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swivel walker, stability, trajectory

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COMPUTER ANALYSIS OF ELECTROMOTORIC SWIVEL WALKER MOVEMENT

Abstract

The first mechanical construction of swivel walker is from year 1963 and it was aimed for support movement of people with disabilities. This solution was very difficult and it was main reason for purpose of electromotoric module, which facilitates movement and reduce effort of people with disabilities. Therefore further research in this area are still provided. In this paper trajectory of swivel walker with electromotoric modules is described. To analyze the tilt and trajectory structure of the walker SolidWorks software was implemented.

1. INTRODUCTION

Movement with mechanical swivel walker is physically demanding and for this reason we prepared a swivel walker design with electromotoric modules to facilitate a movement for handicapped. This model consists of base platform, pylon, couple of rocking plates (foots) and electromotoric modules. The man has to move his weight (CoG) to one rocking plate and then the second rocking plate together with base platform is turned round the vertical axis of first rocking plate employing only inertial force. Every rocking plate is able to rotate round of the pylon vertical axis. Rotation is stopped after the limit position of the rocking plate is reached (limit stop) in each direction and the rocking plate is returned back to the initial position by the force of spring.

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2. SOLUTION WITH ELECTROMOTORIC MOVEMENT TO FORWARD

From analysis of deficiencies of mechanical swivel walkers focus for ideal function was create proposal of electromotoric module for swivel walker shown on fig. 1 (Butler et al., 1982; May et al., 2004; Stallard et al., 2003).

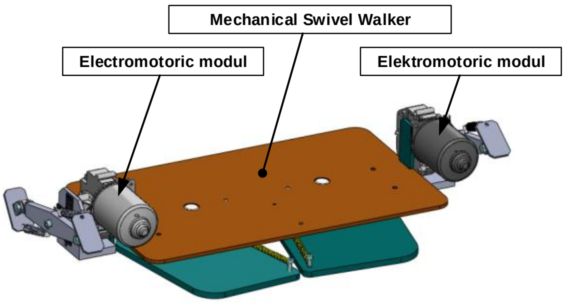

Fig. 1. Swivel walker with electromotoric modules (own study)

The principle of mechanism walking is based on a mechanical feed, where rate is limited by mechanical backstop and long of spring, fig. 2.

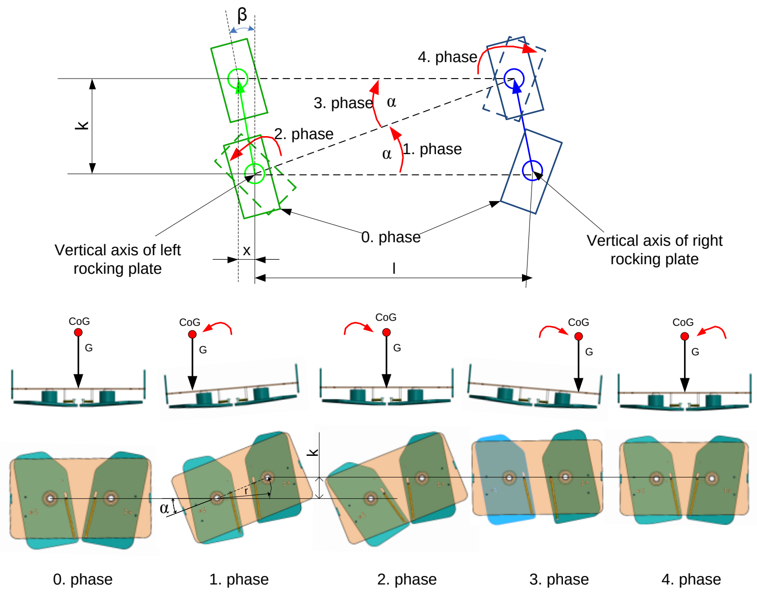

Fig. 2. Phases of movement to forward (own study)

As the driving force of mechanism is used shift of the human CoG to the right or left side. Tilt of mechanism construction is limited by the chamfer of rocking plates. Angle between rocking plates and ground has value θ. This angle and sufficiently large area of the rocking plates prevents overbalance of the whole complex (Knoflíček & Haltmar, 2000; Kaňuch, 2007).

3. TILTING SIMULATION

To determine stability is important to set a degree of structure tilting and height level of subject CoG (Świć at al., 2012; Świć at al., 2014). For this reason was done computer simulation in SolidWorks where we were interested in tilting structure trajectory (Baláž & Sukop, 2005; Čirip & Hajduk, 2010; Hajduk, 2007; Hajduk et al., 2005).

Input parameters for simulation were equipment design and motor speed 10 rpm. Progress of simulation is shown in next pictures split into three stages.

In the stage 0 shown on fig. 3, equipment is in initial position, when the tilting structure is in horizontal position in an angle $\gamma 0$. Central point of the tilting structure (arm) is in the height level z0 above the base.

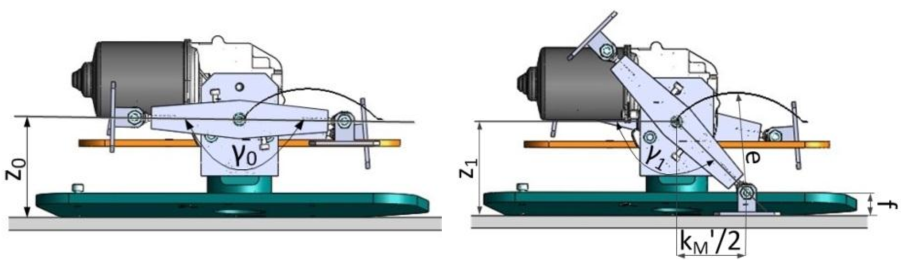

Fig. 3. Zero stage and first stage of tilting simulation (own study)

In the stage 1 shown on fig. 3, stopper of the tilting structure is in contact with the base. There is known distance between axis of stopper and axis of central point of the tilting structure in horizontal position kM'/2, height level of stopper f and vertical height level of center of tilting structure above base z1=z0. In the stage 2 shown on fig.4, tilting structure is in vertical position and left rocking plate is with all surface in contact with the base and center point of tilting structure according to curved path is in the height level z2 above base. In this stage equipment is in the middle of the cycle.

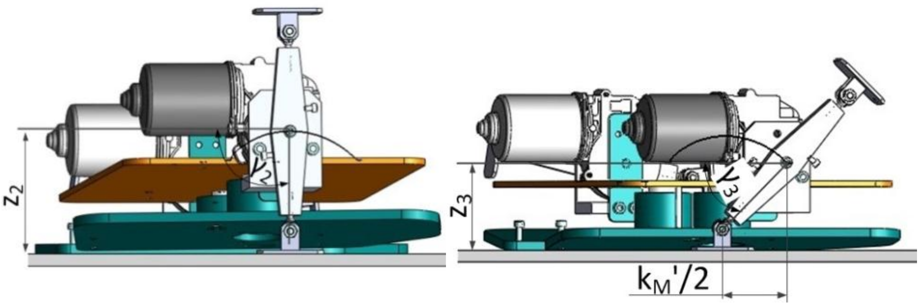

Fig. 4. Second and third stage of tilting simulation (own study)

Followed the length of tilting structure shown on fig. 5 is calculated from the center point to the stopper axis where an equipment is tilted in the angle β.

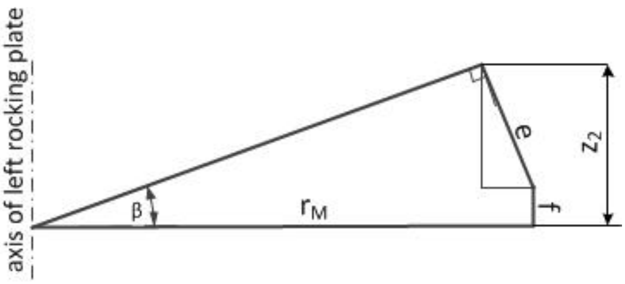

Fig. 5. Length of tilting structure (own study)

Calculating of the tilting structure e:

$$z_2 = r_M \times tg\beta \qquad (1)$$

where: z_2 is height of axis of motor and base,
r_M is radius of stopper via axis of left rocking plate,
β is angle via base plane and height of axis of motor,

$$e = \frac{z_2 - f}{\cos\beta} \qquad (2)$$

where: e is length of tilting structure,
f is height of base and axis of stopper.

In the stage 3 (Fig. 5) equipment is in the end of tilting cycle and both rocking plates are touched with inner edges in contact with base.

2.1. Results of tilting simulation

At first graph is shown the rotary angle of arm in all phases, fig. 6.

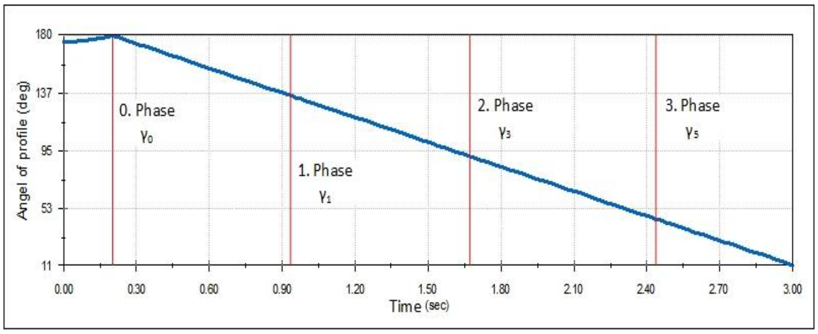

Fig. 6. Process of arm rotary angle (own study)

At second graph is shown linear displacement axis of motor in X plane over the cycle, fig 7.

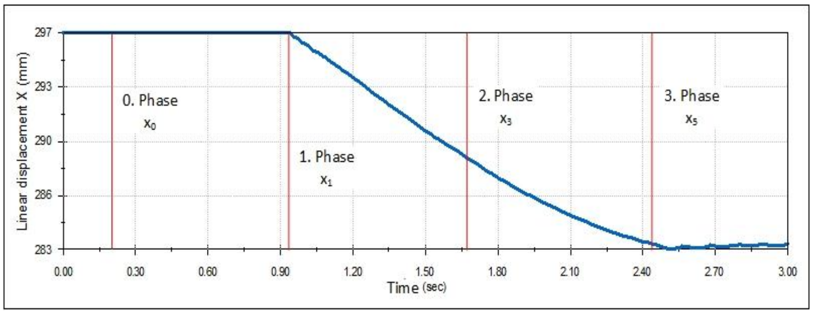

Fig. 7. Process of linear displacement axis of motor in X plane (own study)

At third graph is shown linear displacement axis of motor in Yplane over the cycle, fig. 8.

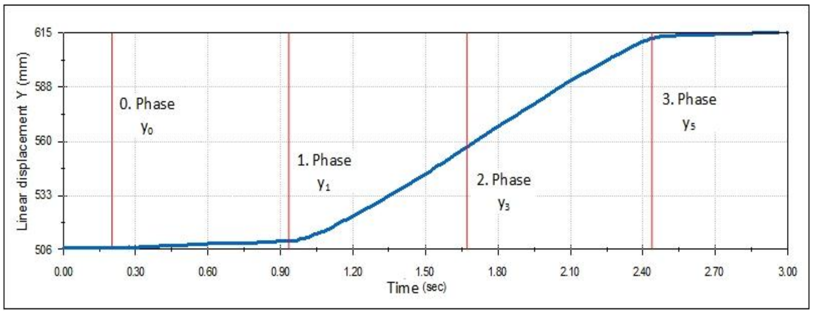

Fig. 8. Process of linear displacement axis of motor in Y plane (own study)

At fourth graph (fig. 9) linear displacement axis of motor in Z plane over the cycle with high difference z3-z1 or z3-z5 is shown.

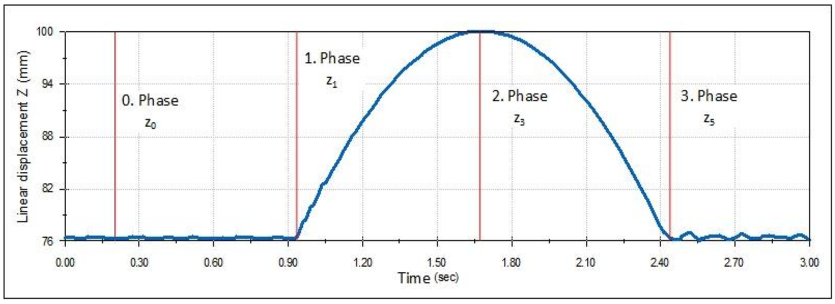

Fig. 9. Process of linear displacement axis of motor in Z plane (own study)

Product of simulation, shown on fig. 10, is 3D trajectory chart of tilting structure center point movement in 3D for time t = 3s.

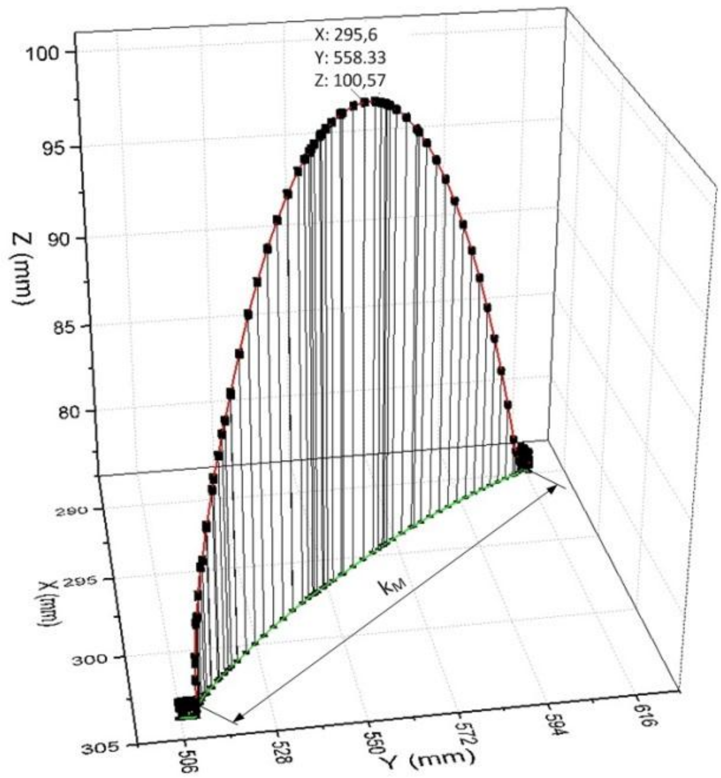

Fig. 10. Path chart of tilting structure (own study)

3. DETERMINATION OF BALANCED POSITION

Balanced position is relative stage of the object body which comes into existence by balancing of forces which determine this condition (Swivel walker, 2016). For this status must be fulfilled condition that all forces and torque forces applied on the object were balanced (Kaňuch, & Kostelný, 2008). Due to the gravitation object has to be stable in all conditions it means balance out gravitation. In this case balanced conditions of the object is taken as an indifferent (even after tilting of the object CoG is still in the same height level and the axis of gravity passes through area of support construction) (Baláž & Sukop, 2005; Hajduk, 2007).

For bipedal structure it is so called double support position, design condition of balance is so that cross point of the gravity axis is near the center of foot supporting area with the base in every phase of movement see picture fig. 11.

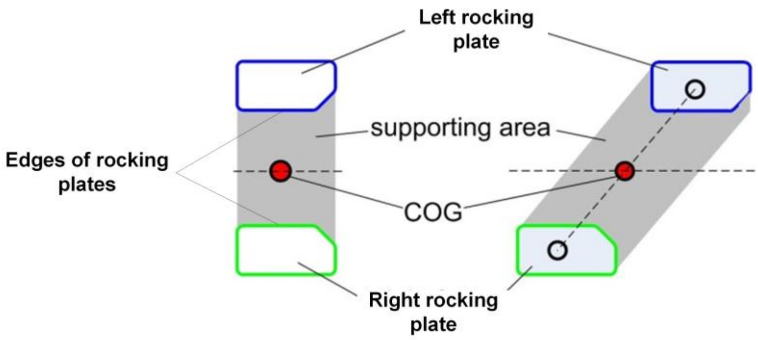

Fig. 11. Double support position (own study)

Important parameter for stability keeping is the distance between the edge of rocking plate and centre of equipment CoG. Gravity axis must not go out of the rocking plate area because system becomes static unstable.

4. CONCLUSIONS

This paper described analyses of humanoid walking – move to forward, proposal of electromotoric module for swivel walker with its structure and located on the base plate. This is an innovative and modern design of Swivel walker. Main advantage is using swivel walker with electromotoric module for people with higher degree of disability. User can choose from two variants: classic swivel walker or swivel walker with electromotoric module.

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