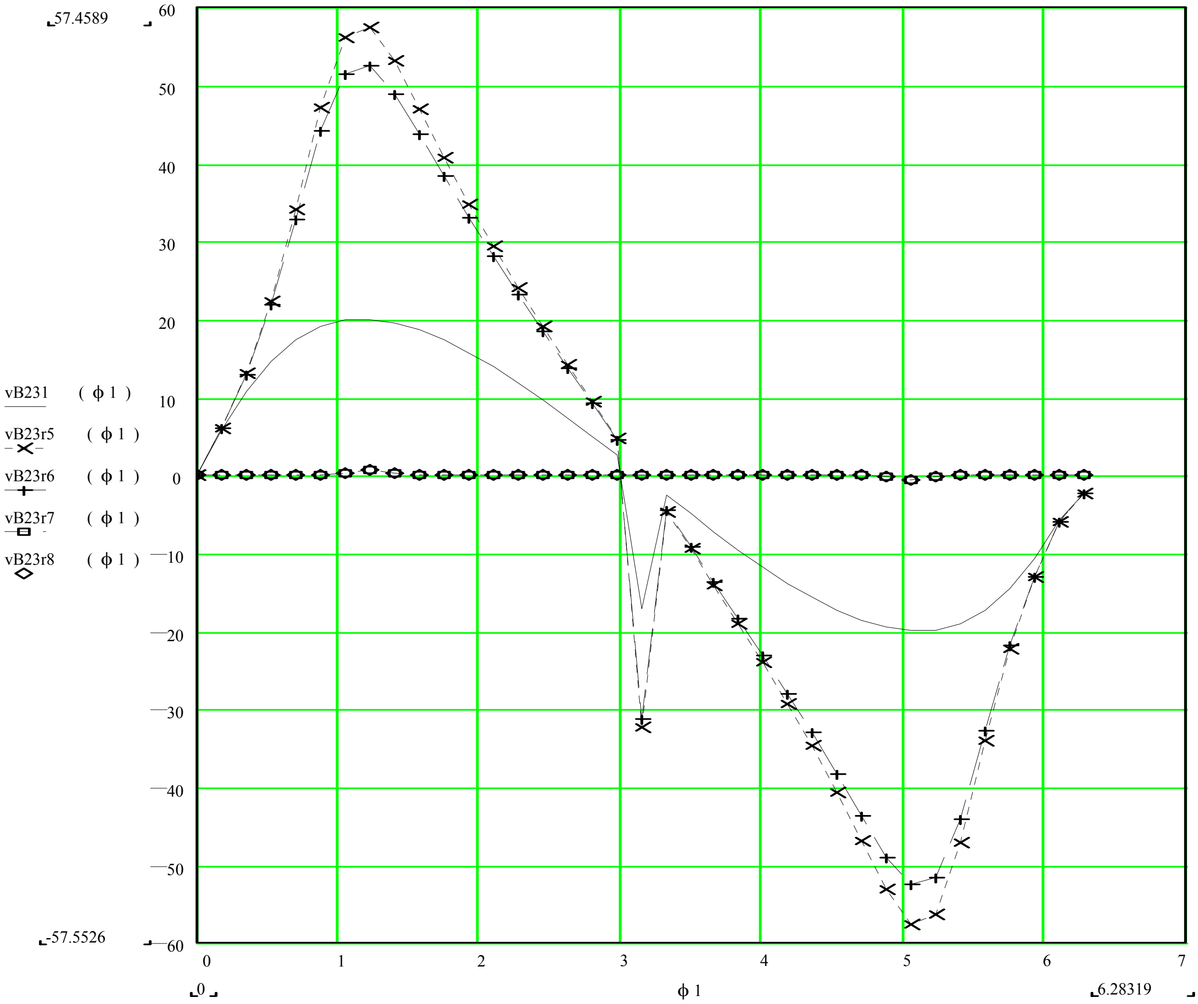

Fig. 13. v_{B231}, v_{B23r5}, v_{B23r6}, v_{B23r7}, v_{B23r8} *depending on* φ_1

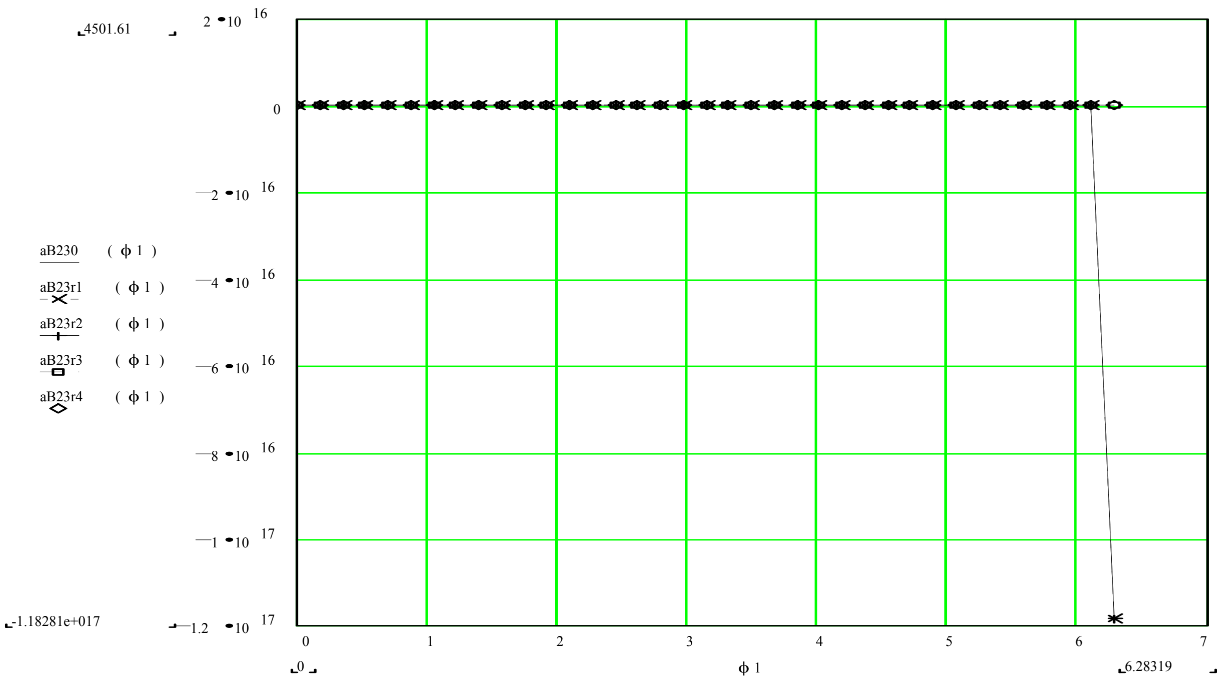

Fig. 14. a_{B230}, a_{B23r1}, a_{B23r2}, a_{B23r3}, a_{B23r4} *depending on* φ_1

5. CONCLUSIONS

Also for oscillatory slider mechanism dynamic velocities and accelerations reach much bigger values in comparison with kinematical and they are strongly variable. Among the eight cases studied the fifth case leads to the biggest values of velocities and accelerations. Cases 3rd, 4th and 7th, 8th lead to insignificant values for dynamic velocities as well as for dynamic accelerations.

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