THE RACK MECHANISM FOR DRIVING THE ACCESS FRAME IN A MULTI-STOREY ROBOTIC PARKING LOT ON DÂMBOVIȚA RIVER

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Abstract: Considering the large number of cars, the necessity to build a robotic parking lot appeared. The work refers to the design of a mechanism with racks included in a robotic parking lot. For the access to the parking lot, a mechanism will be used that includes a shaft on which there are two engaging gears with two racks mounted on the vertical sides of the frame.

Key words: robotic parking lot, mechanism with racks, reduction gear

1. INTRODUCTION

The necessity, actuality and importance of an automated parking lot.From recent data published in the press (hotnews.ro, etc.), it results that the number of vehicles registered in Bucharest and Ilfov has reached almost 1.8 million. The Market Study shows the need to build as quickly as possible in Bucharest, at least one automated parking lot with as many places as possible. Due to the lack of vacant land, the optimal solution consists in the construction of a multi-storey parking lots, equipped with the necessary equipment for the movement of vehicles on the different levels. The construction of robotized elevators represents one of the conditions necessary for the execution of modern parking systems, corresponding to a civilized city.

2. THE ELEMENTS THAT SHOULD BE CONSIDERED AT THE DESIGN AND EXECUTION OF THE MECHANISM WITH TWO ELEVATORS FOR THE PARKING LOT

- Dynamic operating regime of the elevating elements (pistons, connecting rods, translating cam, rods of the cam roll follower);
- The weight of the installation (as reduced as possible for the general assembly)
- Vibration level (as reduced as possible for each element during operation);
- Allowed noise (as reduced as possible depending on the place where the parking lot is located);
- Installation reliability (the ability to use for as long as possible without major interventions);
- Electricity consumption as low as possible, using green energy;
- Components cost (as reduced as possible);
- Commercial availability of the components (as facile as possible);
- Exploitation and maintenance conditions (as reduced as possible).

Each of these factors induces one or more restrictive elements, ultimately resulting in an assembly that can satisfy all the required requirements [1].

The fig.1. presents a model that includes the auxiliary elevator composed of the translating cam (1) and the translating cam roll follower together with the platform on which the vehicle is parked (2). The vehicle parking platform (3) and the photovoltaic cell electricity supply facility (4) also appear in the figure. The auxiliary elevator can be disconnected if necessary, in this case only the main elevator remains in use, according to chapter 3.

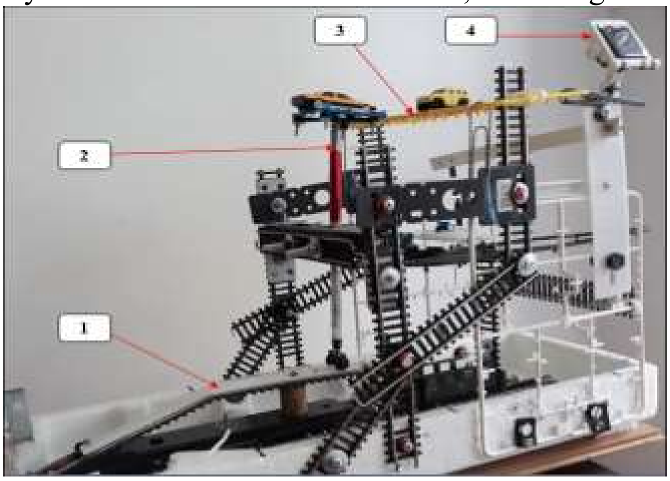

Figure 1. The model of the auxiliary elevator of the automated parking lot

3. PARKING LOT MECHANISM

The mechanism of the parking lot includes several coupled mechanisms.

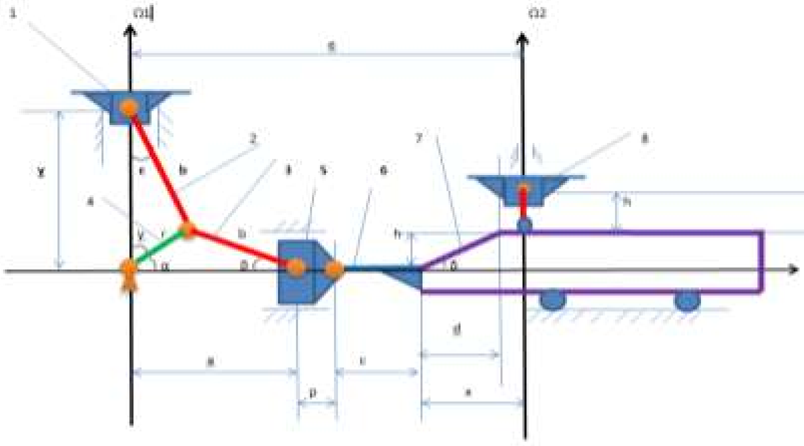

Figure 2. The mechanism of the parking lot with two elevators. Kinematic scheme

3.1 The mechanism with connecting rod and crank

The mechanism with connecting rod and crank includes the slider (1), piston (5), crank (4) and connecting rods (2 and 3) (Fig. 2).

a) The crank and connecting rods

According to Fig. 2., the crank (4) is actuated by electric engine and in turn actuates the connecting rods (2) and (3) which, in turn, are coupled with the slide (1) and the piston (5), respectively. Connecting rods are double-jointed elements, identical in shape and size. They have a plane-parallel movement and are subjected to compression and bending, being dimensioned according to the strength and stiffness conditions [2]. This results in a value of the diameter of the connecting rods, subsequently being necessary to check them for buckling.

Regarding the mechanism in fig.2, the buckling behaviour of the connecting rods is analysed taking into account the following buckling verification hypotheses [3]: The connecting rods are straight bars subjected to compression; Connecting rods are slender rods (connecting rods are rods of large length compared to the cross-sectional dimensions; The balance shape of the compressed bars can be stable or unstable, using different calculation relations for each situation; Connecting rods are double articulated, the buckling length being equal to the length of the connecting rod.

b) Slider and piston- For the analysed case, the mass of the slider 1 and the mass of the piston 5 in Fig.2 are considered equal.

3.2 Auxiliary elevator

The auxiliary elevator includes the translating cam (7) to which a welded rod is attached (6) and translating cam roll follower (8) that also includes a platform for parking vehicles, according to figure 2.

a) The translating cam - A translating cam is used that moves on rollers, the system being similar to that used in the rolling mill (Fig.2.). At the left end, the cam is equipped with a welded rod (6), forming an assembly that can move alternately left-right, and between the rod and the piston (5) there is a cylindrical joint. This joint can be disengaged when it is not necessary to use the auxiliary elevator consisting of the cam (7) and the cam follower (8).

The following data have been considered for the determination of the centre of gravity and cam mass:

- Maximum elevation level of the cam follower in case of the auxiliary elevator h;
- The maximum elevating time of the cam follower;
- The elevating speed of the cam follower;
- The displacement of the cam follower on the superior platform until the vehicle is positioned on the robot platform x_2 ;
- The length of the superior horizontal platform of the cam l_2;
- Pressure angle $\alpha = 35^0$;
- Interior and exterior diameters of the supporting cylinders of the superior platform;
- The width of the cam according to the calculation at the minimum contact width l_3;
- The thickness of the platforms a;
- The number of supporting pillars of the superior platform. 4 pillars will be used.

The calculation of the contact width between the translating cam and the translating cam roll follower is made taking into account the resistance condition of the cam to the Hertzian contact stress. This calculation is performed for the version of a system with 4 rods.

The data necessary for this calculation are: 1. The mass of the vehicle parked on the platform; 2. The mass of the cam follower rod; 3. Pressure angle; 4. Elasticity module of the cam material E_c ; 5. Elasticity module of the cam follower material E_t ; 6. Radius curvature of the cam roll follower r; 7. The allowed contact pressure of the cam material p_{ac}; 8. The allowed contact pressure of the cam follower material p_{at} .

b) The translating cam roll follower

Being provided with a roller, for the determination of the positional analysis it is considered that it comes into contact with the cam with a theoretical profile equidistant from it located at a distance equal to the radius of the roller. It results in the displacement of the cam follower according to the displacement of the cam. In case of a mechanism with cam, the design theme is given in the form of the cyclogram of the movement. For example, for the mechanism with translating cam and cam roll follower presented for moving up to the first floor with a height h= 3m of the auxiliary elevator, this cyclogram includes: The movement of the cam follower that also includes: a) elevation h=3m (corresponding for 1 floor); b)parking on the superior section; c) descending; d) parking on the inferior section; The adopted movement law of the cam follower - linear; The movement of the cam (corresponding to the angle); The allowed pressure angle δ_a= 35^0.

4. THE MOVEMENT LAW OF THE CAM FOLLOWER

In order to be able to adopt a certain law of movement of the cam follower, a comparative analysis was carried out between certain laws of displacement. In case of the linear motion law, at the connection points of the elevating/lowering profiles of the cam follower when changing the movement phase of the cam follower, the velocities make a finite jump, and the accelerations make theoretically infinite jumps (in reality they are very large values) that generate hard shocks in the mechanism. To avoid these shocks, the profiles are connected by parabolic or sinusoidal connection curves.

The cam follower in this case has a uniform movement and the law is preferred for mechanisms operating at low speeds as in the case under consideration. The cam has a linear profile, and the cam follower has a linear displacement law, the most advantageous for the presented case because the displacements take place at low speeds, of approximately 2.5 m/min= 5 cm/s. The use of this linear motion law is advantageous in this case, and considering the uniform consumption of electricity required for raising and lowering the cam follower with platform.

5. CONCLUSIONS

1. It is necessary to create a system consisting of the two elevators in different areas - for example on a concrete platform built above the river Dâmbovița or in a storied area that allows this;
2. For the studied parking lot, a mechanism will be used that includes a main elevator and an auxiliary elevator that are connected and can be disconnected in case of need, which is a novelty in the field, being a personal contribution.
3. Considering the movement of the cam follower with a reduced speed of elevation or lowering, the law of linear movement is established as usable in this case.
4. The only disadvantages related to the realization of a mechatronic parking lot are the high price compared to the other analysed models and the relatively high time required for the execution of such an assembly.

6. REFERENCES

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