Forces in the Lock-Off Device During the Rolling of the Brake Pulley Roller Over the Brake Ramp in the Built Automatic Parking House

Leopold Hrabovský1, Václav Žáček2

1VŠB - Technical University of Ostrava, Faculty of Mechanical Engineering, Institute of Transport, 17. listopadu 2172/15, 708 00 Ostrava - Poruba, Czech Republic
2 KOMA Industry s.r.o., Ruská 514/41, 706 02 Ostrava - Vítkovice, Czech Republic
leopold.hrabovsky@vsb.cz

Abstract. The paper describes the design of the device, which allows for the scanning and recording of force sizes impacting in horizontal and vertical directions during the rolling of the pulley, which is part of the brake of the lock-off device of the pallet truck, over the top surface of the brake ramp. The paper also presents the results of two experimental measurement procedures. The first measurements taken to obtain the values of the applied resistive forces when the cylindrical part of the pulley was inserted into the brake body were carried out without an installed cylindrical coil spring. The aim of the second measurement was to determine the forces acting on the brake body when the brake pulley holder resists the insertion into the brake body due to the rigidity of two types of compression cylindrical coil springs, type R16-102 and V16-102. These measurements were carried out in order to verify the theoretically calculated values of the acting forces. In the chapter “Pallet brake design” there is a suggestion and recommendation of the lock-off device manufacturer, which is used in the automatic parking system of variants “KOMA TOWER” and “KOMA MULTI TOWER”, to use a sensor to eliminate inaccuracies of parking location in a parking house using this APS option. The forces acting on the brake body, shown in the tables and graphs in this paper, are forces that occur when the brake pulley rolls over the upper surface of the brake ramp until the pulley engages in a circular recess in the brake ramp.

1. Introduction
An Automated Parking System [11, 12, 13] or APS is a mechanical system that automatically moves cars from the car park entry to an available parking space. It uses multiple levels and stacks cars vertically to use the least square footage possible in order to park as many cars as possible.

The concept for the APS was and is driven by two factors: a need for parking spaces and a scarcity of available land. The earliest use of an APS was in Paris, France in 1905 at the Garage Rue de Ponthieu. The APS consisted of a ground-breaking multi-story concrete structure with an internal elevator to transport cars to upper levels where attendants parked the cars.

Automatic parking systems can be generally divided into several basic variants according to various ways of parking vehicles [14]:

- trolley system: the horizontal parallel APS system consists of several parking layers, in which the movement and storage of vehicles is carried out by automatic moving and transport trolleys. The
transport of vehicles between the parking layers and between the terminal located on the level of the outdoor road is ensured by a vertical conveyor. The vehicles on pallets are stacked side by side in order to optimize space utilization. They can be positioned transversely or longitudinally to the travel axis of the transfer unit.

- horizontal sliding system: characterized by the highest space use. The vehicles are placed on pallets in a layer so that they are interdependent, and when the rearmost vehicle is parked, it is necessary to make several shifts, with the front vehicles moving further into the rear positions. The vehicles are placed in two rows side by side and there must be one, or preferably two, spaces in the layer for handling. Increasing the capacity of parking spaces can be achieved by adding two pallets in a layer or stacking several systems in blocks side by side or in succession. For multiple layers, one lift and one terminal are designed for 5 to 20 vehicles. The disadvantage of the system is greater time and energy demands. The speed of the system is directly proportional to the number of consecutive vehicles. It isn’t suitable for operations requiring temporary parking (theater, sports hall).

- longitudinal series system: the vertical series parking system is particularly suitable for small and narrow spaces, determined practically by the length of the transport pallet. Horizontal conveyors are used to move vehicles horizontally. Vertical movement of the vehicles is performed by vertical conveyors, while the front conveyor also moves the vehicles between the terminal. The terminal can be placed above or next to the vertical conveyor. Lateral positioning speeds up the system as it can perform internal operations while parking the vehicle. Turntable for convenient exit from the parking can be placed in the terminal, on a vertical conveyor or in the lower level of the parking system.

- column (raster) tower system: The tower type system, using vertical central conveyor technology, is not demanding in terms of area size, may be above ground, underground or partially underground.

It is especially suitable for dense areas of higher buildings. With this parking system, elevators are used for the vertical transport of cars and the cars are placed on the left or right side of the system.

2. Device for testing lock off brakes
In order to verify the theoretically determined [1] and in order to obtain information about the actual magnitude of the forces applied in both the horizontal and vertical directions when rolling the pallet pulley roller [2] along the ramp of the brake [1] a device for testing parking brakes has been designed, see Fig. 1.

There are two holes (4 mm diameter) drilled into the front face of the upper 1.1 profile, see left view Fig. 1, the distance of first hole axis from the front left edge of the profile 1.1 is 123.6 mm. The distance of the second hole axis from the left front edge of the profile 1.1 is 457.1 mm. Threaded rods are guided through these holes 37 length 95 mm. The dislodging of the threaded rod 37 from the holes (diameter 4 mm) of the profile 1.1 is prevented by the washers 36 and nuts 14 threaded onto threaded rods on the rear of profile 1.1. There are digital position sensor holders 17 [3] mounted on the threaded rods 37, which protrude from the front face of the profile, then washers and nuts are screwed onto the ends of threaded rods. With the help of these two screw connections, the digital position sensor 17 is firmly fixed in the desired position to the profile 1.1.

6 screws M2 x 5 mm attach the connector part 41 against rear surface of the digital encoder slider 17. By a 6 diameter hole, the connector part 41 is threaded onto the threaded rod 11, one end of which is screwed into an M6 internally threaded hole (10 mm long) of the connector part 42. The base of the connector part 42 is fastened to the linear guide rail slider 33 by 4 M3 x 13 mm screws [4].

The dislodging of the threaded rod 11 from the M6 internally threaded bore (10 mm long) in the connector 42 is prevented by washer 9 and nut 10. The other end of this threaded rod 11 is screwed into the M6 internally threaded bore (5 mm depth) in one of the front faces of the force sensor 12 [5]. The dislodging of this threaded rod end 11 from the M6 internally threaded bore in the force sensor 12 is prevented by nut 10.
One of the ends of the threaded rod 11 (5 mm depth) is inserted into the M6 internally threaded bore (25 mm length) in the second face of force sensor 12. The unscrewing of this threaded rod end 11 from the M6 inner thread hole in the force sensor 12 is also prevented by nut 10. The other end of this threaded rod 11 is screwed into a bore (10 mm depth) with M6 internal thread in the upper surface (see right view Fig. 1) of the brake body holder 32. The unscrewing of this threaded rod end 11 from the M6 inner threaded bore from the brake body holder 32 is prevented by nut 10.

The linear guide rail 33 is attached to profile 1.1 using 3 pcs of screws 38, 3 holes of 3 mm diameter are drilled through the profile 1.1, the axis of the first hole from the front left edge profile 1.1 is designed to be 153.6 mm. The axis of the second hole from the front left edge profile 1.1 is designed to be 303.6 mm, and the axis of the third hole from the front left edge profile 1.1 is designed to be 533.6 mm. The washers 39 and nuts 40 are mounted at the ends of the threaded parts of the screw shafts 38 based on profile 1.1 (see right view Fig. 1) the one of the threaded rod ends 11 is screwed into (length 25 mm) the M6 inner threaded hole (10 mm depth) in the left face in the brake body bracket 32 (see right view Fig. 1).

The dislodging of this threaded rod end 11 from the M6 inner threaded hole from the bracket of the brake body 32 is prevented by nut 10. The other end of this threaded rod 11 is screwed into the M6 internal thread hole (5 mm depth) in one of the front faces of the force sensor 12. The unscrewing of this threaded rod end 11 from the M6 internally threaded bore in the force sensor 12 is prevented by nut 10.

One of the ends of the threaded rod 11 (5 mm depth) is inserted into the M6 internally threaded bore (25 mm length) in the second face of force sensor 12. The unscrewing of this threaded rod end 11 from the M6 inner thread hole in the force sensor 12 is also prevented by nut 10. The other end of this threaded rod 11 is screwed into a bore (10 mm depth) with M6 internal thread in the front surface (see right view Fig. 1) of the hub of the motion screw 34. The unscrewing of this threaded rod end 11 from the M6 inner threaded bore in the hub of the motion screw 32 is prevented by nut 10.

The bore (diameter 12 mm, depth 13 mm) of the hub of the motion screw 34 is mounted onto a pin of a small screw of the motion screw (screw spindle) [6] 35. The dislodging as well as turning of the small bolt of the motion screw 35 at the opening in the hub of the motion screw 34 is secured by screw connection 45.

Holes with M8 internal thread (distance between the hole axes and the bottom edge of the profile 2.1 and 2.2, see right view Fig. 1 is 140.6 mm) are drilled through profiles 2.1 and 2.2. Screws, ends of which are modified (by turning), are screwed onto the M8 thread 44 so that they can be inserted into holes (5.7 mm diameter, 5 mm depth) at the perimeter of the nut of the motion screw 35.

Figure 1. Lock brake testing equipment, 2 D design
The ones used for testing the locking brake 28 are described in [1, 2].

The implemented equipment for testing the locking brakes is shown on Fig. 2.

Both MCF 30 - 500 N force transducers 12 [5] are connected to the DEWESoft DS-NET measuring system with D-Sub 9-Pin computer plugs.

By turning in the direction of the screw spindle 35, the brake of palette 28 moves horizontally. The horizontal shift of the pallet brake 28 is recorded on the display of the digital position sensor 17.

3. Forces acting on the brake body

By turning in the direction of the screw spindle 35, see Fig. 1, the brake of palette 28 moves horizontally. The horizontal shift of the pallet brake 28 is recorded on the display of the digital position sensor 17.

Tables 1 to Table 3 show the horizontal displacement values L [mm] and horizontal \( F_{xij} \) [N] of the pallet brake 28 (where \( i = 1 \) to 3, \( j = 0 \) to 14) and vertical \( F_{yij} \) [N] forces recorded by force sensors 12 [5] when the pallet brake 28 was not fitted with the spring R16-102 [2, 9] nor spring V16-102 [1, 7].

Table 1. Horizontal and vertical forces - the pallet brake is not fitted with a spring (a)

| j  | 0   | 1   | 2    | 3     | 4     | 5     | 6     | 7    |
|----|-----|-----|------|-------|-------|-------|-------|------|
| L [mm] | 0  | 5,12| 10,35| 15,67 | 20,37 | 25,34 | 30,58 | 35,09 |
| \( F_{xij} \) [N] | 0  | 2,3 | 4,2  | 5,2   | 5,9   | 7,9   | 9,0   | 9,2  |
| \( F_{yij} = T_{cij} \) [N] | 0  | 4,46| 5,06 | 4,72  | 6,30  | 17,58 | 19,14 | 21,42 |

| j  | 8   | 9   | 10   | 11   | 12   | 13   | 14   |
|----|-----|-----|------|------|------|------|------|
| L [mm] | 40,35| 45,11| 50,38| 56,05| 60,21| 65,51| 70,70 |
| \( F_{xij} \) [N] | 9,8 | 7,7 | 7,6  | 7,7  | 7,6  | 7,5  | 7,2  |
| \( F_{yij} = T_{cij} \) [N] | 21,03| 19,37| 20,77| 21,68| 21,52| 21,48| 24,19 |

Table 2. Horizontal and vertical forces - the pallet brake is not fitted with a spring (b)

| j  | 0   | 1   | 2    | 3     | 4     | 5     | 6     | 7    |
|----|-----|-----|------|-------|-------|-------|-------|------|
| L [mm] | 0  | 6,38| 10,49| 15,13 | 20,17 | 25,10 | 30,67 | 35,25 |
| \( F_{xij} \) [N] | 0  | 0,7 | 0,7  | 2,1   | 3,1   | 3,7   | 2,7   | 3,3  |
| \( F_{yij} = T_{cij} \) [N] | 0  | 4,11| 9,08 | 13,67 | 16,63 | 16,92 | 16,74 | 17,52 |

| j  | 8   | 9   | 10   | 11   | 12   | 13   | 14   |
|----|-----|-----|------|------|------|------|------|
| L [mm] | 40,53| 45,16| 50,29| 55,55| 61,03| 65,19| 70,44 |
| \( F_{xij} \) [N] | 2,9 | 3,1 | 2,9  | 3,0  | 2,4  | 2,9  | 3,3  |
| \( F_{yij} = T_{cij} \) [N] | 18,27| 16,56| 17,93| 19,07| 17,33| 18,20| 20,02 |
Table 3. Horizontal and vertical forces - the pallet brake is not fitted with a spring (c)

| j | L [mm] | F_{xj} [N] | F_{yj} [N] |
|---|---|---|---|
| 0 | 0 | 2.1 | 2.2 |
| 1 | 5.32 | 10.25 | 15.14 |
| 2 | 15.14 | 20.41 | 25.22 |
| 3 | 20.41 | 25.22 | 30.71 |
| 4 | 25.22 | 30.71 | 35.31 |
| 5 | 30.71 | 35.31 | 3.7 |
| 6 | 35.31 | 3.7 | 2.1 |
| 7 | 3.7 | 2.1 | 2.1 |

The aim of these measurements was to determine the amount of friction resistance $T_{cij}$ [N] when inserting the cylindrical part of the pulley bracket into the circular recess in the brake body. These friction resistances $T_{cij}$ [N] are resistances which together with the compressive forces of the compression coil spring $F_{pj}$ [N] derived by immediate compression of a compression coil spring of a given rigidity ($k_p = 7.8$ N/mm for spring V16-102 and $k_p = 19.3$ N/mm for spring R16-102) define the total resistance $T_{cij}$ [N], see Table 4.

Table 4. Friction resistance the cylindrical part of the pulley bracket

| j | L [mm] | $T_{cij}$ [N] | $F_{csj}$ [N] |
|---|---|---|---|
| 0 | 0 | 11.36 | 3.79 |
| 1 | 11.36 | 21.76 | 7.25 |
| 2 | 31.27 | 10.42 | 15.18 |
| 3 | 37.27 | 12.42 | 15.11 |
| 4 | 49.72 | 16.57 | 15.57 |
| 5 | 50.57 | 16.86 | 17.34 |
| 6 | 53.92 | 17.97 | 17.34 |
| 7 | 53.92 | 17.97 | 17.34 |

On Fig. 4 There is a graphical representation of the course of the experimentally obtained horizontal $F_{xj}$ [N] and vertical $F_{yj}$ [N] forces recorded by force sensor J2 depending on the horizontal displacement of the pallet brake body 28 L [mm].

The DEWESoft DS-NET measuring apparatus was connected to the cable end of both used force sensors MCF 30 - 500 N /J2 (see Fig. 1). The graphs, created by DEWESoft X2 SP5 software, which is installed on the pc, show the acting forces $F_x$ [N] and $F_y$ [N] in the direction of horizontal and vertical axis depending on the horizontal displacement L [mm] of the pallet brake, i.e. the horizontal projection.
of the pallet brake roll path along the upper surface of the brake ramp. The projection information was stored in the form of data files on the PC disk, see Fig. 3.

![Graph of Forces](image)

**Figure 4.** Horizontal $F_{xij} \text{[N]}$ and vertical $F_{yij} \text{[N]}$ forces depending on the horizontal displacement of the pallet brake body $L \text{[mm]}$.

**Table 5.** Vertical forces, subtracting the magnitude of the mean friction resistance values and the spring compressive force values $V16$-$102$

| j | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
| $F_{yj} = F_{y8j} + F_{y9j} + F_{y10j} \text{[N]}$ | 0   | 19,99 | 52,72 | 131,38 | 160,77 | 185,62 | 210,29 | 234,66 |
| $F_{ysj} = F_{yj} / i \text{[N]}$ | 0   | 6,66 | 17,57 | 43,79 | 53,59 | 61,87 | 70,10 | 78,22 |
| $F_{ysj} - F_{csj} \text{[N]}$ | 0   | 2,88 | 10,32 | 33,37 | 41,17 | 45,30 | 53,24 | 60,25 |
| $F_{yj} = F_{y8j} + F_{y9j} + F_{y11j} \text{[N]}$ | 258,03 | 277,76 | 304,26 | 325,99 | 351,75 | 372,29 | 393,46 |
| $F_{ysj} = F_{yj} / i \text{[N]}$ | 86,01 | 92,59 | 101,42 | 108,66 | 117,25 | 124,10 | 131,15 |
| $F_{ysj} - F_{csj} \text{[N]}$ | 68,11 | 75,99 | 83,71 | 90,02 | 99,26 | 105,68 | 110,64 |

On Fig. 5 there is a graphical representation of the course of the experimentally obtained horizontal $F_{xij} \text{[N]}$ and vertical $F_{yij} \text{[N]}$ forces recorded by force sensor 12 depending on the horizontal displacement of the pallet brake body $28 \text{L [mm]}$. A dashed line see Fig. 6 shows the dependence of theoretically calculated values of compressive force $F_{pj} \text{[N]}$ springs $R16$-$102$ (stiffness $k_p = 19.3 \text{N/mm}$).

On Fig. 6 there is a graphical representation of the course of the experimentally obtained horizontal $F_{xij} \text{[N]}$ and vertical $F_{yij} \text{[N]}$ forces recorded by force sensor 12 depending on the horizontal displacement of the pallet brake body $28 \text{L [mm]}$.

A dashed line see Fig. 6 shows the dependence of theoretically calculated values of compressive force $F_{pj} \text{[N]}$ springs $R16$-$102$ (stiffness $k_p = 19.3 \text{N/mm}$).
In Table 5 mean values of vertical force $F$ are given $y_{ij} [N]$ (where $i = 8$ to $10$, $j = 0$ to $14$), obtained by subtracting the magnitude of the mean friction resistance values $T_{cij} [N]$ and compressive force values $F_{pj} [N]$ springs V16-102 depending on the horizontal shift of the pallet brake $28 L [mm]$.

**Figure 5.** Horizontal $F_{xij} [N]$ and vertical $F_{yij} [N]$ forces depending on the horizontal displacement of the pallet brake body $L [mm]$

**Figure 6.** Horizontal $F_{xij} [N]$ and vertical $F_{yij} [N]$ forces depending on the horizontal displacement of the pallet brake body $L [mm]$
4. Pallet brake design

In industrial application APS concept variants KOMA TOWER [10] (or KOMA MULTI TOWER [11]) in the parking house, the insertion/withdrawal of pallets with cars into/from the shelf units is done with a chain conveyor, which is installed on the cage of the freight elevator.

Four roller chains 7, see Fig. 7, drive the drive sprockets 5, which are fitted with tight tongues at the ends of the torsion shafts 3. The torque needed to guide the pallet with the vehicle to the desired position in the rack unit is generated by the electric drive unit, the so-called electric transmission 1, 2. The driving motor 1 is equipped with an incremental speed sensor and its speed is controlled by a frequency converter.

The chosen electric motor 1 has a speed of \( n_m = 3450 \text{ rpm} \) (= 57.5 rpm), chain speed is designed in \( v_r = 0.33 \text{ m/s} \). Required speed of drive sprockets 5 at the selected pitch diameter \( D_r = 106.14 \text{ mm} \), can be determined according to (1).

The gearbox 2 with the gear ratio \( i_p = 58.667 \) is used to achieve the required rotational speed \( n_r \) [1/s] (1) of the drive sprockets 5 at speed \( n_m \) [1/s] of the electric motor.

\[
v_r = \omega_r \cdot D_r/2 = 2 \cdot \pi \cdot n_r \cdot D_r/2 = \pi \cdot D_r \text{ [1/s]}
\]

The design of the chain conveyor, see Fig. 8, and the configuration of its power unit (with respect to e.g. a high gear ratio \( i_p \) [-] gearboxes 2, torsion bar torsion 3, clearance in the joints of the propeller shafts 4 will often not allow the car pallet to be guided to the desired parking position. An inaccurate guidance of the pallet to the parking position; If the pallet brake pulley does not engage the circular recess in the brake, or if the pallet brake pulley is pushed out of the recess on the ramp, the control software identifies a “malfunction” and the APS is immediately disabled due to a reported “Error”.

\[
\frac{v_r}{\pi \cdot D_r} = n_r \text{ [1/s]}
\]
In order to remove, or at least significantly reduce the APS decommissioning due to inaccurate guidance of the car pallet to the parking position, the Institute of Transport, Faculty of Mechanical Engineering, Technical University of Ostrava designed the fitting of sensors onto lock-off brakes of pallets (by limit switches) [8, 12], which would inform the control software that at this point the pallet brake pulley is in the circular recess on the brake ramp [1].

In this paper [1, 2] there are two design variants of the pallet brake described which are used in APS variant KOMA TOWER [10].

Fig. 8 shows the attachment of sensor 1 [8] to the 1st variant of pallet brake 3 and the attachment of sensor 2 [12] to the 2. variant of the pallet brake 4 and the design modification of the brake ramp 5 to which two pins 6 are attached, one controlling the switching mechanism of the sensor 1, and pin 7, controlling the switching mechanism of sensor 2.

![Figure 8. Structural modification of the pallet lock-off brake system](image)

Both sensors 1 [8] a 2 [12] are equipped with an electrical switch with two pairs of contacts placed one above the other. If sensor 1 or 2 is in the position, where the 1st or 2nd variant of the pallet brake is rolling on top surface of the brake ramp, the upper contacts are closed and the lower contacts in the sensor switch 1 or 2 are opened.

If the pallet brake reaches the position where the pallet brake pulley engages the circular recess on the brake ramp, the arm of sensor 1 triggers pin 6 and the upper contact is opened and the lower contact in the sensor switch 1 is closed.

If the pallet brake reaches the position when the pallet brake pulley engages the circular recess in the brake ramp, the shaft of sensor 2 is pushed by pin 7 into the sensor body 2 and the upper contact is disconnected and the lower contact in the sensor switch 2 is closed. Closing the bottom contacts in the electrical sensor switches 1 and 2 sends the APS control software of the KOMA TOWER conceptual variant [10], the information that at this point, the pallet brake roller is located in the circular recess in the brake ramp.

A limit switch ME-8108 is fixed by four screws (M4 x 12 mm and M4 x 25 mm) [8] to the front face of the brake body (variant 1, see [2] Fig. 2) of the implemented device for testing the lock-off brakes, see Fig. 2.

5. Conclusions
The Faculty of Mechanical Engineering, Technical University of Ostrava was approached by KOMA Industry to prepare an expert opinion on the design of the pallet lock-off system in the context of the overall pallet handling solution in the parking house, which has been in trial operation since 6/2014.

Since its opening, there has been a significant number of operational faults at the parking house, which require the parking operators to remove them.

When the pulley moves into the circular recess of the brake ramp, the pulley is extended by the spring force and thus the pallet is braked and locked against unwanted movement. The pallet is
released by the horizontal force exerted by the chain carrier installed on the lift cage.

In many cases, operational faults are caused by the fact that the pallet brake pulley does not engage in the circular recess in the brake ramp.

The paper presents the design of a device, which detects horizontally and vertically acting forces when rolling the pulley over the upper surface of the brake ramp. The device has been designed to eliminate operational faults caused by the fact that the pallet brake pulley does not engage with the circular recess in the brake ramp.

The paper describes the recommendation and implemented proposal of fitting two types of sensors (limit switches) on the body of two types of pallet brakes, which should remove, or at least significantly reduce, the decommissioning of APS due to inaccurate guidance of the car pallet to the parking position.

There are values of experimentally obtained horizontally and vertically acting forces, which act in the pallet arresting system when the pallets are inserted by the chain carrier into the rack cell presented in tables and graphs in this paper. Experimentally obtained values of vertical forces, which were theoretically calculated in [1], acting in the pallet locking system when pushing the pallet brake pulley out of the circular recess in the brake ramp, will be presented in a paper entitled “Force Effects During the Disengaging of the Brake Pulley Roller from the Circular Recess on the Brake Ramp”.

The vertical forces occurring when the pulley is pushed out of the circular recess of the brake will be determined for three different stiffnesses of coil cylindrical springs.

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References
[1] L. Hrabovský, T. Mlčák and G. Kotajný: Forces Generated in the Parking Brake of the Pallet Locking System. Advances in Science and Technology Research Journal, 13 (4), 2019.
[2] L. Hrabovský, J. Dluhoš: Calibration of Transducers and of a Coil Compression Spring Constant on the Testing Equipment Simulating the Process of a Pallet Positioning in a Rack Cell. Open Engineering, 2019.
[3] PRIMADILNA 2019, https://www.primadilna.cz/Digitalni-snimac-polohy-horizontalni-300-mm-Warlo-d2605.htm.
[4] LASKARDUINO 2019, https://laskarduino.cz/3d-tisk-cnc-stroje/230852-kolejnice-linearniho-vedeni-300mm-s-vozikem-mgn12h.html.
[5] TENZOMETRY 2019, http://tenzometry.eu/comforia/index.php?nahled_snimace=7
[6] PKOTVIRACEOKEN 2019, https://pkotviraceoken.cz/wp-content/uploads/2018/03/TELESKOPICK%C3%89-5-POLE-%C5%98ETENO.pdf.
[7] EICHLERCOMPANY 2018, https://www.eichlercompany.cz/pruziny/vinutepruziny/pruzina-v-1/vinuta-pruzina-s551331282.
[8] GME 2019, https://www.gme.cz/prumysovy-koncovy-spinac-me-8108-nastavitelne-ramenovo-s-valeckem
[9] EICHLERCOMPANY 2018, https://www.eichlercompany.cz/pruziny/vinutepruziny/pruzina-r-l/vinuta-pruzina-s551371782.
[10] KOMA PARKING 2019, http://www.komaparking.cz/koma-tower/
[11] KOMA PARKING 2019, http://www.komaparking.cz/koma-multi-tower-en/
[12] SKYLINE Parking 2019, https://skyline-parking.com/automated-parking-systems/
[13] KLAUS Multiparking GmbH 2018, https://www.multiparking.com/index.php?Robotic-Automatic-Parker-Systems
[14] B. Čihal: Types of automatic parking systems. Verlag Dashöfer, 2015, 12-16 (In Czech).