SYSTEM MADE UP OF AN ELEVATOR ACTUATED BY A TRANSLATING CAM AND AN AUXILIARY ROBOT FOR BEING USED IN OVERGROUND OR UNDERGROUND PARKING

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Abstract: *The paper deals with the types of automated parking facilities in operation, taking into account the advantages and problems induced by them. There are presented underground parking, one-and two-platform elevators and their mechanisms, as well as robotic parking along with the existing mechatronic system. Tabular cyclogram of the used cam mechanism*

Keywords: Parking, elevator, robot, mechanism

1. Introduction

Considering the extremely hectic traffic and very high number of vehicles to be found in the large cities, it is absolutely necessary to adopt a modern parking system that would lead to a maximum performance in terms of the number of provided parking spaces, minimum area covered within a city and also the cost that must be invested for its accomplishment in a short as possible timeframe.

Regarding the number of parking spaces, this indicator must be as high as possible in a small as possible area, and it must be performed as a mechatronic system that includes a mechanical part, an electronic part and an automated (robotised) part. Thus, the system featuring an underground or overground vertical elevator, built on several levels in a circular (fig.1 and 3) or rectangular (fig.2) area is adopted.

Fig.1. Automated parking featuring an underground or overground vertical elevator in a circular area (https://www.sistemedeparcare.ro/html-parcari/multiparker-710.htm)

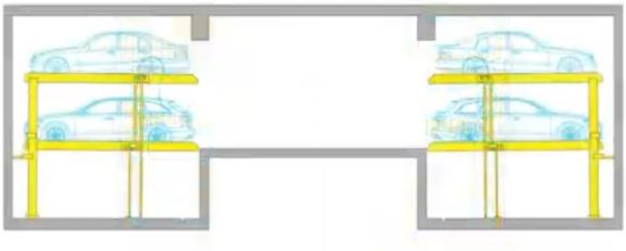

Fig.2. Automated parking featuring an underground or overground vertical elevator in a rectangular area(https://atlas**elevators**.ro/sisteme-de-**parcare**/sisteme-hidraulice)
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The underground construction (fig.3) provides high safety regarding the reaction of the structure in the case of vibrations. As disadvantages, it implies a very deep excavation, depending on the number or floors of the parking, and a difficulty of evacuating the vehicles in case of fires or blockages of the mechatronic system.

Fig.3. Automated parking featuring an underground vertical elevator

The underground construction (fig.1) implies a construction on a metallic skeleton at the surface of the ground, easier to execute than the underground one, and leads to the possibility of executing a system of vehicle evacuation in case of problems (power cut or fires).

2. The need to adopt a device for the evacuation of cars from the parking lot. Components and working phases of the device

For the circular overground system, one considers the design of a mechatronic system for evacuating the vehicles located in the parking (fig.4), which is made up of the following elements:

- A translating cam mechanism with a roller translating [1], [2] follower that would elevate the vehicle together with the platform on which it is parked at a certain height
- A robot provided with a platform that takes the vehicle elevated by the cam mechanism, and transports it outside the parking.

In figure 4, one can see the components of the system. These are the following:

1) Translating cam 1 that can alternatively move from left to right by elevating or lowering roller follower 2

2) Roller follower 2 that is driven by translating cam 1, which is in a rigid connection to platform 4 [1] ,[3] ,[4], [6]
3) Guide 3 of translating follower 2 that is fitted by means of non-demountable (welding, riveting) or demountable (using screws) assembling to the metallic structure of the parking (the structure is not represented in the figure) [1], [3]
4) platform 4 that elevates vehicle 5 to a higher level than the sum between its ground clearance and the thickness of platform 6 of robot 7
5) the parked vehicle
6) the platform of robot 6 that acts in the second phase of elevating vehicle 5 located on platform 4
7) robot 7 that alternatively moves from left to right and removes vehicle 5 from the parking by means of platform 6

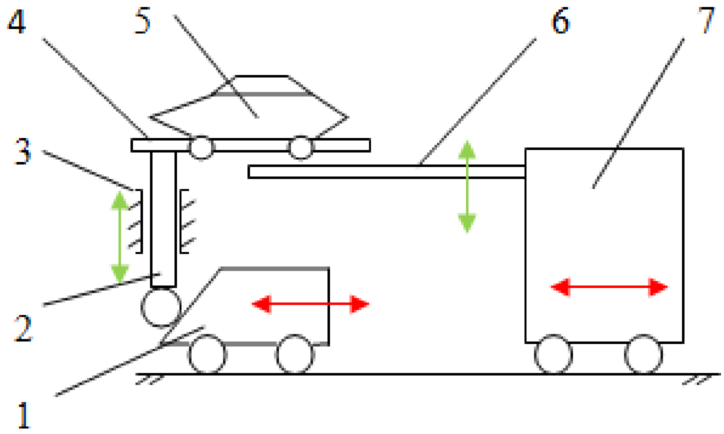

Fig.4. The mechatronic system for removing vehicles from the parking in case of emergency – first elevation phase

In the first phase, cam 1 moves to the left and translating follower 2 moves vertically upwards, thus elevating vehicle 5 from the parking platform where the vehicle is initially located on platform 4, which is found in connection to the follower at a level equal to the follower elevation height, higher than the sum of its ground clearance and the thickness of platform 6 of robot 7. In the second phase, robot 7 provided with adjustable horizontal platform 6 moves to the left, its platform is elevated, coming into contact with the wheels of the vehicle and releasing the platform of follower 4 from the weight of the vehicle. Robot 7 and its platform 6 move to the right outside the parking, releasing the vehicle at the ground level, and cam 1 moves to the right, while follower 2 performs the lowering stroke.

For another vehicle to be found on the circular route within the parking in fig.1, the cycle is resumed and thus vehicles are gradually removed in case of extreme emergency. For each vertical set of parking to be found on the side of the circular parking assembly, a mechanism featuring a cam and a translating follower is installed on the ground floor for the removal of a vehicle from an upper floor. The system may be used for a reduced number of floors because it implies an extremely rigid mechanism and a follower that would not yield to axial compression.

The robot provided with a platform is analogue to a classic elevator used in the car services shown in fig. 5 but its format is longitudinal.

Fig.5. Robot used in car services

In case of a cam mechanism, the design theme is given in the form of the movement cyclogram. For instance, for the mechanism featuring a translating cam and roller follower under study, this cyclogram is presented in table 1. It is considered that both the elevation and lowering of the roller follower are performed on the same side of the cam. For a vehicle with a ground clearance of h_1= 200 mm= 0.2 m and the width of the robot platform h_2= 300 mm= 0.3 m, the result is an elevation, i.e. lowering stroke of the follower of 0.5 m. The cyclogram implies the use of the mechanism featuring a cam and roller translating follower without using the robot presented in figures 4.

Table 1. Tabular cyclogram of the used cam mechanism

Follower movement	IS ELEVATED / IS LOWERED h= 0.5 m	STANDS
Follower movement law	LINEAR	
Cam movement(related to the angle)	$\varphi_1 = 60^0$	$\varphi_2 = 60^0$
Admissible pressure angle	$\delta = 35^0$	

Table 2. Identifying the area, speed and acceleration depending on position x

LINEAR MOVEMENT LAW h= 0.5 m, fi1= 60 degrees, fi2= 60 degrees									
Movement phase	POSITION x	ANGLE FI	X	Y	S (m)	Y'	Y"	s' (m)	s" (m)
elevation/ lowering on fi1= 60 degrees	0	0	0	0	0	1	0	0.00833	0
	1..	5	0.08333	0.08333	0.04167	1	0	0.00833	0
	12	60	1	1	0.5	1	0	0.00833	0
Stand on fi2= 60 degrees	13..	65	0	0	0.5	0	0	0	0
	24	120	0	0	0.5	0	0	0	0

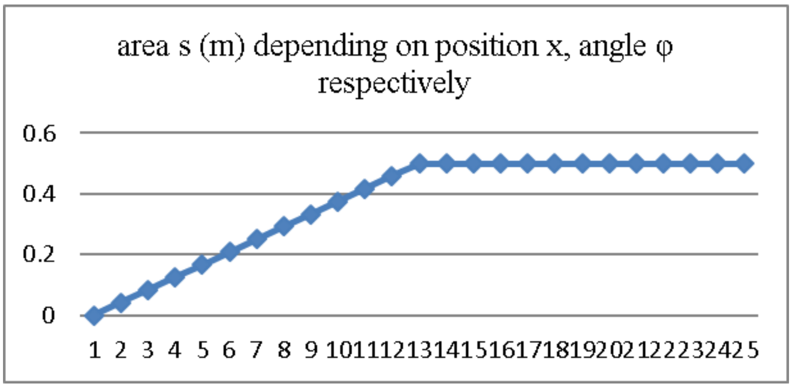

Fig.6 Diagram of the area

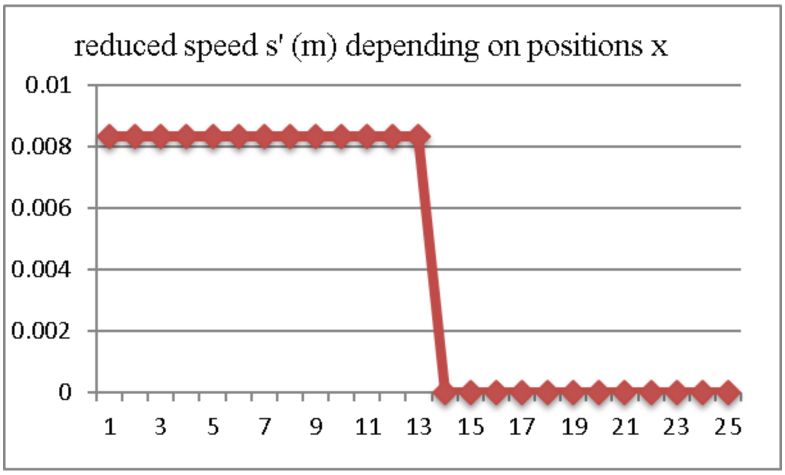

Fig.7. Diagram of reduced speed

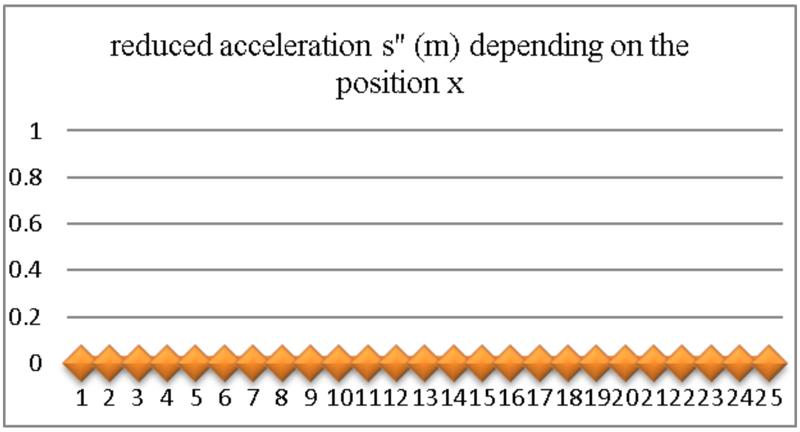

Fig.8. Diagram of reduced speed

In the connection points of the elevation/lowering profiles of the follower (points x=12.13 table 2), upon changing the follower movement law, the speeds take a finite leap (fig. 7 in point 12 in fig. 2), and accelerations take theoretically infinite leaps (in reality, there are very

high values) that generate hard shocks in the mechanism. In order to avoid these shocks, the profiles are connected using parabolic or sinusoidal connection curves. [6], [7]
The follower has, in this case, a uniform movement and one prefers the law for the mechanisms that operate at low rotations or speeds, as in the analysed case.
The cam has a linear profile, and the follower has a linear movement law, the most convenient for the presented case, because movements occur at low speeds. (fig.7).

3. Conclusions

Finally, the following conclusions can be drawn:

- the model of the overhead elevator is the best in terms of construction (construction facility, possibilities of various locations, ease of protection ensuring in case of hazards - for example fires)
- the overhead elevator allows the possibility of installation of a system provided with a robot that can take vehicles out of the parking lot in case of special situations (lack of power supply)
- In the case of the translatable cam and roller rod provided with the robot that takes out the vehicle from the parking lot, the law of the rod travel is linear and the travel speeds of the cam are reduced 1 ... 2 m / s (the elements leading to the maximum yield in this case)

References

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