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DESIGN AND BUILD PROTOTYPE OF AUTOMATIC CURTAIN MOVING SYSTEM

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Abstract: The paper deals with an automatic curtain moving system. Here shown the process of design and build prototype. Solution of problem included design of mechanical construction, electric circuit and program of control. Nowadays is so popular to build houses by sandwich panel. This building method allows quick and modular process of building of halls. In this paper found a possible way for also quick and modular automatic curtain moving system. Chapters deal with initial known and added parameters and the problem. Furthermore, paper says about curtain cornice solutions, sliding ways, design of sheet metal components, DC motor choice, microcontroller and communication preparing. At the end found the conclusion of first prototype.

Keywords: *curtain moving, automatization, Arduino Uno*

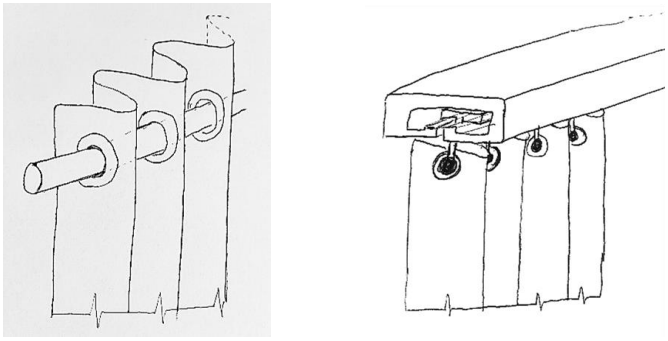
1. INTRODUCTION

Today, modular construction is becoming more and more common, because it allows quick implementation, and unique assemblies can be created [1–3]. In this paper found a solution for an automatic curtains problem in a big hall. *Figure 1* is shown one of the five windows, which need automatic curtains. The hall's inner height is 9 meters, the distance between columns is 5.5 meters, the depth is 15 centimetres, and the special curtain will be 2.3 meters vertical-long with 700 grams per m^2 weight.

2. MOVING TECHNIQUE

First, there was walked around question of curtain cornice and sliding ways [4–6]. There exist two class based on the curtain moving direction: vertical moving direction created by roller blinds, the horizontal one is the traditional curtains. Because of the fire safety part of window, there was chosen the horizontal moving direction. *Figure 2* presents the main two class of the traditional one. *Figure 2*, part *a)* shows 'rod with hoops' technic, while *Figure 2*, part *b)* shows 'rail track with sliders' solution. The version b) is compact, but in this length would have required a custom order and caused complication in automatic moving process. Therefore, the design continued with the 'rod with hoops' technic.

Figure 1. *One of the windows in the hall inside and outside*



a) b)

Figure 2. *Horizontal moving direction classes*

Cost-effect solution kept in mind, the designed construction become steel wire rope with metal hoops and plastic sliders [7]. Compared to the sliding track, the rod material is 50 percent cheaper, while compared to the rod material, the steel wire together with the tensioners turned out to be financially more favourable. *Figure 3* shows sheet metal consoles on the wall and the steel wire rope solution. The consoles were designed by 3D software Autodesk Inventor and was produced by 3 mm steel material and production by the company AR-Robotics in Debrecen. The consoles were fixed with concrete dowel screws because the columns are made of reinforced concrete. The sheet metals included extra holes, because of the iron shank in the concrete column and other connecting elements.

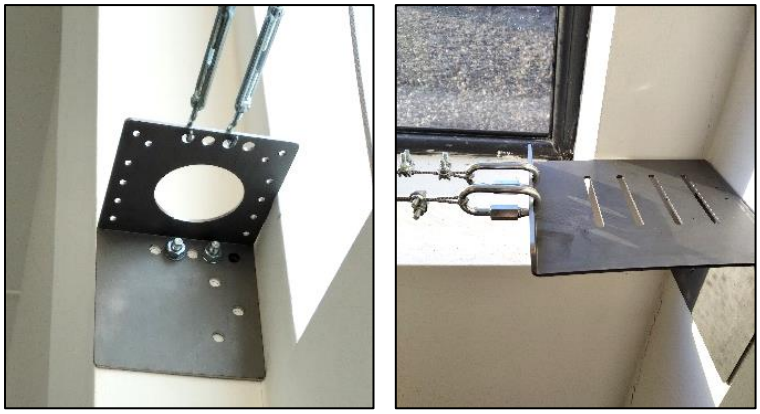


Figure 3. *Steel wire with tensioners and the consoles on the wall*

Figure 4. *First prototype with weight representation*

First prototype was built in laboratory at the Institute of Machine Tools and Mechatronics. In this case consoles were fixed at the other direction on the wall, because of the possibilities. It is a difference between the first prototype and the final structure. Sacks filled with salt were hung at the bottom of the curtain strip, which were represented the weight of the 2.3 meters vertical-long curtain, it is shown in *Figure 4*. This prototype was 'two side closing' layout due to the centrally located fire safety window-part. In fire-case, this layout is the most fastest opening way. At the 'one wire solution' was necessary to support it in the middle, because otherwise it would hang too much, furthermore the two curtain sides must overlap. *Figure 5* included two used consoles in the middle. The left one is made of aluminium profile with a rectangular cross-section with two fixed screws. In this case the one wire was hung on screws, its benefit is the quick installation. The right one is built from three holed steel L-profile, this solution was not required a custom manufacturing, but the wire was threaded into holes.

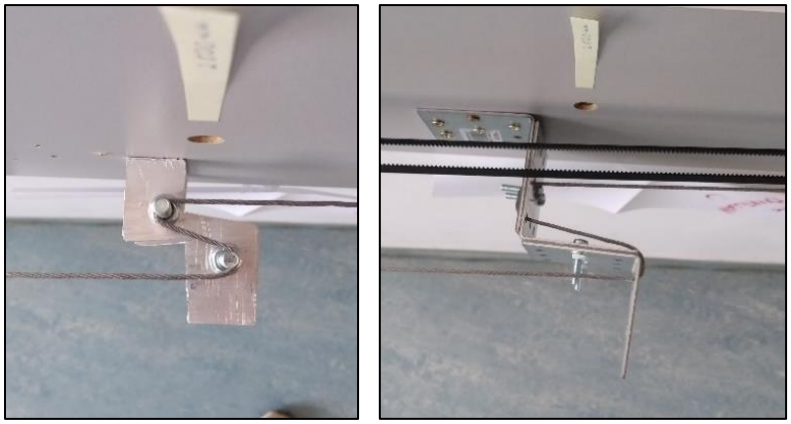


Figure 5. *Wire support in the middle and the overlapping*

Taking additional options and simplicity into account, at the end, there were used the 'two wire solution'. It gave a simple holder in the middle and some extra holes on the end-consoles. One extra steel wire tensioner was acceptable for cost-effect solution.

Automatization of the opening and closing can be solved by controlled electric motor. This motor could rotate a drum and pull rope, its needed pulley and appropriate rope fixing and way. *Figure 6* presents an example for it. It is known that the motor can be installed by its own weight stretching the rope. On the other hand, we can build a space-saving solution with stretched ribbed belt.

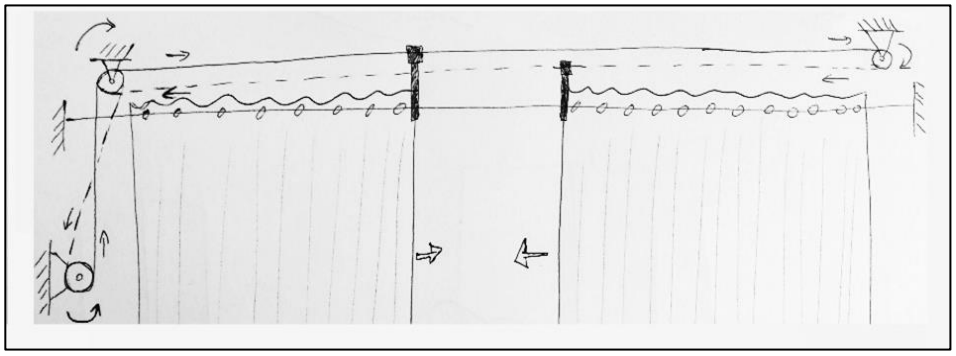


Figure 6. *Curtain moving by motor with drum, pulley and rope*

The pulling with ribbed belt contact with the electric motor shaft via rib wheel, on the opposite side we can create a ribbed belt stretching structure on the consol. *Figure 7* present this structure made by Bosch-profile with groove nuts, fixing screws, threaded stem, ribbed idler element, and an extra perpendicular aluminium part. The ribbed idler is rotating free, the groove nuts can slide in the groove. Stepless tensioning is achieved by the threaded stem in the threaded aluminium element with locknuts.

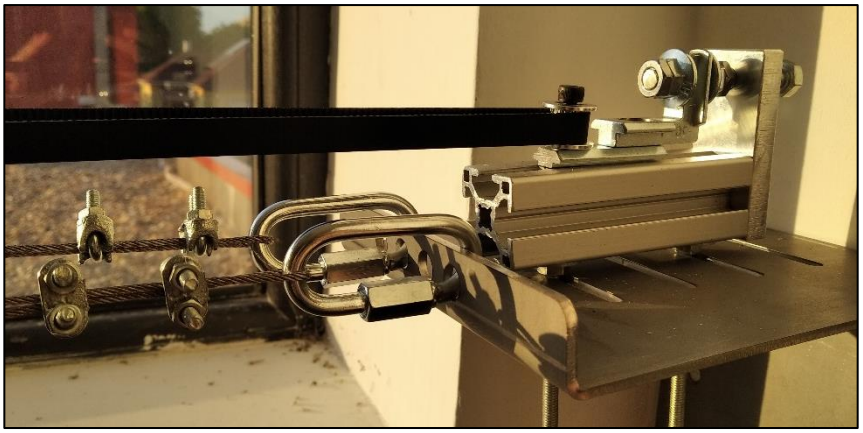


Figure 7. *Stretching structure of ribbed belt*

It is needed to note, compared to the prototype built at the department, in the case of the finally installed version rotated by 90 degrees, such a tension could be achieved with the steel ropes that it was not necessary to fix them in the middle, and the overlap was realized with two steel ropes. During the tests, it was found that the aluminium hoops dragged on the steel rope wear out, so a towing hoop made of wear-resistant plastic rod was applied with the help of a quick connector. This from and connection element shown in *Figure 8*.

Figure 8. *Wear-resistant plastic and connection between the rope and belt*

3. MOTOR SELECTION

During the building of prototype were tested four different direct current motors. As *Figure 9* shows the first was an 12V DC motor without gearbox. Rib wheel was fixed on the shaft by a fixing screw. This motor was proved to be underpowered. The next DC motor was a windscreen wiper motor, because of enough power. At the same time was tested the third motor, which were moved electric controlled window of car. Both turned out good power to moving the automatic curtain, but due to the availability and validity of the warranty, a fourth solution was created.

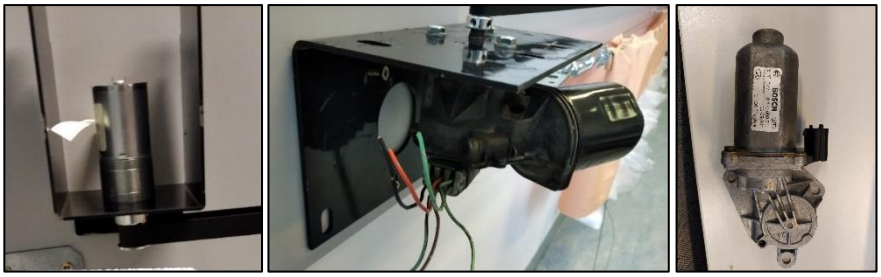


Figure 9. *Tested direct current electric motors*

Since there was looking for the right power, the ability to change the direction of rotation and the right gear ratio, the installation of a hand drill proved to be an obvious solution. Thus, the customer purchased five PARKSIDE brand hand drills. This drill has a threaded connection, which were suitable for attaching an extra pliers. There was designed next sheet metal component to fixing the drill used this connection opportunity. Furthermore, the starter switch and the direction change handle were electrically wired out.

Next testing period focused on accuracy, repeatability, and operational stability. The conclusions of tests were as follows: reduce the distance between the ribbed belt and steel rope; curtain-dragging carriage to build higher. Moreover, it was necessary to put a bearing on the shaft of the rotating rib wheel, because it was bent due to the tension of ribbed belt.

Figure 10 shows the fixed hand drill by thread connection place, wired out electric points, tensioned ribbed belt and tensioned steel rope.

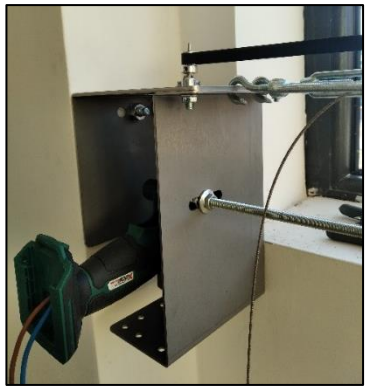


Figure 10. *Application of hand drill with ribbed belt and wired out electric points*

There were two ideas for put a bearing onto the shaft of the rotating rib wheel. One of them is a turned element, the other one is building a structure by sheet metal parts. It was chosen sheet metal structure because manufacturer of this project was suggested a solution, which is shown in *Figure 11*. The shaft diameter

was caused by the parameter of rib wheel, it was necessary to have chamfer for the fixing screw. On this shaft could put the bearings. Position of bearings determined by height and width of sheet metal.

Accuracy of fitting is ensured by laser-cutting of sheet metal, which punctuality is 0.1 mm. The bearing SKF 608 has 7 mm width, it could be achieved by 3 + 1.5 + 3 mm metals; 8 mm inside diameter, it is enough for the shaft; and 22 mm outside diameter, it is possible to produce by laser cutting.

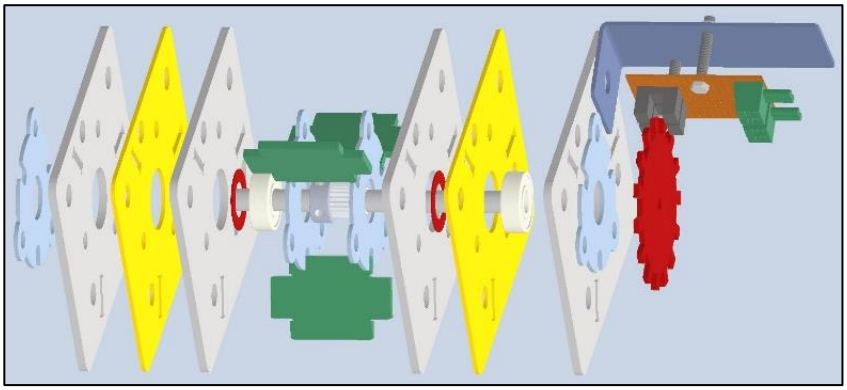


Figure 11. *Bearing and speed measurement*

Assembly process is as follows. Put the bearing (colour white) into the fixed sheet metals, fixing the sheet metals (colour grey, yellow and grey) by plates (colour blue) and screws. Put the rib wheel onto the shaft, fix by screw. Put the fixed bearings onto ends of shaft. Take spacer plates (colour green) into and between fixed sheet metals. Use long through screw to fixing sides. Applicate this structure on the consoles.

After it is possible to put up the optical speed measuring part, which included two opto-gate and one encoder dial. The encoder dial could be fixed with threaded nut onto the shaft.

4. MOVING CONTROL

The automatic curtain is open by default, the idea of control process is as follows. When the customer gives a signal of closing task via Ethernet, which included slow or fast motion. Arduino Uno receives the signal and interprets it, gives a command to the H-bridge with PWM and logical high and low signal pairs. It will cause an intermittent supply voltage corresponding to the speed and well direction of rotation.

At the same time, two opto-gate give to microcontroller a square wave signal arriving with a phase difference. So, the controller could check the speed and intervene if necessary. *Figure 12* shows the system of microcontroller, sensors, and actuators. It can be seen, there are sensors for case of closed, case of opened and

case of fire. Opening and closing processes work until the respective sensors are switched on.

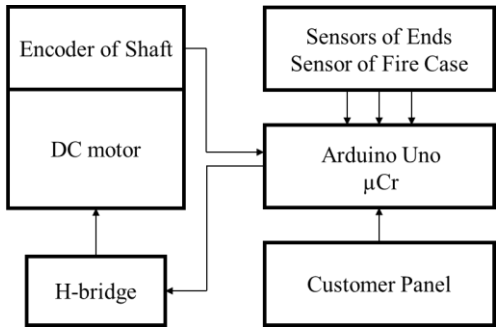


Figure 12. *System of microcontroller, sensors and actuators*

In fire case, the middle part of window automatically starts opening by a linear direct current motor. There is only 800 msec to react this opening signal by the curtain moving controller. At the right side of *Figure 13* shown a test circuit and program for Arduino Uno, which fulfilled the control tasks. At the left side of figure can be seen a validated hand drill with motor control h-bridge. It is worth noting that the end-switches had to be placed further away from the wall consoles, so that in the case of fast moving, overrunning due to momentum would not cause a problem.

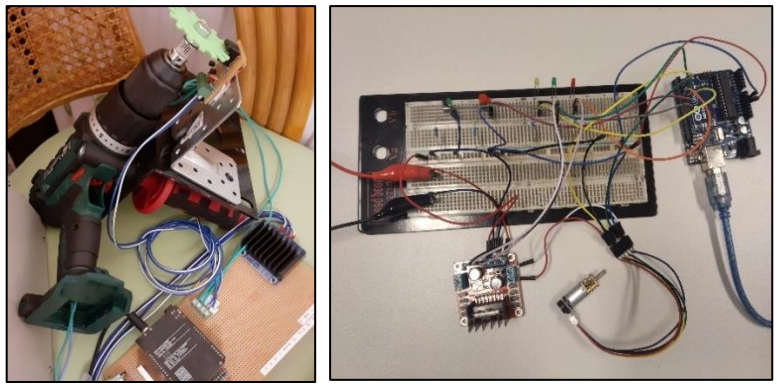


Figure 13. *Validation of electrical circuit and Uno programming*

5. SUMMARY

This paper deals with design and prototype an automatic curtain moving system. It says about how was chosen technique of sliding structure, designed and manufactured sheet metal elements, test circuit of microcontroller, sensors and controlled direct current motor. Here was presented choice of respective electric motor. There were designed own sheet metal structure for bearings, furthermore a

system of opto-gate with dial-plate for works as encoder. The presented system is suitable for opening with a sufficiently fast reaction in the event of a fire

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